

Population characteristics of 453 bitches undergoing 510 cesarean section procedures between 1999 and 2009—a retrospective study*

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Abstract

Objective: To evaluate the characteristics of a population of bitches undergoing cesarean section and report the associated etiological diagnoses.

Study design: Retrospective case series of 510 cases of cesarean section performed on 453 bitches between 1 July 1999 and 31 June 2009.

Methods: Medical records were reviewed for information related to signalment, reproductive history, gestation, clinical features, ultrasonographic findings and treatment in bitches undergoing cesarean section. The number of pups was reviewed and deaths or fetal abnormalities recorded. An etiological diagnosis was sought for each case based on reported findings.

Results: Median age was four years and brachycephalic breeds were overrepresented. It was common for non-maiden bitches to have previously undergone cesarean (87/152). Forty-one bitches (9.1%) had anatomical vaginal abnormalities, 81 (17.9%) had uterine abnormalities and 19 (4.2%) had placental abnormalities. Fetal heart rates were detected in 96.6% of 409 cases in which ultrasound was successfully performed. The most common induction agent was alfaxalone. The Utrecht suture pattern was used in 418 cases (88.9%). Few anesthetic or post-operative complications were reported. Mean litter size was 5.6, with a mortality rate of 11.5%. The origin of dystocia was considered to be maternal in 63 cases (13.2%), fetal in 177 cases (37.0%) and related to litter size in 79 cases (16.5%).

Clinical relevance: These results suggest that brachycephalic and dolichocephalic breeds are more likely to require cesarean section than mesocephalic breeds. Risk appears to be reduced in small breeds and increased in giant breeds compared with medium and large breeds. Alfaxalone and propofol both confer minimal risk to the bitch when used for induction of anesthesia. The Utrecht suture pattern is appropriate for closure of the hysterotomy.

Keywords: Cesarean, canine dystocia, alfaxalone, Utrecht suture pattern, fetal ultrasound

Introduction

Cesarean section is a commonly performed procedure both in general practice and in emergency centers. It is usually performed in cases of dystocia or fetal distress, when there is a history of difficulty with natural birth, or when difficulty is expected due to anatomic abnormalities, breed or other factors. However, breeders are increasingly electing to proceed with cesarean section in the absence of the aforementioned factors, based on estimation of parturition date using progesterone assays or at the first indication of parturition.

The largest study of cases of cesarean section to have been performed to date involved 808 bitches from multiple veterinary hospitals throughout the United States and Canada.¹ This study investigated bitch signalment, perioperative management and mortality rates but did not assess historical or clinical features of these cases, and did not speculate as to the etiology of dystocia. The two other recent relatively large-scale reports on dystocic bitches included both medically and surgically treated cases.^{2,3} This study aims to provide a large-scale and up-to-date report on aspects of signalment, parity, reproductive history, gestation, reasons for presentation, clinical features, ultrasonographic findings, treatment methods and mortality rates in bitches undergoing cesarean section in northern Brisbane, Australia.

Previous articles in the scientific literature regarding cesarean section also have not addressed the seasonality of this procedure. This study examines the day, month and season of

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accession, hypothesizing based on the personal experience of staff that the frequency of accession would be increased on Sundays, when primary care veterinarians are often not open for business.

The use of alfaxalone as an induction agent in the management of dystocia has been rarely reported or discussed in the literature. Similarly, the Utrecht suture pattern has previously not been investigated as a means of closing the hysterotomy incision in dogs. This study will provide an insight into the appropriateness of this anesthetic agent and suture pattern and may provide the clinician with further anesthetic and surgical alternatives when performing cesarean section.

Materials and methods

The medical records database at Queensland Veterinary Specialists (QVS) and Pet Emergency Room (Pet ER) was searched for records of dogs examined between July 1999 and June 2009 for which an invoice item 'cesarean section' had been entered. This yielded 453 cases; a further 57 cases were recovered while searching through individual records. Bitches were included in the study if they had undergone cesarean section within the specified dates and an adequate history was available. Fifteen dogs were excluded because the medical records had not been satisfactorily completed. Ultimately, 510 cases of cesarean section performed on 453 bitches were included; 46 bitches had more than one cesarean section performed within the study period. In this paper, when the word 'cases' is used then all procedures are considered individually, whereas the word 'bitches' denotes that each bitch is counted once only regardless of the number of times she presented.

The breed, weight and age of the bitch at the time of cesarean section were recorded for each case. Breeds were classified as small, medium, large or giant and as brachycephalic, mesocephalic or dolichocephalic (see Appendix for classifications). In each case, parity and history of past cesarean sections (yes or no) were recorded where possible. The date and time of insemination were recorded when available and the interval from insemination to cesarean section was thus calculated.

Bitches that had presented more than once for cesarean section within the study period were counted only once for the purposes of calculating breed prevalence. To compare the study population to a control population of purebred bitches registered with the Australian National Kennel Council (ANKC) between 1999 and 2008, only 404 purebred bitches were included.⁴ In order to reduce the effect of bias caused by the presentation of multiple animals of the same breed by individual breeders, these calculations were repeated on a population of 307 purebred bitches in which only one bitch of any given breed was included for each breeder.

All cases were treated on an individual basis for calculations involving age, reproductive history and gestation since these parameters were variable between presentations occurring on separate occasions. If medical management had been attempted prior to cesarean section, this was noted.

The date of presentation was recorded and from this data the day, month and season of presentation were determined. The client's reason for presentation and any concurrent disease or medications at the time of presentation were recorded.

The stage and duration of labor, presence or absence of the Ferguson reflex, degree of mammary development, presence or absence of a palpable pup or chorioallantoic sac in the vagina and the lowest measured fetal heart rate were recorded for each bitch. Vaginal abnormalities or discharge were noted. For bitches that had presented more than once during the study period, abnormalities that were noted on more than one occasion were counted once only. No bitch had independent abnormalities noted on different occasions.

A record was made of the anesthetic agents used, type and rate of intra-operative fluid administration and perioperative medications. Surgical complications were noted. The suture pattern and material used to close the hysterotomy were recorded. Any abnormalities in the appearance of the uterus and placentae at surgery were noted.

The number of pups delivered alive and dead vaginally and by cesarean, number of immediate post-operative deaths, total litter size and fetal abnormalities were recorded. For the purposes of calculating the proportions of males and females, cases were included only if the number of males and females were reported as a proportion of the total number delivered by

cesarean. Any complications for which bitches re-presented to Pet ER or QVS that arose as a result of pregnancy, lactation or surgery were recorded.

For each case of dystocia, an attempt was made to determine etiology based on the available history. If a recorded fetal or maternal abnormality was considered likely to have caused dystocia, then the dystocia was attributed to that cause. If no physiological or anatomical abnormalities were detected, or if abnormalities were considered unlikely to have contributed to dystocia, then the dystocia was classified as idiopathic and further classified into one of four categories: (1) failure to commence second stage labor; (2) cessation of second stage labor prior to passage of all pups; (3) prolonged unproductive second stage labor or (4) apparently normal progression of labor with detection of fetal distress.

Data analysis/statistical methods

The primary aim of this paper is to report the epidemiological characteristics of the studied population and not to examine the relationships between variables or to compare the population with a control population, which would be difficult to define. As a result, statistical analysis was seldom required.

Reported statistics were calculated using one of two types of analysis. For comparing observed frequencies with expected frequencies for multiple discrete variables, a chi square calculation was used. For comparing binomial variables in cohorts within the studied population, Fisher's exact test was used. All reported p-values are two-tailed. A value of <0.05 was considered statistically significant.

Results

Signalment and history

The most over-represented breeds were Staffordshire Terrier (n = 48 cases, 10.6%), Labrador Retriever (n = 33, 7.3%), Greyhound (n = 32, 7.1%), British Bulldog (n = 27, 6.0%) and Golden Retriever (n = 15, 3.3%). Of 404 purebred bitches, 176 (43.6%) were brachycephalic, 160 (39.6%) were mesocephalic and 78 (19.3%) were dolichocephalic. A statistically significant difference was found between the proportions of bitches of different head conformations in the purebred portion of the study population compared with the ANKC-registered purebred population (p < 0.0001). Brachycephalic (odds ratio [OR] = 1.36) and dolichocephalic (OR = 1.88) breeds were over-represented, whilst mesocephalic (OR = 0.69) dogs were under-represented. When the study population was altered so that multiple bitches of the same breed were excluded if they were presented by the same breeder, the proportions of bitches of different head conformations remained significantly different than those of the control population (p < 0.0001) and the same trends were noted.

In 296 cases, a weight was recorded on the date of cesarean section. Median weight was 21 kilograms (median, 23.1; mode, 20; range, 2.1 to 86.8 kg). Of 404 purebred bitches, 124 (30.7%) were classified as small breed, 93 (23.0%) were medium, 157 (38.9%) were large and 30 (7.4%) were giant. When the proportions of bitches of different sizes were compared between the study population and the ANKC-registered purebred population, a statistically significant difference was noted (p = 0.016). Small breeds were under-represented (OR = 0.85) whilst giant (OR = 1.55) breeds were over-represented. When the study population was altered so that multiple bitches of the same breed were excluded if they were presented by the same breeder, statistical significance remained (p = 0.0439) and the same trends were noted.

Median age at presentation was 4 years (interquartile range [IQR], 2 to 5; mean, 4; mode, 2; range, 1 to 13 years). Figure 1 demonstrates the distribution of ages. Of 361 cases for which parity was recorded, 194 (53.7%) were maidens and 167 (46.3%) had past litters. Of the 167 non-maiden cases, the presence or absence of past cesareans was recorded for 152. A previous cesarean section had been performed on 87 (57.2%) of these cases; 65 (42.8%) had not required surgical intervention. Methods of insemination for 274 bitches where this was recorded are summarized in Table 1. Of 154 bitches for which a single date of insemination was recorded, the mean interval from insemination to cesarean was 60.0 days (IQR, 59 to 61; median, 60; mode, 60; range, 49 to 70). The distribution of gestation periods is shown in Figure 2.

In 53 cases, a temperature drop had been noted on one occasion in the lead-up to parturition. In two cases, two separate temperature drops had been recorded. In total, 55 cases (10.8%) had at least one recorded temperature drop. Presentation occurred prior to the onset of second stage labor in 47 of these cases (85.5%).

In 46 cases (9.0%), medical treatment had been provided prior to the decision to proceed with cesarean. The treatments provided are summarized in Table 2.

Presentation

The emergency service received 256 cases (50.2%), whilst 254 cases (49.8%) presented as clients of the reproduction service. A theriogenologist performed 317 cesareans (62.2%); 152 (29.8%) were performed by a Pet ER staff member and 41 (8.0%) were performed by a QVS surgical specialist or resident. Bitches presented more commonly on a Sunday (n = 90, 17.7%) or Monday (n = 83, 16.3%) and in autumn (n = 147, 28.8%), but these trends were statistically insignificant (p = 0.1353 and p = 0.1767, respectively).

By far the most common reason for the owner presenting their bitch was a perceived abnormality in the progression of labor—this was the situation in 372 cases (73.1%). This abnormality generally involved one of failure to progress to second stage labor (n = 115, 31.9%), prolonged labor without normal delivery of puppies (n = 173, 48.1%) or cessation of active labor (n = 69, 19.2%). In three cases (0.8%) the clinician felt that labor was apparently progressing normally but fetal distress or obstruction was detected. In 12 cases, there was insufficient information to determine the type of abnormality. A check-up prior to or during parturition was the reason for presentation in 69 (13.6%) and 35 cases (6.9%), respectively. In 20 of these cases, the owner had detected a clinical abnormality. Elective cesarean had been planned in 29 cases (5.7%). In three cases (0.6%), undelivered puppies were detected during a post-partum check-up. In one case the reason for presentation was not recorded.

Of 491 cases for which the stage of labor was recorded, 268 (54.6%) were in second stage labor. Estimates of duration of labor as reported by the owner were available for 220 cases and are summarized in Table 3. Of 223 cases in which second stage labor had not begun, 114 (51.1%) were suspected to be in first stage labor based on history and clinical findings.

Physical examination

At least one vaginal abnormality was noted in 46 bitches (10.6%) at the time of physical examination. These abnormalities included stricture, stenosis or scarring of the vagina or vestibule (21 bitches, 4.6%), vaginal or vulvar hypoplasia (10 bitches, 2.2%), vaginal pain or evidence of trauma (6 bitches, 1.3%), a membranous or band anomaly (4 bitches, 0.9%) and vaginal hyperplasia (1 bitch, 0.2%). Four bitches had had a vaginal anomaly corrected previously (0.9%).

In 124 cases (24.3%), vaginal discharge was described by the owner or observed by the clinician, including green/black (n = 45, 8.8%), watery/clear (n = 41, 8.0%), bloody (n = 9, 1.8%), mucoid (n = 5, 1.0%), yellow (n = 2, 0.4%), brown (n = 2, 0.4%), serosanguineous (n = 1, 0.2%) or purulent/cloudy (n = 1, 0.2%) discharge. Lochia were observed in six cases (1.2%). In 11 cases the discharge was not well-described.

Of 208 cases for which mammary development and milk production was recorded, 185 (88.9%) had good development and colostrum in all glands, six (2.9%) had development of only some glands, eight (3.8%) had scant colostrum, seven (3.4%) had no mammary development, one (0.5%) had mammary development but no milk and one (0.5%) was producing non-colostrum.

Of the 203 bitches for which relevant information regarding the Ferguson reflex was recorded, 27 (13.3%) displayed the reflex. A pup was palpable on digital vaginal examination in 147 cases (28.8%) and chorioallantois was palpable in 38 cases (7.5%).

Other clinical abnormalities included diarrhea (n = 10 cases); abdominal pain (n = 4); dermatopathies (n = 3); injected (n = 1), cyanotic (n = 2), pale (n = 2) or tacky (n = 2) mucous membranes; icterus (n = 1); pyrexia (n = 2); hematuria (n = 1); signs of hypovolemia (n = 2); dyspnea (n = 2); parasitic anemia (n = 2); cardiac murmur (n = 2) and intratracheal pus or uterovaginal suggesting aspiration (n = 2). Dehydration, hypoglycemia, cardiac arrhythmia,

splenic mass, hepatopathy, pregnancy diabetes and ataxia each occurred in single cases. Five cases had more than one abnormality.

Vomiting (n = 33, 6.5%) and ventral edema (n = 14, 2.7%) are known to occur in association with late pregnancy or parturition. It was noted that eight of the 14 cases with ventral edema were British Bulldogs. No bitch presented on more than one occasion with edema. The increased incidence of ventral edema in British Bulldogs compared with other breeds is highly statistically significant ($p < 0.0001$). It was also noted that the incidence of vomiting was increased in Labrador Retrievers (6/33 cases), and this association too was statistically significant ($p = 0.0144$)

Ultrasonographic examination

Non-zero fetal heart rates were detected in 395 (96.6%) of 409 cases in which ultrasound was successfully performed. In 306 of these cases (77.5%), the lowest recorded fetal heart rate was 180 or less. The average lowest recorded heart rate was 159.7 beats per minute (bpm; IQR, 148 to 180; median, 160; mode, 160; range, 40 – 300). In 50 cases (12.2%), at least one fetus with a heart rate of zero was detected, and in 101 cases (24.7%), there was at least one fetus with a normal heart rate (200 – 220 bpm). In ten cases (2.4%) both normal and zero heart rates were detected; 268 cases (65.5%) had neither zero nor normal heart rates detected.

In 57 of 409 (13.9%) successful ultrasonographic examinations, additional abnormalities were detected. These included reduced (n = 33) or increased (n = 4) chorioallantoic fluid surrounding at least one fetus, fetal anasarca (n = 3), abnormal cardiac ventricular emptying (n = 1), abnormal or indistinct fetal echostructure (n = 3), abdominal free fluid (n = 3), transverse fetal presentation (n = 3), flocculent amniotic material (n = 3), abnormal uterine appearance (n = 2), a mass of tissue or organic matter within the uterus (n = 2), a discrepancy in fetal size (n = 2), excessive (n = 2) or reduced (n = 1) intraluminal uterine fluid, loss of definition of uterine contents (n = 1), inability to visualize the urinary bladder (n = 1) and the presence of partially-aborted concepti (n = 1). In six cases, multiple ultrasonographic abnormalities were identified, including one case with three concurrent abnormalities.

Anesthetic

The induction agent used was alfaxalone (Alfaxan, CD-RTU, Jurox, Rutherford, NSW Aust.) in 396 cases (78.3%), propofol (Diprivan, AstraZeneca, Brussels, Belgium) in 102 cases (20.2%), thiopentone (Ilium thiopentone, Troy Laboratories, Smithfield, NSW Aust.) in five cases (1.0%) and mask isoflurane (Isorrane, Baxter Healthcare Pty. Ltd., Old Toongabbie, NSW Aust.) in three cases (0.6%). Alfaxalone was first used in March 2002. Propofol continued to be used frequently until April 2003, after which time it became routine to use alfaxalone. Isoflurane was used to maintain anesthesia in 497 cases (98.0%). Halothane (Fluothane, ICI Pharmaceuticals, Melbourne, VIC Aust.) was used on ten occasions between 1999 and 2003. Few anesthetic complications were encountered. Under a diazepam (Pamlin, Parnell Laboratories, Alexandria, NSW Aust.)/propofol/isoflurane anesthetic one bitch suffered hypotension, tachypnea and tachycardia. Under alfaxalone/isoflurane anesthetics one bitch suffered sudden recovery and one vomited post-operatively, but that bitch had also vomited pre-operatively.

Intravenous crystalloid solution was recorded to have been administered to 497 cases (97.5%) at rates varying from maintenance to shock rates. Most commonly, fluids were administered at four times (n = 178, 35.8%) maintenance rates. Two cases received glucose in saline. In 11 cases, fluid administration was not recorded.

Surgery

Of 470 cases in which suture pattern was recorded, a Utrecht pattern was used in 418 (88.5%). The use of other patterns is summarized in Table 4. Ovariohysterectomy (OHE) was performed in six cases. The most commonly used suture materials were 2/0 or 3/0 polyglyconate (Maxon, Davis and Geck, Danbury, CT), accounting for 410 cases (99.0%), including five OHE's. Three cases (0.7%) were sutured using polydioxanone (PDS II, Ethicon Inc., Somerville, NJ), and catgut was used for one OHE (0.2%). In 96 cases, the suture material utilized was not recorded.

Complications at surgery included five bitches with excessive hemorrhage (n = 5), milk contamination of the surgery site (n = 2 [1 bitch]), severe scarring of the linea alba (n = 1) and requirement for concurrent splenectomy (n = 1).

Four cases required emergency OHE for uterine rupture (n = 2) or middle uterine artery hemorrhage (n = 2). Two cases with unilateral uterine ischemia required emergency hemiovariectomy. A further two OHEs were performed on an elective basis. Twelve bitches received a packed red blood cell transfusion. No bitches died.

In 502 cases, peri-operative medications were recorded. The most commonly administered medications were oxytocin (Ilium Syntocinon, Troy Laboratories, Smithfield, NSW Aust.; n = 424, 84.4%), meloxicam (Ilium meloxicam, Troy Laboratories, Smithfield, NSW Aust.; n = 274, 54.6%), amoxicillin-clavulanic acid (Clavulox, Pfizer, Mt. Eden, Auckland NZ; n = 307, 61.2%), methadone (Methone, Parnell Laboratories, Alexandria, NSW Aust.; n = 58, 11.6%) and diazepam (n = 52, 10.0%).

Outcome

A total of 81 bitches (17.9%) had at least one uterine abnormality noted at the time of surgery. Five of these bitches had abnormalities noted on more than one occasion. Two simultaneous independent abnormalities were noted in 17 bitches, and three bitches had three independent abnormalities. The most common observed abnormality was uterine tearing or rupture (n = 21/453 bitches, 4.6%), followed by adhesions (n = 17, 3.8%), ischemia (n = 10, 2.2%), hematomata (n = 9, 2.0%), hyperemia or subserosal hemorrhage (n = 9), atonicity (n = 7, 1.5%), stenosis (n = 7), distension (n = 7), torsion (n = 7), cystic changes (n = 5, 1.1%), friability (n = 5), thinning of the uterine wall (n = 4, 0.9%), myometrial thickening (n = 4), failure to dilate (n = 4), stricture (n = 3, 0.7%), folding of a uterine horn (n = 3), myometrial hypercontraction (n = 2, 0.4%), endometritis (n = 1, 0.2%) and a uterine polyp (n = 1).

Nineteen (4.2%) bitches had placental abnormalities as follows: excessive ease of placental detachment (n = 6), placentitis (n = 5), remnants of aborted concepti (n = 4), excessive hemorrhage from placental sites (n = 1) and abnormal placentation with absent underlying endometrium and myometrium (n = 1).

A total of 2736 pups were born from 489 litters for which relevant information was available. Of these, 387 (14.1%) were born vaginally, 71 (18.3%) of which were dead on delivery, and 2350 (85.9%) were delivered by cesarean section, 157 (6.7%) of which were dead on delivery. Overall, 8.4% of pups were dead on delivery. A further 86 pups failed to be resuscitated (n = 42, 48.8%) or were euthanized for fetal deformities (n = 44, 51.2%) in the immediate post-operative period, giving an overall short-term puppy mortality rate of 11.5%.

The mean litter size was 5.6 (IQR, 3 to 8; median, 5; mode, 5; range, 1 to 16). Particularly small (one or two puppies) or large (eight or more puppies) litters were observed in 76 (14.9%) and 84 cases (16.5%), respectively. The number of males and females as a proportion of the total number delivered by cesarean was recorded for 272 litters. Males accounted for 571 (47.7%) and females 626 (52.3%) of the puppies born from these litters. This deviation from the expected 1:1 ratio is not statistically significant (p = 0.1117).

A total of 29 bitches gave birth to 38 pups with cleft palate, and 17 bitches produced 41 pups with anasarca. A variety of other fetal abnormalities were observed, including eight fetuses with ventral hernias (born to eight bitches), seven with hydrocephalus (four bitches), five with limb deformities (five bitches), four with tail deformities (two bitches), four with oronasal deformities (two bitches), two with anencephaly (two bitches), two with facial deformities (two bitches), one with polydactyly, one with syndactyly, one with evisceration, one with an ulcerated dermal mass, one with anury and one with hindlimb amelia. Seven fetuses had unspecified anatomic abnormalities (six bitches).

Three pups born to two bitches had no apparent placental attachment and five pups born to one bitch had brown mucoid material around a marginal hematomata in the chorioallantois. Five mummified pups were delivered from five bitches. Macerated pups were recovered from 23 bitches. Fifteen bitches produced puppies with premature passage of meconium. Fifteen bitches had immature puppies.

Post-operative complications were rarely reported. The most common diagnoses were metritis (n = 7) two to 23 days post-operatively, mastitis (n = 9) three days to one month post-operatively and hypocalcaemia (n = 6) one to five days post-operatively. Within ten days of surgery, four cases presented for wound dehiscence, two for herniation at the incision site, one for nasal discharge, one for ileus and one for laryngitis. Two cases presented for subinvolution of placental sites nine and 11 weeks after surgery. Four bitches presented for more than one complication. It should be noted that there are likely to have been other complications for which owners presented to their primary care veterinarian, and in these cases there was no record of these complications having occurred.

Etiology

Of the 510 cases, 479 (93.9%) were considered to be in dystocia. Of 31 cases that were not, 25 underwent elective cesarean procedures, four were aborting and two underwent cesarean prior to the commencement of parturition—one because abnormal fluid accumulation and an undefined mass were observed on ultrasound and one because of abnormal ‘nasty’ vaginal discharge.

Dystocia was considered to be of maternal origin in 63 cases (13.2%), of fetal origin in 177 cases (37.4%), and a result of a particularly small (n = 30, 20 of which were singletons) or large (n = 49) litter size in 79 cases (16.7%). In 160 cases (33.0%), the cause of dystocia was not obvious and classification was instead based on the criterion that was used to diagnose dystocia. The specific causes of dystocia are reported in Table 5.

Thirty-one bitches underwent elective cesarean, 29 of which presented with this in mind. Reasons for proceeding with surgery included previous dystocia (n = 5, 16.1%), breed risk (n = 5, 16.1%), singleton litter (n = 4, 12.9%), vaginal abnormality (n = 2, 6.5%), passage of a dead puppy (n = 1, 3.2%), a splenic mass requiring laparotomy (n = 1, 3.2%) and nulliparity in an old bitch (n = 1, 3.2%). The reason was not known in 11 bitches, but three of these bitches had large litters, three had previously undergone cesarean section, one had a singleton pregnancy and one was an at-risk breed. Three (9.7%) bitches presented for elective cesarean with no obvious predisposition to dystocia or other indication for cesarean section. Ten bitches (34.5%) presenting for elective cesarean had reduced fetal heart rates on ultrasound.

Discussion

Many studies have attempted to identify the factors influencing the risk of dystocia or requirement for cesarean section, and the associated outcomes. Factors considered to be associated with increased risk of dystocia include immaturity, old age, anatomical or physiological abnormalities, small or large litter size, absolute or relative fetal oversize, fetal malposition or malpresentation and fetal anatomical abnormalities. It is to be hoped that these data allow clinicians to gain perspective with regard to the prevalence of various abnormalities in cases of dystocia, and hence be guided in the most important aspects of clinical examination. In particular, it is important to realize when dystocia has been caused by an irreversible maternal abnormality, so that future breeding can be discouraged and/or so that cesarean section can be planned for subsequent pregnancies.

In the current study, three of the five commonest breeds—Staffordshire Terrier, Labrador and Golden Retriever—were also among the five most popular breeds registered with the ANKC between 1999 and 2008. Greyhounds and British Bulldogs were commonly presented by breeders as clients of the reproduction service. Three breeders were responsible for presentation of 21 of the 27 British Bulldogs, whilst six breeders presented 21 of the 32 greyhounds. This is likely to have contributed substantial bias and makes it difficult to judge the true prevalence of these breeds.

Retrospective studies of bitches in dystocia have, to date, failed to demonstrate a definitive relationship between breed size and occurrence of dystocia. In one study, medium-sized breeds were over-represented compared with all registered bitches and in another study, incidence of dystocia was increased in toy and miniature breeds.^{2,3} The comparison between this study population and the population of ANKC-registered purebred dogs is not ideal, as it includes both males and females throughout Australia, whereas the study population is

exclusively female and located primarily in Brisbane. Bearing this in mind, it is still interesting to note that small breeds are significantly less prevalent and giant breeds more prevalent in the studied population compared with the 'control' population. This result contrasts with the commonly held belief that small size confers a greater risk of dystocia. Part of the discrepancy may be a result of differing methods of classification with regard to size.

It is widely accepted that brachycephalia is associated with increased risk of dystocia, and the current results lend support to this theory. More surprising is the finding that dolichocephalic breeds also appear to be significantly more likely to require cesarean section than mesocephalic breeds. These relationships remained statistically significant even after removing bitches of the same breed presented by the same breeder from the population under analysis to reduce bias.

The result that 53.7% of bitches were maidens supports previous findings by Gaudet² and Funkquist, et al.⁵ in which the percentages of maidens were reported at 67.0% and 51.0%, respectively, but disagrees with the 28.0% reported by Walett Darvelid and Linde-Forsberg.³ Of the non-maidens, the percentage that had previously undergone cesarean (57.2%) was increased in the current study compared with previous reports. The apparently high incidence of dystocia in bitches that have previously experienced dystocia, even in idiopathic cases, suggests that there may be a genetic influence on risk of dystocia as has been previously proposed.⁶ In one study of cases of cesarean section where only 21.7% of non-maiden bitches had previously undergone cesarean, it was reported that radiography was a major diagnostic method, with no mention of ultrasonography.⁵ Many of the bitches in the current study had previous cesareans performed at QVS or Pet ER. In this setting, the routine use of ultrasonography to detect fetal stress may have led to more frequent early surgical intervention rather than medical management, potentially accounting, at least in part, for the observed discrepancy. The combination of an attitude towards performing early cesarean section and client willingness to proceed with surgery, particularly those presenting to the reproduction service, may also explain the reduced percentage of cases to have received medical treatment prior to cesarean section in the current study. Only 9.0% of cases had received prior medical treatment in the current study, compared with previous reports of 42.0% and 74.8%.^{2,3} In general practice, cost constraints may lead to the decision to try medical treatment before resorting to surgical means.

The normal gestation period as measured from breeding date has been previously reported to be 57-72 days.⁷ All calculated gestation periods in the current study fell within the range of 58-70 days except for one case, in which the bitch was diagnosed with late term abortion. The mean interval from insemination to cesarean of 60.0 days is considerably shorter than the mean of 63.8 days reported by Walett Darvelid and Linde-Forsberg.³ These results are skewed by the high percentage of artificially inseminated bitches, as these procedures are generally performed one to several days later than an untimed natural mating. Interestingly, though, even when artificially inseminated bitches are excluded the mean gestation period is shorter at 60.47 days. Clients and veterinarians should be aware of this high variability in normal gestation length to avoid incorrectly diagnosing prematurity or failure to commence labor.

It is worth noting that 54 bitches presented prior to the detectable onset of labor with no clinical abnormalities detected by the owner, and were subsequently determined to require cesarean section. This may prompt clinicians to encourage clients to attend pre-partum check-ups even if no perceived abnormalities are present, to allow early detection of dystocia and hence early intervention if required. For high-risk or valuable pregnancies, there may be a case for once- to twice-daily ultrasound checks or at-home monitoring in the form of tocodynamometry and Doppler fetal heart checks in the lead-up to parturition.

It is interesting to note that ventral edema occurred in late pregnancy in 29.6% of British Bulldogs, a significantly higher proportion than the general study population. It may be worth warning clients of this; similarly, clients should be warned that vomiting is a common feature of first stage labor, possibly more so in Labradors. The statistical significance of the increased frequency of vomiting observed in Labradors may be a result of Type II error due to small sample size.

In 45.4% of all cases, second stage labor had not commenced at the time of presentation and in 31.9% this was the owner's reason for presentation. In these cases, since the first stage of labor is poorly defined and sometimes lengthy, the clinician without access to ultrasonography

may be forced to wait until 24 hours have elapsed or until second stage labor commences before being able to confidently diagnose dystocia and consider cesarean section. This is a concern as the fetuses are at risk of hypoxia and death during this time. With fetal ultrasound, the detection of low heart rates gives an early indication of fetal distress and allows more timely intervention. It has been shown that fetal heart rate is relatively stable during pregnancy at around 200-225 bpm but that there is a significant decrease at the time of parturition and that this is associated with fetal hypoxia.^{8,9} Opinions vary as to how low the heart rate must be to warrant emergency intervention, but it is generally agreed that persistent heart rates <180 bpm indicate fetal distress.^{10,11} In one study, rapid intervention reduced fetal mortality from 9% to 3%.¹² In this study, fetal heart rates of 180 or less were detected in 77.5% of cases where ultrasound was successfully performed. Survival rates are higher than those reported by Moon, et al. in a study where the varying approaches of a wide range of general practices would dictate inconsistent if not infrequent use of ultrasonography.¹ Survival rates of 92% immediately post-surgery and 87% at two hours post-surgery in the aforementioned study of 3,410 cesarean-derived puppies compare with respective survival rates of 93.3% and 89.7% in the current study. The difference between two-hour survival rates is statistically significant ($p = 0.0022$) and the difference between immediate survival rates ($p = 0.0662$) approaches statistical significance using Fisher's exact test, but the practical significance of either observation is difficult to quantify—even if the observed increase in survival rate is attributable to the use of fetal ultrasound, an increase in survival rate of 1-3% may not be incentive enough to use it routinely. Further research is required in order to appreciate the advantage, if any, that fetal ultrasound confers in improving neonatal survival. A controlled study comparing populations evaluated with and without fetal ultrasound would be required to prove an association between survival rate and utilization of fetal ultrasound.

Of the few anesthetic complications that were encountered, there was no strong evidence to contraindicate any anesthetic protocol. The bitch that suffered poor pulse pressure, tachypnea and tachycardia under an anesthetic protocol of diazepam, propofol and isoflurane was one of 48 bitches in which an identical protocol was followed; none of the other bitches suffered complications. It is known that rapid recoveries can be a complication with either alfaxalone or propofol, particularly without premedication.^{13,14} It would seem, based on the results of the current study, that both alfaxalone and propofol are good choices of induction agent and that isoflurane is an appropriate agent for maintenance of anesthesia. Overall, studies conducted recently have found low bitch mortality following cesarean section but this is the first study to report a zero mortality rate.^{1,3,15,16} The effect of anesthetic agents and perioperative medications on puppy morbidity and mortality was not examined in the current study.

A double-layered closure using a continuous inverting suture pattern is reportedly preferred for closing the hysterotomy but, to the authors' knowledge, no study has compared the use of different patterns and associated complications.¹⁷ In the current study, the Utrecht pattern was used in 418 cases. Polyglyconate was used in all but one of these cases. Whilst this study did not involve direct follow-up of cases subsequent to discharge, medical records were searched for any subsequent visits indicating possible complications of surgery involving dehiscence of the uterine incision site and none were identified. There may be instances in which these complications may have been handled by a primary care veterinarian; however, 229 cases in which the Utrecht pattern was used were handled by the reproduction referral service and it would be expected that these cases at least would have returned to QVS for re-evaluation if complications had arisen. No definite conclusions can be drawn without a controlled prospective study involving detailed follow-up, but these results suggest that the use of polyglyconate in a Utrecht pattern is a good choice for closing the hysterotomy, and provides a basis for further research in this area.

Etiology was largely determined based on subjective judgment as to whether recorded abnormalities were likely to have caused dystocia. This method leaves obvious capacity for error. In a clinical setting, however, this information is applicable as the clinician's judgment is the principal deciding factor in assigning etiology when extensive diagnostic tests are not indicated, practical or available.

Two studies have examined the etiology of dystocia in bitches with relatively large sample sizes.^{2,3} In these studies, dystocia was attributed to fetal causes in 25% and 40% of cases.

The current data support these statistics, with 37.4% of cases considered to be of fetal origin. Most commonly the underlying cause was fetal malorientation in previous studies (15.4% and 15.8% of cases), whereas absolute fetal oversize was more common in the current study.

In the remaining 75% and 60% of cases, respectively, dystocia was deemed to be of maternal origin. In both studies, physiological causes of dystocia were categorized using the terms 'complete primary uterine inertia' (48.9% and 7.4%), 'partial primary uterine inertia' (23.1% and 34.7%) and 'secondary uterine inertia' (0.0% and 12.6%). The high variability between the values obtained in these two studies may be at least in part due to the unclear definitions of these terms. To avoid such uncertainty in the current study, if no anatomical or physiological abnormality with reasonable capacity to cause dystocia was directly observed, the dystocia was classified as idiopathic. For this reason, comparisons cannot be made between this and previous studies with regard to overall prevalence of maternal dystocia. The percentage of cases attributed to relative fetal oversize agreed with previous reports, but the percentages attributed to uterine (6.0% compared with 2.1% and 1.1%) and vaginal abnormalities (2.4% compared with 1.1% and 0.5%) were increased.

We expect uterine abnormalities to be detected more commonly since all uteri were examined at cesarean section. Obviously, this is not the case in studies where some bitches are treated medically. In this study 17.9% of bitches had at least one reported uterine abnormality, compared with previously reported incidences of 4.8%, 1.6%, 12.1% and 16.2%.^{2,3,16,18} The large discrepancy observed here may demonstrate one advantage to proceeding with cesarean section over medical management, since it would appear that we may be missing uterine disease in cases where the uterus is not visualized. This failure of diagnosis may result in later complications.

Vaginal abnormalities may have been reported more commonly in the current study since many cases were examined by a reproduction specialist, who may receive referrals of cases with vaginal abnormalities and may also be more adept at detecting subtle abnormalities. Furthermore, the common use of surgical insemination means that pregnancy may have been achieved in bitches with vaginal abnormalities capable of precluding natural conception. At least one vaginal abnormality was noted in 10.6% of cases, compared with 0.4% and 0.8% in previous studies.^{2,3} Vaginal abnormalities commonly necessitate surgical intervention, so the lack of medically managed cases in the current study may also have influenced this observed increase in prevalence compared with previous reports. It should be noted as well that vaginal abnormalities were not emphasized as a measurable outcome in these earlier studies and hence some cases may not have been recorded; however, this is still a notable difference. These statistics are higher than one might expect and serve to highlight the importance of a thorough physical examination.

There are obvious limitations to the epidemiological data yielded from this study. The use of an emergency and referral based population is unlikely to be completely representative of the populations of bitches presenting to primary care veterinary clinics and may lend itself to inaccuracies, particularly involving breed prevalence. Naturally, there are many limitations inherent to any retrospective study including the absence of certain data points in many cases, and the absence of scheduled follow-up. It is difficult to quantify the bias attributable to these factors and, as such, no attempt has been made to do so. It follows then that these results should be interpreted with due caution.

Conclusion

This study aims to describe a population of bitches undergoing cesarean section and hence make observations that may direct clinicians in their recommendations to clients with pregnant bitches and aid in the formulation of an appropriate clinic protocol for managing cases in which cesarean section may be considered to maximize success.

It has been demonstrated that risk of requiring cesarean section appears to be increased in brachycephalic, dolichocephalic and giant breeds, and decreased in mesocephalic and small breeds. No concrete conclusions can be drawn from the study without a suitable control population, but it highlights some possible trends that may serve as the basis for future studies.

On the basis of these results, a clinician should be able to confidently use alfaxalone or propofol in the anesthetic protocol for cesarean section since both have been shown here to confer minimal risk to the bitch when used for induction of anesthesia. The absence of significant post-

operative complications in these bitches provides compelling evidence that the Utrecht pattern is appropriate for hysterotomy closure.

One of the most notable differences between this study and that performed by Moon, et al. is the routine use of ultrasonography. It is certainly possible that this difference may be at least in part responsible for the observed increase in pup survival in the current study, and it will be interesting to see the results of future studies that investigate this possibility.

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Appendix

Classification of breeds by head type:

Brachycephalic:	Boston Terrier	Rhodesian	Beagle
Lowchen	Leonberger	Ridgeback	Chinese Crested
Maltese Terrier	Saint Bernard	Kelpie	Irish Setter
Staffordshire Terrier		Old English	Puli
Pug	Mesocephalic:	Sheepdog	Schipperke
Cavalier King Charles	Golden Retriever	Weimaraner	Dalmatian
Spaniel	Labrador Retriever	Bearded Collie	Basset Hound
Bulldog (all varieties)	Dalmatian	Schnauzer	
Mastiff (all varieties)	Corgi	Bull Terrier	Dolichocephalic:
Chow Chow	West Highland	Viszla	Greyhound
Rottweiler	White Terrier	Hamiltonstovare	Italian greyhound
Shih Tzu	Alaskan Malamute	Lakeland Terrier	Rough coated collie
Pekingese	Cocker Spaniel	Husky	Great Dane
Chihuahua	Samoyed	Scottish Terrier	Dobermann
Lhasa Apso	Poodle	Shepherd (all	Dachshund
Papillon	Silky Terrier	varieties)	Whippet
Boxer	Fox Terrier	Soft wheaten terrier	Afghan
Pomeranian	Jack Russell Terrier	Kangal	
Bichon Frise	Border Collie	Tenterfield terrier	
Dogue de Bordeaux	Cattle Dog	Miniature pinscher	

Classification of breeds by size:

Small:	Lakeland Terrier	Siberian Husky	Hamiltonstovare
Bichon Frise	Maltese Terrier	Cocker Spaniel	Hungarian Vizsla
Chihuahua	Silky Terrier	Scottish Terrier	Irish Setter
Chinese Crested	West Highland	Soft wheaten terrier	Old English Sheepdog
Miniature Dachshund	White Terrier	Staffordshire Terrier	Standard poodle
Italian greyhound	Tenterfield Terrier	Whippet	Golden retriever
Pekingese			Labrador retriever
Miniature pinscher	Medium:	Large:	Rhodesian Ridgeback
Pomeranian	Afghan	Alaskan Malamute	Rottweiler
Toy poodle	Beagle	Bulldog (all varieties	Giant Schnauzer
Pug	French Bulldog	except French)	Bull Terrier
Schipperke	Australian Cattle	Shepherd (all	Weimaraner
Miniature Schnauzer	Dog	varieties)	
Shih Tzu	Bearded Collie	Basset Hound	Giant:
Cavalier King Charles	Border Collie	Boxer	Dogue de Bordeaux
Spaniel	Corgi	Chow Chow	Great Dane
Australian Terrier	Kelpie	Rough coated collie	Kangal
Boston Terrier	Puli	Dalmatian	Leonberger
Miniature fox terrier	Samoyed	Dobermann	Mastiff (all varieties)
Jack Russell Terrier	Standard Schnauzer	Greyhound	Saint Bernard

Figure 1: Age distribution of bitches undergoing cesarean section

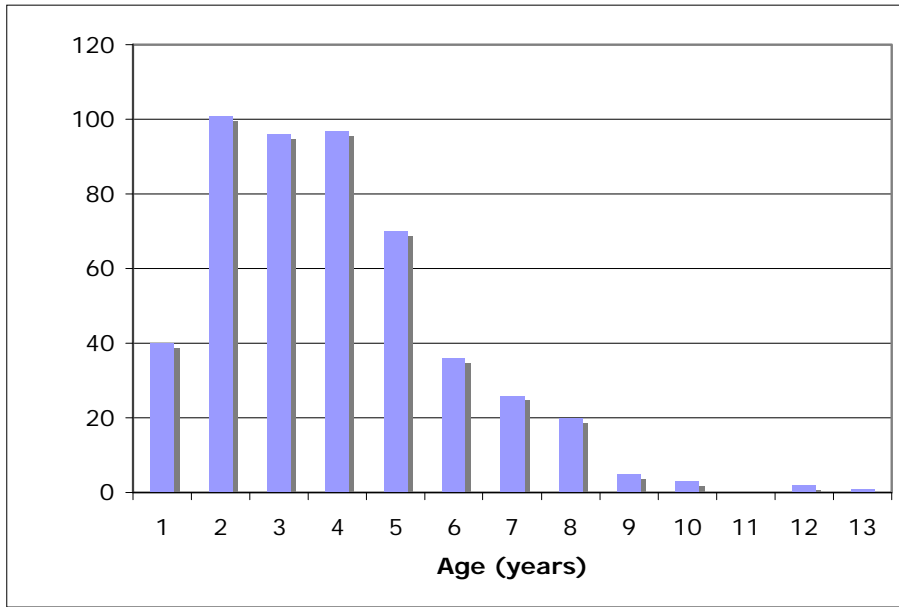


Figure 2: Distribution of gestation periods of bitches undergoing cesarean section

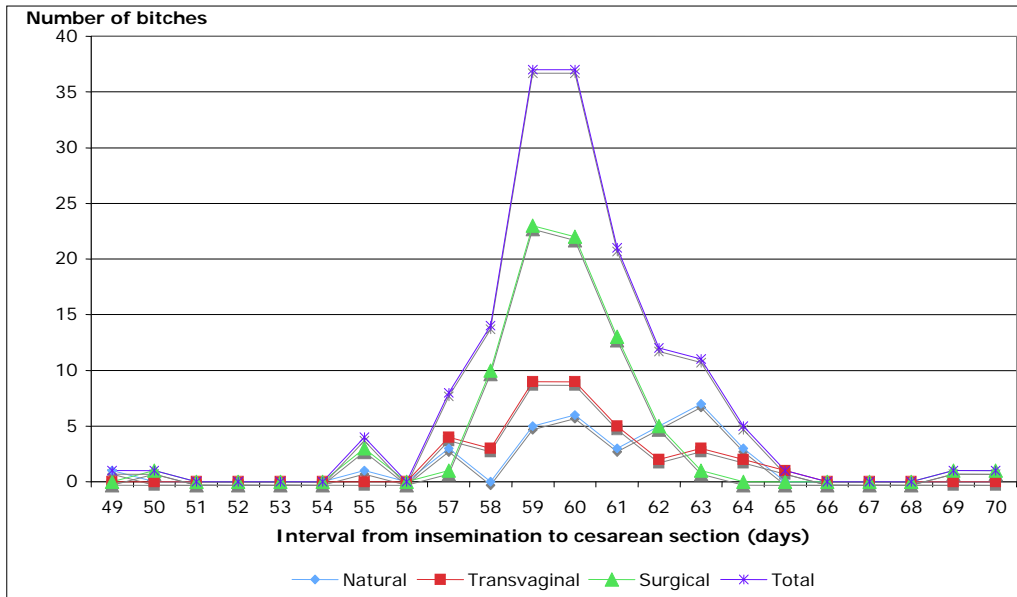


Table 1: Methods of insemination

Method of insemination	n =
Natural mating	131 (47.8%)
Transvaginal insemination	83 (30.3%)
Surgical insemination	54 (19.7%)
Natural and transvaginal insemination	4 (1.5%)
Natural and surgical insemination	1 (0.4%)
Transvaginal and surgical insemination	1 (0.4%)

Table 2: Medical treatments provided prior to surgery

Type of medical treatment	n =
Oxytocin (once only)	16
Oxytocin (more than once)	7
Manipulation (successful)	13
Manipulation (unsuccessful)	4
Manipulation (successful), oxytocin	2
Oxytocin, calcium	2
Glucose	1
Parturition induction agent	1

Table 3: Duration of labor at time of presentation, as reported by owner

Duration	n =
0-3 hours	66
3-6 hours	82
6-9 hours	38
9-12 hours	11
12-18 hours	15
18-24 hours	1
24-36 hours	3
36-48 hours	3
>48 hours	1

Table 4: Suture patterns used for closing the hysterotomy

Pattern	n =
Utrecht single-layer	416
Utrecht double-layer	2
Cushing	19
Cushing/Lembert	10
Unspecified double-inverting	5
Unspecified single-inverting	11
Simple interrupted/continuous with inverting oversew	6
Appositional	1

Table 5: Etiology of dystocia

Etiology		n =	
Maternal (n=63)	Vaginal/vestibular abnormalities	12	
	Relative fetal oversize	5	
	Uterine torsion	10	
	Uterine rupture	2	
	Uterine luminal narrowing	9	
	Other uterine abnormalities	10	
	Systemic disease	4	
	Hydrops	3	
	Excessive chorioallantoic fluid	2	
	Premature placental separation	5	
	Hypoglycemia	1	
	Fetal (n=177)	Absolute fetal oversize	36
		Fetal malposition	8
Fetal malpresentation		18	
Postural abnormality		3	
Deformity		9	
Fetal death		7	
Fetal dysmaturity		1	
Fetal obstruction, idiopathic		95	
Litter size (n=79)	Small (1 or 2)	30	
	Large (8 or more)	49	
Idiopathic (n=160)	Failure to commence stage II labor	89	
	Premature cessation of stage II labor	28	
	Prolonged unproductive stage II labor	35	
	Labor apparently progressing normally	2	
	Progression of labor not recorded	6	

