ANESTHESIA FOR CESAREAN SECTION AND ASSOCIATED OUTCOMES IN THE BITCH IN NAIROBI COUNTY, KENYA

A thesis submitted in partial fulfilment of the requirements for the award of the degree of Master of Veterinary Surgery of University of Nairobi

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DECLARATION

This thesis is my original work and it has not been presented for award of a degree in any other University.

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DEDICATION

This is for my family, my pillars, for the love and support you have always given me.

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ABBREVIATIONS

CO……. Cardiac output

CRI…… Continuous rate infusion / Constant rate infusion

CRT……. Capillary refill time

CS……. Cesarean section

FRC……... Functional residual capacity

GA…… General anesthesia

GLM……. Generalized linear model

HR…… Heart rate

IV……. Intravenous

NSAIDS……... Non-steroidal anti-inflammatory drugs

TRP……..... Temperature, respiration, pulse

ABSTRACT

Cesarean section (CS) refers to the surgical delivery of neonates by hysterotomy, and it is often performed to relieve dystocia. Dystocia is a complication associated with any impediment to initiate or complete labour, as a result of either maternal factors, fetal factors or a combination of both. A major maternal factor in dystocia, is physiological derangement occasioned by pregnancy. Management of dystocia through CS requires prudent choice of anesthetics and anesthetic adjuncts to minimize deleterious outcomes like morbidity or mortality for both the dam and the fetuses/puppies.

Despite advances in veterinary anesthesiology, no single anesthetic protocol exists for use in every cesarean section performed in pregnant beaches. Furthermore, information on the frequency of anesthetic protocols, outcomes and challenges encountered when CS is performed in pregnant bitches in Nairobi County is scant, thus, the need for the study. The main objective of this study was to survey and document anesthesia regiments for cesarean section in bitches and an associated outcomes in Nairobi County. Furthermore, identifying challenges encountered in managing cesarean section in bitches in Nairobi County was just as important.

The study was two phased. The first phase was a retrospective study where patient records over a 12 year period were retrieved from 5 selected veterinary practices and examined for data and information on CS procedures. Data that included breed, age, parity, preoperative assessment of bitch and fetus-in-utero, and presentation of the bitch whether, emergency or elective was captured. In addition, information regarding pre-anesthetic management of the patients; drugs used for premedication, induction and maintenance of anesthesia; analgesia, fluid therapy and outcomes of the CS in bitches and puppies was also extracted from the records. Phase two was a cross-sectional study in which a questionnaire was administered to veterinary practitioners and it focused on perioperative activities associated with CS as well as challenges faced by veterinarians when managing bitches undergoing CS. Data and information generated formed the basis for descriptive statistics which were generated for anesthetic protocols, post operative

pain management and outcomes of the cesarean sections in bitches and puppies. Logistic regression model was used to evaluate the determinants of the outcomes of CS.

A total of 107 CS procedures were performed in the five practices over the 12 year study period. Seventy nine percent of these came in as emergencies, while 21% (23/107) were elective procedures. Xylazine was preferred for premedication in 46% (49/107) of the cases. No premedication was done in 19% (20/107) of the cases. Anesthesia induction was largely by use of propofol (33%; 35/107), followed by thiopentone (32%; 34/107) and ketamine (19%; 20/107). In 3% (4/107), 6% (7/107/) and 9% (10/107) of the CS cases, ketamine, thiopentone and propofol, respectively, were used as agents for maintenance of general anesthesia on top of their use as induction agents. Halothane and isoflurane were also used to maintain anesthesia in 42% (46/107) and 12% (13/107) of the cases respectively. Propofol-halothane and thiopentone-halothane were the most commonly used anaesthetic combinations for the CS cases. As per the records 98.1% (105/107) of the CS cases had a successful outcome, while only two cases (1.9%; 2/107), did not survive the procedure. All puppies were delivered alive in 30% (32/107) of the cases, while in 11% (12/107) of the cases, all the puppies were dead on delivery. In 50% (54/107) of the cases, some puppies were delivered alive and others dead. Mummification, maceration and monster puppies were noted in 9% (10/107) of the cases. For management of postoperative pain, analgesics of choice were: phenylbutazone (31%; 34/107), flunixin meglumine (20%; 21/107), and meloxicam (5%; 5/107).

In 80% of the practices, the main challenge encountered in managing CS cases included poor access to better anesthetic drugs and techniques, lack of patient monitoring equipment during and after the CS and sometimes lack of experienced personnel to assist during surgeries.

In conclusion, premedication with xylazine and induction of general anesthesia by either propofol or thiopentone, with maintenance using halothane were the commonest anesthetic combinations used for CS procedures in pregnant bitches in Nairobi County. Furthermore, CS was a relatively safe procedure with low mortality rate in bitches. NSAIDs are the mainstream analgesics used to manage pain in bitches after CS procedures; veterinarians require better

anesthetics and anesthetic adjuncts to effectively manage CS cases; and there was a major gap in record keeping in veterinary practices in this study. This study therefore recommends that veterinary practices invest more in a wider range of anaesthetic drugs and equipment in order to allow protocols to be tailored well according to procedure and status of patients, while veterinarians are encouraged to partake in continuing professional development courses in order to keep up with current and improve anesthesia protocols, including record keeping.

CHAPTER ONE

1. INTRODUCTION

1.1. Background

Cesarean section (CS) can be defined as the surgical delivery of neonates by hysterotomy (Gilson, 2016). The indications for the procedure include; fetal or maternal causes of dystocia, prolonged gestation, and therapeutic emergency or elective surgery in selected breeds (Dodam, 2010, Batista *et al.*, 2014; Vilar *et al.*, 2018).

The major body systems of the female canine go through various physiological changes during gestation. These changes affect absorption, metabolism and excretion of drugs (Degan *et al.*, 2017). Adaptations in the cardiovascular, gastrointestinal and respiratory systems may affect the anesthetic management of patients undergoing CS and result in increased risk of anesthesia-related complications. Caution should be exercised in tailoring anesthetic protocols to ensure analgesia for the dam and prevent anesthesia-related complications (Robertson, 2009).

Most anesthetics cross the placenta into fetal circulation and cross the blood-brain barrier, with potential deleterious effects to fetuses. Complications such as hypotension, hypothermia, hypoventilation and hypoxia, can result from anesthesia and contribute to morbidity and mortality for both the dam and her puppies (Kraus, 2016; Degan *et al.*, 2017). The main goal of anesthesia for CS is to reduce the undesirable effects of anesthetic drugs. This will minimize depression of fetal cardiovascular, respiratory and neurological systems and ensure delivery of live and vigorous puppies (Doebeli *et al.*, 2013).

Anesthetic management for CS starts with perioperative preparations which include physical examination and assessment of vital parameters. Laboratory testing, diagnostic imaging, correction of electrolyte imbalances or stabilization of the patient is dictated by the overall patient's status (Dodam, 2010). Pre-oxygenation before induction of anesthesia and

intravenous fluid therapy before and during the operation should be done. Premedication reduces maternal stress and anxiety and decreases the total dose of drugs for induction and maintenance of general anesthesia. Reversible drugs such as benzodiazepines and opioids are preferred for premedication. Thiazine derivatives, for example xylazine, are not recommended due to their undesirable cardiopulmonary effects (Ryan and Wagner, 2006; Robertson, 2016; De Cramer *et al.,* 2017). Propofol and alfaxalone are deemed appropriate for injectable induction of general anesthesia in pregnant bitches. Inhalant anesthetics like isoflurane and sevoflurane have been commonly used for maintenance of general anesthesia during CS (Alef, 2017; De Cramer *et al.,* 2017). Epidural or spinal anesthesia may also be used as a source of anesthesia and analgesia for CS procedure since it produces minimal fetal depression. Post-operative pain management is strongly recommended since a painful mother is likely to refuse nursing the newborn neonates (Mathews *et al.,* 2014).

Mortality rates for bitches that undergo CS vary from 0%- 4% depending on the emergency nature and patient's physiologic status at the time of the surgery. An accompanying ovariohysterectomy can be performed when the owner expresses no desire for future reproduction or when surgical complications such as uterine tears and uncontrollable bleeding occur (Van Goethem, 2016). Risk factors that lower chances of survival for puppies delivered by CS include having a brachycephalic dam, being born from a litter of minimum 4 puppies and having the CS done as an emergency procedure. Inclusion of xylazine in the anesthetic protocol, low vigor upon Apgar scoring as well as presence of deformed littermates have also been seen to increase mortality of puppies (Moon *et al.,* 2000). Apgar score is a neonatal assessment system adapted from human medicine, which is used to assess puppy viability and short-term survival prognosis in veterinary medicine (Batista *et al.,* 2014).

1.2. Problem statement and justification

Dogs have been historically kept for companionship and security purposes, the world over. Cosmopolitan households such as those within Nairobi County and its environs, have recently

embraced pet ownership due to economic growth and increased breeding of dogs. Surgical management involving cesarean section, is often required for relief of dystocia, which poses serious challenges regarding anesthesia-related complications to the dam and fetuses. Information on the frequency, anesthetic protocols, outcomes and challenges encountered when CS is performed in pregnant bitches in Nairobi County is scant. There is a need to know the most effective anesthetic protocols that veterinarians use, given the resources at their disposal, to effectively manage cases of cesarean section in the bitch.

Despite advances in veterinary anesthesiology, no single protocol exists for use in every cesarean section performed in pregnant bitches. Furthermore, information on the type of anesthetic protocols used by veterinary practitioners in Nairobi County and its environs and their experiences during CS in bitches, is scant. It is therefore necessary to design a study aimed to determine the nature, suitability and outcomes of anesthetic protocols used for CS in pregnant bitches in Nairobi County and its environs.

This study was designed with the aim to identify protocols with optimal anesthetic outcomes for patients that require CS, and benchmark against international best practices. This study was aimed at providing data on incidence of CS among dog breeds, anesthetic management and associated outcomes of CS in dogs. This is vital in managing individual client cases and more so for breeders whose livelihoods depend on the delivery of live, healthy and vigorous puppies for sale. Additionally, another aim was to improve existing expertise in Small Animal Anesthesia and Analgesia as a specialized discipline in this region by identifying areas that require more attention and by adding to the pool of information already available. The findings will inform veterinary training, and continuing professional development and improve the quality of veterinary practice in the region.

1.3. General and specific objectives

1.3.1. General objective

To survey and document anesthesia regiments for cesarean section in bitches and associated outcomes in Nairobi County from 2009 to 2020.

1.3.2. Specific objectives

To, over the period from 2009 to 2020:

i. Identify and document anesthetic protocols used for cesarean section procedures in bitches in Nairobi County.

ii. Evaluate the outcome of cesarean section in the bitch and the puppies in Nairobi County.

iii. Determine post-operative pain management following cesarean section in the bitch in Nairobi County.

iv. Identify challenges encountered in managing cesarean sections in bitches by veterinarians in Nairobi County.

CHAPTER TWO

1. LITERATURE REVIEW

1.1. Definition and indications for cesarean section

Cesarean section (CS) can be defined as the delivery of neonates by hysterotomy (Gilson, 2016). It is a relatively common procedure, since veterinarians provide obstetrical care quite often throughout their career. The indications for the procedure include; fetal distress (which presents as decreasing fetal heart rate) or if the bitch is in dystocia. It may also be indicated for animals with prolonged gestation period (Dodam, 2010). In small animal practice, a pregnant bitch may be presented as an emergency and approximately 60 – 80% cases require a surgical procedure (cesarean section) to resolve dystocia (Vilar *et al*., 2018). Dystocia is what happens when there is any impediment to initiate or complete labor. Causes of dystocia include maternal factors, fetal factors, or a combination of both. Uterine inertia is the most common maternal factor. Other factors include small pelvic size and abnormalities (congenital or acquired) of the caudal reproductive tract. On the other hand, fetal malpresentation, malformations and oversize are causes of dystocia of fetal origin (Batista *et al.,* 2014). The prevalence of dystocia in bitches during whelping is approximately 5- 36% in all dog breeds (Roos *et al.,* 2018). However, brachycephalic breeds such as the English bulldog, French bulldog and Boston terrier are usually over-represented (Doebeli *et al.,* 2013; Vilar *et al.,* 2018). CS can also be performed under more routine conditions as an elective procedure upon client request in patients with history of dystocia. It can also be performed electively in certain breeds that are prone to difficult labor due to their conformation, for example Chihuahua, Yorkshire terrier and Bull terrier (Batista *et al.,* 2014; Vilar *et al.,* 2018). Elective procedures are preferable because there is time for thorough assessment, diagnostic workup and preparation for setup required for receiving newborn puppies and puppy resuscitation if need be (Cavanagh, 2017). On the other hand, emergency procedures carry a higher risk for both dam and puppies as the dam and fetuses are both in distress.

2.2. Physiological changes during pregnancy

Major body systems in the dam go through adaptation during pregnancy. There are major physiological changes that happen during the peri-parturient period for the bitch. Many of these changes have a significant impact on anesthetic management during CS (Robertson, 2009; Self, 2019). They influence how drugs are absorbed, metabolized and excreted. Anesthesia protocols for cesarean section must therefore factor in the foregoing physiological changes.

2.2.1. Changes for the dam

During pregnancy, heart rate (HR) and stroke volume increase in an effort to raise cardiac output (CO). This is because about 25% of CO goes to the uterus and placenta during gestation. Hemodilution occurs with expansion of plasma volume towards whelping (Gilroy and DeYoung, 1986; Self, 2019). The demand for oxygen increases with the need to supply fetuses and from physical exertion during birthing. Hypotension can potentially occur as a result of decreased CO that follows compression of aorta and caudal vena cava by an enlarged uterus when the bitch is placed on her back. When these changes are coupled with the effect of anesthetic drugs, dehydration and intra-operative fluid loss, they exacerbate hypotension in the dam. The fetuses become vulnerable to these changes as well (Robertson, 2009).

The pressure of an enlarged abdomen on the diaphragm decreases the functional residual capacity (FRC) of a pregnant animal. This makes pregnant patients more susceptible to rapid hemoglobin desaturation (Mason, 2006). Pre-oxygenation then becomes a prerequisite to beef up oxygen reserves before an anesthetic session. The time taken for hemoglobin to de-saturate in the event of induction apnea or when intubation is difficult is prolonged when adequate pre-oxygenation has been done. An increase in respiratory rate, tidal volume and minute volume occurs to cater for increased oxygen demand. These changes mean that inhalation agents will be rapidly taken up and offloaded and the patient will quickly respond to alterations in gaseous anesthesia administration (Kraus, 2016; Self, 2019).

A gravid uterus displaces the stomach and intestines. Gastric emptying is delayed and lower

esophageal sphincter tone is decreased. This makes it more likely for gastric reflux to occur. Regurgitation, aspiration pneumonia and esophagitis become a potential risk (Raffe and Carpenter, 2007; Kushnir and Epstein, 2012).

The minimal alveolar concentration of inhalation agents is generally decreased during pregnancy. It is theorized that elevated levels of progesterone at term are responsible for this phenomenon. Therefore, during CS, a lower vaporizer dial setting is required to maintain anesthesia (Mason, 2006; Kraus, 2016).

The onset of milk production, coupled with physical exhaustion and pain during labor, may trigger an imbalance in calcium levels and other electrolytes in the body. These will need to be corrected prior to administration of anesthetics and the surgery itself (Self, 2019).

2.2.2. Assessment of the bitch

When the bitch is presented whether as an emergency or elective case, a thorough history taking and physical examination are to be performed. It allows the veterinarian to evaluate the bitch's physiological status and ensures that any physiological abnormalities such as dehydration and hypoglycemia are detected and appropriate action taken to correct them before the procedure. These actions improve the anesthetic management for pregnant bitches undergoing CS (Robertson, 2016). During physical examination, the abdomen is palpated to assess fetal size and uterus tone. Abdominal auscultation will detect fetal heart beats. Abdominal palpation together with digital vaginal examination can also determine presence of obstruction in the birth canal (Ryan and Wagner, 2006). The physical status of the patient suggests which laboratory tests are to be performed. Tests to measure packed cell volume and total protein are helpful in determining level of dehydration and influences the type of fluid therapy to be initiated. When possible, blood urea nitrogen, calcium and glucose levels can be measured as well. These tests will suggest the patient stabilization activities to be performed prior to anesthetic induction (Ryan and Wagner, 2006; Robertson, 2016).

2.2.3. Assessment of fetuses in-utero

Pre-operative diagnostic imaging techniques are used to assess the fetuses in-utero. Radiographs will identify the presence, number, size and position of fetuses. Abdominal ultrasound imaging has the added advantage of determining the viability, fetal heart rate (HR) and detect distress of fetuses (HR < 150bpm) (Ryan and Wagner, 2006; Robertson, 2016).

2.3. Anesthesia for cesarean section

Ideally, during cesarean section, anesthesia should allow for completion of the surgery without untoward effects to both the dam and the puppies. Analgesia, muscle relaxation and unconsciousness are desirable during CS (Ruiz *et al.,* 2016; De Cramer *et al.,* 2017; Vilar *et al.,* 2018). The main aim of anesthesia for CS is to limit as much as possible, the deleterious effects of drugs administered to the dam so that the viability of the puppies is not affected. The outputs of a CS should be live and vigorous puppies whose cardiopulmonary and neurological systems are not depressed, as well as rapid uncomplicated recovery of the dam (Doebeli *et al.,* 2013; Kraus, 2016).

Nearly all drugs used for anesthesia are able to cross the placenta and the blood-brain barrier of a fetus. This translates to a variable extent of fetal depression upon anesthesia administration in the dam. The type of placenta in canines allows for close maternal-fetal contact and passive diffusion of drugs (Degan *et al.,* 2017).

2.3.1. Pre-operative management and initial stabilization

Safe anesthesia relies on proper pre-operative patient evaluation and management (Bednarski *et al.,* 2011). Impaired labor is usually associated with a number of physiological derangements including dehydration, exhaustion, pain, sepsis, hypoglycemia and hypocalcemia. These abnormalities have to be identified through a thorough pre-anesthetic assessment (Robertson, 2009). Bitches scheduled for elective CS should get a complete physical examination and laboratory diagnostic workup. In emergency situations, there might not be enough time to wait for laboratory tests and results but effort is made to measure hematocrit, total protein, glucose

and blood urea nitrogen (Robertson, 2009). An intravenous (IV) cannula should be placed to allow drug and fluid administration in dehydrated, hypotensive or hypovolemic patients before surgery. Isotonic crystalloids, at a rate of 10 – 20ml/kg/hour, should be administered to treat for existing fluid deficits and anticipated ongoing losses. Colloids can be used for severe dehydration and when there is need for rapid volume replacement (Robertson, 2016). To minimize the risk of hypoxia and apnea following induction of general anesthesia, the patient is pre-oxygenated for 3-5 minutes prior to induction of anesthesia via a face mask (Dodam, 2010). To reduce anesthesia duration, preoperative preparation of the dam (shaving, scrubbing and transporting to the theatre) is performed while she is awake (Kushnir and Epstein, 2012; Self, 2019).

2.3.2. Premedication

Premedication of veterinary patients can be achieved using drugs that include; opioids, phenothiazines, anticholinergics, alpha-2-adrenoceptor agonists and benzodiazepines. Premedication calms or sedates an excited or vicious animal for ease of handling and enhances comfort of both patient and anesthetist. It also reduces or eliminates possible adverse effects of general anesthetics e.g., salivation associated with ketamine; and bradycardia following opiate administration. It reduces the amount of general anesthetic required (by up to 50% depending on the premedicant given) to induce general anesthesia, thus minimizing cardiovascular and respiratory depressant effects of general anesthetics. It also provides intra-operative and post-operative analgesia and patient comfort (Raffe and Carpenter, 2007).

Premedication of the dam, despite having several benefits, is still a big concern because of the potential diffusion of the drugs from dam to fetus (Self, 2019). Tranquilizers and sedatives are not routinely indicated in pregnant patients because they are able to rapidly accumulate in fetal circulation and act for longer periods (Raffe and Carpenter, 2007). Phenothiazines like acepromazine are generally avoided because even at low doses they cause depression of the dam and consequently fetuses. Alpha-2-adrenoceptor agonists are not recommended

due to undesirable cardiopulmonary effects and respiratory depression. Xylazine is known to potentially increase the risk of puppy mortality, but medetomidine was observed to be associated with good puppy Vigor and survival rates (Robertson, 2016; De Cramer *et al.*, 2017; Self, 2019). Benzodiazepines have also been observed to cause depression, although appropriate antagonists exist to reverse their effects if need be. Premedication if performed at all in a pregnant patient, is best done solely with an opioid (meperidine, oxymorphone and hydromorphone). This provides sedation and analgesia to the dam and the effects can be reversed in the newborn puppies with an appropriate antagonist (usually naloxone) soon after delivery (Raffe and Carpenter, 2007; Kushnir and Epstein, 2012). Anticholinergic drugs, such as atropine or glycopyrrolate, can be added to the protocol to counter excessive salivation and vagal tone that is brought about by traction of the uterus during the CS procedure (Raffe and Carpenter, 2007).

2.3.3. Regional anesthesia

Regional anesthesia techniques include performing line blocks and epidural anesthesia with local anesthetics. The most common drug of choice for these procedures is 2% lignocaine. Line block only effectively blocks the site of surgical incision and requires a well sedated animal to ensure cooperation of the patient throughout the procedure. Epidural anesthesia includes deposition of the drug into the epidural space at the lumbosacral space which results in the caudal half of the body being anesthetized (Mason, 2006).

Epidural or spinal anesthesia is often used as an adjunct to general anesthesia in an effort to reduce total drug doses and may result in producing sedative effects on the neonates. With an epidural, very little amounts of lignocaine 2% are transferred to the fetuses producing minimum fetal depression. It allows the dam to remain awake and take care of her puppies soon after surgery (Degan *et al.*, 2017). The disadvantage is that systemic vasodilation often results in hypotension, fetal hypoxia, and exacerbation of surgical bleeding (Gilson, 2016).

Administration of IV fluids before and during the surgery will ensure adequate uterine perfusion and decreased fetal compromise. A challenge with epidural anesthesia alone as a primary source of anesthesia is that the patient cannot be intubated and the airway is left unprotected. With regurgitation and vomiting being more likely when the dam is placed in dorsal recumbency, it predisposes the patient to aspiration pneumonitis and esophagitis (Robertson, 2009).

2.3.4. Induction and maintenance of general anesthesia

General anesthesia (GA) can be defined as a drug induced and reversible state of unconsciousness, muscle relaxation and a reduced sensitivity to noxious/painful stimuli. The general anesthetics for animals are broadly divided into two. Injectable general anesthetics include barbiturates (commonly thiopental), propofol, dissociative anesthetics (ketamine and tiletamine), etomidate and alfaxalone. Some of these drugs are used to maintain general anesthesia for a prolonged period of time (Mason, 2006). Inhalation agents like isoflurane, sevoflurane, halothane, and desflurane are the most common means to maintain GA during surgery, but in some instances, they can also be used to induce general anesthesia (Ryan and Wagner, 2006; Self, 2019).

In the pregnant patient, GA can be achieved by a combination of various drugs. The main advantages of GA are complete immobilization and analgesia; whereas fetal and maternal depression is a major disadvantage. Propofol was deemed an appropriate induction agent for CS, with an inhalation agent being used to maintain GA (Luna *et al.*, 2004). Since it does not accumulate in tissues, it is suitable for total intravenous use to maintain GA (Degan *et al.*, 2017). Alfaxalone has been suggested as a good alternative to propofol for induction in the bitch. It has almost the same desirable effects similar to propofol. In a clinical trial done by Ruiz *et al.*, (2016), it was noted that constant rate infusion (CRI) of alfaxalone to maintain GA, produced poor recovery in bitches after CS. This effect is undesirable because of prolonged interval between delivery and first contact of bitch and puppies. Therefore, recovery from

anesthesia should be smooth and rapid (Doebeli *et al.,* 2013, Ruiz *et al.,* 2016). Protocols that included ketamine (and xylazine) have proved to increase risk on puppies and are therefore to be avoided. Etomidate is recommended when the dam is considered compromised, for example in cases of prolonged labor or history of cardiac disease (Degan *et al.,* 2017).

Inhalation agents can be used to induce and maintain anesthesia. This method works for a dam that is either calm and cooperative or depressed. Agents that have rapid onset of action and produce faster recovery, such as isoflurane, sevoflurane and desflurane, are preferred (Ruiz *et al.,* 2016). These gaseous anesthetics are administered in 100% oxygen, and they are to be given at the lowest possible vaporizer dial setting. This is because the minimal alveolar concentration of most volatile anesthetics is reduced by approximately 25% during pregnancy (Ryan and Wagner, 2006; Robertson, 2009). The depressant effects of inhalation anesthetics in newborn puppies generally depend on the concentration and duration of administration. Therefore, it is recommended to add these anesthetics after the puppies have been delivered. This facilitates closure of the uterus and abdomen but reduces exposure of puppies to anesthesia. The use of propofol followed by isoflurane has become an acceptable protocol with good outcomes (Doebeli *et al.,* 2013; Alef, 2017; De Cramer *et al.,* 2017).

2.3.5. Post-operative care

Perioperative hypothermia, hypovolemia and hypotension are common anesthesia related complications associated with CS (Van Goethem, 2016). Dams should be monitored continuously after surgery to determine if they need further cardiovascular support, warmth or oxygen supplementation.

Pain is a complication of surgery, hence postoperative analgesia should be provided to the dam to allow her puppies to nurse (Robertson, 2009). Analgesics that can be excreted in milk should be avoided. Opioids (e.g., morphine and fentanyl) are potent analgesics, but when administered pre-operatively, they can cross the placenta and cause significant CNS (central nervous system)

and respiratory system depression in canine neonates (Mathews, 2008). When administered for short-term analgesia post operatively, opioids are compatible with nursing and are useful for pain management (Kushnir and Epstein, 2012; Mathews *et al.,* 2014). Non-steroidal anti-inflammatory drugs (NSAIDs) (e.g., ketoprofen and carprofen) are found in low levels in milk. According to Mathews (2008), a single intravenous dose of meloxicam immediately after delivery of the last puppy is safe. However, NSAIDs should be avoided in patients that are hypovolemic or hypotensive since they will interfere with renal perfusion. Local anesthetic techniques such as line blocks (using lignocaine or bupivacaine) and epidural anesthesia (using morphine or local anesthetics) can be used to enhance the anesthetic protocol as well as provide analgesia during or after CS (Matthews and Sinclair, 2018).

2.4. Challenges for the puppies

The viability of puppies is a major concern during anesthesia management (Self, 2019). Any physiological deterioration that occurs in the bitch is likely to negatively affect the puppies. The viability of puppies can be reduced by disturbances such as hypercapnia, acidosis and the effects of anesthetic drugs administered to the bitch (Batista *et al.*, 2014). Hypoxia commonly occurs in puppies and is caused by respiratory depression. The respiratory depression is likely to be a result of residual anesthetic drugs, hypothermia, or lack of physical stimulation (Kushnir and Epstein, 2012; Batista *et al.*, 2014). A resuscitation protocol performed by a team of trained assistants immediately after uterine delivery is required to reduce mortality and increase survival of the newborn puppies (Batista *et al.*, 2014; Self, 2019). The process of neonatal resuscitation involves clearing of mucus and debris from oral and nasal cavity of newborn neonates, as well as vigorous rubbing to stimulate breathing, and supplementing warmth and oxygen. Immediately following uterine delivery, a rapid and accurate clinical evaluation of the newborn puppies is to be performed. This exercise identifies neonates that require medical assistance and help establish a correct clinical approach that improves puppy viability (Veronesi *et al.*, 2009; Self, 2019).

2.4.1. Assessment of new born puppies

Clinical assessment of neonates after normal delivery, vaginal dystocia or CS delivery has been reported in bitches. There is a scoring system that can be used to assess puppy viability and short-term survival prognosis immediately after delivery. It was adapted from human medicine and has been modified for veterinary medicine. This is known as the Apgar score (Batista *et al.*, 2014). The parameters assessed are heart rate, respiratory rate, mucous membrane color, reflex irritability, mobility and vocalization. For each of the parameters a score is allocated, which ranges from zero to two. The total sum of scores for all parameters is calculated, ranging from zero to ten. Three classes of neonatal viability are defined according to the final total sum. A score of less than 3 means the neonate is critical and requires immediate medical assistance to survive. Between 4 and 6, the neonate is considered to be moderately viable and should be monitored or submitted to medical assistance as required. A score of 7 to 10 means the clinical condition of the newborn puppy is normal and only routine care should be provided (Batista *et al.*, 2014; Veronesi, 2016).

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Study area

The study was carried out in Nairobi County, which is home to Nairobi, the capital city of Kenya (Appendix 4) and occupies approximately 695 km^2 of total area. The County lies between 1,600 and 1,850 meters above sea level on the Southeastern edge of Kenya's agricultural heartland at 1^o 16'S latitude and 36^o 48'E longitude (Otiso, 2012). Nairobi County was purposively selected for this study because it is a metropolitan area and an economic hub and therefore, expected to have not only the highest number of veterinary practices but also the affluent owners who can afford to pay for cesarean section for their dogs. Furthermore, Nairobi County is home to the university where the investigator was based, which made the proximity convenient.

3.2. Selection of veterinary practices

In order to recruit small animal practices to participate in the study, a list of all the registered veterinary practices in Nairobi County were obtained from the Kenya Veterinary Board. Formal requests to participate in the study were made to owners with practices that met the criteria for inclusion into the study.

Selection of veterinary practices was purposive and was founded on the following criteria:

i. Practice had to be registered by the Kenya Veterinary Board.

ii. Practice had to have been operational for a minimum of 10 years.

iii. Practice had to be operating and located within Nairobi County.

iv. The responsible veterinarian had to express their willingness to participate in the study.

v. Practice had to be keeping records which were vital in retrieving data to be used in the study

3.3. Study design

The study was conducted in two phases.

Phase 1: Retrospective study

To achieve Specific Objective 1- *To identify and document anesthetic protocols used for cesarean section procedures in bitches in Nairobi County from January 2009 to December 2020*, a data collection tool was designed (Appendix 1) and used to collect data from the retrieved records. The specific data of interest included the year when the surgery was done (which was recorded as case code), breed, age, and parity of the bitch and whether the CS was elective or an emergency. Information related to the methods used for pre-operative assessment of the bitch, and assessment of the fetuses in-utero was also obtained.

A different data collection template (Appendix 2) was developed and used to extract information on anesthetic protocols that were used for cesarean section. The information relied on included, specifically, pre-anesthetic management of the patients (pre-anesthetic patient evaluation / assessment and any procedures carried out to stabilize the patient prior to the patient being anaesthetized); drugs used for premedication, induction and maintenance of anesthesia; the type of analgesia used; and fluid therapy (if any and type).

To achieve Specific Objective 2 – *to evaluate the outcome of cesarean section in the bitch and the puppies in Nairobi County from January 2009 to December 2020*, information extracted from the form in Appendix 2 on outcomes of cesarean section in the bitch and the puppies and part of information from the form in Appendix 1, was relied on. This included occurrence of a good or complicated anesthetic recovery for the bitch; post-operative care of the bitch; death or survival of the bitch following the CS; the level of consciousness of the delivered puppies; deformities on the puppies if any; and survival (number alive) or death (number dead) of the retrieved puppies.

To achieve Specific Objective 3 – *to determine post-operative pain management following*

cesarean section in the bitch in Nairobi County from January 2009 to December 2020, information and data collected and relied on included drugs and techniques used for intraoperative and post-operative analgesia for the bitch; duration of pain management; and timing of analgesic administration, as collected using the form in Appendix 2.

Phase 2: Cross-sectional study

To achieve Specific Objective 4 – *to identify challenges encountered in managing cesarean sections in bitches by veterinarians in Nairobi County*, a semi-structured questionnaire (Appendix 3) was developed and administered to consenting veterinary practitioners within the select practices. The focus of questions in the questionnaire was on peri-operative activities associated with a CS which included confirmation of pregnancy, assessment and evaluation of bitches and pre-operative stabilization (if needed) prior to administration of anesthesia; as well as challenges faced by veterinarians when managing bitches undergoing cesarean section.

3.4. Data management and statistical analysis

The information and data extracted from the accessed records and questionnaires were entered into Microsoft Excel® (2016), cleaned, filtered and saved as comma separated values (.csv) in preparation for further analysis. Descriptive data generated from the analysis included frequencies of the different aspects of the data in terms of presentation of patient, patient assessment of bitch and fetus in-utero, pre-anesthetic management, anesthesia (drugs used for premedication, induction and maintenance), drugs used for pain management; fluid therapy and outcomes (condition of the bitch and puppies post-operatively). For challenges encountered by veterinarians in managing cases of caesarean section, analysis was based on the number of veterinary practitioners who cited a particular challenge in the questionnaire out of the total number of respondents, expressed as a percentage. Pie charts and bar graphs were generated in Microsoft Excel® (2016) while heat maps were created in R® version 4.0.3. using the *ggplot2* package. All figures were then exported into Adobe Illustrator CS ® for

further editing and visualization.

For statistical analysis, logistic regression to evaluate the determinants of the outcome of CS performed at Veterinary practices in Nairobi County from the list of independent variables was performed in R® version 4.0.3 using the generalized linear model (GLM) for binary responses.

To determine the independent variables that were associated with the outcome of a CS, univariable logistic regression analysis was performed. Odds ratios, confidence intervals, and *P*-values were estimated, with a *P*-value of < 0.05 being considered statistically significant.

CHAPTER FOUR

4. RESULTS

4.1. Demographics

Data were extracted from the records of 107 cesarean section surgical cases that were performed over a 12-year period (January 2009 to December 2020) at 5 selected veterinary practices in Nairobi County.

4.2 Anesthetic protocols used for cesarean section procedures in bitches in Nairobi County from January 2009 to December 2020

4.2.1: Annual distribution of CS cases

The annual distribution of CS cases is illustrated in Figure 4.1 below. Generally, the highest number of the CS procedures was recorded in 2018 (18/107) and the least in 2012 (3/107).

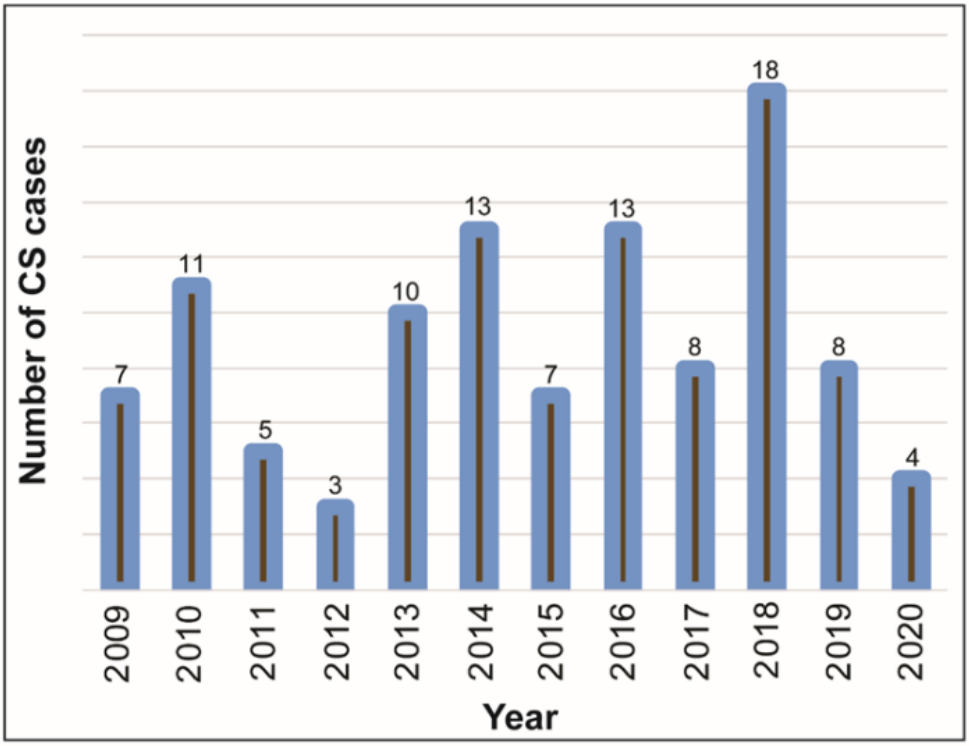

Figure 4.1: Yearly occurrence of cesarean section cases performed in bitches at selected veterinary practices in Nairobi County between January 2009 and December 2020.

4.2.2: Breed distribution of CS cases

The 107 CS procedures were performed in 21 different breeds of dogs with 66% (71/107) of surgeries carried out in medium to large breeds of dogs and 29% (31/107) in small breeds. Information on the breed of the bitch was not available in 5 of the 107 cases retrieved from the records. In reference to specific breeds, the highest number of CS procedures were performed on Boerboels (18%; 19/107) followed by German shepherds (16%; 17/107) and Labradors (12%; 13/107). On the other hand, Yorkshire terriers, St Bernards, Springer spaniels, Pugs, Border Collies and Chihuahuas were the least represented breeds. Breed distribution among the 107 cases is given in Figure 4.2 below.

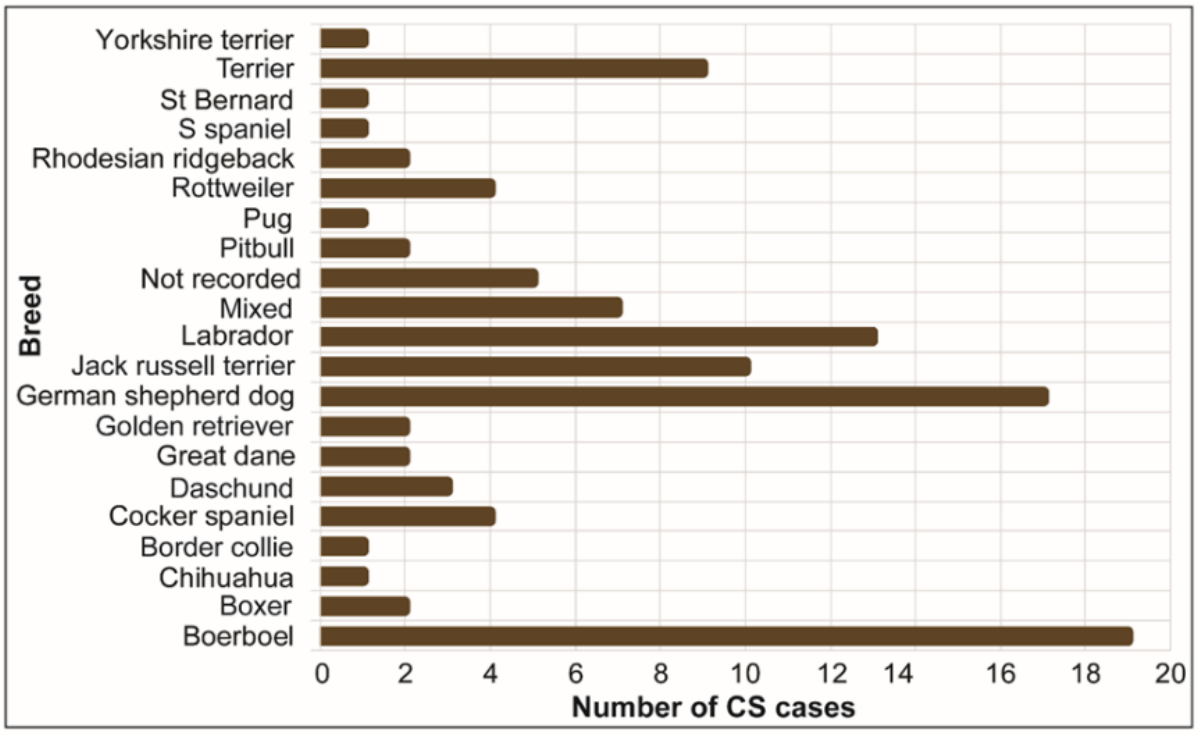

Figure 4.2: Occurrence of cesarean section cases by breed in bitches at selected practices in Nairobi County between January 2009 and December 2020.

4.2.3: Age and parity distribution of CS cases

The age of the bitches in this study ranged between 12 months to 15 years. The age of the bitch was not available in about 49% (52/107) of the records. The average age for pregnant bitches that were presented for CS was 4.6± SD years. The parity of the bitch was reported in only two of the 107 records that were examined, in which case, both bitches were in their first parity.

4.2.4: State of presentation of the bitch

Most of the CS cases during this study period were presented as emergency procedures (79%; 84/107) rather than elective (21%; 23/107) as shown in Figure 4.3.

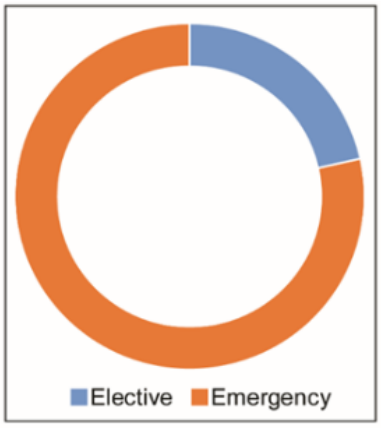

Figure 4.3: The state of the cesarean section cases on presentation at selected veterinary practices in Nairobi County between 2009 and December 2020.

4.2.5: Assessment of the bitch and fetus(es)

Before the surgery was carried out on any presented bitch, a standard physical examination (assessment of vital parameters: temperature, heart rate and respiratory rate only) was carried out on 36% (38/107) of the bitches. In a few of these cases, the veterinarian went further and performed an abdominal auscultation and palpation. A vaginal examination was done in 26% (28/107) of the cases while information was lacking on the kind of assessment done in 20.5% (22/107) of the cases presented for cesarean section (Figure 4.4). In 4/107 cases, no form of assessment was carried out in the bitch presented for CS.

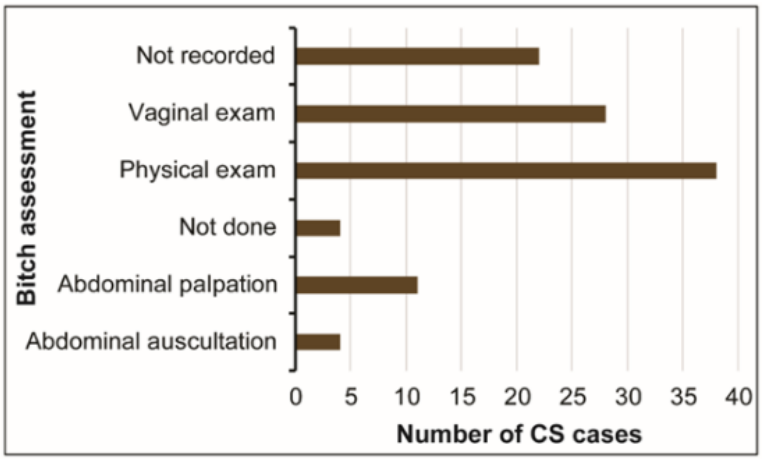

Figure 4.4: Assessment of bitches scheduled for cesarean section at selected veterinary practices in Nairobi County between January 2009 and December 2020.

Fetuses were assessed in 43% of the cases presented for CS. Radiography was performed in 25% (27/107) of the cases to enumerate and evaluate the position of fetuses. Ultrasound scanning was carried out in 18% (19/107) of the cases mainly to assess for viability of fetuses. Information on the technique used for assessment of fetuses was not available in 21% (23/107) of the recorded CS cases.

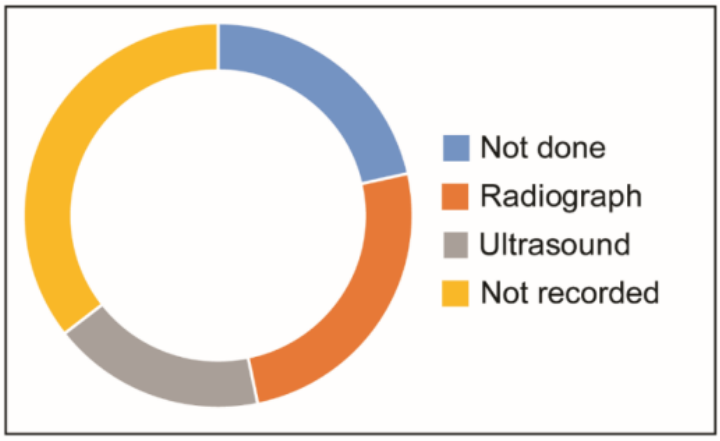

Figure 4.5: Assessment of fetuses in bitches presented for cesarean section at selected veterinary practices in Nairobi County between January 2009 and

4.2.6: Pre-anesthetic evaluation and stabilization of the bitch

The records showed that only physical examination was carried out as pre-anesthetic evaluation on 49.5 % (53/107) of the bitches presented for CS, while no information was available for 50.5% (54/107) of the cases. A few of the cases were further stabilized with intravenous fluid

therapy (8%; 9/107) although the type of fluid administered was not specified in the records.

4.2.7: Anesthesia protocols used for CS procedures in bitches

Information regarding the agents used for premedication was unavailable in 34% (36/107) of cases. Where recorded, bitches undergoing CS were mainly premedicated using xylazine (49/107) and medetomidine (2/107) while the remaining 19% (20/107) were never given any premedication. Induction of general anesthesia was mainly achieved by administering propofol (33%; 35/107), thiopentone (32%; 34/107) and ketamine (19%; 20/107). In 16% (18/107) of the cases, the induction agent used was not available in the retrieved records as shown in Figure 4.6 below.

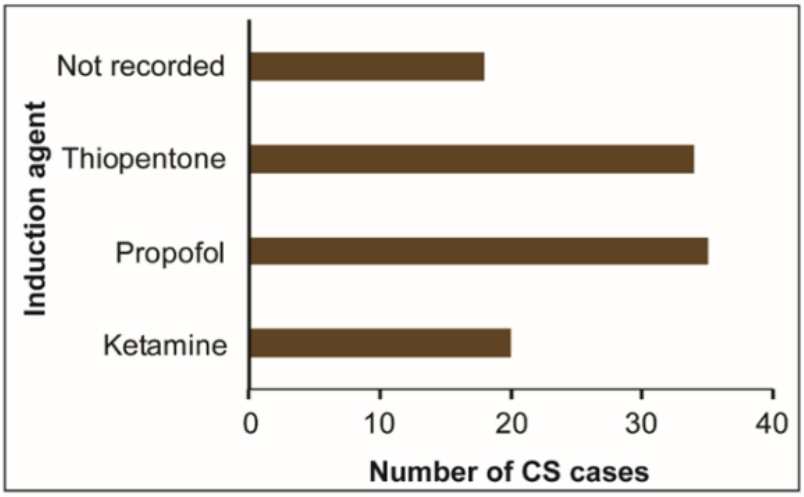

Figure 4.6: Induction agents used in bitches scheduled for cesarean section at selected veterinary practices in Nairobi County between 2009 and December 2020.

Figure 4.7 shows the trend in the evolution of drugs used for anesthetic induction over the study period. The use of ketamine and thiopentone fluctuated over the study period while there seemed to be a consistent rise in the use of propofol as an induction agent.

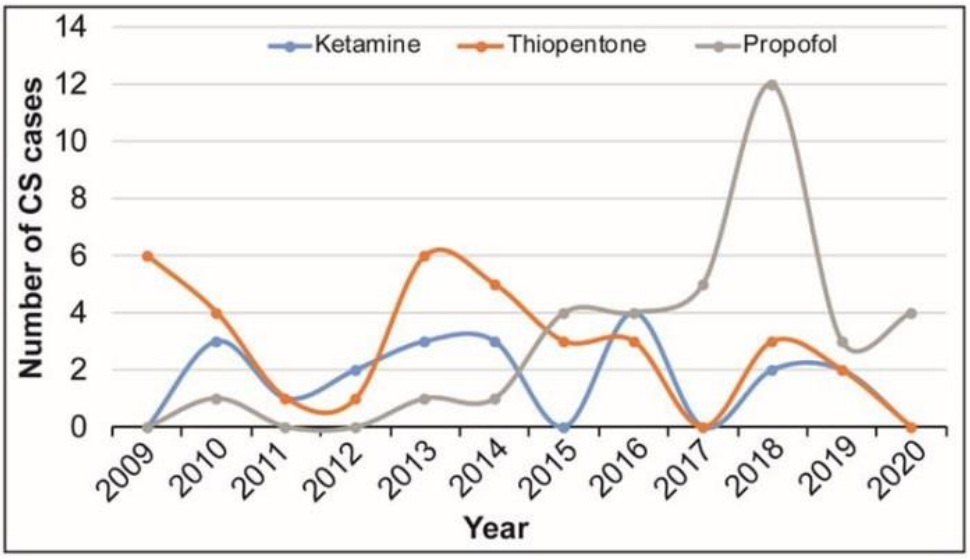

Figure 4.7: Trend in the usage of the three different induction agents used for cesarean section in the bitches in Nairobi County at selected veterinary practices between January 2009 and December 2020.

Several agents were used to maintain general anesthesia with some of them having been used as induction agents previously. In 3% (4/107); 6% (7/107) and 9% (10/107) of the CS cases, ketamine, thiopentone and propofol, respectively, were also used as agents for maintenance of general anesthesia on top of having been used as induction agents. In addition to these agents, halothane and isoflurane were used to maintain anesthesia in 42% (46/107) and 12% (13/107) of the CS cases respectively. A ketamine-xylazine combination was used in 8% (9/107) of the cases while the agent used to maintain general anesthesia was not listed in 17% (18/107) of the records (Figure 4.8).

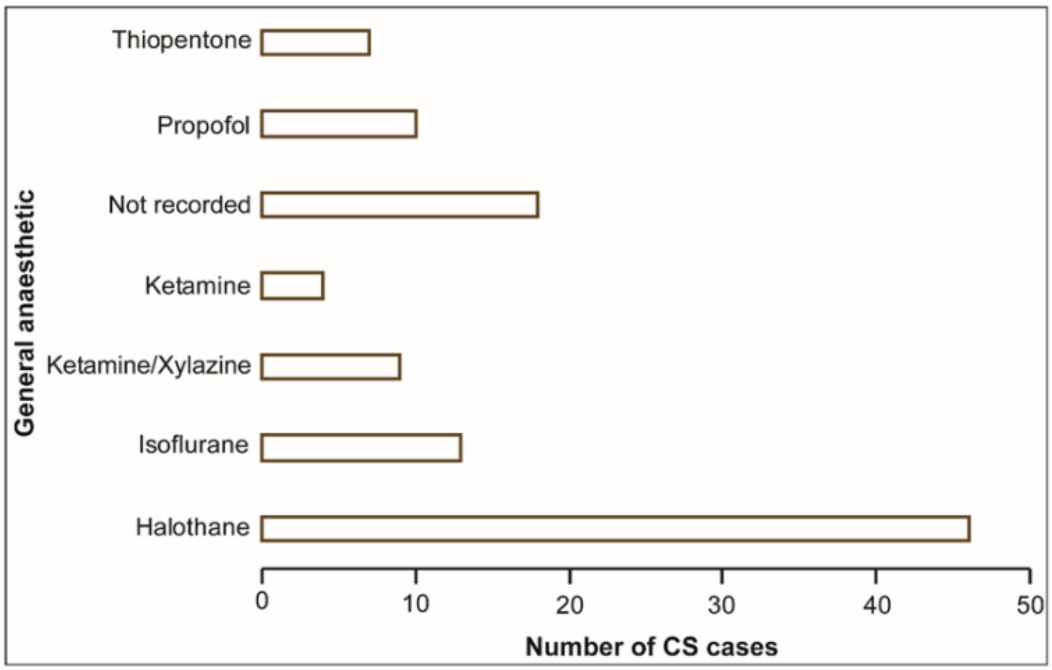

Figure 4.8: Agents used for maintenance of general anesthesia for cesarean section in the bitches in Nairobi County at the selected veterinary practices between January 2009 and December 2020.

The use of halothane fluctuated over the study period but it was consistently higher than the other methods employed for maintenance of general anesthesia, while the use of propofol like its use for induction of general anesthesia increased over time. Notably, the use of thiopentone for maintenance of general anesthesia in CS cases in Nairobi County dropped over the study period as illustrated in Figure 4.9 below.

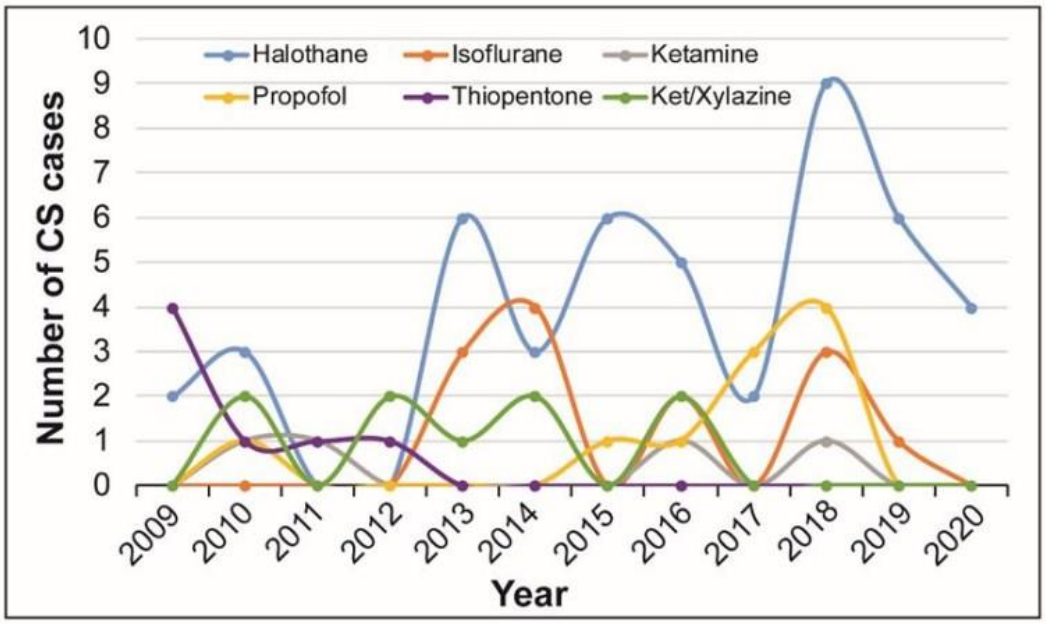

Figure 4.9: Trend in changes in the use of different general anesthetics for maintenance of general anesthesia for cesarean section in bitches over the study period at selected practices in Nairobi County between January 2009 and December 2020.

The heat map below (Figure 4.10) summarizes the relationship between the anesthesia induction and maintenance agents. The most popular induction agents were propofol and thiopentone according to appearance in the anesthetic combinations as shown in the heat map while halothane and isoflurane were the most commonly used agents for general anesthesia maintenance. Propofol-halothane and thiopentone-halothane were the most commonly used anesthetic combinations for the CS cases described in this study. This was followed by cases where propofol-propofol and thiopentone-thiopentone regimens were used.

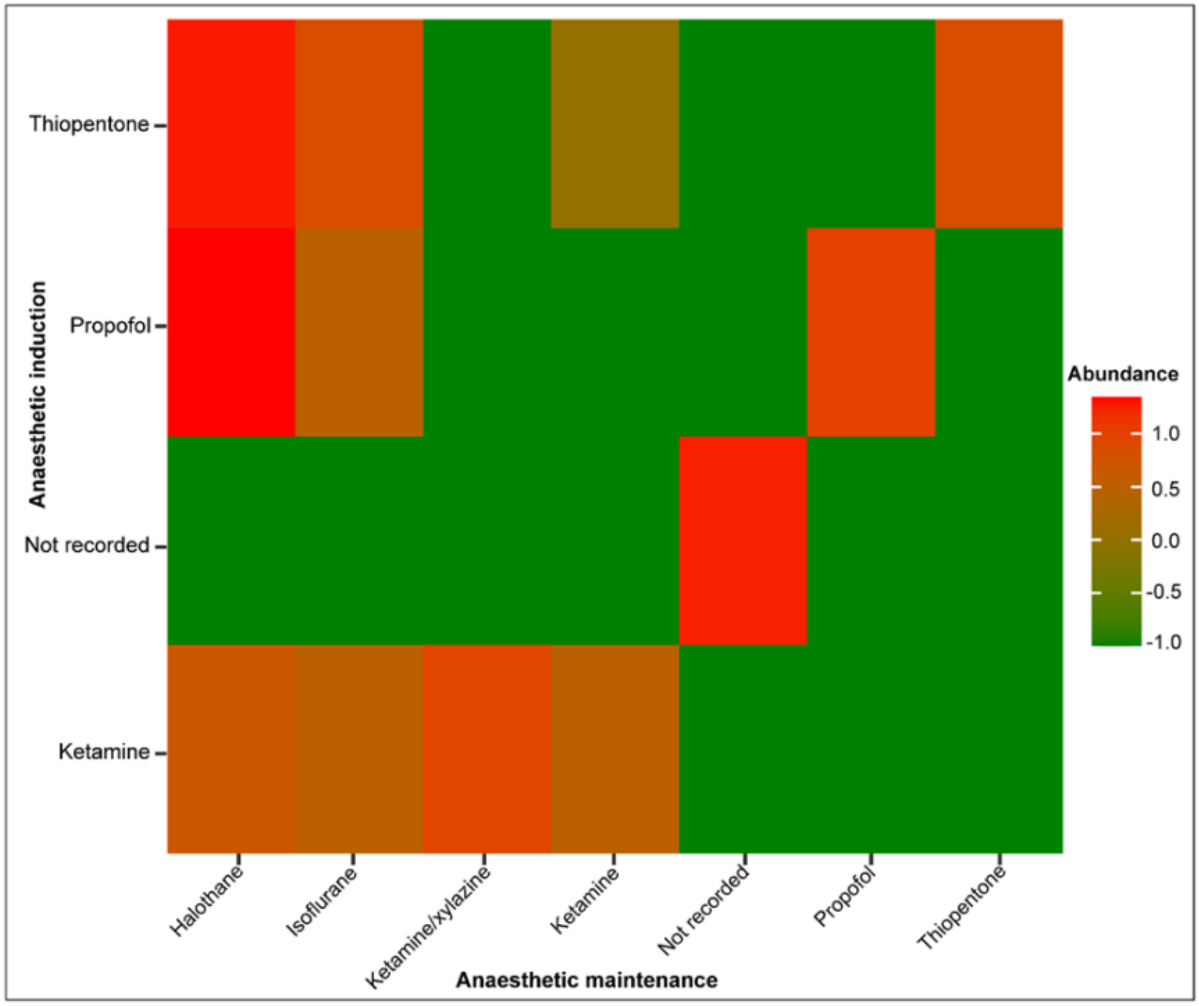

Figure 4.10: Heat map shows the common anesthetic combinations used for cesarean section cases in bitches in the selected veterinary practices in Nairobi County between January 2009 and December 2020.

4.2.8: Type of fluids given to bitches during CS

During the CS procedure, normal saline and Hartmann solution were administered in 41% (44/107) and in 32% (34/107) of the cases, respectively. Dextrose solution was the fluid of choice in 10% (11/107) of the cases while fluids were never administered in 17% (18/107) cases. The heat map below (Figure 4.11), shows that fluids were mostly given in emergency CS, in which case normal saline and Hartmann's solution were favored.

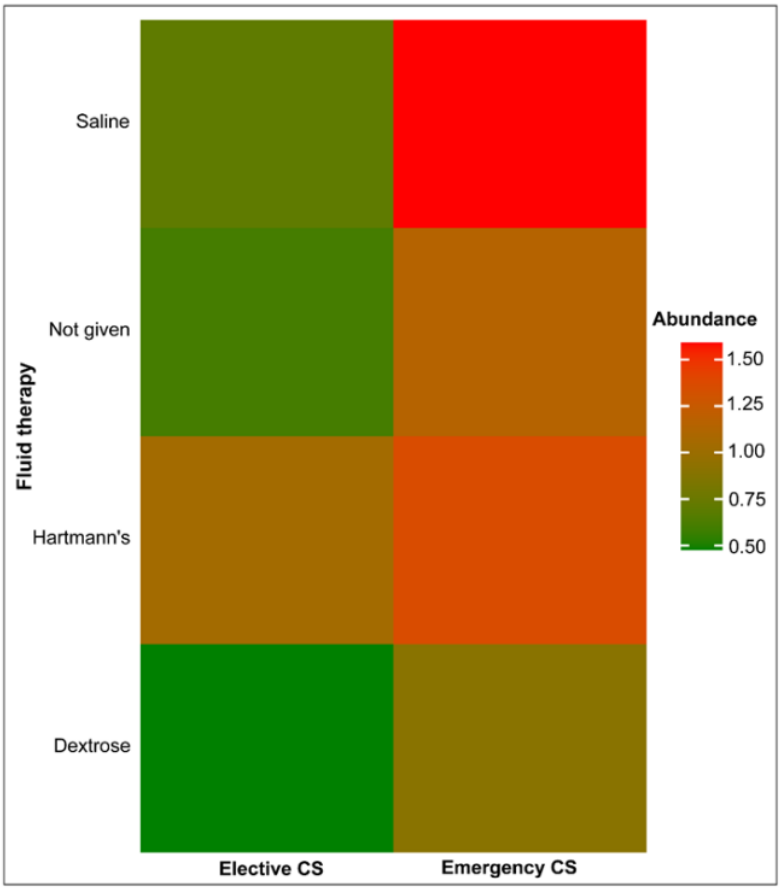

Figure 4.11: Heat map showing the use of fluid therapy during cesarean section in bitches in Nairobi County between January 2009 and December 2020 based on the presentation of the case.

4.3: Evaluation of the outcome of cesarean section in the bitch and puppies in Nairobi County from January 2009 to December 2020.

Based on the outcome assessment criteria for the bitch following CS in this study, 98.1% (105/107) recorded a successful outcome, while only two cases out of the 107 (1.9%) did not survive the procedure. In 21% (23/107) of the cases, an ovariohysterectomy was done in addition to the CS while it was not done in the remainder (79%; 84/107) of the cases (Figure 4.12).

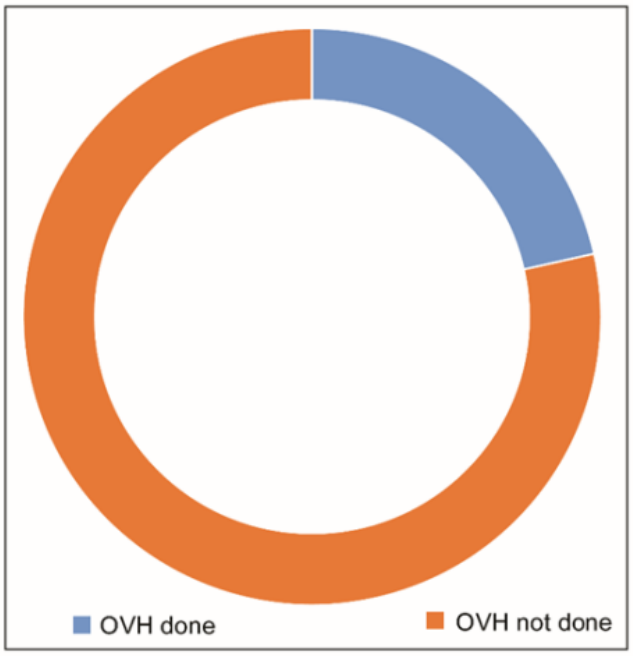

Figure 4.12: Proportion of cesarean section cases in the bitch in which an accompanying ovariohysterectomy was done in the selected veterinary practices in Nairobi County between January 2009 and December 2020.

All puppies were delivered alive in 30% (32/107) of CS procedures while they were all dead in 11% (12/107) cases. In the majority of the cases, some puppies were born alive while others were dead (50%; 54/107). Records were not available on the outcome of the puppies in the remainder (9%; 9/107) of the cases (Figure 4.13).

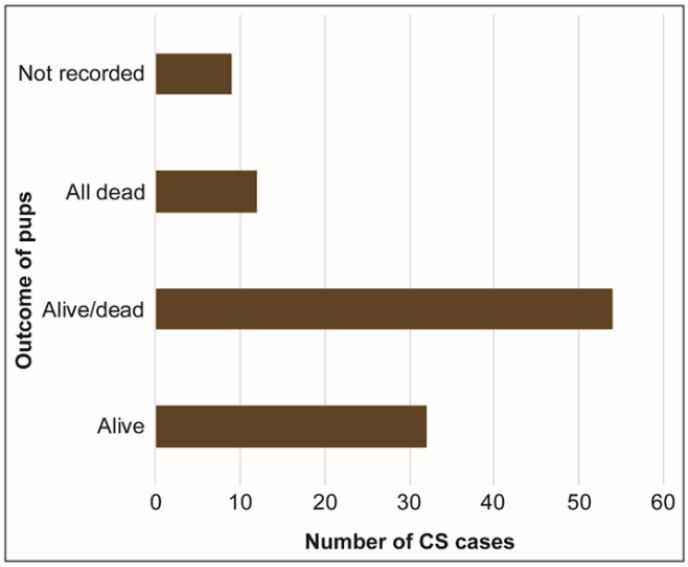

Figure 4.13: Outcome of the puppies in cesarean section cases carried out in bitches at selected veterinary practices in Nairobi County between 2009 and December 2020.

No deformity in puppies was noticed in 84% (90/107) of the CS cases while a range of deformities that included maceration (7/107), mummification (1/107) and monster puppies (2/107) were recorded in 9% (10/107) of the cases. No information was available in the records on the remainder (7%; 7/107) of the cases (Figure 4.14).

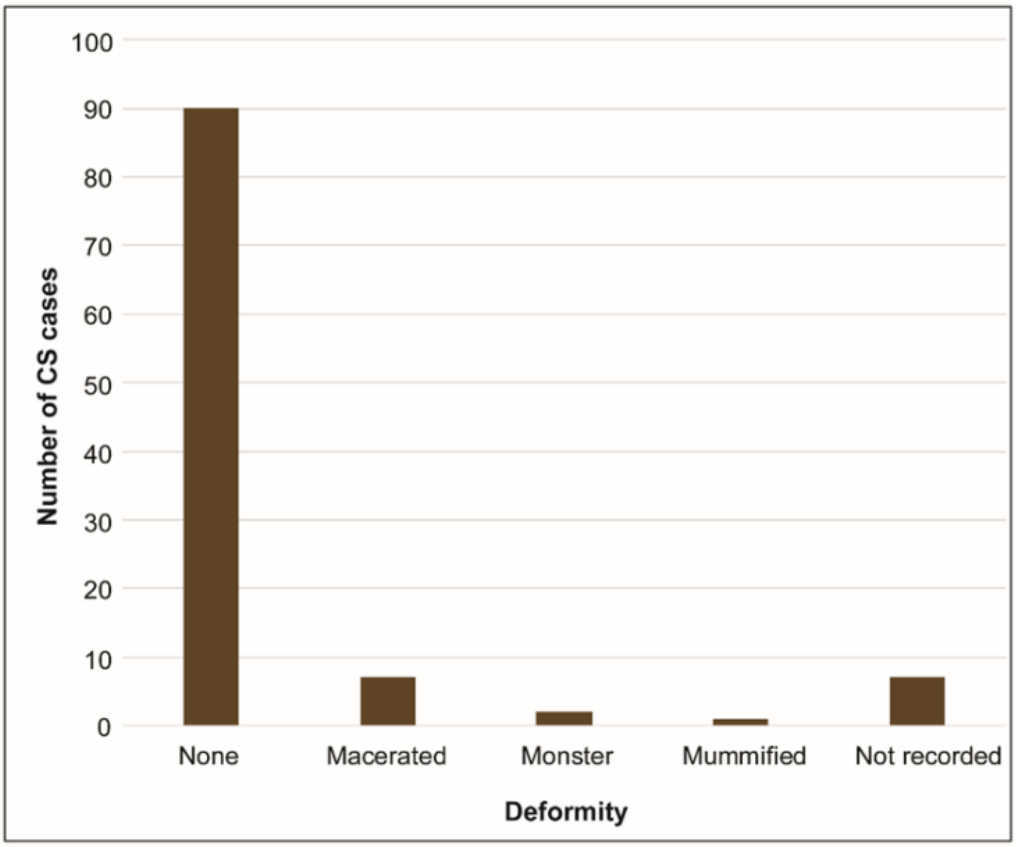

Figure 4.14: Deformities recorded in puppies delivered via cesarean section during the study period at selected veterinary practices in Nairobi County between 2009 and December 2020.

None of the independent variables (anesthetic and non-anesthetic) were significantly associated with outcomes after a cesarean section. Outcomes included whether puppies were born alive or dead, success of the CS in the bitch, occurrence of deformities and whether an ovariohysterectomy was performed during CS. Table 1 below shows the results of logistic regression of the independent variables that were likely to influence the outcome of CS in pregnant bitches.

Table 4.1: Univariate logistic regression of non-anesthetic and anesthetic factors that could influence the outcome of cesarean section performed in bitches at selected veterinary practices in Nairobi County between January 2009 and December 2020.

	Death of puppy		**Deformity of puppy**		**OVH done in bitch**	
Variable	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Breed						
Small	0.28 (0.01 - 1.72)	0.252	0.84 (0.12-4.09)	0.705	0.65 (0.13-2.41)	0.544
Medium	0.47 (0.02 – 2.95)	0.493	0.65 (0.03-4.39)	0.844	0.31 (0.02-1.9)	0.292
Large	Reference		Reference		Reference	
Presentation						
Emergency	0.27 (0.07 – 1.89)	0.256	0.36 (0.09-1.62)	0.265	0.19 (0.06-1.72)	0.223
Elective	Reference		Reference		Reference	
Induction anesthetic						
Propofol	0.64 (0.13 – 3.05)	0.565	0.22 (0.03-1.79)	0.293	0.35 (0.06-1.61)	0.234
Thiopentone	0.27 (0.04 – 1.57)	0.262	0.21 (0.03-1.81)	0.278	0.88 (0.24-3.43)	0.842
Ketamine	Reference		Reference		Reference	
Maintenance anesthetic						
Ketamine-xylazine	2.24 (0.28 – 1.22e+01)	0.377	3.92 (0.69-1.97e+01)	0.199	9.80e-01 (4.85e-02-6.89)	0.985
Ketamine	2.61 (0.12 – 2.5e+01)	0.436	2.49e-08(NA-8.96e+257)	0.997	3.33e+08 (2.19e-90-NA)	0.992
Propofol	2.24 (0.06 – 9.71)	0.819	2.49e-08 (NA-8.92e+167)	0.997	3.13 (3.9e-01-18.68)	0.226
Thiopentone	1.84e – 07 (NA – 3.01e+47)	0.992	2.49e-08 (NA-3.54e+168)	0.997	3.13 (3.90e-01-18.68)	0.226
Gaseous	Reference		Reference		Reference	

OR = odds ratio; CI = confidence interval. Gaseous = either halothane or isoflurane was used for maintenance of anesthesia

4.4: Post-operative pain management following cesarean section in the bitch in Nairobi County from January 2009 to December 2020.

In the CS cases investigated in this study, all bitches received analgesic to manage pain.

Seventy-two percent (77/107) of the bitches had analgesics administered post-operatively while in the remainder of the cases (28%; 30/107) information was not available on the timing (pre-operatively or post-operatively) of administration of the analgesics. Where information was available, the analgesics of choice were: phenylbutazone (31%; 34/107), flunixin meglumine (20%; 21/107) and meloxicam (5%; 5/107). Information on the drugs used for analgesia was not recorded in 44% (47/107) of the cases. Post-operatively, bitches were also managed with antibiotics. An antibiotic (which was unspecified) was administered in 66% (71/107) of the cases. The duration of pain management could not be determined from the records for all 107 cases.

4.5: Challenges encountered in managing caesarean sections in bitches by veterinarians in Nairobi County.

A total of five veterinary practices were recruited for this part of the study. A veterinary practitioner at each of them was able to answer questions pertaining to anesthetic protocols and other selected factors that might influence the outcome of CS in bitches. In addition to identifying the challenges faced by practitioners, the questionnaire also sought to make a comparison of the historical approach and current practices when veterinary practitioners are faced with a case of CS in bitches.

The years of experience in the interviewed practitioners ranged from 5 to 20 years in practice and all of them had performed a cesarean section before. They all indicated that it was normal practice to confirm pregnancy before attempting a CS. Forty percent (2/5) of the practices carried out only abdominal palpation to confirm pregnancy while the remaining 60% (3/5) of the practices, employed imaging techniques which also allowed them to assess the viability of the fetus in utero. The reasons influencing the decision to perform a CS included client insistence, history of dystocia and failure of medically assisted delivery.

All the five practices concurred that they carried out patient evaluation and stabilization as part

of their preanesthetic management of the patient. The parameters they used for evaluation of the patient included temperature, respiration, pulse (TRP), hydration status and capillary refill time (CRT) via assessment of mucous membranes.

At two of the five practices, patients were stabilized by rehydration while in another two, blood volume re-establishment was performed. At one of the practices, electrolytes replacement was also considered.

Only one of the practices indicated that they performed premedication with the drug of choice being xylazine. Propofol was used as an induction agent at three of the practices while the other two used thiopentone and ketamine. Maintenance of general anesthesia was by gas (2/5; 40%), propofol (1/5; 20%), thiopentone (1/5; 20%). Most of the parameters that were used for patient evaluation (TRP and CRT), were also used to monitor anesthesia intra- and post-operatively.

All the practitioners had their own approaches to assess viability of the puppies which was not the Apgar Score. The common complications associated with CS were neonatal/maternal deaths, excessive bleeding, prolonged recovery and respiratory distress.

At four of the practices (80%) the challenges encountered in managing cesarean section cases included poor access to better anesthetic drugs and techniques, lack of patient monitoring equipment during and after the CS and sometimes, lack of experienced personnel to assist during surgeries.

CHAPTER FIVE

5. DISCUSSION

The results from this study on CS in bitches in Nairobi County established that this procedure is carried out on a wide range of dog breeds of different age groups, using different anesthetic protocols, with a number of different outcomes, and that the veterinary practitioners who carry out this procedure face a number of challenges associated with the conduct of the procedure.

The number of CS procedures performed per year fluctuated during the study period, with the least being recorded in 2012 and the highest number of CS procedures performed in 2018. The number of CS procedures recorded was expected to rise steadily during the study period, correlating to the increase in pet ownership and popularity of certain dog breeds (Conze *et al.*, 2022). However, this was not observed in this study and it could be due to missing records, few practices recruited into this study owing to the COVID-19 outbreak over the study period and poor record keeping systems encountered at the practices which participated in this study.

The results of this study showed that CS procedures in Nairobi County were performed on a wide range (21) of breeds of dogs. The highest number of CS procedures were performed on Boerboels, followed by German shepherds and Labradors in that decreasing order. These are all medium to large breeds of dogs. According to Batista *et al.*, (2014), brachycephalic breeds such as the English bulldog, French bulldog as well as small breeds like Boston terrier are prone to dystocia and usually are the ones that require therapeutic CS. This is not what was observed in this study. This pattern could be attributed to the fact that larger dogs are the popular breeds kept in Nairobi County mainly for security reasons (Murani, 2022).

The average age for pregnant bitches taken to practitioners for CS was 4.6 years. In 49% (52/107) of the cases, the age of the bitch was not available. The age of an animal is important when formulating an anesthetic protocol. Drugs and dosages are usually altered depending on age (young vs old) and physiological status of a patient undergoing anesthesia. Advanced age is associated with increased anesthetic risk due to altered cardiovascular and respiratory

function as well as aging liver and kidney functions that would impair drug metabolism and excretion. Neonates and pediatric patients are at increased anesthetic risk since detoxification and drug excretion mechanisms are not fully developed (Bednarski *et al.,* 2011). Parity was recorded for only 2 out of 107 patients. We could attribute the low record of parity to the owners mostly being uncertain of how many times their animal has birthed or it could be that the practitioners rarely ask the question themselves. In most instances, it was observed that owners bring dogs to the veterinarian but it is the caretakers that spend time with the animals, and are more likely to know the day-to-day wellbeing of pets than the owners themselves. The parity is not essential in anesthesia protocol formulation, but it could be important in making the decision to schedule for an elective CS, especially if it is multiparous with a history of dystocia.

Most of the CS cases during the period of this study were presented as emergency procedures (79%; 84/107) rather than elective (21%; 23/107) indicating that this is a procedure that is not routinely done. This could be because most owners only realize their dogs are in distress after they notice lack of progress of the parturition process or when the bitches are past the expected dates for delivery. It could also be because not all dog owners understand the need to perform elective CS especially in specific breeds and also in those with previous history of dystocia.

These results were contrary to studies by Roos *et al.,* (2018) and De Cramer and Ne Crame (2019) which indicated a rise in the need for planned (elective) cesarean section as compared to emergency CS in bitches. Cavanagh (2017), stated that planned CS delivery carries a lower risk and a favorable outcome while the risk increases in the case of an emergency, as the veterinarians and their teams have adequate time to plan for the elective procedure and to make sure that the setup is ready. It also means that the bitch and fetuses are not in distress and this translates to a physiologically stable patient for anesthesia. These factors contribute to lowering the risk of mortality and morbidity on the part of both dam and neonates (Moon and Erb, 2002; Robertson, 2016).

The records showed that most bitches presented for CS received some kind of assessment prior to the procedure and it was in only 4/107 of the cases where this was not done. Bitches that are scheduled for CS, just like any other surgery, have to go through a pre-operative physical examination and evaluation. It allows the veterinarian to evaluate their physiological status and determine if they are suitable anesthetic candidates and ensures that any physiological abnormalities such as dehydration and hypoglycemia are detected and appropriate action taken to correct them before the procedure. These actions improve the anesthetic management for pregnant bitches undergoing CS (Robertson, 2016). In the current study, abdominal palpation, vaginal examination and diagnostic imaging using both radiography and ultrasonography were used.

Palpating the abdomen detects presence and position of pups, uterine contraction as well as abdominal pain that might indicate uterine pathology. According to Gendler *et al.,* (2007), a vaginal examination would be carried out to check for vaginal or pelvic abnormalities, presence of fetus lodged in the birth canal and fetal presentation. If a puppy(ies) is / are lodged in the birth canal delivery by traction would help avoid the need for CS. Diagnostic imaging was used to assess fetuses in-utero. With radiography, numbers can be determined but not viability. A study by Eneroth *et al.,* (1999) illustrated the usefulness of radiologic assessment of pelvic anatomy in bitches with obstructive dystocia. Ultrasonography confirmed viability of the fetuses as well as allowed their enumeration. Where imaging was not done, it was established that it was due to lack of imaging equipment. In situations where both radiology and ultrasonography were available, taking a radiograph was the preferred option. This could be because abdominal radiographs are valuable in quickly and easily identifying mal-positioned puppies, fetal-maternal disproportion and in providing an accurate fetal count. Radiographs are also important in ruling out the presence of an obstructive mass lesion (e.g., pelvic fracture, neoplasia) that could impede normal parturition (Gendler *et al.,* 2007).

Pre-anesthetic evaluation in the form of physical examination was carried out in almost 50%

of CS cases. Safe and effective anesthesia of dogs relies on pre-anesthetic patient assessment and preparation (Bednarski *et al.,* 2011). Impaired labor is usually associated with dehydration, hypovolemia, sepsis, stress, exhaustion, and hypocalcemia; which if not identified and remedied before the procedure will result in an untoward outcome (Kushnir and Epstein, 2012). In an elective situation, there is time for a complete physical examination and blood work. In an emergency, there may be no time to wait for results of all blood work, but a hematocrit, total protein, blood urea nitrogen, and blood glucose should always be determined before surgery (Robertson, 2009). In the current study, no laboratory diagnostics were employed to evaluate bitches pre-operatively. A possible reason could be the need to minimize costs of the surgery.

This study determined that the class of alpha-2-adrenergic agonists, particularly xylazine hydrochloride, seemed to be the popular sedative that was used for premedication. The other drug in this class that was used albeit minimally, was medetomidine. This observation was not surprising since xylazine hydrochloride is widely used in most veterinary practices in Nairobi County for sedation especially in small animal medicine and surgery (Mwangi *et al.,* 2013). Its popularity is attributed to ease of availability, familiarity and affordability as compared to other classes of drugs like opioids. According to Robertson (2016), alpha-2-adrenoceptor agonists are not recommended for premedication of bitches undergoing cesarean section due to their undesirable cardiovascular effects and respiratory depression. Moon *et al.,* (2002) and Brodbelt *et al.,* (2008) associated xylazine with increased neonatal mortality, while newer alpha- 2-adrenoceptor agonists like medetomidine were not associated with anesthesia related mortality (De Cramer *et al.,* 2017). Some authors (Moon *et al.,* 2000; Doebeli *et al.,* 2013; Vilar *et al.,* 2018) have proposed anesthetic protocols which do not include premedication. A number of cases in this study did not receive any premedication as well. While premedication generally has the advantages of calming the patient, reducing amount of general anesthetic requirement, relieving anxiety and enhancing patient comfort; the potential for diffusion of the drugs from

the dam to the fetus poses a great risk to the viability and survival of the puppies at delivery as the drugs rapidly accumulate in fetal circulation and act for longer periods (Raffe and Carpenter, 2007). Premedication, if performed at all in a pregnant patient, is best done solely with an opioid (meperidine, oxymorphone and hydromorphone). An opioid provides sedation and analgesia to the dam and the effects can be reversed in the newborn puppies with an appropriate antagonist (usually naloxone) soon after delivery (Kushnir and Epstein, 2012).

Propofol, thiopentone and ketamine were used to induce general anesthesia for most of the cases undergoing cesarean section at the selected practices that participated in this study. This study revealed a consistent rise over time in the use of propofol as an induction agent while on the other hand, the use of thiopentone and ketamine fluctuated over the same study period. While propofol is a typical induction agent in most cesarean section anesthetic protocols (Luna *et al.,* 2004; Doebeli *et al.,* 2013; De Cramer *et al.,* 2017), protocols that included ketamine (and xylazine as premedication) proved to have increased risk on puppies and are therefore are better avoided (Matthews *et al.*, 2014). Propofol owes its suitability as an appropriate induction agent for CS to some of its most desirable effects which include being titratable to effect, rapid and smooth induction and recovery, rapid metabolism as well as lack of cumulative effect in tissues after administration (Doebeli *et al.,* 2013; Robertson 2016; Degan *et al.,* 2017). The use of thiopentone as an induction agent for cesarean section has not been widely reported in recent literature. This could possibly be due to emergence of newer drugs such as propofol which prove to be better suited for the CS procedure. Moon (2002) suggested the avoidance of thiopentone as an induction agent for bitches scheduled for cesarean section, as it was associated with less vigorous puppies post-delivery, which would require intensive care to survive. Undesirable effects of thiopentone for cesarean section patients include cumulative effects which prolong recovery especially with repeated doses in addition to poor muscle relaxation and recovery which is not smooth (Robertson, 2016). Matthews *et al.,* (2014) cited a report from a study which indicated that bitches induced with thiopentone produced puppies with inferior Apgar scores as compared to those that received propofol induction. Its use as an

induction agent in 32% of the cases in this study is most probably due to availability, familiarity with the surgeons as well as affordability as was the case with xylazine.

The use of the same drugs for induction and maintenance of general anesthesia is not uncommon (Mason, 2006) as was apparent in this study where ketamine, thiopentone and propofol were used as induction and maintenance agents for general anesthesia. According to Degan *et al.,* (2017), propofol was deemed suitable for total intravenous use to maintain GA since it does not accumulate in tissues. Thiopentone, as mentioned before, has cumulative effects with repeated doses and this prolongs recovery in the bitch and also likely results in less vigorous puppies with cardiopulmonary depression. This effect is undesirable because of prolonged interval between delivery and first contact of bitch and puppies (Ruiz *et al.,* 2016). Ideally, recovery from anesthesia should be smooth and rapid (Doebeli *et al.,* 2013, Ruiz *et al.,* 2016). Ketamine when used together with xylazine has been associated with increased puppy deaths and thus is better avoided (Degan *et al.,* 2017). In contrast, Robertson (2009) suggested that ketamine combinations do not affect puppy survival but lowers puppy vigor on delivery. Its use in the current study could be attributed to familiarity, availability and affordability. Halothane was however the most popular agent used to maintain general anesthesia in this study. Isoflurane was also used in about 12% of the cases. Ideally, agents that have rapid onset of action and produce faster recovery, such as isoflurane, sevoflurane and desflurane, are preferred (Ruiz *et al.,* 2016). This was contrary to the findings of the current study, and it was probably because halothane is a cheaper option as compared to isoflurane. Several studies by Luna *et al.,* (2004), Doebeli *et al.,* (2013) and Ruiz *et al.,* (2016) recommends isoflurane as the agent of choice for maintenance of general anesthesia in cesarean section procedures.

Premedication with xylazine and induction of general anesthesia by either propofol or thiopentone, with maintenance using halothane were the commonest anesthetic combinations described in this study. These protocols might not tally with various protocols that have been cited as the best ones for cesarean section by different authors before. Luna *et al.,* (2004) and

Lopate, (2012) state that a typical CS anesthetic protocol includes no premedication, propofol for induction, with either isoflurane or sevoflurane as maintenance agents. Traas (2008) proposed induction with propofol, followed by intubation and maintenance with a propofol CRI, followed by inhalant anesthetic after the last fetus is delivered. Recent studies by Doebeli *et al.,* (2013) and Ruiz *et al.,* (2016) illustrated the efficacy of administration of alfaxalone, alone or in combination with isoflurane, for both induction and maintenance of anesthesia in bitches undergoing cesarean sections. Other researchers (Traas, 2008; Lopate, 2012) have proposed using epidural anesthesia to perform a cesarean section. With an epidural, very little amounts of lignocaine 2% are transferred to the fetuses producing minimum fetal depression. It allows the dam to remain awake and take care of her puppies soon after surgery (Degan *et al.,* 2017). A challenge with epidural anesthesia alone as a primary source of anesthesia is that the patient cannot be intubated and the airway is left unprotected. With regurgitation and vomiting being more likely when the dam is placed in dorsal recumbency, it predisposes the patient to aspiration pneumonitis and esophagitis (Robertson, 2009). Mortality rates for both dams and offspring during CS procedures have decreased over the years and this is credited to improved anesthetic management, the use of newer anesthetic agents and avoidance of drugs that, based on published evidence, are associated with greater morbidity and mortality in pregnant animals and their offspring (Robertson, 2016).

For the majority of the CS cases (73%) in the current study, isotonic crystalloids (normal saline and Hartmann's solution) were used for intra-operative fluid therapy especially in emergency CS procedures. In emergency dystocia cases, the dam is likely exhausted and dehydrated and the puppies are in distress. Even in elective situations, fluid losses can be large therefore intravenous fluids (isotonic crystalloids) are recommended and should be started prior to induction of anesthesia and continue until the procedure is done (Matthews *et al*, 2014; Robertson, 2016).

The current study observed that there was a sizeable number of cases with missing information

with regards to signalment, history, diagnostics, treatments – both pre-and post-operatively, as well as drugs and techniques that were used for anesthesia of the patients. This made it difficult to identify and document protocols in their entirety because some of the information was not recorded. It also became difficult to properly evaluate the outcomes associated with the different protocols that were identified. However, since this is the first study to investigate anesthetic protocols for a cesarean section in Nairobi County, it can be used as a reference by veterinarians and students who wish to undertake anesthesia related studies in the future. It also helps to identify gaps such as the need for better record keeping systems, better anesthetic drugs and techniques as dictated by the specific procedure and the need for continued education for veterinarians, in-order to keep up with current and recommended anesthesia practices.

This study revealed that a majority of the bitches that underwent cesarean section procedures (with the exception of only two bitches) survived, which meant that the procedure was successful. According to Van Goethem (2016), mortality rates for CS in small animals vary from 0%- 4% depending on the emergency nature and patient's physiologic status at the time of the surgery. Results from this study indicated that ovariohysterectomy was carried out in one out of every five bitches. Ovariohysterectomy is usually done after delivering the puppies from the hysterotomy incision when the owner expresses no desire for the bitch's future reproduction. It can also be considered in cases where there is uterine pathology such as unrepairable tears and uncontrollable bleeding (Van Goethem, 2016).

Litters which had both dead and live puppies at the time of delivery represented half of the cases that were recorded in this study, while 11% and 30% were all born dead and alive, respectively. Risk factors for puppy survival and complications during cesarean section delivery have been investigated before by Moon *et al.,* (2000) and the study illustrated that mortality was significantly reduced if the surgery was not an emergency, the dam was not brachycephalic and the litter size was 4 or less. Presence of deformed puppies, inclusion of xylazine in the anesthetic protocol and low puppy vigor score at birth were also noted to likely

increase the risk of death (Moon *et al.,* 2000; Van Goethem, 2016). In this study, the majority of the litters (84%) did not have any deformities. However, 9% of the cases were collectively identified as macerated, mummified and monster puppies.

Despite the foregoing, no significant association was found between the types of anesthetic drugs used and the outcomes of the cesarean section procedures performed during the study period in the selected practices.

Pain management is part of postoperative care that should be provided for the dam soon after surgery in-order to allow her puppies to nurse (Robertson, 2009). The majority of bitches in this study received an analgesic to manage pain after the procedure. The analgesics of choice (phenylbutazone, flunixin meglumine and meloxicam) were all Non-Steroidal Anti-inflammatory Drugs (NSAIDs). NSAIDs work by inhibiting the enzyme cyclooxygenase thus preventing production of inflammatory prostaglandins (Edwards, 2022). Opioids such as fentanyl and morphine are considered compatible with nursing. They would be the best choice especially if they had already been incorporated into the anesthetic protocol since they have an antidote which can be administered to reverse undesirable effects on the neonates upon delivery (Kushnir and Epstein, 2012; Matthews and Sinclair, 2018). In cesarean section bitches, the use of NSAIDs may raise concerns with regards to potential uptake and negative effects on the newborn puppies as they suckle, but only a small percentage of the dam's dose of NSAID is secreted in milk and a single post-operative dose is regarded as a suitable compromise (Matthews *et al.,* 2014). According to Mwangi *et al.,* (2018), multi-modal analgesia such as an opioid-NSAID combination, is more effective in managing pain post-surgery than single drug therapy. That same study associated a combination of pre-emptive and post-operative analgesia with better pain management, while illustrating the effectiveness of a protracted course of pain therapy post-surgery. Since there was no information on duration of pain management after the procedure in the records, the study was not able to determine how long this treatment went on for.

This survey established that all practitioners who participated in this study had carried out a CS before. Standard examination and evaluation of the bitch as well as confirmation of pregnancy before proceeding to surgery were common practice amongst practitioners, although this was not reflected by the records that were examined in this study. Techniques employed to confirm pregnancy in bitches included abdominal palpation and diagnostic imaging. This tallies with earlier results from the records regarding assessment of bitches and fetuses. Since only 3/5 of the practices had imaging equipment, it confirmed why other practices only employed physical examination techniques (abdominal palpation and auscultation) to confirm pregnancy and assess their patients.

A trend similar to pre-anesthetic evaluation and stabilization of the bitches from the records was reflected in this part of the survey as well, where no bloodwork was done pre-operatively. Laboratory diagnostics help identify abnormalities in electrolyte, acid-base, calcium or glucose levels that require correction prior to the surgery (Kushnir and Epstein, 2012; Degan *et al.*, 2017). Intravenous fluids were used to rehydrate the bitches as part of pre-operative stabilization. As previously mentioned, fluid therapy is part of patient management in-order to replace fluid deficits in dehydrated bitches and to cater for on-going loses during the procedure (Mathews *et al.*, 2014; Robertson, 2016).

All the practitioners had their individual approaches to assess viability of the puppies. A Scoring system, adapted from human medicine, is used to assess puppy viability and short-term survival prognosis in veterinary medicine; and it is known as the Apgar Score (Batista *et al.*, 2014). None of the practitioners were aware of this scoring system and thus they resorted to what they deemed appropriate to assess the newborns upon delivery.

Four out of the five practitioners that were interviewed identified limited access to better anesthetic drugs, techniques and monitoring equipment that would improve anesthetic management of cesarean section cases, and therefore the outcomes. This is because less

desirable drugs like xylazine, thiopentone and halothane are the ones commonly available to them whereas drugs such as opioids, isoflurane, sevoflurane, are not readily available due to cost (Mwangi *et al.,* 2013). As previously mentioned, protocols which include opioids, propofol, isoflurane/sevoflurane are associated with better anesthetic outcomes in both dam and newborn puppies (Vilar *et al.,* 2018). The veterinarians would rather use these protocols but the drugs are not at their disposal. Lack of knowledge on some anesthetic techniques such as epidural anesthesia for cesarean section (Mwangi *et al.,* 2013) and propofol CRI is another huddle identified by the practitioners. These can however be addressed through continuing professional education seminars when experts can teach and illustrate how to best apply these techniques in practice (Mwangi *et al.,* 2013). A well prepared and experienced team assisting the surgeon during a CS surgery contributes to a positive outcome in both dam and newborns (Cavanagh, 2017). This is because the assistants are the ones who handle the puppies on delivery and are responsible for clearing airways, stimulating the puppies, assessing their viability and catering to their immediate medical needs soon after delivery (Degan *et al.,* 2017). Training of such personnel on Apgar scores for assessment of neonatal viability, neonatal care and neonatal resuscitation protocols would be needed in-order to bridge that gap.

One notable surgical complication mentioned by all practitioners was excessive bleeding. This is partly attributable to the increased cardiac output, blood pressure, and venous distensibility that comes with gestational changes in the dam (Van Goethem, 2016; Degan *et al.,* 2017). Severe uterine hemorrhage can be caused by uterine vessel tears secondary to obstetric trauma, inherited or acquired coagulopathies, uterine or vaginal masses or subinvolution of placental sites. Management sometimes would warrant an emergency ovariohysterectomy (Van Goethem, 2016). Respiratory distress and prolonged anesthetic recovery in the dam may be as a result of the anesthetic drug choices used for the procedure as previously discussed, and probable unmitigated hypothermia in the dams. Propofol, despite being appropriate for CS, is a potent respiratory depressant (Kraus, 2016). Thiopentone, when used additively, is also known to prolong anesthetic recovery. Although there may be other factors which might

contribute to prolonged recovery, they were not covered in the scope of this survey, or did not emerge through the questionnaire survey.

CHAPTER SIX

6. CONCLUSIONS AND RECOMMENDATIONS

This study concludes that;

1. Cesarean section procedures in bitches in Nairobi County were performed on a wide range of dog breeds, and such cases are usually presented as emergencies. Despite being mostly emergencies, the CS was a relatively safe procedure with low mortality rate in the bitches, which should be assuring to dog owners and breeders. It is therefore recommended that veterinarians familiarise themselves through CPD on the management of dystocia in bitches and the current anesthetic and surgical management procedures of such cases as they are most likely to encounter them as emergencies at some point in their practice careers.

2. Premedication with xylazine and induction of general anesthesia by either propofol or thiopentone, with maintenance using halothane were the commonest anesthetic combinations used for CS procedures in pregnant bitches in Nairobi County between January 2009 and December 2020. It is however, strongly recommended that veterinary practices in Nairobi County invest more in a wider range of anesthetic drugs and adjuncts that will allow formulation and use of anesthetic protocols which are in line with international best practices.

3. Post-operative management of the bitches which included administration of antibiotics (which were unspecified) and analgesics (phenylbutazone, flunixin meglumine and meloxicam) was a common practice. However, the current study could not determine the post-operative management for new-born puppies, as well as the duration of pain management for the bitches from the records. The use of analgesia protocols tailored to meet the needs of specific surgical procedures, following trends in current pain therapy

in small animal practice is highly recommended. Veterinarians are also encouraged to improve on their record keeping techniques.

4. Practicing veterinarians in Nairobi County faced a number of challenges when carrying out CS in bitches, which included limited access to better anesthetic drugs and techniques, lack of patient monitoring equipment during and after the CS and sometimes lack of experienced personnel to assist during surgeries. It is recommended that practitioners seek to acquire better anesthetic drugs and equipment to enable them to effectively manage CS cases. Veterinarians and veterinary para-professionals are also encouraged to partake in continuing professional development courses in-order to keep up with current and improved anesthesia practices.

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APPENDICES

Appendix 1: Data collection sheet

Case code	Breed	Age	Parity	Presentation		Assess bitch	Assess fetus	Assess pups	#pups		Deformed pups	P.O.C bitch
				Emergency	Elective				Live	dead		

P.O.C = post-operative care

Appendix 2: Anesthetic protocol template

Case code	Pre-anesthetic Mgt		Premed	Induction	Maintenance	Analgesia			Fluid therapy	Outcomes	
						Drug	Time	duration		Dam	Pups
	Evaluation	stabilization									

Appendix 3: Questionnaire

1. **Practice identification (code)**…….

2. **For how long have you been in practice?**.....

3. **Have you managed a cesarean section (C.S) case before?**

Yes…….

No…….

If the answer is yes, proceed to Q4 (Tick to indicate where appropriate).

4. Do you confirm pregnancy in the bitch?

Yes……

No……

5. **What techniques do you use to confirm pregnancy in the bitch?**

Abdominal palpation…….. Abdominal auscultation

Radiology…….. Ultrasonography

Others……

6. **Do you confirm fetal viability in-utero?**

Yes…….

No…….

7. **What technique do you use to confirm fetal viability in-utero**?

8. **What factors influence your decision to perform C.S**?

Client request……. History of dystocia……

Patient's breed predisposition to dystocia…… Failure of medical management of dystocia……

Others…….

9. **What activities do you carry out as part of pre-anesthetic management of the patient?**

Patient evaluation……. Patient stabilization……...

10**. What parameters do you assess during patient evaluation?**

Parameter	Elective CS		Emergency CS	
	YES	NO	YES	NO
Heart rate				
Respiratory rate				
Temperature				
Blood pressure				
Hydration status				
Mucous membrane color				
Capillary refill time				
PCV				
TP				
OTHERS				

11. **What parameters are most frequently stabilized?**

Blood pressure…….. Hydration status……..

Blood volume…… Acid base imbalances…….

Electrolyte imbalances…….. Others…….

12. **What anesthetic protocols have you used for CS before?**

Premedication	Induction	Maintenance	Analgesia	Monitoring	Any other activities

13. **Do you monitor a patient during CS?**

Yes…...

No……

14. **Which parameters do you monitor during the procedure?**

Heart rate……. Pulse rate……. Respiratory rate…….

Temperature…… Blood pressure……. Mucous membrane color…….

Capillary refill time……. Oxygen saturation……. EtCO2…….

Palpebral reflex……. Eyeball position……. Tongue movement…….

Pedal reflex……. Others…….

15. **Do you assess newborn puppies after delivery?**

Yes….

No……

16. **Which technique do you use to assess newborn puppies soon after delivery?**

APGAR score……... Own scoring system……

Other……

17. **Do you care for the puppies after delivery?**

YES……

NO…...

18. **How do care for puppies soon after delivery?**

Provide physical stimulation……. Provide warmth…….

Reversal of sedatives…… Other……

19. **What post-operative care services are offered to the dam after CS?**

Analgesia……... Warmth……

IV fluids…… Antibiosis…….

Oxygen supplementation…… Other……

20. **What are some of the challenges and complications you encounter when managing a CS case?**

Complications	

Challenges	Possible solution

Appendix 4: Map of Nairobi County

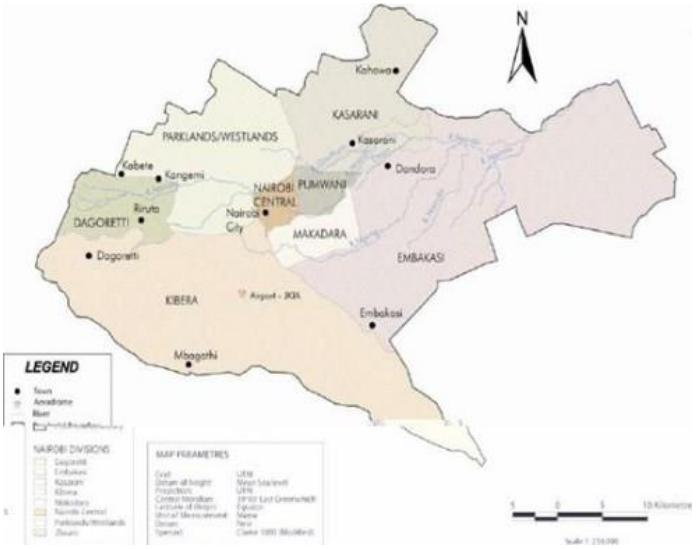

Figure 0.1: Map of Nairobi County, Kenya. (Otiso, 2012).