BMJ Open Respiratory Research

Is continuous positive airway pressure (CPAP) a new standard of care for type 1 respiratory failure in COVID-19 patients? A retrospective observational study of a dedicated COVID-19 CPAP service

Rebecca Nightingale ,[1,2] Nneka Nwosu,[2] Farheen Kutubudin,[2] Tom Fletcher,[1,2] Joe Lewis,[1,2,3] Frederick Frost,[2,3] Kathryn Haigh,[2] Ryan Robinson,[1,2] Ayesha Kumar,[2] Gareth Jones,[2] Deborah Brown,[2] Michael Abouyannis,[1,2,3] Mike Beadsworth,[1,2] Peter Hampshire,[2] Stephen Aston,[2,3] Manish Gautam,[2] Hassan Burhan[2]

To cite: Nightingale R, Nwosu N, Kutubudin F, *et al*. Is continuous positive airway pressure (CPAP) a new standard of care for type 1 respiratory failure in COVID-19 patients? A retrospective observational study of a dedicated COVID-19 CPAP service. *BMJ Open Resp Res* 2020;**7**:e000639. doi:10.1136/bmjresp-2020-000639

RN and NN are joint first authors.

Received 15 May 2020
Revised 18 June 2020
Accepted 23 June 2020

For numbered affiliations see end of article.

Correspondence to
Mrs Rebecca Nightingale; rebecca.nightingale@lstmed.ac.uk

ABSTRACT

The aim of this case series is to describe and evaluate our experience of continuous positive airway pressure (CPAP) to treat type 1 respiratory failure in patients with COVID-19. CPAP was delivered in negative pressure rooms in the newly repurposed infectious disease unit. We report a cohort of 24 patients with type 1 respiratory failure and COVID-19 admitted to the Royal Liverpool Hospital between 1 April and 30 April 2020. Overall, our results were positive; we were able to safely administer CPAP outside the walls of a critical care or high dependency unit environment and over half of patients (58%) avoided mechanical ventilation and a total of 19 out of 24 (79%) have survived and been discharged from our care.

INTRODUCTION

To date, there have been over 10 million confirmed cases of COVID-19 worldwide. It is thought that 5% of cases become seriously unwell, and of these, 20%–30% require critical care support.[1] Continuous positive airway pressure (CPAP) is a potential supportive treatment for patients in type 1 respiratory failure, and despite initial concerns regarding its use in COVID-19, including the risk of lung barotrauma and increased SARS-CoV-2 aerosolisation, early anecdotal experience has been favourable with newer guidelines now suggesting CPAP as an option for care.[1–7] NHS England guidelines now recommend its use while acknowledging the lack of evidence for efficacy.[8] To address this knowledge gap, we present here our experience to date of CPAP use during the COVID-19 outbreak in Liverpool, UK.

METHODS

In late March 2020, one of the isolation wards in the Tropical and Infectious Disease Unit at the Liverpool University Hospitals NHS Foundation Trust was repurposed as a CPAP/COVID-19 unit. CPAP was delivered in negative pressure single rooms with newly installed continuous non-invasive monitoring that was visible from outside the rooms. Negative pressure capacity was rapidly increased using an innovative approach developed in the South Korean COVID-19 outbreak with industrial HEPA filtered air purifying units that vent externally to create 10–15 air changes per hour. Staff wore appropriate personal protective equipment (PPE) as recommended for aerosol generating procedures by Public Health England (this included the use of FFP3 masks) and completed competencies in donning and doffing PPE before being involved with patient care. To reduce oxygen demands at the hospital and to limit the amount of new equipment staff required training for, standard electronically powered non-invasive ventilators (Philips A30) were used to provide CPAP with wall oxygen entrained into the circuit as per NHS England guidelines.[8] A non-vented mask or visor that covered the patient's nose and mouth was used. HEPA viral filters were fitted to the expiratory port of the circuit. Medical

and nursing staff who were non-respiratory specialists completed CPAP competency training, with the respiratory team providing ward-based medical, physiotherapy and nursing care. Due to the rapid increase in critically ill patients being admitted with COVID-19, CPAP trials could not take place inside the critical care unit; however, the critical care team provided an outreach and oversight service. Patients were monitored frequently with three consultant led multidisciplinary board rounds taking place each day. Patients were eligible for a trial of CPAP if they were deemed appropriate for mechanical ventilation, had type 1 respiratory failure and did not have a standard contraindication to positive pressure. Patients were initially trialled with one hour of CPAP, with a starting CPAP of 5 cmH_2O increasing to 10 cmH_2O as needed based on respiratory rate, oxygen saturations and clinical assessment; arterial blood gases were only taken if clinically indicated. CPAP of more than 10 cmH_2O was used, if required, after consultation with a respiratory or critical care consultant. Oxygen flow was titrated to maintain oxygen saturation of above 94%.

For the purposes of this service evaluation, we identified all patients undergoing CPAP on the infectious disease unit between 1 April and 30 April 2020. Data presented here were retrospectively extracted from patient records. Continuous variables are presented as medians and IQRs and categorical variables as proportions. Analysis was done using Stata V.14.2 (StataCorp, V.14, 2015). As a service evaluation using anonymised and routinely collected patient data, informed consent and research and ethical committee approval were not required.

RESULTS

Twenty-four patients were treated with CPAP; all had type 1 respiratory failure, and all were deemed appropriate for intubation and invasive mechanical ventilation (IMV) prior to a trial of CPAP. Clinical details and outcomes of CPAP are shown in table 1. The majority of patients (21/24 (88%)) were male, with a median age of 52 and median body mass index (BMI) of 31. The majority (23/24) had a clinical frailty score of two, one patient had a score of three. Prior to starting CPAP, all patients had some level of respiratory distress with a median P/F ratio of 122 mm Hg, significant oxygen requirements (median FiO_2 0.77) and median respiratory rate was 33. All patients have now completed their episodes of care. Over half (14/24 (58%)) of the patients that received CPAP did not require intubation and IMV; of these, all have recovered sufficiently to be discharged home. Nine out of 24 (38%) patients failed CPAP and required critical care admission for IMV; all required intubation within 24 hours of initiating CPAP, with a median time to intubation of four hours (IQR 2–9 hours). At the time of writing, five out of nine (56%) of those intubated have been successfully extubated and recovered, four (44%) have died. The median age of those that died was 60, with two out of four patients aged over 70, all four patients were male. Hypertension and diabetes or a cardiac history was recorded in two out of four patient's medical history, with two patients having no significant medical history (including one patient under the age of 70). Overall, 19 out of 24 (79%) patients have survived to discharge. One out of 24 died having had CPAP without IMV as their clinical picture had changed while on CPAP and the decision to escalate was rescinded. There were no serious adverse incidents reported via our internal incident reporting mechanisms during this period related to CPAP.

Table 1 Demographics and CPAP outcome

Variable	Value (IQR/%)
N	24
Demographics	
Age	52 (46.5–60)
Male sex	21/24 (88%)
Median BMI (kg/m^2)*	31 (27–33.5)
Comorbidities	
Hypertension	8/24 (33%)
Diabetes	6/24 (25%)
Heart disease	3/24 (13%)
Other	8/24 (33%)
Smoking status	
Current	1/23 (4%)
Ex	4/23 (17%)
Never	18/23 (79%)
Respiratory function prior to CPAP	
Median F_iO_2 (%)	77 (45–100)
Median SpO_2 on oxygen therapy (%)	93 (89–95.9)
Median RR	33 (28–40)
Median PF ratio (mm† Hg)†	122 (97–175)
CPAP settings (first hour)	
Median starting CPAP (cmH_2O)	8.75 (7.5–10)
Median starting oxygen on CPAP (L/min)	9 (6–15)
Outcomes	
Weaned off CPAP and discharged	14/24 (58%)
Died on CPAP	1/24 (4%)
Intubated	9/24 (38%)
Median time on CPAP (days)	4.5 (2.5–5.5)
Median bed stay (days)	10.5 (7.5–11.5)
Median time to intubation (hours)	4 (2–9)
Died once IMV	4 (44.5%)
Weaned and Recovered once IMV	5 (55.5%)

*n=20.
†n=21.
BMI, body mass index; CPAP, continuous positive airway pressure ; IMV, invasive mechanical ventilation.

CONCLUSION

In the context of the COVID-19 pandemic, we were able to safely deploy CPAP on a rapidly repurposed ward with increased negative pressure capacity, outside a traditional critical care environment. Over half of patients treated successfully avoided mechanical ventilation and those who failed CPAP did so rapidly, usually within a few hours. Careful patient selection and close monitoring is crucial to ensure that those who are not improving on CPAP are identified early. Collaboration between respiratory and infectious disease staff and the installation of enhanced monitoring were key to ensuring that CPAP was delivered safely and those who required IMV received this in a timely manner. Due to the aerosol-generating nature of CPAP, concerns have been raised regarding the safety of its use in COVID-19. We ensured that CPAP was provided in negative pressure rooms with staff who had both the correct PPE and a high standard of training in how to use it. To date, there have been no cases of COVID-19 among nursing staff who looked after this cohort of patients.

In conclusion, our experience of a novel combined infectious disease and respiratory CPAP service for patients with COVID-19 outside of a critical care environment for patients with type 1 respiratory failure has been positive. Our data suggest that, with careful patient selection and close monitoring, CPAP can be a successful treatment strategy in critically ill patients with type 1 respiratory failure in COVID-19, and that it can be safely deployed outside the critical care environment. We also believe that CPAP could be a valuable treatment option in lower resourced settings with limited capacity for mechanical ventilation, and note that it is included in the WHO COVID-19 clinical guidance.[7] Nevertheless, we recognise that many questions remain; our study has a small sample size and is uncontrolled. Clinical trials are needed in order to guide clinical recommendations as to optimum timing of CPAP and selection of patients who are most likely to benefit. The role of CPAP in patients with significant comorbidities who are not deemed appropriate for invasive ventilation is uncertain and the relative merits of other non-invasive mechanisms of respiratory support such as high flow oxygen are unknown. We await the results of a randomised controlled trial to compare the effectiveness of CPAP, nasal high flow oxygen and standard wall oxygen in reducing mortality or the need for IMV in COVID-19.[9] Until such time as robust data are available, our experiences suggest that CPAP has a role in the management of type 1 respiratory failure due to COVID-19.

Author affiliations
[1]Department of Clinical Sciences, Liverpool School of Tropical Medicine, Liverpool, UK
[2]Department of Respiratory Medicine, Tropical and Infectious Disease Unit, Intensive Care Unit, Liverpool University Hospitals NHS Foundation Trust, Liverpool, UK
[3]Institute of Infection and Global Health, University of Liverpool, Liverpool, UK

Contributors Design and service setup: RN, NN, TF, GJ, DB, MA, MB, PH, SA, MG and HB. Acquisition of data: RN, FK, JL, FF, KH, RR and AK. Analysis: RN, FK,JL and HB. Interpretation: RN, TF, GJ, MA, MB, PH, SA, MG and HB. Significant draft contribution: All authors. Approval of final version and accountable for all aspects of the work: All authors.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information

ORCID iD
Rebecca Nightingale http://orcid.org/0000-0001-5636-8531

REFERENCES

1 Centers for Disease C. Interim clinical guidance for management of patients with confirmed coronavirus disease (COVID-19), 2020. Available: https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-guidance-management-patients.html.Accessed [Accessed 4thMay 2020].
2 Li HC, Ma J, Zhang H, *et al*. [Thoughts and practice on the treatment of severe and critical new coronavirus pneumonia]. *Zhonghua Jie He He Hu Xi Za Zhi* 2020;43:396–400.
3 Ñamendys-Silva SA. Respiratory support for patients with COVID-19 infection. *Lancet Respir Med* 2020;8:e18.
4 Harari SA VM, Blasi F, Centanni S, *et al*. Managing the respiratory care of patients with COVID-19: Italian thoracic Society, (AIPO), Italian respiratory Society (SIP), 2020. Available: https://www.ersnet.org/covid-19-blog/sharing-italian-recommendations [Accessed 4th May 2020].
5 Nicola M, O'Neill N, Sohrabi C, *et al*. Evidence based management guideline for the COVID-19 pandemic - Review article. *Int J Surg* 2020;77:206–16.
6 Anaesthesioloigsts WFoSo. Coronavirus - guidance for anaesthesia and perioperative care providers, 2020. Available: https://www.wfsahq.org/resources/coronavirus [Accessed 1st May 2020].
7 WHO. Clinical management of severe acute respiratory infection when COVID-19 is suspected, 2020. Available: https://www.who.int/publications-detail/clinical-management-of-severe-acute-respiratory-infection-when-novel-coronavirus-(ncov)-infection-is-suspected [Accessed 1st May 2020].
8 NHS England. Guidance for the role and use of non-invasive respiratory support in adult patients with COVID19 (confirmed or suspected), 2020. Available: https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/03/specialty-guide-NIV-respiratory-support-and-coronavirus-v3.pdf [Accessed 4thMay 2020].
9 RECOVERY-RS Respiratory Support : Respiratory Strategies in COVID-19; CPAP, High-flow, and standard care. Available: http://www.isrctn.com/ISRCTN16912075 [Accessed 16th Jun 2020].