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Spontaneously arising disease

Fatal complications associated with caesarean section in the bitch: post-mortem investigation of 17 cases

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ABSTRACT

This case series describes the post-mortem findings in 17 bitches (*Canis lupus familiaris*) with a recent (<7 days) history of caesarean section, most (94%) of which had undergone conservative caesarean section with preservation of the uterus. Brachycephalic breeds accounted for 71% of all cases, with the French Bulldog (35%, n = 6), English Bulldog (18%, n = 3) and Boston Terrier (12%, n = 2) overrepresented. Eleven animals (65%) died between 4 and 48 h after surgery, whereas six (35%) died during the procedure. The most common cause of death was septicaemia (41%, n = 7) associated with *Streptococcus canis* (29%, n = 5) and/or *Escherichia coli* (24%, n = 4). Other causes of death included brachycephalic obstructive airway syndrome (BOAS)-associated respiratory failure (24%, n = 4), haemorrhagic shock (18%, n = 3), inconclusive (12%, n = 2) and gastric dilatation and volvulus (6%, n = 1). Histopathological changes were seen in the uterus of 10 cases and included marked inflammation (60%, n = 6), marked haemorrhage (20%, n = 2) or both (20%, n = 2). Metritis was often characterized by fibrinonecrotic, neutrophilic to mixed inflammation, consistent with acute infection. However, prominent lymphohistiocytic infiltrates in two cases suggested that infection had been present prior to surgery. Peritonitis, myositis and panniculitis commonly (35%, n = 6) surrounded the incision sites. The presence of inflammation and bacterial colonies within multiple surgical sites suggested iatrogenic implantation of bacteria, potentially from the uterine lumen. Bacterial culture and isolation, as well as tape measurements for evaluation of conformational BOAS risk factors where applicable, are recommended as part of the routine post-mortem work-up for bitches that die shortly after caesarean section.

1. Introduction

Caesarean section is a surgical intervention that can either be performed as an elective procedure aimed at reducing the risk of parturition-associated complications or in an emergency to save the life of the bitch and/or her puppies. Emergency caesarean section is usually performed on animals that present for dystocia. However, surgery comes with its own risks and complications. Firstly, pregnant bitches undergo several physiological changes, including altered cardiac output and pulmonary ventilation, which may affect anaesthetic capacity [1] and result in perioperative hypotension and hypovolaemia [2]. Secondly, the increased uterine blood flow associated with pregnancy predisposes to intra- and post-operative haemorrhage, which can have disastrous consequences when combined with suboptimal surgical technique or coagulation disorders. Other reported complications in bitches post caesarean section include endometritis, mastitis, peritonitis, uterine scarring, uterine rupture, uterine prolapse and hypocalcaemia [2,3]. For some cases, these complications may result in the death of the patient and one study determined an overall mortality rate of 3.11% in bitches undergoing caesarean section [4]. Although non-fatal complications of caesarean section and their treatment have been described, no detailed mortality reviews are available for the bitch. Therefore, the aim of this case series was to elucidate some of the common causes of death following caesarean section in bitches. This information can help clinicians identify animals that are at higher risk of fatal complications and may benefit from enhanced preventive measures. Additionally, it can guide pathologists who are about to perform a post-mortem examination (PME) on an animal with a recent history of caesarean section.

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2. Materials and methods

2.1. Animals

Cases were selected from the digital archives of the University of Liverpool (UoL) Veterinary Pathology Department, spanning from July 2015 to July 2023. Digital records from before this period were incomplete or unavailable, which hampered data collection. Ethical approval was granted by the UoL School of Veterinary Science ethics committee (approval number RETH000942). The study population selection criteria entailed bitches that were submitted for diagnostic PME after having undergone a caesarean section and died within 7 days following the procedure. The total number of female dogs over 6 months of age submitted to the UoL for PME during the study period was also obtained to enable risk factor assessment. For this study, brachycephalic breeds were considered to be French Bulldogs, English Bulldogs, other Bulldogs (including American, micro and cross breeds), Boston Terriers and Pugs.

2.2. Routine diagnostic investigations

Histology was routinely pursued unless the client explicitly requested a gross examination only diagnosis. Samples from all major organ systems were fixed in formalin, sectioned (5 mm), placed into cassettes and subsequently processed into paraffin blocks via standard procedures. Sections (4–5 μm) of paraffin-embedded tissues were cut on a microtome, transferred onto glass slides and stained with haematoxylin and eosin (HE) for examination by light microscopy. Gram staining was performed on uterine sections from animals in which clinically relevant gram-positive bacteria were isolated.

Bacterial culture was performed at the discretion of the pathologist on fresh tissue specimens collected at PME of the following organs: lung, liver, spleen, uterus and bone marrow. These were submitted for routine bacteriology to the UoL Veterinary Microbiology Diagnostic Laboratory. Bacterial culture was performed by first sealing the surface of the tissue specimens with a hot spatula followed by an incision with a sterile scalpel and transferring a small amount of the deeper tissue onto culture plates. Sterile intravenous catheters were used to aseptically collect bone marrow. Samples were grown on 5% Sheep Blood Agar (Oxoid, www.oxoid.com/uk) and Fastidious Anaerobe Agar (E&O Laboratories Ltd., www.eolabs.com) at 37°C for 5 days under aerobic and anaerobic conditions. Organism identification was attained by matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS) (Bruker Daltonics, www.bruker.com) with a score >2.

2.3. Statistics

Odds ratios (OR) with a 95% confidence level were obtained via an online webtool (Medcalc; www.medcalc.org) to evaluate representation of the different breeds in the study.

3. Results

3.1. Signalment and clinical history

The search yielded 17 bitches that had died with a history of recent caesarean section out of 381 female dogs (≥6 months) submitted for PME at the UoL (4.46% of total PME submissions). Of the 75 brachycephalic bitches submitted for PME, 12 (16%; OR: 11.66; 95% CI: 4.00–34.26, P <0.001) had died within 7 days of caesarean section. Only five (1.63%; OR 0.09; 95% CI: 0.03–0.25; P <0.001) of the bitches that were not classed as brachycephalic had been submitted with a recent history of caesarean section. French Bulldogs were most frequently represented with six out of 26 animals of that breed submitted for PME and out of 17 bitches with a history of caesarean section (35%; OR 9.68; 95% CI: 3.25–28.85; P <0.001). Other brachycephalic breeds included the English Bulldog (3/17; 18%; OR: 4.80 95% CI: 1.26–18.31; $P = 0.021$) and Boston Terrier (2/17; 12%; OR: 14.50; 95% CI: 2.43–86.43; $P = 0.003$) and a single Bulldog cross breed (1/17; 6%). The other animals included two Dachshunds (12%), a Labrador Retriever, a Cocker Spaniel and a Pomeranian (Table 1).

The age of the animals ranged from 1.5 to 5.7 years, with an average of 2.8 years at presentation. Six bitches (35%) died during anaesthesia and the remaining 11 animals (65%) died between 4 and 48 h after the procedure. There were no deaths in the 2–7 days post-surgery category. For eight animals, dystocia was mentioned as the reason for caesarean section, whereas the procedure was an elective decision in at least two Bulldogs. The presence of dead puppies was reported for six cases, at least five of which had a history of dystocia. Information regarding the reason for caesarean section or the viability of puppies was not available for the other

Table 1
Details of 17 bitches that died during or shortly after undergoing a caesarean section

Animal	Age (years)	Breed	Nature of procedure	IPD (hours)	Cause of death	Other
1	4	English Bulldog	N/A	6	Shock from GDV	Gross diagnosis only
2	2	Bulldog cross	Emergency (dystocia)	0	BOAS, pulmonary oedema	Dead puppies, mild *S. canis* endometritis
3	2	French Bulldog	N/A	8	BOAS, pulmonary oedema	Possible septicaemia
4	3.5	Dachshund	Emergency (dystocia)	24	*E. coli* septicaemia	Dead puppies, severe endometritis, PMP, mastitis
5	3	French Bulldog	N/A	0	BOAS, pulmonary oedema	Cyanosis
6	2.1	French Bulldog	Elective	0	Haemorrhagic shock	
7	3.8	Boston Terrier	Emergency (dystocia)	48	Inconclusive, pulmonary oedema	Dead puppies, *E. coli* vaginitis
8	N/A	Dachshund	Emergency (dystocia)	0	*E. coli* septicaemia	Dead puppies, severe metritis
9	5.7	Labrador Retriever	N/A	0	Inconclusive	Dead and live puppies
10	2	Cocker Spaniel	Emergency (dystocia)	24	*S. canis* and *E. coli* septicaemia	Severe endometritis, PMP with dehiscence
11	4	English Bulldog	Emergency (dystocia)	0	BOAS, pulmonary oedema	Single dead puppy
12	2.3	French Bulldog	Emergency (dystocia)	48	*S. canis* septicaemia	Severe metritis, PMP
13	2	Boston Terrier	N/A	48	*S. canis* septicaemia	Severe metritis, PMP with dehiscence
14	2	English Bulldog	Elective	6	Haemorrhagic shock	BOAS
15	2.7	French Bulldog	Emergency (dystocia)	7	*E. coli* septicaemia	Moderate endometritis, PMP aspiration pneumonia
16	2	Pomeranian	N/A	24	*S. canis* (mixed) septicaemia	Severe metritis, PMP
17	1.5	French Bulldog	N/A	4	Haemorrhagic shock	Vaginal haemorrhage, mycobacterial lymphadenitis

IPD, interval between the procedure and death; N/A, information not available; GDV, gastric dilatation and volvulus; BOAS, brachycephalic obstructive airway syndrome; PMP, peritonitis, myositis and panniculitis surrounding the surgical incision site.

animals, which precluded risk factor investigation via statistical analysis. Sixteen animals received a conservative caesarean section and one bitch had a concurrent ovariohysterectomy (case 7).

3.2. Post-mortem investigations and findings

Bacteriological investigation was pursued for 14 animals and histological examination was performed for 16 of the 17 animals (excluding case 1). The post-mortem interval (PMI) was less than 48 h for nine animals and between 48 and 96 h for three animals; one animal had been frozen for a 1-week period and the PMI was unknown for the remaining four cases.

On gross examination, external suture apposition appeared adequate for all but two animals (cases 10 and 13, Fig. 1). Surgical wound dehiscence of the uterus was observed in one case (case 10), while loss of structural integrity of the uterine wall was seen in another (case 13), both of which were considered the reason for peritonitis in the affected animals. Haemoabdomen was present in one animal (case 14), while three animals had prominent intrauterine haemorrhage.

Histologically, mild focal to multifocal, lymphocytic aggregates within the endometrium and a few neutrophils/macrophages surrounding incision sites, as well as erythrocyte extravasation and moderate blood vessel dilation, were commonly (n = 5) seen in the uterus; this is considered a normal post-partum/post-operative finding. Pathological uterine changes were seen in 10 cases and were either related to marked inflammation (n = 6), marked haemorrhage (n = 2) or both (*n* = 2) (Fig. 2). Although neutrophils were often (n = 4) the dominant inflammatory cell type, two metritis cases were described as lymphohistiocytic, while prevalence rates of neutrophils, lymphocytes, plasma cells and macrophages were considered equal for another two cases. Most (n = 5) metritis cases were characterized by severe necrosis with fibrin deposition, which applied to all cases with a prominent neutrophilic component. Gram staining was performed on uterine sections from animals with a diagnosis of *Streptococcus canis* septicaemia (n = 5), all of which had abundant dark blue bacterial colonies and individual cocci, especially surrounding the incision site. For six cases, peritonitis, myositis, panniculitis and occasionally dermatitis were observed at the surgical incision sites, often with numerous leucocytes, fibrin, bacterial colonies and areas of necrosis.

3.3. Diagnoses

The most common cause of death was septic shock (7/17) associated with *S. canis* (5/7) and/or *Escherischia coli* (4/7) (Table 2). This was followed by suspected brachycephalic obstructive airway syndrome (BOAS)-associated respiratory failure (4/17) and haemorrhagic shock (3/17). One animal died of hypovolaemic shock associated with gastric dilatation and volvulus. The cause of death was unclear in the remaining two bitches, although septicaemia was suspected in one but proved difficult to establish with confidence because of putrefaction.

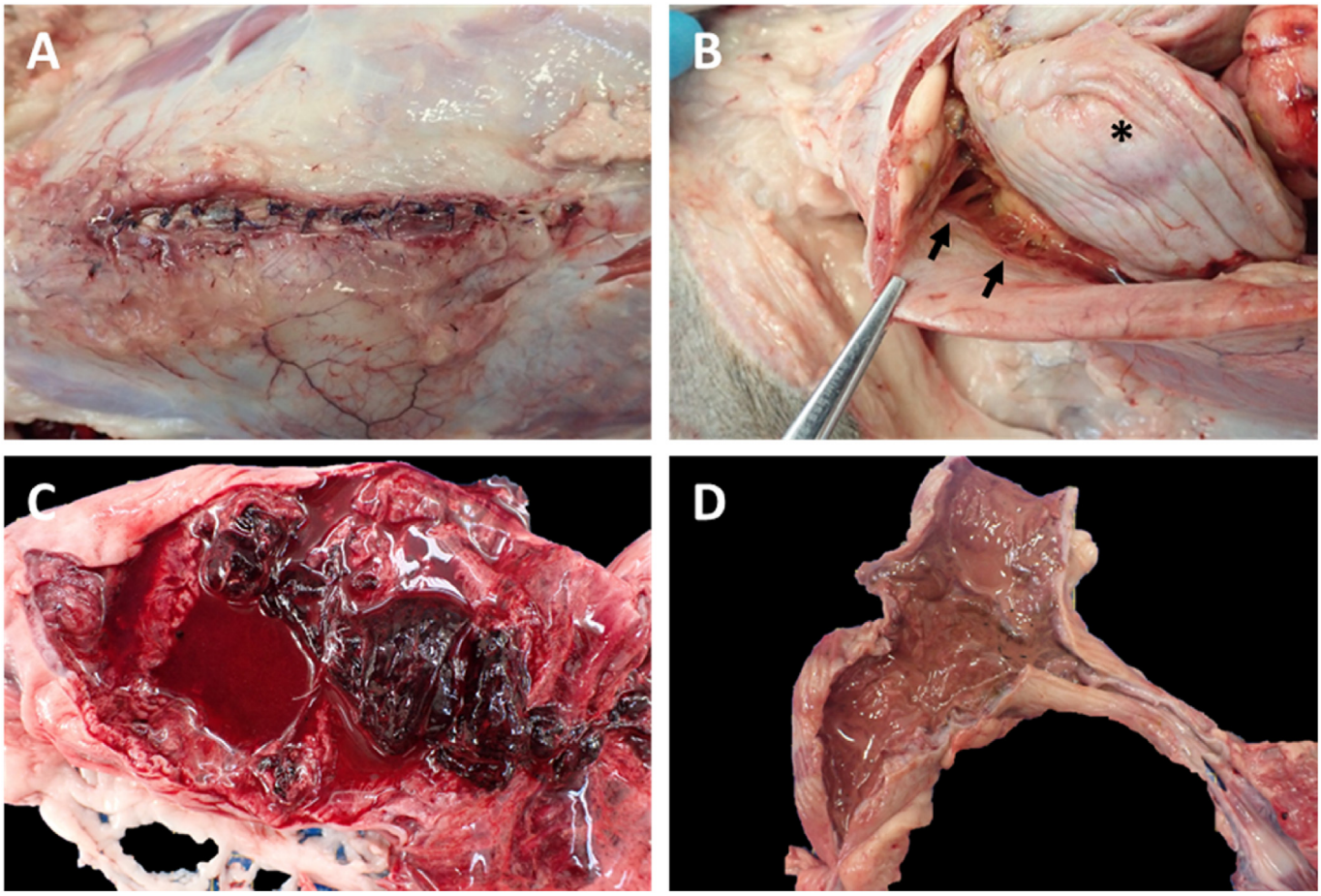

Fig. 1. Gross lesions associated with death following recent (<7 days) caesarean section, dogs. (**A**) Case 10. Incision site after skinning. Wound dehiscence, mild oedema, erythema and moderate presence of yellow exudate with fibrin at edges of ventral abdominal muscle. (**B**) Case 10. Multifocal adhesions (arrows) between uterus (*) and peritoneum. (**C**) Case 17. Large blood clots and moderate volume of liquid blood in uterus. (**D**) Case 13. Brown, cloudy liquid containing neutrophils, fibrin, mucus, erythrocytes and sloughed endometrial cells in uterus, as confirmed by histology.

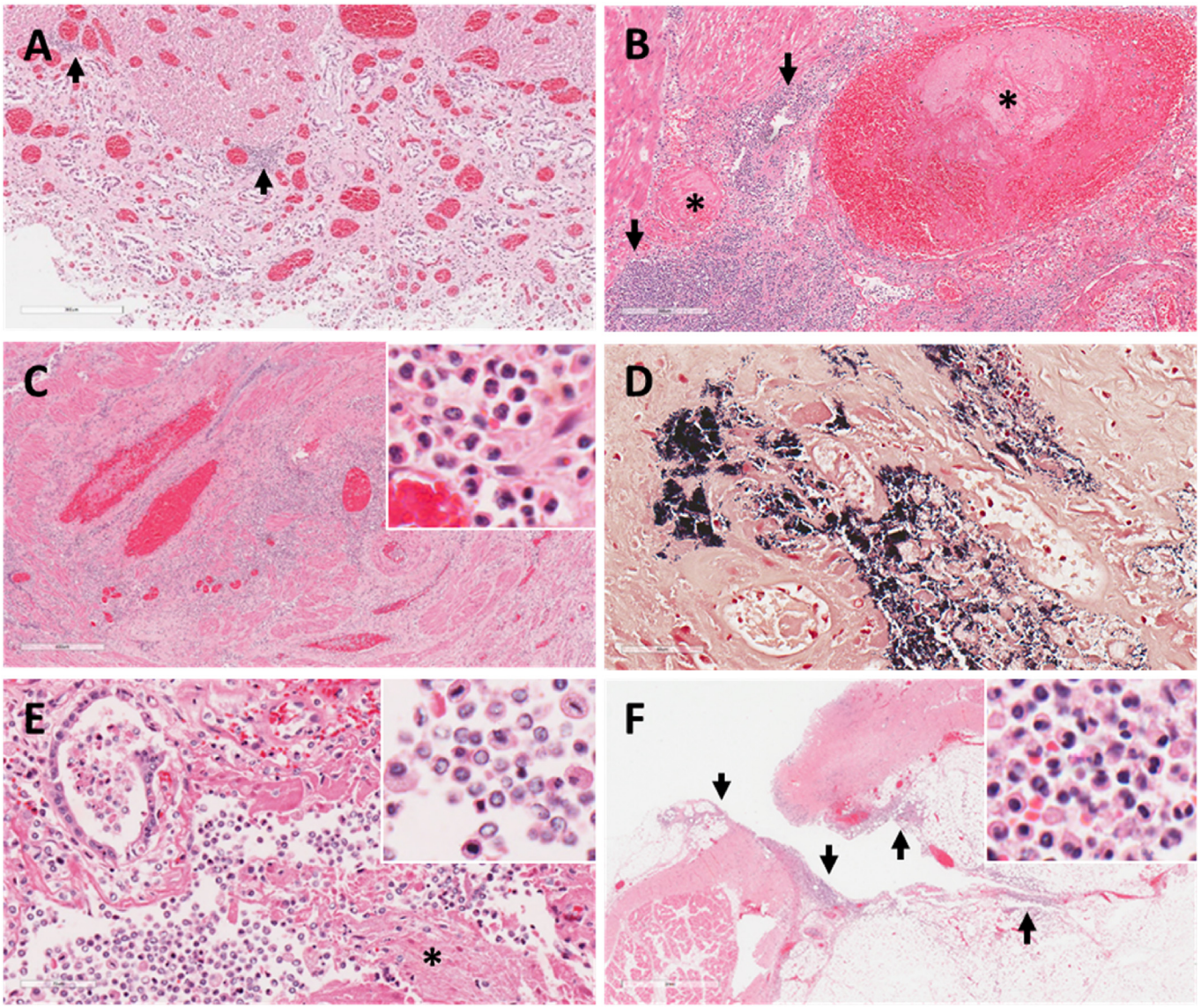

Fig. 2. Histological lesions associated with death following recent (<7 days) caesarean section, dogs. (**A**) Case 11. Normal uterus after caesarean section has mild lymphocytic aggregates (arrows) within endometrium and prominent transmural dilation of blood vessels. HE. (**B**) Case 4. Marked metritis with large neutrophilic to histiocytic aggregates (arrows), thrombosed blood vessels (*), extravasated erythrocytes and fibrin. HE. (**C**) Case 12. Marked neutrophilic to lymphohistiocytic inflammation of myometrium. Inset: detail of cellular infiltrate. HE. (**D**) Case 12. Uterine incision site. High-power image of gram-positive bacterial colonies (dark blue) and necrotic cells. Gram. (**E**) Case 10. Uterus. Numerous macrophages, sloughed epithelial cells and fibrin deposition (*) within endometrium. Inset: detail of cellular infiltrate. HE. (**F**) Case 10. Body wall. Moderate neutrophilic to histiocytic inflammation (arrows) in muscle and adipose tissues surrounding incision site. Inset: detail of cellular infiltrate. HE.

Table 2
Bacterial culture results from bitches that died during or shortly after caesarean section, including seven with septicaemia

Animal	Uterus	Liver	Spleen	Lung	Bone marrow
3	N/A	*E. coli* +++	*E. coli* +++	*P. multocida* +++; *H. haemaglobinophilus* +++	*S. canis* +++; *E. coli* +++
4	*E. coli* +++	*E. coli* +++	*E. coli* +++	*E. coli* +++	*E. coli* +
7	N/A but vagina *E. coli* +++	*E. coli* +	−	*E. coli* +	−
8	*E. coli* +++	*E. coli* ++	*Enterococcus* spp.+−	−	*E. coli* ++
10	*E.* coli ++; *P. mirabilis* ++; *S. dysgalactiae* var. *equisimilis* ++	−	−	−	N/A
12	*S. canis* +++	*S. canis* +++	*S. canis* +++	*S. canis* +++	*S. canis* + -
13	*S. canis* +++	*S. canis* +++	*S. canis* +++	*S. canis* +++	*S. canis* +++
15	N/A but rods seen on histology	N/A	N/A	*E. coli* +++	N/A, but aorta *E. coli* +++
16	*S. canis* +++; *P. mirabilis* +++; *E. coli* +++	*S. canis* +++; *P. mirabilis* +++	*S. canis* +++; *E. coli* +++	*S. canis* +++; *E. coli* +++	*S. canis* +++; *P. mirabilis* +++

N/A, not available.
−, no growth; +, scant growth; +, light growth; ++, moderate growth; +++, heavy growth. Based on semi-quantitative assessment of bacterial growth.

4. Discussion

This case series provides an overview of the signalment and various causes of death in 17 bitches that had undergone caesarean section. Most bitches in this study were classified as brachycephalic breeds and this overrepresentation may have three plausible explanations. Firstly, brachycephalic breeds are predisposed to dystocia and may require a caesarean section more often compared with other breeds [5]. A similar predisposition is reported for Dachshunds [5]. Secondly, this study focuses on cases with a fatal outcome, and dogs suffering from BOAS have an increased risk of perianaesthetic death [6]. Thirdly, brachycephalic dogs are popular and financially valuable animals in the UK [7], therefore owners may elect for conservative caesarean section, retaining the uterus, over ovariohysterectomy to enable future breeding. In this case series, ovariohysterectomy following caesarean section was performed on only one animal, whereas the uterus was maintained in all the others.

The main cause of death in bitches undergoing a caesarean section was related to septicaemia, which may be associated with various risk factors including dystocia, surgical technique, tissue trauma, haemorrhage and dead puppies potentially acting as bacterial substrates, and an altered immune system during pregnancy [2,8,9]. A post-mortem diagnosis of septicaemia is usually made at the discretion of the pathologist, supported by culturing and isolating bacterial agents in multiple organ systems, with monocultures from the bone marrow matching isolates from other organs being especially significant. Signs of disseminated intravascular coagulation and histological evidence of inflammation associated with bacterial colonies can provide additional evidence. Light to heavy growths of *S. canis* (n = 5) and *E. coli* (n = 4) were commonly obtained from multiple organs from bitches diagnosed with septicaemia, both of which were also prevalent in a study on canine bacteraemia [10]. Case 16 also yielded *Proteus mirabilis* on cultures of several organs; however, isolation of this organism from various tissues often suggests post-mortem tissue lysis.

S. canis is a gram-positive, beta-haemolytic, Lancefield group G pyogenic organism for which dogs and cats appear to be primary hosts [11]. It is regarded as an opportunistic pathogen and common colonizer of the skin and mucosal membranes of healthy individuals, most frequently residing in the mouth, nostrils, ear canal and gastrointestinal and genital tracts of small animals [11]. Infections in these species may vary in severity and be associated with dermatitis, otitis, pneumonia and urogenital tract infections [11,12]. Severe clinical disease attributable to *S. canis* includes septicaemia, which may result in hyperacute streptococcal toxic shock syndrome with multiple organ failure and rapid death [12]. Additionally, *S. canis* has been associated with fetal and neonatal septicaemia leading to abortion or neonatal death [12,13].

E. coli is a gram-negative rod belonging to the order Enterobacterales and is naturally found in the intestinal and, less frequently, the urogenital tract of humans and many animal species including dogs [14,15]. Extraintestinal pathogenic *E. coli* (ExPEC) strains [16] are usually associated with a variety of infections at non-intestinal sites [14,16,17] including urogenital infections and pyometra. ExPEC isolates are of particular concern because of their enhanced virulence and dramatic increase in antimicrobial resistance in recent years [18]. Most *E. coli* isolated in this case series were beta-haemolytic strains but regrettably their pathotype, virulence and antimicrobial resistance profile were not investigated.

There are several hypotheses regarding the route of entry of the bacterial agents that resulted in septicaemia in the described cases. The first could be ascending infection from the lower urogenital tract into the uterus [14]. A second possibility is iatrogenic introduction through contamination of surgical consumables or breaches in aseptic technique; post-operative skin wound infection is also feasible. Histological examination of surgical sites including the uterus, body wall and skin, together with identification of bacteria and the interval between surgery and death, can provide clues to help determine which is most likely. The presence of severe neutrophilic inflammation and bacterial colonies within multiple surgical sites, in the absence of similar generalized uterine changes, can be suggestive of surgical bacterial implantation. These findings applied to four out of seven cases diagnosed with septicaemia, all of which died between 24 and 48 h after surgery. Case 15 had moderate neutrophilic inflammation at the surgical sites and died 7 h after caesarean section, which may imply a peracute infection. However, for two animals (cases 8 and 10), severe generalized lymphohistiocytic endometritis suggested a more chronic disease process whereby uterine infection was probably already present prior to surgical intervention. In fact, surgical incision of the uterus had not been performed on case 8; the animal had died during anaesthesia, with a diagnosis of septicaemia. The hypothesis of post-operative wound contamination is less likely for animals in this case series, considering the relatively short interval (<48 h) between surgery and death, as well as the presence of marked uterine inflammation.

It should be emphasized that the uterus is not a sterile environment. In one study bitches that had undergone a caesarean section for dystocia harboured a wide variety of bacterial agents including *Staphylococcus* spp, *S. canis* and *E. coli*, with greater bacterial diversity and higher loads observed when the uterus contained both live and dead puppies [9]. Presumably most animals with septicaemia in this case series contracted infection via surgical implantation of intrauterine bacteria at the sites of incision, with rapid (7–48 h) development of septicaemia. Based on this evidence, preventive intravenous broad-spectrum antibiotic therapy and additional precautionary sterility measures should be considered when handling the uterine body, especially in bitches with prolonged dystocia.

Brachycephalic breeds are known for their vulnerability to perioperative respiratory complications including hypoxia, hypercapnia and increased airway resistance [19], which may increase their risk for perianaesthetic death [6]. Moreover, pregnancy can amplify respiratory clinical signs due to increased abdominal pressure, reduction of lung capacity and increased tidal volume and respiratory rate that could further compromise already constricted airways [1]. Therefore, the surgical stress and physiological demands of pregnancy and parturition may elevate the risks of anaesthesia in these animals, especially after prolonged labour [20]. Nevertheless, respiratory failure associated with BOAS often relies on exclusion diagnosis. In this study, three out of four animals with a diagnosis of BOAS died during the surgical procedure. For one of these animals (case 11), bacteriological investigation was not pursued despite a history of dystocia and a dead puppy. The fourth animal diagnosed with BOAS (case 3) died during recovery, 8 h after the procedure. Interestingly, heavy growths of *E. coli* and *S. canis* were obtained from this animal's bone marrow, but it proved difficult to distinguish between septicaemia and post-mortem overgrowth given the state of early decomposition. Therefore, septicaemia cannot be excluded in these two cases and may well have contributed to death.

In the absence of conclusive bacteriology results or pathological findings that can directly be linked to death, measurements of brachycephalic morphological features can help in reaching a most likely diagnosis. External features include neck to chest girth ratio (NGR) and the degree of nostril stenosis [21], while helpful internal observations can include soft palate elongation, laryngeal saccule eversion (collapse) and tracheal hypoplasia. When these findings support BOAS, with subsequent indications of compromised

pulmonary ventilation such as marked lung oedema and signs of hypoxia (eg, cyanosis and neuronal necrosis), it may be reasonable to consider BOAS-associated respiratory failure as a likely cause of death. Such a diagnosis applied to four animals in this study, all of which had moderate to severe pulmonary oedema, soft palate elongation and laryngeal saccule eversion. NGR was only measured for two bitches (cases 2 and 3), both of which had an NGR value of >0.71. BOAS features were not investigated or mentioned for case 7, despite an inconclusive diagnosis and the presence of severe pulmonary oedema.

Mortality following haemorrhagic shock depends on many variables including the volume of blood loss per unit of time, packed cell volume and coagulation factors [22–25]. Despite lack of a reliable cut-off point, haemorrhagic shock can be considered a plausible diagnosis if approximately 30% or more of the total circulating blood volume is lost within a relatively short timeframe. It has been suggested that approximately 8% of the body weight of an adult dog is represented by circulating blood [26]. Therefore, the presence of ≥24 ml blood per kg body weight found outside of the circulatory system (eg, intrauterine or within the peritoneal cavity) can support a diagnosis of haemorrhagic shock. This applied to two animals (cases 6 and 17) with intrauterine haemorrhage, while estimation of the total blood loss was difficult for the third (case 14) because haemorrhage occurred in multiple organ systems. Although peripartum haemorrhage (PPH) is a major cause of peripartum mortality in humans and horses [23,27], it has only occasionally been reported in dogs [28] and its pathophysiology is not well documented. In theory, failure of surgical haemostasis, compromised uterine wall integrity and underlying coagulative disorders predisposing to increased bleeding tendency may all play a role. For the animal in this study with haemorrhages in the uterus, intestines, abdominal cavity and mammary gland, a coagulation disorder was suspected. However, such conditions can prove challenging to diagnose [29] and further investigation was not pursued. The presence of bloody faeces, as well as adrenal and subendocardial haemorrhages, can also be associated with acute haemorrhagic shock [22,24].

Although Conze *et al* [4] recorded a lower mortality rate for conservative caesarean section (2.59%) compared with caesarean section followed by ovariohysterectomy (4.19%), other authors reported no significant difference between the procedures [30]. The findings from this study suggest that, at least for some cases, preservation of the uterus may have acted as a source of bacterial infection or haemorrhage, which resulted in the death of the patient. Therefore, conservative caesarean section may pose a risk factor, especially for cases with prolonged dystocia or dead puppies and those with concerns regarding the integrity of the uterine wall. For the previously described cases, subsequent ovariohysterectomy may be recommended.

This study inferred which breeds are at higher risk of being presented for PME shortly after having undergone caesarean section. Although presumably a good approximation, it does not equate to which breeds have a higher risk of dying after caesarean section, which requires clinical rather than pathological data. A history of dystocia (n = ≥8) and dead puppies (n = ≥6) was common and may have predisposed to subsequent septicaemia. However, proof would require a larger study population.

5. Conclusion

Septicaemia caused by *S. canis* or *E. coli* should be considered an important fatal complication of caesarean section in the bitch. Infection may be iatrogenically introduced from the uterus, with prolonged dystocia potentially acting as a risk factor. Therefore, bacterial culture and isolation should be part of routine PME for bitches that have undergone recent caesarean section. Given that brachycephalic breeds made up a large proportion of animals presented for caesarean section, BOAS-associated respiratory failure was another common cause of mortality, albeit that this diagnosis remains speculative. Finally, haemorrhagic shock resulting from PPH also caused mortality, but the exact underlying pathophysiological mechanism responsible for the blood loss proved difficult to elucidate.

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Statement of author contributions

Y. Van de Weyer: Conceptualization; Methodology; Data curation; Writing. **A. Orlowska:** Writing; Reviewing. **F. Zendri:** Writing; Reviewing. **H.E. Crosby-Durrani:** Reviewing; Supervising.

Declaration of competing interests

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