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An investigation of the development of intensive care of adults in England and Wales.

Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Doctor of Medicine

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Glossary

Cuffed endotracheal tube	An endotracheal tube which has its end surrounded by an inflatable cuff which ensures that it is an airtight fit in the trachea to allow the lungs to be inflated and prevent secretions running down from the throat into the lungs.
Endotracheal tube	A tube which can be inserted through the mouth and glottis into the trachea
ICU	Intensive care unit
INPR	Intermittent negative-pressure respiration. Usually supplied by an iron lung.
INPV	Intermittent negative-pressure ventilation of the lungs (previously called INPR).
IPPR	Intermittent positive pressure respiration
IPPV	Intermittent positive-pressure ventilation of the lungs (previously called IPPR).
Iron lung. Also called a tank- or cabinet respirator	A cabinet which encloses the patients limbs and trunk. The head is outside the cabinet, protruding through a hole in the end-plate and resting on a pillow. Sub-atmospheric pressure is applied intermittently (12-14 times per minute) to expand the thorax of a paralysed patient and suck air into the lungs through the mouth.
(G)ITU	(General) Intensive therapy unit
NHS	British National Health Service
Polio	Poliomyelitis
SpR	Specialist registrar, a grade of physician in training. Recently used for specialist nurse practitioner.
Trachea	Windpipe
Tracheostomy, previously tracheotomy	A surgically created opening in the trachea through which a tube can be placed to inflate the lungs
UK	United Kingdom of Great Britain and Ireland
US	United States of America

Abstract

The development of adult intensive care in England and Wales has been researched using primary and secondary literary sources and the oral history of participants in intensive care in England and Wales from soon after its inception until the present (2011). The development of theory has been inductive.

In 1952 Bjørn Ibsen, a Danish anaesthetist, treated patients with bulbo-spinal poliomyelitis (polio) with a regime based on intubation of the trachea (windpipe) and intermittent positive-pressure ventilation (IPPV) of the lungs. This resulted in a reduction of mortality of about fifty percent in patients in Copenhagen with this condition. This dramatic result is considered to have initiated the development of modern intensive care throughout the world. The significance of this event is re-evaluated: IPPV was not new. It was in common use in anaesthesia in 1952. It was not more successful than treatment in advanced negative-pressure cabinet respirators in use in the United States. The use of IPPV in paralytic polio was not inevitable. Nevertheless, IPPV did have advantages that made it generally preferable in intensive care. It was applicable to a wider range of conditions which cause respiratory failure, the equipment required was much less expensive and generally available than advanced cabinet respirators and it allowed unrestricted access to the patient. Ibsen's contribution was to bring an anaesthetic technique into use in an infectious disease unit and later into intensive care units. He also extended the applicability of IPPV by combining it with the use of relaxant drugs.

The development of respiratory support techniques in the 40 years before 1952 is described and it is argued that some of these earlier practitioners should be credited with having practised what would later be called intensive care. For a decade after the introduction of IPPV in paralytic polio and tetanus its use in the United Kingdom was largely by infectious disease physicians, sometimes in collaboration with anaesthetists. The development of the specialty of anaesthesia to a point where anaesthetists were able to become the major participants in intensive care after polio and tetanus had become rare after 1963 is described. Intensive care is not simply a matter of connecting a patient to a mechanical respirator: The part played by nurses in the US and the UK in establishing intensive care units is stressed.

Oral histories have shown that medical participation was for many years often by one or two enthusiastic clinicians whose work in intensive care was not given financial or sessional recognition and was in addition to full-time work in their base specialties Funding of units, apart from a contribution for nurses' salaries, was largely from local or regional budgets, often supported by charitable donations. Since the 1980s intensive care has received government funding and has been recognised nationally and internationally as an independent specialty and full-time medical cover for ICUs has been provided. However, these processes are (in 2011) not complete and further development may be anticipated.

Chapter 1. Introduction

This study is an investigation of the factors which contributed to the development of intensive care in England and Wales up to the present time (2011). The development of adult intensive care in England and Wales has been the development of a medical specialty.

Historiography

The historiography of specialisation

The most primitive form of specialisation among medical practitioners can be seen in the tripartite division of medical practitioners which existed in pre-industrial times, although in England the division between physicians, surgeons and apothecaries was not as clear cut as in continental Europe. Physicians claimed eminence on the ground of their lengthy formal education in universities. However they did not dominate medical practice because their numbers were small. Probably more numerous were the *practitioners* of physic, who were not university trained but saw themselves as qualified by reading and experience. The second group, the barbers or barber-surgeons were more popular than the physicians. Their services ranged from beard-dyeing through blood-letting and tooth scraping to surgery and the treatment of sores. They were of middling status and were probably the nearest equivalent in their period to the modern general practitioner. The third group were the apothecaries. They grew from traders in expensive commodities such as drugs and spices and gained expertise in the use of medicines.[1]

Medical specialisation in the modern sense, the acquisition by a practitioner or group of practitioners of knowledge of a particular branch of medicine or surgery, or the establishment of an institution for particular diseases or categories of patients, has been situated by George Weisz as emerging in the nineteenth century.[2] He suggests that by the 1880s specialisation had been perceived as a necessity of medical science as a result of the realization of two preconditions:

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[1] Pelling M, Harrison M. Preindustrial health care 1500-1750. in Webster C.(Editor) Caring for health: History and diversity. 3rd edition. Buckingham: Open University Press; 2001: p.44-48

[2] Weisz G. The emergence of medical specialisation in the nineteenth century. Bull Hist Med. 2003;77:536-74

> First, a new collective desire to expand medical knowledge prompted clinical researchers to specialize; only specialization, it was believed, permitted the rigorous observation of many cases. Second, administrative rationality suggested that one could best manage large populations through proper classification, gathering together individuals belonging to the same class and separating those belonging to different categories. Both of these conditions emerged first and most powerfully in early nineteenth-century Paris. They were, in contrast, uniquely underdeveloped in the fragmented medical community in London during this period.[3]

Weisz explains that the organisation of medicine in Paris in the nineteenth century, with very large hospitals and medical schools, where scientists cooperated with physicians, provided a more fertile ground for the implementation of these ideas than did London, with its multiplicity of small medical schools, many not attached to university academic department. This remained the situation in London until the 1990s when five schools were formed by amalgamation of medical schools and association with universities.[4]

Cooter and Sturdy refer to the emphasis in medicine in Britain in the early 1900s on increased efficiency, sometimes emulating industry with such innovations as the establishment of 'firms'; a group of junior doctors led by a consultant.[5] The development of an increasingly formal and refined division of labour in clinical practice was usually accompanied by a significant measure of specialisation in the kind of cases handled. They cite as an example the clinic organised by the surgeon Robert Jones (1857-1931) in the Royal Southern Hospital, Liverpool. One of Jones' colleagues recalled:

> Jones got through an immensity of work…rendered possible by the systematic preparation of the patients and by the work of the anaesthetists who had each successive patient ready by the time the operation of its predecessor had been completed…He had trained a number of helpers, some of them medical men glad to get the experience, others consisting of a

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[3] Weisz G. The emergence of medical specialisation in the nineteenth century. Bull Hist Med. 2003;77:536 (Summary).

[4] Rivett G. The development of the London Hospital System. Accessed 8.11.2011. Available at The Development of the London Hospital System 1823-1982 Follow links 'District to Trusts' and then 'University decisions.'

[5] Sturdy S, Cooter R. Science, scientific management, and the transformation of medicine in Britain c. 1870-1950. Hist Sci. 1998;36:421-53.

> nursing team trained in the application of splints and plasters. Other workers who had had some training kept an eye on the home conditions of the patients with reference to their feeding and regular attendance for massage, or other special treatments, at the hospital.[6]

Jones concentrated almost entirely on orthopaedic cases. After discussing opposition to specialisation within the culture and social relations of elite medicine, particularly because of the effect that diversion of their patients to specialists would have on their private practice, Cooter and Sturdy cite several specialist practitioners in provincial towns and cities, where specialisation was seen as more acceptable than it was in London. By the early twentieth century the new division of labour was becoming an accepted part of elite practice.

A further factor in the growth of specialisation in the nineteenth century has been described by Rosen.[7] He has ascribed it to a new concept of disease; which he called 'organ localism'. The rise of the understanding of pathological anatomy moved the conceptualisation of disease towards damage or malfunction of particular organs rather than the earlier 'humoral' theories. At the same time some of these organs came to be accessible to examination in the living patient with the invention of ophthalmoscopes and laryngoscopes. This encouraged some practitioners to become skilful in such procedures and to concentrate on the treatment of diseases which could be diagnosed and monitored by the new techniques. Weisz agreed that the development of pathological anatomy both stimulated the emergence and shaped the form of some specialties but he suggested that it 'was not necessarily determinant, since many of the emerging specialties were not in fact based on organic localism.'[8] Many had predated pathological anatomy and some surgical specialties were based on specific surgical procedures.

Burnham has situated specialisation within professionalisation: 'The impact of technology, the existence of hierarchies, the exercise of power in economic, social or gender terms – all gain a dimension when cast in the additional framework of

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[6] Macalister C. The origin and history of the Liverpool Royal Southern Hospital with personal reminiscences. Liverpool: W B Jones; 1936. Cited in Sturdy S, Cooter R. Science, scientific management, and the transformation of medicine in Britain c. 1870-1950. Hist Sci. 1998;36:426

[7] Rosen G. The specialization of medicine with particular reference to ophthalmology. New York: Froben Press; 1944. Cited in Weisz G. The emergence of medical specialisation in the nineteenth century. 2003

[8] Weisz G. The emergence of medical specialisation.. 2003: 545.

"profession". Even the process of specialization could be better understood in terms of professional functioning.'[9] The status of specialists and specialties within the medical profession has certainly reflected the dynamics and constitution of the medical profession in which the specialties have developed.

Rosemary Stevens has traced the development of specialties in Britain between 1914 and about 1964.[10] The First World War (1914-1918) stimulated the development of special skills and special interests particularly in psychiatry, orthopaedics, thoracic surgery and plastic surgery. Anaesthesia for thoracic and plastic surgery of the face presented particular problems the management of which could only be undertaken by a small but increasing number of specialist anaesthetists. By the 1920s specialisation was generally accepted as necessary and inevitable. However specialists aligned themselves with either medicine or surgery. A consultant in any specialty was expected to have the membership of the Royal College of Physicians (MRCP) or the Fellowship of the Royal College of Surgeons (FRCS). Stevens saw medical practice between the two World Wars as a struggle between the two Royal Colleges which wanted to retain medicine as a unified whole, with the emerging groups which wanted to raise standards in their own special fields and to advance their own status. Some specialties introduced specialist Diploma qualifications the possession of which would guarantee at least a minimum standard of practice, but the diplomas were obtainable after only a short period of experience (six months) and an examination which was far below the standard of an FRCS or an MRCP. They were largely of use to general practitioners. The definition of a specialist was not always clear. Many general practitioners claimed to specialise in some aspect of medicine or surgery. Towards the end of the inter-war period the imminence of the Second World War was the stimulus for the Military to ask the Association of Anaesthetists of Great Britain and Ireland to provide criteria by which an anaesthetic specialist could be recognised and given a military rank appropriate to a Specialist Medical Officer.[11]

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[9] Burnham JC. Garrison Lecture: How the concept of profession evolved in the work of historians of medicine. Bull Hist Med. 1996;70:1-24. John C. Burnham is Professor of History and of Psychiatry at The Ohio State University.

[10] Stevens R. Medical practice in modern England. The impact of specialisation and state medicine. New Haven and London: Yale University Press; 1966. p. 38 et seq.

[11] Mennell Z. Letter to an Authoritative Military Source. In Minutes of an emergency Council Meeting (27 October 1939) recorded in the minutes of the Association of

The monopoly of the Royal Colleges of Medicine and Surgery was first broken by the foundation of The British College of Obstetricians and Gynaecologists. The College was founded in September 1929 by Professors William Blair-Bell of Liverpool and William Fletcher Shaw of Manchester. Membership of the College soon became the *sine qua non for* a consultant appointment in obstetrics and gynaecology. The college was granted a 'Royal' title by His Majesty King George VI in 1938. Stevens traces the development of training structures for ophthalmologists, otolaryngologists, dental surgeons and anaesthetists within the Royal College of Surgeons. The College created semi-autonomous Faculties which created specialty fellowship examinations comparable to the FRCS and which were recognised as defining eligibility for a consultant post in the specialty. No such arrangements were made by the Royal College of Physicians and many physicians were designated ‘physician with a special interest in’ for example, cardiology, haematology or diabetology.

Stevens concluded her description of specialties in England with a chapter on specialties in the 1960s (her book was published in 1966). The period was characterised by the formation of Colleges by psychiatrists and pathologists. Both of these branches contained by 1964 more than ten percent of all consultants; each was exceeded in size only by general medicine, general surgery and anaesthesia. In both cases the impetus came from the respective specialist Societies. Both specialties had diploma examinations but they were not of the same level of the MRCP. The size of the specialties and the increasing divergence of the specialties from the subject matter examined in the MRCP were the principal arguments for specialty colleges or faculties. Following ballots, both branches decided to establish independent Colleges rather that to press for faculties within the Royal College of Physicians. The Royal College of Pathologists was founded in 1962 after a long campaign which was by no means harmonious; some of the older members of the specialty simply did not want to be organised.[12] The Royal Medico-Psychological Association was in 1971 granted a Supplemental Charter accorded the Association the status of the "Royal College of Psychiatrists".

Several recent studies have investigated other influences that have driven the formation of specialties. Two of those influences have been status and financial

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Anaesthetists of Great Britain and Ireland. Book No.1 1932-1947:197.

[12] Peter Davey. The Widdicombe file. Lancet.1956;1:375-7.

advantage. In the years before the National Health Service (NHS) specialisation could enable a general practitioner to become a hospital consultant; which carried superior status, both socially and within the medical community. Claims to be a specialist could be based on the type of patient treated; children or women, or on the method of treatment; surgery or internal medicine, or on the ability to use complex diagnostic procedures; radiology or laboratory techniques, chemical, bacteriological or immunological. As well as superior status, specialism often offered the possibility of lucrative private practice.[13] However not all specialties attracted private practice; there were, for example, few private patients in intensive care because few private hospitals could afford to staff and equip an intensive care unit. In dentistry, after the Dental Act of 1921 made unregistered dental practice illegal in Great Britain, there was such a shortage of registered dentists that general dental practice became very lucrative and there was therefore no incentive for the ordinary dentist to diversify his practice into specialised orthodontics.[14]

Vanessa Heggie classified factors which influenced the formation of specialties as external and internal.[15] She focused on the case of sports medicine, in which specialisation was strongly influenced by external factors. At first, sports medicine was largely available only to elite sportsmen, including some highly paid footballers. Clubs were willing to pay very large fees to anybody who could get an injured player back on the field with the minimum of delay, but they needed to know that the treatment was provided by a 'real' expert. They wanted a specialist. Many players were insured against injury, and insurance companies wanted to be assured that when they paid for treatment of sports injuries they were paying for the services of recognised and accredited specialists. The clubs and insurance companies, bodies external to medicine, pressed for the definition of specialists in sports medicine. In addition to these external or contextual pressures, there have been internal pressures, to aggregate those who possess knowledge and skill to a specialty.

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[13] Granshaw L. Fame and fortune by bricks and mortar: the medical profession and specialist hospitals in Britain, 1800-1948, in Granshaw L, Porter R. The hospital in history. London: Routledge; 1989: Pages 199-220

[14] Taylor GS, Nicolson M. The emergence of orthodontics as a specialty in Britain: the role of the British Society of Orthodontics. Med Hist. 2007;51:379-98

[15] Heggie V. Specialization without the hospital: The case of British sports medicine. Med Hist. 2010;54:457-74.

There were internal pressures from within medicine to define specialties. Medical practitioners of the new knowledge had an altruistic wish to protect the public from 'quacks'. Hospital administrators needed to know what they were employing the consultant to do: an anaesthetist treating a patient with asthma was not practising anaesthesia, which was what his contract said was his specialty, the reason for his employment. He could not be (and was not) paid for practising intensive care until it was defined as a specialty. Staff in these areas had to be recognisable by defined criteria. At a higher level, Government needed advisory bodies from which policies could be formulated. Peter Coventry and John Pickstone in their study of the emergence of genetics in the Manchester Region of the NHS provided a specific instance of the value of specialisation to the NHS. The emergence of consultant geneticists was strongly supported by government because of popular demand for antenatal diagnosis of genetic abnormalities after 'prevention' became available following the Abortion Act of 1967. 'One of the major arguments for extending the genetics service was the fear that inadequate counselling of tested mothers might have unfortunate consequences, including action against the health authorities.'[16] In other words, geneticists were cost effective. Money spent on the appointment of accredited specialists who could give advice which would stand up in court was considered to be money well spent.

Historians of medicine have thus identified a variety of factors, including social, economic, managerial and technical influences that have shaped the specialisation process at different times and places and in different specialties.

Aims of this thesis

The aim of the present thesis is to add to and reflect on this literature by undertaking a detailed case study of the process of specialisation of intensive care with particular attention to its development in England and Wales

The modern specialty of intensive care started in 1952 with the use in a poliomyelitis ('polio') epidemic in Copenhagen of techniques previously used in surgical anaesthesia. It has variously been called intensive therapy and intensive care. The former term has fallen into disuse and 'intensive care' will be used

[16] Coventry PA, Pickstone JV. From what and why did genetics emerge as a medical specialism in the 1970s in the UK. A case-history of research, policy and services in the Manchester region of the NHS. Soc Sci Med. 1999;49:1227-38.

throughout this thesis unless a primary source uses 'intensive therapy' The. investigation has had to include the evolution in the first half of the 20th century of the techniques which were used in 1952. Intensive care continues to develop and has been integrated into critical care. The later term has been used since at least 1969, when the American Association of Cardiovascular Nurses changed its name to the American Association of Critical Care Nurses (AACCN). This name change 'symbolized the idea that nurses working in all critical care situations, not cardiovascular settings, should be included.' [17] Intensive care medicine has now become part of critical care medicine. In Britain the Intensive Care Society has not changed its name and the new Faculty of the Royal College of Anaesthetists is called the Faculty of Intensive Care Medicine but the section of the Royal College of Nursing which deals with intensive care has been called the Critical Care Forum since 2003.[18] The Department of Health for England has recommended the existing division into high dependency and intensive care based on beds be replaced by a classification that focuses on the level of care that individual patients need, regardless of location.[19] Levels of 'acuity' are defined as:

Level 0: Patients whose needs can be met through normal ward care in an acute hospital.

Level 1: Patients at risk of their condition deteriorating, or those recently relocated from higher levels of care, whose needs can be met on an acute ward with additional advice and support from the critical care team.

Level 2: Patients requiring more detailed observation or intervention, including support for a single failing organ system or post-operative care, and those 'stepping down' from higher levels of care.

Level 3: Patients requiring advanced respiratory support alone or basic

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[17] Lynaugh, J E. Fairman, J. New nurses new spaces: A preview of the AACN history study. Am J Crit Care. 1992;1:19-24.

[18] Royal College of Nursing Website available at http://www.rcn.org.uk/development/communities/rcn_forum_communities/critical_inflight/newsletter_archive accessed 4 May 2011. In 2009 the Critical Care Forum merged with the In-Flight Nursing Forum.

[19] Department of Health. Comprehensive critical care: A review of adult critical care services. Available at http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4082872.pdf accessed 12 July 2011

respiratory support, together with support of at least two organ systems. This level includes all complex patients requiring support for multi-organ failure.[19]

It will be seen that Level 1 includes advice and support on an acute ward by the critical care team; 'outreach support'. Patients in the critical care unit are those classified as Level two and Level three. These definitions are now in every-day use among staff in critical care units in England.[20]

For several reasons the study has been confined to developments in England and Wales. The organisational changes in Scotland and Northern Ireland have often been different from those in England and Wales, reflecting their different circumstances. Examples are the inaccessibility of isolated, particularly island, communities in Scotland and the civil unrest in Northern Ireland. Intensive care of neonates and children has not been included in this investigation because in many centres (including Liverpool) it developed completely separately, it presents different problems, particularly of ethics, and it would be impossible to do justice to it here.

The development of intensive care has been considered in the context of changes in the medical and social environment in which it has occurred. Financing, medical and nursing staffing and training have all been developed or constrained by resources and their allocation and the demands of the wider National Health Service (NHS). Only the changes in the NHS which have had some recognisable effect on intensive care have been examined and described. Following the example of Geoffrey Rivett, no attempt has been made to investigate the political background to governmental management of the NHS.[21]

Much of the development of intensive care has been driven by advances in medicine and particularly in surgery and these have been described, together with the effect they have had on intensive care. The development of coronary intensive care and renal dialysis units, which differ in staffing and organisation from other ICUs has been investigated but has not been described in the thesis because of spatial limitations, but renal and cardiovascular support in general intensive care is discussed.

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[20] Conversations with Wenstone R, Consultant in Intensive Care, Royal Liverpool University Hospital and Gilbertson NJ, Consultant in Paediatrics, Royal Cornwall Hospital, April 2011

[21] Rivett G. From cradle to grave. Fifty years of the NHS. London: Kings Fund Publishing; 1998:xii

The thesis has been organised on broadly chronological lines. The first section describes the treatment of respiratory failure before 1952 and the development of the techniques and expertise which would be needed when intensive care began to be practiced in 1952-3. The second section describes the development of intensive care in the early period (c. 1953 – c. 1963) when intensive care was predominantly the care of patients with respiratory failure due to infectious diseases. The early application of intensive care techniques to other pathologies is also included in this section. The third section concerns the late 1960s and the 1970s during which an ICU gradually became the rule rather than the exception in large hospitals in England and Wales. In this section chapters eight to ten trace the development of ICU in various specialised areas of intensive care . The final section, which does not fit neatly into a precisely defined chronological era, describes, in chapter 11, the development of intensive care medicine toward standardised training, and national and international recognition of intensive care medicine as an independent specialty and, in chapter 12, the specialisation of intensive care nursing and its integration into critical care nursing. A final chapter summarises the findings and the conclusions reached from this study.

The aim of this study has been to situate the development of the specialty of intensive care of adults in England and Wales within the historiography of medical specialism in general, to identify areas where it might differ from described patterns of medical specialisation and to discover which influences described by other writers have been found to be operative in the development of intensive care in England and Wales.'

Chapter 2. Methodology (Oral history and literature review)

Modern intensive care developed in the UK after the introduction of positive pressure respiration for the treatment of respiratory failure in the polio epidemic in Copenhagen in 1952. Searches for literature of the period 1952 to 2011 revealed that the origins of intensive care techniques lay in work conducted since 1903, so searches were extended for literature published since that date. Literature searches were conducted through local and national libraries and through the internet. Reports in the first half of the twentieth century were mostly in the relatively few general medical and surgical journals published at that time. The later development of intensive care methods and practice were found in specialist medical and nursing journals and in historical reviews. A study of the Register of Patients in the ICU of the Royal Liverpool University Hospital was truncated after the records were destroyed after the first year had been transcribed to a spread-sheet.

Oral history as a research methodology

Black and Macraild situate the emergence of modern history in the nineteenth century.[22] The principle mode of operation was empirical, the scientific investigation of sources. The primacy of archival research and documentary sources led to a marginalisation of oral evidence. Gradual acceptance of the usefulness of oral evidence and the increasing availability of portable tape recorders underpinned a revival of oral history after the second World War (1939 – 1945).

Perks and Thompson identify four paradigm shifts in oral history and practice: First, after the Second World War there was a renaissance of memory as a source of ‘peoples history’. Second, from the late 1970s post-positive approaches to memory and subjectivity gained respectability. Third, a transformation in the perceptions of the role of the oral historian as interviewer and as analysis emerged in the 1980s and fourth, the easy availability of digital equipment since the late 1990s has greatly facilitated the recording of oral history.[23]

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[22] Black J, Macraild DM (editors). Palgrave study skills: Studying history. Basingstoke: Palgrave Macmillan; 2007. page 29.

[23] Perks R, Thompson A. (eds). The oral history reader. 2nd edition. London: Routledge; 1998. p. 1-13.

The source of the first of these 'shifts' arose in part from the availability of portable tape recorders but there were other influences. In Britain the post-war political change towards socialism stimulated renewed interest in the lives of the 'working class'. Tape recorders allowed the evidence of previously unrecorded people and groups to be unearthed and preserved. These people were not necessarily an 'underclass' but their oral reports shed light on aspects of events not thought worthy of documentary recording.

The second paradigm shift, the development from the late 70s of post-positive approaches to memory and subjectivity, was a response to positivist critics. Perks and Thompson characterise those critics as 'for the most part traditional documentary historians of a conservative political persuasion who feared the politics of the peoples history and who targeted the 'unreliability' of memory as its weakness'. [24] They were therefore attacking oral history on the grounds that it was politically biased and unreliable. Alleged sources of unreliability are the unreliability of memory, unreliability due to subjectivity or due to selection bias or political bias.

To accuse oral history of unreliability is to say that it does not accurately describe what actually happened. The relation between historical 'fact' i.e. what actually happened, and oral descriptions of those happenings has been a source of much research and discussion. Allesandro explained that oral sources are 'credible but with a different credibility. The importance of oral testimony may lie not in its adherence to fact, but rather in its departure from it, as imagination, symbolism and desire emerge. Therefore there are no false oral sources.'[25]

Unreliability of a personal account of an event might arise from distortion of memory by the physical deterioration and nostalgia of old age, the personal bias of both or either of the interviewee or the interviewer and the influence of collective and retrospective versions of the past.[26] Oral historians have developed guidelines to assess the reliability of memory. They have used social psychology and anthropology to determine bias and fabulation in memory, the significance of introspection and the effects of the interviewer-interviewee interaction. From sociologists oral historians learnt methods of avoiding sampling bias, and they used the methods of documentary

[24] Perks R, Thompson A (eds). The oral history reader. 2nd ed. London: Routledge; 1998. p. 3.
[25] Portelli A. What makes oral history different? In: Perks R, Thompson A.(eds) The oral history reader. 2nd ed. London: Routledge; 1998 p. 37.
[26] Perks R, Thompson A.1998. Page 3.

history (while taking account of its weaknesses) to modulate their opinion of the reliability and consistency of their oral historical sources.

It is undeniable that an interview is subjective. It is the personal view of the subject. Recollections may always not reflect what happened, but they may tell us much about *the effect* of the happening on the individual and perhaps upon society. 'Every historical source derived from human perception is subjective but only the oral source allows us to challenge the subjectivity; to unpick the layers of memory, dig back into its darknesses, hoping to reach the hidden truth.' [27]

Historians have learnt from psychoanalysts to be more perceptive in unpicking the layers of memory, to approach the hidden truth. Thompson admits that few historians are going to be able to practice psychoanalysis, but gives examples of the way previous life experiences affect later interpretation and memory of situations and events. It is not the specific theories of psychoanalysis which prove most useful as much as a new sensibility, an ability to notice what is missed. 'The important lesson is to learn to watch for what is not being said and to consider the meaning of silences.'[28]

Luisa Passerine considers 'it is highly productive to assume that oral sources refer to and derive from a sphere which I have chosen to call subjectivity. By this I wish to connote that area of symbolic activity which includes cognitive, cultural and psychological aspects.'[29] The terms used to define this area more narrowly (mentality, ideology, culture, world view and consciousness) are generally confused and vague. In a study of work ideology and consensus under Italian fascism she states that the traditional concept of anti–fascism as comprised of clandestine political activity should be questioned. 'We should seek to perceive in what way, at the level of day-to- day subjectivity, forms of consensus and acceptance contained within themselves a potential dissent even greater than that displayed in the more narrowly conceived political sense.'[30] In other words, Passerini sees subjectivity as not something to be avoided but as a useful aspect of oral history.

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[27] Thompson P. The voice of the past. Oral history. 3rd ed. Oxford: Oxford University Press; 2000. p. 173.
[28] Thompson P. The voice of the past. 2000. Pages179-80.
[29] Passerini L. Work ideology and consensus under Italian fascism. Hist Workshop J 1979;8:85.
[30] Passerini L. Work ideology and consensus 1979;8: 105.

A source may be unreliable due to sampling bias. Of course written history also involves sampling. A written historian tries to include as wide and as complete a range of written sources relating to the events being studied, but the surviving documents may not be representative. They will sometimes have been preserved by a person or a group with a particular axe to grind; they will promulgate documents which demonstrate the success of their policies or the wickedness of their enemies. Because of the small number of interviewees available for this study it was not possible to select interviewees by some sort of randomisation process. However a range of viewpoints has been obtained by the availability of two professors of anaesthesia, consultants in London and provincial teaching hospitals and in a district general hospital in Cumbria and one of the earliest physician intensivists. The nurses included a sister in a general hospital, a nursing administrator and a clinical academic with membership of government advisory committees.

Oral history has tended to focus on giving a place in the sun to the history of people who had been ignored by documentary history. The lives and stories of the majority of people were rarely recorded unless perhaps they were criminals, heretics, revolutionaries or were in some other way extraordinary.

The political contexts of oral history can be seen as a weakness of the method only if that context is not admitted. Consideration must also be given to the possibility that a political point of view biases the interpretation of the data (interviews, conversation) by the oral historian. These strictures could be levelled at any version of history.

An interview or a document may ‘spin’ a report of an event in a way which will appear to support a wanted conclusion. Paul Thompson illustrates his contention that oral history is not less reliable or more biased than written history by quoting a conversation between Richard Crossman, a former cabinet Minister in the British government and the historian A J P Taylor:

> ‘I’ve discovered, having read all the Cabinet papers of meetings I attended, that the documents bear virtually no relation to what actually happened. I know now that the cabinet minutes are written by Burke Trend (secretary to the Cabinet), not to say what did happen in the cabinet, but what the Civil

> Service wishes to be believed happened, so that a clear directive can be given'.[31]

Apparently even Cabinet papers were unreliable. They are biased; biased towards a Civil Service objective, the formulation of a clear directive.

Conclusion

The strengths of oral history are its ability to reveal the history of groups of people whose history has previously been ignored, either because they have not been considered worthy of consideration or because of a paucity of documentary evidence and its ability to reveal not just what happened but the effect on people's lives and the subtle influences which caused or hindered what happened.

The weakness lies in the unreliability and selectivity of memory, the bias of the narrators and perhaps the selection of uninformed or unrepresentative witnesses. These weaknesses can be limited by utilisation of methods from psychology, social science and documentary history. Subjectivity in oral history can be as much an asset as a liability. Oral history should not be judged against the 'Gold Standard' of what has been since the 19th century conventional documentary history. Critiques have been undertaken of other sources and of a series of works of oral history which have at least demonstrated the equal worth of oral and other sources.[32]

Methodology of oral history in this study

Instruction in interview technique was received at The North West Sound Archive in February 2009 and at the Oral History Society Training Day at the University of Sheffield in April 2009. The Online Research Skills Course and the 12-week Lecture Series and Workshops on Qualitative Research were completed.

Interviews were conducted with medical practitioners who were involved in the early development of intensive care in the United Kingdom (UK). Several were known from contacts with the author in the Intensive Care Society, the Royal Society of Medicine Sections of Anaesthesia and Intensive Care, The Royal College of Anaesthetists particularly the Senior Fellows Club. Others were identified from their publications. A few were recommended by interviewees already identified, in a similar manner to the identification of references in the literature from the citations

[31] In Thompson P. The voice of the past. 2000. Page 60.
[32] Thompson P. Problems of method in oral history. Oral Hist J. 1972;1(4):1-47.

of already known articles and books (snowballing or ancestry searching). Intensive care was practiced by a relatively small number of practitioners in the early years and it is unlikely that any significant contributors were not detected by these methods. Interviewees who could describe their experience in the early years of intensive care (the 1950s and 1960s) were given precedence because their testimony would not be available to workers in the future. Nurses still in practice in intensive/critical care nursing were contacted through enquiries at the Royal Liverpool University Hospital Critical Care Unit. Retired nurses were contacted through informal social networks.
Two of the earliest workers were not in good health and were not contacted. Twenty-two people were asked to agree to be interviewed. A copy of the invitation letter is appended. All except one accepted. The exception was not available to be interviewed but sent valuable unpublished material. A list of those interviewed is attached as Appendix 3. Two other participators in the recent development of intensive care, Jean-Louis Vincent and Julian Bion, were contacted by email and supplied useful information about the professionalisation of critical care medicine. Several interviews were supplemented by subsequent telephone calls.

Sources of bias in the selection of interviewees

It has not been possible to select for interview a ‘representative sample’ of early pioneers. This study has been conducted at this time (2007-2011) because it was considered important to obtain the evidence of those early practitioners who are still available for interview. As the physicians who engaged in intensive care were already relatively senior in the 1950s it is inevitable that few were still available. It is fortunate that Eric Sherwood Jones, a very prominent physician intensivist and the fourth President of the Intensive Care Society agreed to be interviewed and was able to describe his experience of the early days of intensive care in England and Wales. Three other physicians, James Macrae, Barnett Christie and Alex Crampton Smith all contributed substantially to the early development of intensive care in England but were no longer available for interview, but comprehensive accounts of their work have been obtained from the literature. The number of anaesthetists engaged in intensive care started to increase in the early 1960s and most of the interviewees have been among their number. No surgeons from the early years were available to be interviewed but the anaesthetists interviewed were able to describe the

management of post-operative problems and their cooperation with surgical colleagues and to provide a comprehensive view of the development of intensive care in the two countries.

Conduct of interviews

The interviews were recorded in a place convenient for the subject; the interviewees' home in six cases, the author's home for four subjects who lived in or were passing through Liverpool and in a mutually convenient location (e.g. The Royal College of Anaesthetists or the Royal Society of Medicine, both in London) for the remainder.

After an explanation of the subject of the research and of oral history the narrator was led to describe his or her life and involvement in intensive care in the UK by a series of prompts rather than explicit questions. The prompts were 'open' and leading questions were avoided, although Cutler recommended them as 'yet another technique to improve the accuracy of an interview'.[33] He cites research which showed that leading questions did not lead to more distorted answers than 'straightforward' questions.

The recording equipment was Olympus WS-311M with Yoga EM-102 individual tie-clip condenser microphones. The audio files were loaded onto an Acer PC and backed up onto CDs. All the interviews except one were transcribed by the interviewer using Express Scribe Professional Transcription Playback software. One interview was much longer than the others and so the audio file was sent to Voicescript Ltd, for professional transcription.

All the interviewees signed a standard permission form (copy appended) assigning copyright of the recordings and transcripts to the interviewer for use in subsequent publications relating to this project. One interviewee considered that his interview had been less coherent than he would have liked and contained some sections which though factual might give offence and although he agreed that the transcript was accurate he was not willing to give permission for it to be used. He deleted some parts of the transcript and revised others. He then signed an edited version of his interview. As it would not be ethical to use the parts of the original

[33] Cutler WW III. Accuracy in oral history interviewing. Historical methods newsletter. 1970;3:1–7.

transcription for which he has not given permission, only those parts of the original transcript which are included in the edited version are reproduced or used in this thesis. The audio recordings and transcripts will be archived in the Liverpool Medical Institution. The aural files will be stored on high quality CDs as recommended by the Oral History Society.

Analysis of data

The method of interpretation of the interviews is phenomenological.[34] That is, it attempts to understand and convey the experiences of the subjects in the context in which they lived those experiences. Verification and added precision (particularly in the matter of dates) has been possible for several of the interviews by comparing events with written sources. Boulton has written an autobiography of his professional life and Sykes has written a book which contains some biographical detail.[35] [36.] Other events described in the interviews are also described in articles or conference proceedings.

The analytic process was based on the method described by Okley.[37] A list of broad topics was constructed on the basis of previous concepts of the history of intensive care in England and Wales. As the oral evidence accumulated these topics developed. Some were found to be irrelevant and were discarded and others had to be added. Subheadings also had to be added as more detailed evidence about the various topics emerged. At first topics and subheadings were coded, at first alphabetically and later numerically, but this was found to be unwieldy and unhelpful. Oakley suggested that a file be opened for each topic. She used file envelopes but suggested

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[34] Literally, phenomenology is the study of "phenomena": appearances of things, or things as they appear in our experience, or the ways we experience things, thus the meanings things have in our experience. Phenomenology studies conscious experience as experienced from the subjective or first person point of view. For example it is not enough to know that an intensive care unit was opened in 1956; how did the experience of opening it affect the narrator? What were the motives for what the narrator did? How did his colleagues react? For an accessible description of phenomenology see the Stamford encyclopaedia of philosophy accessible at http://plato.stanford.edu/entries/phenomenology/#1 and Manen MV. Researching lived experience. New York: The State University of New York Press; 1990.

[35] Morris LE, Boulton TB, Giesecke AH, Zavaleta JR. Careers in anesthesiology. Illinois: The Wood Library Museum of Anaesthesiology; 2007.

[36] Sykes K, Bunker J. Anaesthesia and the practice of medicine: Historical perspectives. London: Royal Society of Medicine Limited; 2007.

[37] Okely J. Thinking about fieldwork. In: Doing social science research. Yates SY, London: Sage; 2004: 193–196.

that the advent of computers would enable the files to be documents in a word processor and in this study a document in Microsoft Word has been created for each topic and its subheading. An example in the present study would be a file 'Anaesthesia in the 1950s' containing copies of sections of any transcript which refers to that heading. This topic was expected to be relevant because the first example of modern intensive care had been the result of the application of techniques used by the Danish anaesthetist Ibsen. Subheadings were found to be necessary when, for example, interviewees reported that abilities of anaesthetists in certain 'centres of excellence' were found (sometimes) to be better than those of part-time anaesthetists in district hospitals. Each transcription has been examined for descriptions of the interviewee's experience of anaesthesia in England and Wales in that period.

As the transcripts have been examined sections of the text which refer to each topic have been colour coded, a comment has been inserted in the margin to mark the position of the section and the topic referred to and that section of the text has been copied to the relevant Topic File. The Topic Files have then each been examined to compare the evidence on that topic from the various interviewees. Where possible evidence has been amplified or validated from supporting sources.

Literature search.

It might be expected that the multiplicity of databases which contain details of articles on almost every conceivable medical subject published throughout the world would make the search for articles on any subject very easy. However studies have demonstrated that even searches conducted by skilled librarians detect only half the eligible citations.[38] Searches by less experienced trainees and medical staff at a university medical centre retrieved only 55% of the articles retrieved by reference librarians and retrieved 55% more irrelevant articles.[39] A lack of appropriate indexing terms, the accuracy and consistency with which they are applied and the extent to which authors adequately describe their research are all factors which affect the retrieval of reports from bibliographic databases.[40] The limitations of such

[38] Conn V S, Isaramalai S-a, Rath S et al. Beyond MEDLINE for literature searches. Journal of Nursing Scholarship 2003;35:177-182.
[39] Haynes RB, McGibbon KA, Walker CJ et al. Online access to MEDLINE in clinical settings. A study of use and usefulness. Ann Intern Med. 1990;112:78-84.
[40] McDonald S, Lefebvre C, Antes G et al. The contribution of hand searching European

literature searches are particularly evident in searches for articles written before or in the early years of electronic databases.

The searches described in this thesis were conducted using MEDLINE and OLDMEDLINE with the OVID interface, and SCOPUS through the University of Liverpool portal. The catalogues of the Wellcome Library and the Royal College of Physicians were also consulted. Other sources cited are *Hansard* which is available free of charge on-line and *The Times Archive* which is available on subscription. Searches of primarily medical databases were found to be inadequate for retrieving contextual material and searches of other databases such as ISI Web of knowledge were required.

Ideally a search should identify all the articles in the database which are relevant to the subject being studied and should not select any articles which are not relevant. The ability to include all relevant articles is called sensitivity, or in the context of literature searches, recall. The output of the search should not include any articles which do not comply with the search criteria. This property is called specificity or precision. Ideally, the search should be 100% sensitive to the presence of relevant articles and 100% specific. Such an ideal result is probably impossible in the struggle to find relevant articles in a database.

The main problem with searches with high sensitivity is that such searches find a very large number of references; a number which is virtually unmanageable. For example a search using the search term ‘intensive therapy’ will find 53,369 references. Such a search can be limited so that it produces only those references which relate to more particular aspects of the general subject or are limited by some other characteristic. Limiting the above search by HUMAN and ENGLISH LANGUAGE reduced the number of ‘results’ to 39,441. However the warning ‘Too many results to sort’ is displayed. A search showed that there had been no papers before 1964 so the results were reduced still further by limiting the publication dates to the ten year period 1964 – 1973. This period, chosen arbitrarily as likely to find a manageable number of references, yielded 1227 results. This group was scrutinized in detail to identify papers which should be included in the study. Searches for publications in later decades were facilitated by the fact that with the increasing

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general health care journals to the Cochrane Controlled Trials Register. Eval Health Prof. 2002;25:65-75.

sophistication of intensive care, searches could be conducted using keywords which had come to be used more specifically.

A further difficulty in achieving high sensitivity is that a search using intensive care or intensive therapy as keywords will not find papers from the earlier years. because intensive care was practiced before these terms came into use, so many papers, sometimes the most relevant and interesting ones to the historian, have to be searched for separately using a wide variety of terms such as the name of the disease being treated or the treatment being used.

Lack of *specificity* arises from the use of terms in contexts other than the context of this thesis. This study is about treatment of patients with vital system failures in specialised units characterised by a high ratio of specially trained staff to patients and with specialised equipment. A search using the term 'intensive therapy' will reveal for example many articles in which the term intensive therapy is used to describe the use of a high dose of a drug for a short period. A search can be made more specific by selecting only some of the related subjects which would otherwise be included in the search.

Alternatives to searching on-line databases include ancestry searching. This refers to the systematic review of references cited in articles and reviews to hand. A network or 'family tree' of references results with a new 'generation' being added as one text refers to others which in turn refer to yet more. More articles were brought to light in interviews with the earlier practitioners of intensive care.

Hand searching of the indices of journals is a further method which can be used for the retrieval of early articles about intensive care. In the past there were fewer journals than exist today. The majority of articles published in the Unites Kingdom were published in the *Lancet* (founded 1823), *the British Medical Journal* (founded October 1840) and a relatively few specialist journals. In the case of articles about the management of respiratory failure, which formed the basis of intensive care, the specialist journals in the UK were *The British Journal of Anaesthesia* (founded 1923) and *Anaesthesia* (first edition 1946). As many of the advances were made in Denmark, *Acta Anaesthesiologica Scandinavica* frequently published articles of worldwide importance. Searching the indices of these journals, which were at first published only monthly or quarterly, yielded a large proportion of the early articles relevant to this study. The importance of hand searching was emphasised by McDonald and colleagues. They hand-searched 119 journals for

accounts of controlled trials. They found 21,620 reports. Of these 30% were not indexed in MEDLINE. Of the 11,426 which were indexed, only 24% were indexed as controlled trials. The authors conclude that 'The identification of reports not identified by searches of databases is one of the essential steps in preparing systematic reviews'.[41]

Conclusion

The methodology for this study of the history of the development of intensive care in the United Kingdom is based on oral histories and analysis of primary and secondary sources. A series of interviews with practitioners has been recorded, transcribed and analysed. The interviewees were selected by their practical involvement with the discipline and by their availability. Their accounts elucidated not only when and where intensive care was practiced but also the social and personal context in which developments took place.

These oral sources have been complemented by contemporary accounts and later reviews of the history retrieved from literary sources. They have been found by database searches, ancestry searches and hand searching. These three search methods are complementary, and no method or combination of methods is perfect.

The philosophical basis of this research is phenomenological and ethnographic. This has been reflected in the attention paid to the subjective reactions of the participants and to the social, political and economical environment in which the events described took place. The theory which might explain why events transpired in a particular way emerged from the gradually accumulated data, so the method was predominantly inductive.

Ethical Approval

The Chair of Liverpool Research Ethics Committees ruled that this project did not require ethical review by a NHS Ethics Committee.

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[41] McDonald S, Lefebvre C, Antes G et al. The contribution of hand searching European general health care journals to the Cochrane Controlled Trials Register. Eval Health Prof. 2002;25:65-75.

Chapter 3. Surgical origins of intensive care

Thoracic surgery and the pneumothorax problem.

Surgeons had been struggling to maintain adequate respiration in their patients during surgical operations since the beginning of the twentieth century. The problem was particularly intractable during thoracic surgery. If surgeons are to operate on the organs in the chest (the lungs, the oesophagus (‘gullet’) and even the heart) they must make a wide opening in the thorax. This will inevitably seriously impair the mechanism by which the lungs are inflated. In normal breathing the lungs are inflated by the diaphragm and intercostal muscles causing the chest cavity to increase in volume as the person inhales. There is a small space (the pleural cavity) between the outside of the lungs and the interior of the thoracic cavity but it is very small and is filled with a thin film of fluid. As fluid cannot expand, when the thorax increases in size during inspiration, the lungs must expand by the same amount and air is sucked in through the mouth and larynx. However if the thorax is incised and opened as in trauma or in thoracic surgery, when the thorax expands during inspiration, instead of air being sucked into the lungs, air is sucked through the opening in the chest wall into the space around the lungs (Figure 1).

The lungs are no longer forced to conform to the shape and size of the thorax. Air rushes in through the opening in the chest into the pleural space and the lungs, being elastic and no longer held open by the negative pressure in the pleural space, shrink and collapse. The condition in which there is air between the interior of the thorax and the exterior of the collapsed lung is called pneumothorax. In this condition the uptake of oxygen and excretion of carbon dioxide are seriously impaired.

Vesalius (1514-1564), the Flemish-born anatomist described how he could keep an animal alive while he examined the thoracic contents. When he opened both sides of the thorax, the exposed lungs collapsed and the animal died.

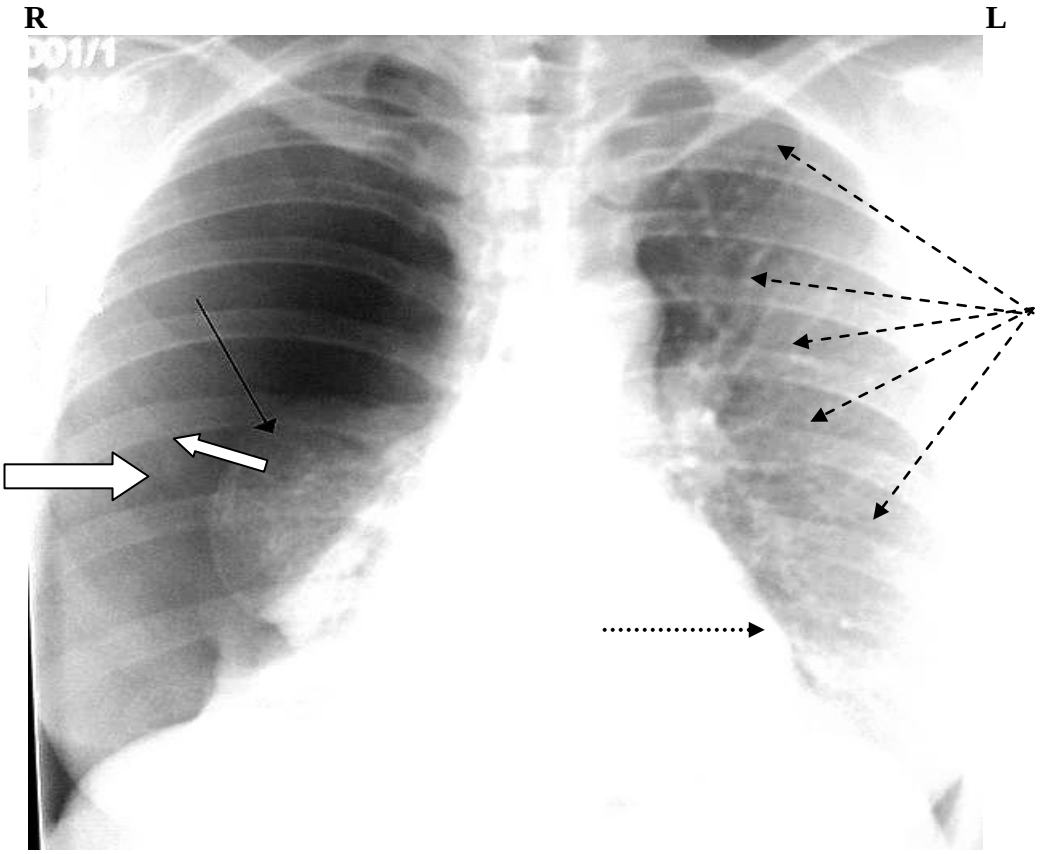

Figure 1. Radiograph of right-sided pneumothorax. [42]

⇨	Air entering thoracic cavity through surgical incision or through a chest wound
⇦	Air escaping into the thoracic cavity from damaged lung.
⟶	Edge of collapsed right lung surrounded by air (pneumothorax)
- - - - - - ▸	Normal lung markings – left lung fully expanded
····· ▸	Heart and great blood vessels moved to the left

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But that life may in a manner of speaking be restored to the animal, an opening must be attempted in the trunk of the trachea, into which a tube of reed or cane should be put; you then blow through this so that the lung may rise again and the animal take in air. Indeed, with a slight breath in the case of this living animal the lung will swell to the full extent of the thoracic cavity and the heart become strong and exhibit a wondrous variety of

[42] Adapted from http://en.wikipedia.org/wiki/File:Rt sided_pneumoD.jpg Accessed May 2010. (With permission of James Heilman,MD / Wikipedia)

> motions. So with the lung inflated once and a second time, you may examine the motion of the heart by sight and touch as much as you wish… .And as I do this and take care that the lung is inflated at intervals, the motion of the heart does not stop.[43]

The difficulty of passing a tube into the human trachea inhibited the application of Vesalius's technique to humans for many years and even in the early twentieth century, endotracheal intubation was a skill possessed by very few. (See Willy Meyer's comments below).

In 1904 a German surgeon, Ernst Ferdinand Sauerbruch (1875 – 1951) approached the problem of the collapsing lung in chest surgery differently. His solution is illustrated in figure 2. He built 'negative (i.e. sub-atmospheric) chambers in which to perform thoracic surgical operations with the chest open.

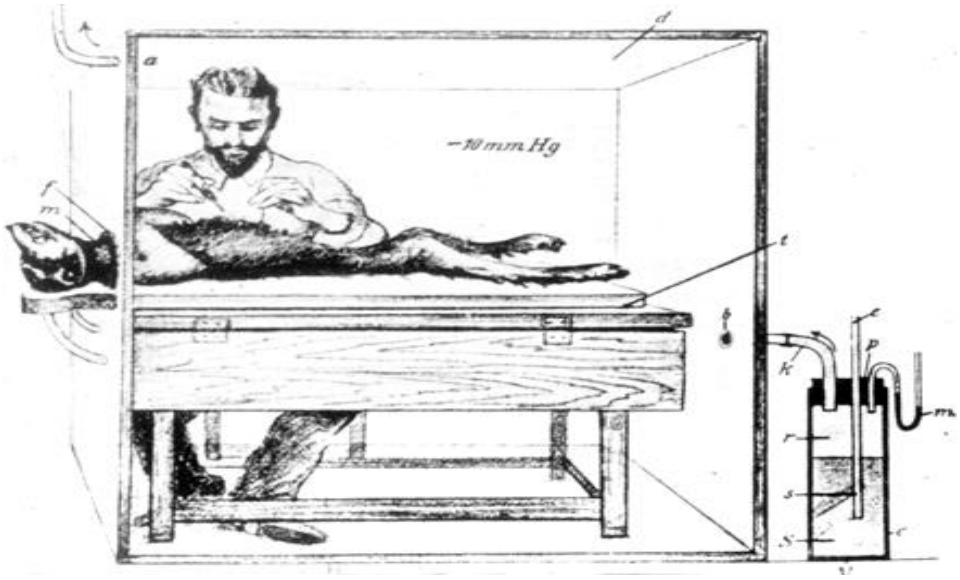

Figure 2. Negative pressure chamber for operations in the chest (Sauerbruch 1904)[44].

The pressure inside the cabinet is 10 mm Hg lower than atmospheric. The dog is breathing air at atmospheric pressure from the outside of the cabinet. The lung

[43] Vesalius A. De humani corporis fabrica Liber VII. Caput XIX. De vivorum sectione nonnulla. Basle: Oporinus; 1543. p. 658–59.

[44] Naef A P**.** The mid-century revolution in thoracic and cardiovascular surgery: Part 1 Interact Cardiovasc Thorac Surg. 2003;2:219-26. © 2003 European Association of Cardio-Thoracic Surgery with permission from the European Association for Cardio-Thoracic Surgery.

remains inflated in spite of the open chest because the pressure on the outside of the lung (-10 mm. Hg) is lower than the pressure inside it.

Surgeons were delighted with this amazing surgical advance. Unfortunately, it was in fact a 'dead end' incapable of further development and its deficiencies would be revealed later. But when it was introduced it did offer hope to patients needing thoracic surgery, who previously had no hope of a surgical cure. The chamber (and other brilliant surgical innovations) brought Sauerbruch great fame and authority. He was invited to the United States where he demonstrated his cabinet in several cities including New York.[45] Willie Meyer (1858-1932), Professor of Surgery at the New York Post-graduate Medical School was impressed by Sauerbruch's chamber and he and his brother built an improved model.[46] He wrote 'We owe it to the work of Sauerbruch and Brauer that the thoracic cavity has been definitely opened to surgery. There now remains no nook, no corner of the human body to which the knife cannot be applied with safety.' [47]

Meyer explained why he considered the negative pressure cabinet better suited for clinical surgery than the intermittent positive pressure ventilation of the lung demonstrated on laboratory animals. He wrote:

> The physiologists, it is true, had solved the problem long ago in their laboratory work on animals. With a cannula tied in the incised trachea, or later with an intubation tube, air was rhythmically forced into the lungs by bellows and artificial respiration thus kept up as long as needed (Fell-O'Dwyer and others.). [48] But with such devices the surgeon could not be satisfied for regular operative work on sick human beings. His requirements differ from those of the physiologists. He must be enabled to do operations within the thorax as safely as in other parts of the body, at least so far as general anesthesia with its possible sequel and accidents is concerned. He

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[45] Sauerbruch EF. A surgeon's life. Renier GR, Cliff A. (translators) London: Andre Deutsch; 1953. Page 82.

[46] Meyer W. Pneumonectomy with the aid of differential air pressure. JAMA. 1909;53:1978-87.

[47] Brauer L. Die praktische durchfürung des uberdruckverfahrens (the practice of positive pressure technique). Dtsch Med Wschr. 1905;31:1489-92.

[48] Meyer did not supply a reference for the Fell-O'Dwyer apparatus but it is described in Mushin WW, Rendell Baker L Thompson P, Mapleson WW. Automatic ventilation of the lungs. 2nd ed. Oxford.: Blackwell Scientific Publications; 1969. p. 186.

> should not be obliged to put a cannula into the trachea, either through the mouth or directly through a tracheal incision to produce anesthesia. The head and mouth must be as unencumbered and within as easy reach of the narcotizer in thoracic surgery as in other operative work while an acute pneumothorax must be avoided, that stumbling block which, up to the beginning of the century, practically excluded the lungs and intrathoracic part of the esophagus. [49]

Meyer's chamber was installed in the Lennox Hospital in New York and used during the First World War. Meyer however was too intelligent a man not to recognise the superiority of Meltzer's positive pressure ventilation by intratracheal intubation (see below).[50] His chamber was demolished and sold for scrap in 1928.

In the same issue of the Journal of the American Medical Association in which Meyer described his negative pressure cabinet, two experimental surgeons, also from New York, Henry Janeway (1873-1921) and Nathan Green (1871-1954) , described their *positive* pressure cabinet.[51] A positive pressure cabinet encloses only the head (in their case of the dog) and supplies air to the dog under pressure greater than atmospheric. This ensures that the lung remains inflated in open-chest surgery because the pressure inside the lung is greater than the atmospheric pressure outside it. The big difference between Janeway and Green's apparatus and that of Meyer (they both produced a differential pressure, the pressure inside the lung being greater than that outside it) is that the positive pressure hood had a valve which opened rhythmically, allowing the pressure on the head to drop to atmospheric. The lungs were rhythmically inflated and allowed to deflate, as in normal breathing.

A third paper published in 1909 emanated from the laboratory of Samuel Meltzer (1851-1920) and John Auer (1879-1929) at the Rockefeller Institute for Medical Research in New York. They had developed a method of insufflating (blowing) air into a tube inserted into a dog's or rabbit's trachea.[52] The air was blown

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[49] Meyer W. Pneumonectomy with the aid of differential air pressure: an experimental study. JAMA.1909;LIII:1978-87.

[50] Naef A P. The midcentury revolution in thoracic and cardio-vascular surgery: part 1. Iteract CardioVasc. Thorac. Surg. 2003;2: 219-26

[51] Janeway HH, Green NW. Experimental intrathoracic esophageal surgery. JAMA. 1909;53;1975-78

[52] Meltzer SJ, Auer J. Continuous respiration without respiratory movements. J Exp Med.

in under a pressure of 15 to 20 millimetres of mercury. They found that the air must be able to escape from the trachea to allow the removal of carbon dioxide. The lungs apparently did not have to move and they called this method 'continuous respiration without respiratory movements'. It is noteworthy that they stated that 'the animal may receive now an intravenous injection of curare sufficient to completely abolish any spontaneous or reflex movements; its life is as safe as under regular artificial respiration'. This was 37 years before Cecil Gray, John Halton and Jackson Rees, anaesthetists in Liverpool, described the safe use of curare in humans.[53, 54]

In the following few years two groups applied Meltzer and Auer's findings to humans. In 1911 Charles Elsberg (1871 – 19480), a Professor of Clinical Surgery in New York published two papers on intratracheal insufflation of air and ether. The first paper described the technique of the method and a portable apparatus for use in man.[55] He had at that time anaesthetised about 30 patients by tracheal insufflation. The insufflation was occasionally interrupted to allow the lung to collapse and it was observed that in many but not all the patients respiratory movements ceased altogether and apnoea ensued. A paper published three months later described the use of the technique in about 200 patients for general surgery. It had been useful for thymectomy (removal of the thymus gland in the neck), for removal of the larynx and for operations on the face and jaws. They had also anaesthetised nine cases for thoracic surgery.[56] All survived surgery and anaesthesia although four died later from sepsis.

As will be seen in the next chapter, this influenced anaesthetists in England. Ivan Magill, in 1936, 25 years later, wrote that 'the chief stimulus to modern development in endotracheal anaesthesia was due to Elsberg who applied to human subjects the insufflation principles which Meltzer and Auer had demonstrated with

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1909;1:622-25.

[53] Gray TC, Halton J. A milestone in anaesthesia? (d-tubocurarine chloride) Proc R Soc Med. 1946;39:400–10.

[54] Gray TC, Rees JG. The role of apnoea in major surgery. Br Med J. 1952;2:891–92.

[55] Elsberg CA. Anaesthesia by the intratracheal insufflation of air and ether. Ann Surg. 1911;53:161-68 (plus 2 un-numbered illustrations).

[56] Elsberg CA. Experiences in thoracic surgery under anaesthesia by intratracheal insufflation of air and ether. Ann Surg. 1911:54:749-757.

such success in animals'.[57] Magill over a period of many years played a leading part in advancing anaesthesia in England to a level which enabled anaesthetists there to take up Ibsen's challenge in the treatment of patients with respiratory failure.

The following year (1912) Henry Janeway and Nathan Green developed an apparatus which blew a stream ('insufflated') of air and ether down a 'medium sized' catheter inserted into the trachea, the gas escaping up the trachea round the outside of the cannula. The insufflation was stopped at intervals to allow the lung to deflate, this was *intermittent* positive pressure. They wrote 'These interruptions are a very important part of intratracheal inflation. Not only do they materially aid the diffusion of oxygen to the alveoli of the lungs, but they also bear a direct relation to the character of the circulation by facilitating the return of the venous blood to the heart.'

Janeway was not satisfied with the insufflation of air and ether. He would have preferred to use nitrous oxide rather than ether as the anaesthetic but it was more expensive than ether. With the insufflation method a high flow of gas was essential to maintain the pressure in the lung and keep it inflated. Such a large amount of nitrous oxide would be prohibitively expensive. So Janeway invented a cuffed endotracheal tube.[58] A rubber cuff could be inflated round the tube in the trachea making it a gas tight fit. An electric pump intermittently passed nitrous oxide at a suitable regulated pressure into the lung to inflate it then released the pressure and allowed part of the nitrous oxide/oxygen mixture to pass into a rebreathing bag, to be used at the next inflation or, about half the time, allowed the gas to be exhausted to atmosphere to allow the exhaled carbon dioxide to escape.

Meyer had said that the surgeon should not be forced to intubate the trachea, and most were unable to do so. Janeway was able to pass his tube into the trachea because he could visualise the larynx using the laryngoscope invented by the distinguished Pittsburgh surgeon Chevalier Jackson (1865 – 1958) who devoted his long life to the investigation and treatment of diseases of the larynx, bronchi and the oesophagus.[59.60] Janeway 'touched the back of the patient's tongue' with 10% cocaine, a powerful local anaesthetic. The patient was anaesthetised preferably with

[57] Magill IW. Endotracheal anaesthesia. Am J Surg. 1936;34:450-55.
[58] Janeway HH. Intratracheal anaesthesia: a. By nitrous oxide and oxygen; b. by nitrous oxide and oxygen under conditions of differential pressure. Ann Surg. 1913;58:927-33.
[59] In Memoriam. Chevalier Jackson. Laryngoscope. 1958;68:2120–7.
[60] Janeway HH. Intratracheal anaesthesia 1913:929.

chloroform. And then the Jackson Direct Laryngoscope was used to visualize the larynx and the tube was passed through the larynx into the trachea. (Fig 3). In the three years since Meyer had insisted that surgeons and anaesthetists should not be required to put a tube into the trachea the development of instruments for visualizing the larynx had made tracheal intubation possible, and usually quite easy for a trained operator.

Chevalier Jackson was not the first to develop methods for visualising the larynx. The first person to publish on the movements of the larynx during phonation and singing was probably Manuel Garcia. His method was indirect. He did not view the larynx directly but through a little mirror fixed to a long handle. 'The party ought to turn himself toward the sun so that the luminous rays falling on the little mirror may be reflected on the larynx.' [61] When the subject took a deep breath, the epiglottis being raised he was able to see the movements of the larynx and vocal cords.

The first report of direct laryngoscopy was by Horace Green in 1852.[62] But his method was forgotten and Alfred Kirstein (1863-1922) in 1895 reintroduced direct examination of the larynx.[63] The difficulty in passing a tube through the vocal cords in the larynx and into the trachea lies in the fact that the tongue obscures the view from the mouth into the larynx. The early pioneers viewed the larynx in awake patients who could be asked to say 'Ahhh' which causes the tongue to move out of the line of vision between the mouth and the larynx. .With the patient anaesthetised and lying on his or her back, the tongue hangs down and has to be lifted out of the way by the laryngoscope so that the anaesthetist can see down the throat to the vocal cords. The laryngoscope illuminates the larynx so that the operator can guide the tube between the vocal cords and into the trachea.

Kirstein had illuminated the larynx with a bulb outside the mouth shining through a prism. Chevalier Jackson was influenced by Kirstein and designed his first direct laryngoscope in 1903. He added a light carrier so that a bulb at the end of the laryngoscope would shine directly on the larynx. He also shaped his laryngoscope as a tube rather than as a flat spatula.

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[61] Garcia M. Observations on the human voice. Proc R Soc London. 1855;7:399-410.

[62] Green H. Morbid growths within the larynx. In: On the surgical treatment of polypi of the larynx and oedema of the glottis. New York: G P Putnam; 1852. pages 56–65.

[63] Kirstein A. Autoscopy of the larynx and trachea (direct examination without a mirror). Philadelphia: F A Davis Co.; 1896.

The endotracheal tube could be passed through the laryngoscope into the trachea and then the lateral part of the tube could be removed to allow the laryngoscope to be extracted without disturbing the endotracheal tube (Figure 3). Chevalier Jackson described his first laryngoscope in 1903 and developed them over the next 20 years.[64] His laryngoscopes are still in use today, although British anaesthetists use a model devised by Robert Macintosh (1898-1989), Professor of Anaesthesia at the University of Oxford.[65] It has the advantage that it enables the larynx to be seen by lifting the back of the tongue without touching the epiglottis and, because the tongue and epiglottis are innervated by different nerves, the Macintosh laryngoscope can enable the larynx to be intubated under lighter anaesthesia than would have been the case if the Chevalier Jackson laryngoscope had been used.

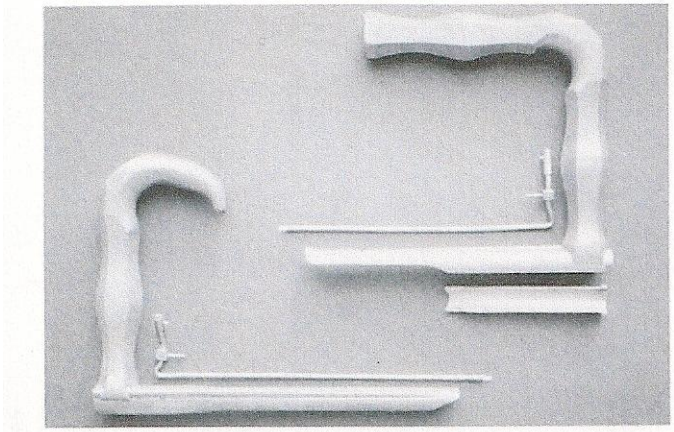

Figure 3. Early 20th century Jackson Pilling laryngoscope with bulb holder which slides into a groove in the laryngoscope tube to illuminate the larynx (with permission from Elsevier).[66]

In his paper on intratracheal anaesthesia Janeway described a mechanical patient triggered ventilator[67]. He also demonstrated in the same paper that he understood that

[64] Zeitels SM. Chevalier Jackson's contributions to direct laryngoscopy. Journal of voice. 1998; 12: 1-6. This article also provided the references to Garcia and Kirstein and the illustration in Figure 5.
[65] Macintosh RR. A new laryngoscope. Lancet. 1943;1:205.
[66] Zeitels SM. Chevalier Jacksons contribution to direct laryngoscopy 1998. (Pilling was the company which manufactured Chevalier Jacksons laryngoscopes.).
[67] Janeway HH. Intratracheal anaesthesia. 1913: 931.

with controlled ventilation he could if necessary use large doses of drugs such as morphine without being limited by their respiratory depressant effect.

There was therefore in 1913 all the knowledge and technology needed to introduce positive pressure ventilation of the lungs through cuffed endotracheal tubes for thoracic surgery and for the management of respiratory failure due to polio.

For nearly twenty years after Janeway's papers, intermittent positive pressure ventilation was ignored. In Europe most thoracic surgeons used differential pressure chambers until the end of the 1930s. In the United States and Britain most surgeons used tracheal insufflation described by Meltzer and Auer in 1909 as 'continuous respiration without respiratory movements'.[68, 69] Their work was published almost immediately before the start of the First World War. Doctors in the trenches were presented with thousands of soldiers needing thoracic surgery and complicated equipment could not possibly be available. The only way a patient could survive open-chest surgery was for the surgeon to operate very quickly so that the chest was open for a very short time.

One might question why constant differential pressure was thought to be acceptable. One reason was that it did not require tracheal intubation. It has been seen that possession of the skill necessary to visualise the larynx and pass a tube into the trachea was regarded as something which should not be demanded of a person administering anaesthesia.[70] This view, widely held by surgeons in Europe, effectively ruled out positive pressure inflation of the lungs on that Continent.

If the anaesthetiser could not intubate the trachea, differential positive pressure would be considered to be the best available alternative. It did permit the thorax to be opened but only for a short time. The weaknesses of continuous positive pressure breathing had been investigated as long ago as 1916 by Giertz.[71] He had shown that not only was ventilation inadequate but carbon dioxide retention

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[68] Meltzer SJ, Auer J Continuous respiration without respiratory movements. J Exper Med. 1909;11:622.
[69] Mushin WW, Rendell Baker L, Thompson P, Mapleson WW. Automatic ventilation of the lungs. 2nd ed. Oxford: Blackwell Scientific Publications; 1969. p. 187, 188.
[70] Meyer W. JAMA. 1909;LIII:1978-87.
[71] Giertz KH. Studier över tryckdifferensanding enligt Sauerbruch och över konstgjord andning (rytmisk luftinblasning) vid intrathoracicala operstioner. Upsala Lakere Forth 1916;17:22.

occurred, oxygenation was poor, filling of the heart was poor, and venous return was reduced.

This was work was published in Sweden in a journal unlikely to be widely read. Eighteen years later Frenckner investigated Sauerbruch's continuous positive pressure method in dogs. Sauerbruch had stated that ventilation is fully adequate during thoracic surgery using his differential pressure method. A number of experiments controlled with a gas meter consistently showed an actual and marked decrease in the ventilation with unilateral pneumothorax and almost no ventilation with bilateral pneumothorax. He showed that Sauerbruch's method gives sufficient ventilation over a moderate period of time. However with bilateral or with wide open unilateral thoracotomy and a longer operation, experiments and clinical findings both showed that Sauerbruch's method was dangerous to life.'[72]

If Giertz's work had been published in a main-stream journal in 1916 it might have been more influential. In the course of condemning positive pressure Giertz does explain why it had limited usefulness. It will maintain life for a short time with a limited chest opening. In the early years of the twentieth century surgeons expected to have to be fast operators, and prided themselves on their speed. They also accepted a high mortality and often blamed it on 'shock' (which was not understood) or the anaesthetic: 'He couldn't take the anaesthetic' was the explanation commonly given to explain a surgical death. Continuous positive pressure with all its dangers was acceptable in an era when an anaesthetist could not be expected to possess skills such as tracheal intubation or intermittent positive pressure ventilation of the lungs.

One of the reasons why continuous positive-pressure ventilation, or rather underventilation, was tolerated for so long was that there was no reliable clinical means of assessing the adequacy of respiration. Before the understanding of the importance of carbon dioxide retention during underventilation of the lungs surgeons and anaesthetists relied on the onset of cyanosis to tell them when ventilation of the lungs was inadequate. The first instruments to measure arterial oxygen and carbon

[72] Frenckner P. Bronchial and tracheal catheterization. Acta Oto Laryngol Scand.1934; Sp 20: 100-34

dioxide levels did not become available until 1953.[73] Cyanosis is a purple colour of the skin caused by a change in the oxygen-carrying pigment haemoglobin in the red blood cells. If the amount of oxygen in the blood is reduced below normal, the haemoglobin becomes deoxygenated and the colour changes from red to blue, giving the purple hue to the skin. The presence of cyanosis is certainly a sign of inadequate oxygen in the blood but unfortunately ventilation of the lungs can be seriously inadequate before cyanosis appears. Cyanosis is only detectable when the pressure of oxygen in the blood has fallen to what many anaesthetists would regard as a dangerously low level.[74] Moreover ventilation of the lungs has not only to supply oxygen to the blood. Ventilation has also to be adequate to remove the carbon dioxide produced by metabolism. The level of carbon dioxide in the blood is much more sensitive to underventilation. By the time the ventilation has been reduced to a level low enough to produce cyanosis the level of carbon dioxide will be twice the normal level. During open chest surgery (thoracotomy) levels of carbon dioxide up to eight times normal were recorded before the value of artificial ventilation were generally appreciated.[75] Such levels produce acidosis and profound changes in the circulation which may be badly tolerated by sick patients.

Thoracic surgeons in the early twentieth century could not measure oxygen or carbon dioxide levels in the blood. They knew that shortage of oxygen produced cyanosis and went on to assume that absence of cyanosis implied adequate lung ventilation; if patients during open chest surgery in constant positive or negative pressure chambers were not cyanosed, they must be adequately ventilated. It is perhaps understandable that until carbon dioxide and oxygen levels in the blood could be measured in the 1950s it was difficult to convince them that intermittent positive pressure ventilation of the lungs was essential in open chest surgery.

The work described above on anaesthesia for thoracic surgery was all the work of academic surgeons whose aim was to extend the scope and reduce the risk of thoracic surgery. Not only was it necessary to find a way to maintain respiratory function in patients with open chests, they had to devise surgical techniques for

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[73] Astrup P, Siggaard Andersen O. Micromethods for measuring acid-base values of blood. Adv Clin Chem. 1968;6:1-28.
[74] Nunn J F. Applied respiratory physiology. London: Butterworth; 1969. Page 378.
[75] Ellison RG, Ellison LT, Hamilton WF. Analysis of respiratory acidosis during anaesthesia. Ann Surg.1955;141:375–82.

operating on intrathoracic pathology. For example, they had to find ways to close the end of a bronchus, which is a cartilaginous tube, not easy to seal after it has been transected to enable diseased lung tissue to be excised, or to join the stomach to the oesophagus after removing a length of the oesophagus to excise a cancerous tumour. Meyer's paper in which he advocated thoracic surgery in a negative pressure chamber does not mention his 'new American built apparatus for thoracic surgery' until the second section of his paper, on the fifth page.[76] The first 4½ pages deal with methods of closing stumps of bronchi (it has to be an airtight closure) after removal of diseased lung. Janeway and Green's paper in 1909 devoted only one page to their positive pressure head box with intermittent inflation of the lungs and more than two pages to oesophageal anastomosis. In both cases the work was experimental; the subjects were dogs, not humans. Janeway's paper of 1913 in which he describes his semi-closed circuit, cuffed endotracheal tube and patient triggered respirator, is about anaesthesia in patients although he does not state how often it had been used. Neither of these surgeons maintained a lifetime interest in lung ventilation: Janeway left thoracic surgery in 1914 and became a pioneer of radiotherapy.[77] Green became a distinguished thoracic surgeon but did not publish again on respiratory problems.[78]

There was in the early years of the twentieth century almost no academic anaesthesia and very few expert or professional anaesthetists. Margaret Boise, a nurse anaesthetist at the Presbyterian Hospital in New York, described the anaesthesia and the anaesthetists in her hospital: 'Anesthesia at that time was crude and given by the house staff who were not at all interested in the subject. During my time in New York……positive pressure was invented and Doctor H H Janeway had his machine at Presbyterian Hospital. I learnt its use but it was too cumbersome ever to be popular.' [79]

Outside university hospitals (and sometimes in them) anaesthesia was administered by anyone who might be 'at hand'. The person might be professionally

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[76] Meyer W. Pneumonectomy with the aid of differential air pressure: an experimental study. JAMA. 1909;LIII:1978-87.
[77] Obituary. Dr Henry H Janeway. Radium. 1921;16:81-2
[78] Necrology. Nathan W Green. N Y State J Med. 1955;55:1773.
[79] Thatcher VS (1953) History of anesthesia. Philadelphia: Lippincott; 1953. p. 84, quoted in Mushin et al. Automatic ventilation of the lungs. Oxford: Blackwell Scientific Publications; 1969. pages 193-4

qualified or not. There was a financial disincentive for the surgeon to share any considerable part of his fee with a highly qualified (and expensive) skilled anaesthetist. Some general practitioners took an interest (and some became skilled) in anaesthesia, but it was a sideline. Such anaesthetists tended to be peripatetic, working at the surgeons' request at several hospitals. They were unlikely to purchase cumbersome equipment which would have to be transported from place to place. Only in university hospitals with staff anaesthetists (or staff who gave anaesthetics) would such equipment be provided. Constant pressure methods of maintaining the lung inflated during open-chest surgery were accepted at least partly because skilled anaesthetists who could pass a cuffed endotracheal tube and ventilate the lungs by rhythmic pressure on a reservoir bag were not usually available. An indication of the persistence of continuous positive pressure respiration in the face of the superiority of IPPR is given by the fact that a positive pressure apparatus was still listed in the catalogue of the well known manufacturer of anaesthetic equipment, Drager Co. of Lübeck, as late as 1948.[80]

In Britain thoracic surgeons had the benefit of some outstanding doctors who had made anaesthesia their full time occupation. They had never used the continuous positive-pressure cabinets which had been popular in continental Europe, relying instead on an evolving system of endotracheal anaesthesia. The development of anaesthesia in the United Kingdom will be described later in this chapter (page 49).

Advances in anaesthesia 1924 – 1934.

Anaesthesia (anesthesiology) as an academic discipline.

Ralph M Waters (1883 – 1979), was the first professor of anaesthesia in the world. He was professor in Madison, Wisconsin from 1927 until 1949. He said his mission was 'to work toward bringing back anesthesia into the medical profession where it originally was and where it undoubtedly belongs. The only way I could see of really basically helping this movement was through the educational institutions.'[81]

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[80] Mushin WW, Rendell-Baker L. The principles of thoracic anaesthesia past and present. London: Blackwell Scientific Publications; 1953. page 66.

[81] Waters RM. Letter to Frederick W. Clement, M.D., February 3, 1933. The collected papers of Ralph M. Waters, M.D., Steenbock Library, University of Wisconsin Archives, Madison,

At a time when anesthesiology was just being defined as a medical specialty, Waters worked to ensure that it was set on an equal footing within the university with surgery, internal medicine and paediatrics as well as the traditional hospital-based specialties of radiology and pathology.

In addition to his seminal influence on raising the status of anaesthesia and anaesthetists in the US and abroad Waters made several advances in anaesthetic practice which were later used by anaesthetists such as Ibsen to treat patients with respiratory paralysis. The first was the introduction of carbon dioxide absorption in a closed breathing system (the Waters closed circuit) in 1924.[82] A mixture of oxygen and the anaesthetic gas nitrous oxide (N_2O) is supplied to a large rebreathing bag. (figure 4).

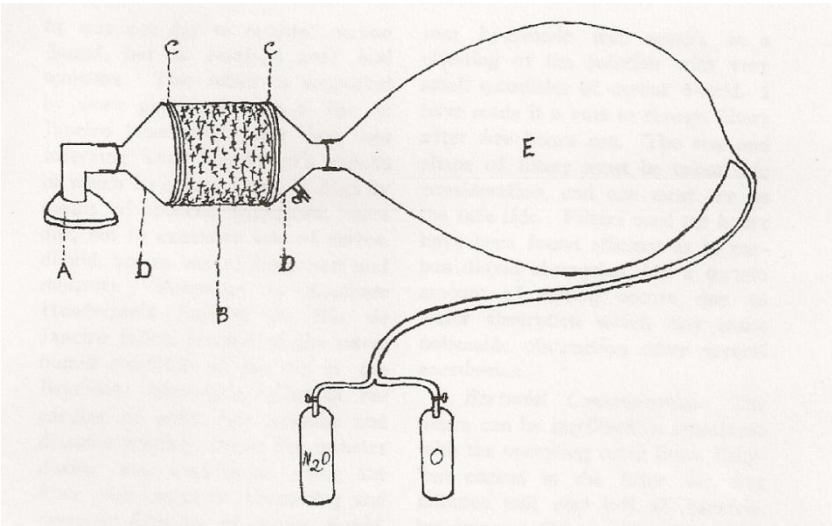

Figure 4. Diagramatic [sic] sketch of carbon dioxid [sic] filtration system.[70]

A. Mask with well fitting rubber face cushion

B. Cylinder of granular soda lime 3 ½ inches in diameter and 4 inches long.

C. Wire gauze dams to hold soda lime in place.

D. Cone shaped ends of filter, the distal one bearing a stopcock through which to obtain gas for carbon dioxide test.

E. Rebreathing bag.

Wisconsin. Cited in Bacon DR. Why Celebrate Ralph Milton Waters? ASA Newsletter 2010; 65 (9).

[82] Waters RM. Clinical scope and utility of carbon dioxid filtration in inhalation anesthesia. Anesth. Analg. 1924; Feb. (Volumes were not at that time numbered): 20–22 and 26. Note: The unusual spelling of dioxide (dioxid) and diagramatic (diagrammatic) is reproduced from the article. It is not a typographical error; all Waters' papers use these spellings.

The patient breathes this mixture through a cylinder containing soda lime. During expiration the carbon dioxide in the expired air is absorbed by the soda lime. The expired gas can therefore be re-breathed indefinitely, only oxygen which is absorbed by the patient (about 200 ml per minute) needs to be replaced. This system could be used for anaesthesia using nitrous oxide, ethylene, ether or ethyl chloride. Its advantages were simplicity and economy of agents, particularly of nitrous oxide which was expensive. It was not described as having been used to ventilate the lungs, the patients continued to breathe through the circuit spontaneously.

Waters' next step towards positive pressure ventilation of the lungs in anaesthesia was his introduction of cyclopropane into clinical practice in 1934. Cyclopropane is a gaseous anaesthetic which was more pleasant for the patient than the previously used ether or chloroform (induction of anaesthesia by intravenous agents had yet to be invented), produced better relaxation of the abdominal muscles and allowed easier access to the abdomen for the surgeon. In their preliminary report on its use in 10 dogs and 447 patients Waters and his colleagues make little mention of respiratory depression but emphasise that it was fully as easy to introduce an endotracheal catheter with this agent as with ether. 'In fact the laryngeal reflex is eliminated more quickly than with ether and [vocal] cord relaxation is quite as complete.'[83] A further paper in the same year (1934) stated that 'Respiratory excursion was definitely less in patients receiving cyclopropane', but added 'often adding considerably to the convenience of the surgeon'.[84] So respiratory depression was seen as an advantage and no mention was made of assisted or controlled respiration.

In the following year, 1935, Schmidt and Waters stated briefly what they believed the surgeon could reasonably expect from his anaesthetist in the light of (then) modern anaesthetic knowledge. In quite a long list of expected capabilities and also in a separate paragraph they wrote 'under operating conditions which demand a specialized technique the surgeon should be able to expect of the anaesthetist;

[83] Styles JA, Neff WB, Rovenstine EA, Waters RM. Cyclopropane as an anaesthetic agent: A preliminary clinical report. Anesth Analg. 1934; March-April:56–60.
[84] Waters RM, Schmidt ER. Cyclopropane anaesthesia. JAMA. 1934;103:975-83.

abilities to provide positive pressure respiration during thoracotomies, passive respiration for difficult abdominal closures, closed endotracheal airways to preclude the possibility of aspiration in oral or stomach surgery.' [85] This list is in stark contrast to Meyer's 1909 dictum about what should be demanded of a thoracic surgeon (Page 21) 'He should not be obliged to put a cannula into the trachea, either through the mouth or directly through a tracheal incision to produce anesthesia.'[86] By 1935 the anaesthetist should be appropriately skilled and not be simply anyone who was 'at hand' to assist the surgeon with the minor task of 'etherizing' the patient while the surgeon performed his operation.

It was left to Arthur Guedel, writing in 1940, to grasp the nettle and realise that if a patient's respiration is depressed by cyclopropane then the anaesthetist must ventilate the lungs.[87] The first full page of his paper 'Cyclopropane anaesthesia' was devoted to 'Controlled Respiration'. He described the normal mechanism in which the carbon dioxide level in the blood stimulates respiration. If the subject's breathing is less than required, the carbon dioxide level in the blood rises, the respiratory centre in the brain is stimulated and emits impulses which increase the activity of the respiratory muscles. The increased rate and depth of breathing cause more carbon dioxide to be exhaled so that its level in the blood is reduced to normal and the emissions from the respiratory centre returned to produce normal breathing. The threshold level of carbon dioxide to which the respiratory centre will respond by hyperventilation can be elevated by anaesthetic agents. So a person anaesthetised by cyclopropane will not hyperventilate when the carbon dioxide level rises in the blood. His breathing will actually be depressed. If deep anaesthesia is require to produce relaxation of the abdominal muscles to allow surgical access to the abdomen, the respiratory centre will not respond at all to the rising CO_2; breathing will stop. The anaesthetist must be prepared to take over the patient's breathing completely by rhythmically and continuously squeezing the rebreathing bag. She or he must do this for as long as the operation requires muscular relaxation. Guedel called this 'passive' respiration – the patient plays no part in ventilating his lungs –

[85] Schmidt ER, Waters RM. Cyclopropane anesthesia: Post operative morbidity in 2200 cases. Anesth Analg. 1935;14:1-3
[86] Meyer W. Pneumonectomy with the aid of differential air pressure. JAMA 1909;LIII:1978-87.
[87] Guedel A. Cyclopropane anesthesia. Anesthesiology. 1940;1:13-25.

he is passive. It is now called controlled ventilation. When relaxation is no longer required the cyclopropane is turned off or reduced and the patient will start to breath spontaneously again. 'Controlled ventilation had become an essential part of the anaesthetist's armamentarium.'[80]

A second insight provided by Guedel was that raised concentration of carbon dioxide in the blood was more dangerous than a lowered concentration. This was important because at that time and for decades thereafter there was no way of monitoring the arterial carbon dioxide pressure (pCO_2) in clinical practice. The anaesthetist could not know whether in controlled ventilation the lungs were being ventilated more or less than was required to maintain a normal pCO_2.

As has been shown in the previous section, in normal breathing the volume of air inhaled and exhaled (the minute volume of ventilation) will be regulated by the brain to be sufficient to remove from the blood the amount of carbon dioxide produced by the body each minute so the level of carbon dioxide in the blood will stay within normal limits (36 – 44 mm Hg.) If an anaesthetist applied controlled ventilation she or he will not know whether the lungs are being ventilated too much or too little. Guedel stated that the anaesthetist should not be deterred from controlling respiration by the fear that he might ventilate the lungs 'too much'. He showed that little if any damage had resulted from over-ventilating the lungs (hyperventilation) and thereby reducing the amount of carbon dioxide in the blood. More damage would be produced by a ***raised*** carbon dioxide level if the anaesthetist accepted the depression of respiration during cyclopropane anaesthesia and did nothing about it.

It had been known that excessive positive pressure within the chest can cause deleterious effects on the circulation. This can be seen if one tries to further inflate an already distended balloon. As one blows hard against the unyielding resistance of the fully inflated balloon one creates a very high pressure in the thorax. Blood can not return to the heart against this pressure so the blood pressure falls, and the organs become starved of blood. Because the circulation to the brain is reduced one becomes dizzy and, if stupid enough to persist (and the balloon does not burst), one may faint.

When early anaesthetists started to maintain positive pressure in the lungs to prevent them deflating during thoracic surgery, they were aware of the potentially

negative effects on the circulation of raised intrathoracic pressure. As they progressed to assisted respiration by squeezing the rebreathing bag, they tried to limit the extent and duration of positive intrathoracic pressure and were deterred from adopting continuous controlled respiration. Instead they gently squeezed the bag from time to time (and usually ineffectively) when the patient's respiration was seen to be obviously and severely depressed, as in deep cyclopropane anaesthesia.

In 1948 André Cournand and his colleagues at Columbia University, New York published the results of their research into the effects of intermittent positive pressure breathing on cardiac output.[88] They found that the effect on cardiac output depended upon the type of respirator and the way it inflated the lungs. Crucially they found that if the expiration part of the respiratory cycle (when the machine stops inflating the lung) is twice as long as the inflation time, and if the pressure is allowed to fall to atmospheric during expiration, there was little if any effect on cardiac output. There may be a slight fall during the inflation phase but it is compensated during the deflation phase. Cournand's group were studying different types of lung ventilators, but their findings applied equally to manual ventilation of the lungs (bag squeezing).

Anaesthesia in Great Britain

Endotracheal anaesthesia

British anaesthetists were aware of the advances made by their American colleagues and had made their own contributions. Dr Ivan Whiteside Magill (1888 – 1986) was the leading proponent in Britain of endotracheal anaesthesia. In the United States, the main stimulus for the development of endotracheal anaesthesia and IPPR had been the need to solve the pneumothorax problem and the need to support the patient's respiration when using the respiratory depressant anaesthetic cyclopropane. In England, Magill was faced with a different problem; when he was posted in 1919 to the Queen's Hospital for Facial and Jaw Injuries in Sidcup, Kent, Magill was faced with the problems of maintaining a clear airway when the surgeons were

[88] Cournand A, Motley HL, Werko L, Richards DW. Physiological studies of the effects of intermittent positive pressure breathing on cardiac output in man. Am J Physiol. 1948;152: 162-74.

operating on the face of soldiers injured during the First World War (1914 – 1918). The usual anaesthetic for face and jaw operations was oil and ether administered per rectum.

Magill and his colleague Dr E S Rowbotham instituted a series of improved methods, progressing from insufflation (i.e. blowing a stream of air and ether) into the larynx (the emerging blast of gas sprayed the unfortunate surgeon with ether and blood) to 'blind' intubation of the trachea, skilfully introducing the tracheal tube through the nose without seeing the larynx.[89] [90] The same year he wrote of endotracheal anaesthesia: 'Within recent years the advantages of the method have become widely known. Surgeons are increasingly anxious to avail themselves of these advantages and many expert anaesthetists in England now employ the method as a routine for operations which formerly involved many anaesthetic difficulties.'[91] This may be interpreted as a statement that endotracheal anaesthesia was widely practiced, but Magill used the qualification 'expert'; most anaesthetics were not given by experts at that time. Magill's next sentence acknowledged this: 'Nevertheless, in some hospitals endotracheal anaesthesia is not available'. In the same paper he described endotracheal intubation through the mouth. 'When the oral route is chosen I prefer to pass the tube by direct vision with the aid of a speculum. ... A self contained battery in the handle is a convenient means of illumination.' This 'speculum' was a laryngoscope. By 1936 Magill was anaesthetising patients for thoracic surgery using a cuffed endotracheal tube or even one of a variety of tubes which could be passed into one of the branches of the trachea (the main bronchi) to isolate a lung infected with tuberculosis and protect the sound one.[92] He was not convinced however of the safety or necessity of intermittent positive pressure respiration in patients with an open chest.

So the use of endotracheal tubes by anaesthetists was well established among expert anaesthetists in Britain sixteen years before it would be required for the

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[89] Rowbotham ES, Magill I. Anaesthetics in the plastic surgery of the face and jaws. Proc R Soc Med. 1921;Section of anaesthetics;17–27.
[90] Summary of proceedings. Technique in endotracheal intubation. Br Med J. 1930;Sept. 13: 434.
[91] Magill IW. Techniques in endotracheal anaesthesia. Br Med J. 1930;Sept 13:817–9.
[92] Magill IW. Anaesthesia in thoracic surgery, with special reference to lobectomy. Proc R Soc Med. Section of anaesthetics. 1936;29:643– 53.

treatment of patient with respiratory failure in intensive care. But the use of manual ventilation of the lungs by anaesthetists came later.

The British anaesthetist Dr Michael Nosworthy (1902 – 1980) visited Guedel and his group in Los Angeles in 1939.[93] As has been described above, although Waters found that his new anaesthetic depressed the patient's respiration, it was left to Guedel in 1940 to determine that that the degree of respiratory depression was often unacceptable and even dangerous.[94] Guedel's paper was published in 1940 but obviously he was able to communicate his conclusions during the latter's visit to Los Angeles the previous year. Guedel taught that the patient's breathing should be completely controlled by the anaesthetist squeezing the rebreathing bag of the anaesthetic circuit and intermittently inflating the lungs. In his paper given at the Royal Society of Medicine in London in 1941 Nosworthy discussed the advantages of controlled intermittent positive pressure respiration.[95] 'Controlled' in this context means that the patient makes no respiratory efforts, all the lung ventilation is provided by rhythmical squeezing of the rebreathing bag. This is in contrast to 'assisted respiration' in which the patient is still breathing but his respiratory efforts are inadequate and are supplemented by the anaesthetist squeezing the bag either gently or intermittently. This process has been referred to by many synonyms in the literature; passive respiration, controlled respiration and more correctly, intermittent positive-pressure ventilation of the lungs (IPPV). The later term and its acronym will be used henceforth in this thesis. It was IPPV which anaesthetists would need to use if they were to be able to treat patients with respiratory failure in intensive care.

Relaxants

In 1946 Professor T Cecil Gray (1913-2008) and Dr John Halton (1903-1968) of Liverpool added one more element to the need for effective (that is intermittent positive pressure) ventilation in anaesthesia, not only for thoracic surgery but for all major surgery. They described their use of relaxants in Britain at a meeting of the Royal Society of Medicine in London.[96] These agents, the prototype of which is

[93] Nosworthy MD. Anaesthesia in chest surgery, with special reference to controlled respiration and cyclopropane. Proc R Soc Med 1941;34:479–506.
[94] Guedel AE. Cyclopropane anaesthesia. Anesthesiology 1940;1:13-25.
[95] Nosworthy MD. Anaesthesia in chest surgery. 1941:495.
[96] Gray TC, Halton J. A milestone in anaesthesia? (d-tubocurarine chloride) Proc R Soc Med.

curare, relax the muscles. One of the problems of surgery in the abdomen is that unless the muscles of the abdominal wall are very relaxed and slack, the intestines are forced out of the surgical incision and access for the surgeon to the intra-abdominal organs is difficult. Until the introduction of relaxants the abdominal muscles had to be relaxed by very deep anaesthesia, which is toxic and recovery is slow and unless it is carefully supervised, is dangerous. The injection of curare while the patient is lightly anaesthetised provides perfect surgical conditions without the disadvantages of deep anaesthesia. There is a catch; curare and its congeners do not only relax the muscles of the abdominal wall, they relax all muscles including those of respiration. In a second paper in 1952, Gray, this time with Jackson Rees, wrote 'As a result of the respiratory depression subsequent upon adequate doses of the relaxant agents there has been no hesitation in resorting to completely controlled respiration for the cases in which this technique has been employed.' [97]

Perhaps surprisingly, the 'adoption very widely' of relaxants and controlled respiration did not lead to widespread development of automatic respirators. Anaesthetists were prepared to use manual ventilation of the lungs for the few hours necessary for most operations. The 'feel' of the bag and the resistance of the lung to inflation gave the anaesthetist an idea of how relaxed the patient was. He or she could interrupt the movement of the lungs for a minute or two to allow the surgeon to do a delicate part of the operation. A partnership between the surgeon and the anaesthetist developed, the latter watching the progress of the operation and anticipating the need for more gentle respiration, or for more inflation pressure to ensure the lung was fully inflated before closure of the chest. Most anaesthetists were resigned to the need to ventilate the lungs by hand during anaesthesia for surgery.

One anaesthetist thought differently, and as a result an IPPR machine, the Blease Pulmoflator (P1) became the first commercially available in Britain in 1950. The strange history of its designer John ("Jack") Blease has been described by McKenzie.[98] A self-taught engineer and successful racer of motor cycles which he built himself, Blease made parts for an anaesthetic machine designed by a friend, Dr Henry Roberts, a general practitioner who was also an anaesthetist at the Liverpool

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1946;39:400-10.

[97] Gray TC, Rees J G. The role of apnoea in major surgery. Br Med J. 1952;2:891-92.

[98] McKenzie AG. The inventions of John Blease. Br J Anaesth. 2000;85:928-35

Dental Hospital. When his friend died suddenly, Blease took over his role as dental anaesthetist and became highly skilled at the art. Although anaesthesia is generally the preserve of registered medical practitioners in the UK, dental anaesthesia was for many years an exception, being regularly administered by dentists or even persons with no qualifications at all. In the early 1940s Blease was appointed Emergency Anaesthetist to Birkenhead General Hospital, Merseyside and even anaesthetised for thoracic surgery. In 1941 he designed a lung ventilator which was tested on patients with the help of Dr John Halton, the anaesthetist who with Cecil Gray introduced the modern use of relaxants.[99] After several prototype Pulmoflators, the first ventilator freely available commercially in Britain, the Blease Pulmoflator (P1) was launched in 1950. Over five years about 200 were produced.

In the first half of the twentieth century Janeway had intubated the trachea with a cuffed endotracheal tube, and had applied positive pressure to the lungs intermittently. Waters had introduced cyclopropane which was an excellent anaesthetic but a powerful respiratory depressant. He had also introduced a carbon dioxide absorption rebreathing circuit. Guedel had taught that intermittent positive pressure ventilation of the lungs (he used the term ‘passive respiration’) was necessary in deep cyclopropane anaesthesia. He had shown that over-ventilation was relatively innocuous. Cournand and his colleagues had shown how to ventilate the lungs by intermittent positive pressure ventilation without disturbing the circulation. Ibsen was able to demonstrate in 1952 that application of these techniques reduced the mortality in bulbo-spinal paralysis due to polio.

In Great Britain by 1952 endotracheal intubation and IPPV were in use by British anaesthetists and had been said to be necessary not only in thoracic or facial surgery but in routine abdominal surgery. There was even a perfectly effective automatic lung ventilator available. It might be expected that British anaesthetists would be ready to introduce intensive care by using these techniques to treat respiratory failure due to polio and other diseases. However for several years after 1952, few anaesthetists participated in intensive care in England and Wales. The care of patients with respiratory failure continued to be undertaken for several years by those who had had that responsibility before 1952-3; usually the epidemiologists and

[99] Gray TC, Rees JG. The role of apnoea in major surgery. Br Med J. 1952;2:891-92.

specialists in infectious diseases, with or sometimes without the help of anaesthetists. The reasons for the apparent disinterest among anaesthetists will be discussed in the next chapter.

Surgical and wound shock

The success of intermittent positive-pressure respiration in reducing the mortality of bulbo-spinal polio has tended to focus attention on the respiratory system. However many patients were saved in ICUs by the application of knowledge of the management of 'shock'.

In the nineteenth and early twentieth century sudden collapse during or after surgery was ascribed to a little-understood condition known as surgical shock. The causes were thought to include nervous shock and the effects of anaesthetics. George Washington Crile (1864-1943) developed a 'shockless method' of anaesthesia. [100] He believed shock originated in the nervous system and attempted to isolate the operative site from the nervous system by blocking the nerves from the operation area with local anaesthetics. Although Crile's theory was wrong, in fairness it should be recalled that Crile also attempted to reduce shock by minimising blood loss and that he was one of the first to use blood transfusion.

André Frédéric Cournand (1895-1988) used cardiac catheterisation to investigate the circulation in shock patients who had sustained haemorrhage.[101] He found decreased cardiac output and increased peripheral resistance as the small arteries (arterioles) contracted to maintain blood pressure in the face of loss of blood volume. However in more recent years the ability to monitor cardiac output and peripheral resistance has shown that in shock due to sepsis there is a different haemodynamic state; there is usually vasodilatation, leading to reduced arteriolar resistance together with a very high cardiac output. In a third type of shock, cardiogenic shock seen in some patients with myocardial infarction, the clinical picture of shock is due to reduced cardiac output from the damaged heart.[102]

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[100] Crile GW, Lower WE. Surgical shock and the shockless operation through anoci-association. London: W B Saunders Company; 1920.
[101] Cournand A, Riley RL, Bradley SE et al. Studies of the circulation in clinical shock. Surgery. 1943;13:964-65.
[102] Wilson RF, Thal AP, Kindling PH. et al. Hemodynamic measurements in septic shock. Arch Surg. 1965;91:121-9

During the Second World War 'shock tents' were set up.[103] Shock in those circumstances would be due to blood loss from wounds. By bringing the most seriously injured patients together under one medical officer it was possible to provide a high level of monitoring and care. As well as a high standard of treatment the record keeping and research carried out in these tents was astonishing. Henry Knowles Beecher (1904-1976) and his colleagues introduced a clinical grading of shock, the correlation of degree of shock with blood loss. They measured blood volume and recorded the ECG changes in shock. Levels of plasma proteins, haematocrit, haemoglobin, serum electrolytes and lactic acidosis were measured in a laboratory tent. Renal and liver function were related to blood volume change. All measurements were carefully recorded and graphs were produced. All of this was done in tents and only a few miles behind the battle front.[104]

It might be expected that this level of trauma care would be carried on in civilian practice after the war. The first Trauma Centre in Britain was opened during the war in Birmingham.[105] The Birmingham Accident Hospital and Rehabilitation Centre opened its doors on 1st April, 1941.[106] The first medical director was Professor William Gissane (1898-1981). By 1947 there were three trauma teams operating, each consisting of two consultant surgeons and a consultant anaesthetist, as well as a burn team of three consultant surgeons. The hospital operated on three basic principles: First; segregation of the ill from the injured; only trauma victims were treated at the Accident Hospital. The second principle was that there was continuity of care and unity of control; the same consultant surgeon continued to be responsible for the patient throughout their hospital stay. The last principle was one which has continued to distinguish the care of injured military personnel and has informed civilian rehabilitation of the injured in England. It was that rehabilitation

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[103] Beecher HK. Resuscitation and anesthesia for wounded men. Springfield: C C Thomas; 1949.

[104] Harrison M, The medicalisation of war – The militarisation of medicine. Soc Hist Med. 1996;9:267-76.

[105] Shoemaker WC, Elwyn DH, Rosen AL. Development and goals of a trauma and shock research centre. Mt Sinai J Med. 1968;35:451-72.

[106] History of trauma: Trauma systems. Available at http://www.trauma.org/archive/history/systems.html accessed 4 March 2011.

was an integral part of trauma management throughout recovery and rehabilitation.[107] While the Birmingham Accident Hospital was supposed to be a model for trauma care throughout the UK, the formation of the NHS in 1948 essentially halted the development of trauma services in the UK. The hospital finally closed its doors in 1993.

Thus the example set by the military medical officers in shock tents did not immediately lead to the opening of similar institutions, ICUs for trauma victims, but the lessons learnt were incorporated into civilian surgical practice. When ICUs were opened in England and Wales patients benefitted from the lessons learnt in the shock tents during the Second World War. The high rates of survival of the seriously injured during the Second World War and subsequent conflicts have been said to have raised public awareness of the possibility of survival of the seriously injured and contributed to a general acceptance of intensive care. It was expensive in terms of money and resources but the public expected no less. [108]

[107] Hettiaratchy S, Tai N, Mahoney P, Hodgetts, T. UK's NHS trauma systems: Lessons from military experience. Lancet. 2001;376:149-51.
[108] Lynaugh JE, Fairman J. New nurses, new spaces: A preview of the American Association of Critical Care Nurses history study. Am J Crit Care. 1992;1:20.

Chapter 4. Emergence of respiratory support in polio

Introduction

It is often stated that modern intensive care started with the dramatic success of Bjørn Ibsen's use of intermittent positive pressure ventilation (IPPR) to save the lives of patients dying of respiratory failure caused by poliomyelitis (polio) during the epidemic in Copenhagen in 1952.[109] To explain the impact of this revolutionary treatment it is necessary to consider the nature of polio, the evolution of epidemics of the disease and the treatment of respiratory failure in polio patients before 1952.

Polio is an infectious disease caused by transmission of a virus of the enterovirus group, poliovirus, from person to person. The virus causes paralysis by damaging the anterior horn cells of the spinal cord which supply nerve impulses to muscles and sometimes by destruction of the motor nuclei of the brainstem.

There are four ways in which a person may react to infection by the polio virus: First, some patients develop immunity without any symptoms of illness. Second, in some patients the symptoms are of a mild general infection not involving the nervous system. These are abortive cases. Third, many patients, as many as 75% in some epidemics, develop fever, malaise and often meningism and show an excess of cells in the cerebrospinal fluid but never develop paralysis. Forth, in a minority of patients the disease runs its full course and causes paralysis.[110] The muscles most commonly affected by polio are those of the lower limbs. Patients are commonly left with wasting and shortening of the leg and a tilted pelvis.

The threat to respiration in polio is threefold: paralysis of the spinal nerves supplying the diaphragm and intercostal muscles; paralysis of the lower cranial nerves causing laryngeal and pharyngeal paralysis which impairs deglutition and permits inhalation of food or of secretions from the upper respiratory tract; and finally, in some cases, paralysis of the respiratory centres causes respiratory arrest. Paralysis of the vasomotor centre may cause vasomotor collapse. The proportion of patients in whom breathing is seriously

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[109] Sykes K, Bunker J (contributing editor). Anaesthesia and the practice of medicine: Historical perspectives. London: The Royal Society of Medicine Press;. 2007. Page 175.
[110] Walton J. Brain's diseases of the nervous system. Ninth ed. Oxford: Oxford University press; 1985. p. 283.

affected varies. During the epidemic in Copenhagen in 1952 out of 2241 patients with a confirmed diagnosis of polio, 345 (15.4%) were categorised as life threatening.[111] In Los Angeles County Hospital in the 1949 epidemic 151 (13.3%) of 1128 cases had respiratory distress which was severe in 130 patients.[112]

Polio was formerly called infantile paralysis because of its tendency to affect infants or young children. There are accounts of infantile paralysis in the seventeenth century. The first was by Jean Godfroy Salzmann of Strasbourg. It was published in a brochure in 1734, which was in turn reported by Nicholas Andry (1658-1742) which in its turn was described by Maloney in 1949.[113] Salzmann was the actual witness of this case; a boy who had never had an ailment until the use of his legs was lost at the age of six when he was riding on his elder brother's shoulders. According to Maloney's account, for some time this game had delighted the child and done him no harm, when one day in 1699, while riding as usual, he was seized with weakness of both legs. Presently the left leg recovered but not the right. There is no mention of sphincter, sensory or trophic trouble. Salzmann dissected the affected right leg on the man's death aged forty in 1733.

His account of the damaged muscles is very detailed. He sought witnesses to the onset of paralysis in the child's infancy. He attributed the damage to the muscles of the right leg to strain of the muscles caused by them being stretched round his big brother's neck. This in turn had compressed the blood supply of the muscles and deranged the circulation thus damaging the spinal cord and even the brain. By comparison of the disability with spinal injuries Salzmann concluded that the lower part of the nerves which accompany the muscles was affected; what would be called now a lower motor neurone lesion.

Accounts of what might have been infantile paralysis in Lancashire, England in the seventeenth century have been found by Fessler from English

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[110] Lassen HCA. A preliminary report on the 1952 epidemic of polio in Copenhagen with special reference to the treatment of acute respiratory insufficiency. Lancet. 1953;1:37-41.
[112] Bower AG, Bennett VR, Dillon JB, Axelrod B. Investigation on the care and treatment of polio patients. Part ll. Ann West Med Surg. 1950;4:686-716.
[113] Maloney WJ. A seventeenth century case of polio. Edinb Med J. 1949;56(7):304-311.

local history documents.[114] While carrying out an investigation of Lancashire records with regard to the conditions of the sick poor in that era he found many who described themselves as being lame. The further details allow a degree of certainty in diagnosing the cause of the lameness.

The two principal causes were 'apoplexy' (now called a stroke), and paralysis of limbs due to a crippling form of arthritis. The former was likely if weakness was sudden and in an older age group, and arthritis would be more likely in someone with persistent pain in multiple joints, possibly with back pain.

However, among the petitions for poor law relief are a few concerning lame children or people who became lame in their youth, which suggest that infantile paralysis had been the cause of their lameness. In contrast to those 'born lame' or who had been 'lame since infant' these children or adolescents had been healthy until they were suddenly 'struck lame'. The lameness usually affected the lower limbs, some of the children recovered partially, sometimes it was stated that the distemper proved to be incurable. All the cases occurred at two different periods in the century; the first period lasted from 1630 – 1640, the second started towards the end of the century.

Fessler states that it is difficult, sometimes even impossible, to substitute a modern diagnosis for a diagnosis in use in former times especially when the condition is described and often even diagnosed by lay people, but in spite of these reservations it 'might be possible to state that the Lancashire Poor Relief Records indicate the occurrence of infantile paralysis in England during the 17th century'.[115]

Epidemic polio

At the end of the nineteenth century polio in some areas changed. From having been an endemic disease in many countries with a low incidence it began to occur in large epidemics. In 1894 there was an epidemic in New England and at least thirteen epidemics comprising over 18,000 cases occurred during the

[113] Fessler A. Infantile paralysis in 17th century Lancashire. Manchester University Medical School Gazette. 1954;34(1):40-2.
[115] Fessler, Infantile paralysis, 1954:42.

next twenty years, with a death rate of over 20 percent. In 1916 in the outbreak in the City and State of New York 18,000 persons caught the disease and 25 percent died.[116]

In contrast, England and Wales suffered only randomly scattered relatively minor outbreaks against a background of randomly scattered sporadic cases. These outbreaks, together with details of American and Continental outbreaks of polioencephalo-myelitis (his preferred term) were assiduously recorded by Dr. Frederick Batten in 1911.[117] His paper includes a table of epidemics worldwide. The first two outbreaks recorded in England hardly deserved to be called epidemics. The first large epidemic in England occurred in Bristol in June 1909, with 32 cases being reported between June and October. Hardy in her study of polio from the perspective of neurologists published in 1997 has pointed out that thirty cases of measles would not have been called an epidemic but thirty cases of polio were – and she quoted Tony Gould's book *A summer plague*: 'Everything to do with polio in Britain – not least the disease itself- was on a minor scale'.[118,119] 84 cases were recorded in the North West of England in 1910. In the years between the Wars, for the most part notifications averaged a few hundred per annum; exceptionally, in 1926, 1938 and 1940 they numbered more than a thousand.[120] During the 1926 epidemic the cases notified from the beginning of May to the end of October numbered 875 and gave rise to fears that a major epidemic such as those experienced in North America must sooner or later occur in England.[121]

In 1947 these fears were realised. The epidemic pattern of polio notifications in England and Wales suddenly changed.[122] There were 7766 notifications before the year was out. The epidemic claimed an unusually high proportion of adult victims. In 1946 the outbreak was concentrated on London.

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[118] Leading article. Rest for polio. Br Med J. 1926;2:947-8.
[117] Batten FE. The epidemiology of poliomyelitis. Proc R Soc Med. 1910-11;49:198-226.
[118] Hardy A. Polio and the neurologists: The view from England 1896-1966. Bull Hist Med. 1997;71:249-72.
[119] Gould T. A summer plague. Polio and its survivors. New Haven and London: Yale University Press;1995. page 161
[120.] Martin WJ. Polio in England and Wales 1947-1950 Br J Soc Med. 1951; 5:236-46 .
[121] Leading article. Rest for polio. Br. Med J. 1926;2:947-8.
[122] Registrar General's Statistical review of England and Wales in Hardy A. 1997. page 267.

In subsequent years many more centres were involved. In a study of polio published in 1953 of the geographical variation in the incidence of notified polio in England and Wales during 1947 to 1950 Benjamin and Logan noted that there had been a tendency for some areas to suffer successions of years with higher than average prevalence, and for other areas to experience successive years with lower than average prevalence; on balance there are some areas of the country which within the period studied had significantly higher prevalence than others.[123] This differential incidence does not appear to be associated with social conditions as measured by the proportion employed in unskilled occupations or housing density. The notifications in the County of London were examined by Benjamin and Logan to see whether there was any occupational factor in the transmission of the virus. The results were negative.

Why did polio suddenly change, from being an endemic disease of low prevalence with occasional small epidemics, to a disease characterized by very large epidemics? It has been suggested that improvements in hygiene and social conditions had protected infants from subclinical infection by the polio virus.[124] These infections would have conferred immunity. In the absence of this immunity in more hygienic communities, infection at a later age would spread in the susceptible community causing the severe epidemics seen in the 1940s, and as the disease tends to be more severe in adults and older children there would be high death rates. The relative absence of epidemics in England would seem to indicate that levels of personal and public hygiene here were lower than those in America, particularly perhaps in New York. Evidence for this has not been found.

Two epidemics were to have lasting effects on the history of polio. First, the severity of the 1916 epidemic in New York, together with the fact that the President, Franklin D Roosevelt was himself crippled by the disease in 1922, showing that polio was no respecter of persons or class, caused polio to become a major concern for the American people. Large amounts of money were raised, much of it by the general public, to enable the US to make progress in social and scientific studies which culminated in the introduction of the Sabin and Salk

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[123] Benjamin B, Logan WPB. Geographical and social variations in the incidence of notified polio. Brit.J prev soc. Med. 1953;7:131.
[124] Topley WWC, Wilson GS. Topley and Wilson's principles of bacteriology, virology and immunity. 8th ed. London: Arnold; 1990. p. 346-348.

vaccines in 1955 and 1962. Jonas Salk's killed vaccine, funded by the famous March of Dimes, was trialled in the United States in 1951 while trials of Albert Sabin's live oral vaccine took place in the Soviet Union two years later.[125] Second, the treatment of respiratory paralysis caused by polio in the epidemic in Copenhagen in 1952 led to a new, effective treatment of respiratory failure by anaesthetists, and to the development of Intensive Care Medicine.[126]

Treatment of polio in 'iron lungs'.

Patients had been surviving complete and prolonged respiratory failure at least since the introduction of the Drinker Respirator in 1929.[127] Several machines to help people breath had been invented before Drinker and his colleagues described their machine but the Drinker machine was the first practical one. It was originally (later frequently modified) a sheet metal cylinder sealed at one end. The other end of the cylinder has a lid (a circular metal plate) with a large hole in it. The patient lay on a mattress in the cylinder with his head sticking out of the hole. A rubber collar fitted in the hole and made an air-tight seal round the patient's neck. The sides of the cylinder had boat-type portholes for observing the patient. There were several other holes which permitted attendants to gain access to the patient's body.

A pump was attached to the cylinder so that air could be extracted 10 to 40 times a minute. As the air is extracted the pressure in the tank is reduced the thorax expands and air is sucked into the lungs through the mouth, which is outside the tank. These respirators were referred to as negative-pressure tank respirators or colloquially as 'iron lungs'. There is however no such thing as negative pressure. The pressure in the tank was 'sub-atmospheric' and it was the pressure difference between the atmospheric pressure outside the tank and the sub-atmospheric pressure

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[125] Moulin AM. The defended body. In: Cooter RP, Pickstone J, editors. Companion to medicine in the twentieth century London: Routledge; 2000. pages 385-398, page 392. It is not quite clear why Sabin chose the Soviet Union for the trial but Anne Marie Moulin has pointed to the use of vaccines as a defensive weapon during the Cold War. The implication is that in bacteriological warfare the possession of an effective vaccine is an asset. If the United States had a vaccine protective against polio, the USSR needed one too.

[126] Lassen HCA. A preliminary report on the 1952 epidemic of polio in Copenhagen with special reference to the treatment of acute respiratory insufficiency.. 1953; 1: 37-41.

[127] Drinker P, McKhann CF. The use of a new apparatus for the prolonged administration of artificial ventilation. A fatal case of polio. JAMA. 1929;92:1658-60.

in the tank (and therefore around the patient's thorax) which drove air into the lungs. The pump cycled by means of valves so that the air was rhythmically sucked out of the chamber or allowed back in, so the patient was helped to inhale or allowed to exhale at a rate which simulated normal breathing.

The story of the development of machines for providing intermittent negative pressure ventilation, including those described here, has been described very comprehensively in two papers by Woollam.[128, 129] In addition to the cabinet or tank respirators there were two other types of respirators in use in the period 1930 – 1952. Cuirass respirators consisted of a hollow rigid shell which fitted over the patient's thorax. A negative pressure was provided rhythmically to expand the lungs. They were less efficient than cabinet respirators but cheaper and portable.[130] Of particular interest because it was almost the only respirator available to Ibsen and Lassen during the Copenhagen polio epidemic was the Sahlin-Stille cuirass. Alternating positive and negative pressure were produced in the shell, assisting expiration and inspiration respectively.

A third type of respiratory assist device was the Bragg-Paul Pulsator which consisted of hollow rubber tubes strapped round the abdomen and lower thorax. A small air pump inflated the tubes intermittently, thus compressing the lungs and expelling air. During the intervals between inflations the lungs were free to expand and allow air to enter. The device was used successfully in many cases but unfortunately there were problems due to the rubber perishing. At the beginning of the Second World War the Admiralty bought up all available belts for use at sea .[131]

First successes.

One of the first survivors from respiratory failure sufficiently severe to require artificial respiration was a boy aged nine described in a paper by Drinker and

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[128.] Woollam CHM. The development of apparatus for intermittent negative pressure respiration. (1) 1832-1918. Anaesthesia. 1976;31:537-47.
[129.] Woollam CHM. The development of apparatus for intermittent negative pressure respiration. (2) 1919-1976, with special reference to the development and uses of cuirass respirators. Anaesthesia 1976;31:666-85.
[130] Plum F, Lukas D. The evaluation of the cuirass respirator in acute polio with respiratory insufficiency. Am J Med Sci. 1951;221:417–24.
[131.] Medical Research Council. Special report. Breathing machines and their uses. 1938:237.

his colleagues in Detroit in 1929 as E.B.[132] On 9th September 1929 E.B. went to school but came home again almost immediately. He was feverish, irritable and nervous with tremor, spinal rigidity and paralysis of the left arm.

By the third day, the paralysis had spread to both arms and the intercostal muscles. He was driven the 7 hours' journey to New York. On admission his respirations were rapid and diaphragmatic, his chest did not move at all with inspiration. He was removed to the respirator room where he remained for sixteen days. He was in the tank for half the time for the first week and about one-third of the time in the following week. On admission, although he was 'not in urgent need of artificial respiration' the effect of the machine was considered most beneficial because the boy hardly slept at all outside the machine but would fall into a deep sleep as though exhausted when the assistance of the machine was given to him, his anxious attitude was replaced with a sense of security, rapid respiration outside was replaced by slower breathing inside, and the boy periodically asked to be put into it.

Reports in medical journals are not usually framed to convey excitement- 'purple passages' are frowned upon by editors and are ruthlessly eliminated. Nevertheless, the earlier papers do convey something of the delight of the physicians when they found for the first time that they were at last able to do something constructive for a patient who could not breathe. For example in the discussion which followed the delivery of a paper by Drinker and his colleagues in Detroit, Dr Fitz of Boston commented :

I was rather doubtful about the machine at first. It looked cumbersome, it was noisy, and it looked more like a torture chamber than anything else, but certainly the boy I saw getting well in it entirely convinced me as to the practical value of this method of giving artificial respiration.[133]

Dr. Aycock had brought E.B. on his seven hour drive to New York and said 'Many devices have been tried for aiding the patient with artificial respiration. None has ever been successful ... due to the fact that one is dealing with a perfectly conscious patient who realises his breathing difficulty and will not permit any muzzling of his face when he is in this condition. To one whose job it is to sit by

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[132.] Drinker P, Shaughnessy TJ, Murphy DP. The Drinker respirator. Analysis of case reports of patients with respiratory failure treated from October 1928 to June 1930. JAMA 1930;95(17):1249-1253.

[133] Drinker, Shaughnessy, Murphy. The Drinker respirator. 1930: 1252

these gasping moribund patients, to see them immediately take on the aspects of a perfectly well person when placed in the machine is gratifying.'[134]

The reference above to muzzling of the face refers to machines which had been used to treat respiratory failure by applying positive pressure to the lungs through a face mask. Drinker and McKhann describe the use of such a machine, the Pulmotor:[135]

> The patients are usually mentally alert to the end: they fight any mask over the face and oppose the efforts of the machine. In one patient, in whom life was maintained for 2 days by the Pulmotor, the stomach and the oesophagus were ruptured, and gastric contents were present in large amounts in the mediastinum. The terminal efforts of this child had opened the oesophagus rather than the trachea to the forceful inrush of air. [136]

Other patients had been kept alive by manual artificial respiration; for example Dr Redden described how a rescue squad which he had trained in Ohio, was called to give artificial respiration to a victim of Landry's ascending paralysis which had gradually involved the diaphragm.[137] The men continued artificial respiration for about twenty-eight hours during which time the victim remained conscious. Eventually he died. Dr Redden described the manual method of artificial ventilation; the patient is placed on his back and manual pressure is applied simultaneously in the anterior costal margin by two operators one standing on each side. This manual pressure soon becomes unbearable for the conscious patient. Dr Redden said 'The description members of the rescue squad gave me of the discomfort and even agony that this man suffered from the application of artificial respiration by manual pressure made me realise that the type of apparatus developed by Dr Drinker has marked value.' [138]

These descriptions of earlier methods of artificial respiration are quoted to emphasize that although negative pressure respirators are little used now, in 1928

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[134] Drinker, Shaughnessy, Murphy. The Drinker respirator.1930: 1253

[135] Drinker P, McKhann CF. The use of a new apparatus for the prolonged administration of artificial ventilation. Jour. A.M.A.1929;92:1658-60 This journal was later referred to as JAMA.

[136] Drinker, McKhann. Artificial ventilation. 1929: 1658

[137] Drinker, Shaughnessy , Murphy. The Drinker respirator. 1930:1253

[138] Drinker, Shaughnessy, Murphy. The Drinker respirator. 1930: 1253

they were a tremendous advance over methods previously available for the treatment of respiratory failure.

Evaluation of intermittent negative pressure respiration (INPR).

In those early, exciting days every life saved was a wonderful, exhilarating achievement; an occasion for a triumphant report. Then came more sober assessment. How many treatments were successful? How many patients were saved to suffer and die soon afterwards? The large series reported were inevitably of polio. It was probably the commonest cause of potentially reversible respiratory failure and the reason for the invention of the respirator. The results were in general not good. The respirator was possibly worse than useless in cases with pharyngeal paralysis. Drinker and his colleagues had recognised this problem from the beginning 'Our failures so far indicate that in bulbar involvement the respirator is apt to be ineffective.' [139, 140] The reason for this is that bulbar involvement, i.e. damage to the cranial nerves resulting in paralysis of the pharyngeal muscles which are involved in swallowing, together with inability to cough due to paralysis of the diaphragm and muscles of the thorax, combine to make it impossible for the patient to prevent secretions from the mouth and nose running down to the lungs, blocking the airways and making the lungs stiff and preventing their inflation. Forcing the lungs to expand in a respirator only makes the situation worse by sucking the secretions down into the lungs.

In 1934, Landon published an analysis of cases of polio reported to the New York City Department of Health in 1931.[141] There were no less than 4138 cases. Eighty-eight cases were treated in respirators. Due to a shortage of respirators, many patients for whom respirator treatment was indicated were not so treated. This provided an opportunity to compare these cases with those (said to be equally severe)

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[138] The 'cranial nerves' including the glossopharyngeal nerve and the vagus nerve, which control sensation in the larynx and pharynx and the muscles involved in swallowing, emerge from the lower part of the brain, the archaic term for which was the bulb. The nerves to the lower body emerge from the spine, the motor nerves emerging from tracts in the anterior part of the spinal cord. When polio affects the limbs and respiration it is called spinal or anterior polio, and when it affects swallowing it is bulbar polio. Bulbo-spinal is the combination causing paralysis of both breathing and swallowing.

[140.] Drinker, Shaughnessy , Murphy. The Drinker respirator. 1930: 1251

[141] Landon JF. An analysis of 88 cases of polio treated in the Drinker respirator, with a control series of 68 cases. J Pediatr. 1934;5(1):1-8.

who had received respirator treatment. The mortality in the respirator-treated cases was no better than those equally severe cases for whom no respirator was available; and in the 18 months after discharge from hospital many more respirator treated cases had died (table 1). It must be remembered that this report was of cases treated only two years after the introduction of the tank respirator and experience was very limited. In many cases the respirator was used only as a last resort in already moribund patients.

	Respirator		No respirator	
	Cases	Deaths	Cases	Deaths
In hospital	88	53 (60%)	68	40 (59%)
18-month follow-up	35	16 (46%)	28	3 (11%)
Total	123	69 (78%)	96	43 (63%)

Table 1. Comparison of survival in patients treated in a respirator and in similar patients for whom a respirator was not available. Compiled from data in Langdon, 1934.[142]

James L Wilson reviewed about 400 patients who were treated in respirators in the USA in 1940. He stated that two-thirds of the patients had pharyngeal paralysis.[143] Of these, two-thirds died. But in about one third of the patients, the use of the respirator was dearly indicated because they had respiratory paralysis without pharyngeal paralysis. Of them 80% survived. Wilson also argued in favour of early use of the respirator rather than the common last ditch attempts to save the already moribund.

In 1945 a rather sketchy preliminary report was published from Stockholm of 827 cases of polio described as 'suffering from respiratory troubles' treated in the Swedish-made Sahlin-Stille cuirass respirator.[144] The results were poor: 542 (65 percent) of the 827 cases succumbed while still in the respirator. Another 37 cases died soon after they were removed from the ventilator. The early survival rate is given as only 15 per cent. Ninety of the 126 survivors were followed up. Thirty were described as invalids, 46 were partially disabled and only 19 could earn their living.

[142] Landon JF. Polio treated in the Drinker respirator. 1934; 3:1-8
[143] Wilson JL. The use of the respirator. JAMA 1941;117:278-279.
[144] Bergman R. Eight hundred cases of polio treated in the Sahlin respirator. Acta Paediatr 1948;36:470.

This extremely poor outcome may be an example of failure to select patients rationally because there were reports of better results.

The contemporary literature indicates that early workers were well aware of the ethical problem of selection of patients for their new technology. Wilson in 1941 affirmed that a great many patients recovered as competent individuals, but many were left severely disabled. [145] Smith described in 1952 a patient who had survived respiratory paralysis due to polio and was then dependent on a respirator for eighteen years.[146] From the detailed description of this case it is evident that the prolonged illness and its complications imposed great strain on the patient, his parents and to his attendants, but they nevertheless regarded his survival as worthwhile.

Respirators in Britain

Respirators were widely available in Britain because in November 1938 Lord Nuffield, a motor car manufacturer and philanthropist announced his intention to present respirators free of charge to institutions in Great Britain and the Commonwealth with a genuine need of them. Three remarkable men were involved in this donation; Lord Nuffield, Sir Robert Macintosh and Edward Both.

Lord Nuffield was born William Richard Morris on 10 October 1877.[147] He was one of seven children. Both parents came from Oxfordshire farming stock, which Morris later traced back to the thirteenth century. His first enterprise began at the age of sixteen, when he left his apprenticeship and set up a small cycle-repair business in his parents' house at 16 James Street, Oxford, with £4 of capital. He sold the cycle business and in 1909 set up the Morris Garage, where he sold, hired, and repaired cars. Sales quadrupled in four years. In 1912 Morris took the predictable step of moving from the sale and hire of cars to actual manufacture. In the late 1920s, Morris supplied a third of all cars made in Britain.

Morris's greatest public achievements lay in philanthropy. In total he donated £30 million, two-thirds of it for educational and medical purposes. In 1926 he gave £10,000 to enable parents to visit their children in Borstal (corrective) institutions.

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[145] Wilson JL. The use of the respirator. JAMA. 1941;117:278-279.
[146] Smith SL. Eighteen years of dependence on a respirator. JAMA. 1952;149:654-5
[147] Overy RJ. Morris, William Richard, Viscount Nuffield (1977-1963) in Oxford Dictionary of National Biography. Mathew HCJ, Harrison B (eds) Oxford: Oxford University Press; 2004

He gave benefactions to hospitals in Birmingham and Coventry and to St Thomas's Hospital, for the rebuilding of the Radcliffe Infirmary in Oxford and the Oxford orthopaedic Hospital, which later became the Wingfield Morris Hospital. Morris was knighted in 1929 and raised to the peerage in 1934. He chose the name of the village in which he lived for his title and became Lord Nuffield. He gave funds for the purchase of the Oxford University Observatory, which was used to house the Nuffield Institute of Medical Research.

Morris's main recreation was golf. A number of doctors from Guy's Hospital frequented his golf club (he owned it). He proposed to them that he would donate money to the University of Oxford to establish chairs in each of the three dominant specialties, medicine, surgery and obstetrics and gynaecology. Macintosh, an anaesthetist was present and casually joked that anaesthetics had been left out again. Nuffield took his remark seriously but the University opposed the idea. Eventually it relented, the Chair was created and Macintosh was appointed.

Nuffield retained a lively and informed interest in medical science and was responsible for the initial supply of iron lungs to British hospitals when still in an experimental stage. When he died on 22 August 1963 the bulk of his remaining estate, valued at over £3 million, was given to Nuffield College (Nuffield had donated the land to the College when it was founded in 1937).

Robert Macintosh was born in Timaru a small town in South Island, New Zealand on 17 November 1897.[148] He excelled in sport and academically and was Head of his School. After a remarkable career as a pilot in the Royal Flying Corps in the First World War he trained at Guy's Hospital Medical School and qualified in 1924. Starting with anaesthesia for dentistry he built up a lucrative practice. His competitors (whose rooms were heated by fuel supplied by the Mayfair Gas Light and Coke Company) christened Macintosh's anaesthetic practice the Mayfair Gasp Fight and Choke Company.

Edward Thomas Both (1908–1987) was a young man in his twenties when he set up a laboratory to develop scientific and medical apparatus at Adelaide University in the early 1930s.[149], [150]At that time he had a staff of one, his wife

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[148] Sykes K, Bunker J. Anaesthesia and the practice of medicine: Historical perspectives. London: Royal Society of Medicine; 2007. p. 71-2.
Hicks M. The story of the 'Both' portable cabinet respirator. 2003; Available at: http://archive.amol.org.au/hmm/pdfs/hmm24.pdf. Accessed 2009.10.28. This url is no

Eileen, but by the mid-1930s they had been joined by his younger brother, Donald (D.J.R. or Don). The company became known as Both Equipment Limited. Over the following few decades Edward (often referred to as E.T. or Ted) developed and produced a huge number of different kinds of instruments ranging from a portable electrocardiograph in the 1930s to electric delivery vans in the 1950s and an electric tennis score board for the Davis Cup and the Melbourne Olympic Games in the 1950s.

When the severe epidemic of polio or 'infantile paralysis' broke out in 1937, health authorities in South Australia approached the Boths to see if they could produce a breathing machine to help polio patients who were dying of respiratory paralysis. There were only a few examples of the Drinker respirator in Australia. The Boths were able to design a simple, inexpensive respirator. Working non-stop with the help of several other enthusiastic young men, the Boths produced sufficient machines to cope with the polio epidemic in South Australia. The respirators were a modification of the Drinker machine, but the cabinets were made of wood, not iron. They were cheaper, lighter and easier to manufacture. In 1937 Both came to England to arrange for the manufacture of his machines under licence.[151] While he was in London another polio epidemic started. He offered his services to London County Council and started to manufacture his ventilators in North London.

Robert Macintosh had been asked to give a lecture on artificial ventilation and decided to make a film. He went to the Western Fever Hospital in London where Drinker and Both machines were in use and there he met Ted Both. Shortly afterwards Lord Nuffield was shown the film when he visited the Nuffield Institute of Medical Research in Oxford. Nuffield was advised by Macintosh that there was a widespread need for such a machine. Hence Nuffield's offer to donate one to any hospital in the British Commonwealth which needed one. By the end of 1939, 1600 machines had been allocated and training in their use was provided by members of the Nuffield Department of Anaesthetics in Oxford. In the British Isles at the end of

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longer available (Dec 2011) but similar information is provided at http://www.achha.org.au/ironlung.php Accessed Dec 18 2011.

[150] McGowan SW. Edward Thomas Both: Australia's Thomas Edison. Hist Anaesth Soc Proc. 1995;17:66-69 .

[151] Sykes K, Bunker J. Anaesthesia and the practice of medicine. 2007: p. 182 -184

March 1939 there were over 1000 respirators (including in the Services). There were 965 Both machines, 43 Bragg Paul machines, and 30 Drinker respirators.[152]

Respirators in conditions other than polio

The application of the respirator to a wide range of conditions other than polio started almost as soon as the Drinker machine was invented. By June 1930, 80 patients (46 adults, 6 children and 28 infants) had been treated in Boston, Philadelphia and New York.[153] They had treated cases of asphyxiation of the new-born where it met with limited success, seven cases polio of whom at least two survived, and seventeen cases were coal gas poisoning of which nine recovered and were discharged. There were five cases of drug overdose; morphine, heroine, and barbital. Three of these recovered. A woman was treated in a Drinker respirator for post-operative respiratory failure after an operation for scoliosis. She was unconscious and deeply cyanosed. She was obviously in a terminal state and certainly owed her survival to the respirator. She was in the tank constantly for ten days and at night for one month. She took twice daily naps in it for several weeks more.

The same paper reported that in the Bellevue Hospital in New York the respirator was used in the emergency ward two or three times each month (31 cases between May 1929 and June 1930). It therefore appears that use of the machine had become quickly commonplace. There were other reports of the use of the ventilator in the treatment of a wide variety of conditions including snakebite, drowning, alcoholic coma and flail-chest injuries. [154, 155, 156, 157]

In twelve months (October 1935-0ctober 1936) twelve cases of respiratory paralysis following diphtheria were treated by Dr McSweeney in Cork Street Hospital in Dublin using the Bragg Paul Pulsator described earlier. Four of the

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[152] Smith RE. Modified Both respirator. Lancet. 1953;1:674-6.
[153] Drinker P, Shaughnessy TJ, Murphy DP. The Drinker respirator. Analysis of case reports of patients with respiratory failure treated from October 1928 to June 1930. JAMA. 1930;95(17):1249-1253.
[154] Linton R, Sarkar N. Case of snake bite successfully treated with help of "iron lung". Ind M Gaz. 1941;76:92-3.
[155] Drinker P, Shaughnessy TJ, Murphy DP. The Drinker respirator ... 1930:1249-1253.
[156] Drinker P. Prolonged administration of artificial respiration. Lancet .1931;1:1186-88.
[157] Hagen K. Multiple rib fractures treated with a Drinker respirator. J Bone Joint Surg. 1945;XXVII:330-34.

twelve cases survived. Dr McSweeney concluded: 'There can be no doubt that the introduction of this simple hut ingenious apparatus marks a great advance in the treatment of respiratory paralysis following diphtheria, a condition which in my previous experience has always proved fatal.'[158]

A case of post-diphtheritic paralysis of the diaphragm was reported by Dr Todesco from the Borough Hospital, Croydon.[159] A child of 3½ years was treated in a box respirator for four days. She was in hospital for 92 days and was discharged cured two days before Christmas. Professor Macintosh described a case in Oxford in 1939 in which the respirator was used after an overdose of paraldehyde for mania after an epileptic fit.[160] He and Mushin described the use of the respirator in patients in post-operative respiratory failure.[161, 162] By 1944 an Editorial in the *Lancet* stated that the use of the respirator in barbiturate poisoning was routine.[163]

The Drinker intermittent negative-pressure cabinet respirator had obviously offered hope of recovery for many patients suffering from respiratory paralysis which would previously have been fatal. Lewis Thomas cited the iron lung as one of the 'half way technologies which offered a temporary solution to a disease that cannot be cured.[164] This is only half true. The iron lung did not cure polio but in the majority of cases the disease burnt itself out and when death was threatened by respiratory failure the iron lung could keep patients alive until that occurred. However, events in Copenhagen in 1952 revealed its limitations.

The Copenhagen polio epidemic in 1952

In the summer of 1952 the epidemic of polio which hit Copenhagen was exceptionally dreadful. Between 24 July and 3 December 1952 (a period of 19 weeks), 2899 patients with polio were admitted to the Blegdam hospital. 866

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[158] McSweeney CJ. The treatment of post-diphtheritic respiratory paralysis with the Bragg-Paul Pulsator. Lancet. 1936;2:1093-94

[159] Todesco JM. Diphtheritic diaphragmatic paralysis treated in box respirator. Lancet. 1942;1:261.

[160] Macintosh RR. Paraldehyde poisoning treated in a Both respirator. Br Med J. 1939;1:827.

[161] Macintosh RR. New use for the Both respirator. Lancet. 1940;1:745-6.

[162] Mushin WW, Faux N. Use of the Both respirator to reduce post operative mortality. Lancet. 1944;2:685-686.

[163] Editorial. Mechanical respirators. Lancet. 1944;2:695.

[164] Thomas L. Notes of a biology watcher: The technology of medicine. N Engl J Med. 1971;285:1366-8.

had paralysis of whom 316 patients had respiratory or pharyngeal paralysis or both. In four months, the number of such patients was three times as many as had been admitted in the previous ten years. A dramatic and very moving account of the epidemic was written by Dr Hans Christian Alexander Lassen.[165] He was the chief physician at the Blegdam hospital which was the centre for infectious diseases for Copenhagen and Eastern Denmark. It is necessary to discuss this paper at some length because it was influential in changing the treatment of respiratory failure, and particularly respiratory failure with co-existing failure of swallowing. The latter condition had had a very high mortality rate, usually greater than 80%, and the methods Lassen described reduced the mortality rate to 40% or less.

He described how respiratory failure due to polio had been managed in Copenhagen before 1952. Between 1934 and 1944, 76 cases had been treated. Only cuirass respirators were used. The results are shown in Table 2.

	Patients:	Died:
Respiratory paralysis without bulbar involvement	17	5 (28%)
Respiratory paralysis with bulbar involvement	51	48 (94%)
Respiratory paralysis of undetermined type	8	8 (100%)

Table 2. Management of respiratory paralysis in Copenhagen before the polio epidemic in 1952-3.[166]

Patients with respiratory paralysis alone were easier to manage (28 percent mortality). In those with paralysis of both breathing and swallowing, which were the majority, mortality was 94 percent. That, of course, is to be expected: a negative pressure respirator does not prevent inhalation of secretions pooled in a paralysed pharynx. In fact, because it forces the patient to breathe deeply it may increase inhalation of secretions. The overall mortality in cases with respiratory and/or pharyngeal paralysis was 78 percent.

In 1948 the use of tracheotomy had been instituted to try and remove the secretions in cases in which it was impossible to maintain an open airway because of pooling of secretions and aspiration into the lungs (table 3). The use

[165] Lassen HCA. A preliminary report on the 1952 epidemic of polio in Copenhagen with special reference to the treatment of acute respiratory insufficiency. Lancet. 1953;1:37-41.
[166] Lassen HCA. The 1952 polio epidemic in Copenhagen. 1953:37

of tracheotomy did not decrease mortality for patients with both respiratory and pharyngeal paralysis. Fourteen patients were treated this way - all died. This may have been because the tracheostomy tubes were not cuffed, so that pharyngeal secretions could leak past it into the bronchi and alveoli. Of the five patients who survived in the 'respirator alone' group, only one had pharyngeal weakness, and that was slight and transient.

	Patients:	Died:
Respirator alone:	15	10 (66%)
Respirator plus tracheotomy:	14	14 (100%)
Total:	29	24 (82%)

Table 3: Results of treatment of respiratory paralysis 1948-1950. (compiled from data in Lassen 1953.[167])

This, then, was the treatment available in Denmark for respiratory failure due to polio when the epidemic struck Copenhagen in July 1952. Lassen wrote: 'To my knowledge, nothing comparable has ever been seen in Europe ... in these few months we have been in a state of war ...' [168]

Between 24 July and 3 December 2722 patients with polio were admitted to the Blegdam Hospital, the only hospital for communicable diseases serving Copenhagen. 866 of these patients had paralysis. 316 patients needed what Lassen called 'special measures, that is tracheotomy, artificial respiration, postural drainage, or combinations of these. At times they had 70 patients requiring artificial respiration and at the time of Lassen's communication to the Lancet they still had 50 to 60 patients needing artificial ventilation. To put this into perspective, the average number of beds in ICUs in England in 2003 was six, ranging from 2 to 22.[169]

In the first month of the epidemic (24 July-26 August) 31 patients were admitted with respiratory paralysis and/or laryngeal paralysis. They were treated in negative pressure respirators (one Emerson tank respirator and six cuirass respirators) with, in some cases, an uncuffed tracheotomy tube. All but four patients died, nineteen of them within 3 days of admission. The mortality rate was thus 87 percent.

[167] Lassen HCA. The 1952 polio epidemic in Copenhagen. 1953:38
[168] Lassen HCA. The 1952 polio epidemic in Copenhagen. 1953:37
[169] Crocker C. The development of intensive care in England. Intense Crit Care Nurs. 2007;23:323-30.

Lassen continues: ‘At this point we consulted our anaesthetist colleague, Dr. B. Ibsen, and on August 27th the first patient was treated with the method which soon became our method of choice in patients with impairment of swallowing and reduced ventilation - namely, tracheotomy just below the larynx, with insertion of a rubber-cuff tube into the trachea, and manual positive-pressure ventilation from a rubber bag (bag ventilation).

Ger Wackers has described the circumstances surrounding the introduction of Ibsen’s physiological insights and techniques.[170] He described Lassen’s reluctance to accept Ibsen’s ideas and mentioned that Lassen was urged to consult Ibsen by Mogens Bjørneboe, a member of the hospital’s medical staff who had invited Ibsen to help with a child with tetanus a few months earlier when Lassen was on holiday. Wackers’ paper throws a somewhat different light on Lassen’s statement: ’At this point we consulted our anaesthetic colleague Dr B Ibsen and on August 27 the first patient was treated by the method which soon became our method of choice...’ According to Wackers, Lassen had to be persuaded to consult Ibsen. It is strange that Lassen described the details of what he describes as ‘our method of choice’, which was in fact entirely the method of Ibsen, without adding Ibsen as co-author.

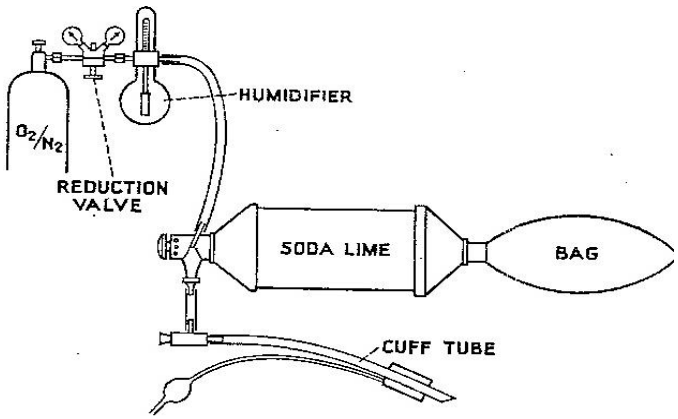

Figure 5. Anaesthetic circuit used for ventilation of the lungs in Copenhagen by Ibsen in the 1952 polio epidemic.[171]

The patients were anaesthetized with cyclopropane for the operation of tracheotomy. Pulmonary ventilation was with 5-10 L/min of a humidified

[170] Wackers GL. Modern anaesthesiological principles for bulbar polio: manual IPPR in the 1952 polio-epidemic on Copenhagen. Acta Anaesthesiol Scand. 1994;38:420-31
[171] Lassen HCA. A preliminary report on the 1952 epidemic of polio in Copenhagen 1953;i:38.

mixture of 5 percent oxygen and 5 percent nitrogen through soda lime in a to-and-fro circuit (Figure 5).

Nitrogen and oxygen pass from the cylinder through the soda lime canister into the bag. When the bag is squeezed gas passes through the tube to inflate the lungs. When pressure on the bag is released expired gas passes back through the soda lime, which extracts exhaled carbon dioxide, into the bag, where, enriched by a slow flow of oxygen from the cylinder, it can inflate the lungs when the bag is squeezed again.

The first case was treated this way on 27 August (Table 4). Thirty-seven percent of the 250 patients requiring one of the forms of 'special treatment' died after the institution of Ibsen's methods. Lassen compared this with the 87 percent mortality rate in patients admitted in the first month who required special treatment and he concluded that Dr Ibsen's new methods had saved about 100 lives (40 percent of 250 = 100 patients saved).

Treatment method	Cases	Died (%)
Tracheotomy and bag-ventilation	172	77 (45%)
Mechanical ventilator only (purely spinal paralysis with normal swallowing)	10	1 (10%)
Tracheostomy and tank respirator	11	5 (45%)
Postural drainage + nasogastric tube (pooling of secretions but respiration normal)	20	0
Tracheostomy +/- postural drainage +/- nasogastric tube	33	10 (30%)
Admitted moribund, no treatment	5	5 (100%)
Total	250	98 (37%)

Table 4. Patients requiring 'special treatment'.(Compiled from data in Lassen 1953.[172])

The most significant group was the patients treated with tracheostomy and bag ventilation. They were the ones with respiratory and laryngo-pharyngeal paralysis who usually would have drowned in their own secretions even if their respiration had been supported by the older methods. Of the 172 cases in this group, mortality was reduced to 45 percent.

[172] Lassen HCA. The 1952 polio epidemic in Copenhagen. 1953; page 40.

Ronald Trubuhovitch has analysed the data about mortality in this epidemic provided by Lassen's papers and derived from various sources and has arrived at the conclusion that, with some small adjustments, the figures are broadly correct.[173] In the later months of the epidemic (17 November – 19th December 1952) the mortality rate among a cohort of 50 patients with life-threatening polio (polio+) was reduced to 26%.

It was immediately apparent that support of respiration by bag ventilation required the assistance of what were described as 'well-trained personnel all round the clock'. The 'well trained personnel' were 200 medical students per day who ventilated 40-70 patients at a time for several weeks. They were paid 30 shillings (equivalent to about £50 in 2007) for an eight-hour shift, and the cost of the gas mixture was also about 30 shillings a day. Their courage is admirable because of course medical students are in the age group most vulnerable to polio, and there was at that time no immunization against it. They were risking their lives. In the same year, Ritchie Russell wrote a monograph on polio. Among the 35 patients he described, one patient was a 21-year-old night-nurse who had been looking after polio patients (fortunately she recovered): but another was a young general practitioner who died of the disease.[174] However no record of infection among the medical students has been found.

The aftermath of the epidemic.

Within a year Ibsen had applied his regime to the treatment of another infectious disease which caused fatal respiratory failure, tetanus. His treatment was successful. Soon afterwards another case was treated on another ward. Thirteen years later Ibsen recalled the circumstances in which the intensive therapy unit was opened in the hospital:

> The teaching and instruction had to start all over again. Thus it was reasonable to recommend the installation of a tetanus room ready for the treatment of future cases – and to pool the experience of the same nursing staff from case to case – a fundamental background for intensive therapy units. The first intensive therapy unit not concerned with polio or barbiturate

[173] Trubuhovitch RV. Further commentary on Denmark's 1952-53 polio epidemic, especially regarding mortality; with a correction. Acta Anaesthesiol Scand. 2004;10:1310-1315.
[174] Russell WR. Polio. London: Edward Arnold; 1952: pages 16 and 20.

> poisoning was inaugurated at the Kommune hospital in Copenhagen on 1 August 1963. Such an establishment was made possible because during 1953-1954 independent departments of anaesthesia were set up in three Copenhagen hospitals with chief anaesthetists ranking equally with chief surgeons.[175]

Earlier in the same article Ibsen had written that before the demonstration of their ability to treat respiratory failure during the 1952-3 epidemic 'the few doctors who worked in anaesthesia were considered in the way of technicians by the other doctors and they had no professional standing.'[176] After the epidemic Ibsen's status rose very quickly. After a disappointment when the younger and less-experienced Ole Secher (1918-1985) was appointed Professor at an independent department of anaesthesia at Rigshospitalet in Copenhagen, Ibsen was appointed on 1 April 1953 as Senior Resident (anaesthetist) at the Kommunehospitalet, the Municipal Hospital, where he gained control of the treatment of surgical patients in the recovery room and wards. Scandinavian authors have recently (2003) described the Observation Room was the world's first ICU.[177] However an article published earlier had given precedence to the Neurosurgical Recovery Room established in 1923 by Walter Edward Dandy at Johns Hopkins Hospital, Baltimore.[178] The question can perhaps be resolved by recognition of the difference between intensive (nursing) care and intensive therapy (treatment). The Baltimore unit was an ICU; the continuous care and observation given by a special nursing group would qualify as intensive care. However there was not the technical monitoring equipment or vital system support which characterised the Copenhagen Unit. The latter could therefore be better called the first intensive therapy unit.

Exactly a year later a separate department of anaesthesia was established with Ibsen as chief. He received the same salary as the chiefs of surgery, which made him free of surgical patronage and enabled him to do the work he found most useful in the specialty. In Ibsen's own words 'In developing intensive therapy this practical

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[175] Ibsen B. Intensive therapy: Background and development. 277-294.
[176] Ibsen. 1966:282.
[177] Berthelsen PG, Cronqvist M. The first intensive care unit in the world: Copenhagen 1953. Acta Anaesthesiol Scand. 2003;47:1190-5.
[178] Harvey AM. Neurosurgical genius – Walter Edward Dandy. Johns Hopkins Med J 1974;135:358-68.

arrangement was of tremendous importance.'[179] By the time that Ibsen had elevated the status of anaesthetists in Denmark, anaesthetists in Great Britain had also been accepted as of equal professional status to that of other specialists. As in Denmark, this had been necessary to enable them to contribute to and in many cases to direct intensive care, and will be the focus of chapter five.

[179] Ibsen B. The Municipal Hospital of Copenhagen (Kommunehospitalet) . Acta Anaesthesiol Scand. 1975;Suppl. 61:29-33.

Chapter 5. The professionalisation of anaesthesia

Anaesthesia was introduced to Great Britain from the United States in December 1846.[180, 181] The story of the first days and weeks of anaesthesia in this country is dramatic. The first anaesthetic was administered on 19 December 1846 for extraction of teeth by Mr James Robinson (1816-1832, first president of the College of Dentists) at the home of Dr Boott (physician and botanist 1792-1863) in Gower Street. Only two days later ether anaesthesia was used for amputation of a leg by Robert Liston (1794-1847) at University College Hospital.[182] The first performance of such an operation without causing the unimaginable agony of the operation in the conscious subject is one of the most exciting events in the history of medicine and surgery. But there is considerable doubt about whether the London operations were the first in Europe. There have been believable claims that a Dr Scott performed an operation on an etherized patient in Dumfries Infirmary, Scotland on the same day, 19 December 1846, as that on which James Robertson gave ether for the extraction of a tooth. The supporters of Dr Scott's claim do not regard extraction of a tooth as a 'surgical operation' and claim that as Dr Scott's operation precedes that of Robert Liston, Scott was the first in the United Kingdom to use ether for a surgical operation. However it has not been possible to discover the nature of Scott's operation. The evidence pro and con has been assembled by William Stanley Sykes.[183] The story, which involves the probable speed of a Cunard steamer across the Atlantic, the possibility of obtaining a seat on the first-ever train from Liverpool to Carlisle and details (or indeed lack of any details) of the persons of the ship's doctor, Dr William Frazer and of the surgeon Dr Scott is dealt with in great detail

[180] Duncum B. The development of inhalation anaesthesia. London: Oxford University Press; 1947. Pages 131-2.
[181] Snow SJ. Blessed days of anaesthesia. How anaesthetists changed the world. Oxford: Oxford University Press; 2008. Pages 28-30
[182] The biographies of both Boott, Robinson and Liston are to be found in the Oxford Dictionary of National Biography available at http://www.oxforddnb.com accessed March 2011.
[183] Sykes WS. Essays on the first hundred years of anaesthesia. Volume 1. Edinburgh: E & S Livingstone; 1960. p. 48-59

and considerable length. Sykes's conclusion, which remains tentative, is that 'it was a dead heat'.[184]

The connection between Francis Boott, a physician and botanist in Gower Street London, James Robinson, a dentist in the same street, and Henry Bigelow, newly appointed surgeon at Massachusetts General Hospital demands explanation. The link is Harvard University. Francis Boott was born in Boston, Mass. His father was English and the family had business affairs in England. Boott attended Harvard College where he was contemporary with Henry Jacob Bigelow (who is variously referred to in the literature by either or both of his forenames). Boott travelled between England and America pursuing his interests in art, literature and botany, eventually settling in London and to support his family, studied medicine and graduated in Edinburgh in 1824 at the age of 32 years.[185] It is not surprising therefore that when Bigelow was introduced to ether anaesthesia by Dr Morton, a Boston dentist and had tested it in several surgical operations, he should have communicated the news to his friend Francis Boott.

The first anaesthetics were brief; the subject inhaled ether vapour for about three minutes, became insensible but only very lightly anaesthetised and the operation was performed in the three or perhaps five minutes before consciousness returned. Often the patient recalled something of the operation but felt no pain. Within a year new techniques, equipment and anaesthetic agents were introduced, longer anaesthesia was attempted and with it the hazards of anaesthesia became evident. Experience and expertise came to be appreciated.

In the nineteenth century a few doctors were recognised as experts in administering anaesthetics. The first professional anaesthetist was the Yorkshireman John Snow (1913-1958). He was the first to carry out experiments on the physiology of the anaesthetic state and then construct inhalers for clinical use for ether and for chloroform, to regulate the concentration of the anaesthetic that the patient received. Snow was the founder of the English professional tradition of anaesthesia. The historian Barbara Duncum wrote 'Although Snow's teaching was far from being put into practice generally in England his professional prestige was great, both with

[184] Sykes WS. Edinburgh: E & S Livingston; 1960. Page 51
[185] Boott Francis. Boase GC. Oxford Dictionary of National Biography. Oxford: Oxford University Press. 2011.

medical men, and after he had twice anaesthetised Queen Victoria herself, with the public, so that his views were widely accepted as embodying an ideal of anaesthetic conduct.'[186]

Although the ether practice in London came almost exclusively to Snow, elsewhere and with junior surgeons the anaesthetist or 'anaesthetiser' could be anyone; a medical student, a nurse or a junior doctor. House officers were expected to administer anaesthetics with in some cases, little or no training in anaesthesia. At the turn of the year 1853-4 the University College Hospital Medical Committee accepted a suggestion made to them by Sherard Freeman Statham (1826-1858), the junior assistant surgeon. Statham proposed that all the hospital's medical students, as part of their course of studies, should receive some practical instructions from the Resident Medical Officer (RMO) on how to administer chloroform, and that a certificate to that effect should be among the requirements for final qualification.[187, 188] Sir Ivan Magill (1888-1986) recalled in an article written in 1965 that on presenting himself for his final examination for his qualifying degree in 1913 he was armed with a certificate that he had received instruction (in anaesthesia) and had personally administered one anaesthetic. He went on to say that 'a newly qualified doctor could be called upon to give anaesthetics for any operation regardless of the gravity of the patient's condition, though he was not expected to undertake major surgery except in an emergency. Appointment to a hospital staff were often made more because of the size of the doctor's general practice than on his ability as an anaesthetist.' [189] It would have been impossible for such anaesthetists to accept responsibility for the care and treatment of critically ill patients such as polio patients with respiratory paralysis.

A first stage in the process of the formal 'professionalisation' of the specialty had to be definition of the criteria by which a competent anaesthetist could be recognised. This required the institution of professional examinations and acceptable training. There needed to be organisations which could represent the interests of

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[186] Duncum B. The development of inhalation anaesthesia. 1947. p. 21.
[187] Merrington WR. University College Hospital and its Medical School. London: Heinemann; 1976. p. 38.
[188] Zuck D. Obituary. Barbara Duncum. Med Hist. 2002;46:265.
[189] Magill I. An appraisal of progress in anaesthetics. Ann R Coll Surg Engl. 1966;38:154-65.

anaesthetists. There also had to be improved conditions of service which allowed time for anaesthetists to provide continuous care of patients. It was also necessary for the specialty of anaesthesia to have a structure which offered a stable and satisfying career carrying adequate remuneration equal to that enjoyed by other specialists. All these conditions had to be in existence before other specialists could be satisfied that in entrusting the care of some of their most seriously ill patients to an anaesthetist they were collaborating with a professional of proven competence.

The oldest known society of physicians with mutual interest in anaesthetising patients for surgery was the Society of Anaesthetists founded in London in 1893. The Society amalgamated with the Royal Medicine and Chirurgical Society and with several other specialist societies in 1908 to form the Royal Society of Medicine (RSM). Specialists in the RSM meet as Sections and a Section of Anaesthetists was formed. This was an important step towards the of establishment of anaesthetics as a recognised medical specialty. Learned articles on anaesthesia appeared regularly in the *Proceedings* and later the *Journal of the Royal Society of Medicine.*

In 1922 the first journal devoted entirely to anaesthesia appeared in the United States: *Current Researches in Anaesthesia*. The following year the second journal was launched: the *British Journal of Anaesthesia*. Its history has been described by John Norman, Emeritus Professor of Anaesthesia at the University of Southampton.[190] The first editor was Dr Hyman Maurice Cohen (1875-1929) an American who gained his MD from Harvard and Baltimore and served in the US Army. In 1904 he married a lady from Manchester and in 1913, having resigned his commission, he came to England and qualified again at St Bartholomew's Hospital London in 1916. He became a full time anaesthetist in Manchester. His American origins are significant in the history of the Journal and also in the history of anaesthesia in Britain. Dr Cohen maintained his American connections and had the intention that from its inception the *British Journal of Anaesthesia* would have an international character, which it retains to this day. Dr Cohen's foreword to the first issue shed light on the condition of anaesthesia and anaesthetists in Britain in 1923. For example 'With the exception of the Section [of Anaesthetics of the RSM] in London and the Society [of Scottish Anaesthetists] in Scotland the general majority

[190] Norman J. The British Journal of Anaesthesia. An informal history of its first twenty-five years. Br J Anaesth. 2002;88:445-50.

of something like 500 practitioners of Anaesthesia have no affiliations with similar bodies. It is a self evident fact that anaesthetists united in one large, virile body can do much to advance the science and practice of anaesthesia.'[191]

The next major step in the professionalisation of anaesthesia was the foundation of the Association of Anaesthetists of Great Britain and Ireland (AAGBI or 'the Association') in 1932.[192] The reasons for its establishment were recalled by Dr Henry Walter Featherstone (1984-1967) in 1946 in the first issue of *Anaesthesia*, the official organ of the AAGBI. He explained that the Anaesthetic Section of the RSM was limited by the Society's Charter to discussion of scientific aspects of anaesthesia. It was not permitted to concern itself with organisation of the nascent specialty or payment or conditions of service. Practitioners of the specialty had no means of representing the needs of the anaesthetic service. No standard of training had been laid down and there was little means of distinguishing trained workers from unskilled but optimistic novices. This was unsatisfactory for patients, for surgeons and for hospital authorities, while skilled anaesthetists were inclined to think that devotion to this branch of the Profession had exposed them to an unstable career where goodwill could not be established, the problems of routine work could not be voiced and there was no official body representative of anaesthetists to whom medical or lay authorities could turn for advice.

The Association's first and most far-reaching achievement was the establishment of the Diploma in Anaesthetics (DA). The first examination was held on 8 November 1935. The Diploma was administered under the wing of the Conjoint Examining Board in England of the Royal College of Physicians of London and the Royal College of Surgeons of England. No other measure was as important in establishing anaesthesia as a specialty in British medicine in the eyes of other disciplines. The Diploma was also destined to become the key to the recognition of physician anaesthetists as specialists in the armed forces in the Second World War and ultimately as consultants of equal status on the establishment of the NHS in 1948.[193] Without this mark of specialist quality anaesthetists, instead of being the

[191] Foreword. Br J Anaesth. 1923;1:1-3
[192] Featherstone HW.The Association of Anaesthetists of Great Britain and Ireland. Its inception and purpose. Anaesthesia 1946;1:5-9.
[193] Boulton T B. The Association of Anaesthetists of Great Britain and Ireland 1932-1992

majority of specialists of intensive care in England and Wales would be, as they still are in many countries, employed by surgeons and other medical specialists as respiratory technicians, called in to an ICU to advise or administer 'respiratory therapy'.

In 1939 at the outbreak of War Dr Zebulon Mennell (1938-1941), then President of the Association was asked by an 'authoritative military source' "What constituted the status of a specialist anaesthetist?" Mennell's reply was:

> In reply to your letter to me as President of the Association of Anaesthetists, the answer to your questions are as follows:-
>
> An anaesthetist on the staff of a London Teaching Hospital or big Hospital included in the Cambridge List should be considered a specialist.
>
> As regards the small London or Provincial Hospitals, many of the anaesthetists employed in these hospitals are General Practitioners and I do not think they come into this category.
>
> Any man who has got the DA (Diploma in Anaesthetics) can safely be considered a specialist.[194]

This letter is of particular interest because it provides evidence, not otherwise easy to find in the absence of national statistics on hospital staffing, that the high standard of anaesthesia in some hospitals was not representative of the general standard in the majority of hospitals. According to the quotation above, general practitioner anaesthetists should not be recognised as specialists. Two outstanding examples were Dr Robert James Minnitt (1889-1974) and Dr Hilda Garry s (1907- 1999). Dr Minnitt was a general practitioner in Liverpool as well as being Honorary Anaesthetist at three teaching hospitals including the Liverpool Maternity Hospital.[195] In 1925 he wrote a remarkable MD thesis on surgical shock and two years later he introduced his original 'Gas and Air' machine for pain relief for self-administration by mothers

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and the development of the specialty of anaesthesia. Dissertation for the degree of Doctor of Medicine, University of Cambridge: 1999. Page 30

[194] Mennell Z. Letter to an Authoritative Military Source. In Minutes of an emergency Council Meeting recorded in the minutes of the Association of Anaesthetists of Great Britain and Ireland. Book No.1 1932-1947:197. The Minutes are archived at the Association of Anaesthetists of Great Britain and Ireland at 21 Portland Place, London W1B 1PY

[195] Maltby R. Minnitt gas and air apparatus. Robert James Minnitt (1889-1974). In ; Notable names in anaesthesia. London: RSM Press; 2002: p. 144-46.

in childbirth attended only by a midwife without medical supervision.[196] For this he was awarded Honorary Fellowship of the Royal College of Obstetricians and Gynaecologists. With an MD and a Fellowship he became an anaesthetist of unique standing and was promoted to be the first statutory Lecturer in Anaesthesia in Liverpool University.[197] However he did not entirely abandon general practice; he did not enter the National Health Service but retained a few devoted patients in his private general practice.

Hilda Garry Gibbons was considered by many to be the first research anaesthetist in Britain.[198] She reported on the first 500 and later 1000 patients who used the Minnitt machine and showed how safe it was for use by midwives. She managed to combine her post as consultant anaesthetist at Broadgreen Hospital Liverpool with a busy general practice. During the Second World War she and her husband looked after the patients of five GPs who had been called up. She would do a surgery in the morning, spend the rest of the day doing anaesthetics at one of the Liverpool hospitals, and then return to do two further evening surgeries. At the end of the War anaesthetists were in short supply although GP anaesthetists were relatively common. If anaesthesia were a speciality it was argued it should be confined to practitioners with special qualifications.[199] 'Surgeons themselves were partly responsible for the present anomalous state of affairs by permitting general practitioners to anaesthetize their own cases.'[200] This statement disregards the fact that the surgeon was frequently himself a general practitioner.

The establishment of the National Health Service in 1948 led to a national scale of payment for consultants. There was a body of opinion that anaesthetists should not be paid as much as consultant surgeons and physicians.[201] The Association argued effectively that anaesthetists who were qualified to become consultants should be paid the same amount as other consultants. There was still

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[196] Minnitt RJ. Self-administered analgesia for the midwifery of general practice. Proc R Soc Med. 1934;27 (2):1313-18
[197] Gray TC. Proc Hist Anaesth Soc. Two nudges to progress. Proc Hist of Anaesth Soc. 1997;21:10-14.
[198] Gibbons KG. Obituary. Hilda Garry Gibbons. Br Med J. 2000; Jan 15:189-190.
[199] Stevens R. Medical practice in modern England. The impact of specialization and state medicine. New Haven and London: Yale University Press; 1066. Page 113.
[200] Dawkins M. Teaching of anaesthesia. Br Med J. 1944 Feb 12;1:233.
[201] Staffing of County Hospitals; Posts and pay. Lancet. 1945;1:717.

however the suggestion that only a few anaesthetists should be granted consultant status. The criteria by which consultant status would be recognised had to be defined. The definition recorded in the Minutes of the Council of the Association in March 1946 was:

> 'The Council of the Association has considered the criteria which should be adopted for the recognition of Consultant status in the NHS.
>
> Realising that the only true definition of Consultant and specialist status is the fact that he is recognised as such by colleagues in the locality or hospital in which he works, the Council is of the opinion that this should be the chief criterion. It is also recommended that:
>
> He [sic] should have the Diploma of anaesthetics of the Conjoint Board of the Royal College of Physicians of London and Surgeons of England.
>
> He should have been in practice in the specialty for at least 5 years
>
> He should be on the full staff of a recognised hospital as an anaesthetist
>
> The Association has accepted the criteria of the Royal Colleges for future consultants. It will be remembered that one of these is that the Consultant should be engaged whole-time in the specialty. Some who should be recognised as Consultant Anaesthetists at the present time, however, may have other duties, but it is essential that the major portion of their time should be devoted to the specialty
>
> The Council wishes to draw attention to the fact that on its recommendation the examining Board in England has recently doubled the period which must elapse after qualification before a candidate may sit the Diploma in Anaesthetics, so as to bring it in line with other diplomas.'[202]

Boulton considers that the second paragraph in this minute ('Realising that...') was an unfortunate inclusion. A considerable number of anaesthetists who satisfied all the specific criteria were at the onset of the NHS placed in the lower grade of Senior Hospital Medical Officer (SHMO). In other specialties this grade was reserved for senior specialists who had not gained the appropriate specialist Diploma. This may have been because the local opinion in their hospitals refused to accept anaesthetists

[202] Special Meeting of Council 13 March 1946. Association of Anaesthetists of Great Britain And Ireland. Minute book 1; 1932-1947: 57. Minutes archived at the Association of Anaesthetists of Great Britain and Ireland at 21 Portland Place, London W1B 1PY.

as being equal in status to other specialists – a course of action apparently justified by the second paragraph of the Definition.[203] The Association protested vigorously and the President of the Association reported in the first months of the NHS that a considerable number of injustices had been ironed out.[204]

A further step in the accreditation of specialist anaesthetists was at least hastened by the imminent establishment of the NHS. Sir Alfred Webb-Johnson was the President of the Royal College of Surgeons of England from 1941 until 1949. He was invited to address the Council of the AAGBI on 11 April 1947.[205] He supported the concept that anaesthetists should be regarded as of equal status for remuneration in the NHS as had been the case in the Second World War, both in the Armed Services and the wartime Emergency Medical Service. He believed, however, that this equality could only be achieved if anaesthetists continued their wartime interests outside the operating theatre in peacetime in such areas as pre- and post-operative care, resuscitation and oxygen therapy. Web-Johnson's immediate concern was that the Diploma in Anaesthetics was of too low a standard to be certain of acceptance as a higher qualification which would automatically be considered to be adequate for an anaesthetist to be accepted as a Consultant in the NHS. The quickest solution would be to upgrade the Diploma to include a Primary Examination in basic science as soon as possible and to found a Faculty of Anaesthetists within the Royal College of Surgeons. The Faculty could then award its Fellowship to the more senior holders of the original DA who by their merits or attainments were entitled to it and to those who passed the new upgraded DA in the interim. The new regulations for the two-part DA became effective from 1 January 1948 and the first examination took place in November 1948. The Faculty of Anaesthetists of the Royal College of Surgeons met for the first time on 24 March 1948.[206] Twelve of the original 20 anaesthetists on the original faculty Board were also on the contemporary Council of the AAGBI including all the Association's Officers. Archibald Marston, the immediate Past

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[203] Boulton TB. The Association of Anaesthetists of Great Britain and Ireland 1932-1992 and the development of the specialty of anaesthesia. Dissertation for the degree of Doctor of Medicine. Cambridge: University of Cambridge; 1999. p. 30.

[204] Council's Report presented at the Annual General Meeting October 1948. AAGBI Minute Book no 2. 1947-1963.:43.

[205] Association News. Anaesthesia. 1947; 2:122-3

[206] Association News. Anaesthesia.1948; 3: 129

President became the Dean of the Faculty. The remaining members of the Faculty had been at some time members of the Board of the Association. One of these was Katherine Lloyd-Williams, consultant anaesthetist and Dean of the Royal Free Hospital, the first lady to sit on the Board of Faculty and the Association Council.

The Faculty of Anaesthetists quickly introduced the Fellowship examination and began the inspection of hospital posts and their approval for training. When a consultant post was advertised a Faculty representative was always a member of the selection committee. He or she was a full voting member of the committee, but more importantly his or her real power lay in the fact that if the committee selected as a consultant anaesthetist a doctor who did not meet the Faculty criteria for consultant status, their representative would report the decision to the Faculty who could withdraw recognition from the hospital as a training hospital for junior anaesthetists. This would inevitably make it impossible to recruit junior anaesthetists, with a devastating effect on the provision of anaesthesia for routine surgery in the hospital. Within a very short time it became virtually unknown for an anaesthetist in England to be appointed without Faculty or later Royal College of Anaesthetists accreditation. As will be seen in Section 3, the situation was different in Wales, where only teaching hospitals were recognised for training of junior anaesthetists, a circumstance which, until it was changed, inhibited the development of intensive care outside Cardiff.[207]

The professionalisation of junior anaesthetic staff

In the years before the Second World War most provincial hospitals had no resident anaesthetists and all emergency anaesthetics were performed by house officers. Even in big London hospitals which might employ a resident anaesthetist many of the emergency (and therefore sickest) patients would be anaesthetized by house officers and very few by honorary anaesthetists. The following figures published in 1930 cover a period of six months in hospitals of different types (Table 5).

Edwards complained that the ‘Honorary Anaesthetists who were experienced and skilful anaesthetized only fit patients for planned operations and the unskilled inexperienced house officers had to anaesthetise the most ill and vulnerable patients.’

[207] Edwards EM. Interview. June 2010.

Before the Second World War none of the hospitals in Liverpool, teaching or municipal, had any junior anaesthetic staff until the drift back to civilian life of demobilised service doctors after 1945.[208]

Hospital	Beds	Anaesthetists	Anaesthetics
Provincial general	80	None	All given by house surgeons
Suburban general	200	4 'visiting' and 5 HOs	All emergency given by HOs
London general	350	5 honorary and 1 resident.	36 emergencies: 15 anaesthetised by resident and 21 by HOs
London general	650	5 honorary and 1 resident	56 emergencies: 5 anaesthetised by visiting anaesthetists, 31 by resident and 20 by HOs

Table 5. Anaesthesia in 4 hospitals of different type during 6 months of 1930.[209]

At the inception of the NHS in 1948 a career structure based loosely on the pre-war hierarchy of juniors in the teaching hospitals was put in place (i.e. consultant, senior registrar, registrar, senior house officer (SHO) and house officer).[210] A sub-consultant grade, the Senior Hospital Medical Officer (SHMO) was created for specialists who had completed their training in a specialty but who had not been able to be appointed to a consultant post, usually because they had been unable to pass the appropriate Royal College examination.

These training grades were implemented in anaesthesia, but in January 1953 a compulsory provisional registration year after qualification was introduced under the Medical Act of 1950.[211] Anaesthesia was not listed as a medical or surgical appointment for the provisional registration year so there could be no anaesthetic house officers. Anaesthetic training started after the provisional registration year when aspiring anaesthetists could be appointed to Anaesthetic SHO posts.

[208] Rees GJ. The Liverpool Course. Hist Anaesth Soc Proc 1997;21:15-17.
[209] Edwards G. Emergency anaesthetics in hospitals. Br J Anaesth. 1930;8:15-18.
[210] Rivett G. From cradle to grave. Fifty years of the NHS. London: The King's Fund;1998. Page100.
[211] The Medical Act. 1950.Section 2 (a),(b).

Practitioners who went into general practice after their provisional registration year had then no experience in anaesthetics and were unable to become general practitioner anaesthetists. By 1953 therefore all anaesthetics in hospitals were given either by trainees in hospitals whose training programmes were approved by the Faculty of Anaesthetists or by consultants or SHMOs.

Thus in England and Wales by 1953 anaesthetists had achieved full consultant status and a fully staffed training programme. They were therefore qualified to accept the work of caring for patients with respiratory failure which Ibsen had pioneered in Copenhagen. The reasons why they did not immediately do so will be examined in Chapter nine.

Chapter 6. Intensive care of infectious diseases after 1952

During the epidemic of polio on Copenhagen in 1952-3 Lassen and Ibsen had used a treatment regime based on tracheostomy, intermittent positive pressure respiration and postural drainage to reduce the high mortality in bulbo-spinal polio. Very soon afterwards Ibsen had applied a modification of this regime to treat a case of tetanus. Physicians specialising in the treatment of infectious disease were the first to apply Ibsen's regime in Britain.

Lassen's account of the Copenhagen epidemic of polio and Ibsen's use of manual positive pressure ventilation of the lungs was published in the *Lancet* in the first week of January 1953. Doctors in Britain, particularly those who would have the responsibility for responding to a similar catastrophe if it were to happen in this country, had to consider how they would treat perhaps hundreds of patients who would need pulmonary ventilation and protection of their airways. Because the decrease in mortality in bulbo-spinal polio in Denmark had been achieved by applying techniques previously used in anaesthesia, anaesthetists in Britain not unnaturally expected that they would play a central role in the event of an epidemic of polio.

An editorial in the *British Journal of Anaesthesia* in March 1954 started 'The season in which an epidemic of anterior polio may be expected will soon be at hand again.'[212] The article went on to describe the large number of patients admitted to the Blegdam Hospital who 'exhibited the triad of impairment of swallowing, pooling of secretions in the hypopharynx and respiratory insufficiency.' 'It is widely accepted that anaesthetists, especially those attached to thoracic units, can contribute usefully to the treatment of these cases. The matter may soon become urgent and they should start thinking about the issues involved.'[213] However the article is surprisingly non-committal: Anaesthetists 'should start thinking now' (fourteen months after Lassen's article). After stating that clinicians were still hesitant to advocate early tracheotomy in every patient with impairment of swallowing and respiratory insufficiency, largely from a fear of ulceration or of ultimate stenosis they advise 'Anaesthetists and other respiratory physiologists should think about these problems now, talk to their

[212] Editorial. Br J Anaesth. 1954;26:81-2
[213] Editorial. Br J Anaesth. 1954;26:81

colleagues and define their attitude so that if we have an epidemic here an agreed plan can be put into operation at once.'[214]

After criticising an unspecified Ministry of Health memorandum about modifications to existing negative-pressure cabinet respirators, which according to the Editorial were sometimes referred to abroad as the "English coffin" the opinion was expressed that the only sensible short-term policy was to press on with the development of a positive-pressure machine. It went on 'We ought now to make up our minds which machine is best and to start producing it at once so that sufficient numbers will be available to cope with a large epidemic this summer.'[215] In an Educational Supplement in the same journal the five automatic ventilators which had been invented in Britain by that time were described.[216] In the event 'the market' selected three ventilators and they were produced in large numbers.

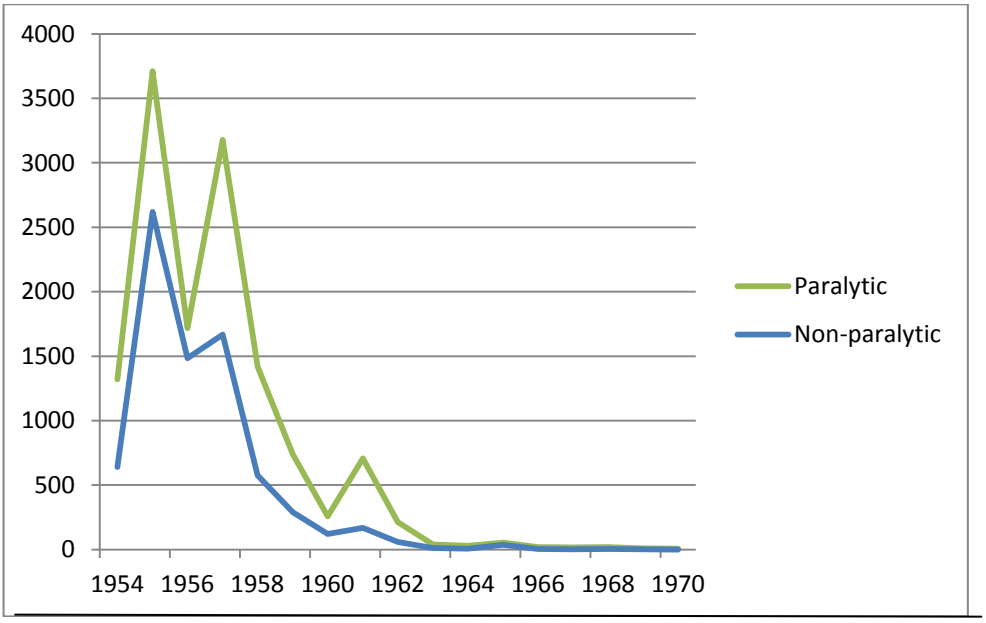

Figure 6. Notifications of polio between 1956 and 1970.[217]

[214] Editorial. Br J Anaesth. 1954;26:81-2.
[215] Editorial. Br J Anaesth. 1954;26:81-2.
[216] Mushin WW, Rendall-Baker L. Modern automatic respirators. Br J Anaesth. 1954;Educational Supplement:131-47
[217] Health Protection Agency. Acute poliomyelitis: Annual corrected notifications & deaths, England and Wales 1912-2007. Tabulated data used with permission. http://www.hpa.org.uk/Topics/InfectiousDiseases/InfectionsAZ/Polio/EpidemiologicalData/polioAccutePoliomyelitisAnnualNotifDeathsEW/

Anxiety about an epidemic was to some extent justified (figure 6). There were two large epidemics in England and Wales after 1953: 3712 paralytic cases were notified in 1955 and 3177 were notified in 1957. A smaller outbreak occurred in Hull in 1961. After 1963 the number of paralytic cases per annum had dropped to single figures. The first year in which there were no notified cases was 1970. Sporadic cases have occurred since and are attributable to vaccine-related cases or to foreign imports, i.e. the diseased had been contracted abroad.

Although the number of paralytic cases in the peak years appear large, in comparison with epidemics in the USA and Scandinavia, they were relatively small: in 1955 there were 241 deaths due to the epidemic and 226 in 1957. In New York in 1916 2,400 people had died. In Copenhagen in 1952 between 24 July and 3 December 1952 (a period of 19 weeks), 2899 patients with polio were admitted to the Blegdam Hospital for Communicable Diseases. In that single Danish hospital the admissions totalled about one half of the admissions in the whole of England and Wales in 1955.

The response of the medical profession to the epidemics was phlegmatic. This was not wholly a manifestation of 'British stiff upper lip'. The author of an editorial in the *British Medical Journal* in 1947, the year of the largest epidemic seen in Britain, with 7646 notified cases of polio and 688 deaths put the effect of the outbreak in perspective: 'A state of panic is rather easily produced by press publicity and it is hoped that the daily papers in this country will not draw undue attention to the present outbreak. In any year the cases and deaths due to polio will be far fewer than the injuries and deaths caused by road accidents.'[218]

Apparently the epidemics after 1953 were not regarded as overwhelming. The 1947 outbreak had been largely concentrated in London, whereas later outbreaks were scattered across the country and not concentrated in one area.[219] This might make it less likely that any one hospital would be overwhelmed. Hospitals in England and Wales where better equipped to treat respiratory failure than the Blegdam Hospital had been in 1952. Lord Nuffield had provided about 1000 Both type respirators before the Second World War. Ritchie Russell, a neurologist who was to be the founder of a Respiratory Unit in the Radcliffe Infirmary in Oxford

[218] Editorial. Poliomyelitis. Br Med J. 1947;Jul 26:135-136.
[219] Hardy A. Polio and the neurologist: The view from England, 1896-1966. Bull Hist Med. 1997;71:249-272. Page 267.

wrote in 1952: ‘ through the generosity of Lord Nuffield many hundreds of hospitals in Britain were provided with the *Both* type respirator. These are still the only type widely available in Britain and have performed yeoman service during many outbreaks of polio, especially the 1947 epidemic in which most of the available machines were in use. An unexpected result of Lord Nuffield’s generosity has been that improvements in design have not been developed by manufacturers in Britain in the way that has occurred in the United States, and more recently in Western Europe. This state of affairs is likely to be corrected before long but in the meantime we must be content with what is available.’ [220]

Ritchie Russell’s prediction was soon fulfilled. By the following year Barnet Christie and Joseph Esplen in Liverpool had described their cabinet respirator with a split front and a positive pressure hood.[221] The ability to bring into use about a thousand respirators is in stark contrast to the situation in Copenhagen in 1952-3 when only one tank respirator and six cuirass respirators were available. In Britain platoons of medical students were not needed to ventilate the lungs of paralytic cases of polio.

In spite of Ibsen’s demonstration of the success of techniques used by anaesthetists most cases of polio in England and Wales were not treated by anaesthetists. They were treated by those who had always treated it, physicians in general hospitals or in isolation hospitals for infectious diseases. In some places these physicians were assisted by anaesthetists.

The term ‘physician’ need some explanation. Physician can be used as a general term to describe any medical practitioner. However the title ‘physician’ is used in Britain in a particular sense when applied to a hospital specialist; those who practice general hospital medicine (as opposed to, for example, radiology, pathology or anaesthesia) are called physicians (perhaps with a subspecialty such as geriatrics, paediatrics, diabetology, rheumatology). In the 1950s polio patients were usually treated by physicians in the wards of general hospitals or by physicians specialising in infectious diseases or neurologists or by epidemiologists. Several of the latter set up centres of excellence which will be described later. But as several witnesses have

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[220] Russell WR. Polio. London: Edward Arnold;1952. Page 50.
[221] Christie AB, Esplen J R. Positive pressure hood and split front for the Both respirator. Lancet. 1953;1:1027-9.

described, lamentable treatment of respiratory failure was to be seen in general medical wards.

Dr Thomas Boulton was from 1954-1956 senior registrar in St Bartholomew's Hospital, London. In an interview in 2010 he compared the ineptitude in the management of respiratory paralysis by physicians at St Bartholomew's Hospital with the expertise of the staff at The Western Fever Hospital in Fulham, London:

> In Barts it was appalling really; if they got a polio case they put them in a respirator. Nobody really knew how it worked, there was no dedicated nursing for it, no monitoring nursing or anything like that. In about 1954, before I went to St Albans I had a ghastly experience. Anaesthetists were only called on to suck these wretched people out and one night I was called to see one of our nurses actually, who was drowning in her own sputum and I wanted to intubate the patient and suck her out properly but the medical registrar said his chief had absolutely forbidden intubation and so I said well 'Can I speak to your chief?' He very reluctantly (out of hours) tried to speak to his chief but he couldn't contact him – unavailable. And it is a most extraordinary coincidence because [Alex] Crampton Smith, who was running a Respiratory Unit in Oxford, one of the few in the country, was giving a presentation with several of his people at the Anaesthetic Section of the Royal Society of Medicine [RSM]. I wasn't yet a member, but I had this poor girl, and so I rang up the RSM and I managed to get him out of the meeting and said I really needed some help – I only got as far as saying that she needed intubating and sucking out and he was very good – he arrived within an hour with Alex Crampton Smith with him and Crampton Smith looked at the patient and said "The only thing to do is to intubate the patient, put her on an Ambu bag and take her over to the Western Fever Hospital."
>
> So on our own initiative, ignoring physicians or anything like that, we took the patient in an ambulance to the Western Fever where there was an outstanding Unit all ready half-way between iron lungs and the new Copenhagen thing with respirators (IPPV) and a very large ward. Expert, absolutely expert registrars and so on and away they took this girl and put in a tracheostomy and started to ventilate her. I was so terribly impressed but

> so terribly upset really about the whole thing but it was my first encounter with all this. However I'm afraid the girl died two or three days later but it was a revelation to me….[222]

Professor Michael Rosen described his experience of an 'iron lung' in the management of a patient in post-operative respiratory failure in Bradford in 1951:

> Decamethonium came out and we had this woman who had a Caesarean section and I gave her some decamethonium and she wouldn't breathe after the operation so I got the consultant, Dr Finney and he came in and we were ventilating her – this was the first intensive care. She was doing all right but she wasn't waking up. She wasn't starting to breathe on her own. They were a bit worried – if we carried on with the IPPB [sic] we might stop her heart. So we said this is dangerous. We had a tube down so we said we had better put her in the iron lung. Dr. Frazer who was registrar in medicine has been instructed in how to use the iron lung. Where is it? They brought the iron lung which was the Both type and he knew the zips etc. They got it out and they put her in it and she opened her eyes and looked great - it took about half an hour to put her in. So she was moving around – she was obviously uncomfortable, moving her head so we said we had better take the tube out. We took the tube out – you can guess the rest. She obstructed and it took us 10 minutes to get her out of the thing and she was dead. That was my first feeling about post-operative ventilation and it was based on falsehoods of course. No knowledge about the airway – it wasn't done deliberately it was just stupid. You can see now how foolish it was. And the difficulty of getting her out of the ventilator – it wasn't the alligator front and that was why if they had polio and they couldn't swallow it was entirely useless for that because they couldn't keep the airway.[223]

Fortunately in other hospitals patients with respiratory paralysis due to polio and other causes were treated by physicians and some anaesthetists with experience and expertise in the management of their equipment.

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[222] Dr Thomas Babington Boulton. Interview 17.8.2009.

[223] Professor Michael Rosen. Interview. June 2010.

Management of respiratory failure in Respiratory Units

Respiratory units in the Churchill Hospital, Oxford, Ham Green Hospital, Bristol, the infectious diseases hospital in Fazakerly, Liverpool and in the Western Fever Hospital, London will be discussed.

William Ritchie Russell (1903–1980) lecturer in clinical neurology in Oxford University had had previous experience of the problems of bulbo spinal paralysis during the polio epidemic of 1947.[224, 225] After the Copenhagen epidemic he began to prepare for the setting up of a respiration unit in Oxford. He realised that to replicate Ibsen's methods he needed an anaesthetist to join John Spalding, his research assistant. This anaesthetist would need to have had experience of anaesthesia which had included ventilation of the patient's lungs. In the early 1950s such anaesthesia was most likely to have been provided for patients undergoing thoracic surgery. Alex Crampton Smith (1917-2010) had been appointed anaesthetic registrar in the Nuffield Department in 1947.[226] After two years he had left Oxford to gain experience in chest surgery at the London Chest Hospital and two years later he was appointed consultant there. When a chest surgeon was appointed to Oxford he needed an anaesthetist trained in chest surgery so Crampton Smith returned to Oxford as a consultant in 1951. He was thus on hand when on 28 August 1953 a sixteen-year-old schoolgirl, Jane Deeley, was admitted to the ear nose and throat Department (ENT) of the Radcliffe Infirmary in Oxford. She had respiratory paralysis and dysphagia (inability to swallow). At first she was nursed in a tank (negative pressure) respirator but it soon became clear that artificial respiration was actually sucking secretions into her lungs. A decision was made to perform a tracheotomy and establish positive pressure ventilation. Jane recovered and was discharged from hospital within six weeks. In fact she had not been paralysed by polio but by acute toxic polyneuritis. She had been totally paralysed and could move only her eyes.

Radcliffe Respiration Pumps devised by Ritchie Russell and Edgar Schuster were used to deliver IPPV. [227] Their paper in the *Lancet* only five weeks after Jane

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[224] Obituary. W Ritchie Russell. Br Med J. 1981;Jan 3: 78
[225] Beinart J. A history of the Nuffield Department of Anaesthetics, Oxford 1937-1987: Oxford: Oxford University Press; 1987. p. 113.
[226] Beinart J. A history of the Nuffield Department of Anaesthetics. 1987. p. 113-114
[227] In the early 20th century machines for inflating the lungs were called respirators and

Deeley's admission describes two respiration pumps Pump A and Pump B.[228] In both pumps the pressure in which air is delivered to the patient is obtained by weights pressing downward on the top of a bellows or piston mounted vertically. In Pump A a rotating eccentric cam driven by an electric motor alternately lifted an arm to which weights were attached, thus expanding the bellows and allowing expiration and then released the arm allowing the arm to descend and compress the bellows which inflated the lungs. In Pump B the ward suction system applied intermittently to the cylinder above the piston lifted the piston during the expiratory part of the respiratory cycle then as the suction was disconnected by valves driven by a gramophone motor the weights depressed the piston and inflated the lungs. Pump A was the predecessor of a range of respirators made by H G East and Co. Oxford.

Russell and Schuster seemed to be a most unlikely pair to invent and produce lung ventilators. They were both academics and neither had any training in engineering. Ritchie Russell (born in Edinburgh in 1903) qualified in Edinburgh in 1926 and was awarded a Gold Medal for his MD Thesis in 1932. After training at the National Hospital for Nervous Diseases in Queen's Square, London he was appointed in 1934 as Assistant Physician at the Royal Infirmary, Edinburgh with an interest in neurology. He was also appointed lecturer in neurology at Edinburgh University and thereafter began to confine his practice largely to neurological medicine. During the Second World War he served as Specialist Neurologist and developed his major interest in head injuries and the effect of wounds on the brain. He became in 1966 the first holder of the Chair in clinical neurology in Oxford and continued research into head injury, multiple sclerosis and polio. He retired in 1970 and died in 1980.[229]

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respiration was commonly used for inflation of the lungs . Since the 1950s the term ventilation (hence intermittent positive pressure ventilation - IPPV) has been preferred and except in direct quotations will be used henceforward in this thesis. Similarly an incision in the trachea was called a tracheotomy (a cut in the trachea) whereas it is more correctly called a tracheostomy (a stoma or opening in the trachea) The latter term will be used from now on except in direct quotations. Kelleher distinguished between the operation (tracheostomy) and the resultant opening in the trachea (tracheostome) but the latter term did not come into general use.

[228] Russell W R, Schuster E. Respiration pump for polio. Lancet. 1953;2:707-9.

[229] Walton J. Russell, (William) Ritchie (1903–1980)'. rev. Oxford Dictionary of National Biography, Oxford: Oxford University Press; 2004. Available at http://www.oxforddnb.com/view/article/31641. Accessed 8 Oct 2010]

Edgar Hermann Joseph Schuster (1897-1969), was the son of a banker and nephew of Sir Arthur Schuster FRS. Edgar won an open scholarship at New College Oxford and took a B.A with first class honours in Natural Science in 1901.

In 1904 Schuster was the first holder of the Galton Research Fellowship for a three year study of eugenics.[230] After publishing several studies he gave up his appointment 'perhaps because eugenics had become for Galton a creed rather than a science.'[231] In 1913 he published his book *Eugenics*.[232] During the Second World War experiments in eugenics in Nazi Germany gained for the science an unsavoury reputation but Schuster was perhaps 'The acceptable face of eugenics'. In the first paragraph of *Eugenics* he wrote:

> There are those who would claim that the ultimate goal of eugenics is a patriotic one – namely to increase the commercial and fighting efficiency of the nation. We do not however intend to advocate it on these grounds, but would rather recommend it as a road to increased happiness for the human race, or at any rate, as a means of preventing much unnecessary misery.

During the First World War, after service in the Royal Garrison Artillery he was seconded to the Medical Research Committee, predecessor of the Medical Research Council (MRC). In the report of the MRC for 1921-1922 the discovery by Schuster of his real vocation emerges.

> It happens by fortuitous coincidence that Dr Edgar Schuster in charge of the Department [the publication department] is highly skilled in the arts of mechanical design and construction. He has devised and executed in his spare time many pieces of scientific apparatus for use in the research work of his colleagues.... After his retirement from the staff of the MRC he gave freely of his fertile invention, supreme originality and skilled craftsmanship to the medical scientists nearest to his home. To their great good fortune these were the medical scientists of Oxford.'[233]

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[230] Pearson K. Life, letters and labours of Francis Galton. Vol 3a. London: Cambridge University Press; 1930.
[231] Rec R Soc Lond. 1973;28:112
[232] Schuster EHJ. Eugenics (the nations library). London: Collins;.1913.
[233] Paton WDM, Phillips CG. E H J Schuster (1897-1969). Notes and records of the Royal Society of London. 1973;28:111-17.

Schuster had invented a respiratory pump in 1922 for use in physiological experiments.[234] It was completely different from the pumps he and Ritchie Russell used in humans in 1953 but he was famous for the alacrity with which he designed, made, scrapped and remade (in his workshop in his garden) equipment for his colleagues. His collaboration with Ritchie Russell spawned a succession of East Radcliffe Ventilators which were the mainstay of intensive care in Britain for the first twenty years.

The moist mucous lining of the nose normally humidifies the inspired air and prevents drying out and crusting of the secretions in the lungs and bronchi. When the lungs are ventilated with air or a gas mixture through a tracheostomy the nose is bypassed so crusts of dried secretions form in the respiratory passages. These crusts are extremely difficult to remove from the lower air passages and may be so extensive as to form casts of the bronchial tree and are very likely to cause intractable obstruction of the airways.[235] It is therefore essential that the air is thoroughly humidified as it enters the tracheostomy. Before treating Jane Deeley a humidifier had been developed by Spalding and John Marshall who also worked in the Department of Neurology. Crampton Smith recalled the prototype used in this case:

> Dick Salt made the first humidifier..... It was a copper water bath from the Physiology Department and Dick brazed a lid on it. It had a kettle element and a very crude thermostat and he had to support the thing with brass bands and this made a musical note when the positive pressure hit it because the tin distorted –the lid distorted. [236]

It was essential to lag the tubing between the humidifier and the tracheostomy, because if the air was allowed to cool the water would condense in the tubing, and become dry. Keith Sykes found this to be a particular problem when he was ventilating the lungs of children suffering from tetanus in South Africa:

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[234] Schuster EHJ. A simple double action respiration pump. Proc Physiol Soc. 1922;Feb 18:x-xi.

[235] Spalding JMK, Crampton Smith A. Clinical practice and physiology of artificial respiration. Oxford: Blackwell scientific publications; 1963. p. 33.

[236] Crampton Smith, interview 12 April 1984. In fact a patient had died prior to this while being ventilated without humidification, although not under Crampton Smith's care. Quoted in Beinart J. A history of the Nuffield Department of Anaesthetics, Oxford. p. 114. Dick Salt was Professor Macintosh's laboratory assistant in the Nuffield Department of Anaesthetics.

> I learnt a lot about patient care in South Africa. The main problem was in providing adequate humidity. We had old-fashioned, large volume, hot water Radcliffe humidifiers and, by the time the inspired gas reached the baby, it was at room temperature. So I started measuring the temperature close to the tracheostomy tube and increased the temperature in the humidifier until the inspired temperature reached about 32°C.[237]

Jane Deeley's recovery proved to Spalding and Crampton Smith's colleagues in Oxford that no patient should ever be left to die of respiratory failure without being treated by IPPV. Their success with their first case had vindicated their treatment as had Ibsen's in Copenhagen. There was at that time no respiration unit in Oxford. At first Spalding and Crampton Smith worked in the ENT Department where the surgeon allowed them to use his beds because the ENT surgeons might be needed to assist with the management of the tracheotomy. They then worked in a former air raid shelter at the Churchill Hospital until a respiratory unit was established there in 1955.[238] Dr Crampton Smith became the second Professor of Anaesthesia in the Nuffield Department of Anaesthesia in Oxford in 1965. He retired in 1980 and died in 2010.

It cannot be assumed that negative pressure respiration was abandoned after this early introduction of IPPV at Oxford. Pat Ashworth was a nursing sister at Broadgreen Hospital Liverpool. In 1960 it was proposed that two side-wards in the cardiothoracic surgical unit should be reserved for patients who needed IPPV in the postoperative period.

> So they sent me to Oxford to the Churchill Unit for three weeks, where I saw almost entirely polio patients nursed almost entirely in tank ventilators.[239]

However a report of the activities of the Respiration Unit before 1963 shows 153 patients treated by IPPR and only eight in tank respirators.[240] The explanation for Pat Ashworth's comment may be that those in tank respirators were in the unit for longer periods than those treated by IPPR. The period covered by the report is probably ten years so there were on average ten patients per year receiving IPPR. There must have

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[237] Sykes NK. Interview. Sept 7 2009.
[238] Beinart J. A history of the Nuffield Department of Anaesthetics, Oxford 1937-1987. p 115
[239] Ashworth P. Interview. Liverpool. July 2009.

been periods when the positive pressure respirators were standing idle and Ashworth apparently visited during such a time.

Ham Green Hospital, Bristol.

The first polio patient to be treated by tracheotomy and positive pressure respiration was treated in Ham Green Hospital for infectious diseases, near Bristol. Ham Green was an infectious diseases hospital. The medical superintendant was a remarkable man, Dr. James Macrae. He was a physician of a type not found since the years after the Second World War. His remarkable range of ability is recorded in his obituary published in the *British Medical Journal*. After qualifying in Glasgow University in 1934 he held junior hospital posts in practically every medical and surgical specialty. After service in the Royal Army Medical Corps during the Second World War and a period as deputy medical officer of health in Weston-super-Mare he was appointed consultant general physician to Ham Green Hospital and worked there continuously until his retirement in 1976. His obituary pays tribute to his extraordinary range of clinical and engineering ability:

> With his wide experience Jimmy Macrae was a classic example of the devoted whole-time medical superintendent who could turn his skills as necessary to practically every branch of clinical medicine and surgery. In the 1950s he pioneered the development of assisted respiration in the south west of England and designed and built most of the early apparatus himself. He personally performed nearly 250 tracheotomies for diphtheria, polio , and respiratory failure and in 1962 carried out the first renal dialysis to be performed in the Bristol area.[241]

The equipment referred to in the obituary included the Clevedon ventilator which he designed with his colleagues in 1953 and is described later in this chapter. The new ventilator was used on a patient (Max) for the first time on 28 Sept 1953:

> A well-developed man, aged 21, was admitted at 6.30 am on Sept. 28th, 1953, with severe polio. At 7.30 am he was placed in a Drinker-type tank respirator because of partial failure of his respiratory muscles. During the day his paralysis spread, and by 6 pm the respiratory muscle paralysis was

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[240] Beinart J. A history of the Nuffield Department of Anaesthetics, Oxford 1937-1987. Oxford: Oxford University Press; 1987. p. 116

[241] Obituary. J Macrae. Br Med J.1987;Mar 7:654.

> almost complete. In addition he had developed bulbar involvement, with inability to swallow, and was accumulating pharyngeal mucus. Continued treatment in the tank respirator was obviously going to prove rapidly fatal, since it was impossible to keep the airway clear. It was decided to try the positive-pressure ventilator.
>
> Max was on the Clevedon ventilator for six weeks from 28th September. He was finally discharged in May 1954, having made an excellent recovery. By this time his vital capacity had recovered to 1800 ml. Max remained well with the exception of the period 1970 to 1981, when he was admitted to hospital several times until he was given a permanent tracheostomy and a portable lung ventilator (Cape Minor) to use at night. During the day he blocked off the silver tracheostomy tube and disguised it with a collar and tie. He died in 1998, 45 years after what would have been until 1953, a fatal illness.[242]

One of the many remarkable features of the institution of Ibsen's regime at Ham Green was that the tracheotomies were performed by the physician superintendant, not by an ENT surgeon and that the ventilation of the lungs was instituted and supervised by physicians, not anaesthetists.

Macrae wrote *A Memorandum on Infection* in about 1969.[243] He describes the 'ward with special rooms and facilities' which was taken into use on 15 August 1957. This was probably the first ICU to be opened in Britain. The following is an excerpt of Macrae's memorandum:

> For 12 years after 1947 we treated about 1500 cases of acute anterior polio demonstrating various degrees of paralysis. .... Initially these patients were treated in isolation wards which catered for many patients with other diseases. Even before the advent of positive pressure respiration in 1953, it was becoming painfully obvious that severe cases of polio required separate accommodation. But it was not until the 15th of August 1957 that a ward with special rooms and facilities was taken into use. Without knowing it, we

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[242] Powell J. Gasman. A Personal History of Anaesthesia. Copyright © John Powell 1999. reproduced with permission. Available at http://www.johnpowell.net/pages/clevedon.htm Accessed April 2010

[243] Macrae J. A memorandum of infection. Appendix B. Bristol 1969. Available at http://www.johnpowell.net/pages/macrae.htm

had evolved an intensive care unit and the transformation was extraordinary. This was especially evident among the nurses who were able to concentrate on their duties to individual patients each with individual problems. Quite suddenly the whole business of artificial respiration took on a calmness never experienced in a mixed ward.

I have extracted some figures of work done in an ordinary cubicle mixed ward, during the period 15th August 1956 - 14th August 1957, and similar work in our special ward during the next year 15th August 1957 - 14th August 1958 (Table 6). These were all patients who would have died without artificial respiration: the only differences in management were a new ward environment and concentrated nursing care. Not only do these figures speak of improvement among patients who were deadly ill, but they reflect, in the poor fashion that figures do, the real spiritual satisfaction engendered by work well done.[244]

Diagnosis	No. of patients		Tracheostomy		Artificial respiration		Recovered		Died	
	Ward	ITU	Ward	ITU	Ward	ITU	Ward	ITU	Ward	ITU
Polio	17	15	13	11	17	15	7	12	10	3
Infective polyneuritis	1	4	1	4	1	4	1	3	0	1
Cor pulmonale	0	2	_	2	_	2	_	1	0	1
Tetanus	0	4	_	4	_	4	_	3	0	1
Totals	18	25	14	21	18	25	8 44%	19 76%	10 56%	6 24%

Table 6. Diagnosis, treatment modalities and survival/mortality for patients treated at Ham Green Hospital, Bristol in the 12 months before (Ward) and 12 months after (ITU) the opening of the ICU in August 1957. [245]

[244] Macrae J. A memorandum of infection. Appendix B. Bristol 1969. Available at http://www.johnpowell.net/pages/macrae.htm

[245] Macrae J. A memorandum of infection. Appendix B. Bristol 1969. Available at http://www.johnpowell.net/pages/macrae.htm. Accessed October 2010

Fazakerley Hospital, Liverpool

Not all physicians were convinced that Ibsen's regime of IPPV and tracheotomy was always necessary for patients with respiratory paralysis and with additionally inability to swallow. In chapter 1 it was shown that in the United States Bower and his colleagues had demonstrated good, perhaps even better results with their Drinker Collins respirators with a positive pressure attachment. Similarly some specialist infective disease hospitals in Britain were unwilling to abandon negative-pressure respirators. In contrast to the situation in the Blegdam Hospital in 1952–3 they had enough 'iron lungs' and the number of cases of polio was never as great in Britain as it had been in Copenhagen during that epidemic. The physicians and nursing staff in the infectious disease hospitals already had extensive experience of management of large numbers of polio patients in 'iron lungs'. They recognised the difficulty of controlling secretions in patients with laryngeal paralysis but produced two different solutions:

At Fazakerley Hospital for infectious diseases in Liverpool Dr Andrew Barnett Christie (1909-1992) was medical superintendant and consultant physician. Even in the 2nd edition his book *Infectious diseases: Epidemiology and clinical practice* published as late as 1974 he explained that a physician who might have to look after a patient with respiratory insufficiency for years rather than for days or weeks might have reservations about the advantages of Ibsen's regime and IPPV:

> When the patient has both pharyngeal paralysis and weakness of the intercostals or diaphragm, neither iron lung treatment nor postural drainage will suffice. ….The treatment for such patients is tracheotomy (sic) and the insertion of a cuffed tube into the trachea.

This accords with Ibsen's treatment of such cases. But Christie goes on to write:

> There is often confused thinking on this point as when it is said that some form of positive ventilation is the correct treatment for this combined form of paralysis.
>
> Once the tube is in position and the cuff inflated, the method of artificial ventilation is a matter of choice. Most physicians do connect the tracheotomy tube to some form of positive pressure respirator, but it is quite possible to ventilate such patients by negative pressure, in an iron lung, or as I have frequently done, in a negative pressure plastic gown respirator. The

> primary purpose of the tracheotomy is to bypass the secretions which have accumulated due to pharyngeal paralysis. This paralysis is likely to disappear in the first fortnight of treatment. If the patient is ventilated by a negative pressure appliance the tracheotomy tube can then be removed and the wound allowed to heal, artificial ventilation being continued as long as the condition of the intercostal muscles or diaphragm requires it. But if the patient is being ventilated by a positive-pressure machine the tracheotomy must be maintained as long as ventilation is required, though the primary reason for the tracheotomy, the pharyngeal paralysis, has long since ceased to exist.
>
> There are disadvantages both in negative- and positive pressure methods of ventilation; it is not my purpose to argue in favour of either, but there are dangers, mainly infection, inherent in prolonged tracheotomy. Nor is it my purpose to recommend one machine rather than another; each physician becomes accustomed to his own, and a physician using a machine he fully understands is likely to be of more benefit to his patient than a doctor who has a better machine but less understanding of how to use it.[246]

Christie thus had perfectly logical reasons for not using IPPV. He had the facilities for negative pressure respiration and he and the staff at Fazakerly were experienced in their use. He was not faced as Ibsen was, with the task of saving (or losing) the lives of a very large number of patients with very few respirators of any kind. He had enough tank respirators for the number of patients he was treating. He could therefore afford the luxury of considering the longer term treatment of his patients; how would they manage after the acute emergency of combined respiratory and pharyngeal paralysis had passed; many of them would need continued respiratory support, some for the rest of their lives. With a negative pressure respirator this could be provided without the need for a permanent tracheostomy. He therefore continued to use ‘iron lungs’ and developed them, improving access to the patient, attaching positive pressure hoods so that the patient could continue to have help with breathing while taken out of the cabinet for short periods of treatment and arranging the neck

[246] Christie AB. Infectious diseases. Epidemiology and clinical practice. Second edition. Edinburgh: Churchill Livingstone; 1974. Pages 597-605.

collar so that it accommodated a tracheostomy more comfortably.[247] Many years later Christie wrote;

> Writing in 1980 I realise that there are few doctors now in practice who have ever used an iron lung, but I can look back to the days when many were expert in their use. In 1974 a judge in the English high court ruled that to use an iron lung was a negligent act, but I am glad to say his verdict was reversed on appeal.[248]

The Western Fever Hospital, London

The Western Fever Hospital had been founded in Fulham, West London in 1877 during a severe epidemic of smallpox. Boulton's delight at the excellence of his patient's management there in 1954 has been described earlier (Chapter 6. Page 88). A paper by W Howlett Kelleher the physician superintendant in this hospital and his former registrars, JM Medlock and DGB Powell was published in 1956. They noted that although tracheostomy for complicated cases was strongly supported by American workers, they had not been convinced by the argument for IPPV and continued to maintain respiration in cabinet respirators which were more sophisticated than most of those in other hospitals in Britain. Kelleher and his colleagues had also been unconvinced of the advantage of IPPV so they had continued to use cabinet respirators and supplied a table of their results (table 7).

Type	No. of cases	Method of respiration						Total mortality (rate)
		Cabinet		IPPR		None required		
		Cases	Died	Cases	Died	Cases.	Died	
Spinal	39	32	1 (3%)	3	2 (67%)	4	0 (0%)	3 (8%)
Bulbar	2	_	_	_	_	2	1 (50%)	1 (50%)
Bulbo-spinal	22	8	2 (25%)	5	3 (60%)	9	1 (11%)	6 (27%)

Table 7. Treatment and mortality in polio in the Western Fever Hospital; December

[247] Christie AB, Esplen JR. Positive pressure hood and split front for the Both respirator. Lancet. 1953;1:1027-9.
[248] Christie AB. Infectious diseases: Epidemiology and clinical practice. 3rd ed. Edinburgh: Churchill Livingstone; 1980. p. 594-614.

1954- January 1956.[249]

The mortality in bulbo-spinal polio treated in cabinet respirators in the Western Hospital was nearer to Lassen's later mortality rate using IPPV, whereas the mortality among those they treated with IPPR had been high. Eight years after Ibsen's introduction of IPPV for the treatment of respiratory failure in polio Kelleher described a 'New pattern of "iron lung" for the prevention and treatment of airway complications in paralytic disease.'[250] Kelleher recognised the difficulty of treating severe cases of polio and other neuromuscular diseases in the older types of respirator, particularly because of the inaccessibility of the patient and the lack of manoeuvrability. He explained that the Coventry Alligator pattern had satisfied most of the criticisms, but he had found that in the Western Hospital's necropsy reports in the previous 20 years lung damage had been a depressingly common feature. Kelleher was convinced that many of the serious lung complications could have been prevented or treated had it been possible to apply the physics of drainage and to maintain patency of the terminal airway. He and his colleagues had in a previous publication emphasised the importance of lung drainage in patients treated in a respirator.[251] Drainage of secretions from the tiny airways in the periphery of the lungs is primarily effected by microscopic hair-like processes called cilia which line the interior of the bronchial tubes. By a concerted wave-like motion the cilia sweep secretions from the final small airways up to the larynx from which they may be expelled by coughing. Leonard Hill had shown in 1928 that cilliary action may be twice as effective if aided by gravity, that is if the patient is if the bronchial tubes are tilted downwards toward the larynx.[252] This is possible if the patient is nursed head down. Drainage is further increased if the patient is turned from one side to the other every hour so that each lung can benefit from the consequent increased tilt of its bronchi. The effectiveness of a head down tilt can be improved still further if the patient can be nursed prone (i.e. face down) instead of supine (face up). Kelleher's

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[249] Adapted from Kelleher WH, Medlock JM, Powell DGB. Maintenance of respiratory function in polio and other neuromuscular disorders. Lancet. 1956;2:68-74. Only the results for polio (90% of the total) have been reproduced in this table.
[250] Kelleher WH. A new pattern of iron lung for the prevention and treatment of airway complications in paralytic disease. Lancet. 1961:2:1113-6
[251] Kelleher WH, Medlock JM, Powell DGB. Lancet. 1956;2:68-74
[252] Hill L. The ciliary movement of the trachea studied in vitro. A measure of toxicity. Lancet. 1928;2:803-5.

new respirator was designed to, for the first time, make this possible in a cabinet respirator and also to improve access to the patient. It could be rotated about its longitudinal axis through 180 degrees in either direction by one person turning a handle. It could also be tilted 25 degrees head down. The patient was held comfortably in a harness so that they did not slide when tilted. Importantly this prevented the neck sliding down through the collar and disturbing a tracheostomy if one were present.

Kelleher had previously asserted that secretions could be cleared by 'postural drainage'. His new respirator allowed the patient to be placed by one attendant in the best position for drainage of secretions from any part of the lung, whereas in earlier respirators four attendants had been necessary and the manoeuvring had caused greater discomfort for the patient. He provided three 'illustrative case reports'. None had pharyngeal or laryngeal paralysis. One had had polio five years previously and had severe residual respiratory weakness, with a vital capacity of only 500 ml. She had been admitted to hospital several times with respiratory or renal complications. She was admitted in March 1960 with a bronchial infection with her right middle and lower lobes collapsed. She was treated in the rotary respirator with frequent turning and continuous artificial respiration aided by vigorous physiotherapy with manually assisted cough. There was dramatic improvement in the atalectasis (lung collapse) 24 hours later and virtual disappearance of the collapse radiologically six days after onset. The second case had been discharged from another hospital six weeks previously after paralytic polio contracted fourteen months earlier. She developed a respiratory infection with purulent secretions and a vital capacity reduced from 1400 ml to 500 ml. She was treated similarly in the rotary respirator. She was discharged with a vital capacity of 1200 mls. and her secretions had cleared. The third case was the only case of acute polio. The others were patients chronically disabled by the disease. This woman had a two-day history of the rapid onset of polio with symmetrical weakness. Her cough effort was very poor. She was treated in a Coventry type negative-pressure respirator with manually assisted coughing (her chest was pummelled and squeezed by a physiotherapist while she exhaled) and supine head inclination at intervals but not much drainage was achieved and her secretions were increasing. The next day she was put into the rotary respirator and turned frequently into the prone position with fifteen degrees head down tilt. This

resulted in the expulsion of large quantities of purulent sputum and expansion of the collapsed base of the left lung. After three weeks she no longer needed the respirator and her functional recovery was good.

This patient did well with a greatly improved version of the traditional iron lung treatment of polio. However she did not have laryngo-pharyngeal paralysis so no tracheostomy was done. Kelleher did not advocate his rotary respirator for cases of bulbar palsy. He wrote 'such a state is best dealt with by tracheostomy and a cuffed tube and the application of artificial respiration by intermittent positive-pressure ventilation or the cabinet respirator.'[253] Dr Kelleher is the sole author of his paper but he thanks the assistant physician Dr EP O'Sullivan and also Dr PH Byles, research anaesthetist at the Western Hospital for their help. [254] There was never a consultant anaesthetist on the staff of the Western Hospital although there were orthopaedic and ear nose and throat surgeons. The absence of a senior anaesthetist is puzzling because the minutes of meetings of the Weston House Committee report that one-day courses were run at the hospital at the request of the Faculty of Anaesthetists at the Royal College of Surgeons on 12 and 19 April 1961. No mention has been found of the presence of an operating theatre in the hospital.

From the above it might be inferred that Kelleher was a die-hard reactionary who had resented the intrusion of an anaesthetist (Ibsen) into Kelleher's area of expertise – negative-pressure respiration. But he wrote: 'I am not prejudiced against other methods; indeed in 1951-2 I advocated the use of tracheostomy in bulbo-respiratory polio with practice of such techniques as were then being studied in certain centres in the USA. Furthermore, the pioneer work on I.P.P.V. by the Danes in 1952 was studies in Denmark during the polio epidemic by Dr Brian Sellick and myself and we made strong advocacy to interested branches of the profession and to

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[253] Kelleher WH. A new pattern of iron lung for the prevention and treatment of airway complications in paralytic disease. Lancet. 1961;2:1113-6

[254] There are not many references to The Western Hospital in the medical literature. A brief description is included among 'Lost Hospitals of London' accessed through http://www.ezitis.myzen.co.uk/western.html
Records of the hospital can be located through the website of the National Archives. http://www.nationalarchives.gov.uk/hospitalrecords
The database should be searched using Western Hospital as Hospital name and London as the Town name. Both were accessed 10.10.2010.

the Ministry of Health to introduce the techniques in this country and to develop apparatus.'[255]

The use of the iron lung was attacked in 1969 by John Robinson, Professor of Anaesthesia at Birmingham University.[256] He reviewed the various forms of apparatus used for assisted respiration. In his view most of them were useless. The iron lung, he said, should be relegated to the museum. Many anaesthetists might have agreed with him. Their experience of tank respirators was, like that of Boulton and Rosen, of primitive versions of the iron lung being used on unsuitable patients by general physicians unskilled in their use. Kelleher wrote a spirited reply in a letter to the Lancet:

> With an experience extending over many years in the use of, at first, iron lungs (cabinet respirators), but also of tracheostomy and positive pressure ventilation (I.P.P.V.), I have seen scores of patients whose existence today is due to the use of one or other of the machines then or currently used, and whose ventilatory state has been satisfactorily maintained by such apparatus, particularly with what I prefer to call the cabinet respirator. I appreciate that until the limitations imposed by earlier designs had been corrected the patient with a wet airway and a total respiratory paralysis was most unlikely to survive in a cabinet. Indeed, in our practice the patient in the acute stage of polio with a wet airway was never nursed in a cabinet respirator after techniques allowing tracheostomy and I.P.P.V. had been satisfactorily developed. [257]

This letter was important on two counts; first because it is evidence that IPPV and tracheostomy were used when they were considered indicated in the Western Hospital in spite of Kelleher's insistence that negative pressure respirators were still useful and indeed preferable in polio, especially but not exclusively in patients with long-term respiratory weakness and secondly because Kelleher clearly distinguishes patients with wet lungs (i.e. profuse secretions), in the acute stage of the disease as distinct from those episodes of acute respiratory infections in patients with residual

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[255] Kelleher WH. Respirators in respiratory failure. Br Med J 1969;Aug 30:528-9
[256] Robinson JS. Annual Scientific meeting 7-10 July: proceedings. Assisted ventilation. Br Med J. 1969;Jul 19:165
[257] Kelleher WH. Respirators in respiratory failure. Br Med J. 1969;August 30:528-9

respiratory weakness. He treats the latter in his improved cabinet respirator, the former need IPPV and tracheostomy.

Kelleher retired on 20 May 1967 and the Western Hospital closed in 1979. Before ending this description of a remarkably successful hospital for infectious diseases it should be seen from another point of view; that of the patient. Simon Parritt was, like Dr Boulton's patient, transferred from another hospital to the Western Hospital.

> My parents weren't allowed to visit me for a while; they were only allowed to look through a window in the ward. All I can remember is being in a darkened environment, being fed through a tube. – raw egg and milk I think. I think it was my favourite – the only thing I could taste ... When I came out of hospital I tried it and it was disgusting.
>
> What was extremely unpleasant was the physiotherapy.. It was so painful just to move – there was a lot of pain, it wasn't just stiffness. My physio used to walk in at 9 o'clock and I remember there was a central speaker playing *Housewives Choice* and the music for *Housewives Choice* used to precede the physio by about three minutes; it was like the knell – or toll – of doom. Physiotherapy was the hardest thing. [258]

In this thesis the focus in polio has been on the treatment of respiratory failure because that is the aspect of treatment which led to modern intensive care. However it should be remembered that that is only one aspect of the disease, and occurs in the minority of patients. Peripheral muscles, not just respiratory muscles, were not only paralysed, they were painful and frequently led to lifetime disability. Efforts to reduce contracture of limbs were often misguided, some causing more harm than good and much of the regime inflicted on patients, perhaps especially children was justified by the dictum 'One must sometimes be cruel to be kind'.

The end of the polio years

The full story of vaccination against polio with Salk's killed virus vaccine, which had to be given by a course of three injections, and Sabin's attenuated live virus vaccine given as a single dose orally on a sugar lump has been told in great

[258] Gould T. A summer plague. Polio and its survivors. New Haven and London: Yale University Press; 1995. Pages 233-4

detail by Tony Gould in his book 'A Summer Plague. Polio and its survivors'.[259] After a slow take-up of the injected Salk killed vaccine in 1958, a publicity campaign and the acceptance by the Ministry of Health in 1961 that the Sabin live vaccine, which could be administered on a sugar lump, was safe led to a rush for immunisation and the incidence of the disease dropped sharply. Although occasional cases of polio continued to occur in Britain, the effect of polio on the development of intensive care in England and Wales was negligible after 1963. (Figure 7).

Although polio was the major preoccupation among doctors treating acute respiratory failure between 1953 and 1963, another usually fatal infectious disease, tetanus, was also amenable to treatment by IPPV, tracheostomy and intensive specialised nursing: Very soon after Ibsen treated polio by IPPV he applied his technique successfully to the treatment of tetanus. This disease had a considerable influence on the founding of early respiratory units in Britain.

Tetanus

Tetanus is a disease caused by a bacterium *Clostridium tetani*.[260] The natural habitat of *C. tetani* is soil, where it exists as spherical spores which may remain alive for many years. In certain conditions the spores germinate into rod shaped organisms which produce toxins which produce the effects of the disease by binding to receptors on the nerve endings. The essential condition which allows the germination of the spores and the release of the toxin into the tissues is a low oxygen content in the tissue containing the spores. The spores may enter the body through a wound contaminated by soil, but there are many other sources. Tetanus has followed operations, notably on the gallbladder but even minor operations such as circumcision. It has followed road accidents, and injections of various substances. Neonatal tetanus is extremely common and highly fatal in some countries but has not occurred in Britain for over 30 years. The toxin has a high affinity for nervous tissue binding to the myoneural junction whence it spreads to the cell body. It is now known that it acts by causing a failure to inhibit motor reflexes. This causes intense, painful spasm of the muscles on the slightest stimulation. The reflex spasms are sufficiently strong to cause tendon rupture, and bone fractures. During spasms the

[259] Gould T. A summer plague. Polio and its survivors: 1995. Pages 173-6.
[260] Christie AB. Infectious diseases. Epidemiology and clinical practice. 2nd ed. Edinburgh: Churchill Livingstone; 1974. p. 567 et seq

patient is unable to breathe and may suffocate. The autonomic nerves supplying the heart, gut and blood vessels are also affected and may cause alternate hypertension with tachycardia and hypotension with bradycardia and sometimes cardiac arrest.

Treatment of tetanus consists of pain relief and sedation to control the spasms and the autonomic disturbances. In severe cases, particularly when respiration is threatened, muscle relaxants must be used. For many years they were tried. They were an obvious treatment for life threatening muscle spasms, but were not successful because doses sufficient to control the spasms weakened the muscles of respiration causing unacceptable respiratory depression.[261] As late as October 1952 Ronald Woolmer, senior lecturer in anaesthesia and J E Cates, lecturer in medicine in the University of Bristol treated a patient with succinylcholine, a short acting relaxant.[262] Their aim was to achieve muscular relaxation while avoiding respiratory paralysis. The patient recovered and it was concluded that succinylcholine given in this way seemed to be a valuable contribution to recovery. However they did not succeed in avoiding either spasms or respiratory depression with cyanosis. However as described above (Chapter 3) in 1952 Gray introduced the concept of administration of a dose of relaxant sufficient to give complete relaxation of the muscles and treating the inevitable cessation of breathing by ventilation of the lungs via an endotracheal tube. Ibsen applied this principle to a case of tetanus in May 1953.[263] British anaesthetists quickly adopted the same philosophy. They administered a sufficient dose of long acting relaxant (d-tubocurarine) to completely abolish the spasms. This also caused complete cessation of respiration so the patient's lungs were ventilated by a mechanical ventilator attached to a tracheostomy tube. These patients needed the one-to-one attention of a specially trained nurse supervised by a physician (usually an anaesthetist) trained in the management of paralysed patients. J J L Ablett described the treatment in detail in 1956. [264]

In August 1953 a farm labourer who developed tetanus after piercing his foot with a fork was admitted to The Royal Hampshire County Hospital where he was

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[261] Florey HW, Harding HE, Fildes P. The treatment of tetanus. Lancet. 1934;2:1036-41.
[262] Woolmer R, Cates JE. Succinylcholine in the treatment of tetanus. Lancet. 1952;2:808-9.
[263] Lassen HCA, Bjørneboe M, Ibsen B, Neukirch F. Treatment of tetanus with curarisation, general anaesthesia and intratracheal positive-pressure ventilation. Lancet. 1954;2:1040-44.
[264] Ablett JJL. Tetanus and the anaesthetist. A review of the symptomatology and the recent advances in treatment. Br J Anaesth. 1956;28:258-273.

treated with succinylcholine. He was kept ventilated for six days. Shackleton described the arrangements with a touch of wry humour:

> We settled down to this life for six days. Any member of the staff who could not provide an alibi for the next twenty-four hours might find himself on a two-hour bag-squeezing and aspiration shift. Our trials and tribulations were many. We thrombosed veins; we got atalectasis of his lower lobes; we put him in steep Trendelenberg position [i.e. head down] and got atalectasis of his upper lobes. We got peripheral circulatory failure from the insidious build-up of carbon dioxide. On one occasion we even filled his trachea with soda lime, most of which we recovered. We used dozens of cylinders of oxygen and nitrous oxide and thoroughly disorganised the rest of the work of the hospital. All ended well and he made a complete recovery.[265]

This patient and his treatment were described in two papers; one by Shackleton in which he included 'The role of the anaesthetist' in the title and another by the medical registrar A T T Forrester.[266]

Information about the intensive care of tetanus in England and Wales is contained in a report on A Symposium on Tetanus in Great Britain which was held at Leeds in April 1967. The report contains papers from practitioners treating the disease records the dates on which a regime based on tracheostomy, curarisation and IPPV was instituted and in some cases the date when specialised units were opened to provide intensive care of tetanus patients.[267] Respiratory units in operation since the 1950s included units in Leeds (opened in August 1954), Belfast (reported patients treated in the unit since 1959), Portsmouth (reported patients treated in the Wessex Regional Polio Unit since 1957), Southampton (Respiratory Unit opened in 1958) and Ham Green Hospital, Bristol where polio had been treated in the Respiratory Unit since at least 1947. The first patient treated with IPPV at Ham Green has been described above, and they treated the first severe case of tetanus in May 1958. In

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[265] Shackleton P. The treatment of tetanus: the rôle of the anaesthetist. Lancet. 1954;1:155-7
[266] Forrester ATT. Treatment of tetanus with succinylcholine. Br Med J. 1954;Aug 7:342-4.
[267] Ellis M (ed) Symposium on tetanus in Britain held at Leeds 7-8 April 1967:Leeds. Leeds United Hospitals;1967. This booklet was not published, copies were distributed at the symposium. The author is indebted to Professor John Norman for the loan of a copy.

Newcastle curarisation was not used until the early 1960s. Horton wrote 'In many it [early curarisation] would have led to a more favourable outcome'.[268]

Decline in Tetanus in England and Wales after 1971.

The incidence of tetanus has declined in England and Wales due to immunisation. (Figure 7). However it does still occur and there has been a small increase in incidence in recent years due to infection among intravenous drug users.

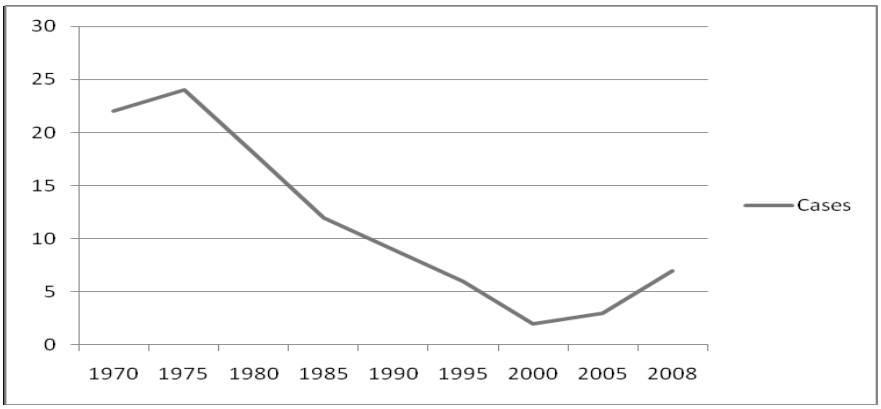

Figure 7. Tetanus cases in England and Wales between 1970 and 2008.[269]

The intensive care of tetanus has continued to attract attention. In 2000 Cook and his colleagues in Bath reviewed the literature on the disease.[270] They commented on newer treatments such as magnesium, which in a study from Sri Lanka had been shown to be effective in controlling spasms, and on intrathecal injection of baclofen, a drug used to treat spasticity. [271] [272] Its beneficial effects result from actions at spinal and supra-spinal sites. As tetanus is now rare in England and Wales investigation of

[268] Horton JAG. A report of some complications in severe tetanus. In Ellis M (editor) Symposium on tetanus in Britain held at Leeds 7-8 April 1967: Page 26.
[269] Health Protection Agency. Tetanus Cases by Age Group and Year of Onset (All Sources*): England and Wales. Tabulated data used with permission. Available from http://www.hpa.org.uk/Topics/InfectiousDiseases/InfectionsAZ/Tetanus/EpidemiologicalData/tet01TetanusCasesAge/. Accessed 1 November 2010.

[270] Cook TM, Protheroe RT, Handel JM. Tetanus: A review of the literature. Br J Anaesth. 2000;87:477-87.
[271] Attygalle D, Rodrigo N. Magnesium for the control of spasms in severe tetanus. Can we avoid sedation and artificial ventilation? Anaesthesia. 1997;52:956-62.
[272] Engrand N, Guerot E, Vilain G. The efficacy of intrathecal baclofen in severe tetanus. Anaesthesiol. 1999;90:1773-76.

new treatments has to be pursued in countries where the disease is still common. Cook notes the absence of randomised controlled trials of treatments for tetanus.

The physicians' role in early intensive care in England and Wales.

A review of the management of respiratory failure before Ibsen's innovative positive pressure ventilation in 1952-3 suggests that the support of respiration in polio patients in the years following the invention of the negative-pressure tank respirator in 1923 was an early form of intensive care. Physicians treating respiratory failure in that era with their now generally disparaged 'iron lungs' were in fact early practitioners of intensive therapy, although the term had not then been coined. They saved lives in patients with hitherto fatal respiratory system failure, they and their nurses had special expertise and had concentrated their equipment into efficient Respiration Units.

The work of two physicians who practiced intensive care without the help of anaesthetists has been described in this chapter. Macrae's memorandum was published in 1969 and Christie's textbook in 1974. Macrae immediately adopted Ibsen's methods after their publication.[273, 274] He did not apparently need to co-operate with anaesthetists. He learned their skills and practiced them himself. His memorandum is a valuable account of the methods he used and the context in which he used them. He did not mention other specialties or other centres. The results he describes did not compare IPPV and negative pressure ventilation, they compare the results of the same treatments based on IPPV before and after the opening of his respiratory unit in 1956 and provided a useful riposte to those who doubted the benefits of intensive care. Christie's classical textbook is written from the point of view of a specialist in infectious diseases who would have not only to look after polio patients in the acute phase but would have to care for them for months or years later. This influences his reservations about Ibsen's treatment of bulbo-spinal polio and his choice of cabinet respirators and where possible avoidance of tracheostomy. This unusual view is very well argued.

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[273]Macrae JA. Memorandum of infection. Appendix B. Bristol;1969. Available at http://www.johnpowell.net/pages/macrae.htm

[274]Christie AB. Infectious diseases. Epidemiology and clinical practice. Second edition. Edinburgh: Churchill Livingstone;1974. Pages 597-605

The present chapter also includes excerpts from the oral histories of Boulton and Rosen. They both describe treatment of respiratory failure by physicians. These accounts suffer from the disadvantages of oral reminiscence but profit from the subjectivity defended by Louisa Passerini (see Chapter 2. Methodology).[275] Thomas Boulton, an eminent anaesthetist, gives credit to those physicians with special experience of the treatment of polio whom he had seen in the Western Hospital, London and in the United States. They persisted in using tank respirators for intensive therapy of bulbo-spinal polio rather than tracheostomy and IPPV because they had negative-pressure respirators which were more sophisticated than the earlier respirators still to be found in most British hospitals. Rosen had no contact with physicians with expertise in the management of respiratory failure but provides a graphic account of the use of respirators by physicians without such expertise. They both give free rein to their subjective response to the loss of a polio patient and a post-operative death caused at least in part by the use of cabinet respirators by people who were in the case of the patient described by Boulton, closed-minded and in Rosen's case, simply lacked competence in the use of a cabinet respirator. These accounts add flesh to the dry bones of written accounts, nearly always written by those who used their chosen methods successfully.

The history of the part played by physicians after 1953 in the care of patients with respiratory failure was important. Anaesthetists were not ready to accept the responsibility of looking after patients other than in and immediately after surgical operations. In the first decade after Copenhagen, physicians treated respiratory failure either by methods they already knew and had refined or by the new techniques introduced by the Danes. Accounts of the history of intensive care written by anaesthetists have largely neglected this part of the development of the specialty.

Two papers on the history of intensive care were given at the History of Anaesthesia Society; one by the present author was given in 2004.[276] It concerned development of intensive care in Britain immediately after 1953. It was prepared before the present study commenced and before the author was aware of the part played by physicians in the treatment of respiratory failure in the first years

[275]Passerini L. Fascism in popular memory. The cultural experiences of the Turin Working class. Cambridge: Cambridge University Press; 1987.
[276] Gilbertson AA. History of intensive care. Chapter two. Hist Anaesth Soc Proc. 2004;35:34-9.

following Ibsen's demonstration of the efficacy of IPPV. It largely ignores the part played by physicians in early intensive care. Michael Palmer's paper was delivered in 1999. [277] Palmer is an anaesthetist and he does refer to physicians but only to mention the criticism by Professor Dornhorst of St Georges Hospital who said in 1966 that 'anaesthetists were quick to master apparatus used and over-ready to employ these treatments but had a shallow understanding of disease processes.'[278] Dr Sheila Willatts, in an interview with the author, concurred with Dornhorst's view. She (an anaesthetist) obtained the Membership of the Royal College of Physicians to increase her acceptance as an intensivist who was well trained in general medicine, not just in anaesthetics.[279] Palmer did not make any mention of the part played by physicians in the early development of intensive care and it is tacitly assumed that intensive care developed from the efforts of anaesthetists: 'Modern intensive care was founded when anaesthetists brought techniques developed in the operating theatre into the field of general medicine...' [280]

A book by Professor Keith Sykes, retired Professor of Anaesthesia at Oxford deals extensively with the early development of intensive care. [281] However the subject of this book is *The contribution made by anaesthesia to the practice of medicine* so it naturally emphasises the part played by anaesthetists, but he does give credit to Lassen, the epidemiologist.

Professional historians might be expected to have taken a larger less partisan approach. *Blessed days of anaesthesia; how anaesthesia changed the world* by Stephanie Snow is another book about anaesthesia which has a section on the history of intensive care, in this case a very brief section.[282] However the development of intensive care is again attributed to advances in anaesthesia: '... the new demands placed by surgery stimulated new techniques and technology. Mechanical ventilation coupled with rigorous observation of the patients' bodily systems – nervous system,

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[277] Palmer MI. Intensive Care Medicine: A brief history of development. Hist Anaesth Soc Proc. 1999;26:16-20.
[278] Dornhorst AC. Intensive care units. Proc R Soc Med. Section of anaesthetics. 1966;59:1293-6.
[279] Willatts, SM. Interview. March 2011.
[280] Palmer MI. Intensive Care Medicine: A brief history of development. 1999. Page19.
[281]Sykes K and Bunker J (contributing editor). Anaesthesia and the practice of medicine: Historical perspectives. London: The Royal Society of Medicine Press Limited; 2007.
[282] Snow SJ. Blessed days of anaesthesia. How anaesthetics changed the world. Oxford: Oxford University Press; 2008. Page 188.

respiration, circulation, digestion, and so on – became an integral part of open heart surgery and laid the structures for ICUs.' There is undeniably a great deal of truth in this statement. After the early years surgical postoperative units did raise the standard of post-operative care and many anaesthetists did learn in cardiac surgical units the techniques and philosophies which they would soon expand into general intensive care, and most intensive care was, after the first decade, practiced by anaesthetists. Snow did not mention that the burden of treatment of respiratory failure in the first decade after the Copenhagen epidemic was borne largely by infectious disease specialists, not anaesthetists. Jenifer Beinart however in discussing the development of the Respiration Unit at the Churchill Hospital Oxford does give credit to the neurologist Ritchie Russell and cites him as the initiator of the Unit. As her book was about the history of the Nuffield Department of Anaesthetics in Oxford she does not discuss the part played by physicians in other units.[283]

The years after the last (small) epidemic of polio in England and Wales in 1961 did not see the departure of infectious disease physicians and epidemiologists from intensive care, W Howlett Kelleher was still defending his cabinet respirator in 1969 but new cases of polio were by then rare. [284] Kelleher's paper in 1961 described the use of his respirator in three patients in respiratory failure but in only one of them was the respiratory failure caused by a new attack of an infectious disease – infective polyneuritis.[285] The other two patients needed the respirator because of late infections superimposed on respiratory weakness caused by previous attacks of polio. After 1963 the emphasis shifted away from the support of respiration in infections of the nervous system. The next chapters will deal with the blossoming of intensive care and intensive therapy units throughout England and Wales, the establishment of a range of specialist units and the recognition of Critical Care medicine as a specialty in its own right.

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[283] Beinart J. A history of the Nuffield Department of Anaesthetics, Oxford. Oxford: Oxford Medical Publications; 1987. p.113.
[284] Kelleher WH. Respirators in respiratory failure. Br Med. J. 1969;August 30:113.
[285] Kelleher WH. A new pattern of "iron lung" for the prevention and treatment of airway complications in paralytic disease. Lancet. 1961;2:1113-6

Chapter 7. Intensive care beyond infectious diseases

As respiratory failure due to polio and tetanus became rare in England and Wales intermittent positive pressure respiration (IPPV) began to be used to treat other conditions, post-operative, medical and traumatic. Intensive care units proliferated, slowly at first. Some were developments of pre-existing respiratory units, most were the opening of a unit in hospitals where IPPV had previously been used in general wards. In this chapter some of the earliest of these units and the range of diseases treated, the new technology employed and the difficulty of providing accommodation in an age of austerity will be described.

Southampton General Hospital

Units such as the Respiration Unit at Oxford and the unit at Ham Green Hospital, Bristol which were established as units for the treatment of polio and other infectious diseases had later offered their treatment to other causes of respiratory failure, but possibly the first unit to be opened to treat respiratory insufficiency from whatever cause was opened in Southampton. Douglas J Pearce (1926-) was a consultant anaesthetist in Southampton General Hospital. In an interview Pearce told how the Respiratory Unit evolved there. Dr Patrick Shackleton (1904-1977) was the consultant in charge of anaesthesia and as has been described earlier he had treated a patient for tetanus in 1953. [286]

> So that really started it and then I came along and being young and naive it sort of landed in my lap really, so in 1958 we planned a side ward in a medical ward. In those days the old hospital had the old nightingale wards with the Sister's office at the entrance and two side rooms. ...We planned the facilities in this. It was only a ward. It had three beds in it. We had to get the equipment, some oxygen and we had a Radcliffe Respirator (a ventilator) and a Blease Pulmoflator. We had a Parkinson Cowan gas meter, a humidifier. We didn't have any blood gas samples in those days. We had a Moran Campbell thing. It was all pretty simple stuff really. We had special facilities, cupboards and all that. We were about to open and then in August 1958 there was a young boy brought over from Guernsey with a shot gun

[286] Shackleton P. The treatment of tetanus: the rôle of the anaesthetist. Lancet. 1954;1:155-7.

> injury with the most severe tetanus I have ever seen in my life. I hadn't seen any tetanus at that stage: There was quite a lot in this part of the world. That is why there had been the stimulus to set it up. This boy came in, there was no opening, we were in business, and that's how we started.
>
> Our experience in the past few years had been one of frustration in trying to deal with these problems in large hospital wards. There have been difficulties in mobilising even the simplest resuscitation equipment, while the long-term treatment has involved considerable problems of nursing and overall supervision of mechanical apparatus. Results were naturally unsatisfactory. It was because of these problems that it was decided to equip a small two-bedded unit for the treatment of respiratory insufficiency – from whatever cause.
>
> The neurologists caught on this and you got things like Guillain Barré Syndrome, strokes, of course barbiturate poisoning in those days was quite a major thing. All these things tended to creep in, and then occasionally one or two severe post-operative things.[287] Such was the demand for this small bed space that after the first eighteen months the unit was enlarged to a total of five beds.[288]

Although the first patient treated by Shackleton and Pearce for respiratory failure was suffering from an infectious disease (tetanus) their unit was set up for the treatment of respiratory failure from any reversible cause. Pearce emphasised the importance of multispecialty team work; skilled nursing attention and physiotherapy while overall supervision is given by a physician with an anaesthetist to manage the respiratory aspects of the case.

Table 8 shows that the wide range of illnesses treated in the Southampton Unit suggests that it was possibly the first general intensive therapy unit to be opened in England and Wales. Fourteen cases of tetanus had been treated in the Unit. Nine were severe and of these six survived. The survival of six out of nine severe cases of tetanus was a considerable achievement in 1960.

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[287] Pearce DJ. Interview. 1 December 2009.

[288] Pearce DJ. Experiences in a small respiratory unit of a general hospital. With special reference to the treatment of tetanus. Anaesthesia. 1961;16:308-16.

Disease	No of cases	Tracheostomy	Curarisation
Tetanus	14	11	9
Neurological	23	13	1
Respiratory	6	4	1
Post-operative	7	6	1
Poisoning	8	3	_
Miscellaneous	4	1	_
TOTAL	62	38	12

Table 8. Diagnostic categories and treatment of cases treated in the Respiratory Unit of Southampton General Hospital between August 1958 and September 1960.[289]

Only one death could be attributed to inexperience; a tracheostomy was made too low in the trachea and it eroded the wall of the trachea and perforated the innominate artery which crosses the bifurcation of the trachea; the patient died of a torrential haemorrhage. One of the patients who died was in chronic ill health and a woman died of a pulmonary embolism. Table 9 provides an analysis the cases described in table 8 as 'neurological'. Polio, apart from one case of residual polio, is not included in the list because polio was normally treated in the Regional Polio Centre in Portsmouth.

Barnet General Hospital

A unit in Barnet General Hospital in Hertfordshire was initially called a Recovery Ward but a description published in 1966 recalled that from 1960 until 1964 the Ward had served a dual purpose, and 192 'ITU-type' patients had been treated there. In 1965 an independent Intensive Therapy Unit was opened. [290] No cardiac, pulmonary or neurosurgery was carried out in the hospital and the authors cited the fact that the unit had admitted 172 patients in the first year of its operation as evidence that an intensive therapy unit is of benefit in a general hospital.

[289] Pearce DJ. Experience in a small respiratory unit.
[290] Birley DM, Collis JM, Gardner EK. The place of the intensive therapy unit in the general hospital. Acta Anaesthesiol Scand. 1966;23:97-102.

Disease	Cases treated	Survived
Head injuries	6	3
Cerebral haemorrhage	1	0
Subarachnoid haemorrhage	1	1
Bulbar palsy	1	1
Brain stem lesions	1	0
Encephalitis	3	2
Pneumococcal meningitis	1	0
Status epilepticus	1	1
Polyneuritis	5	5
Myotonia	2	2
Residual polio	1	1
Totals	23	16

Table 9. Neurological cases treated in the Respiratory Unit of Southampton General Hospital between August 1958 and September 1960: diagnosis and survival.[291]

Kettering General Hospital

Perhaps the best documented opening of a unit was the opening in 1962 of an intensive care unit in Kettering General Hospital, Northamptonshire, which was within the Oxford NHS Region. It was described in two papers, one by a physician Dr Gerard Samuel Crockett (1919-2001) and the Oxford Regional Statistical Officer Dr Alex Barr, and the other by the Kettering hospital matron Miss Theresa Hothersall (1912-93).[292, 293] The unit was appropriately called 'intensive care' instead of the then-popular title 'intensive therapy' because the emphasis in both papers was on intensive nursing care by specially trained nurses rather than on technical treatment. However Miss Hothersall wrote in her paper 'Advanced techniques in medical treatment can be carried out in an ICU – for example forced diuresis in barbiturate and aspirin poisoning, artificial cooling in patients with fat embolism or head injuries employing lytic cocktail, intermittent positive pressure ventilation of the lungs by means of the Bird and East Radcliffe respirators, peritoneal dialysis and minicoil haemodialysis and continuous monitoring of ECG tracings in severe coronary thrombosis or heart block.' Although she said that all these procedures can

[291] Pearce DJ. Experience in a small respiratory unit.
[292] Crockett GS, Barr A. An intensive care unit: Two years experience in a provincial hospital. Br Med J. 1965;13 November:1173-5
[293] Hothershall T. Intensive care unit. Nursing Times.1966;June 10:760-3

be carried out in an ICU she did not go as far as to say that they had actually been carried out in Kettering. The matron paid tribute to Dr Crockett and he in turn thanked Dr Patricia Wallace, consultant anaesthetist at Kettering.

This unit was minimally staffed by modern standards (‘one trained nurse per patient is impractical and on the whole unnecessary’).[294] It was not considered big enough to have its own medical staff, either senior or junior. The patients remained under the care of their admitting consultant but the physicians’ paper emphasised multi-disciplinary co-operation. However it was realised that there had to be a leader – a doctor in administrative charge. Anticipating the emergence of a specialist ‘intensivist’ by nearly 40 years Crockett and Barr state that ‘a doctor with a particular interest in the physiological and metabolic aspects of disease and injury should have administrative charge. He must keep in touch with developments in resuscitation, “reanimation”, and patient monitoring of both physical and biochemical parameters. His colleagues should be able to seek advice from him on points of fluid, electrolyte and acid-base balance. The nurses must have someone to turn to when problems of admission or discharge arise, especially when the unit is full. The doctor in administrative charge should also be responsible for acquiring much of the specialised equipment and for teaching the nurses how to use it.’[295]

Leeds General Infirmary

The unit in Leeds General Infirmary started as a unit for treating tetanus and has been mentioned in that context in Chapter 6. Although a dedicated ICU was not opened until 1964 the Tetanus Unit was apparently treating a wide range of patients several years earlier. Professor John Norman (1935-) has described his experience when he was a medical student in the 1950s. Tetanus patients were paralysed by a continuous intravenous infusion of the short acting relaxant succinylcholine and the lungs were ventilated by relays of students as in the 1952-3 polio epidemic in Copenhagen.[296] In 1961 when Norman was a senior house officer in anaesthetics and in the following year when he was registrar, the tetanus unit existed in the amenity ward of the hospital, which was one ward of the private wing. There were a number

[294] Hothershall T. Intensive care unit. 1966:761.
[295] Crockett GS, Barr A. An intensive care unit: 1965:1173.
[296] Lassen HCA. A preliminary report on the 1952 epidemic of polio in Copenhagen with special reference to the treatment of acute respiratory insufficiency. Lancet. 1953;1:37-41.

of single rooms and two four-bedded rooms which could be taken over for anyone needing artificial ventilation. He described the admission to the unit of one of his previous consultants, a thoracic surgeon who had suffered a subarachnoid haemorrhage (the arachnoid is one of the membranes inside the skull around the brain) and was unconscious, breathing through a tracheostomy. As an anaesthetic registrar in the hospital in 1962 one of the rotas was to be the 'tetanus registrar' for three months.

> My turn started on July 1st when there was one patient recovering from the disease. He famously described the onset as getting such a stiff jaw that he "couldn't get the tatties in whole." I then acquired three patients on the 13th and 28th July and the last on August 10th. In addition we were ventilating patients with myasthenia gravis, crushed chest injuries, epilepsy and the odd barbiturate overdose. ... The basis was that the tetanus registrar looked after the patients between 8.30am and 5.30 pm and also carried the crash bleep. There was one half day a week off and one night in five on duty as the emergency registrar.
>
> The consultant team was four specialists, two anaesthetists, a neurologists and an A and E surgeon. The nursing staff was led by a sister with two or three staff nurses. Each patient was under the care of four student nurses each doing an 8 hour shift with the next 24 hours off until the patient was breathing spontaneously safely. The patient was *never* left alone. [297]

Norman stresses that the nurses developed a marvellous rapport with the patient – they knew what the patient was feeling. Jennifer Stanton writing of nurses in ICUs asked 'How do such technologies affect nursing care?[298] She quotes Marjan Groen who showed that the nurses' mastery of technology did not necessarily distance them from patients.[299] Norman's experience would confirm this impression, but Stanton went on to write that it might be argued that the special training, high status and technical competence of ICU nurses has made them more like doctors, thereby

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[297] Norman J. Personal communication 2010

[298] Stanton J. Supported lives in Cooter R, Pickstone J. (editors) Companion to medicine in the 20th century. London: Routledge; 2000. p. 610

[299] Groen M. Technology, work and organisation. A study of the nursing process in intensive care units. Maastricht: The Netherlands University of Limburg Dissertation no 95-29:1995:76-7

increasing the likelihood of distance from patients. The evidence of Professor Norman and Marjan Groen does not support that argument.

Norman describes the equipment used in Leeds in the 1960s. Originally the infusion fluids were in glass bottles connected to the intravenous infusion needles by rubber tubes. The needles were metal, large and often blunt. Their sharp edges soon cut the veins and the fluid leaked out into the tissues so the needle had to be changed; it soon became difficult to find suitable veins. It was a great relief when the German plastic tubes (which were inserted over a needle which was then withdrawn) came into production in 1964.[300] Tracheostomy tubes were also made of rubber; when disposable plastic ones replaced them the plasticiser leaching out from the tubes caused damage to the trachea. Several types of ventilators were used; Smith Clarkes, Blease and an Engstrom. Monitoring was simply by measuring the volume of air coming from the expiratory port of the ventilator. There was no blood gas monitoring. The tetanus patients were fed by a gastric tube using a nutrient mixture (Complan) and a vitamin and trace element solution (Abidec). It is evident that general intensive care was practiced in the Leeds unit from 1962 and earlier. In 1964 dedicated intensive care ward was created by modifying an old Nightingale Ward.[301, 302]

New applications for intensive care.

In the years following 1953 the techniques of intensive care, particularly respiratory support, were applied to a widening range of critical illness.

Crushed chest

Patients with crushing injuries to the thoracic cage usually have several ribs fractured both at the front and at the back of the chest so that a portion of the chest wall is rendered ineffective; when the rest of the chest wall expands during inspiration, the damaged part, instead of moving outward, is sucked in and therefore does not contribute to expanding the lung. In 1956 Avory, Mørch and Benson

[300] Rivera AM, Strauss KW, Van Zundert A, Mortier E. The history of peripheral intravenous catheters: How little plastic tubes revolutionized medicine. Acta Anaesth Belg 2005;56:271-82.

[301] Norman J. Personal communication 2009

[302] Note: a Nightingale ward was a large ward with typically 32 beds and a Sister's Office at one end. It was named after the pioneer nurse Florence Nightingale. A primitive system of progressive patient care was maintained by putting the most seriously ill patients at the end of the ward nearest to the Sister's Office.

successfully treated a very severely injured patient by IPPV. [303] As the lung is inflated by the ventilator the damaged part of the chest wall is pushed out to its normal position; in effect the chest wall is 'pneumatically splinted' by the intrathoracic pressure. Two papers on the use of IPPV in crushed chest injuries were published in the British medical literature: In 1957 AK Boyle and colleagues in Glasgow described two patients with crushed chests treated with fixation of the ribs and positive pressure ventilation.[304] Their lungs were ventilated with a Newcastle ventilator which had a patient triggered function. It inflated the lungs when the patient attempted to breathe. Both patients died. A patient reported in a paper from Clarkson and Robinson at Whiston Hospital near Liverpool survived being run over by the back wheels of a lorry.[305] He did not have surgical fixation of his ribs. Instead he was rendered apnoeic by administration of d-tubocurarine ('curare') and his lungs were deliberately inflated through a tracheostomy to a greater extent than normal (hyperventilated) . His ribs were thus pneumatically splinted as described above and the fractures were kept in their normal place while they healed.

Head injuries.

Ian MacIver (a neurosurgeon), Ivor Frew (an ear nose and throat surgeon) and John Matheson (an anaesthetist) in Newcastle General Hospital described the importance of maintaining adequate oxygenation in patients with head injuries.[306] Initially the emphasis was on tracheostomy to maintain a clear airway. Later pulmonary hyperventilation and hypothermia were used to reduce cerebral oxygen demand to a level which could be supplied when cerebral blood flow might be reduced, particularly by swelling of the injured brain. The Newcastle group recommended that such patients should be treated in a special unit but they had not at this time managed to establish one.

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[303] Avery EE, Mørch ET, Benson DW. Critically crushed chests: a new method of treatment with continuous mechanical ventilation. J thoracic surg. 1956;32:291-311.
[304] Boyle AK, Murray JR. Crush injury of the chest: A report of two cases. Anaesthesia. 1957;12:453-62.
[305] Clarkson WB, Robinson JS. Deliberate hyperventilation in the treatment of a crush injury to the chest. A case report. Br J Anaesth. 1962;34:471-5.
[306] MacIver IN, Frew IJC, Matheson JG. The role of respiratory insufficiency in the management of severe head injuries. Lancet. 1958;1:390-3.

Asthma

Philip Hugh-Jones delivered a paper at the Royal Society of Medicine in 1958 describing the treatment of acute asthma at Hammersmith Hospital.[307] The paper contained a detailed description of the mechanism by which breathing is regulated, emphasising (with experimental evidence) that breathlessness (dyspnoea) is caused by overstimulation of nerves sensitive to stretch of the lungs rather than as is conventionally taught, by falling oxygen and rising carbon dioxide levels in the blood. Hugh-Jones described the treatment of acute shortage of breath, which he idiosyncratically called 'oligopnœa', with oxygen and drugs, but stated that although this would be sufficient in the majority of cases, if it is not completely successful, he had no hesitation in performing tracheostomy and using artificial mechanical ventilation. He had an East Radcliffe ventilator, which incidentally was the same machine with which Keith Sykes instituted postoperative cardiac surgical patients at the Hammersmith Hospital. Hugh-Jones realised the importance of humidification of the inspired air to liquefy the 'rubbery' secretions which were blocking the patients' airways.

Hugh-Jones's paper ended with the statement 'The use of mechanical ventilation in the ventilatory defects of polio, tetanus &c., is well established. We would like to see the treatment of acute oligopnœa in chronic respiratory disease become equally accepted.' [308] Their wish was granted. Over the next decade IPPV was used to treat more patients so that by the late 1960s several series had been published. In a retrospective description of the development of the ICU in Whiston Hospital, Merseyside, Eric Sherwood Jones and Ian Gordon were able to state 'The results over the 10-year period from 1970-1980 showed that only one patient on our [asthma] register died from asthma. This was in contrast to 23 patients who died in our area between 1974 and 1977 but who were not on the register.[309] Anthony Gilbertson opened an intensive therapy unit in 1970 at Sefton General Hospital, Liverpool and until the Hospital closed in 1979 no patient died who was alive on arrival at the unit suffering from acute asthma. It is a sad fact that there are still

[307] Hugh-Jones P. Oligopnœa. Proc R Soc Med. 1958;51:104-8.
[308] Hugh-Jones P. Oligopnœa 1958:108.
[309] Jones ES, Gordon IJ. The evolution and nursing history of a general intensive care unit (1962-1983). Intensive Crit Care Nurs 1998;14:252-7.

accounts in the press of patients who have died of asthma without having been referred to an ICU.

Poisoning

In 1958 R P Wise of the Department of Anaesthetics at the Westminster Hospital, London described the treatment of barbiturate poisoning.[310] The treatment of respiratory depression in patients overdosed with barbiturates had since the 1930s been based on the use of respiratory stimulants. The complications included convulsions, vomiting (with an aspiration hazard) and cardiac arrhythmias. Wise described treatment by the alternative strategy of ventilation of the lungs until the patient excreted the barbiturate as described by Plum and Swanson in the USA in the previous year.[311] This became the accepted method of treating barbiturate poisoning, which was a very common method of attempted suicide in the 1950s and 1960s. Wise advocated the treatment of such patients in special units but had not at that time established one.

Myasthenia Gravis

Another condition which required collaboration between specialists in medicine, surgery and anaesthesia was myasthenia gravis. This is a disease characterised by muscle weakness and muscle fatigue. The receptors which transmit the signal for a muscle to contract become blocked by antibodies, and do not respond to the transmitter acetylcholine which conveys the signal to contract from the nerve to the muscle. The medical treatment of the disease is by means of drugs such as neostigmine or its congeners which prevent the breakdown of acetylcholine (anticholinesterases), thus allowing its concentration at the nerve endings to increase and overcome the insensitivity of the receptor site on the muscle. However as the receptors become increasingly insensitive to acetylcholine this treatment becomes ineffective, weakness increases and may lead to respiratory failure. Surgical removal of the thymus gland at the base of the neck (thymectomy) may cause remission in myasthenia gravis. In severe cases with respiratory failure and failure to respond to

[310] Wise RP. Treatment of barbiturate poisoning. Br J Anaesth. 1958;30:533-41.
[311] Plum F, Swanson AG. Barbiturate poisoning treated by physiological methods; with observations of effects of beta-beta-methylethyl-glutarimide and electrical stimulation. JAMA. 1957;163:827

anticholinesterases, a period of IPPV with withdrawal of the drug may 'rest' the receptors and they may again become responsive to neostigmine. In 1958 Griffin, Nattrass and Pask described a case of a complicated condition in a fifteen-year old boy in Newcastle.[312] He had at first muscle weakness not helped by neostigmine, but greatly improved by ephedrine, given to him by a friend who had asthma. There is no obvious reason why ephedrine should help in such a condition but it had worked and his general practitioner therefore prescribed it for the next three years! In June 1955 the boy developed more typical myasthenic symptoms with weakness greatly improved by rest and a temporary response to neostigmine. However the weakness increased and after a week he had a respiratory arrest and IPPV was started at first through an endotracheal tube. After two days a tracheostomy was performed. On the 36th day, with great trepidation due to the boy's poor condition, thymectomy was done. After nine days the patient was able to breathe by himself and never needed the respirator again. At the time of writing, he had for four months been back at his work as a clerk and his only medication was ephedrine. Thymectomy and support by IPPV became accepted treatment for myasthenia gravis.

Technological advances 1953-1963

The most important innovations in the period 1953-1963 were the development of mechanical lung ventilators and methods of measuring the acidity (pH), carbon dioxide tension (pCO_2) and oxygen tension (pO_2) in the arterial blood of patients receiving artificial ventilation of their lungs – intermittent positive-pressure ventilation (IPPV). A coincidental benefit of the availability of these measurements was the increased understanding of the effects of respiratory insufficiency and increased accuracy of diagnosis of respiratory failure and, to a lesser extent, renal failure.

Mechanical ventilators

As has been described in Chapter 3, by 1953 the Blease Pulmoflator was commercially available in Britain. As intermittent positive-pressure ventilation (IPPV) and tracheostomy began to be used in Britain several anaesthetists and epidemiologists developed 'home-made' ventilators and a few became commercially

[312] Griffin SG, Natrass FJ, Pask EA. Thymectomy during respiratory failure in a case of myopathy with myasthenia gravis. Lancet. 1956;2:704-8.

available. The Clevedon ventilator was developed by James Macrae at Ham Green, Bristol.[313, 314] Edgar Pask (1912-1966, Professor of Anaesthesia in the University of Newcastle 1949-1966) developed a series of ventilators in Newcastle.[315, 316] Joseph Esplen described the Aintree ventilator before the Copenhagen epidemic. Ibsen had not yet introduced the use of IPPV outside the operating theatre, so Esplen described the use of the Aintree machine only in surgical anaesthesia. [317] However after Ibsen's use of IPPV in polio the Aintree, and Esplen's later invention, the Fazakerly ventilators were used for the treatment of polio. [318, 319]

By 1959 the number of ventilators was sufficient to justify the publication of the first edition of *Automatic ventilation of the lungs* by William Mushin (1910-93), Professor of Anaesthetics at the Welsh National School of Medicine and his colleagues and a second edition was published in 1969. [320] This is an encyclopaedic work which includes a list of 53 manufacturers of ventilators. Eighty-one ventilators are described in detail; in the case of the Bird Ventilator eight variants are described.

Only a few of the 81 ventilators described by Mushin and his colleagues were used in England and Wales. The East Radcliffe in various forms, designed and manufactured in Oxford was very reliable although sterilisation was difficult. The sterilising solutions originally used tended to stick the valves and the alternative, ethylene oxide gas, had to be handled carefully to avoid explosions. The Barnett was a very simple but reliable ventilator although its valve tended to stick when wetted by the moisture in exhaled breath. The Beaver ventilator was available from 1953, The evolution of the Blease ventilators has already been described. The Cape series of anaesthetic and intensive care ventilators were somewhat more sophisticated. Two patient-triggered ventilators made in the United States were commonly available in

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[313] Macrae J, McKendrick GDW, Claremont JM, Sefton EM, Walley RV. The Clevedon positive-pressure respirators. Lancet. 1953;2:971-2.
[314] Macrae J, McKendrick GDW, Sefton EM, Walley RV. Positive pressure respiration. Management of patients treated with Clevedon respirator. Lancet. 1954;2:21-2.
[315] Pask EA. A simple respirator. Lancet. 1953;2:141.
[316] Horton JA, Pask JS. Two more respirators. Br J Anaesth. 1956;28:65-75.
[317] Esplen JR. A new artificial respirator. Br Med J. 1952;Oct 25:896-97.
[318] Esplen JR. The Fazakerley respirator Br J Anaesth. 1956;28:176-86.
[319] JC Richardson. Interview. September 2010.
[320] Mushin WW, Rendall-Baker L, Thompson PW, Mapleson WW. Automatic ventilation of the lungs. Oxford: Blackwell; 1959.

the UK. They were mostly used for 'weaning' the patient from the ventilator as the patient recovered his ability to breathe.

There was thus no shortage of ventilators available for intensive care. It was however not simply a matter of connecting one to the patient's tracheostomy or endotracheal tube; the pathophysiology of the lungs and the interaction of the lungs and the ventilator had to be understood. The stiffness of the lungs, the resistance of the air passages, the adequacy of the blood volume, the rate and pressure of inflation by the respirator all had to be adjusted for the individual patient and the characteristics of the ventilator to avoid lung damage and circulatory depression. The complexity of the respirator controls was such that most hospitals adopted a particular type of respirator with which the medical, nursing and technical staff became familiar rather than having a selection of different ventilators.

Blood gas analysis

Ibsen showed that improved ventilation of the lungs could restore total carbon dioxide content in the blood to normal. This in itself was helpful because total carbon dioxide content (TCO_2) depends on the amount of carbon dioxide dissolved in the blood, and also on the amount of bicarbonate ion (HCO_3-). Carbon dioxide is produced in the tissues and removed by breathing, so a high TCO_2 in the blood could be the result of inadequate breathing. Confusingly (for the physicians of 1952) bicarbonate is removed from the body by the kidneys, so a high TCO_2 content could be due to failure of the kidneys to remove bicarbonate. When they found a high TCO_2 they thought it could not be due to inadequate breathing because the patient was pink, which they thought must meant that the breathing was fine, so the high TCO_2 must be due to kidney failure. They were wrong. The breathing was inadequate. Ibsen proved that by ventilating the patient she recovered consciousness and the TCO_2 in her blood returned to normal. Her breathing *had* been inadequate, but she was pink in spite of poor breathing because she was receiving oxygen, which can oxygenate the blood and keep it pink in spite of weakened breathing. [321]

Unfortunately the estimation of total plasma carbon dioxide content was tedious and took half an hour by a skilled technician.[322] The clinical pathologist, Poul

[321] Wackers GL. Modern anaesthesiological principles for bulbar polio: manual IPPR in the 1952 polio-epidemic in Copenhagen. Acta Anaesthesiol Scand. 1994;38:420-31.
[322] Sykes MK, Bunker J.(contributing editor). Anaesthesia and the practice of medicine:

Astrup (1915-2000) devised an ingenious way of determining carbon dioxide tension (pCO_2) in the arterial blood using simply a pH meter.[323] The method takes only a few drops of blood and can be done in about five minutes by an clinician untrained in pathology laboratory techniques. This meant that any patient requiring mechanical artificial ventilation of the lungs can have the ventilator set at a rate and volume which is thought to be about what is required to bring the pCO_2 to normal (36 – 44 mm Hg) and after say half an hour the pCO_2 can be checked by Astrup's method, usually in a small laboratory attached to the ICU, and if necessary the settings on the ventilator can be adjusted until the pCO_2 is kept within normal limits.

The measurement of pCO_2 became even easier when Richard Stow (1916-) described his CO_2 electrode. Stowe described his electrode in 1954 but it was some years before it was sufficiently stable to be made available commercially. John W Severinghaus (1923-) modified the electrode but did not patent it because he considered it to be Stowe's idea.[324]

It was not at that time possible to measure the amount of oxygen in the blood and so the lungs were ventilated by high concentration of oxygen to avoid shortage of oxygen in the blood (hypoxaemia). Unfortunately high oxygen concentration of blood oxygen can cause lung damage.[325] In 1956 Leland Clark (1918-2005) an American biochemist, described his self-contained electrode for measuring the oxygen tension in the blood.[326] A year later Severinghaus combined the carbon dioxide electrode and the oxygen electrode in one machine and produced the first blood gas analyser.[327] In 1968 they added a pH electrode and produced the first three-function blood gas analyser.[328] Several firms began marketing these analysers

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Historical perspectives. London: Royal Society of Medicine Press; 2007. p. 189.

[323] Siggaard Andersen O, Engel K, Jorgensen K, Astrup P. A micro method for determination of pH, carbon dioxide tension, base excess and standard bicarbonate in capillary blood. Scand J Clin Lab Invest.1960;12:172–6.

[324] Severinghaus JW. Classical Essays. First electrodes for PO_2 and PCO_2 determination. J Appl Physiol 1958;13:515-20.

[325] Nash G, Blennerhassett JB, Pontoppidan H. Pulmonary lesions associated with oxygen therapy and artificial ventilation. New Engl J Med. 1967;276:368-74.

[326] Clark LC Jnr. Monitor and control of blood and tissue oxygen tensions. T Am Soc Art Int Org. 1956;2:41-48.

[327] Severinghaus JW. Classical essays. First electrodes for blood pO_2 and pCO_2 determination. 2004.

[328] Severinghaus JW. Classical essays. First electrodes for blood pO_2 and pCO_2 determination.. 2004.

in the 1960s. It then became possible, and normal intensive care practice, to regulate lung ventilation so that normal oxygen and carbon dioxide levels were maintained in the patient's arterial blood and lung damage due to excessive oxygen levels could be avoided.

The history of the understanding of oxygen transport and the acid-base chemistry of blood from the twentieth century and their application in modern intensive care had been reviewed by John Severinghaus and Poul Astrup in 1998.[329] Replete with portraits and photographs of the pioneer scientists from the eighteenth century until Ibsen in the twentieth it (at least the latter part) is written with the authority of two men who themselves were responsible for much of the technology and modern understanding of the subjects on which they write. The third author, John F Murray is possibly not so well known; he is a Professor Emeritus of Respiratory Medicine at the University of California in San Francisco.

Advances in the management of the circulation

In the early part of this period the adequacy of the circulation and of the blood volume was measured by physical signs such as colour of the skin, capillary refill time, pulse rate and quality, filling of the peripheral and jugular veins and arterial blood pressure. In 1963 measurement of central venous pressure (CVP) was described by M Keith Sykes (1925-) from the Hammersmith Hospital, London.[330] He investigated the factors which influenced pressure in the central veins by passing a long catheter up from a peripheral vein towards the large veins entering the heart. He found that, provided the physiology of the nervous system is understood, the pressure in these central veins is a good indicator of the adequacy of blood transfusion after haemorrhage. The CVP could be monitored with little special equipment (a set containing a long catheter and a simple manometer tube which is attached to a standard intravenous infusion set). It quickly became part of the ordinary armamentarium of anaesthetists and was used whenever serious blood loss occurred or was to be expected.

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[329] Severinghaus JW, Astrup P, Murray JF. Blood gas analysis and critical care medicine. Am J Crit Care Med. 1998;157:S114-S122.

[330] Sykes MK. Venous pressure as a clinical indication of the adequacy of transfusion. Ann R Coll Surg Engl. 1963;33:185-97.

For the diagnosis of congenital heart disease cardiac catheter laboratories were set up in Regional Cardiac Centres in the early 1960s. There were facilities for measurement of right heart catheterisation, right and left heart catheterisation, dye dilution and hydrogen dilution techniques, angiocardiography, coronary arteriography, and phonocardiography.[331] These facilities were not available in ICUs but the information gained in cardiac catheter laboratories greatly increased the understanding of cardiovascular pathology and physiology, knowledge which aided the rational treatment of cardiovascular failure in shock and sepsis syndrome.

Technological advances in electronics led to greatly improved monitors for displaying intravascular pressure and wave forms and electrocardiograms (ECGs). At the beginning of the period arterial blood pressure was measured intermittently, perhaps every 15 or 30 minutes and recorded on a chart. The ECG would be displayed on an oscilloscope as a moving dot leaving a trace of the ECG waveform but the trace only remained visible for a matter of seconds. This was greatly improved when a memory was build in to the electronic circuit so that the trace remained visible across the whole width of the screen. At any one time the ECG trace of several heart beats could be studied.

The continuous reading of arterial and central venous waveforms and pressures became possible with the introduction of arterial and central venous catheters and electronic manometers.[332] A plastic catheter was introduced into the artery or central vein. A column of fluid (saline or dextrose solution) filled the catheter and the catheter was connected to a transducer. The pressure was transmitted from the artery or vein through the fluid in the catheter to a diaphragm in the transducer. A sensor on the diaphragm converted the pressure applied to the diaphragm to an electric current which was amplified and reproduced the arterial or venous pressure waveform on an oscilloscope, giving a continuous display of the wave form and its upper, lower and mean values. Later the pressure and volumes from a ventilator and (in the 1980s) the output from a pulse oximeter displaying the pulse rate and tissue oxygen saturation could also be displayed on the oscilloscopes.

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[331] Feldman S. Anaesthesia for cardiac surgery. Int. Anesthesiol Clin.1967;5:132-59.
[332] Atkinson RS. Monitoring. Int. Anesthesiol Clin. 1967;5:246-77.

Hospital accommodation

The 1950s and 1960s were a period of great austerity, the country was recovering from the cost of the 2nd World War and there was little money for building new hospitals. As Sir George Godber (Chief Medical Officer 1960-1974) recollected, the slender resources that were available were dedicated to repairing bomb damage and supplying desperately needed facilities such as casualty departments, operating theatres, X-ray departments and laboratories.[333] Housing had a higher priority than hospitals; after the Blitz people were waiting for years for new council houses.

The lack of modern hospitals had been obvious since the inception of the NHS in 1948 and for many years before. It had been exacerbated by the damage to hospitals during the Second World War and it continued long into the era of the expansion of intensive care. In 1955 twenty major capital schemes were given official approval. The first new district general hospital in Britain after the start of the NHS was in Swindon, Wiltshire. It began in 1957. The first phase (outpatient facilities) of the Princess Margaret Hospital in Swindon was completed in 1959, the second phase containing ward blocks was not completed until 1964 leaving two more stages still to be constructed. The nearest equivalents in Wales was the West Wales General Hospital in Glangwili near Carmarthen, the first phase of which was opened in 1959. Swindon and Glangwili were two of only six such schemes open in England and Wales at that date.[334] In January 1962 the Times reported 'The national plan for hospital building and development, described in a White Paper, was presented to Parliament yesterday by Mr. Powell, Minister of Health.'[335] The plan was to build 90 new District Hospitals in the next ten years. As will be discussed in Chapter 8, that did not happen.

ICUs in this period were always situated in parts of a hospital adapted for the purpose. There were very few new hospitals and no purpose build units. Intensive care was not mentioned in Parliament until it was mentioned simply as a concept in the House of Lords debate on the Hospital Plan on 14 February 1962. The Lord

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[333] Webster C. The National health service. A political history. New edition. Oxford: Oxford University Press; 2002. Page 40.
[334] Webster C. The National Health Service. A political history. New edition. Oxford: Oxford University Press;2002. Pages 41–45.
[335] 90 New Hospitals For England And Wales. The Times. 24 January 1962.

Bishop of Lichfield described a system of progressive patient care: 'Presumably in the new hospitals we shall have a system of intensive care wards where maximum nursing staff can be brought to bear at the critical moment, and other wards where patients who are not so ill will be found.' [336]

There were no further references in parliament to intensive care or intensive therapy after the Bishop of Litchfield's tentative prediction until the late 1960s. Consultant medical staff continued to working intensive care 'in their own time' and without payment. Their salaries were for a fixed number of half-day sessions usually nine or eleven but sometimes fewer and the salary varied directly with the number of sessions in the contract. There were no sessions for intensive care and so consultants' work in that area was not remunerated. Nursing and equipment continued to be funded from local resources.

[336] The Hospital Plan. HL Deb 14 February 1962 vol 237 cc472-581
Available at http://hansard.millbanksystems.com/lords/1962/feb/14/the-hospital-plan#column_472 Accessed 19 March 2011

Chapter 8 Staffing and accommodation

Intensive care units

By the early 1960s intensive care was expanding beyond the confines of infectious disease hospitals. Some physicians and anaesthetists were using intermittent positive-pressure ventilation (IPPV) to treat individual patients in general wards and a few were opening ICUs, often a couple of beds in a side ward. A 'unit' was usually defined as a place in the hospital in which the nurses had been specifically trained in the care of patients receiving treatment with technically demanding equipment, particularly automatic lung ventilators, together with a supply of such equipment. Many so-called ICUs would not later qualify as ICUs. For example at the Liverpool Royal Infirmary there was a recovery unit, used occasionally for short term post-operative respiratory failure. There were no permanent nursing staff.[337] Other units were well sited and equipped and staffed but were almost unused. Clifford Franklin (1931-) was appointed to a consultant anaesthetists post in the new West Cumberland Hospital, Whitehaven in 1964. He was shown a site for an intensive care unit:

> I wandered round the hospital and they had got it in a remote place, away from operating theatres, away from acute wards, and after having a fairly close look around the hospital, the only room that I could find, of any value, in close proximity to supporting clinical care, was going to be the committee board room! And I requisitioned the board room with the help of the Chairman of the Hospital.[338]

After a short time at Whitehaven Franklin was offered a post in Liverpool, which he refused because he had been for only a short time in Whitehaven, and then another post in Manchester. This time he decided to put in an application for the post in Wythenshawe Hospital in Baguley, Manchester. He said the post was better than that in Whitehaven. When asked in what way was it better he replied:

> There was no work to do in Whitehaven: All I was faced with was with mountain rescue. If there was an accident on the fells they would phone me at the hospital. A taxi would come to collect me. It would take me down to

[337] Drury P. Interview. September 2009.
[338] Franklin C. Interview. June 2009.

> the base they'd set up for bringing casualties down 'cos I said there's no point in taking me half way up a mountain, because I'll be exhausted by the time I get there and I'll not be able to carry out any clinical care. What you need are trained ambulance men who can go up the mountain, bring these people down, resuscitating them, and I can get on with my job when they get down. I had two calls to go on mountain rescue in three years because most of them were minor injuries. The clinical work was not what I was expecting it to be…

An idea of the number of intensive care or intensive therapy units during this early growth period can be gained from two sources: In 1965 a report of a meeting of nurses to discuss planning of intensive care units was published in the *Nursing Times*. Twenty-one nurses attended; all were described as 'in charge of intensive care units' which indicates that at least 21 units existed at that time, although the reservations about the definition of an intensive care unit should be remembered. Most were reported as under the control of anaesthetists.[339] Even if the figure of 21 units is taken at face value, that represents a small number of units in a country the size of Britain.

The Intensive care Society was founded in 1970. In 1981, sixteen years later, the Society circulated all its members who worked in England and Wales. One hundred and one members replied to the questionnaire.[340] They represented 74 hospitals of which 58 were non-teaching hospitals. General ICUs predominated in the survey (88 percent) but there were also replies from neonatal, renal, neurosurgical and cardiac surgical units. Seventy eight of the respondents to the questionnaire were anaesthetists and most of the remainder were internal medicine specialists. Not only had the number of units identified increased compared with the small number established in the first few years after the seminal demonstration of the success of intermittent positive pressure respiration (IPPR) by Ibsen in 1953, but the majority of units were no longer simply respiratory units treating polio and tetanus, they were general intensive therapy units and specialised units such as renal and coronary units as well as specialised surgical units.

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[339] Editorial. Nurse planners meet. Intensive care Units. Nursing Times. 1965;Dec 31:1804-5.

[340] Gilston A Intensive care in England and Wales. A survey of current practice, training and attitudes. Anaesthesia. 1981;36:188-93.

This expansion of intensive care could not have happened without several changes in hospital medicine in England and Wales. These changes affected the organisation of nurses in hospitals, the contracts of employment of hospital doctors and the establishment of anaesthesia as a defined and respected medical specialty.

Nursing and intensive care

Both in the United States and in the UK, nurses have claimed that advances in medicine and surgery had placed a burden on them that could only be met by concentrating appropriately trained nurses in one area of the hospital. In the USA nurses have even claimed that they changed the hospital to make intensive care possible. The American Association of Critical Care Nurses **(**AACCN**)** studied the evolution of nursing and hospital care for people with life-threatening illnesses during the 40-year period from 1950 until 1990 and published a preview of their findings in 1992.[341] They described the state of affairs in American hospitals in the 1950s and early 1960s: except in recovery rooms in a few hospitals, in a typical hospital unit patients were admitted according to their diagnosis or according to the admitting specialist (e.g. Dr X's ward), not to the severity of their illness. The unit would therefore contain a mix of patients capable of self care and those needing intermediate care, postoperative observation and other intensive care. If a patient was critically ill and the family had the means a private duty nurse was hired. However inasmuch as requests for private duty nurses frequently went unfulfilled, extra duty nursing care paid for by the family was a diminishing option for hospitals.

When pioneering nurses answered the researchers question 'Where did intensive care units come from?' they said 'The Units were invented because of the problems that came from a patient being desperately ill and needing one nurse...finding a way to respond to this situation multiplied by thousands of times forced us to change the hospital'.[342] The formation of areas where desperately ill patients could be concentrated in an area with a sufficient number of trained nurses to give individual care was only part of the way in which American nurses 'changed the hospital'. A system of Progressive Patient Care was instituted. Areas of the

[341] Lynaugh JE, Fairman J. New nurses, new spaces: A preview of the American Association of Critical Care Nurses history study. Am J Crit Care. 1992;1:19-24
[342] Lynaugh JE, Fairman J. 1992. Page 20.

hospital were adapted to meet the need of different categories of patients defined by their need for more or less intense nursing care:

Community care – required only occasional visits by a nurse

Long term care – requiring continuous low-tech care

Self care patients – who require hotel-type accommodation

Intermediate care unit – for patients needing 'ordinary' ward nursing

Intensive Care Unit – patients who need continuous observation. [343]

In the words of Limbaugh and Farman: 'Nurses and physicians turned to the familiar, traditional system of triage to determine who had need of special treatment. They trained nurses to deal with these most seriously ill patients. The concepts of triage and special nursing were combined, and the intensive care unit was born.'[344, 345]

This view of the origin of intensive care *units* is a point of view with which many early practitioners of intensive care in Britain would concur, although in the National Health Service of the 1950s hiring a special duty nurse was not an option. The Ward Sister or Deputy Matron would be asked to provide a nurse to 'special' a patient needing individual attention. The nurse allocated had more often than not no previous experience of nursing a patient receiving mechanical artificial ventilation of the lungs. Several of the people interviewed for this study described the very heavy work load imposed on doctors when artificial ventilation was first practiced in the general wards. A physician (often a consultant anaesthetist or general physician) had to be present at the start of each nursing shift so that the oncoming nurse could be instructed in the management of the patient and of the respirator. M K Sykes at the Hammersmith, London said 'Well, you see, we started treating patients in the side wards and, of course, that was a big problem because the nurses worked on shifts. So I made simple instruction sheets and we had to go every time there was a change of

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[343] Haldeman JC. Progressive patient care. Public health reports. 1959;74:405-8.

[344] Lynaugh JE, Fairman J. 1992 Page 22

[345] This is only one concept of triage. Treating the most seriously ill, that is those who need and should be able to expect a higher standard of care, is the egalitarian notion of triage. The utilitarian concept is to give priority to those whose recovery will be most beneficial to some objective, such as winning a war. In military medicine this led to the use of scarce penicillin to treat soldiers with venereal disease rather than to treat those who had been injured in battle, because the former were more likely to return to the front than those with perhaps shattered legs or arms. This subject is reviewed in Baker R, Strosberg M. Triage and equality. An historical reassessment of utilitarian analyses of triage. Kennedy Institute of Ethics Journal. 1992;2:103-23

shift and tell them what to do.' [346] Leo Strunin described the situation at the London Hospital with a vehemence which indicates clearly that the frustration he felt is still remembered after half a century:

> So here we have a situation when at any one time we have three, maybe four, patients scattered round the building being ventilated. Things went badly wrong. The nurses didn't like them, the doctors didn't like them. Nobody wanted them, and they would be sending for help and the Anaesthetic Department didn't want them so I was the lad and I was sent to try and deal with all this and I complained and said 'This is just hopeless!'
>
> So they said what is the solution? We should put them all in one place, and we should have a group of nurses who will look after them. So the first Intensive Care Unit – general, it wasn't for anything specific, we took over about half-a-dozen secretary's offices at one end of the hospital on the level of the operating theatre.[347]

Even when some small units had been opened, the burden of instruction in the special skills needed by intensive care nurses was still heavy but fell on the backs of senior nurses who by then had learnt to manage ventilators and other highly technical equipment. Sister Pat Ashworth in her two side wards off the cardiac surgical ward at Broadgreen Hospital, Liverpool described her struggles with the Beaver respirator:

> It had a valve, which got very wet and got stuck. I don't draw but I got desperate enough to draw diagrams of the valve – how to take it apart and put it together, because do you remember the valve, it had two bits and a rubber bit in the middle, and then a clip that held it together. Well I thought that there was only one way to put that together but people managed to invent so many that I had to draw diagrams. ... But anyway that's how the two bed intensive care started, But remember at this time our staff were mostly students so the staff of F2 was myself, and a junior sister and a staff nurse, the rest were all students
>
> Interviewer: How did you teach them?
>
> Ashworth: Well, by example. You showed them what to do and explained what's happening and – I did get frustrated – I remember at one point I was

[346] Sykes MK Interview. July 2009.
[347] Strunin L. Interview. November 2009.

> not only teaching the day staff, but we had been going for a year or two by this time and I found that every night I was on I was having to stay an extra half-hour to teach someone else to deal with the ICU patients and I said to the night sister I thought they would have to do something about it because I couldn't keep teaching somebody new every time.[348]

The problem of teaching individual nurses as they came on shift largely faded away as units became bigger, with fully trained permanent nursing staff and education of nurses in intensive care became more formalised in the mid-1960s and beyond. Recruitment and retention of nursing staff was a perennial problem. Many ICUs were regularly unable to utilise all the available beds because insufficient nurses were available. Pat Ashworth recounted a typical incident:

> I remember one day Pat Molloy [a consultant cardiac surgeon] drawing himself up to his full height and saying 'Are you telling me I can't operate on my patient?' and I said 'No I'm telling you I can't nurse her.' We were short of staff – we may have had the normal amount of staff but for one reason or another we'd got more than enough work to go with the staff and it was just nonsense to start and do another open heart where we knew there would be a lot of work.[349]

Joseph Stoddart, Consultant anaesthetist in the Royal Victoria Hospital, Newcastle-upon-Tyne tried the patience of the night nursing superintendant:

> I said 'Look, you've got to find me a staff nurse who worked on the intensive care unit.'
>
> She said 'Are you listening carefully?' I said 'Yes.'
>
> She said 'Can you hear me knitting?'
>
> I said 'No.'
>
> She said 'I'm knitting you one.'
>
> But there were times when it was really grim, the nursing problem. The Matron who was there then didn't stay very long but she genuinely believed that her nurses could do anything.[350]

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[348] Ashworth P. Interview. July 2009.
[349] Ashworth P. Interview. July 2009.
[350] Stoddart JC. Interview. July 2009

There was concern that intensive care nursing imposed increased strain on nursing staff and led to 'burn out' which would cause the nurse to leave intensive care. However some nurses accepted the challenge and continued to work in the ITU for many years. Colette Feenan, Senior sister in the ICU in Sefton General Hospital, Liverpool said:

> I can think of quite a few nurses that were on the Unit for a long time. I suppose it's like in any profession you've got to like what you're doing because you've really got to put your heart and soul into it. Also you have to try and remember when you go off duty you must leave it behind you. It's not easy but I think it's very rewarding and I don't regret any time at all that I spent – my 19 years.[351]

A study at Whiston Hospital, Merseyside showed that more than half of the senior nursing staff in the ICU during the period 1962-1983 had remained in post longer than fifteen years. Only ten percent of the nurses stayed for less than five years.[352]

There is no doubt that the need to concentrate nurses specifically trained for intensive care was a potent stimulus for the formation of intensive care units, but the concentration of not easily transportable equipment and the appointment of physicians trained in intensive care and resident in the units were also important reasons for concentrating patients needing intensive care in one place. Sister Ashworth described the need to keep respirators in one place as the primary reason for the formation of the Broadgreen ICU:

> I arrived in '59. Somewhere in 1960 – I think it was Noelle Fenton who came and talked to me, and said she and her colleagues had been talking and they decided when they wanted to ventilate somebody it would be a good idea to keep the equipment in one place, and bring the patient to it, rather than to move it around all over the place, and they thought they would like to use our ward, our side-wards. What did I think about it? [353]

The conclusion must be that there were several reasons for creating intensive care units, which would not have been created and could not have worked without trained nurses in numbers sufficient to provide care on at least a one-to-one basis, immediate

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[351] Feenan C. Interview. May 2009

[352] Jones ES, Gordon IJ. The evolution and nursing history of a general intensive care unit (1962-1983). Intensive Crit Care Nurs.1998;14:252-257.

[353] Ashworth P. Interview. July 2009.

availability of necessary equipment and monitors and of trained medical staff. All were essential to meet the requirement of advances in medicine, surgery and anaesthesia. The designation of these areas as units, as opposed to wards (English) or floors (American) was perhaps felicitous. A unit was (at least at first) a small area with a clearly defined structure appropriate to its function, a group of workers; nurses, technicians and, gradually, specialised doctors who possessed the expertise needed to treat and care for the patients for whom the unit was designed. The design of intensive care units was the subject of Hospital Building Note (HBN). 27 first promulgated by the Department of Health and Social Serviced (DHSS) in 1967 and updated in 1970, 1974 and 1992. The Note excluded guidance on specialist units. The Intensive Care Society prepared a detailed document defining standards for intensive care units in 1997.[354]

As treatments became more specialised other similar but different units were opened; coronary care units and dialysis unit, cardio-thoracic and neurosurgical units. The staff of these units were recognised as being trained in general nursing or medicine but also at an advanced level in the skills demanded by the unit. Although the government recognised the need for these units they were not funded directly by central government but by local Hospital Boards or Regional Health Authorities and not infrequently from charitable sources. Hazel Melhuish, in 1967 Deputy Matron of Sefton General Hospital, was asked how the hospital was able to employ nurses for the ITU which opened in 1970:

> You were allowed by the Region to employ x number from medical ward beds, x number of surgery, x number of gynae[cology] and you got a little more to do GITU. You got the money for them. [355]

Sir Walter Clegg, MP for North Fylde replied in May 1978 to a question about the redevelopment of the Victoria Hospital, Blackpool: The health authorities have identified this problem and have given priority to the need to develop the Victoria

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[354] The Intensive Care Society. Standards for intensive care units 1997. Available at http://www.ics.ac.uk/intensive_care_professional/standards__safety_and_quality and follow links 'Standards published', 'Published documents' and 'Administration and organisation'. Accessed May 2007. This document expands Department of Health guidelines (e.g. HBN 27) and includes relevant European and occasionally American and Australasian guidelines. Earlier editions of HBN 27 may be obtained from HMSO London.

[355] Melhuish RH. Interview July 2009.

Hospital, Blackpool. The regional health authority is proposing in phase IV of the development of this hospital—which is in the capital programme to start in 1982–83—to provide more acute beds, intensive care units and more theatres.[356] His reply exemplifies the slow pace of provision of intensive care facilities. Only after several publicised 'scandals' were central funds allocated for the expansion of intensive care units.[357]

The AACN history relies largely on oral contemporary evidence from nurses who were working in intensive care as it evolved in America.[358] A paper by Cheryl Crocker, published in 2007 criticises the lack of mention of nurses in earlier papers and traces the developing recognition in a series of British government publications of the part played by nurses.[359] However it is marred by many inaccuracies. For example Ritchie Russell was a neurologist, not an anaesthetist. The allegation that he 'did not broaden the scope of treatment to include other groups of patients who would have benefitted' is untrue.[360] The statement that in the Copenhagen polio epidemic in 1952: '31 patients were treated for polio, 27 died' is also inaccurate: the reference she cites and misquotes is a secondary source which states that in the Copenhagen epidemic 31 patients had been treated for respiratory or pharyngeal paralysis. [361] It was only these patients who had such a high mortality. Literally thousands more without these complications, which occur in a relatively small proportion of polio patients, had a much lower mortality rate.

Medical staffing in intensive care and anaesthesia

In many, perhaps most, hospitals the arrangements for hospital medical staffing introduced with the National Health Service (NHS) in 1948 led to a fully professional anaesthetic service. Consultants worked and taught during the day and

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[356] Hansard. Orders of the Day — National Health Service (North-West Region). Available at http://www.theyworkforyou.com/debates/?id=1978-05-10a.1363.7&s=Blackpool+Victoria+Hospital+speaker%3A17154#g1367.1

[357] Berridge. V. Making health policy. Networks in research and policy after 1945. Amsterdam: Rodopi; 2005. p. 26-7.

[358] Lynaugh JE, Fairman J. A preview of the American Association of Critical Care Nurses history study. 1992.

[359] Crocker C. The development of critical care in England. Intensive Crit Care Nurs. 2007;23:323-330.

[360] Beinart J. A history of the Nuffield Department of Anaesthetics, Oxford. 1937-1987. Oxford: Oxford University Press; 1987. p. 116.

[361] Hilberman M. The evolution of intensive care units. Crit Care Med.1975;3:159-65.

there would be an on-call rota for them to be called in if necessary at night and weekends. Most emergency anaesthesia was however still carried out by trainees, whose competence was generally adequate, and the most junior could call on resident registrars and senior registrars for help. However although this staffing structure was adequate for the provision of an adequate anaesthetic service, it was not designed to provide consultant anaesthetic staffing for intensive care.

Their recognition as equal professionals by other medical specialists together with the demonstration of their ability to apply their skills to a range of patients with potentially reversible critical illness created requests for the help of anaesthetists in the care of patients outside the operating theatre. Because of their terms of service, responding to these requests was difficult for almost any NHS anaesthetist. In the NHS a large majority of consultants had fixed sessions for surgical anaesthesia occupying every half day of the working week, with sessions often in several hospitals. No provision had been made for them to undertake continuous supervision of patients in intensive care. It could be said that the expansion of intensive care occurred in spite of the Government's failure to recognise that almost no consultants had any allotted time or received any recompense for intensive care.

31/12/1949	496
31/12/1950	602
31/12/1951	655
31/12/1952	714
31/12/1953	748
30/6/1954	767

Table 10. Number of consultants in anaesthesia at various dates since December 31, 1949 (Great Britain)[362]

At the start of the National Health Service (NHS) in 1948 and for several years afterwards the number of consultant anaesthetists had increased year by year (Table 10). However the number did not seem to be enough, because questions were asked in parliament about the shortages of consultants in various health service areas and their effect on the provision of anaesthesia for surgery. In 1962 the Minister of Health was asked what was the total deficiency of anaesthetists in the hospital

[362] Editorial. Consultant and other specialist staff in National Health Service hospitals. Br Med J. 1955;Feb 26 (Suppl 2614):66-7.

service; and by how many each regional hospital board was short.[363] The minister (Mr Enoch Powell) did not know.

There were a bewildering number of reviews of hospital medical staffing in the 1960s. Sir Robert Platt (1900-1978) was chairman of the first joint working party of the profession and the health departments, set up in 1958 to review the medical staffing of hospitals. It reported in 1961.[364] The 'Platt Report' was critical of the arrangements then in place. It defined the consultant as 'A person who has been appointed by a statutory hospital authority by reason of his ability, qualifications, training and experience to undertake full personal responsibility for the investigation and for treatment of patients in one or more hospitals without supervision in professional matters by any other person. The report commented on excessive or inappropriate delegation of consultant duties:

> 41. Evidence both from hospital authorities and professional bodies indicates that under present arrangements work properly belonging to consultants is being regularly discharged by senior registrars and members of more junior grades. Further it suggests that notwithstanding the number of consultants that has occurred under the National Health Service this number is still inadequate to the needs of the hospitals. Our own investigation confirm that this evidence is sound.[365]

The next paragraph described the factors responsible for this situation as complex. They included lack of an adequate number of trained candidates for consultant vacancies in some specialties, e.g. mental health, radiology and anaesthetics.

The response to the report was positive. A leading article in the *British Medical Journal* noted that there was little in the report that had not before been urged on the Minister by the profession, but this was the first time that an officially appointed body had been asked to make recommendations. 'Their proposals merit the most careful study'. The anonymous author expressed the hope that the

[363] HC Deb 29 January 1962 vol 652 c65W 65W
[364] Medical staffing report in the hospital service. Report of the Joint Working Party 1961. London: HMSO. Reported in: Editorial. Medical staffing in hospitals.Br Med J. 1961; Mar 25:883-884
[365] Medical report on the staffing of the health service 1961. Section 12, para 41

government's response would not merely be aimed at papering over the cracks in the structure.[366]

In 1968 the number of consultants in all specialties was still increasing at the rate of 280 additional consultants per annum.[367] However vacancies were often difficult to fill. The BMA Central Committee for Hospital Medical Services gave in evidence to the Royal Commission on Medical Education details of 30 posts which had been vacant for an average of 12 months.[368] The 30 posts were not confined to the northern regions or the minor specialties. Figures are not given separately for anaesthetic posts.

Several leading articles in the *British Medical Journal* in 1968 and 1969 reported on the deliberations of committees set up to propose solutions to the problems of hospital medical staffing.[369, 370, 371] In the editorial in the Journal of 8 December 1969 it was suggested that the proposals to increase the number of consultant posts in the following decade would outstrip the supply of applicants from juniors who had completed their training, and that was what happened. In August 1976 the Secretary of State for Social Services was asked in the House of Commons if he would give details of the percentage increase in consultant posts established for the years 1973–74, 1974–75, 1975–76 and of the number of consultant posts which currently remain vacant; and in which specialities these vacancies lay.[372] He (Dr David Owen) replied that on 31 September 1975 there were 457 consultant vacancies. The largest number (67) were in anaesthetics. There was no ready supply of anaesthetists who could be spared from surgical anaesthesia to undertake sessions in intensive care.

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[366] Editorial. Medical staffing of hospitals. Br Med J. 1961;March 25:883-4.
[367] Hansard. Consultants and registrars. *HC Deb 01 July 1968 vol 767 c185W available at* http://hansard.millbanksystems.com/written_answers/1968/jul/01/consultants-and-registrars
[368] Langston HH. Hospital career structure. Br Med J. 1968;Jul 13:119.
[369] Editorial. Hospital medical staffing. Br Med J. 1968;Mar 16:655-6.
[370] Leading article. Hospital staffing structure. Br Med J. 1968;Dec 21:720-1.
[371] Leading article. Progress report on hospital staffing Br Med J. 1969;Dec 6:573-4.
[372] Hansard. Doctors and dentists. HC Deb 04 August 1976 vol 916 cc839-41W. Available at http://hansard.millbanksystems.com/written_answers/1976/aug/04/doctors-and-dentists#S5CV0916P2_19760804_CWA_288 . Accessed 31 Dec 2010

An editorial in *Anaesthesia* published in 1986 describes the doctor 'whose responsibilities include involvement of an intensive therapy unit (ITU). With few outstanding exceptions in the United Kingdom such responsibilities originally rested with anaesthetists who gave freely of their skills, interest and time without sessional recognition'.[373] Dr John C Richardson, one of the driving forces behind the creation of intensive care in the Cardio-thoracic Surgical Unit at Broadgreen Hospital, Liverpool was asked how he managed to supervise care of patients at Broadgreen when his sessions included work at other hospitals several miles away:

> Interviewer: You started ventilating patients at Broadgreen so you must have been able to spend quite a lot of time at Broadgreen?
>
> Richardson: We used to go in every day.
>
> Interviewer: Even if you were working at Walton?
>
> Richardson: Yes. Wherever we were working we attended Broadgreen every day. [374]

This was a typical arrangement: consultant anaesthetists used to call in the unit or the ward perhaps at 8am before an operating list and on the way home after their theatre list, and occasionally at lunch time. In the meantime if an emergency in the unit demanded the intervention of an anaesthetist, a trainee anaesthetist would have to cope. The most common emergencies demanding resolution within a minute or two were respirator failures, which a trained intensive care nurse could manage, or a displaced tracheostomy or endotracheal tube, which must be replaced immediately by an anaesthetist. If the artificial ventilation of a patient is interrupted for more than four minutes brain damage is almost inevitable.

The work done in intensive care by Richardson and his contemporaries was not recognised in their contracts which were for a full week's work in their base specialty, usually anaesthesia but in some cases medicine or surgery. However in the 1970s consultant posts began to be advertised in which there were sessions allocated specifically to work in intensive care. Details of these posts have been sought in advertisements in the medical journals. However the advertisement pages are usually torn out of medical journals before they are bound in hard covers. Fortunately some unbound copies of the *British Medical Journal* have been kept in the British Medical

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[373] Stoddart JC. Editorial A career post – with intensive therapy? Anaesthesia. 1986;41:1181-83. By 'originally' Stoddart refers to the early days of intensive care in the UK

[374] Richardson JC. Interview. September 2010

Association archives.[375] Only a few (about ten) issues are available for each year so they form a completely random sample. The first advertisement found for a post in anaesthetics in which intensive care was mentioned was for a registrar in the department of anaesthetics and intensive care at Sefton General Hospital in Liverpool in the issue of 3 January 1970. The first consultant post was for a post in the Leicester Royal Infirmary in the issue of 5 November 1977. The advertisement was for two consultant anaesthetists posts, one of which was 'with a special interest' in intensive care. Two weeks later Birmingham Health Authority advertised a post which actually included a sessional allocation for intensive care although the number of sessions per week was not stated: 'Sessions will include work in thoracic surgery, pain and therapeutic nerve blocks and in the intensive therapy unit'.[376] Two more advertisements in the following two months carried advertisements for posts which included intensive care. In 1978 (14 January) Newcastle Area Health Authority placed an advertisement stating 'An 8-bedded ITU will be established at the Freeman Hospital and the direction and development of the Unit will form a significant part of the duties of the post.'[377] This advertisement is particularly significant because it was a break from what had been the usual pattern of development of ITUs, in which one or more enthusiastic consultants had gradually obtained accommodation and facilities in an existing hospital. The Freeman Hospital had opened the previous year (1977) and the Health Authority were planning a unit and recruiting a consultant to direct and develop it, with a 'significant' part of the post (sessional allocation) for work in the Unit. The number of intensive care posts cannot of course be found from this small selection of journals, but it can be said that some posts did exist in the early 70s but that a large majority of advertisements for posts in anaesthesia which were found did not include sessional allocation for intensive care.

Accommodation

In January 1962 The Minister of Health Enoch Powell had announced a 10-year Hospital Building Plan. The intention was to build 90 new hospitals.

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[375] The author is indebted to Mr Leigh Sand, archivist at the British Medical Association's Library for finding about twenty unbound issues of the British Medical Journal.

[376] Advertisement. Consultant anaesthetist at Leicester Royal Infirmary. Br Med J. 1977;Nov 5:1240.

[377] Advertisement. Consultant anaesthetist. Br Med J. 1978;Jan 14: Advertisement section. (page not legible).

Expenditure of about £500m between 1961-62 and 1970-71 had been assumed for the purpose of the plan. The plan was to build general hospitals with an average of 600 beds or more. In addition there would be about 360 other hospital schemes for major development and improvements costing more than £100,000 each.[378] The plan was optimistic, even grandiose. The results were disappointing: in the subsequent decade Hansard and the newspapers were full of questions and letters about delayed hospital building schemes.[379] The failure to invest in hospital modernisation was an increasing cause of political embarrassment.[380] With regard to Hansard, there were 59 questions about hospital building delay in the 1960s. The following exchange gives an idea of the frustration they caused: The Member of Parliament for Bromley, Kent asked the Minister of Health Mr Loughlin 'why the redevelopment plans for Bromley Hospital have been deferred; when he now anticipates this work will commence; and whether he will make a statement'. The reply was: 'This decision was made by the South East Metropolitan Regional Hospital Board in re-assessing the priorities of its building programme. I am not yet able to say when the work will start.' The intervention of Lord Balniel in the debate revealed a wider problem: 'My hon. Friend the Member for Bromley (Mr. Hunt) is absolutely correct. Does not the hon. Gentleman realise that the postponement since October, 1964, of 20 hospital building projects, each costing over £100,000, which were due to be started in 1965–66 has caused a very widespread sense of frustration'[381] So Bromley was only one of twenty postponements at that time (1965).

The newspapers drew attention to the contrast between modern hospitals springing up throughout Europe and the UK's dilapidated hospital stock.[382] *The Times* repeatedly reported delays in the Ten-Year Programme. On 20 July, 1966 it carried an article entitled Hospital Building from Dr R1K Elliott and others: 'Eighteen months, and several crises, ago the building of phase I of our new Royal Sussex County Hospital was postponed for two years.'.[383] Ten years later (January 23, 1975) *The Times* reported

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[378] The Times. January 24, 1962.
[379] For example Elliott RIK et al. Hospital Building. The Times. July 20, 1966.
[380] Webster C. The National Health Service. A political history (New edition). Oxford: Oxford University Press; 2002. Page 44.
[381] Hansard. Bromley Hospital. HC Deb 31 May 1965 vol 713 cc1154-6 1154
[382] Webster C. 2002. page 44.
[383] Elliott The Times. July 20, 1966

> Government defers rebuilding of hospital: A 15-year project to redevelop St Mary's, Paddington, one of London's teaching hospitals, has been put back because of the present economic situation, Dr Owen, Minister of State for Health, announced last night. It had been hoped to start work on the £36m project in July. In a letter to the chairman of the North-West Thames Regional Health Authority, Dr Owen said the project had been delayed, not abandoned. He hoped the country's economic position would improve sufficiently before long to enable the Government to give further serious thought to St Mary's.

The Minister, it will be noted, hoped that the Government might 'give further serious thought' at some indeterminate time in the future. [384]

Records of finance allocated specifically to intensive care have been almost impossible to trace. *The evolution of intensive care in the UK* published by the Intensive Care Society in 2003 refers to a publication by the Ministry of Health and states that 'with this document came funding to establish intensive care units'.[385, 386] Efforts to discover the nature of this funding have been fruitless.

These comments on the slow progress of replacement of hospitals in the 1960s provide a background for the descriptions in the next chapter of the development of intensive care units during the period of expansion between 1964 and 1980.

Charitable contributions to the establishment of intensive care units

A significant feature common to the provision of several intensive care units was a contribution from charitable sources. As has been shown, finance from the NHS was often slow in coming even if it was available and charitable monies sometimes accelerated or assisted development of intensive care facilities.

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[384] The Times 23 January 1975.

[385] Intensive Care Society. 2003. Evolution of Intensive Care in the UK. Available at http://www.ics.ac.uk/intensive_care_professional/standards_and_guidelines/evolution_of_intensive_care_2003 . Accessed May 2011.

[386] Ministry of Health. Progressive Patient Care: Interim report of a departmental working group. Monthly Bulletin MOH and PHLS 1962;21:218–26.

Intensive care in Broadgreen Hospital, Liverpool had been provided in two side-wards attached to the cardio-thoracic surgical unit since 1960. As stated above, a new purpose-built unit was opened in 1964. The nurse in charge of the Unit, Sister Pat Ashworth, said in an interview:

> It was probably 1960 or not long after that that they set about getting money from the Nuffield Fund to build a new Unit. And the good thing about that was because it wasn't the NHS, it was the Nuffield Fund, we could do what we wanted and say what we wanted. [387]

This unit more or less satisfied requirements until about 1969 when it became obvious that the Unit could not cope with both general intensive therapy and postoperative cardiac care. In an article in the *Nursing Times* Sister Ashworth and two consultant anaesthetists explain that in 1971 it was decided to expand the Unit and graft on a new section. 'This decision coincided with the rather unexpected recovery of a very determined man who spent the first three years after a mitral valve replacement in collecting £40,000 to be spent on the development of the Unit.' [388] This brief statement hides a remarkable story. The very determined man was Brigadier Sir Philip Toosey (1904-1975) who was the original Colonel in the building of the Bridge on the River Kwai during the Second World War. The story is told in *The Man behind the Bridge* by PN Davies. [389, 390]

The following is a slightly expurgated version of Dr Richardson's description of events:

> Charles McKendrick [consultant cardiologist] said David Hamilton [cardiac surgeon at Broadgreen] had an upper age limit of 60 on replacement valves. Toosey was way over it. Charles McKendrick said it's a good cause – go for it, and we did. He died so many times. He was a difficult patient. He was

[387] Ashworth PM. Interview. July 2009.
[388] Ashworth PM et al. Nursing Times 1973.
[389] Davies PN. The Man behind the Bridge. London: Athlone Press; 1991. Pages 191–192.
[390] Brigadier Toosey was the Colonel portrayed in the film *Bridge over the River Kwai* released in 1957 by Colombia Pictures in which he was misrepresented as having collaborated with his Japanese captors during World War 2. The story is told, using tapes of recordings of interviews with Brigadier Toosey, in Davies PN. The man behind the bridge. London: Athlone Press; 1991. Pages 191-192.

> sent to H1, a cardiac ward and he got a case of Beaujolais under the bed and he had his batman dispense the Beaujolais to the Scousers down the ward.[391]

But the difficult patient showed his gratitude by raising £40 000 for the development of the unit.

The intensive care unit in Whiston Hospital Merseyside also received help from local charities as did the coronary care units in the Bolingbroke Hospital and Sefton General Hospital, Liverpool.392 393 Clifford Franklin said that when he arrived at Wythenshawe Hospital, Manchester to take up a post as consultant anaesthetist:

> One of the things that I had not discovered until then was charitable gifts from the families of people who had been in the intensive care unit and had not survived. I got my first big ventilator donated to me by the family of a patient who had died in the Unit.[394]

The Cardiac Surgical Intensive care unit in Wythenshawe was equipped with an advanced patient data display system. Clifford Franklin commented on the funding for this very expensive equipment:

> We got our stuff, our equipment from Sweden and we had a lot of equipment there. It was donated to us by charitable gifts.[395]

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[391] Richardson JC. Interview. September 2010
[392] Jones ES. Interview. May 2009
[393] Coronary care unit at Bolingbroke Hospital. Nursing Times. 1968;64:220-21.
[394] Franklin C. Interview. July 2009
[395] Franklin C. Interview. June 2009.

Chapter 9. Post-operative and general intensive care

In the 1950s and early 1960s the opening of an intensive care unit was an event often regarded as worthy of a report in the medical literature, published at the time of the opening or sometimes many years later. Some idea of the growth of intensive care can be traced through these reports. A report on a Conference on Tetanus held in Leeds in 1967 contained details of the foundation of several units.[396] The existence of others is known by the evidence provided by the colleagues interviewed for this study. There were certainly more units whose existence went unrecorded because as noted previously, an article in the *Nursing Times* on 21 December 1965 reported a meeting attended by 21 sisters in charge of intensive care units, so there were apparently at least 21 units in operation by that time.[397] Some of them were Coronary Intensive Care Units. While the published reports are valuable records of the establishment and activities of the early units, the oral history provides much valuable contextual information about how and why intensive care units were found to be necessary and how they were made possible.

Stanton lists several overlapping explanations of the origin of intensive care; from polio, from cardiac surgery, from Accident and Emergency medicine and from the need to concentrate human and technical resources. She suggests that from a historiographical point of view, 'the tenure of so many alternative explanations for the origins of intensive care ('several supported by accounts from 'insiders' belonging to one tradition or the other') reinforces an interpretation that sees intensive care as multi-stranded.' [398]

Intensive care units England and Wales can be grouped according to their different origins and functions. The first respiratory units were to provide treatment for patients with infectious diseases, usually of the nervous system. Units in Oxford, Ham Green, Bristol and the Western Hospital, London adopted (sometimes with

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[396] Ellis M (ed) Symposium on tetanus in Britain held at Leeds 7-8 April 1967. A book containing the text of the contributions at the Leeds Symposium was produced for the participants but was not published commercially. I am grateful for a copy sent to me by Professor John Norman. Emeritus Professor of Anaesthesia, University of Southampton.

[397] Editorial. Nurse planners meet. Intensive care Units. Nursing Times. 1965;Dec 31:1804-1805

[398] Stanton J. Intensive care: Measurement and audit in an expensive area of medicine. In: Berridge V. Making health policy after 1945. Amsterdam: Rodopi; 2005. p. 243-272.

reservations) the innovative regime based on IPPV and tracheostomy in the treatment of respiratory paralysis usually due to polio. Soon afterwards they were able to treat tetanus and respiratory insufficiency due to a variety of causes. These early Respiratory Units have already been described in Chapter 6. Secondly, many intensive care units were opened to meet the post-operative requirements of patients who had had cardio-thoracic surgery. Neurosurgical units also provided specialised treatment for head injuries. Other specialist post-operative units were required for the care of patients admitted for liver surgery and for those requiring renal or liver transplant. Thirdly, other units developed as General Intensive Care Units (or more often 'Intensive Therapy Units') treating patients with respiratory or other organ failure due to diseases or trauma treated in general hospitals. Finally, specialist units were opened to treat myocardial infarction (coronary intensive care units) or renal failure (dialysis units). These latter units treat mainly single-organ failure and differ in many ways from general ICUs (for example patients attending dialysis units on only a few days per week). They are not described in this thesis although the application of renal and cardio-vascular physiology and technology in general intensive care is described in Chapter 10.

It was recognised as long ago as 1923 that patients were very vulnerable in the first few hours after surgical operations. They were suffering from 'surgical shock', then not well understood, and from the after-effects of anaesthesia. In 1923 a postoperative recovery room was set up adjacent to the old operating room in the Johns Hopkins Hospital in Baltimore USA, where neurosurgical patients were cared for round the clock by a special nursing group prior to returning to their rooms. This was the beginning of airway care, temperature control, circulatory monitoring, fluid and electrolyte balance, and observation of the state of consciousness of the patient.[399] It has been convincingly argued that this was the first intensive care unit in the world. If this is accepted, intensive care started 30 years before the treatment of polio by Ibsen in Copenhagen in 1953, which is the more commonly accepted beginning of modern intensive care.[400] The Johns Hopkins recovery room was the

[399] Harvey AM. Neurosurgical genius – Walter Edward Dandy. Johns Hopkins Med J 1974;135:358-68.
[400] Lassen HCA. A preliminary report on the 1952 epidemic of polio in Copenhagen with special reference to the treatment of acute respiratory insufficiency. Lancet. 1953;1:37-41.

inspiration of the neurosurgeon Walter Edward Dandy (1886- 1946).[401] Post-operative rooms were opened in other American hospitals. Dr Thomas Boulton recalled that during a year when he went from St Bartholomew's Hospital in London to work and gain experience in Ann Arbour Hospital in Michigan in 1956-7, 'at Ann Arbor there was a recovery room, something which I had never seen except at Southend on Sea where Alfred Lee had organised one.' [402]

Alfred Lee was the senior anaesthetist at Southend-on-Sea Hospital. Boulton later went to work at Southend and he explained in an interview how it was, in an era when most anaesthetists had a very low status in hospitals, that Alfred Lee had gained considerable authority and indeed power in his hospital:

> Well I went to Southend in my final year as Senior Registrar. Alfred Lee of course was very famous, very colourful career. Started up as a GP in Southend, took an interest in anaesthetics, in the war he was taken into the civilian service. All the hospitals were put together which was really the beginning of the National Health Service, the Emergency Medical Services. He went into that as a salaried anaesthetist, and then when the Health Service came in '48 he was immediately made a Consultant. At that time in Southend Hospital, apart from Alfred Lee, who worked there, all the surgery was done by eminent chaps who came down and would do an outpatients in the morning and two or three cases in the afternoon and then go up to London. The result was that Alfred Lee really had the run of the place. What he said in Southend went, and he created a magnificent department which was very well known. He had various students from abroad come and work with him in his department, it was very well run and we were allowed study days; he was very encouraging.[403]

This recovery room in Southend, possibly the first post-operative recovery room in England, might be seen as similar to that at Johns Hopkins and was certainly a step towards intensive care. A publication by Alfred Lee and Clive Jolly describes specialised nursing by a small staff of permanent nurses, and cases which were not

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[401] Harvey AM. Neurosurgical genius – Walter Edward Dandy. Johns Hopkins Med J. 1974;135 (S). Page 364.
[402] Boulton TB. Interview. August 2009.
[403] Boulton TB. Interview August. 2009.

necessarily post operative were treated there.[404] However post-operative ventilation of the lungs was not described. These early post operative units might be regarded as intensive observation units rather than as intensive care units, which provide both observation and highly specialised treatment. The area of post-surgical care which undoubtedly had the largest influence on the development of intensive care in England and Wales was care following cardiac surgery.

Cardiac surgery and intensive care

For many anaesthetists who included intensive care in their practice, their first experience of intensive care was when they were called upon to engage in the care of patients after cardio-thoracic surgery, The first cardiac surgical operations on the heart were performed before 1964, but post operative care was usually in large cardiac surgical wards. James Le Fanu expresses his surprise that recognition that ventilation (IPPV) after cardiac surgery would save lives was so long delayed after Ibsen had demonstrated its efficacy in Copenhagen in 1952. 'The mortality in the early days of cardiac surgery was as high as that for infantrymen at the Battle of the Somme, which has usually been attributed to the inexperience of the surgeons in undertaking these innovative operations but in reality is due to the fact that most of these patients were inadequately ventilated following the operation.'[405] He quotes figures from Massachusetts General Hospital in Boston: in 1958 only sixty-six patients were ventilated for twenty-four hours or longer following major surgery. By 1964 the number had risen to 400 and by 1982 to 2,000. The first often very small intensive care units for cardiac surgical patients opened around 1960. As the volume of cardiac surgery grew in the mid-1960s larger, purpose-build units were opened. These offered advanced training in the management of the cardiovascular system to anaesthetic trainees, especially senior registrars, and produced a generation of young consultant anaesthetists who would be unhappy to leave post operative care to junior surgical residents and who had the knowledge and ability to open intensive care units +in general hospitals. The emergence of this cadre of consultant anaesthetists was a major factor in the rapid increase in the growth of general intensive care in England and Wales during the late 1960s and the 1970s. Some units were directed by physicians or surgeons or had consultants from more than one specialty on their staff

[404] Jolly C, Lee JA. Post-operative observation ward. Anaesthesia. 1957;12:49-56.
[405] Le Fanu J. The rise and fall of modern medicine. London: Little Brown; 1999. p.81.

but a National Audit of general intensive care units in the United Kingdom in 1992 by the Royal College of Anaesthetists showed that 82 percent of ITU directors were anaesthetists.[406] The function of a director varied from hospital to hospital. The earlier descriptions of intensive care units recognise that one consultant should be in administrative charge but patients were admitted under the referring consultant.[407] By the 1970s it was realised that a large body of knowledge had developed in intensive care (management of nutrition, renal and cardiovascular failure as well as respiratory failure etc). Referring consultants recognised that only those who practiced it daily had the necessary knowledge and expertise to direct the treatment. The referring consultant would in most cases take part in one of the daily ward rounds and advise on his area of expertise but the minute to minute management of patients would be under the unit director and his staff. *Standards for intensive care units* published by the Intensive Care Society in 1997 stated 'An ICU should have: An identifiable consultant as director, supported by consultants with allocated intensive care sessions sufficient to provide continuous non-resident availability.'[408] The ICS document divides ICUs into closed units where the intensive care consultant is completely responsible for clinical management and open units where clinical management remains the responsibility of the admitting (referring) consultant. Having stated that the latter arrangement is better suited to general ICUs serving a wide range of admitting specialties, it points out that units in which the intensive care consultant has a high degree of autonomy and control of patients in the intensive care environment have been consistently shown to produce better patient outcomes.[409, 410]

The first cardiac surgical operations in Britain were for the repair of heart valves damaged usually by rheumatic fever contracted in childhood. In many cases valve damage was not manifest until many years later. Other operations at that time were for the correction of congenital defects of the heart and great blood vessels.

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[406] Stoddart JC. National ITU audit 1992-3. London: The Royal College of Anaesthetists; 1993.
[407] Crockett GS, Barr A. An intensive care unit; Two years experience in a provincial hospital. Br Med J. 1965;Nov 13:1173-5.
[408] Intensive Care Society. Standards for intensive care units. 1997 p. 7. Available at http://www.md.ucl.ac.be/didac/hosp/architec/UK_Intensive_care.pdf. Cited 12.11.2011.
[409] observations based on organisation case studies in nine intensive care units:
[410] Knaus WA, Draper ED, Wagner DP et al. An evaluation of outcome from intensive care in major medical centers. Ann Intern Med. 1986;104:410-18.

The first heart valve to be treated surgically was the mitral valve. This valve allows blood brought by the pulmonary veins from the lungs to the left atrium to pass into the left ventricle. When this strong muscular chamber contracts, it delivers blood to the rest of the body. The mitral valve is so designed that when the left ventricle contracts the valve closes and prevents blood being forced back to the lungs. The mitral valve can be damaged in either of two ways; the orifice can be narrowed (mitral stenosis) so that the flow of blood through it is reduced, or the valve may leak (mitral incompetence), so that when the left ventricle contracts some of the blood ejected goes back towards the lungs instead of to the rest of the body.

The first operations were to treat narrowing (stenosis) of the mitral valve (mitral valvotomy). An opening can be made in the wall of the left atrium and a finger passed through it to reach the tight mitral valve and it can be widened. A knife can be attached to the finger to enable the orifice in the valve to be widened more effectively. The hole in the atrium can then be stitched up. The heart does not need to be stopped for this manoeuvre. In 1948 Russell Brock at Guy's Hospital London performed a successful mitral valvotomy for mitral stenosis. Brock's work was followed by Thomas Holmes Sellors at the Middlesex Hospital London in 1951.[411]

Two anaesthetists in London teaching hospitals, Dr Thomas Boulton in St Bartholomew's Hospital ('Bart's'), and Professor Keith Sykes at the Hammersmith Hospital described their involvement with cardiac surgery and intensive care in their hospitals. Boulton worked with the surgeon, Oswald Tubbs (1908-1993) who devised the finger knife used in mitral valvotomy. Boulton was given his first experience of cardiac surgery in 1953-4 when he was appointed to a registrar post at the St Bartholomew's Sector Hospital at Hill End, St Albans, around 22 miles (35 km) north of central London. Hill End housed the specialist thoracic surgery and neurosurgical units pending the completion of a new building adjacent to Barts in the City of London. At Hill End Boulton learnt the techniques of anaesthesia for thoracic surgery and early cardiac surgery.

[411] Rivett G. From cradle to grave. Fifty years of the NHS. London: King's Fund;1998: page 65.

> I went up to Hill End and there I met Oswald Tubbs, who was a bit of an autocrat and became very important as I shall relate in the matter of intensive care for me. He was a thoracic surgeon at his prime. [412]

Four years later (1958) Tom Boulton was appointed consultant anaesthetist in Reading, Berkshire. He introduced modern anaesthetic techniques to the other anaesthetists there. However by 1961 Oswald Tubbs was working in a new cardiac surgical unit in St Bartholomew's Hospital and he wanted to proceed to more advanced cardiac surgery: open heart surgery. The anaesthetists at Bart's wanted Boulton's help because he had had in the USA experience of the technology needed to allow surgeons to open the heart for advanced surgery.

In order to open the heart so as to replace damaged heart valves with animal or mechanical valves or to repair congenital defects such as abnormal openings between different parts of the heart, the heart had to be stopped. Two techniques were introduced to allow the organs to survive this period of cardiac arrest. The first involved cooling the body, which reduced the rate of metabolism and hence the demand for oxygen. This allowed the tissues, and crucially the brain, to survive undamaged without receiving oxygen for perhaps an hour (normally the brain is damaged by more than 2-4 minutes cardiac arrest). This hypothermic technique allowed hurried surgery inside the heart.

The second more advanced but technically demanding technique was to divert the blood by sucking it from the two great veins leading to the heart and pumping it through a 'heart-lung machine' which oxygenated the blood and pumped it back into the circulation. The pumps on the machine had to be meticulously adjusted from minute to minute to ensure that the amount of blood that was returned to the circulation was the same as the amount extracted, and the blood pressure was maintained. The gases introduced to the machine had also to be regulated so that the oxygenation and acidity of the blood was maintained within acceptable limits. The surgeon could not do this because the operation demanded his undivided attention and a common arrangement was that two consultant anaesthetists would manage the anaesthesia of the patient and the minute adjustment of the heart lung machine. The closest co-operation between the surgeon(s) and anaesthetist was essential. As the surgeon tightened the clamps on the veins and the volume of blood diverted to the

[412] Boulton TB. Interview. August 2009.

pump-oxygenator was increased, the anaesthetist controlling the pumps had to exactly balance the volume of blood received by the machine and the volume returned to the patient. Getting the patient 'off bypass' when the surgeon had closed the heart was even more exacting – the circulating function of the pump had to be gradually reduced as the patient's own heart gradually recovered its function. The recovery could be incomplete and prolonged perhaps for hours. Management of the circulation and respiration in the post-operative period also demanded deep understanding of the heart, lungs and peripheral circulation by the team. The patient was returned to the post cardiac surgical unit still heavily sedated and receiving artificial ventilation of the lungs usually for at least 24 hours.

Both Sykes and Boulton in their interviews described the often difficult progress in their respective hospitals (the Hammersmith and St Bartholomew's) towards the development of these techniques from initially innovative operations with a high mortality towards a routine with an acceptable mortality rate.

Boulton described his reluctance to leave his consultant post in Reading when he was asked by colleagues at St Bartholomew's ('Bart's') to return and take a consultant post there. Boulton's experience was especially wanted at Barts because he had seen advanced cardiac surgery during a year's work as instructor at the University of Michigan, Ann Arbor, Michigan, USA. Surgeons there were already doing open heart surgery, while the circulation was maintained by pump oxygenators. The surgeons at Bart's wanted to start open heart surgery but the anaesthetists there did not want to be involved. The reason was that there were no private beds in Bart's so they had to earn their extra money by work in private hospitals. They could not stay in Barts for long hours, greatly exceeding their sessional commitment to anaesthetise for long cardiac operations and stay to participate in the necessary post-operative care. Boulton emphasises that the anaesthetists were performing their contractual duties assiduously but they wanted to be 'sessional' theatre anaesthetists. Boulton went back to Bart's and proceeded to anaesthetise the patients for open heart surgery and run the pump oxygenators and manage the hypothermic techniques.

> I was involved there with the post-operative care of Os's patients ['Os' was Oswald Tubbs, the surgeon who Boulton had met at Reading and who by now had come to Barts.] A lot of them needed ventilating, much more so

> than they do today after cardiac surgery, and I really took that over. But it was very awkward, it had to be done in the cardiac surgical ward and finally Os said to me 'You really ought to be concentrating these ventilators. I'll give you four beds in the side room'. He was by then in his prime and very powerful; he was also a Governor of the Hospital. I said 'I'll need a Sister to run that and two or three nurses'. And somehow he persuaded the Board to give me that, and then of course I was oversubscribed. I only had these four beds. I had to say 'We fill the beds and we treat the patients but we don't send anyone out early. We treat what we can.' People thought it was a bit callous but I found that if I sent them back too early to the wards they simply died.[413]

The date of the opening of the 4-bedded intensive care unit at St Bartholomew's Hospital is unclear. Boulton locates it sometime after 1961. Boulton's description of the other anaesthetists at Barts who could not give continuous postoperative care to patients because of their commitment to other (private) hospitals corroborates the description given in Chapter eight of the difficulties experienced by anaesthetists in participating in intensive care because of the sessional nature of their contracts.

Keith Sykes described how the early cardiac surgery at the Hammersmith Royal Postgraduate Hospital, London and post-operative care of open-heart surgical patients developed into general intensive care:

> At that time John Beard and Betty Lloyd-Jones were doing the open heart surgery cases and a few patients were starting to survive. Melrose had perfused the first patient with his machine in '53 though the perfusion was only partial. Then they did a number of cases in '55/'56 and they all died, so they stopped operating while Dennis Melrose and Bill Cleland, the cardiac surgeon, went and spent time with John Kirkland at the Mayo Clinic. I had visited the Mayo Clinic in June '55, and I had seen Kirkland do number twelve bypass with the Mayo Gibbon pump, and it was a very impressive set up.
>
> Cleland and Melrose came to realise that the secret for success was a large throughput of cases so they came home and persuaded Bonham-Carter, the cardiac physician at Great Ormond Street, to send them ASDs and VSDs.

[413] Boulton TB. Interview. August 2009.

[These are defects in the partitions separating the right and left atria and the right and left ventricle of the heart respectively.] Bonham-Carter realised that they needed a large throughput of cases and agreed to send them some fifty patients without questioning the results. The team went ahead and soon published a paper showing much improved results. What had made the difference was monitoring, speed and organisation. Hugh Bentall, who was at that time a time-expired Senior Registrar, used to stand up on a platform like a conductor of the orchestra and would check every action on a checklist. That was the key to success.

So, around Christmas '59, when the cardiac team wanted to increase the weekly number of perfusions from two to four, Betty Lloyd-Jones and John Beard asked me if I would join the team. I went and watched. Betty and John would bring the patient back to the side ward and, if he wasn't breathing properly, they would connect a Mapleson D circuit – a bag without a CO2 absorber – and ten litres of oxygen, and then they went home.

Well, by this time I had been working on rebreathing with the Magill attachment (an anaesthetic system similar to the Mapleson D system) and I could see that the patients were dying from CO2 retention. So, one night, I connected one of the patients to the large positive-negative Radcliffe ventilator that Philip Hugh-Jones had used for the first asthma case treated by IPPV.[414] Fortunately, that patient recovered, as did the next two. The surgeons then asked me if I would join the team.

As I say, the first three cases treated with a ventilator survived. We were certainly treating patients in side wards from March '60. I can't remember when they actually opened the post-operative recovery unit, but it was in a corridor over our anaesthetic corridor, and I think it must have opened in March 1961. So that's when I started the intensive care unit. Initially, it was essentially an eight-bedded post-operative recovery unit situated in a corridor opening off the theatre suite. The cardiac physicians were regular visitors and, in no time at all, other physicians were coming to us. I think the first medical case I was asked to treat was a tetanus case from Guernsey

[414] See chapter seven; Beyond infectious diseases; Asthma for a description of Jones's work.

> because the lady anaesthetist there had read my paper on tetanus in *Anaesthesia*.[415] Over the next few years we had, I think, thirteen or fourteen cases of tetanus flown in from Guernsey or Jersey. [416]

Later in the interview Sykes describes the subtlety of his acquisition of a purpose-built intensive therapy unit at the Hammersmith, on the same floor as the operating theatres:

> In '69, Jean Lumley [consultant anaesthetist] was there and I'd had enough of being up night and day and I was travelling an awful lot more, so I gave up the ITU and she took it over. By this time I had designed a new purpose built ITU, which was to be part of a new prefabricated building. The problem was to connect it at third floor level with the theatres and old ITU. I saw an article in The Times that said that the government was offering some money for new renal units, so I persuaded Ralph Shackman, who was the renal surgeon, to put in a bid for a new unit. His bid was successful and it was arranged that his unit should be on the second floor, so that enabled us to put the ITU on top of the building on the same level as the theatres and the old post-operative recovery. We could thus walk through from theatre to ITU. I designed the new unit with two- and three-bed separated units because of the infection problems, so that we could close one down and disinfect it properly before re-opening it. And then Jean took over that and ran that for a number of years.[417]

Two more interviews recount the establishment of another unit which soon catered for a wide variety of critically ill patients but which had its roots in post-cardiac surgical care. Dr John Craig (Dick) Richardson was consultant anaesthetist in the cardio thoracic surgical unit at Broadgreen Hospital, Liverpool. Pat Ashworth was the sister in charge of the cardiac surgical ward at Broadgreen as it developed intensive care of cardiac surgical patients from small beginnings until in 1964 they opened the first purpose-built intensive care unit in England.

In the late 1950s Broadgreen was a regional general hospital, not part of the Liverpool teaching hospitals (the United Liverpool Hospitals) which were at that

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[415] Wright R, Sykes MK, Jackson BG, Mann NM, Adams EB. Intermittent positive-pressure respiration in tetanus neonatorum. Lancet. 1961;1:678-80
[416] Sykes MK. Interview. July 2009.
[417] Sykes MK. Interview. July 2009.

time all small hospitals teaching general medicine and surgery to undergraduates and post-graduates at the University of Liverpool. Specialist units (medical cardiology, cardio-thoracic and neurosurgery) were all in the surrounding regional hospitals. When Pat Ashworth came to Broadgreen in 1959 she was put in charge of Ward F2, a cardio-thoracic surgical ward. When asked how she had been trained to manage such a ward Ashworth explained:

> I did a shortened training at Guys - I didn't start at the beginning but at the end of my first year the surgical ward had some 27 beds, it was a women's ward, and seven of those beds were Russell Brock's and he was doing Blalock's in ... some of them children, some of them adults, on Fallot's Tetralogy at that time [1950] so I got an interest in cardio-thoracic surgery and then I did more later on so that was how I came to Liverpool.[418]

Fallot's Tetralogy is a fourfold congenital abnormality of the heart which causes the blood to be poorly oxygenated and the right ventricle to be strained. Alfred Blalock (1899-1964) devised in 1944 a relatively simple operation, a shunt between the pulmonary artery and the aorta, which diverted blood back to the lungs. It did not repair the four abnormalities but it did greatly reduce symptoms. Russell Brock (1903-1980) later Lord Brock of Wimbledon was a leading British chest and heart surgeon and one of the pioneers of modern open-heart surgery.

As has been mentioned in chapter 8 (page 147), soon after Pat Ashworth became a Sister in the thoracic surgical ward at Broadgreen it was suggested that a side ward should be used for patients needing IPPV. She was sent to the respiratory unit in the Radcliffe Infirmary in Oxford to learn the routines of intensive care nursing. Sister Ashworth explained that the nursing staff in the unit consisted of herself, a junior sister and a staff nurse: the rest were all students, She trained them by example.

> Interviewer: At that time, what sort of patients were you treating? Were they all post-operative cardio-thoracic or ...?
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> Ashworth: Oh no, an awful lot of them were not. You will find my name in the literature periodically: The very first article was actually a case study of a patient who fell 50 feet at Cammell Lairds [Merseyside ship-builders] and

[418] Ashworth PM. Interview. July 2009.

> he had fractured ribs and was ventilated, he had a head injury and so on and he also had renal failure but we managed without having to dialyse him.[419]

Ashworth and Richardson wrote a paper in the *Nursing Times* describing the evolution of their successive intensive care facilities between 1960 and 1973.[420] The Unit built in 1964 was a twelve-bedded intensive care unit designed by a multi-disciplinary team on the basis of experience gained from the use of the two side wards attached to the cardio-thoracic surgical ward as an intensive therapy unit for the hospital from 1960-1964. The 1964 unit consisted of four single rooms and eight beds in an open area which, by the standards of the time, was well equipped with piped oxygen and suction, emergency power supply, service rooms and facilities. One of its most outstanding features was its spaciousness. Although this meant that nurses had further to walk between beds Ashworth insisted that this was less stressful than having to dodge around in an overcrowded space full of bulky equipment, and was essential to reduce cross infection. The amount of bed space provided at Broadgreen was accepted as the norm in DHSS Building Note (1970).

Ashworth and Richardson's article contains valuable figures for the work and case-mix of the unit. During 1964-1969 4,165 patients passed through the unit. Of these 538 were admitted after open-heart operations, 3,052 after other cardio-thoracic operations and 575 patients needed intensive therapy for 'a wide variety of other reasons'

There were probably about 16 senior registrars trained at Broadgreen (one every year) in that period. A considerable number of them went on to open units, and of course they taught their juniors some of whom also went on to participate in intensive care creating a quasi exponential growth. It has to be admitted that the training in intensive care in that period was largely unregulated and by apprenticeship. An organised pathway to recognition of an appropriately trained intensive therapist came much later (Chapter twelve).

Non-cardiac surgical post-operative care.

In a cardio-thoracic surgical unit, patients who have had operations on the lungs may be nursed in the intensive care unit. However in a general hospital or

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[419] Ashworth PM. Interview. July 1909.

[420] Ashworth PM, Richardson JC, Meadows G. Intensive therapy 1960-1973, the development of a unit. Nursing Times.1973;Sept:1164-8.

perhaps a sanatorium such patients would in the 1960s and 1970s be returned to the thoracic surgical ward. Intensive care was not mentioned in the chapter on *Anaesthesia for Pulmonary Surgery* in a standard text book of anaesthesia published at the end of this period (1980).[421] As in any major surgery, careful monitoring of the circulation is necessary and in addition, patients after pulmonary surgery are at increased risk of pulmonary oedema from over-transfusion following resection of any significant amounts of lung tissue.

Patients after neurosurgery frequently require IPPV and special monitoring and so neurosurgical units have a dedicated neurosurgical ICU (the acronym NICU has been used but is usually used for neonatal intensive care unit). The monitoring of such patients is, apart from the more usual monitoring in a general ICU and clinical monitoring of the signs of nervous system damage, directed at detecting abnormalities which may threaten the health or survival of the brain. These abnormalities are ones which cause an imbalance between the metabolic demands of the brain and the supply of oxygen and other nutrients. Important elements consist of a combination of appropriately timed computerised tomography (CT) scans and continuous intercranial pressure monitoring.[422]

The facilities of a neurosurgical intensive care unit should ideally be available for all severe head injuries but frequently have not been. In 1975 Bryan Jennet (1926-2008), Professor of Neurosurgery at the University of Glasgow from 1968-1991, wrote a paper entitled 'Who cares for head injuries' which examined the dilemmas endemic in caring for patients with severe head injuries.[423] Many, probably most accident centres were in hospitals where there was not a neurosurgical unit or the ready availability of neurosurgical opinion. Exceptions in England and Wales were the hospitals where there was a neurosurgical unit (usually one per NHS Region) and an accident department. The other hospitals in the region had to get a neurosurgical opinion from the Regional Centre but it was frequently not possible to

[421] Gray TC, Nunn JF, Utting JE. General anaesthesia. 4th Ed. Volume 2. London: Butterworths; 1980. Page 1347
[422] Marsh ML, Marshall MF, Shapiro HM. Neurosurgical intensive care. Anesthesiology. 1977;17:149-63.
[423] Obituary. Professor Bryan Jennett. The Times. 2008;Feb 21.

transfer patients to the Centre because no ICU bed was available.[424] This unsatisfactory situation continued in some areas until at least 1993.[425]

Before 1980 liver transplantation was still in the experimental stage and was practiced in very few centres. Renal transplantation was however a routine procedure by 1980. Patients were usually managed in an acute dialysis unit before operation and returned there afterwards. If complications ensued they were transferred to a general intensive care unit. A few units were equipped to dialyse patients. In others if the transplanted kidney did not immediately function (and most did) staff from the dialysis unit would dialyse in the general intensive care unit until the new kidney started to function sufficiently well. Heart transplantation was attempted in the UK in the early sixties but discontinued in 1969 owing to adverse results. It was reintroduced in 1979. It was of course performed in specialised cardiac surgical centres and patients were nursed post-operatively in the intensive care unit and later in a rehabilitation unit.

With increasing specialisation in surgery the term 'general surgery' has become obsolescent. Here it is used to denote operations usually carried out in a general hospital rather than in a specialised unit. Some surgical emergencies always carry a high mortality rate. Rupture of the aorta is a tear in the largest artery in the body. In the 1960s death was inevitable unless an operation was performed, and even then half the patients died.[426] An article from Hammersmith and Chelmsford Hospitals in 1965 described the results of treatment of 30 cases.[427] Only seventeen could be operated on and only five patients survived. A paper from King's College Hospital, London in 1972 reported a survival of only four patients out of a total of 40 cases (10 percent).[428] By the end of the period (1980) survival was reported from an English district general hospital as 41 percent of those 29 patients whose ruptured aneurysms were operable but ten were not fit for operation or died before they could

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[424] Jennett B. Who cares for head injuries. Br Med J. 1975;Apr 4:267-270.
[425] Personal experience. The author retired from the intensive care unit at the Royal Liverpool University Hospital in 1993. The Regional Neurosurgical Centre was only a few miles away but was frequently unable to accept head injured patients from 'the Royal'.
[426] Alpert J, Brief DK, Parsonnet V. Surgery for the ruptured abdominal aortic aneurysm. JAMA. 1970;212:1355-9.
[427] Martin P. Ruptured abdominal aortic aneurysms. Proc R Soc Med. 1965;58:867-8.
[428] Pryor JP. Diagnosis of ruptured aneurysm of abdominal aorta. Br Med J. 1972;Sep 23:735-6.

be operated on so the overall survival was 31 percent. [429] A report from Australia did not supply the overall survival of patients but 56 out of 65 patients who survived surgery for ruptured abdominal aortic aneurysms were alive after a mean interval of 36 months after operation and the majority were enjoying a quality of life similar to that experienced before operation.[430] Survival continued to improve with the introduction of newer techniques in later years but they did not change the need for intensive care by a multidisciplinary team.[431]

General intensive care units

Some intensive care units were opened in hospitals which did not contain specialist surgical units. They were opened by anaesthetists who wished to provide care for particularly vulnerable patients after general surgical operations or by physicians who needed to treat respiratory failure in their patients. Operations not normally associated with a high risk may occasionally present post-operative problems requiring intensive care. If the patient presents a high anaesthetic risk the post-operative care may require the full resources of an intensive care unit, especially if the surgery has not gone according to plan. In 1970 during the first seven months of operation of a general intensive therapy unit in a district general hospital with no specialized surgical units, 34 of 83 (41 percent) of admissions to the unit were for post-operative intensive care.[432] The patients included one with a perforated appendix who developed respiratory and renal failure, was ventilated and dialysed for five weeks and made a full recovery, and a patient after a nephrectomy who was found post-operatively to have a pneumothorax. These were all routine operations after which the patient recovered from a life-threatening complication.

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[429] Marsh CH. Experiences with abdominal aortic aneurysms in a district general hospital. Ann R Coll Surg Engl. 1980;62:294-6.

[430] Appleberg M, Coupland GA, Reeve TS. Ruptured abdominal aortic aneurysm: long term survival after operation. Aust NZ J Surg. 1996;66:680-5.

[431] Field ML, Kuduvalli MJ, Oo A. Multidisciplinary team-led management of acute Type B aortic dissection in the United Kingdom. J R Soc Med. 2011:104**:**53–8.

[432] Patient Register of the General Intensive Therapy Unit, Sefton General Hospital, Liverpool. 1970 The admissions in the first seven months after the unit opened in January 1970 were copied to a spread sheet in 2009. The rest of the Registers were then unfortunately destroyed.

The evolution of the intensive care unit in Whiston Hospital, Liverpool was described in a retrospective account by Ian J Gordon and Eric Sherwood Jones.[433] This paper is particularly important in that it emphasises the part played by nurses in the creation of intensive care units and describes the evolution of nurse training in intensive care in the United Kingdom. Gordon and Jones also underline the help given to the Whiston unit by the local community. Their experience in this respect is by no means unique as will become apparent when other units are described later.

Intensive care at Whiston was catalysed in the early 1960s when Ann White CBE, Matron of the Royal Southern Hospital, Liverpool, presented a lecture on progressive patient care. In Whiston Hospital four beds were allocated for a trial period. The physicians were two anaesthetists with special knowledge of ventilatory support and a physician with extensive knowledge of body fluids. The matron provided 'a handful of qualified hospital nurses'. The relation between progressive patient care and intensive care will be discussed in a later section.

The experiment was a success, and in 1964 an eight-bedded ICU was created. Particular features of intensive care at Whiston were clearly defined admission policies, antibiotic policies and standardised treatment of the various conditions, set out in data sheets which later formed the basis for a textbook. The range of conditions treated in the unit gives an idea of the meaning of 'general' intensive care, which can be defined most easily by a statement of what it is *not*: 'general intensive care' is a term used to describe intensive care which is not the specialised care of cardio-thoracic or neuro-surgical patients or intensive care of patients in medical units such as coronary care units or renal dialysis units which are designed to treat only one category of patients. The range of patients treated in the unit in Whiston included major trauma, self poisoning, severe acute asthma, acute myocardial infarction and renal failure. This is a fairly representative list of the conditions treated in intensive care units in general hospitals in England and Wales at that time, although in most general intensive care units renal dialysis was not available. Whiston specialised in the treatment of severe acute asthma. The results showed that deaths from asthma are nearly always avoidable if admission to competent intensive care is immediately available. The Whiston unit maintained an asthma register and

[433] Gordon IJ, Jones ES. The evolution of a general intensive care unit (1962-1983). Intensive Crit Care Nurs. 1998;14:252-257.

patients were given 'open access' to contact the on call ICU registrar at any time of the day or night. Over a ten year period (1970-1980) only one person on the register died of asthma. This was in contrast to 23 patients who died of asthma in the area between 1974 and 1977. Three hundred patients were treated in the Whiston unit in 1964, the year of its opening, and by 1974 the admissions had risen to about 500 per annum.

A great deal of the success of the Whiston unit was due to the genius and enthusiasm of the physician Eric Sherwood Jones (1921-). His anaesthetist colleagues, particularly in the early days John Robinson (later professor of anaesthesia in the University of Birmingham), were possibly equally contributory, but 'Sherwood', as he is known nationally and internationally, was the longest serving and made a very large contribution to the development of intensive care in Britain. He was inter alia the chairman of the panel of the Joint Board of Clinical and Nursing Studies which designed the first national courses for intensive care nursing and he was an early president of the Intensive Care Society of Great Britain and Ireland. Sherwood was an eccentric lecturer. He was one of four brothers. Their father was medical officer of health in nearby Widnes. Three of the brothers became doctors. The fourth was admitted to the Medical School at Liverpool University but left to join the Royal Air Force and became Air-Vice Marshall Sir Edward Gordon Jones. In spite of this exalted background Sherwood attracted a band of devoted local supporters who formed the Whiston Asthma Club. They met in the Dragon pub opposite the hospital and raised a great deal of money for the unit. Sherwood alleged in an interview that having had a somewhat abbreviated medical education during the Second World War he was ignorant of many aspects of medicine so he got into the habit of telephoning a leading authority and asking what he should do when a patient presented a difficulty.[434] He mentioned telephoning Sir John Walton, later Lord Walton of Detchant, former President of the General Medical Council and of the Royal Society of Medicine. Walton told him that if he was the patient he would be pleased to be given steroids. Such a lack of pretension and an ability to mix easily is perhaps particularly an asset for a consultant in intensive therapy who has to take responsibility for the patients of a variety of specialists without antagonising them.

[434] Jones ES. Interview. May 2009.

Mahendran Ambiavagar and Rita McConn have written about their experience in Whiston Hospital. Ambiavagar, an anaesthetist, who had been a registrar and Rita McConn had been a biochemist at Whiston wrote later from the United States of their experience there. [435] Their paper deals with the emphasis in the Unit on medical inter-specialty and nursing co-operation, the importance of nutrition in critically ill patients, the academic standing of the Unit and its clinical research laboratory and the question of clinical responsibility in intensive care units.

The unit in Leeds General Infirmary started as a unit for treating tetanus but in 1964 became a general intensive care unit. It has been described in Chapter seven (page 116). Intensive care was started in the Royal Victoria Infirmary, Newcastle-upon-Tyne in the general wards 1950s and a Unit was opened in 1967. Dr Joseph Stoddart (1932-) described his first contact with Professor Edgar Pask (Professor of anaesthesia in University of Newcastle 1949-1966) .

> Interviewer: What happened when you qualified? What took you into intensive care?
>
> Stoddart: Well first of all I did a medical house job and in 1956 in my medical house job I first came across Professor Pask looking after a patient on a ventilator in my medical ward. The ventilator was a home-made one! He made – I think by the time he died we got to model 12. He was a remarkably interesting man.[436]

In 1960 Stoddart was 'called-up' to do his National Service in the Royal Air Force. He practiced as a Junior Specialist in anaesthesia and from 1963 undertook research at the Institute of Aviation Medicine in Farnborough. He was awarded the degree of Doctor of Medicine for this work. On leaving the RAF in 1965 he returned to Newcastle:

> Stoddart: I came back here in 1965 and straight into intensive care. I came here as University First Assistant, but that job was basically an intensive care research job. We didn't have a Unit, we had patients all over – but we designed one at that time and it was built – finished – I think August 67 we moved in – in a purpose built Unit.[437]

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[435] Ambiavagar ,M. McConn,R. Intensive therapy--a modern necessity. Surg Clin North Am. 1978;58:1031-44.
[436] Stoddart JC. Interview. July 2009.
[437] Stoddart JC. Interview. July 2009.

This was probably the first instance of an academic post in intensive care in England and Wales. Stoddart published many important studies into clinical aspects of intensive care, and conducted an audit of intensive therapy units in the United Kingdom and papers on intensive care medicine as a career.[438] [439] He was the second President of the Intensive Care Society (1974-5). The opening of a four-bed intensive care unit in The Royal Victoria Hospital, Bournemouth was described in 1966.[440] It was located next to a post-operative recovery room with which it shared nursing staff. There was not one nurse per patient, a ratio considered essential in many other units, but the nurses were well trained to look after patients needing complex equipment. A comprehensive pathology service was provided with facilities for *inter alia*, arterial blood gas measurement.

Dr Stanley A Mason, a consultant anaesthetist wrote about the scope and organisation of an intensive therapy unit in King's College Hospital, a London Teaching Hospital.[441] Perhaps not surprisingly he wrote that the role of the anaesthetist in the intensive therapy unit cannot be over-emphasised. He went as far as to say that no intensive care unit should be opened unless the services of a skilled anaesthetist are available 24-hours of the day. He justified this assertion by the following figures: 48 percent of admissions to the King's College unit were unconscious, 53 percent required a tracheostomy, and nearly a third of the patients admitted required artificial ventilation for varying times. At least one resident anaesthetist would be the norm in teaching hospitals at that time, but in smaller hospitals that would not be the case.

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[438] Stoddart JC. National ITU Audit 1992/1993. London: Royal College of Anaesthetists; 1993.
[439] Stoddart JC. A career post – with intensive therapy. Anaesthesia. 1986;11:252-3.
[440] Banazon D. The intensive care unit. Planning and experience. Acta Anaesthesiol Scand. 1966;23:75-9.
[441] Mason SA. The scope and organisation of an intensive therapy unit in a London Teaching Hospital. Acta Anaesthesiol Scand. 1966;23:117-22.

Intensive care in Wales 1963-1980

Cardiff

The development of adult intensive care in Wales began in Cardiff. Professor Emeritus Michael Rosen (1927 -) had qualified in medicine at University College, Dundee which was part of the University of St Andrews, in 1948. After various unsatisfactory junior posts in anaesthesia he was, in his own words ’rescued’ by Professor Edgar Pask in Newcastle (see Chapter 4). He was very well trained there and in 1957 he was appointed to a Senior Lecturer post in Cardiff. In an interview Rosen describes the halting progress towards intensive care in Wales. The hospitals in Cardiff were the Royal Infirmary and Llandough. Rosen described the difficulties of establishing intensive care from scratch.

> Rosen: It was an impossibility. I remember when it first started – I mean they were sporadically doing things on the wards, I was involved at various times with patients who had myasthenia gravis, we had them on a Radcliffe Ventilator and one of them actually spectacularly, when she had been pronounced by the neurologists as dead, recovered. She had as we now understand, an overdose of neostigmine ...She was a very rich woman of the shipping family. That was a good thing – this neurologist hated me forever. For getting it wrong. But that was a bit of luck. She didn’t need very long. She went 48, 72 hours and she breathed.
>
> To return to the 1960s. Sometime after this Llandough had a paediatric unit. We started with an intensive care unit; a sort of sporadic one, in 1965 or 66 in the Cardiff Royal Infirmary and they were doing something because I was involved in intensive care in children in Llandough – there was a paediatric unit there and we had one or two spectacular successes. A child with huge pupils and was ventilated for three or four weeks and he suddenly woke up and appeared to be perfectly normal – an encephalitis case. We had no idea what the Devil it was. We also did a few cases of tetanus...
>
> We had no outstanding man to start with. I was limited because I was interested in other things other fields, neurosurgical, obstetrics, pain... There was an arrangement of the senior lecturers in surgery, medicine and

> anaesthetics to be in charge of the intensive care unit in the Cardiff Royal Infirmary and this worked to some extent but one was a renal physician and the other was a surgeon who didn't take much interest in it and there was lack of direction and lack of appreciation that there was no way that you could manage intensive care unless somebody was in charge and the anaesthetist was the man who put them on to the ventilator but didn't look after the fluids etc it was the worst possible combination; a worldwide mistake.
>
> They also got off on the wrong foot at the Heath. [the Heath is the University Hospital of Wales which is in Heath Park, Cardiff.] They had a laisser faire approach to intensive care – whoever was on dealt with the patient. It never worked out. Eventually they moved it forward in the mid-seventies and Colin Wise came and he started intensive care at the Cardiff Royal Infirmary and that was a much better unit than the Heath.[442]

A retrospective account of the Department of Anaesthesia and Intensive Care Medicine at the University of Wales College of Medicine in Cardiff fills in some of the details of the development of intensive care in South Wales between 1947 and 1997.[443] The Intensive Care Unit (ICU) at the Cardiff Royal Infirmary was established under the control of three senior lecturers in medicine, surgery and anaesthetics. However it was not the only unit in Cardiff. In the late sixties the assisted respiration unit (ARU) was established at Llandough Hospital under the inspired leadership of Dr Hugh Dingle (a consultant anaesthetist). It was set up to cater for the long-term or medium term ventilation of patients in respiratory failure. Dingle set up one of the first patient retrieval services in this country, sending teams of doctors to bring patients from the hospitals in the valleys. This meant initiating treatment and resuscitation and stabilising patients in the local hospital before the long journey to Cardiff. The unit was staffed by a number of junior staff supported by the anaesthetic registrar and a consultant anaesthetist. There was also a research registrar permanently attached to the unit and supported by the Pneumoconiosis

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[442] Rosen M. Interview. August 2010.

[443] Weiner PC, Wise CC. Intensive care at the Royal Infirmary: a new era. In Essays on the first fifty years 1947-1997. Cardiff: Cardiff Department of anaesthetics and intensive care medicine. University of Wales College of Medicine; 1997. Pages 95-7.

Research Trust. This unit was purpose-built, properly staffed and got excellent results.

There was a small intensive care unit at Selly Oak hospital, which was the specialist chest, cardiac and cardiac surgical unit for the principality. It was poorly staffed by junior staff supported by a consultant cardiac surgeon and a consultant anaesthetist. It closed when cardiac surgery moved to the new University Hospital in 1972.

The small intensive care unit at Cardiff Royal Infirmary became the major unit in Cardiff and trained many intensive care physicians. However an account by Dr John Lunn gives a depressing account of the unit and particularly of its management.[444] Lunn was the senior lecturer who, with the senior lecturers in medicine and surgery, was in charge of the intensive care unit in Cardiff Royal Infirmary between 1967 and 1969. The arrangement was quickly abandoned and Lunn was left to run the unit almost alone. There were three or four beds. There was a nursing course but not always an adequate number of nurses. Medical cover 'out-of hours' was by an anaesthetist on call for obstetrics in an adjacent hospital. This was 'far from satisfactory and frankly a disgrace'.[445] The management of an intensive care unit by an academic turned out to be unsatisfactory. His autonomy was not accepted by colleagues, and his research was alleged by Professor William Mushin (1910-1993, Professor of Anaesthetics Welsh National School of Medicine University of Wales 1947- 75) to be neglected. The clinical care of the patients rested with the consultant under whose care the patient had initially been admitted and the anaesthetic input rested with whichever anaesthetist was on call when the patient was admitted. The anaesthetist was likely to have sessions at any or all of five local hospitals which meant that senior advice was frequently unavailable to the junior anaesthetist on-call.

In 1969 Dr Colin Wise was appointed to the consultant staff. He initially had no commitment to the unit but he had been involved in looking after intensive care patients in Birmingham and Cambridge. He was present in the hospital more often than the other consultants so he was consulted more. Gradually more staff were

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[444] Lunn JN. The Cardiff Department of Anaesthetics. – a balanced entity. In Essays on the first fifty years 1947-1997. Cardiff: Cardiff Department of anaesthetics and intensive care medicine. University of Wales College of Medicine; 1997. Pages 92-4.
[445] Lunn JN. The Cardiff Department of Anaesthetics 1997: 92.

appointed, the unit was given more space and more beds (seven of which six were normally available) and Wise was eventually given six sessions for intensive care. In 1980 a senior registrar was attached to the unit with the aim of providing at least six months of intensive acre training. This became a very popular training rotation and remained so at the date of the report (1997).[446]

There were no other intensive care units in South Wales. Rosen commented on this state of affairs: 'No. Swansea was pretty lousy. The North were better by a long chalk.'[447]

Wrexham, North Wales.

Dr Eleri Edwards provided information about the earliest intensive care unit in North Wales.[448] She confirmed that when she started the intensive care unit in Wrexham in 1967 there were no other units in Wales except those in Cardiff. Dr Eleri Edwards was born in Wrexham in 1937 and gained her medical degree from the University of Liverpool in 1960. She trained in anaesthesia in Gravesend, Kent and in Liverpool and became a registrar in Wrexham in 1965. She quickly started to practice intensive care, particularly for children, but was hampered by lack of equipment.

> Dr Edwards: As a registrar I probably I set up the kids' things first. I anaesthetised all the children - set up the kids' resuscitation and established being able to ventilate children.
>
> Interviewer: Because nobody had before?
>
> Dr Edwards: We not only didn't have an oscillotonometer, we didn't have an ECG, we didn't have an anaesthetic machine with a ventilator on it.
>
> Interviewer: Which year was that?
>
> Dr Edwards: 1965. The only ventilator there was the East Radcliffe which you couldn't do much with.
>
> Interviewer: Well certainly not for children.
>
> Dr Edwards: So I managed to get, to borrow, a Philips AV1 with all forms of ventilation and you could adapt it for children.

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[446] Lunn JN. The Cardiff Department of Anaesthetics; 1997. page 96
[447] Rosen M. Interview. August 2010.
[448] Edwards EM. Interview. June 2010.

When Dr Edwards's went to Wrexham there was a serious shortage of junior anaesthetic staff.

> ... because we were part of the Welsh Region all staff was controlled by the Welsh Medical Board, on which Mushin [Professor of Anaesthesia in Cardiff] sat. For what he felt were good reasons he felt that trainees could only be trained in the teaching hospital. Hospitals outside were service hospitals. [She described negotiations]. We eventually agreed that we would put the unfillable registrar post to one side (but I still had it) and I could have two SHOs [senior house officers, a grade lower than registrar]. We slowly set up a training programme. And they attended the Liverpool Course.[449]

The first post-operative facility in Wrexham was a recovery ward opened in 1968 in which patients could be nursed overnight. This was followed in the early seventies by a High Dependency Unit which doubled as an intensive care unit. The junior staff establishment increased as the training facilities became available and some nurses were sent for formal training in intensive care.

The Liverpool School

It is of interest that the biggest problem faced by Edwards in establishing intensive care in North Wales was the difficulty in obtaining junior anaesthetic staff, which was a consequence of the view held by the Welsh Office under the influence of Professor Mushin, that only Teaching Hospitals could run training programmes for junior specialists. This is in complete contrast to the view of Professor T C Gray (1913-2008. Professor of Anaesthesia, University of Liverpool 1959-1976) in Liverpool (36 miles from Wrexham, 45 minutes by road), who formed a partnership with the regional hospitals whereby the University was able to recruit SHO trainees of a high standard for the regional hospitals by offering them access to a training course if in return the hospitals would allow day release to enable the SHOs to attend lectures at the University. This policy attracted young doctors from all over the world to Liverpool; they gained a post in a local hospital and a place on the course and if they applied themselves, a universally recognised qualification (the Fellowship of the Faculty of Anaesthetists of the Royal College of Surgeons of England FFA, RCS). It

[449] Edwards EM. Interview. June 2010.

was because Edwards was able to gain access to the Liverpool Course for trainees from Wrexham that she was able to establish SHO and registrar posts in her hospital.

A pattern established

The development of intensive care in Wrexham was late in the growth period but it echoed what happened in many other hospitals during the 1960s and 1970s. First came a determined consultant, usually but not always an anaesthetist. Sometimes to a well equipped cardiothoracic surgical unit, but far more often to a general hospital. The hospital was often not a major centre; Edwards went to a hospital in a provincial Welsh town. Other early units were in non-teaching hospitals in Barnet, Kettering and Bournemouth. If the consultant was an anaesthetist he or she would be a full-time specialist trained according to the requirements of the Faculty of Anaesthetists and might well replace a sessional GP-anaesthetist, or be in a newly created post. The first task was to procure a ventilator and a suction apparatus and perhaps an ECG oscilloscope. The first patients were treated on general wards with the consultant coming in at the beginning of every shift to teach the nurses how to manage a ventilator.

The presence of this energetic young and recently trained consultant in the hospital was seen to offer training opportunities and junior anaesthetic staff were appointed. The consultant gained the confidence of colleagues in other specialties and referrals for intensive care increased. After a period, usually of a few years, the volume of work was such that the need for separate accommodation became evident to the hospital administration and particularly to the senior nurses. A space was found for conversion to a small intensive care unit. Subsequently a purpose-built intensive care unit was built. This pattern with some variation in specialist units was repeated throughout England and Wales. These first generation units created the early ‘body of knowledge’ of intensive care. This knowledge, and the satisfaction of being able to treat critically ill patients, was passed on to a new generation of trainee specialists. Some units offered a full-time secondment to intensive care (six months to a year) to senior registrars, many of whom went on to open intensive care units in the hospitals in which they became consultants. However their training had been by apprenticeship, there was no curriculum and intensive care was at best a subspecialty of their base specialty, usually anaesthetics, general or specialised medicine or, rarely, a surgical specialty. Intensive care in the 1960s has been described as the

work of 'local heroes', determined consultants or small groups of consultants who had to work hard to obtain the resources required to provide intensive care for their patients.[450] The development of intensive care or critical care medicine as an accredited specialty came later.

[450] Grant IS. Intensive care: The last 25 years. A personal view. Scottish Intensive Care Society Annual Scientific Meeting. 2011. Available at: http://scottishintensivecare.org.uk/meetings/Ian%20Grant%20INTENSIVE%20CARE%20The%20last%2025%20yr.pdf [Cited 11.11.2011].

Chapter 10. The influence of renal dialysis units and coronary care on intensive care

The earliest definitions of intensive care would have included coronary care and dialysis units as intensive care but they are excluded in more recent definitions, which would classify them as high dependency care.[451] However general intensive care includes techniques, knowledge and expertise developed in dialysis and coronary care units. Dialysis was first applied to patients who had acute renal failure which might be expected to recover within a few days if the patient was kept alive by one or two dialyses. With advances of technology it became applicable to patients with chronic renal failure whose life could be extended for many years. Occasionally patients receiving treatment on a renal dialysis unit would need IPPV to treat respiratory failure caused usually by pulmonary oedema or pneumonia. In the late 1960s and 1970s patients in the intensive care units were frequently suffering for multiple-system failure including renal failure. The development of techniques of renal dialysis which enabled it to be used in general intensive care will be described. The development of chronic renal failure units will not be discussed. Their development has been toward provision of dialysis in the patient's home. If patients with chronic renal failure develop respiratory or multi-system complications they are admitted to general intensive care units and are treated by techniques appropriate to acute renal failure.

Understanding of cardiovascular physiology had been necessary in intensive care since the first use of IPPV. It has been seen (chapter 3, page 49) that anxiety about the effect on the circulation of raising the pressure in the thorax had deterred anaesthetists from using IPPR. Andre Cournand had shown that with attention to the ratio of the inflation time to the deflation time the circulation could be protected. Later understanding of cardiac arrest would enable patients in intensive care units to be resuscitated after their hearts had stopped and enable intensive care staff to recognise warning signs which would avert such a catastrophe. This and the management of renal failure in general intensive care will be discussed in this chapter.

[451] Intensive Care Society. Standards for intensive care units. 1997

Renal dialysis and intensive care

The first artificial kidney to be used successfully in humans was invented by Willem Kolff (1911 - 2009) in Holland during the Second World War and it was first used in 1943. After the war Kolff went to Cleveland, Ohio and later to the University of Utah. He died at the age of 96 and the remarkable story of the invention of the artificial kidney is told in his obituary published in the *Daily Telegraph.*[452] Due to war-time shortages and restrictions during the German occupation of his country he had to utilise sausage skins and parts of a crashed German fighter and the cooling system of an old Ford car.

Dialysis is the movement of dissolved substances (solutes) from one solution in which the concentration of the solute is high, through a 'semi-permeable membrane' into another solution where the concentration is low. In renal failure where a machine is constructed to replace the failing kidney, the solution with a high concentration of solutes is the patient's blood, and the solution with a low concentration of solutes is a dialysis fluid in a bath, separated from the blood by a semi-permeable membrane. Semi-permeable means that the membrane will allow small molecules to pass through pores in the membrane but will not allow large molecules to pass through. In the case of Kolff's artificial kidney the patient's blood was taken through tubing to a bath where it passed through a tube of sausage skin (the semi permeable membrane) which was in a bath of fluid (the dialysis fluid or 'dialysate'). The substances which the patient's own kidney could not excrete (mainly urea and potassium) passed through the sausage skin into the dialysate and were washed down the drain. The main problems were the tendency of the blood to clot in the machine (the dialyser) and the low efficiency of this primitive dialyser in terms of removal of toxic solutes from the blood. Nevertheless, Kolff's kidneys were sufficiently effective to save several lives. The details of the dialyser and of the first successful dialysis is told by Ian Gordon, Eric Sherwood Jones and J van Noordwijk in an article in the *Journal of the Royal Society of Medicine* in 2000.[453] They

[452] Obituary. Willem Kolff. Daily Telegraph 2009;Feb 12
[453] Gordon IJ, van Noordwijk J, Sherwood Jones E. The first successful haemodialysis. J R Soc Med. 2000;93:266-8

acknowledged the help of Willem Kolff who was at that time aged 89 years. Somewhat disappointingly these authors wrote that the membrane in the first dialyser was cellophane, not the sausage skin described in Kolff's obituary cited above. Perhaps the story of the sausage skin is apocryphal?

When Kolff went to America one of his artificial kidneys which remained in Holland was donated to the British Post-graduate Medical School at Hammersmith in 1946 because the hospital was a reference centre for cases of renal failure after its wartime experience of 'crush syndrome', a syndrome of renal failure in people who were crushed in bombed buildings. But the dialyser proved less than successful: the first twelve cases treated by dialysis all died with the longest survival being fourteen days.[454] This unsatisfactory outcome could be attributed to several factors. An important limitation of the earliest dialysers was that although they were relatively efficient in restoring the chemical composition of the blood they could not remove excess water, so the circulation and the tissues became water-logged. Later machines removed water by a process of differential pressure across the dialysis membrane forcing water out of the circulation into the dialysate fluid (haemofiltration). A major limitation in the 1950s was the inability to dialyse for more than a short period – usually once and rarely more than three times. The only patients who would survive after dialysis were those in whom the cause of the renal failure could be expected to be temporary, so the kidneys would recover after they had been kept alive for a short time by one or two dialyses. 'Chronic dialysis' programmes, in which a patient in renal failure could be dialysed usually three times per week for years, in hospital or at home, would have to wait until the development of plastics allowed the introduction of shunts and fistulae.

Shunts are plastic tubes which are connected between a cannula inserted into an artery and another one inserted into a nearby vein. Between dialyses blood flows through the shunt from the artery and back into the vein. To start dialysis the shunt is disconnected and blood from the artery is directed into the input end of the dialyser and blood from the dialyser is returned to the venous cannula. At the end of dialysis the shunt is reconnected to the artery and the vein and blood flows through it until

[454] Bywaters EGL, Joekes AM. The artificial kidney: its application in the treatment of traumatic anuria. Proc R Soc Med. 1948;41:420-426

the next dialysis is required a few days later. This allowed dialysis to be performed regularly without repeatedly having to operate on an artery and a vein to connect the patient's circulation to the dialyser. The first shunt was described by Nils Alwall in Sweden in 1949. but their fully practical use had to wait for the introduction in the 1960s of plastics (Teflon and silastic) through which blood could flow for longer periods without clotting. [455, 456] However, even the plastic shunts did not last for more than a few weeks. In 1966 Drs James E Cimino and Michael J Brescia in the Calvary Hospital New York described a technique in which openings were made in the side of a small artery (the radial artery) at the wrist and in the side of an adjacent vein and the openings were stitched together so that blood could flow from the artery into the vein.[457, 458] The pressure in the blood flowing into the vein from the artery caused the vein to dilate, so it was easy to insert a needle into the vein to take blood to the dialyser for each dialysis session, the blood being returned to another vein by another needle puncture. Plastic was therefore eliminated altogether, the fistulae remained patent for long period and patients could be dialysed at home.

However for dialysis of patients admitted to an intensive care unit needing dialysis for acute renal failure more immediate access to the circulation was necessary. Intensive care staff were accustomed to cannulationg the large veins for monitoring the circulation or for intravenous nutrition. A double-lumen cannula was devised by which could be inserted into a major vein (usually the subclavian vein below the collar bone). These catheters have two channels (lumina) arranged on inside the other. Blood could be taken out of the vein through one channel and returned from the dialyser through the other one. For the relatively short time for which patients would be dialysed in the ICU clotting in the cannula could be prevented by filling it with anticoagulant when it was not in use for dialysis.

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[455] Alwall N, Norvitt L, Stein AM. On the artificial kidney. Acta Med Scand. 1949;132:587-602.

[456] Quinton W, Dillard D, Scribner BH. Cannulation of blood vessels for prolonged haemodialysis. T Am Soc Art Int Org. 1960;6:104-13.

[457] Brescia MJ, Cimino JE., Appel K, Hurwich BJ. Chronic hemodialysis using venipuncture and a surgically created arterio-venous fistula. New Engl J Med. 1966;275:1089-92.

[458] Cimino JE, Brescia MJ. The early development of the arterio-venous fistula needle technique for hemodialysis. ASAIO J. 1994;40:923-927.

Several variations of dialysis and haemofiltration are used in general intensive care units.[459] The technical details and differences between them are beyond the scope of this thesis; they did not materially affect the development of intensive care, but the ability of intensivists to use one or other of these modalities greatly extended their ability to treat multiple renal failure effectively. A multinational study found that acute renal failure (ARF) in adult intensive care units affects at least 5-6 percent of all ICU admissions.[460] In a study conducted in 40 centres in 16 countries by the European Society of Intensive Care Medicine the mortality was found to be 43 percent. [461] It was three times higher in patients with ARF than in patients in ICU without it. An inquiry in 2008 into the use of different methods of treating renal failure in 303 British ICUs found that 269 units provide renal replacement therapy. The most frequently used method (65%) was continuous veno-venous haemofiltration. It was used as first-line therapy in the majority of patients.[462] A single double lumen catheter is inserted into a central vein (a procedure demanding considerable skill). The preferred veins are the internal jugular or, for the less skilful, the femoral vein. Haemofiltration requires that the blood is passed through the dialyser at a high enough pressure to force water out of the blood. The pressure of blood coming from a vein to the dialyser would not be sufficient so a pump is inserted into the line between the cannula and the dialyser. The blood is returned to the patient via the second lumen. Although the mortality of ICU patients with ARF is high, recovery of renal function in survivors is over 70 percent.

Although the commonest renal failure in ICUs is acute renal injury (ARI) it is sometimes necessary to admit patients with chronic renal failure, either from a home dialysis programme or from a renal dialysis unit. David Blair, staff nurse of the ICU

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[459] Ghossein C, Grouper S, Soong W. Renal replacement therapy in the intensive care unit. Int Anesthesiol Clin. 2009;47:15-24.
[460] Uchino S, Kellum JA, Bellomo R et al. Beginning and ending supporting therapy for the kidney. Acute renal failure multinational study. JAMA. 2005;294:813-8.
[461] De Nendonca A, Vincent JL, Suter PM et al. Acute renal failure in the ICU. Risk factors and outcome evaluated by the SOFA score. Intensive Care Med. 2000;26:915-21.
[462] Gatward JJ, Gibbon GJ, Wrathall G. Renal replacement therapy for acute renal failure: a survey of practice in adult intensive care units in the United Kingdom. Anaesthesia. 2008;63:959-66.

at the Royal Liverpool University Hospital, described the methods of management of renal failure in the unit:

> Interviewer: What methods of dialysis do you use?
>
> Blair: Well we still use dialysis quite a lot and especially on patients who have CKD, chronic kidney disease rather than acute renal failure, so when they come here and they are on regular dialysis we carry on. They will already have a shunt or an A-V fistula and central lines.
>
> Interviewer: And acute renal failure?
>
> Blair: Acute renal failure is somewhat different. It depends what support they are on, if they are on inotropes...To take a certain amount of fluid off someone in a short time from a cardiovascular point of view is a nightmare and very very dangerous so we either do SCUFFY which is slow continuous ultrafiltration or haemofiltration over a continuous period ...
>
> Interviewer: Slow continuous means 24 hours day after day?
>
> Blair: Yes.
>
> Interviewer: Do many units dialyse chronics?
>
> Blair: We do. I think we are a rare breed but I don't really know. I have not worked in other units. Dialysis machines have to be plumbed in of course. In our new unit every bed can do dialysis or HF. HF is a free standing unit and it doesn't require pumped water but every bed space on the new side of the unit has input and outlet for water and a softener. In fact in one section of the unit we have a softener which serves all the spaces. [463]

Blair's suggestion that the availability of facilities for use of intermittent dialysis is unusual is substantiated by the findings of the survey of practice in renal replacement therapy in UK ICUs.[464] The survey was conducted in 2007 by post and telephone. Out of 306 units questions 303 replied. 89 percent provided renal replacement therapy for acute renal failure but 243 (90 percent) do not use intermittent haemodialysis.

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[463] Inotropes are drugs to improve cardiac output. They also affect the resistance in the blood vessels and are used in conjunction with transfusion to treat some types of shock.
[464] Gatward JJ, Gibbon GJ, Wrathall G. Renal replacement therapy 2008.

Cardiac intensive care in the ICU

'Cardiac arrest' occurs in all animals as they die, but for many years it has been possible and ethically acceptable to restart the heart if there is a reasonable possibility of a return to an acceptable quality of life. This is frequently the case in patients in ICUs. Physicians had been investigating the possibility of restarting the hearts of the apparently dead since in 1935 Carl John Wiggers (1883-1963) restarted by electric 'countershock' the circulation in animals whose hearts had been stopped by occlusion of the coronary arteries.[465] He pressed on the hearts rhythmically to expel the blood (the heart having one-way valves to allow the blood to be squeezed out into the arterial system and prevent it going back into the veins) and by this method was able to maintain an adequate circulation to oxygenate the heart muscle. The heart then responded to electric shocks by returning to a normal rhythm.

To understand further developments in the history of treating 'cardiac arrests' it is necessary to understand the pathology of cardiac arrest: what actually happens. A cardiac arrest is the cessation of the normal beating of the heart. The heart muscle can simply stop contracting (asystole) so no blood is pumped round the body, or the muscle may 'fibrillate', that is the contraction of each bundle of muscle fibres is uncoordinated with the contractions of the others. The muscle in the atrium, the chambers which receive the blood from the veins, can (and in many people does) fibrillate without stopping the circulation. But fibrillation of the much thicker muscle of the ventricles, the chambers which pump the blood round the body, is fatal. So cardiac arrest may be due to asystole or ventricular fibrillation. The patient or animal will become unconscious as there is no circulation of the blood to carry blood to the brain. If the circulation is stopped for more than about four minutes the brain will be irretrievably damaged, in particular the lower part of the brain: the brain stem. This carries the centres controlling the circulation and respiration and without them the person cannot survive. This is called 'brain death' and further treatment is futile. In order to reverse cardiac arrest several conditions must be met:

[465] Wiggers CJ. Cardiac massage followed by countershock in revival of mammalian ventricles from fibrillation due to coronary occlusion. Am J Physiol 1936;116:161-2.

> The circulation must be restored before brain damage occurs. The brain is damaged more quickly than any other organ, in about four minutes.
> The circulation must be artificially maintained until the heart can be started again.
> There must be means of starting the heart if it is in asystole.
> There must be means of restoring a useful rhythm if the heart is in ventricular fibrillation.

These conditions were tackled one by one in the years between 1930 and 1969. After Wiggers' work in animals in the 1930s the first advance was the demonstration of restarting a heart which could be touched and treated because the thorax was opened in the operating theatre. In 1947 Claude S Beck (1894-1971) at the Western Reserve Hospital in Cleveland, Ohio published with colleagues a paper headed 'Ventricular fibrillation of long duration abolished by electric shock.'[466] The paper described the case of a boy of 14 who was operated on to repair a deformity of the chest wall which was compressing his lung and impairing his breathing. 'During the closure of the chest wound the pulse suddenly stopped and the blood pressure sounds could not be heard. The patient was apparently dead. The wound was reopened and cardiac massage was initiated.' At the end of this time the electrocardiogram (ECG) tracing showed a pattern characteristic of ventricular fibrillation. An electric shock was given by electrodes placed actually on the heart. After a series of shocks the heart started to beat, weakly at first but with increasing strength. The operation was completed, the boy responded rationally to questions and after eight hours he was awake and alert.

The big 'breakthrough' which opened cardiac resuscitation to non-surgeons, and even to non-doctors was the description first of 'closed chest' defibrillation and then of closed-chest cardiac massage. Paul M Zoll (1911-1999) Assistant Professor of Medicine, Harvard Medical School and his research assistants and associates described in 1956 termination of ventricular fibrillation by *externally applied* electric

[466] Beck CS, Pritchard WH, Feil HS. Ventricular fibrillation of long duration abolished by electrical shock. JAMA. 1947;135:985-6.

shock.[467] In 1960 closed chest cardiac massage was described by William Bennett Kouwenhoven (1886-1975), an electrical engineer and lecturer in surgery at Johns Hopkins University School of Medicine, Baltimore, Massachusetts and his associates. Circulation could be maintained by cardiac massage until a defibrillator and ECG machine could be brought to the site of the cardiac arrest and the defibrillation shocks could be applied, all without opening the chest. In a summary of their paper they wrote: 'Anyone, anywhere, can now initiate cardiac resuscitative procedures. All that is needed are two hands.' Of particular relevance to the history of the development of intensive care was that after 1956 'anyone and anywhere' included the staff in an intensive care unit who could now restart arrested hearts.

The success of closed chest cardiac resuscitation stimulated the creation of coronary care units worldwide but they will not be discussed further because they did not directly contribute to the development of intensive care. However the techniques of restarting the heart which came to be known as cardiopulmonary resuscitation (CPR) have been an important part of the armamentarium of all intensive care units. The possibility of restarting the heart has led to successive generations of increasingly sophisticated cardiac and circulation monitors which have become, with lung ventilators, iconic in the popular ideas of intensive care units. 'At any one time a patient may be hooked up to up to a dozen pieces of equipment; heart monitor, machines to measure the concentration of gases in the blood and the blood pressure.'[468] Cardiac monitoring in intensive care units is not primarily used to detect cardiac arrest but to recognise dangerous arrhythmias which would, if left untreated, lead to cardiac arrest. In an interview David Blair said: 'A good ITU nurse will see when things are going wrong a long time before they do. That's why you don't get so many arrests on intensive care because we see it happening and prevent it.' Because of this ability to detect arrhythmias, unexpected cardiac arrest is relatively uncommon in ICUs. This is particularly important because, probably because of their concomitant system weaknesses, only eight percent of patients who arrest in an ICU survive to leave hospital.[469] However monitoring of the circulation is not simply the

[467] Zoll PM, Linenthall AJ, Gibson W et al. N Engl J Med. Termination of ventricular fibrillation in man by externally applied electric countershock. 1956;254:727-32.
[468] Le Fanu J. The rise and fall of modern medicine. London: Little Brown; 1999 p. 72.
[469] Jianmin T, Kaufman DA, Zarich S et al. Outcomes of critically ill patients who received

monitoring of an electrocardiogram to detect arrhythmias. Nearly every major illness has an effect on the heart or the peripheral circulation or both. Replacement of blood lost in surgery or trauma is not simply a matter of measuring the amount of blood lost (when, rarely, this is possible). Blood is replaced together with other intravenous fluids such as saline, Hartmann's solution and blood products until the cardiac output is restored to normal or a target value. In conditions such as coronary thrombosis with sometimes cardiogenic shock or pulmonary oedema (escape of fluid from the blood into the lungs) the pressures in the various chambers of the heart have to be measured and regulated.

In the early 1970s long plastic tubes (pulmonary artery flotation or 'Swan-Ganz' catheters) were developed.[470] These tubes had at their tip a balloon. The tube with the balloon deflated is inserted into a peripheral vein. Then it is passed forward into the large veins near the heart. There the balloon is inflated and the catheter tip is carried by the circulation through the right atrium and ventricle and into the pulmonary artery. The ability to measure the pressure in both the great veins and in the pulmonary artery (where the pressure reflects the pressure in the left atrium) has enabled intensivists to understand the cardiovascular pathology in sepsis.[471] It was found that in contrast to shock caused by blood loss, when the cardiac output is depressed and the peripheral arteries are constricted, in severe sepsis the cardiac output is high but the blood pressure is low because the arteries are widely dilated. This understanding has enabled intensivists to assess the need to administer drugs and fluid to patients in sepsis to constrict the dilated arteries in order to provide an adequate filtration pressure for the kidneys to enable them to produce urine and also to improve the output of the heart so as to provide an adequate blood flow for the other organs, particularly the brain. This physiological knowledge and the technology to apply it was first gained from studies in cardiac units and laboratories and then applied to general medicine, surgery and trauma by specialists in intensive care.

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cardiopulmonary resuscitation. Am J Respir Crit Care Med. 2010;182:501-6.

[470] Swan HJ, Ganz W, Forrester J, Marcus H, Diamond G, Chonette D. Catheterization of the heart in man with use of a flow-directed balloon-tipped catheter. N Engl J Med. 1970;283:447–51.

[471] Cournand A et al. Studies of the circulation in clinical shock. Surgery. 1943;13:964-965.

Chapter 11. Specialisation of intensive care medicine

The first discussions about the possibility that intensive care medicine would develop into an independent specialty were somewhat tentative. In 1967 Andrew Hunter (1915-1991) consultant anaesthetist and reader in pharmacology, University of Manchester wrote a *Lancet* article titled 'Intensive Care as a specialty'. His opinion was that 'intensive care requires a multitude of disciplines. The disciplines are too widely dispersed for a single individual to become competent in them all.'[472]

In the following year there was a meeting about intensive care units in the Section of Anaesthetics in the Royal Society of Medicine in London. The session was opened by Professor Anthony (Tony) Dornhorst (1915-2003), Professor of Medicine at St George's Hospital, London from 1959-80. Dornhorst was described in *Munk's Roll* (the biographies of members of the Royal College of Physicians) as one of the outstanding academic clinician-scientists of his generation.[473] He was however, though noted for using novel approaches to solve problems, not impressed with intensive care units. 'Physicians tend to be unimpressed with the published descriptions of units and their working'. He criticised the naive idea that survival in an ICU was equivalent to a life saved (it had to be shown that the life was truly at risk or could not have been saved by a competent physician elsewhere). He asked 'Should specialisation be in terms of the apparatus employed or of the dominant category of disorder affecting the patient? He maintained that anyone who needed it could master a new technique, citing the use of peritoneal dialysis in general medical wards. Thus the right person to treat respiratory failure complicating lung disease is a chest physician, not a respirator expert.'[474]

Anaesthetists were not simply respirator experts but were by 1966 recognised experts in respiratory and cardiovascular physiology and had successfully applied their expertise to the management of acute respiratory failure in many pathological conditions. John Robinson, Professor of Anaesthesia in the University of Birmingham reiterated the then-current definition of intensive therapy: the mechanical support of a vital function until the disease process is corrected or ameliorated. He stressed that:

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[472] Hunter AR. Intensive care as a speciality. Lancet. 1967;2:1151.
[473] Royal College of Physicians. Munk's Roll. 1998-2004;11:63.
[474] Dornhorst AC. Intensive care units. Proc R Soc Med. 1966;59:1293.

> Patients in need of this [mechanical support] seldom suffer from derangement of one system; respiratory failure is often associated with renal impairment; cardio-genic shock following infarction may bring both renal and pulmonary ventilation-perfusion defects. These patients require complex electronic and mechanical equipment, but more important is the requirement for sufficient staff with the knowledge and skill to use the equipment to optimal effect. Such patients can no longer be treated in conventional specialist wards of the hospital nor can they be nursed in side-rooms of the general wards by nurses who have infrequent experience in the use of the equipment. They have a much greater chance of survival when treatment is undertaken by a team of medical and nursing staff working in adequate space and with the necessary skill, experience and apparatus.[475]

Dornhorst was sceptical of medical specialisation in the treatment of the critically ill. He thought the medical specialist who had experience and understanding of the disease should treat the patient. Robinson was maintaining that such specialists should not treat such patients in their own ill-equipped wards and with inexperienced nurses. The description by Boulton of the inadequate treatment by physicians with little understanding of the use of respirators of patients with bulbo-spinal polio supports Robinson's contention. But Dewhurst's emphasis on the need for those treating respiratory failure to have a deep knowledge of the disease was also justified. It will be seen later in this chapter that a new specialty emerged in which physicians and nurses treating critical illness must be trained in both the physio-pathology of critical illness and the means of treating it.

The need for specially equipped areas of the hospital (units) with specially trained staff was quickly recognised. The first units were opened in England in the late 1950s (Chapter 8). The emergence of a specialist branch of medicine to treat patients needing intensive care took much longer. In 1969 William Mushin and John Lunn wrote that they were unable to accept the notion that the care of patients in intensive care units constitutes a new specialty of medicine 'to which some have already given the name of intensivism. Since the intensivist's experience of any one part of medicine is necessarily limited to the acutely ill he cannot be regarded as a specialist in that entire section of medicine. His knowledge, although it may be broad

[475] Robinson JS. In Intensive Care units. Proc R Soc Med. 1966;59:1293.

in extent, is invariably limited in depth. This is not a satisfactory basis for the appellation of specialist.' [476] They also felt that the anaesthetist could not be in two places at once; if (s)he is in the operating theatre (s)he could not be in the intensive care unit. They pointed out that there was a shortage of anaesthetists. It was important for them to examine very carefully every new demand for their services. So in their view, intensive care was not a specialty and anaesthetists should not get involved at the expense of their anaesthetic practice. In another article Lunn said that when as a senior lecturer in anaesthesia he was left to run the intensive care unit at Cardiff Royal Infirmary almost on his own, his professor complained that Lunn's anaesthetic research was neglected.[477]

The rapid expansion of intensive care in England and Wales in the 1960s had given rise to these discussions, but no national consensus was reached. As a later paper from the Intensive Care Society stated: nearly every aspect of intensive care has developed as a reactive response to clinical pressures rather than a logical expansion or extension of a service following estimates of future need or changing workload.[478] Units were directed and staffed by whoever had the energy and enthusiasm to do so, irrespective of specialty. In fact the majority of units were run and staffed by anaesthetists, sometimes with collaborators from other specialties.[479]

Training in intensive care medicine

The Intensive Care Society (ICS) was founded in 1970 following an initiative by Alan Gilston (1926-2005). The Society's regulations originally stated that not less than 20 percent of members should be from specialties other than anaesthesia. In 1981 seventy percent were anaesthetists, the remainder being from a wide variety of medical specialties and their subdivisions including internal medicine, surgery, paediatrics, clinical physiology and many others.[480] The Society publishes its

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[476] Mushin WW, Lunn JN. The anaesthetist and intensive care. Br Med J. 1969;Jun 14:683-4.
[477] Lunn JN. The Cardiff Department of Anaesthetics. – a balanced entity. In Essays on the first fifty years 1947-1997. Cardiff: Cardiff Department of anaesthetics and intensive care medicine. University of Wales College of Medicine; 1997. Pages 92-4.
[478] Intensive Care Society. 2003. Evolution of Intensive Care in the UK. Available at http://www.ics.ac.uk/intensive_care_professional/standards_and_guidelines/evolution_of_intensive_care_2003. Accessed May 2011
[479] Stoddart JC. National ITU audit 1992-3. London: Royal College of Anaesthetists; 1993.
[480] Gilston A. Intensive care in England and Wales. A survey of current practice, training and attitudes. Anaesthesia. 1981;36:88-93.

Journal, organises meetings and publishes guidelines and standards for equipment and clinical practice. Gilston was secretary-general and initiator of the first World Congress on Intensive Care (1973), and founder, president and secretary-general of the World Federation of Societies of Intensive and Critical Care. He emphasized that the Federation embraced all Societies including single specialty as well as multi-specialist societies. In 1981 a questionnaire was sent to all members of the Society who worked in England and Wales. The results showed that although training in anaesthesia was of a high standard, training in intensive care seemed haphazard and unsatisfactory.

Sheila Willatts, director of intensive care at Bristol Royal Infirmary realised that anaesthetists, although adept at using the techniques required in intensive care medicine, were not widely experienced in general medicine and particularly in diagnosis. She studied for and achieved Membership of the Royal College of Physicians in addition to the Fellowship of the Faculty of Anaesthetists in the Royal College of Surgeons (later the Fellowship of the Royal College of Anaesthetists). The regulations allowed the examinations for the Membership to be taken after one year as a medical registrar. Another year of training in addition to the seven post-registration years required for accreditation as a specialist in anaesthesia deterred most anaesthetists but Willatts was not unique in achieving this double qualification.[481] Willatts said in an interview: 'It was the best thing that I ever did. Intensive care is about "doctoring" at the sharp end and it's not really about technology.'[482]

Willatts and others realised that the body of knowledge required for the practice of intensive care medicine was not encompassed in the training programme of any existing specialty. In 1983 a survey was conducted of trainees on training in intensive care.[483] Because the Department of Health and Social Security did not at that time recognise intensive therapy as a separate specialty, no specialist advisory committee existed and there was no recognised training available for doctors. To obtain the views of trainees in intensive care it was necessary to approach trainees

[481] Another known example is Margaret Branthwaite MD, FRCP, FFARCS, Formerly Consultant Physician and Anaesthetist, Royal Brompton Hospital, London and Barrister, Lincoln's Inn.
[482] Willatts SM. Interview. April 2011.
[483] Hillman K, Hinds CJ, Willatts SM. Training in intensive care. A questionnaire to trainees. Anaesthesia. 1983;38:540-5.

(senior registrars (SRs)) in anaesthesia and general medicine. Questionnaires were sent to 343 anaesthetic SRs and 113 were returned. They were also sent to 262 medical SRs and 55 were returned. The low rate of return may have been because many anaesthetic and medical SRs had neither interest nor training in intensive care. The survey showed that of those who responded seventy eight percent of anaesthetists and fifty-one percent of physicians hoped to practise in their parent specialty with an interest in intensive therapy. A sizeable minority had no such interest. The majority of SRs thought that intensive therapy should be a specialty in its own right. The majority in both specialties thought that training should be part of higher professional training and that a period of training in the reciprocal specialty was important. Most respondents thought that training should be more than one year for those hoping to practise their parent specialty with an interest in intensive care and two or more years for prospective full time specialists. Only twenty percent of medical registrars and nine percent of medical senior registrars thought training was adequate whereas 45 percent of anaesthetist trainees in both grades considered their training adequate.

Alan Gilston announced in 1983:

> The time for complacency is over. No longer can we assume that an anaesthetist's training automatically justifies his continued domination of intensive care in this country, despite his vital role in this work and his outstanding contributions to its development.' He described the problems of intensive care in the UK as 'the explosive and uncontrolled growth in the number of units in the past few years; their haphazard staffing structure; the absence of generally accepted standards of good practice and organisation; the lack of a specially designed training programme for this type of work; the dearth of full-time training posts; the fragmentation of intensive care into highly specialised subdivisions, each jealously guarded by physicians of the relevant specialty; and not least, the virtual absence of a career structure for the aspiring specialist in this field.[484]

The first sign of an attempt to remedy at least one of the deficiencies in this depressing list was contained in an address by Dr John Nunn to the Faculty of Anaesthetists (of the Royal College of Surgeons) on 17 March 1982 as he demitted

[484] Gilston A. Editorial. Anaesthesia. 1983;38:211-13

the presidency of the Faculty. He said that the Faculty had been concerned with the matter of training in intensive therapy. The fact that that this branch of medicine is multi-disciplinary contributes to its strength but it also means that intensive therapy units tend to lie outside the competence of any single Faculty or College acting on its own to inspect and recognise units for training or, indeed, to formulate criteria for recognition for training. The Faculty had recently instigated a debate on this problem at the Conference of Medical Royal Colleges and their Faculties. A working party had been formed and it comprised representatives of the Faculty of Anaesthetists, the Surgical Colleges, the Colleges of Physicians and the Intensive Care Society. The first meeting would take place that spring.[485]

The first report of the group (by then called the Liaison Group) was accepted by the UK Conference of Royal Colleges and Faculties in January 1985.[486] The remit of the group had been to establish a training programme for intensive therapy and to identify posts at Senior Registrar level where this training could be undertaken. The report did not recommend the emergence of the 'Intensivist' as a separate specialist but considered that consultants with a special interest in intensive therapy should also pursue a clinical career in their parent specialty. Training in intensive care would be additional to that required for accreditation in the parent specialty. The duration of training would normally be a minimum of seven years. Following the first report the Liaison Group considered the provision of a more detailed training scheme. A working party was established with two representatives from the Liaison Group, two from the Intensive Care Society and three members with expertise in special aspects (paediatrics, trauma and neurosurgery). Some changes were made to the first report. The Liaison Group requested submissions by regional deans of proposals for pilot training schemes. It also asked the Joint Planning Advisory Committee (JPAC), for the creation of a small number of additional training posts.[487]

In 1988 the Joint Accreditation Committee for Training in Intensive Therapy (JACIT) was formed by the Faculty of Anaesthetists and the Royal Colleges of

[485] Nunn JF. Faculty of Anaesthetists annual general meeting 17 March 1882. Address by the Dean. Ann R Coll Sur Engl. 1982;64 (3):209-12
[486] Inter-faculty/collegiate liaison group on intensive therapy. Ann R Coll Surg Engl. 1987; 69 (No 4 suppl.):7.
[487] Inter-faculty/Collegiate liaison group on intensive therapy: 7

Physicians and Surgeons to review training in intensive care medicine.[488] Training posts consisting of up to two years training, post-accreditation (i.e. after completion of training in a parent specialty) were established in 14 centres.

In 1992 an Intercollegiate Body for Training in Intensive Care Medicine (IBTICM) was formed to develop a training programme which would be incorporated within the parent specialty training, as opposed to following that training. Sheila Willatts in an interview paid tribute to the President of The College of Anaesthetists at that time:

> I think some tribute should be paid to Cedric [Cedric Prys Roberts, President of the Royal College of Anaesthetists, (RCoA) 1994-97] for instigating this would be in order, because we then stalled with the next president, (Leo Strunin President RCoA 1997-2000) who was very anxious; he really did not want this new specialty to emerge, he wanted to keep anaesthetists for anaesthesia, not to look more broadly. We fell out on that and I resigned from College Council at that time, but things moved on because there was such a ground swell.[489]

Recognition by the Department of Health of intensive care medicine as a specialty was achieved in 1999 and a 'competency-based training programme' was developed. It comprised three months of basic training, six months intermediate and twelve months advanced training. These blocks could be taken at different stages of training in the parent specialty. In addition, those whose parent specialty was anaesthesia would be required to undertake a minimum of six months training in medicine, and those whose training was in medicine would have to have at least six months training in anaesthesia. Surgeons would have to complete both supplementary training periods. After this training trainees would receive a Joint Certificate of Completion of Training (CCT) in a base specialty and in intensive care medicine. In 2011 the Faculty of Intensive Care Medicine developed a stand-alone CCT in intensive care medicine where the training was *ab initio* in that specialty without the need for training in a 'parent' specialty. To be a specialist in intensive care medicine one no

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[488] Faculty of Intensive Care Medicine. Curriculum for a CCT in critical care medicine (3rd ed.) Available at:http://www.ficm.ac.uk/_assets/pdf/the_cct/2011%20cct%20in%20icm%20part%20i%20-%20handbook%20(cd).pdf accessed May 2011

[489] Willatts SM. Interview. March 2011

longer needs to train in anaesthesia, medicine or surgery. The training in intensive care medicine embodies the necessary elements of all those older specialties.

Intensive care medicine as a specialty

In the early years of intensive care, units were small, as were the numbers of patients they treated. Training of junior doctors was by apprenticeship; they obtained a post which included work in a unit and they were taught in an *ad hoc* manner which depended largely on the availability of a consultant to teach them and on the type of patients admitted to the unit. The consultant would be someone who had taken an interest in intensive care and had gained expertise through experience and, after the first few years, might have worked in some sort of an intensive care unit during their training. The consultant would have no designated sessions for intensive care, which was not recognised by the Department of Health as a separate specialty.

For a specialty of intensive care medicine to be recognised in Britain the Department of Health had to be convinced of the effectiveness of intensive care, would need to distinguish practitioners of intensive care medicine from other practitioners and there had to be criteria which would identify specialists in this field.

In 1981 William A Knaus and colleagues at the George Washington University Medical Centre, Washington DC described the Acute Physiological and Chronic Health Evaluation Score (APACHE). Clinical data could be entered on the patient's admission to the ICU into a scoring system which could be used to compare case-mix and outcomes and evaluate new therapies.[490] The Apache system was developed to a refined version, APACHE II and then further refined in the UK by the Intensive Care National Audit and Research Centre (ICNARC) established in 1994.[491] The results of their studies have resulted in standardised methods of treatment and criteria for admission to ICUs and by identifying the predicted probability of survival of different groups of patients, effectiveness of individual ICUs can be evaluated by comparing their actual survival rates with the predicted probability.

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[490] Knaus WA, Zimmerman JE, Douglas PW, Draper EA, Lawrence DE. APACHE - Acute physiological and chronic health evaluation: A physiologically based classification system. Crit Care Med. 1981;9:591-7.

[491] Young JD, Godfrad G, Rowan K. Development and testing of a hierarchal method to code the reason for admission to intensive care units: The ICNARC coding method. Br J Anaesth. 2001;87:543-8.

In 1995 a ten-year old boy died while being transferred from one hospital to another in search of an ICU bed. This led to intense media interest and questions in the House of Commons.[492] Shortage of ICU beds during an influenza epidemic in 1999 was the cause of an investigation by the Audit Commission. The Commission came to the conclusion that 'the development of intensive care has been unplanned and haphazard and has largely relied on the local interest of local clinicians to develop it.' Wide variations in effectiveness and rising costs were revealed. To improve the situation an expert group was convened 'to produce a framework which is evidence-based (or based on a clear professional consensus) and which sets out operational standards for staffing and transfer levels in ICU and HDU and which makes recommendations about the level, configuration, mix and provision of general adult and neurological ICU and HDU services.' *Comprehensive Critical Care* published by the Department of Health in 2000 contained 29 recommendations for the modernisation of critical care services.[493] £142.4 million was made available for the enhancement of adult critical care services.[494] This was the first planned investment in intensive care since its inception.[495]

At the time of the Audit Commission's review in 1999 there had been 449 ICUs in England and Wales. Many were specialist ICUs but 128 were general ICUs and 83 were general ICUs combined with an HDU. There was a total bed complement of about 1400. Following the recommendations of *Comprehensive Critical Care* and the injection of funds there were, by January 2002, 1700 ICU beds and 1319 HDU beds. Intensive care units had increased in size.[496, 497] The ICU in the Royal Liverpool University Hospital in 2011 has 19 ICU beds and 10 associated HDU beds, a trebling in size since 1991. The medical staffing of intensive care units has also changed. Consultants practising intensive care as a side-line while being paid only for their parent specialty have been replaced by specialists with some or all

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[492] Crocker C. The development of critical care in England. Intensive Crit Care Nurs. 2007;33:323-30.
[493] Department of Health. Comprehensive Critical Care: A review of adult critical care services. London: HMSO; 2000.
[494] Intensive care Society. Evolution of intensive care in the UK. 2003.
[495] Crocker C. The development of critical care. 2007.
[496] Comprehensive Critical Care: A review of adult critical care services. London: Department of Health; May 2000. Available at www.doh.uk/nhsexec/compcritcare.htm Accessed May 2011.
[497] Intensive Care Society 2003. Evolution of intensive care in the UK.

of their sessions designated as for intensive care. By 1998 CCUs were directed or led by a consultant with designated daytime sessions in 96 percent of ICUs and 80 percent of combined ICU/HDUs. The median number of daytime weekly consultant sessions on ICUs was ten.[498]

Formal recognition of intensive care medicine as a specialty in the United Kingdom was announced in a surprisingly low-key way. Statutory instruments 1999 no. 1373: The European Specialist Medical Qualifications Amendment Regulations 1999 contained a list of 15 medical specialties. At the end of the list were the words: '(4) In Part II of Schedule 2– in the appropriate alphabetical positions, insert "Allergy" and "Intensive care medicine'.[499] The amended Regulation was signed by Frank Dobson, one of Her Majesty's Principal Secretaries of State, Health.

The inclusion of intensive care medicine as a specialty in the UK in an amendment to an existing UK regulation (the European Specialist Qualifications Regulation) perhaps requires explanation. The relation of UK law on medical qualifications to EU law is complex.[500] Within the European Union (EU) the organisation and delivery of health services and medical care is a fundamental responsibility of each member state (MS), a principle known as subsidiarity. However there are advantages in harmonising medical educational requirements. A large number of physicians from continental Europe now work in the UK and standardisation of educational standards across Europe is obviously necessary for the safety of patients in Britain. When a European regulation is amended it is generally only necessary to amend existing national regulations rather than make new legislation altogether.[501]

An editorial in the *British Medical Journal* stated that 'Recognition of intensive care medicine not only transforms its transition from amateur to professional status but also lays the foundations for proper development of the specialty.'[502] The development followed quickly. Following the amendment to the

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[498] Intensive Care Society 2003. Evolution of intensive care in the UK.
[499] Dobson F. Statuary instruments. Medical profession. The European specialist medical qualifications amendment qualifications 1999;No. 73:1-3.
[500] Rhodes A, Chiche J, Moreno RP. Improving the quality of training programs in intensive care: a view from the ESICM. Intensive Care Med. 2011;37:377-9.
[501] Jones T. How UK adopts EU laws. BBC News Channel 21 July 2009 available at http://news.bbc.co.uk/1/hi/world/europe/8160808.stm Accessed May 2011.
[502] Soni N, Wincoll D. Intensive Care Medicine has come of age. Br Med J. 1999;31:271-2.

regulation by the Minister of State the Special Training Authority of the Medical Royal Colleges asked for a competency-based training programme. This was constructed and approved in February 2001. In 2009 the Royal College of Anaesthetists endorsed the proposal to establish an intercollegiate Faculty of Intensive Care Medicine

The establishment of the Faculty of Intensive Care Medicine of the United Kingdom was announced by the Presidents of the collaborating Medical Royal Colleges on the 7 May 2010. The listed Colleges were; The Royal College of Anaesthetists, The College of Emergency Medicine, The Royal College of Physicians of Edinburgh, The Royal College of Physicians, The Royal College of Physicians and Surgeons of Glasgow, The Royal College of Surgeons of Edinburgh, The Royal College of Surgeons of England. The collaboration of so many medical Royal Colleges represents an unprecedented triumph of diplomacy, common purpose and goodwill. In March 2011 the General Medical Council approved the primary specialty training programme for Intensive Care medicine and in August of the same year the programme was implemented.

Chapter 12. The development of the nursing profession and the specialisation of intensive care nursing

The definition of a specialty of intensive care nurses has been part of a generalised movement to provide a career structure in which hospital nurses can progress from a student to a post-registration post and onwards to administrative and organisational posts whilst gaining education and training appropriate to their responsibilities at each professional level. Nursing has been long been recognised as a profession. It has been characterised by the skills of nurses, their special training and its self-regulation by the Royal College of Nursing, which was founded in 1916 and received its Royal Charter in 1926. The last half of the twentieth century has seen a concerted movement towards higher standards of education for nurses and towards definition of senior grades in the profession which would recognise their contribution as equal to that of doctors and administrators. Much of this development occurred before 1980 but it is described here in order to provide a coherent context for the specialisation of intensive care nursing after 1980.

In the years after 1953 as intensive care units were being established in England and Wales, the nursing profession was beset by several problems: there was a severe overall shortage of nurses, exacerbated by a very high (nationally 55 percent) student wastage rate. Nursing was a profession in transition.[503] Previously hospitals had had no difficulty in attracting large numbers of young women because there was little else they could do. There were now more opportunities for women and they would not enter or stay in a profession where discipline was severe, training inadequate, and remuneration and career prospects were minimal. Reforms were evidently needed.

The Socialist Health Association (SHA) in a webpage which provides a chronology of the reforms between 1974 and 2006 alleged that during that period the NHS was in an almost continuous state of what some call redisorganisation.[504] All

[503] Rivett. G. From the cradle to grave. Fifty years of the NHS. London: Kings Fund Publishing; 1998. Page 104.
[504] Smith J, Walshe K, Hunter DJ. The “redisorganisation” of the NHS. Another reorganization involving unhappy managers can only worsen the service. Br Med J. 2001; Dec 1:1262.

the reorganisations are said to have had as their objectives better quality of patient care, a better structure of leadership in nursing, better integration of different areas of nursing and a less bureaucratic management style. The SHA document continues: 'Sadly there is very little evidence that structural change produced any of these benefits, although it was seldom left in place long enough for anyone to be able to tell'.[505]

While investigating the changes in nursing structures since 1953 the author has experienced considerable difficulty in retrieving the various mostly eponymous reports and in tracing any continuous lines of development. Rather there seem to be repeated recommendations of basically the same changes and little evidence of their implementation. An attempt has been made to extract those proposals which had a lasting effect and which were to be relevant (often later) to intensive care nursing.

1956. RCN policy statement

In 1956 the Royal College of Nursing (RCN) published a statement of nursing policy.[506] Nurses in training should be given tasks important to their learning needs rather than to tasks important to the hospital. This was a very important idea which was developed in subsequent attempts to improve nurse training. It was the first stage in progress towards student nurse training in which the nurse would be supernumerary; s/he is not there to perform tasks just because they need to be done, they must be done by the trained staff or auxiliaries. The student on a ward must only given work which will teach her the skills she needs (and does not already have) to be a fully trained nurse. The statement also stated that the profession should also develop its leadership, bringing into the profession more trained minds with a broad outlook. perhaps through a university degree course. In the future nurses should be involved in health service management as in the tripartite teams of administrator, physician and matron and make a nursing contribution to policy for example on management bodies, the Ministry and Central Health Services Council. Training for leadership and to develop nursing on a factual and research basis was therefore

[505] Socialist Health Association. Reform of the National Health Service. Manchester. Socialist Health Association 2011. Available at http://www.sochealth.co.uk/news/NHSreform.htm Accessed 30 April 2011.
[506] Royal College of Nursing. Observations and objectives: a statement of nursing policy. London: RCN; 1956.

important. The possibility of nurses acquiring a qualification higher than the University Diploma in Nursing was raised. If it were to be accorded a place in a University, nursing must develop its own principles and laws. It must be neither a 'lower medicine' nor a phase of social work, but be valuable in itself. Academic studies would have to be relevant to the practice of nursing as medical studies were relevant to clinical practice.

1964. The Platt report

The reforms suggested by the RCN were not immediately or fully effected. A leading article on another report commissioned by the RCN and published in 1964 under the chairmanship of Sir Harry Platt, listed a long list of disincentives for student nurses to persist with their training.[507, 508] The problems were virtually identical to those which had existed in 1953, as were the proposed solutions although they concentrated more on pre-registration training. The report recommended two different courses for registered nurses and enrolled nurses. The pre-registration student must be a student *in fact* and the service she gave must be governed by her educational needs rather than by the staffing needs of the hospital. She should not, for example spend most of her training on the same ward, learning, for much of her time, nothing she did not already know. An educational entry standard of five 'O' levels was proposed. Two years' academic study and controlled clinical experience would be followed by the final examination. A third year would be spent in hospital under supervision. University degrees for nurses would be established. As a student she or he would receive an educational grant for the first two years. In the third year, as a full members of the ward team they would be paid two-thirds of a staff nurse's salary. Enrolled nurses would follow a less elaborate apprenticeship and ward assistants would help the nursing team.

1964. Senior nursing structure

In addition to the concern for pre-registration training there was a need to improve training of nurses for more senior clinical, administrative and research functions. Following the Bradbeer report in 1954 which gave more power to hospital

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[507] Royal College of Nurses/ National Council of Nurses. A reform of nursing education. (Chairman Sir Harry Platt). London: RCN; 1964.
[508] Leading article. Nursing in the future. Br Med J. 1964;June 20:1585-6

secretaries (at that time the title given to the senior administrator in a hospital) and less to doctors and nurses the RCN recommended that there should be structure for nursing staff which paralleled that of hospital administrators: a group nursing officer with a sphere of control similar to that of the group hospital secretary and a hospital nursing officer whose role would match that of the hospital secretary. [509] Clinical nursing officers would oversee specialised units.[510] They would free the ward sister from what had become an oppressive amount of administration. These ideas were taken further in the Salmon Report of 1966.

An enquiry into senior nursing structure had been set up by the minister of health, Enoch Powell in 1961. The chairman was Brian Salmon (1911-2011), Director of J Lyons Ltd. and Vice-chairman of the Westminster Hospital Board of Governors. The committee was composed mostly of nurses with one doctor and one hospital administrator. The policy that was announced in 1966 proposed a new pattern of nursing administration and a new grading structure for all registered nurses. The grading of nurses in administration is relevant to later changes in intensive care nursing. The concept of top, middle and front-line management was introduced. At each of these levels there were to be two grades: six grades in all numbered grade 5 to grade 10.[511]

The recommendations were in general accepted by the government and by 1967 pilot trials were started. There were however some unintended consequences: It was expected that not all these grades would be necessary in smaller hospitals but the staff side (union staff who represented those regarded as employees as opposed to employers) saw an opportunity to have a large number of nurses promoted to better paid posts. Unfortunately many were “non-jobs”, virtual roles, and those promoted often had no formal training in administration. Many wards, whose experienced ward sister had been promoted to these administrative grades, were then managed by relatively inexperienced more junior nurses.[512]

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[509] A ‘hospital secretary’ at that time was the senior administrator in a hospital, not a consultant’s secretary.
[510] Bradbeer Report. Internal administration of hospitals. London: HMSO; 1954 quoted in Rivett G. From cradle to grave 1998: p. 96 and 190
[511] Rivett G. From Cradle to the Grave. 1998. Pages 190-1, 261.
[512] Hector W. Nursing in the UK. In: Walton W, Barondess JA, Lock S. (editors) The Oxford

NHS reorganisation 1974.

Rivett states bluntly that 'The new structure [i.e. the Salmon grades] did not survive long because NHS reorganisation in 1974 and subsequent management changes killed the concept of Salmon and ruined the morale of senior nurses.'[513] Subsequent pages do not really explain why the reorganisation had this effect but after a report of a Review Body in 1988 a leading article in the *British Medical Journal* certainly supports the view that the grading of nursing posts recommended by Salmon had not survived. The article commences: 'The nurse's review body must be congratulated for this year's review – not only for recommending sensible pay rises that may help to recruit and retain nurses but also for wheedling the long promised clinical grading review out of the Nurses and Midwifery Staffs Negotiating Council. ... The current grading structure for nurses, midwives and health visitors is as old as the National Health Service. ... There have been no incentives to keep nurses at the bedside – to progress they have to move into management or teaching.'[514] The Review Body report introduced a new grading structure, this time the levels were given letters, not numbers: auxiliaries were to be A or B, state enrolled nurses C or D, state registered nurses to D or E, sisters to F, G or H, and senior nurses to F, G. H or I. Each level would have five to seven annual salary increments. Unlike the Salmon grades, the new structure would also provide a career structure for those nurses who wished to continue in clinical nursing, where the higher salary levels would be better paid than some of the administrative posts. The re-grading structure was seen to be a huge undertaking with over 400,000 nurses' jobs to be assessed and graded within six months.

Project 2000

At the same time that the pay and the re-grading of registered nurses was being reviewed the government was considering its reaction to *Project 2000.* This was a group of proposals by the United Kingdom Central Council (UKCC).[515] The

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medical companions. Oxford: Oxford University Press; 1994. Page 668.

[513] Rivett G. From Cradle to grave 1998. Page 261.

[514] Delamothe T. Nurses make the grade. Br Med J. 1988;May 14:1344.

[515] Project 2000. A new preparation for practice. London: United Kingdom Central Council; 1986 available at http://www.nmc-

UKCC was a body established in 1982 to replace many autonomous statutory bodies which had governed nursing, midwifery and health visitors in the UK. National boards including the English National Board (ENB) were then created. The UKCC and the ENB examined the problem of basic nurse education simultaneously. They were in conflict. The UKCC proposals were formulated by its Education Policy Committee the constitution of which is significant: it consisted of nurses in management or educational positions, with four non-nursing educationalists. There were however no practicing nurses or doctors. The project officer was a sociologist by training with a deep commitment to women's issues. Leadership thus passed from clinical nurses who were deeply involved with medical development to a group more concerned with educational theory, sociology and community issues.[516]

The government's response was greeted with enthusiasm. Jane Salvage, director of nursing developments at the King's Fund Centre for Nursing Development wrote an editorial in the British Medical Journal headed '*Thumbs up from Government for reform of nurse training*'.[517] The health minister supported the sweeping changes in nurse education in principle. The proposals were:

A threefold division of labour. The divisions would be a support worker, a single level of registered nurse (the 'second level nurse' to be phased out) and a more advanced specialist grade, e.g. health visiting and district nursing.

The registered nurse to be a 'knowledgeable doer'

A common foundation programme of 18 months followed by a second 18 months in a 'branch programme' (adult, child, mentally ill or mentally handicapped)

Reorientation from acute towards community care

Schools of nursing to link with higher education

Supernumerary status for 80 percent of the time

Students to receive training grants

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uk.org/Documents/Archived%20Publications/UKCC%20Archived%20Publications/Project%202000%20A%20New%20Preparation%20for%20Practice%20May%201986.PDF Accessed 3 May 2011

[516] Rivett G. From cradle to grave. 1998:343.

[517] Salvage J. Thumbs up from government for reform of nurse training. Br Med J. 1988;Jun 14:1553.

Academic recognition of professional qualifications[518]

Implementation of these proposals was not easy or always satisfactory. On the profit side were that students would not be expected to study after a long day's work on the ward, they would be supernumerary to the ward's nursing establishment, their education would be in a centre of higher education where the academic content and status of their training would be enhanced. On the debit side were, *inter alia*, that finding educationally suitable hospital placements was difficult and labour intensive for some educational institutions and the students graduated with less practical ability than the previous generations of students. One of the conditions on which the Project was accepted was that there should be widened entry into nurse training.[519] This, which meant acceptance of students who had less evidence of academic ability, was not compatible with the increased academic content of the new training programme. Later evidence showed that the more academic entrants were more likely to complete the course. There was also an emphasis on social science which was thought by some to be more than was necessary for critical care nurses. For example, included in 'examples of module learning outcomes' in an honours B.Sc. course at Plymouth University were, under the heading of Contemporary issues for critical care practice: 'Identify the legal, ethical, socio-political and organisational issues which impinge on healthcare practice.'[520] Interesting subjects for discussion certainly but are they part of the essential knowledge for a critical care nurse?

The effects of the implementation of the recommendations of *Project 2000* have been discussed in many articles in the nursing and medical literature. A dominant question is whether the new training scheme, based on centres of higher education rather than hospitals, provides adequate hands-on clinical training to enable the newly qualified nurse to take her part in ward work. The emergent view seems to be that the newly qualified nurse is not adequately skilled, neither clinically

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[518] Rivett G. From Cradle to grave. . London: Kings Fund Publishing; 1998. Page 343.
[519] Le Var. RMH. Project 2000: a new preparation for practice – has policy been realized? Part 1. Nurs Educ Today. 1997;17:171-7. Note: This article which appears to be intended to be the first of two or more articles, does not answer the question in the title but gives a comprehensive account of the events leading up to the publication of *Project 2000.* Later parts have been sought but not yet found.
[520] Cornock M, Goodman B. A future for critical care education. Nurs Stand 2002;16:42-4.

nor administratively, to run a ward. Key clinical skills are learnt in the first few months but the administrative skills take much longer. However one study reveals that nurses who had been trained in 1985 under the system pre-Project 2000 suffered the same inadequacies. The nurses trained in the new system had however more support in the early months and were less stressed than their predecessors.[521]

As to the effect of the linking of nursing training to higher education it has been argued that nursing still occupies a marginal place in higher education in England, and that the process of professionalisation is not a straightforward one and has potentials for reversals of fortune.[522] Pat Ashworth, whose experience in teaching nurses in the Intensive Care Unit in Broadgreen Hospital Liverpool in the 1960s has been described in Chapter 8 page 145 wrote an editorial in 1992: *Too much theory for practice?*[523] Ashworth has progressed from being one of the earliest ICU sisters in England, through an academic career which included research and a Master's degree, and editorship of nursing journals. She has made repeated visits to countries, particularly Romania, where 'facilities are lacking.' She defended the inclusion of an adequate amount of theory in nurse training and concluded that where high technology equipment is in use but even more so when it is lacking, knowledge of what is or is not beneficial must have sound theoretical backing. 'Excellence in nursing demands theory-based practice.'

The development of intensive care nursing education and structure has evolved within the successive reorganisations of general nursing structure and education.

It has been seen in chapter 8 (page 143) that nurses had felt the need to gather together patients who needed the new skills so that the nurses having learnt how to manage respirators, to aspirate secretions and to nurse unconscious patients might perfect their skills by regular practice. They were arguably responsible for the formation of at least some intensive care units. They taught each other and quickly

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[521] Gerrish K. Still fumbling along? A comparative study of the newly qualified nurse's perception of the transition from student to qualified nurse. J Adv Nurs. 2000;32:473-80.
[522] Meerabeau E. Back to the bedpan: the debates over pre-registration nursing education in England. J Adv Nurs. 2001;34:427-35.
[523] Ashworth P. Too much theory for practice? Intensive Crit Care Nurs. 1992;8:65.

became, if not an elite group, certainly a group expert in the intensive care of critically ill patients.

Specialisation of intensive care nurses.

Intensive care nurses saw themselves as '*different'* from the earliest days of intensive care. They learned professional, particularly technical, skills not possessed by the generality of nurses. Intensive care could not be effective unless these specialist nurse were able to work as a group within a hospital all in one place: the intensive care unit. They needed to communicate with other similarly skilled nurses in other hospitals and meetings were convened in London in 1965.[524] Sister Pat Ashworth told how they started:

> I was going to say how we came to have the King's Fund meetings. Those arose because there was a meeting at the King's Fund and they were mostly engineers and doctors and architects etc. and there were about six nurses and we were talking to each other and they said 'Would you like to meet again, you seem to be finding a lot [to talk about]'. We said 'Yes please.' So they started meetings. I think it was originally twice but it became four times a year. And that went on for about three or four years. As a consequence we then got to the stage when we were talking about pay and conditions now and again, and that wasn't allowed because it was the King's Fund, so that was when it became the first specialist group between the Royal College of Nursing Departmental Section, but it was an important developmental period because it got us together to discuss things.[525]

The chronology of further development of corporate bodies representing intensive care nurses (or later critical care nurses) has been difficult to discover. The next stage in professionalisation of intensive care nursing would be to establish an organisation or organisations to represent intensive care nurses. The American Association of Intensive Care Nurses was established in September 1969.[526] The Intensive Care

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[524] Ashworth P. In Reynolds LA, Tansey EM. (editors) History of British Intensive Care, c.1950-c.2000. Wellcome witnesses to twentieth century medicine. Vol 42. London: Queen Mary University of London; 2011. Pages 42-43.

[525] Ashworth P. Interview in Liverpool 23 July 2009.

[526] Lynaugh JE, Fairman J. New nurses, new spaces: A preview of the AACN history study. Am J. Crit Care. 1992;1:19-24.

Society of Great Britain was founded in 1970 and although it was founded by doctors, particularly Dr Alan Gilston (1928-2005), it has for some years included a membership category of Nurse and Allied Healthcare Professionals (N&AHP). Enquiries at the ICS were not able to identify the date when this category was included. However the first nurse or allied health professional having an elected seat on the Council of the Society was elected in 2008 and the N & AHP Committee was subsequently established and is a proactive committee.[527]

The British Association of Critical Care Nurses was founded in 1985.[528] It has recently revised its mission statement after feedback from Regions had suggested that it did not feature the patient prominently enough.[529] The new statement is a good description of the Association and its object:

> The British Association of Critical Care Nurses is a professional organisation dedicated to promoting excellence in the nursing care of critically ill patients. We aim to do this via mutual support, education, research and collaboration with multi-disciplinary groups.
>
> Central to our mission is the delivery of first class patient care and we aim to promote this through enhancing clinical practice, education, professional development, research and contribution to policy and strategy at every level.
>
> As the largest and most well established critical care nursing organisation in the UK our mission is to provide opportunities to our members which support professional development and promote the art and science of critical care nursing. We seek to influence the future development of critical care nursing regionally, nationally and internationally. This will be achieved through collaboration with members, patient and relative representatives, health care providers, industry, other professional organisations and policy makers.

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[527] Written communication from Pauline Kemp, Head of Secretariat, Intensive Care Society. 18 April 2011.

[528] It has been difficult to find official confirmation of this date, which was calculated from the fact that the Association celebrated its 25th Anniversary in 2010.

[529] Gibson V. Mission Statement. BACCN News available at http://www.baccn.org.uk/news/11.03.19.asp accessed 2 May 2011

The Royal College of Nurses has established a Critical Care Forum. Its steering committee met in 2003 and the first edition of its newsletter was published in 2006.[530] The Forum has issued a series of guidance policies for critical care including *Guidance for staffing in critical care* published in 2003.[531] The Forum amalgamated with the In-Flight Nursing Association in 2009 to become the Critical Care and In-Flight Nursing Forum. The Chair and one member of the Forum on the Critical Care Programme Board were cited as main contributors to the *National Education and Competence Framework for advanced critical care* practitioners published by the Department of Health in March 2008.[532] Additionally the document includes an acknowledgment that it was 'compiled in conjunction with representatives from The British Association of Critical Care Nurses, The Intensive Care Society, The Intercollegiate Board for Training in Intensive Care Medicine and The Royal College of Nursing Critical Care Forum.' Evidently, nurses in critical care need no longer feel excluded from government in the United Kingdom.

Training of intensive care nurses

The part played by nurses in the establishment of intensive care units was discussed in Chapter 8. The nurses' object in establishing such units was to be able to concentrate nurses who possessed the skill and training to manage critically ill patients and the equipment on which their lives depended. At first nurses learnt these skills by apprenticeship and experience. The burden of teaching nurses new to the unit (or, before the units were opened, nurses who had been assigned to care for a critically ill patient on a general ward) fell on the senior medical staff. Several

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[530] Website of the Critical Care and In-Flight Nursing Forum available at .http://www.rcn.org.uk/development/communities/rcn_forum_communities/critical_inflight/meettheteam accessed April 2011.

[531] J, O'Riordan B. Royal College of Nursing Critical Care forum: Guidance for nurse staffing in Critical Care. Intensive Crit Care Nurs. 2003;19:257-266.

[532] Department of Health and Skills for Health. The national education and competence framework for advanced critical care practitioners. 8 Apr 2008. available at http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_084011 Accessed 19 April 2011. A shorter version; Advanced Critical care practitioner. Career level 7 is available at: http://www.healthcareworkforce.nhs.uk/newandextendedroles/option,com_docman/task,doc_download/gid,27/

physicians and nurses have described this onerous burden. For example Sister Ashworth at Broadgreen Hospital, Liverpool:

> You showed them what to do and explained what's happening and – I did get frustrated – I remember at one point I was not only teaching the day staff, but we had been going for a year or two by this time and I found that every night I was on I was having to stay and extra half-hour to teach someone else to deal with the ICU patients.[533]

Professor Sir Keith Sykes describes a similar problem when he was treating children with tetanus using intermittent-positive pressure ventilation in South Africa:

> Well, you see, we started treating patients in the side wards and, of course, that was a big problem because the nurses were on shifts. So I made simple instruction sheets and we had to go every time there was a change of shift and tell them what to do.[534]

Several hospitals in England and Wales started intensive care nursing training courses. In 1964 a hospital-based teaching course of four weeks was set up in Whiston Hospital, Liverpool but 'the faults were predictable'.[535] The trainees were already in harness as a nursing team; it was not easy for them to be spared from the unit to attend lectures, the tutorials were not well structured, were given 'off-the-cuff' when opportunity arose and the objectives were not well defined.

A number of government initiatives worked towards setting up an efficient and consistent system of training of pre- and post-registration nurses throughout the UK. In 1970 a Joint Board of Clinical and Nursing Studies (JBCNS) was set up comprising representatives from the Medical, Nursing and Midwifery Royal Colleges and the Department of Health with a team of full-time officers, mostly nurses. [536] A panel of six doctors and seven nurses was appointed to design a course to prepare nurses to work in intensive care units. The outline curriculum of JBCNS Intensive Care Nursing Course Number 100 was approved by the Board on 1972.

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[533] Ashworth P. Interview. Liverpool. July 20099

[534] Sykes MK, Interview. July 2009.

[535] Gordon IJ, Jones, SE. The evolution of a general intensive care unit (1962-1983). Intensive Crit Care Nurs. 1998;14:252-57.

[536] Gardner M. The history, philosophy and evaluation of the Joint Board of Clinical Nursing Studies. J Adv Nurs. 1977;2:621-632.

Sherwood Jones described a Kafkaesque problem in achieving approval for such a course: To run an approved course the unit must have a large and experienced staff, but to maintain this team requires an approved course! He described the JBCNS as an outstanding success (but then he was its first Chairman). [537]

The Briggs Co-ordinating Committee was established in 1970 to formulate a new statutory framework for nursing education. The work of the committee resulted in the Nurses, Midwives and Health Visitors Act 1979 which came into force on 1 July 1983. The United Kingdom Central Council for Nursing, Midwifery and Health Visiting (UKCC) was set up in the same year. The Act abolished a number of supervisory bodies including the Joint Board of Clinical Nursing Studies. These bodies were replaced by the United Kingdom Central Council for Nursing, Midwifery and Health Visiting (UKCC) and four National Boards including the English National Board for Nursing, Midwifery and Health Visiting (ENB). The ENB was required to provide or to approve the provision of training courses for nurses. The Board has to ensure that such courses meet the requirements of UKCC with regard to content and standards. The object of the Act was to subsume local and national nurse training schemes into single national bodies. JBCNS 100 was already a national training scheme but it was replaced by (or renamed) the ENB 100 General Intensive Care Nursing Course.

A further development in nurse training and recognition has been the Post-Registration Education and Practice Project (PREP) introduced by the UK Central Council in 1990.[538] Several of its recommendations have a particular relevance to intensive care. For example recommendation 5 is 'Each practitioner should have a minimum of 5 days study leave every 3 years.' On the one hand that seems a very small allowance of time for study: the JBCNS intensive care Course 100 included 1 day per week of the six month course for lectures, seminars tutorials and practical classes. On the other hand in a unit with a staff of 80 nurses the absence of each nurse for five days in three years would result in 400 shifts when the number of nurses would be reduced by at least one.

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[537] Gordon IJ, Jones SE. 1998

[538] Nursing and midwifery council. Post registration education and practice (PREP). Available at http://www.nmc-uk.org/Educators/Standards-for-education/The-Prep-handbook/ Accessed 16 April 2011.

The project was supplemented by a Credit Accumulation Transfer System by which academic attainment from certificate level such as that awarded on completion of the ENB 100) to masters degree level would be quantified by the allocation of points. Clinical experience would also be accorded credit accumulation points. There appeared to be several anomalies in the system. For example there is no 'grandfather clause' such as has been included in some emerging medical specialties. This arrangement permits the status of senior practitioners who gained their skills and experience before particular academic qualifications were available to be given appropriate credit under the new system. Without such a clause senior clinical nurses would be at a disadvantage (that is seemingly poorly qualified) in competition against younger nurses when applying for more senior posts. Anxiety among diploma-qualified nurses was expressed in a recent interview. [539] The difficulty of providing courses of formal lectures for nurses in intensive care was also apparent. It is difficult to free nurses from their clinical work to attend courses of lectures and the difficulty is compounded by the shift system. Nurses on the night shift cannot be expected to attend lectures during the day. The training was described as 'ad hoc', with individual nurses being taught as the occasion arises – perhaps learning about a particular piece of equipment when they need to use it.

Advanced formal training and quantification of academic achievement and clinical experience is a welcome improvement on the apprentice system by which intensive care nurse acquired their expertise in the early days of intensive care in England and Wales. However there is a limited supply of nurses and training time must inevitably be sometimes at the expense of clinical time in the unit. One solution to this problem is to employ a limited number of nurses in post-registration training (staff nurses in the UK) and increase the number of advanced practitioners who have completed their training and so will need fewer days away from the unit. This is an expensive option but will lead to more effective treatment in the unit which can be quantified as fewer deaths. A study in 2000 showed a four-times higher mortality in an intensive care unit in patients exposed to high than in those exposed to low ICU

[539] Lacy D. Interview. 2011

workload.[540] A higher proportion of survivors will reduce the cost of each life saved, tending to offset the higher cost of senior nurse salaries.

Training of intensive care nurses

Intensive care has been increasingly integrated into a new entity, the critical care unit. The Audit Commission (1999) recommended increased flexibility between the various areas in hospitals in which very sick patients are treated.

'Critical care' is a global term that covers a diverse set of services. Although most people immediately think of the intensive care or therapy unit, intensive care is for very ill patients who can benefit from more detailed observation or treatment than can safely be provided on an ordinary ward. But critical care is also given in high dependency units (HDUs), which provide an intermediate level of care between ICUs and ordinary wards, and in specialist areas such as renal units or coronary care units.[541] Some general wards also develop expertise in the complex management of, for example, patients after particular high-risk operations. Appropriate use of the facilities of ICUs, HDUs and wards can contribute to the efficiency and cost effectiveness of resources. The Audit Commission report is replete with statistics comparing staffing and utilisation of critical care areas throughout the country. Some of the findings would be self-evident to persons with experience in these areas, but some, such as the percentage of and examples of inappropriate use of ICUs and HDUs could encourage policy changes which would improve clinical and economic efficiency.

A Department of Health publication *The National Education and Competence Framework for Advanced Critical Care Practitioners (2008)* describes the role of the Advanced critical care practitioner, how it should function within the nine grades of

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[540] Tarnow-Mordi WO, Hau C, Warden A, Shearer A J. Hospital mortality in relation to staff workload: a 4-year study in an adult intensive-care unit. Lancet. 2000;356:185-9.

[541] Audit Commission. Critical to success. The place of efficient and effective critical care services within the acute hospital. London: Audit Commission; 1999. Available at http://www.audit-commission.gov.uk/SiteCollectionDocuments/AuditCommissionReports/NationalStudies/CriticalToSuccess.pdf accessed 2 May 2011.

the critical care team, the benefits of introducing the role into clinical practice and a national framework of education and competence for the role (table 11).

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9	Clinical director of service	Managing and co-ordinating services
8	Consultant practitioner	Undertaking specific duties, e.g. clinical practice, consultancy, education (under appropriate medical supervision)
7	Advanced critical care practitioner	Functions at similar level to SpR with relevant supervision[542]
6	Senior practitioner. Undertakes nationally recognised education and competency framework leading to Advanced critical care practitioner	Examples: education modules – anatomy, physiology, pharmacology, clinical direction/decision making . Examples: competences – clinical examination, airway management, organ support, interpretation/diagnosis
5	Registered practitioner – nurses, physiotherapists, operating department practitioners	Registered practitioners at the beginning of their professional career in critical care supported by post-registration education and work-bases learning
4	Assistant critical care practitioner	Works at interface with qualified nurses and Allied Health Professionals (AHPs) and supports the work of doctors.
3	Senior HCA support worker level 3 National Vocational Qualification. At this level undertakes nationally recognised education and competency framework	Undertaking NVQ level 1, 2, 3. Gaining relevant healthcare experience
1 and 2	HCA/Support worker.	First exposure to healthcare working. Minimal academic qualifications

Table 11. The National Education and Competence Framework for Advanced Critical Care Practitioners (2008) [543]

[542] The meaning of SpR is not explained in the document. The acronym usually, and probably in this case, denotes Specialist Registrar, a medical grade. Relevant supervision is described in a footnote as 'under appropriate level of medical supervision,'

[543] Department of Health and Skills for Health. The national education and competence framework for advanced critical care practitioners. 8 Apr 2008. available at http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_084011 Accessed 19 April 2011. A shorter version; Advanced Critical care

The document was compiled in conjunction with representatives from The British Association of Critical Care Nurses, The Intensive Care Society, The Intercollegiate Board for Training in Intensive Care Medicine and The Royal College of Nursing Critical Care Forum.

The Department of Health document defines nine grades of critical care practitioner. The grades ascend from health care health care assistant/support workers to clinical directors of service who will manage and co-ordinate services in the critical care department. The two highest grades have departmental and management duties. The advanced critical care practitioner is the seventh grade in this career path.

The tasks of the advanced practitioner are described are described in the document. S/he will:

Undertake an extensive assessment of the critically ill patient, including taking a history and completing a clinical examination

Perform or order diagnostic and therapeutic procedures

Prescribe medications and fluids (subject to current legislation)

Develop and manage an acute management plan and pathway for the patient

Perform invasive interventions, advanced airway skills, vascular access and other practical skills under appropriate supervision dependent upon experience.

Undertake internal and inter-hospital transfers of critically ill patients.

This is yet another grading for nurses but unlike previous gradings such as the Salmon gradings it is in this case a grading structure for a specialised body of nurses and it defines training, tasks and assessment of competencies in unprecedented detail. It is perhaps difficult to distinguish between the tasks of an Advanced Practitioner and those of a specialist registrar in intensive care medicine. The practitioner examines the patient, orders diagnostic procedures, diagnoses the condition, plans management and prescribes treatment. It is perhaps reassuring to note that they ‘work

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practitioner. Career level 7 is available at: http://www.healthcareworkforce.nhs.uk/newandextendedroles/option,com_docman/task,doc_download/gid,27/

alongside medical colleagues. They work autonomously or under supervision in specific circumstances'. The document describes an impressive list of benefits which will accrue from implementation of this training and career structure. They include releasing intensivists to increase the number of operating lists and contribution to compliance with the Working Time Directive (WTD) 2009 which imposes a maximum number of hours that junior doctors are allowed to work in a week.

The document *The National Education and Competence Framework for Advanced Critical Care Practitioners* names several NHS Trusts which contributed to the development of the training structure and provides case studies from two (Sheffield Teaching Hospitals NHS Foundation Trust and Royal Devon and Exeter Foundation Trust). However the structure has not (yet) been implemented country-wide. The nurse educator in the critical care unit at the Royal Liverpool University Hospital, a large unit with nineteen ICU beds and ten HDU beds, stated that no advanced critical care nurse practitioner had been appointed in the unit, and although she was in contact with many other units she did not know of any who had appointed advanced practitioners. Some had appointed nurse consultants. She was of the opinion that this was probably because of the present (2011) constraints on NHS spending. She underlined the importance of nurses who could undertake tasks previously performed by doctors. As the junior medical staff of the unit now included physicians as well as anaesthetists there was not always an 'airway-trained' doctor available. If an endotracheal tube should accidentally be pulled out and need replacement 'hopefully' an anaesthetist would be found to replace it. Neither the physician intensivist nor the nurse could do it and if it was not replaced immediately the patient might not survive. The initial training of the physician trainees was under discussion.[544]

The 2009 newsletter of the Critical Care and Flight Nurses Forum of the RCN contained the following paragraphs:

> Critical care education review.
>
> Following discussions between the RCN Critical Care Forum, CC3N and BACCN it has been identified that there is a nationwide concern about critical care nurse education. There is a consensus that education for critical

[544] Lacy D. Interview. May 2011.

> care nurses is fundamental to the provision of quality clinical services and requires a universal approach in terms of educational outcomes to ensure standards are maintained nationally.

The Newsletter listed the problems discussed:

> ‘ A mismatch between the content and focus of programme delivered and clinical needs of patients
>
> The complexity of some commissioning, funding and delivery models, which affect the uptake and development of courses
>
> A lack of standardisation of these which leads to challenges for both employers and employees when transferring between units and networks.’
>
> A working group has been set up to review what is happening nationally and to identify key competencies that could be developed into a programme of study. [545]

The history of reforms of education and careers for nurses as outlined in this chapter would perhaps not lead to expectation of the introduction of the ideal structure in the immediate future. But when the opportunities available to critical nurses at this stage of the development of the specialty are compared with the education by apprenticeship and a two- stage career path (staff nurse and sister) in the early days of intensive care, at least a qualified optimism may be justified.

Conclusions

The development of nursing in England and Wales in the last half century has been *the enhancement* of professionalism in what was already a profession. After many attempts to improve training so that it would incorporate training in science and the humanities, Project 2000 has taken nurse training to university degree level and has established nurses-in-training as students whose training on the wards is supernumerary to the nursing establishment. Despite anxiety that the new model contains too much theory and not enough clinical nursing the Project 2000 nurses have shown that, with a short period of preceptorship after qualification, they are

[545] Nevin G. Critical care education review. Critical Care mail. 2009.Summer:4 available at www.rcn.org.uk/criticalcare Accessed 2 May 2011

capable of carrying the clinical and administrative burden of 'running a ward'. A nurse educator, who was herself one of the first 'Project 2000 nurses' described her experience:

> I started off with project 2000, quite a big change at the time because that was the new style of training. I started in '94. I was one of the first – it had probably been running about eighteen months. It was a three-year course so the first eighteen months were foundation and then you specialised into adult, children or mental health. The first eighteen months were very much theory and you went to all kind of weird and wonderful places; to B and Q, to look at the work environment, and you went to nurseries.[546]

She thought that, on reflection, such visits had widened her understanding of the lives that other people led. But clinical experience was lacking in the early part of the course.

> By the time we reached our second year we had not really had any ward experience and we were a second-year student nurse. So we arrived on the ward and didn't really know anything. That was really quite difficult because the nurses expected you to know a lot more. But I do think that towards the end it was the best way, a good training programme. Towards the end I just felt ready to qualify.

Lacy had augmented her clinical experience (and her income) by working in a lot of bank work or agency work as an auxiliary nurse; 'doing that you got a lot more experience. You could tell the difference in those that had done that when we qualified and those that had not.'

By analogy with intensive care medicine, intensive care nursing, later critical care nursing, has sought to become an independent specialty within the nursing profession. The Department of Health has accepted critical care nursing as having an officially defined structure in its publication *National Education and Competence Framework for advanced critical care practitioners (March 2008).*[547] This and the representation of critical care nurses on government advisory bodies referred to earlier in this chapter confirm that acceptance of critical care nurses as a group

[546] Lacy, Dawn. Interview. May 2011.
[547] D H/Skills for Health. The National Education and Competence Framework. 2009

possessing unique specialist knowledge and status has been achieved. No doubt further progress in defining the specialty will be sought, but some nurses are concerned that status should not gained at the expense of quality of patient care.

Chapter 13. Conclusion

The majority of papers in the medical literature on intensive care are about the use of different forms of technology. The history of the development at the beginning of the twentieth century and subsequent neglect of techniques which would become in 1952 the basis of intensive care has shown that technology, techniques and apparatus, may not be enough to change medical practice. This study has shown the importance of the understanding of pathophysiology of critical illness rather than simply reliance on new technology. The technology is of course essential but it is a tool which can only be used if the disease is thoroughly understood. Perhaps the earliest example of the priority of physiology over technology is provided by the treatment of the girl dying of polio by Ibsen in 1952; the technology (IPPV and airway protection with a cuffed tracheal tube) had been available for forty years, but it was Ibsen's understanding that the girl was dying of respiratory failure, rather than the physicians' diagnosis of renal failure, which allowed the correct technology to be used and the girl's life to be saved. For technology to be used effectively in the treatment of critical illness there must also be an adequate understanding of the disease being treated and a body of practitioners who possess both the requisite knowledge and ability.

Most anaesthetists in England and Wales were not able to follow Ibsen's lead immediately. The history of the slow and gradual involvement of anaesthetists in intensive care in Britain from 1952 until the late 1960s illustrates the need for changes to their conditions of service which allowed practitioners to concentrate on a new specialty. Inter-specialty co-operation is revealed as an important element in the formation of the specialty of intensive care. Surgeons collaborated with anaesthetists to establish the first intensive care units, and the medical Royal Colleges' co-operated in establishing training and standards for specialist intensivists. Finally and perhaps most importantly, this study has shown that the early development of intensive care in England and Wales can be attributed almost entirely to individual enthusiasts, often working without reward and under considerable difficulties, who gradually demonstrated the value of intensive care.

The importance of Ibsen's introduction of IPPV into the treatment of respiratory failure due to polio in Copenhagen in 1952-3 has been frequently

referred to in histories of intensive care. There is no doubt that Ibsen's work was largely responsible for the development of intensive care world-wide. However there are caveats. What would have happened if Ibsen had not used IPPV to treat respiratory depression due to polio in 1952? Without Ibsen's work would IPPV have emerged from the operating theatre, become more than an anaesthetic technique?

That does appear to have been inevitable. Anaesthetists were already forced to continue ventilating their patients lungs into the post-operative period when, as occasionally happened, the patient did not resume breathing for some hours after discontinuation of relaxant drugs in anaesthesia. The anaesthetists could not go home and leave their patients struggling to breathe when they knew how to apply artificial ventilation until the patient recovered. They set the patient up 'on a ventilator' in the recovery room or post-operative ward and they taught the nurse and junior doctors how to look after the patient and the machine. They remained on call to provide help if anything went wrong. They were called in to provide similar support for patients in reversible respiratory failure from other causes. As numbers of patients increased they needed a dedicated space with trained nurses and readily available equipment (serviced by reliable technicians who have not received the credit they deserve).

Ibsen's expertise was the trigger which stimulated the development of intensive care after 1953, and it is probable that his understanding the physiology of respiratory failure was at that moment, unique. But development of blood gas analysis soon allowed respiratory failure to be diagnosed reliably. Stanton has said that several strands came together to lead to intensive care.[548] This study supports that idea. Intensive care developed when it did in England and Wales because several strands intertwined. They including the need for respiratory support in polio and tetanus, understanding of the physiology of respiratory failure, developments in anaesthesia, and advances in surgery, particularly cardiac surgery. By 1952 the strands had all come together. Ibsen richly deserves the credit for being the first to recognise the life-saving potential of intermittent positive pressure ventilation of the lungs outside the operating

[548] Stanton J. Intensive care: measurement and audit in an expensive growth area of medicine. In Berridge V. Making health policy: networks in research and policy after 1945. Amsterdam: Rodopi: 2005. p. 247

theatre, But it seems likely that even without his initiative, the 1950s would have seen the birth of intensive care. Its time had come.

The historiography includes several analyses of the factors which have stimulated or influenced the birth or development of medical specialties. Weisz cited specialisation as a necessity brought about by a desire to expand medical knowledge by observation of many comparable cases, and also to achieve the efficiency which would be gained by nursing cases needing similar treatment together in one area.[549] The second of these influences has emerged in this study as possibly the over-riding stimulus for the development of intensive care units. Weisz further cites the multiplicity of small medical schools in London in the nineteenth century, not attached to a university, as a deterrent to the formation of specialties Elite physicians wanted to retain control over their own patients and saw specialisation as a threat; it would attract patients away from the generalists and suggest that they lacked competence to treat their patients. It has been shown in this study that this attitude had not completely died out even in the mid twentieth century. Boulton gave a specific example of this attitude.

> We had a very strong myasthenia surgeon. A lot of the patients needed ventilating afterwards. I anaesthetised for him and had some disagreement with him. He wouldn't have a ventilator; he considered it a disgrace if you had to ventilate. However I finally persuaded him. But it was very awkward, it had to be done in a general ward.[550]

Sturdy and Cooter have cited examples of specialisation arising from the need for efficiency.[551] A need for efficiency, in the form of readily available equipment and well trained staff was certainly a stimulus for the setting up of intensive care units. Intensive care needs efficiency because of the urgency of treatment of critically ill patients. Equipment has always to be immediately available, which requires the employment of well-trained technicians, laboratory tests have to be available within a few hours or even (for arterial blood gases) within minutes so most intensive care units include a small clinical laboratory and of course nurses trained in the management of critically ill patients and the

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[549] Weisz G. The emergence of medical specialisation in the nineteenth century. Bull. Med. Hist. 2003; 77: 536-574.
[550] Boulton TB. Interview .August 2009.
[551] Sturdy S, Cooter R. Science, scientific management, and the transformation of medicine in Britain c. 1870-1950. Hist Sci. 1998;36:425

equipment are essential. These requirements could be seen as the principal reason for establishing a 'unit' in which to practice intensive care rather than practicing in general wards. Sturdy and Cooter reiterated Weisz's view that in the nineteenth century many hospital doctors were ambivalent and even hostile towards the emergence of specialisation. Moves toward specialisation tended to be restricted by countervailing pressures within the culture of medicine.

A further factor in the growth of specialisation in the nineteenth century has been described by Rosen.[552] He has ascribed it to a new concept of disease; which he called 'organ localism'. The rise of the understanding of pathological anatomy moved the conceptualisation of disease towards damage or malfunction of particular organs rather than the earlier 'humoral' theories. Organ-specific medicine has been a feature of intensive care but the emphasis has moved from support of one organ (the lung) to multi-organ failure and to the management of sepsis, nutrition and immunity which are not organ specific.

Burnham has situated specialisation within professionalisation.[553] Certainly the practice of intensive care and their acceptance by other consultants as directors of intensive care units could not possibly have been accepted by other consultants if professionalisation of anaesthesia had not been accomplished before 1953. It would have been irresponsible of physicians and surgeons to delegate the care of their most vulnerable patients to colleagues whose education, training and professional status was not assured by membership or fellowship of an accredited examining body such as the Faculty of Anaesthetists of the Royal College of Surgeons.

Several historians have traced the emergence of individual specialties in Britain. By the 1920s specialisation was generally accepted as necessary and inevitable. However specialists aligned themselves with either medicine or surgery. A consultant in any specialty was expected to have the membership of the Royal College of Physicians (MRCP) or the Fellowship of the Royal College of Surgeons (FRCS). Stevens traces the development of training structures for ophthalmologists, otolaryngologists, dental surgeons and

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[552] Rosen G. The Specialization of Medicine with particular reference to ophthalmology. New York: Froben Press; 1944. Cited in Weisz G. The emergence of medical specialisation. Bull Hist Med. 2003;77:544.

[553] Burnham JC. How the concept of profession evolved in the work of historians of medicine. Bulletin of the history of medicine 1996;70: 1-24.

anaesthetists within the Royal College of Surgeons.[554] The College created semi-autonomous Faculties which created specialty fellowship examinations comparable to the FRCS and which were recognised as defining eligibility for a consultant post in the specialty. The importance of the Fellowship of the Faculty of Anaesthetists of the Royal College of Surgeons, which identified the holder as a specialist of status equal to that of holders of the FRCS or MRCP, has been described in chapter 5. Without that mark of status anaesthetists could never have been much more that technicians in intensive care units. The development of the Faculty of Intensive Care within the Royal College of Anaesthetists has been the pinnacle of the development of the specialty of intensive care.

Granshaw wrote that specialisation could lead to 'fame and fortune'.[555] Intensive care certainly could lead to a certain prominence within the medical profession but it did not usually attract private practice. Few private hospitals had intensive care units and none of the practitioners of intensive care mentioned private patients. Boulton specifically describes a difference between 'sessional anaesthetists' who could not commit to anaesthesia for cardiac surgery or to the attendant post-operative intensive care because of the need for them to engage in private practice. 'The whole thing was, as I discovered later on, none of them wanted to do this [anaesthesia for cardiac surgery] because the position at Barts was there were no private beds so they had to earn their extra money at the London Clinic and all sorts of places and they didn't want to be tied to Barts.'[556] Boulton decided to work full time in Bart's, eschewing private practice, so that he could concentrate on and be available for anaesthesia and post-operative care of cardiac surgical patients and later for general intensive care.[557] Prominent practitioners in intensive care (i.e. those who published important articles or engaged in high-level medical administration either in the NHS or the Associations or Royal Colleges) would be eligible for NHS

[554] Stevens R. Medical practice in modern England. The impact of specialisation and state medicine. New Haven and London: Yale University Press; 1966. pages 110-14.
[555] Granshaw L. ;"Fame and fortune by bricks and mortar" the medical profession and specialist hospitals in Britain, 1800-1948, in Granshaw L, Porter R. *The hospital in history*. London. Routledge. 1989: 199-220.
[556] Boulton TB. Interview. August 2009.
[557] Boulton T. Personal communication. November 2011.

distinction awards. [558] However these came late in a consultant's career and were unlikely to influence a young consultant towards the practice of intensive care.

Heggie classified factors which influenced the formation of specialties as external and internal.[559] It is difficult to detect any external pressures towards the early development of intensive care in England and Wales. After 1995, when the death of a ten-year old boy while he was being transferred from one hospital to another in search of an ICU bed was headlined in the newspapers, the lack of intensive care beds became a public concern and attracted the attention of the government and the audit commission, but before that time the specialty was a personal (and peripheral) interest of individual or small groups of consultants. Internal pressures however were strong; pressure for the development of intensive care units came from nurses, who could not effectively nurse critically ill patients scattered in wards throughout the hospital, from practitioners who needed equipment to be centralised in one place and from cardiac surgeons and a few general surgeons who recognised the need for specialised care of their patients.

Relatively few histories of intensive care have been published. This may be because of the haphazard development of the specialty during the early years. They have sometimes focussed on particular aspects of intensive care; the cost, the technology, the more obvious ethical problems such as the avoidance of futile treatment, and the assessment of effectiveness.

Beinart wrote a detailed description of the development of the Respiratory Unit at the Radcliffe Infirmary, Oxford.[560] Her description of the case-mix of the patients treated in the unit between 1953-1963 shows that it was in fact already a general intensive care unit. Beinart's later publication focussed on the audit of intensive care which she describes as an expensive specialty.[561] Intensive care is

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[558] Stevens R. Medical practice in modern England. New Haven and London: Yale University Press; 1966. page 212 et seq.
[559] Heggie V. Specialization without the hospital. The case of British sports medicine. Med Hist. 2010; 54: 457-74.
[560] Beinart J. A history of the Nuffield Department of Anaesthetics, Oxford 1937-1987. Oxford. Oxford University Press. 1987. p. 112-123.
[561] Stanton J. Intensive care: measurement and audit in an expensive growth area of medicine. In Berridge V. Making health policy: Networks in research and policy after 1945.Amsterdam. Rodopi. 2005. p.243-272.

indeed expensive and it has been questioned whether the use of so much money to run units with mortality rates of around 25 percent can be justified. Admission policies have been agreed nationally in an effort to avoid admitting patients who have little or no chance of survival. Rigorous audit is required to determine that the resources allocated to intensive care are used to the best possible effect.

An early commentary on the background and development of intensive therapy was by Bjørn Ibsen himself. In 1966 he wrote 'this is in no way a complete historical review – very likely it is too early for that.'[562] This perception may in part explain the relative lack of attention paid by historians to the history of intensive care. The history of intensive care spans only 54 years. It was officially recognised as a specialty in Britain in 1999. However Nicolson has studied the development of orthodontics which was also recognised as a specialty in 1999 when the *Dental Register* incorporated for the first time, lists of the recognised specialties within dentistry.[563] It may be that enough time has elapsed for more specialties which emerged in the second half of the twentieth century to be subjected to historical study.

Ibsen discussed several more general themes in the early development of intensive care, starting with the low status of anaesthetists in Denmark in 1952. He remarks that, in contrast to the situation in Denmark, in Great Britain and North America anaesthesia had long been recognised as a specialty and the working conditions of anaesthetists had settled into a certain routine in which the surgeon-patient relationship makes most anaesthetists more or less economically dependent on the surgeon. Such independence is necessary if the anaesthetist is to be able to play a major part in intensive therapy, and the progression of anaesthetists in the UK from 'anybody who was available' to specialists of equal status to that of surgeons and other physicians in the NHS has been traced in this study. Ibsen described the difficulty which he experienced in persuading the physicians to accept his advice and the evolution of the physiological knowledge which had led him to the conclusion that patients with bulbar polio were dying from carbon dioxide retention. In his

[562] Ibsen B. Intensive therapy: Background and development. Int. Anesthesiol..Clin. 1966; 4: 277-294.
[563] Dentists Register. London: General Dental Council; 1999.

description of later progress he emphasised advances in circulatory physiology, particularly the idea that blood flow to vital organs may be more important than blood pressure. There can be an adequate flow through dilated arteries even if the pressure is low. Ibsen's history differs from those of historians because it is largely composed of an account of technical and physiological progress. He was one of Stanton's 'insiders belonging to one tradition or another', in his case a clinician, not a sociologist or historian.[564] His account is nevertheless useful, describing the circumstances in which IPPV was used outside anaesthesia, how the 'first intensive care unit in the world' came be established and the acceptance of Danish anaesthetists by their colleagues as of equal status (and remuneration).

Crocker's *Development of intensive care in England* is described in her summary as 'an alternative history of the development of intensive care (ICU) which takes account of the nursing professions contribution, rather than the commonly held view that ICU developed predominantly as the result of new and innovative technology.'[565] She also alleged that 'The nursing contribution is not fully acknowledged in the historical and professional literature'. In this thesis an attempt has been made to correct this omission. Crocker's paper is a valuable account of the development of intensive care in the UK, particularly in the new millennium. Her use of the acronym ICU for intensive care in her summary betrays some confusion of thought. There is a difference between intensive care, (which would include intensive care medicine and nursing) and intensive care units (ICUs). Credit has been given in this thesis to the part played by nurses in the establishment of intensive care *units*. It is however arguable that the majority of intensive care medicine has been the product of the interaction between physiologists, pathologists and clinicians. Crocker's objection to the 'commonly held view that ICU developed predominantly as a result of new and innovative technology' is however supported by this thesis. The basic technology existed for many years before intensive care came into being. It was only when practitioners learnt the necessary physiology and gained understanding of the pathology of system failures that the machinery could be

[564] Stanton J. Intensive care: measurement and audit 2005: 247.
[565] Crocker C. The development of critical care in England. Intensive and Critical Care Nursing. 2007; 23: 323-30.

brought into effective use and improved to meet the needs of intensive care. Ventilators do not treat patients, any more than does a scalpel. Crocker's criticism of the paucity of attention paid to critical care in the histories of the NHS is justified. Intensive or critical care is usually mentioned only in a couple of paragraphs (Webster), a couple of lines (Rivett) or not at all (Stevens).[566, 567, 568] These texts do however give useful information about the general medical background within which intensive care developed in England and Wales. The absence of intensive care in the histories of the NHS lends weight to the contention that the development of the specialty was the work of individuals without any official policy and little support. An important finding in this study has been that most early intensive care and was the result of an individual, usually but not always an anaesthetist, either leading a small group of colleagues or often working alone Their work was gradually recognised and over several years they gained resources and support. These individuals performed the majority of work in intensive care in England and Wales until at least the 1970s. This pattern of development of a specialty has not been found in histories of other specialties, although it undoubtedly existed in some.

Pickstone has inveighed against the illogicality of government management of the health service with frequent policy changes for which there is no evidence base. 'Health professionals are honour bound to respect patients, but governments regularly disregard the judgments of these same professionals about, for instance, their best modes of work. Quack policies are effectively compulsory.' [569] It remains to be seen what benefits (and possibly harms) may accrue from the recognition by the British government of the specialty of intensive care medicine.

This study has been into the development of intensive care in England and Wales. It is not a complete history of intensive care. The emphasis has been on

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[566] Webster C. The National Health Service. A political history. Oxford. Oxford University Press. 2002: 43, 223

[567] Rivett G. From cradle to grave. Fifty years of the NHS. London. King's Fund Publishing. 1998 : 137, 396

[568] Stevens. R. The impact of specialisation of state medicine. Medical practice in modern England. New Brunswick and London. Transaction Publishers. 2003. Neither intensive care or critical care appear in the index.

[569] Pickstone PV. The rule of ignorance: a polemic on medicine, English health service policy, and history. Br Med J. 2011;Mar 3:997.

the development of the patho-physiological and technical knowledge base which has enabled intensive care medicine to be practiced, on conditions in the NHS which have influenced the development of intensive care and on the development of intensive and critical care as medical and nursing specialties. The oral history may be seen to be largely that of the earliest contributors to intensive care in England and Wales. This has been influenced by the practical consideration that this important testimony of people who started intensive care in England and Wales 60 years ago will inevitably soon become unavailable.

In an article on *The future of intensive care* written in 2006, Anne Bachelor, President of the Intensive Care Society predicted that in the future ICUs will no longer be a small but expensive bit of the hospital, often not considered in the fight to gain resources, but will almost become the hospital. 'We will have outreached to the ultimate degree as the proportion of monitored beds to total hospital beds approaches 50 per cent and [570] all patients well enough to be cared for in the community are moved out of hospital.' Whether this dramatic but distinctly possible prediction is correct will be the subject of future historical studies.

[570] Bachelor A. The future of intensive care. The Royal College of Anaesthetists. 2006; Bulletin 40:2041-2943.

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Appendix 2. Invitation to interviewees

Dr A Anthony Gilbertson

Candidate's address

Telephone number

Email addresses

Date

Dear .....

I am in the process of writing a thesis on The History of Intensive Care in the United Kingdom, to be submitted for an MD at the University of Liverpool. I am gathering information from the literature and also by interviewing people who were involved in the early days of intensive care in this country.

I know you were very much involved in developing intensive care in (place) and I wonder whether you would be willing to speak to me about those days.

I have a little recording machine and lapel microphones. I have been tutored by several professional Oral History groups and the form seems to be that I should ask you to talk informally, without any special preparation, about the development of intensive care in this country as you remember it.

I will NOT ask a series of questions. That would skew the interview towards my version of history, my interests. I want the history as you experienced it or as you remember it. If you are vague about dates etc they can perhaps be verified from other sources, but there is no 'correct version'. Everyone will have been impressed by different problems, experiences, triumphs etc. What is wanted is what you remember as important, what drove the establishment of intensive care in your hospital, what was perhaps there before, what obstacles did you encounter, who helped (or perhaps hindered). The interviews are usually shorter than two hours (longer would be tiring) but how long depends on you. My machine records for up to 17 hours!

Appendix 2. Invitation to interviewees

Afterwards I will transcribe the interview, perhaps add a commentary, and I shall send the transcribed interview and the commentary to you for your approval. I also have a form which ascribes the copyright to me so that I can use the interview in my thesis.

If you are happy to join me in this work please will you contact me and we can agree a date and place. I am willing to travel to you or wherever we agree to meet. Perhaps the best way to set up a meeting would be for you to telephone me – there is an answering service if we are not at home, or you might prefer to send me an email or a letter.

I look forward to hearing from you,
With best wishes,

Appendix 3. List of interviewees

Miss Patricia (Pat) Ashworth. Interviewed in Liverpool 23 July 2009. Sister in charge of the first purpose built intensive care unit in England and Wales at Broadgreen Hospital, Liverpool.

Mr David Blair. Interviewed 11 May 2011 in Liverpool. He is a staff nurse in the Intensive Care Unit, Royal Liverpool University Hospital.

Dr Thomas B Boulton. Interviewed in Reading Berkshire on 17 August 2009. Introduced post-operative pulmonary ventilation after cardiac surgery at St Bartholomew's Hospital London 1961.

Dr Peter M Drury Interviewed in Liverpool on 8 September and the interview continued on 28 September 2009. First consultant anaesthetist at the Royal Southern Hospital Liverpool and later consultant in anaesthesia and intensive care Royal Liverpool University Hospital.

Dr M Eleri Edwards. Interviewed in Llangollen, North Wales 21 June 2010. Established the first intensive care unit in North Wales at Wrexham and formed a link with the Liverpool School of Anaesthesia.

Mrs Colette Feenan Interviewed in Liverpool on 17 Mat 2009. Senior sister in the intensive therapy unit, Royal Liverpool University Hospital 1970-89.

Dr Clifford Franklin. Interviewed in Altrincham, Cheshire 23 June 2009. Developed the Intensive Care Unit in Baguley Hospital, Manchester. President of the Intensive Care Society 1975-76.

Dr Eric Sherwood Jones. Interviewed in Prescot, Merseyside 24 May 2009. Consultant physician, Whiston Hospital, Merseyside. Opened the first intensive care unit in Merseyside and President of the Intensive Care Society 1976-77.

Mrs Dawn Lacy. Interviewed 11 May 2011 in Liverpool. She is Practice Educator in the Intensive Care Unit, Royal Liverpool University Hospital. She was trained under the Project 2000 system.

Miss R Hazel Melhuish. Interviewed in Liverpool 30 July 2009. Deputy Matron, Sefton General Hospital, Liverpool at the time of the opening of its Intensive therapy Unit in 1970.

Dr Douglas Pearce. Interviewed in Southampton 1 December 2009. Consultant anaesthetist who with Dr Patrick Shackleton started practicing intensive care in 1954 and opened one of the first Units in Britain in 1958.

List of interviewees

Professor Michael Rosen. Interviewed in Cardiff 1 June 1910. Professor of Anaesthesia, University 0f Wales 1984-93, Dean of the Faculty of Anaesthetists of the Royal College of Surgeons 1988. Supported a close liaison between the Faculty of Anaesthetists and the Royal College of Physicians in order to establish intensive care as a discipline requiring the knowledge possessed by both anaesthetists and physicians.

Dr Joseph C Stoddart. Interviewed in Newcastle-upon-Tyne 22 July 2009. First Assistant in Department of Anaesthesia, University of Newcastle, 1967; possibly the first full-time post in intensive care in England and Wales. President of the Intensive Care Society 1974-1976.

Professor Leo Strunin. Interviewed in London 17 November 2009. Consultant anaesthetist at The London Hospital. Introduced Intensive Care in 1964-5 and developed one of the first Intensive Care Nurse Training Courses. President of the Royal College of Anaesthetists 1997-2000.

Professor Sir Keith Sykes. Interviewed in Budleigh Salterton, Devon on 7 July 2009. Professor of Anaesthesia, Hammersmith Hospital, London 1970-80, Professor of Anaesthetics, University of Oxford 1980-91. Introduced intensive after cardiac surgery in the Hammersmith Hospital in 1960-61.

Dr Sheila M Willatts. Interviewed 2 April 2011 in London. Insisted that a wide knowledge of medicine was requires as well as competence in anaesthesia. She herself achieved double qualification with Fellowship of the Faculty of Anaesthetists and Membership of the Royal College of Physicians. She has been a strong supporter of intensive care as a specialty with its own unique program of training.