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REVIEW ARTICLE

Anaesthetic Considerations in Caesarean Section in Bitch and Queen

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ABSTRACT
In companion animals, caesarean section is an emergency type of obstetrical manipulation. Anesthesia for caesarean section presents a challenge for the veterinarian because the choice of therapy needs to assure a good outcome for both the foetus and mother. Pregnancy results in physiologic changes in the dam, due to hormonal and physical changes e.g. increase in body mass and blood volume. Most of anesthetic drugs having the ability to cross the placenta, and will reach the foetus (though not all at similar concentrations). When choosing sedatives, analgesics and anaesthetics, the veterinarian should take into consideration issues such as physiological changes during pregnancy, teratogenicity of the drugs, perfusion and oxygen delivery to the foetus and cardio-respiratory depression in the neonate. Premedication should be administered to facilitate placement of catheters, provide analgesia, and decrease the dose of induction and inhalation anaesthetics. General anesthesia is a common protocol for caesarean sections in dogs and is preferred over epidural protocols. Propofol, etomidate, alfaxalone, sevoflurane and isoflurane have been shown to be associated with less maternal and fetal mortality. Protocols that use alpha-agonists, ketamine hydrochloride, or methoxyflurane should be avoided because they have been associated with increased mortality in both bitch and foetus.
Keywords: *C Section, Anesthesia, Propofol, etomidate, alfaxalone, sevoflurane and isoflurane*

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INTRODUCTION

Anesthesia of pregnant animals, especially for Caesarean section presents a challenge for the veterinarian because the choice of therapy needs to assure a good outcome for both the foetus and mother (Kushnir and Epstein, 2012). In the bitch, c-sections are done with the intention of saving the life of the bitch and as many puppies as possible. Normally there are two types of caesarean section performed in bitch and queen, i.e. elective (planned) and emergency C-section. Planned C-sections are often a feasible and economic option to guarantee delivery of the greatest number of healthy, viable puppies and preserving the life of the dam. Most often, dystocia (complicated delivery) necessitates an emergency c-section (Traas, 2008). Gilson (2003) reported that surgical intervention is required in approximately 60–80% of dystocia cases in the bitch and queen. Timely and appropriate interventions for dystocia, either medical or surgical, are crucial for both maternal and foetal survival (Mitchell**,** 1966;Moon *et al.,* 2000). Mortality rates for bitches undergoing caesarean section dropped from approximately 13% to 1% over the past 40 years but is high compared to women in developed countries where overall maternal mortality has dropped to approximately 1 in 10,000 deliveries (MacDorman *et al.,* 2006). Much of this improved success in women is attributed to better anaesthetics management (Cooper *et al.,* 2002). A basic requirement of all anaesthetic drugs is their ability to cross the blood brain barrier. When choosing sedatives, analgesics and anaesthetics, the veterinarian should take into consideration issues such as physiological changes during pregnancy, teratogenicity of the drugs, perfusion and oxygen delivery to the foetus and cardiorespiratory depression in the neonate. The ideal anaesthetic protocol for caesarean section would provide ample analgesia, muscle relaxation, and sedation or narcosis for optimal operating conditions and safety without unduly endangering either mother or foetus (Greene, 2002). Agents that affect the maternal central nervous system will also produce foetal effects, which effects are generally

characterized by depression and decreased viability. Selection of an anaesthetic protocol for caesarean section should be based on safety of the mother and

PHYSIOLOGICAL STATUS OF DAM AND FOETUS

Most of the research into the interactions between pregnancy and anaesthesia has been done in humans and in ewes as a research model, and has been extrapolated to companion animals. Although extrapolating between species is problematic it is assumed that many of the changes are similar, because the hormonal changes are similar. Furthermore, the weight of the foetus at term in humans is approximately 5% of the mothers weight, whereas in cats and dogs it is on average 13% and 16% respectively, therefore the effects of the additional weight on the dam should be more pronounced in these species (Dawes, 1968).

During pregnancy, maternal blood volume increases by approximately 40%; plasma volume increases more than red cell mass, resulting in decreased haemoglobin concentration and packed cell volume (Shinder, 1978). Increased heart rate and stroke volume causes cardiac output to increase 30% to 50% above normal (Kerr, 1968). Plasma estrogens decrease peripheral vascular resistance, resulting in an increase in cardiac output while systolic and diastolic blood pressures remain unchanged. Again the posterior vena cava and aorta can be compressed by the enlarged uterus and its contents during dorsal recumbency. This can cause decreased venous return and cardiac output with resultant decreased uterine and renal blood flow. The use of ecbolic agents during or after parturition can adversely affect cardiovascular function (Lipton *et al*., 1962).

During pregnancy, increased serum progesterone concentration enhances respiratory centre sensitivity to arterial partial pressure (tension) of carbon dioxide (PaC02). Ventilation may be further increased during labour by pain, apprehension, and anxiety. Oxygen consumption increases by 20% owing to the developing foetus, placenta, uterine muscle, and mammary tissue. Arterial oxygen tension remains unchanged. Pregnancy also affects the mechanics of ventilation. Airway conductance is increased and total pulmonary resistance is decreased by progesterone-induced relaxation of bronchial smooth muscle (Ryan and Wagner, 2006). Hypoxemia is exacerbated by increased oxygen consumption during labour. Oxygen administration prior to anesthetic induction increases oxygen reserve by facilitating pulmonary denitrogenation (Palahniuk *et al.,* 1974).

Physical displacement of the stomach by the gravid uterus, decreased gastric motility, and increased serum progesterone delay gastric emptying during gestation and are manifest during the last trimester. As a result of altered gastric function, the risk of regurgitation (both active and passive) and aspiration is greater in parturients (Paddleford, 1992). Parturient should be regarded as having a full stomach, and anesthesia techniques should be selected that produce rapid airway management and control to prevent aspiration of foreign material.

Maintaining stable uteroplacental circulation is important to fetal and maternal homeostasis and neonatal survival. Uterine blood flow is directly proportional to systemic perfusion pressure and inversely proportional to vascular resistance created in myometrial blood vessels. Uterine vasoconstriction is induced by endogenous sympathetic discharge or by exogenous sympathomimetic drags having alpha1-adrenergic effects (epinephrine, norepinephrine, methoxamine, phenylephrine, or metaraminol) (Wright *et al.,* 1978). Hypotension induced by adjunctive drugs and increased uterine tone induced by ecbolics should be avoided.

PREANAESTHETIC PATIENT EVALUATION

Parturients are at greater anesthetic risk than are healthy nonparturient patients because of pregnancy-associated physiological alterations. A perfectly safe anaesthetic for caesarean section delivery of puppies does not exist. Almost all anaesthetic and adjunctive drugs cross the placenta to a variable degree depending on lipid solubility, protein binding, molecular size, and concentration gradient (Meyer, 2007). Because drugs administered to the dam reach the neonate, it is prudent to use small doses and to use drugs that neonates are capable of exhaling, metabolizing, or excreting. Considerations also include the need for rapid anesthetic induction, minimal respiratory and cardiac depression, rapid recovery and no lingering side effects. It is important to maintain the physiological status of the dam throughout anesthesia, avoiding hypotension, hypovolemia, hypoxemia, and hypercarbia (Pascoe and Moon, 2001).

ANAESTHETIC MANAGEMENT

In humans, the improvements in epidural and spinal techniques are given credit for the current low mortality rates for both mothers and offspring (Dresner *et al*., 2001). In veterinary medicine there are insufficient data to state whether general or regional anaesthesia is safer. Placental drug transfer occurs with all injectable and inhalant anaesthetic agents. Careful titration of drugs to provide adequate

analgesia for the dam but minimal depression of the foetus is one essential skill the anaesthetist must learn.

(a) Local Anesthesia

Local infiltration or field block may be used, but these techniques have several disadvantages when compared with regional techniques. Infiltration requires larger amounts of anesthetic agent, which are absorbed and can create fetal depression. In addition, muscle relaxation and analgesia are not as profound or as uniform when compared with regional anesthesia. In many cases, field block is supplemented with heavy sedation or tranquilization to calm and stabilize a dam; these agents further contribute to maternal and fetal depression. For these reasons, field block is often abandoned for either general or epidural anesthesia.

(b) Regional Anesthesia

This is a well-established technique for caesarean section. Regional anesthesia (epidural or subarachnoid) has the advantages of technique simplicity, minimal exposure of the foetus to drugs, less intraoperative bleeding and, because the mother remains awake, minimal risk of aspiration (Ratra *et al*., 1972). In addition, muscle relaxation and analgesia are optimal. The spinal cord terminates at the level of the sixth lumbar vertebra in dogs, reducing the risk of subarachnoid (true spinal) injection of the anesthetic agent. The spinal cord terminates variably between L7 and midsacrum in cats, making subarachnoid injection a greater possibility (Hall *et al.,* 1994; Gunn-Moore and Thrusfield, 1995). Epidural anesthesia has been successfully used in dogs and cats for cesarean section anesthesia. In a non-pregnant animal 1 millilitre of 2% lidocaine per 5 kg of body weight deposited epidurally will produce a block up to the level of L2 (Skarda, 1996). In the pregnant animal, this dose may produce a higher block because distended epidural veins, a consequence of increased intra-abdominal pressure, decrease the epidural space. Lidocaine is the agent of choice, as this will provide 60-90 minutes of surgical analgesia, sufficient for a caesarean section and allowing rapid return to function.

Disadvantages of epidural or subarachnoid anesthesia include hypotension secondary to sympathetic blockade. Hypotension induced by epidural anesthesia can be managed with IV fluid and catecholamine administration (Raffe and Carpenter, 2007). Lactated Ringer's solution or 0.9% or 0.45% sodium chloride mixed with equal volumes of 5% dextrose solution can be administered at approximately 20 mL/kg over 15 to 20 min to maintain arterial blood pressure. When hypotension is severe, ephedrine may be administered (0.15 mg/kg IV) (Chan *et al.,* 1997). A danger of this technique is that the airway is not protected and regurgitation and vomiting are possible when the bitch is placed in dorsal recumbency. Because the dam remains conscious, the forelimbs and head often move.

(c) General Anaesthesia

Anticholinergic drugs, such as atropine or glycopyrrolate, shouldbe administered to most parturient patients to decrease salivationand inhibit excessive vagal tone that may occur when traction isapplied to the uterus (Gibbs, 1981). Many parturients have recently eaten,increasing the likelihood of regurgitation, which is enhanced byhypoxia or hypotension. Glycopyrrolate increases gastric pH, thus decreasing severity ofMendelson's syndrome should regurgitation and aspiration ofvomitus occur (Goodger, 1973). Additionally, because glycopyrrolate does not readily cross the placenta, it does not affect the fetus to the same extent as atropine. Therefore, it may be a more appropriate anticholinergic for use in these patients.

Propofol (2- 4 mg/kg/i.v) and thiobarbiturates have the advantage of rapid onset and short duration with minimal residual foetal depression (Siafaka *et al.,* 1992; Jimenez*et al*., 2012), but can cause cardiovascular depression and decreased uterine blood flow. Transient apnoea is common following administration and may result in foetal hypoxia and academia if the mother is not pre-oxygenated, rapidly intubated, and ventilated. Propofol is associated with better puppy vigour than barbiturates (Moon-Massat and Erb, 2002; Pathirathna*et al*., 2005). Maintenance of anaesthesia with propofol is not yet recommended in humans because of lower neurological and adaptive capacity scores in the offspring compared to thiopental (Yau *et al*., 1991). However, when compared to isoflurane, total intravenous anaesthesia with propofol in pregnant ewes resulted in superior haemodynamics (Funquist*et al.,* 1997;Gaynor *et al*., 1998). The dose of all induction agents and therefore their side-effects can be reduced by first giving intravenous diazepam (0.1-0.4 mg/kg), or midazolam (0.1-0.3 mg/kg).Ketamine (4-6 mg/kg i.v.) combined with diazepam (0.1-0.4 mg/kg i.v.) or midazolam (0.1-0.3 mg/kg i.v.) is an alternative induction technique that provides good cardiovascular support. Ketamine combinations do not affect overall puppy survival but have necessitated more vigorous resuscitative efforts. In compromised dams, etomidate (2 mg/kg i.v.) is recommended because of its minimal cardiovascular effects (Doebeli*et al*., 2013).

Opioids provide analgesia and reduce anaesthetic requirements. Morphine, methadone, oxymorphone, hydromorphone and buprenorphine can be used (Moon *et al.,* 2000).Halothane did not have a positive or

negative effect on caesarean-derived puppies and isoflurane was associated with improved neonatal survival. For an uncomplicated C-section, induction with propofol followed by maintenance with isoflurane with or without premedication with acepromazine and an opioid is recommended (Short and Bufalari, 1999;Ambros*et al*., 2008). In critically ill dams, a small i.v. dose of fentanyl (5-10 µg/kg i.v.) prior to induction with etomidate (1-2 mg/kg i.v.) is suggested. In both situations, a line block with local anaesthesia is advocated and an analgesic can be administered as soon as the puppies are removed. Induction of anaesthesia with inhalant agents is not recommended because of the delay in protecting the airway and possible maternal excitement and struggling that would be detrimental to uterine blood flow.

CONCLUSION

Understanding the changes in maternal and fetal physiology that occur during pregnancy and the pharmacokinetics and pharmacodynamics of anaesthetics is necessary to formulate an effective and safe anaesthetic plan for pregnant dogs. No single anaesthetic protocol is suitable for every cesarean section. All patients undergoing cesarean section should be administered intravenous fluids. Pre-oxygenation of the dam for 3-5 minutes before and during induction until endotracheal intubation is strongly recommended to decrease the risk of hypoxemia. Premedications that can be specifically antagonized (e.g., opioids, benzodiazepines) are preferred so that depressant effects in neonates can be reversed. Anaesthetic protocols that include propofol and isoflurane are associated with decreased maternal mortality and increased neonatal survival and vigor. Both alfaxalone and etomidate can be safely used for induction of anesthesia in bitches and queens undergoing emergency caesarean section and produces improved Apgar scores. Selection of appropriate anaesthetics and good perioperative management minimize the risks to the dam and foetus, help decrease maternal and neonatal mortality, and increase neonatal vigour.

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