EVALUATION OF THE RISK FACTORS ASSOCIATED WITH OXYGEN DESATURATION IN DOGS DURING GENERAL ANAESTHESIA AND SURGERY.

A PROJECT SUBMITTED IN PARTIAL FULFILMENT OF REQUIREMENTS FOR THE AWARD OF BACHELOR OF VETERINARY MEDICINE DEGREEOF THE UNIVERSITY OF NAIROBI.

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2015.

DECLARATION

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

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This project report has been submitted for examination with our approval as University supervisors.

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DEDICATION

To veterinarians.

ACKNOWLEDGMENT

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ABSTRACT

Oxygen desaturation is a common occurrence during anaesthesia and surgery. The causes of oxygen desaturation are multifactorial and are associated with anaesthesia, surgical procedure, patient positioning intra-operatively and patient related factors.

A prospective study was carried out in dogs undergoing various surgical procedures with an aim of assessing oxygen desaturation and the risk factors associated with its occurrence intra-operatively.

Twenty three (23) dogs undergoing surgeries were grouped based on varying risk factors. Oxygen saturation was monitored using pulse oximetry at baseline (5 minutes before premedication), 5 minutes before induction of anaesthesia and every 5 minutes until the end of surgery. The lowest oxygen saturation reading throughout the entire surgery was noted for each animal. Mean oxygen desaturation was then computed and compared with varying risk factors.

Female dogs suffered relatively higher levels of oxygen desaturation (11.4±9.5) intra-operatively compared to the male (8.1±8.6) dogs. Those dogs that underwent open cavity surgeries had a relatively higher oxygen desaturation values (13.0±1.9) compared to their counterparts (8.0±6.5) that underwent closed cavity surgeries. Dogs that underwent surgeries lasting less than 60 minutes had the least oxygen desaturation in this category (5.3±1.2), followed by those whose surgeries lasted between 60-90 with a desaturation of 9.4±6.7 and the highest desaturation in this category being 16.0±14.1 in patients that underwent surgeries lasting more than 90 minutes. Dogs premedicated with xylazine had relatively less oxygen desaturation (9.7±9.0) compared to dogs that were premedicated with medetomidine (20.0±7.1). Patients injected with sodium thiopentone had relatively higher levels of oxygen desaturation (11.4±9.7), compared to those under isoflurane (4.3±1.7). Dogs weighing less than 15kg had relatively higher levels of oxygen desaturation (12.7±12.0) compared to dogs weighing more than 15 kg (8.7±5.4). Placing dogs in dorsal position during surgeries resulted in relatively higher levels of oxygen desaturation (12.7±10.6) compared to when they were in the lateral position (6.6±3.8).

It was concluded that dogs undergoing surgeries at the Small Animal Clinic, University of Nairobi suffered varying levels of oxygen desaturation intra-operatively. Furthermore, the risk factors associated with oxygen desaturation at this clinic included anaesthetic drugs, type of surgery, duration of surgery, positioning of patient during surgery, patient weight and sex. So as to minimize anaesthesia related morbidity and mortalities, supplemental oxygen should be administered to all dogs under general anaesthesia. In addition, the surgical skills should be enhanced so as to keep the duration of surgery and anaesthesia to the practical minimum.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

The pulmonary effects of general anesthesia and surgery have been well documented. Impaired gas exchange occurs with induction of general anesthesia and can be attributed to anesthetic effects on ventilation, lung and chest wall mechanisms, ventilation perfusion mismatches and lung volumes (Frazee et al, 1991). Arterial oxygen saturation depends on effective pulmonary ventilation (Murthy et al, 2002).The saturation level of oxygen in hemoglobin, (SaO_2) and partial pressure of oxygen in arterial blood, (P_aO_2) are both measures of the ability of the lungs to deliver oxygen to the blood (Haskins, 1996). A P_aO_2 below 80mm/Hg (hypoxemia), could be caused by a low inspired oxygen concentration and hypoventilation. Anesthetic drugs interfere with the sensory, neural integration and effector mechanisms that control the cardiovascular system thus depressing the cardiopulmonary functions, resulting in reduced oxygen delivery to the patient. During anesthesia, there is difficulty in breathing due to increased airway resistance caused by: reduced functional residual volume, endotracheal intubation, and possible airway obstruction in non-intubated patients (Houman, 2010). The shallow breathing may promote atelectasis and cause a decrease in functional residual volume. Decreased minute volume decreases the overall ventilation/ perfusion ratio of the lung, which decreases partial pressure of oxygen in arterial blood (Houman, 2010). This is likely to occur in spontaneous ventilation during moderate to deep levels of anesthesia. Anesthesia decreases the functional residual volume by 15- 20%, with the maximum decrease being seen within the first few minutes of induction (Houman, 2010). In the lung, gas exchange occurs rapidly between alveolar and capillary membranes (McDonell, 1996).

Oxygen desaturation is common in surgical patients that are not provided with supplemental inhalation oxygen and changes during surgery due to several factors that include altered respiratory dynamics, altered lung volume capacities, changes in pulse rate and blood pressure due to altered heart activity.

There are several factors that predispose patients under general anaesthesia to oxygen desaturation. These factors include: drugs used for sedation, induction and maintenance of anaesthesia; the type, site and duration of surgery; the patient body weight; patient positioning during surgery; and the sex of patient.

Currently there is no report that has documented the risk factor associated with oxygen desaturation in animals during anaesthesia and surgery, and especially in dogs, but such data is available in humans (Dunham et al, 2014; Reamer et al, 1987).This study therefore aims to determine these risk factors in dogs under general anaesthesia and surgery.

1.2 JUSTIFICATION

Oxygen saturation levels change during surgery due to several factors that include altered respiratory dynamics, altered lung volume capacities, changes in pulse rate and blood pressure due to altered heart activity. Oxygen saturation is a rarely noticed parameter in surgical patients, unless it is adverse and critical. Its effects, depending on the level could be deleterious during surgery and in the postoperative period. An arterial oxygen saturation of 86% does not represent a life threatening event, but should some other complication of induction (e.g. laryngeal spasm) supervene, the results could be catastrophic (Thorpe, 1990).

The aim of this study was to evaluate the oxygen saturation in the intraoperative period of surgeries, assess the level of hypoxemia and the risk factors that predispose to oxygen desaturation through monitoring the patterns of low oxygen saturations, using a portable pulse oximeter.

1.3 OBJECTIVES

1.3.1 General Objective

To evaluate oxygen desaturation and risk factors associated with oxygen desaturation in dogs under general anesthesia and surgery.

1.3.2 Specific Objectives

a) To determine the oxygen desaturation in dogs under general anesthesia and surgery.
b) To determine the risk factors associated with oxygen desaturation in dogs under general anesthesia and surgery.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition of SPO_2

Oxygen saturation refers to the concentration of oxygen in the blood and is a measure of the percentage of hemoglobin binding sites in the bloodstream occupied by oxygen (Celia Goiset, 2014). The normal partial pressure of oxygen in arterial blood is 95- 100mmHg and any value below 92% is considered hypoxemia (Getulio et al, 2001). Hypoxemia is caused by inadequate ventilation control, compromised airway patency as a consequence of anesthetics and/or neuromuscular blockers as well as inadequate ventilation/perfusion ratio caused mainly by atelectatic zones in lung-dependent regions. Other causes include low cardiac output, anemia, thermogenic shivering and pain (Getulio et al, 2001). During anaesthesia, hypoventilation is considered a fundamental factor that causes hypoxemia. Changes in ventilation are influenced by respiratory rate, diaphragmatic movements and ventilation abnormalities, such as high respiratory obstruction and broncho-spasm (Getulio et al, 2001).

2.2 Physiology of SPO_2 maintenance

The lower the SPO_2 of tissues, the greater the amount of oxygen the hemoglobin must give up. Several factors increase the availability of oxygen to tissues, and these include; increased circulation, increased respiratory rate (through activation of the respiratory centers) and increased deoxygenation (McDonell, 1996).

Oxygen delivery is the result of cardiopulmonary function (Haskins, 1996). Respiration in the conscious animal is controlled by a complex neural regulatory mechanism, originating from the medulla, modified at the higher brain centers and together with chemoreceptors, pulmonary and airway receptors. Oxygen transport in circulation depends on cardiac output,stroke volume and heart rate. Stroke volume is dependent on cardiac preload, contractility and afterload. Peripheral perfusion and tissue oxygen delivery depend on cardiac output and peripheral resistance. The respiratory system, where there is a patent and open airway and oxygen availability, ensures effective ventilation, which is controlled by the central drive and functional residual activity, oxygen pressure in the air and alveoli and pulmonary capillaries. Sometimes tissue factors play a role in oxygen release, whereby oxygen is readily released in; low pH levels, high body temperatures, high peripheral arterial carbon dioxide (P_aCO_2) and high 2, 3- diphosphoglycerate. Hemoglobin has a high affinity for oxygen in case of high pH levels, low temperatures, low peripheral arterial carbon dioxide levels and low 2, 3- diphosphoglycerate (Ridell, 2014).

2.3 Risk factors associated with oxygen desaturation

2.3.1 Anesthesia based parameters

Most preanesthetic drugs and anesthetic drugs depress respiratory function (Paddleford, 1996).

Phenothiazines have minimal effect on ventilation, although larger doses could depress it, reducing the respiratory rate. However this is usually compensated by an increase in tidal volume.

Alpha- 2 adrenergic agonists have unpredictable respiratory depressant effects ranging from mild to significant, but depending on the dose range. They mainly depress the central nervous system.

Narcotics are potent respiratory depressants, depressing the pontine and medullary centers, causing a decrease in respiratory rate and tidal volume. There is also a delayed response to low carbon dioxide in arteries.

Barbiturates are potent respiratory depressants, depressing the carotid- aortic chemoreceptors, brain, and respiratory rate and tidal volume, and thus minute ventilation. They may also decrease the myocardial contractility.

The dissociative anesthetics, for example *ketamine*, produce a ventilator pattern with a prolonged pause after inspiration. The respiratory alterations do not affect blood gases but in some cases, especially where additional CNS depressants have been used, there could be episodes of hypoxia and hypercarbia. The dissociative agents increase respiratory secretions, resulting in respiratory obstruction.

Propofol produces respiratory depression similar to barbiturates, but with longer apneic episodes.

Inhalant anesthetics example *isoflurane* depress ventilation by reducing the tidal volume, despite their ability to increase the respiratory rate.

Other anesthetic factors include alveolar hypoventilation, ventilation/perfusion mismatch, decreased cardiac output and increased oxygen consumption due to shivering that is induced by volatile agents on recovery from intraoperative hypothermia (Strachan, 2001)**.**

In spinal anesthesia, there are minimal respiratory effects and therefore considered safe, however there are incidences of hypoxemia. This can be explained by a respiratory dead space increase by 31% probably due to a reduction in thoracic blood volume resulting in an increase in the unperfused alveoli proportion. This may lead to a decrease in tidal volume and thus ventilation perfusion abnormalities. (Murthy et al 2002).

General anesthetic agents produce a dose dependent decrease in the sensory input and central response to carbon dioxide. This is usually dose dependent, and the partial pressure of carbon dioxide in the blood increase as the anesthetic dose is increased(Lin, 1996)

2.3.2 Animal based parameters.

a) Patient position

A change in body position often produces lower partial pressure of oxygen in arterial blood levels than expected for the delivered concentration of oxygen. This can occur without hypoventilation, and in controlled or spontaneous breathing, due to altered ventilation/ perfusion ratios within the lung (McDonel, 1996).

Dorsal position

In human patients placed in dorsal position, functional residual volume decreases by 0.5 to 1.0 L, because of a cephalad displacement of the diaphragm by the abdominal viscera (Houman, 2010). This position some of the lung may be continually dependent and below the left atrium. Being in dependent position, the lung is predisposed to fluid accumulation, thus pulmonary edema and subsequently reduced functional residual capacity. Pulmonary vascular congestion may also contribute to the decreased in functional residual capacity.

Lateral position

The dependent lung is more perfused than the nondependent one as pulmonary blood flow follows the vertical gradient caused by gravity (Ashoor, 2009). In lateral position, there is expansion of the extracellular space with fluid, causing the partial pressure of oxygen in arterial blood of blood draining the dependent lung to decrease precipitously to mixed venous levels.

Blood draining the nondependent lung maintain its partial pressure of oxygen in arterial blood for a period of time but in the face of the extracellular fluid expansion also suffers a decline in its partial pressure of oxygen in arterial blood after some hours. Some studies have shown that inpatients undergoing one- lung ventilation, cardiac output increased in response to sudden decrease in arterial saturation (Houman, 2010).

b) Body condition

An excess body mass will have increased metabolic demands which will require an increased cardiac output, there is pulmonary constriction and fatty infiltration of the cardiac conduction system, all which will be exacerbated in anesthetized state.

Increased fat stores require more clearance time for fat soluble anesthetics. Obese patients have an increased reduction of the functional residual capacity, which decreases further with anesthetic induction.

2.3.3 Surgery related parameters

a) Closed and Open cavity surgery

Troell, (1951), documented that open cavity surgeries in man have a profound effect on the lung functional residual capacity. The respirations become more frequent with a small tidal volume.

In anesthetized patients with a closed chest, the lower lung is less ventilated as it occupies a less favorable position in the compliance curve and the diaphragm is pushed upward by abdominal content. In anesthetized patients with an opened chest, compliance of the non-dependent lung is markedly reduced, further decreasing the ventilation of the dependent lung. In both situations there is ventilation perfusion mismatch (Ashoor, 2009). The site of surgery also influences respiratory mechanisms. For instance, upper abdominal and thoracic surgeries lead to a reduction in functional residual capacity. The reduction in partial pressure of oxygen in blood parallels the functional residual capacity changes. In comparison, equally traumatic lower abdominal and pelvic surgery produces less respiratory effect and orthopedic surgical procedures on the limbs have less significant effect on functional respiratory capacity (Strachan 2001***).*** According to Serejo, (2007), thoracic surgeries also results in lung volumes changes secondary to respiratory muscle dysfunction and altered chest mechanics, including reduction in functional residual capacity (FRC), vital capacity (VC) and increase in closing volume (CV). Another study by Murthy et al, (2002), showed no significant difference in desaturation between patients undergoing abdominal and other surgeries (23%) but hypoxemia was more during abdominal surgery, especially when the abdomen was opened by midline incision (37.5%).

2.4 Monitoring peripheral capillary oxygen saturation (SPO_2).

Oxygen saturation level can be obtained using pulse oximetry or by analyzing a blood sample. Analyzing blood samples is a costly and invasive method. The ideal method of assessing peripheral oxygenation is by use of a pulse oximeter. Cutaneous pulse oximetry gives real- time data on the oxygenation of hemoglobin (saturation) and peripheral pulse rate (Ridell, 2014). The principal limitation is that, it does not reliably detect hypoventilation in patients receiving supplemental oxygen (Strachan, 2001)

Pulse oximeter uses two sensors and a light source to determine the percentage of oxygen saturation in the blood. The device uses the color of blood to determine its oxygen content. Each sensor looks for a different color of light. Oxygenated blood is a brighter shade of red than the deoxygenated blood. The device measures the difference between the two to determine the percentage of oxygen saturation. An oxygen saturation value of 90% is generally equated with a partial pressure of oxygen in arterial blood of 60mmHg (Schutz, 2001)

Adequate arterial pulse strength is necessary for obtaining accurate SpO_2 values, so the probe must be placed in a pulsing vascular bed, for example the underside of the tongue and the tip of the ear. The probe identifies arterial blood, the pulse rate and provides a reading if a pulse is detected (Schutz, 2001). The chief value of the reading is based on serial readings of 5 minutes intervals, rather than a single reading. The resulting numbers are expressed as "percentage of oxygen saturation" (SaO_2).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study design

This was an experimental study in which dogs undergoing surgery in the Small Animal Clinic, University of Nairobi were selected for the study. Oxygen saturation was monitored before surgery and intra-operatively. Oxygen desaturation values were then compared with anesthesia, surgery and patient based parameters.

3.2 Assessment of parameters

Objective 1: Assessing oxygen desaturation (SPO_2)

Oxygen saturation was monitored using a pulse oximeter at baseline (5 minutes before premedication), 5 minutes before induction and every 5 minutes till the end of surgery. The lowest oxygen saturation reading throughout the entire surgery was noted for each animal. Oxygen desaturation was then computed as shown below;

$$\text{Oxygen desaturation} = \text{Baseline } SpO_2 - \text{Lowest } SpO_2$$

Mean oxygen desaturation will then be computed as shown below

$$\text{Mean oxygen desaturation} = \frac{\text{Sum of oxygen desaturation in a group}}{\text{Number of animal in a group}}$$

Mean oxygen desaturation was then compared between groups.

Objective 2: Risk factors associated with oxygen desaturation

1. *Anesthesia based parameters*

i) Type of anesthesia protocol

The agents used for pre-medication, induction and maintenance of anaesthesia for each patient were noted. Animals were grouped based on the agents used for pre-medication, induction and maintenance of anaesthesia following which the mean oxygen desaturation in each group was computed.

ii) Oxygen supplementation

Where animals were supplemented using oxygen intra-operatively, this was noted. Their mean oxygen desaturation was then be computed and compared with the mean oxygen desaturation of the animal that did not receive oxygen supplementation intra-operatively.

iii) Temperature and cardio-pulmonary parameters

Temperature, pulse rate, and respiratory rate were assessed at baseline (5 minutes before premedication) 5 minutes before induction and every 5 minutes until the end of surgery. Temperature was assessed using a digital thermometer inserted in the rectum and held against the mucosa. Pulse rate reading was assessed by using the pulse oximeter (G1A-Vet Handheld Pulse Oximeter, General Meditech, Inc.Guangdong, China) while respiratory rate was assessed by counting the number of chest excursions per minute.

iv) Intra-operative fluid therapy

Animals that received fluids intra-operatively were noted. Their mean oxygen desaturation was then computed and compared with the mean oxygen desaturation of the animal that did not receive fluids intra-operatively (Frost, 2014).

2. Animal based parameters

The following animal based parameters were noted: animal body weight (Kgs), sex and body condition score. Based on body weight, animals were grouped into two: those whose body weights were equal to or less than 15 Kgs and those with body weights of more than 15 Kgs. Based on sex, animals were grouped into male and female. Based on body condition, animals were classified as emaciated, lean or obese. Mean oxygen desaturation was then computed for each group.

3. Surgery based parameters

The following surgical based parameters were assessed; patient positioning during surgery, type of surgery and duration of surgery.

i) Patient position during surgery

Based on the patient positioning during surgery, animals were categorized into those that were positioned on lateral recumbency (LR) and those that were positioned in dorsal recumbency (DR). Mean oxygen desaturation was then computed for each group.

ii) Type of surgery

Based on the type of surgery, animals were classified as those that underwent abdominal surgery (AS) and those that underwent non-abdominal surgery (NAS). Mean oxygen desaturation was then computed for each group.

iii) Duration of surgery

Based on the duration of surgery, animals were classified as those that underwent surgeries lasting less or equal to 60 minutes and it lasted for more than 60 minutes. Mean oxygen desaturation was then computed.

3.3 DATA ANALYSIS

Data was entered into Microsoft Office Excel then verified and validated as correct entries based on the data collection sheets. Descriptive statistics were then generated. All data are expressed as means±sd.

CHAPTER FOUR

4.0 RESULTS

4.1 General patient demographics

A total of 23 patients undergoing different type of surgeries in the Small Animal Clinic, University of Nairobi were recruited into this study. The patients were either client owned dogs or dogs undergoing operative surgery (OPS) procedures. Before surgery, patient were fasted for 12 hours but water was provided *ad libitum*. On the day of surgery, for client dogs, the surgeon on duty had the sole discretion of deciding the anaesthesia protocol that was to be used. However for the OPS dogs, the anaesthesia protocol was more standardized and involved premedication with xylazine at 1.1mg/kg and induction and maintenance of anaesthesia achieved by intravenous administration of thiopentone sodium at 10mg/kg.

To be able to evaluate the risk factors that predispose patients to oxygen desaturation during anaesthesia, several factors were considered. These factors included sex, type of surgery, type of anaesthesia, duration of anaesthesia and body weight. These risk factors were further categorized accordingly and the mean oxygen desaturation values computed for animal groups in each category.

4.2. Type of Anaesthesia

4.2.1 Type of premedicants

Twenty one (91.3%) out of the 23 dogs that were recruited into this study, were premedicated with xylazine and had a relatively lower mean oxygen desaturation (9.7±9.0) compared to the 2 (8.7%) dogs that were premedicated with medetomidine, (20.0±7.1).

Table 1.1: Mean of oxygen desaturation in patients premedicated with xylazine and medetomidine.

Risk factors	Category	Number of patients	Mean±Sd Baseline SpO_2 (%)	Mean±Sd Lowest SpO_2 (%)	Mean±Sd Desaturation
Premedication	Xylazine	21	90.4±5.0	80.3±10.2	**9.7±9.0**
	Medetomidine	2	87.0±9.9	67.0±2.8	**20.0±7.1**

4.2.2 Type of Induction agent

The distribution of dogs based on the agent used for induction of anaesthesia is shown in Figure 1 below. Of the 23 dogs used in this study, 20 (86.9%), were induced using sodium thiopentone, 1(4.3%) using ketamine, 1(4.3%) using propofol and 1(4.3%) using epidural lidocaine. Due to the fact that ketamine, propofol and epidural lidocaine were used in only one patient each, the mean oxygen desaturation values could not be computed.

Table 1.2: Distribution of patients induced with thiopentone, ketamine, propofol and epidural lidocaine.

Risk factors	Category	Number of patients	Mean±Sd Baseline SpO_2 (%)	Mean±Sd Lowest SpO_2 (%)	Mean±Sd Desaturation
Induction agents	Thiopentone	20	-	-	-
	Ketamine	1	-	-	-
	Propofol	1	-	-	-
	Epidural lidocaine	1	-	-	-

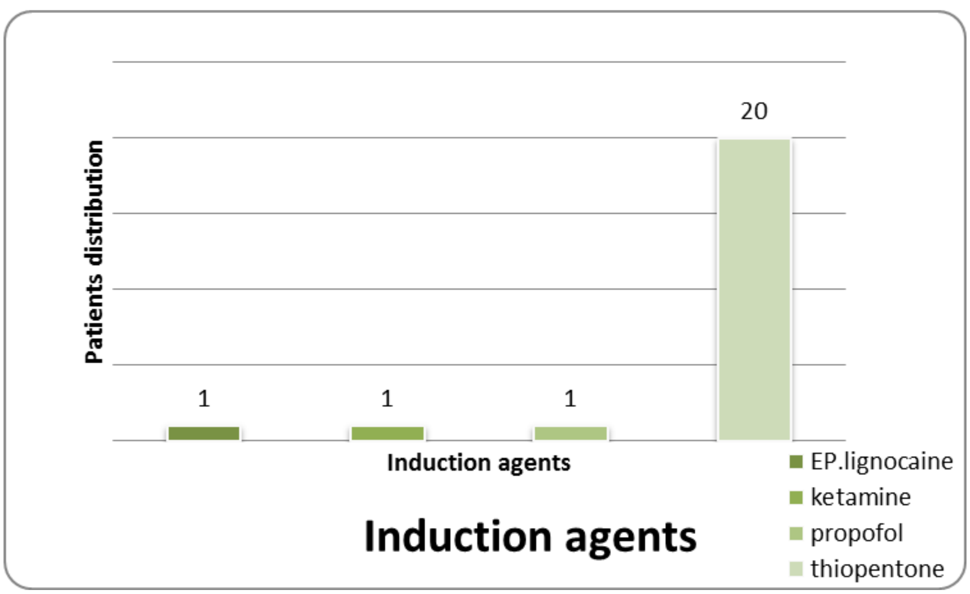

Figure 1: Distribution of dogs based on the agents used for induction of anaesthesia

4.2.3 Type of maintenance agent

Maintenance of anesthesia was achieved using four protocols which were: sodium thiopentone, isoflurane, ketamine and epidural lidocaine as shown in Figure 2 below. Sodium thiopentone was used to maintain anaesthesia in 17 (73.9%) dogs, isoflurane in 4 (17.4%) dogs while ketamine and epidural lidocaine were used in one dog each. Use of sodium thiopentone resulted in relatively higher mean oxygen desaturation (11.4±9.7), compared to isoflurane (4.3±1.7). Mean oxygen desaturation in ketamine and epidural lidocaine group could not be computed since these protocols were used in only one patient each.

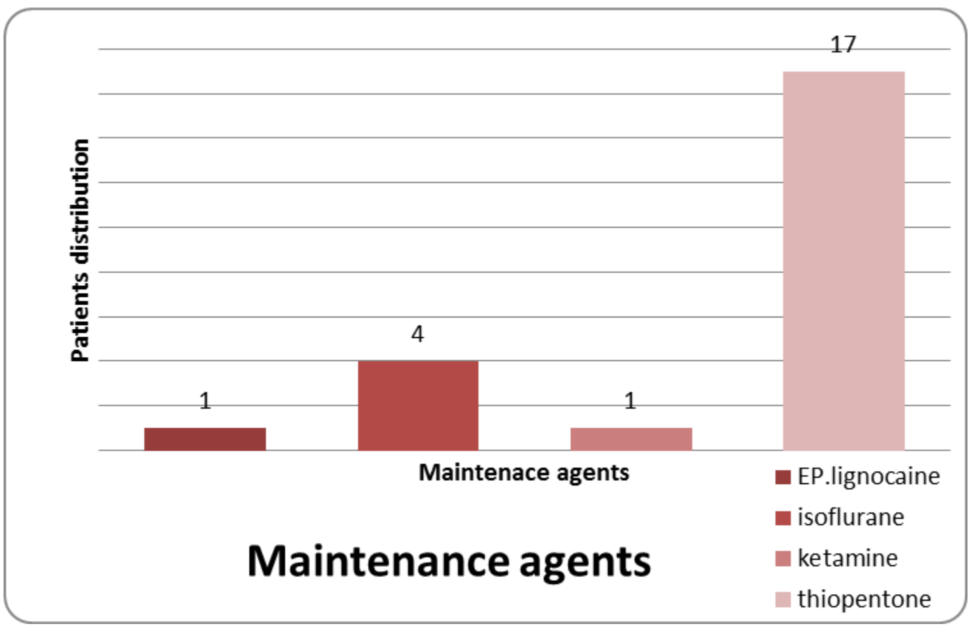

Figure 2: Distribution of patients based on the agent used for maintenance of anaesthesia

Table 1.3: Means of oxygen desaturation in patients maintained on thiopentone and isoflurane

Risk factor	category	Number of patients	Mean±Sd Baseline SpO_2 (%)	Mean±Sd Lowest SpO_2 (%)	Mean±Sd Desaturation
Maintenance of anesthesia	Thiopentone	17	90.2±3.1	78.8±10.1	**11.4±9.7**
	isoflurane	4	93.5±4.2	89.3±5.0	**4.3±1.7**

4.3 Sex

Amongst the 23 patients that were recruited into this study, 6 (26.1%) were male and 17 (73.9%) were female. Female animals suffered relatively higher oxygen desaturation (11.4±9.5) intraoperatively compared to the male (8.1±8.6) animals.

Table 1.4: Means of oxygen desaturation in male and female patients

Risk Factors	Category	Number of Patients	Mean±Sd Baseline SpO_2 (%)	Mean±Sd Lowest SpO_2 (%)	Mean±Sd Desaturation
Sex	Male	6	88.0±7.7	79.8±8.6	**8.1±8.6**
	Female	17	90.4±4.3	78.9±11.3	**11.4±9.5**

4.4 Patient Body Weight

Amongst the 23 patients, 11(47.8%) were less than 15kg body weight, while the other 12 (52.2%) weighed more than 15kg. Dogs weighing less than 15kg had a relatively higher mean oxygen desaturation (12.7±12.0) compared to dogs weighing more than 15 kg (8.7±5.4).

Table 1.5: Means of oxygen desaturation in patients weighing less than 15kg and those weighing more than 15kg.

Risk factor	Category	Number of patients	Mean±Sd Baseline SpO_2 (%)	Mean±Sd Lowest SpO_2 (%)	Mean±Sd Desaturation
Weight (kg)	<15	11	90.0±6.6	77.3±13.3	**12.7±12.0**
	>15	12	89.6±4.0	80.9±7.1	**8.7±5.4**

4.5 Type of surgery

Twelve (52.2%) patients out of the 23 underwent open cavity surgery and 11(47.8%) closed cavity surgery. Those that underwent open cavity surgeries had relatively higher mean oxygen desaturation values (13.0±1.9) compared to their counterparts (8.0±6.5) that underwent closed cavity surgeries.

Table 1.6: Means of oxygen desaturation in patients that underwent open cavity and closed cavity surgeries.

Risk Factors	Category	Number of Patients	Mean±Sd Baseline SpO_2 (%)	Mean±Sd Lowest SpO_2 (%)	Mean±Sd Desaturation
Type of surgery	Open cavity	12	88.7±4.2	75.7±11.6	**13.0±1.9**
	Closed cavity	11	91.0±6.3	83.0±8.0	**8.0±6.5**

4.6 Duration of Surgery

Out of the 23 dogs in this study, 3(13.0%) had surgeries lasting less than 60 minutes, 6 (26.1%) lasted between 60-90 minutes, and 14 (60.9%) lasted more than 90 minutes as shown in Figure 3 below. Those that lasted less than 60 minutes had the least oxygen desaturation in this category (5.3±1.2), followed by those that lasted between 60-90 with a desaturation of (9.4±6.7) and the highest desaturation in this category being (16.0±14.1) in patients whose surgeries lasted more than 90 minutes.

Figure 3: Distribution of animals based on duration of surgery

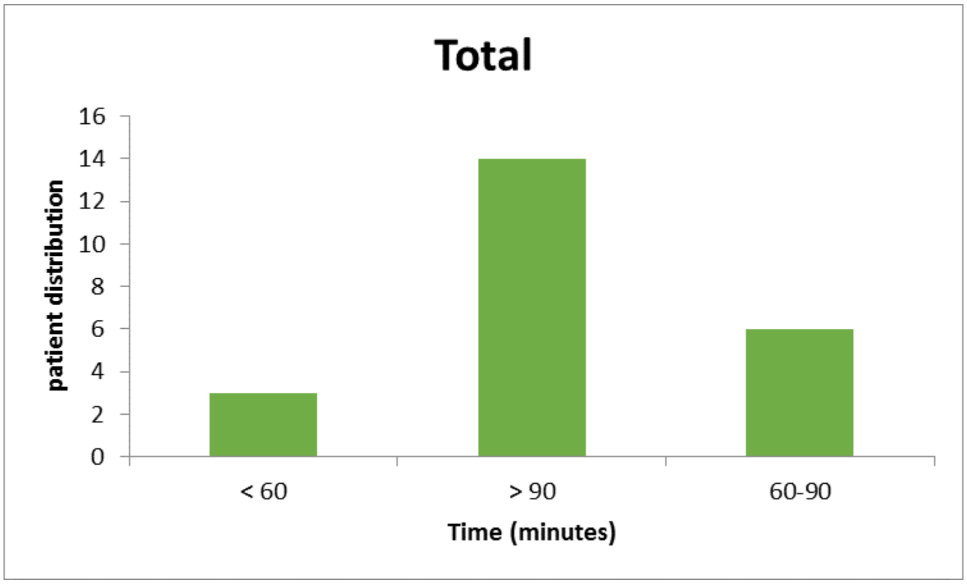

Table 1.7: Means of oxygen desaturation and duration of surgical procedures.

Risk factors	Category	Number of patients	Mean±Sd Baseline SpO_2 (%)	Mean±Sd Lowest SpO_2 (%)	Mean±Sd Desaturation
Duration (Minutes)	<60	3	87.7±11.9	82.3±10.8	**5.3±1.2**
	60-90	6	91.3±3.1	81.9±7.4	**9.4±6.7**
	>90	14	87.3±5.0	71.3±14.0	**16.0±14.1**

4.7 Patient position during surgery

Among the 23 dogs in this study, 15(65.2%3) were in dorsal position, while 8 (34.8%) were in lateral position. during the surgical procedure. Dogs in dorsal position had relatively higher oxygen desaturation (12.7±10.6) as compared to those in lateral position (6.6±3.8).

Table 1.8: Means of oxygen desaturation in dogs on dorsal and lateral surgical positions.

Risk factors	Category	Number of patients	Mean±Sd Baseline SpO_2 (%)	Mean±Sd Lowest SpO_2 (%)	Mean±Sd Desaturation
Position	Dorsal	15	88.5±5.9	75.8±11.2	12.7±10.6
	Lateral	8	92.1±3.0	85.5±4.9	6.6±3.8

CHAPTER FIVE

5.0 Discussion

5.1 Premedication

In this study, premedication using medetomidine resulted in relatively higher oxygen desaturation compared to tranquilization using xylazine. Although the ventilatory effects of medetomidine were not compared with those of xylazine in this study, it is possible that dogs that were sedated using medetomidine experienced high rates of hypoventilation compared to those sedated using xylazine. This is presumably because cardio-pulmonary depressant effects of medetomidine have been shown to be dose dependent and more potent compared to xylazine (Melissa, 2003). Hypoventilation has previously been positively correlated to hypoxemia in humans (Oliveira et al., 2001).

5.2 Maintenance of anaesthesia

Where thiopentone was used to maintain anaesthesia, relatively higher oxygen desaturation values were recorded compared to when isoflurane was used. This may be attributed to the fact that isoflurane is vaporized in oxygen and administered to a patient during anaesthesia. Administration of oxygen to patients under general anaesthesia has been shown to mitigate hypoxemia perioperatively. However, oxygen desaturation has been demonstrated in patients given 100% oxygen postoperatively (Getulio, 2001). This fact supports the thinking that oxygen desaturation is multi-factorial in nature and is caused by synergistic effects of multiple risk factors. In addition, this observation can also be attributed to the fact that thiopentone sodium is a potent respiratory depressant compared to isoflurane.

5.3 Sex

Female dogs in this study experienced relatively higher oxygen desaturation than the male dogs. Though the body mass index (BMI) was not evaluated in this study, it is expected that female dogs have more body fat compared to male dogs. Studies in humans have shown that patients with high BMI have reduced functional respiratory capacity (Damia et al., 1988; Jense et al., 1991) that decreases further with anesthetic induction (Robert and Langer, 1997). These predispose such patients to high oxygen desaturation during anaesthesia (Jense et al., 1991). It is also possible that most female dogs underwent open cavity surgeries, more so ovariohysterectomy compared to male dogs that mostly underwent superficial surgeries mostly castration. This would have contributed to the relatively higher relative oxygen desaturation in female as compared to male dogs.

5.4 Weight

Dogs weighing less than 15 Kgs recorded relatively higher oxygen desaturation values compared to dogs weighing more than 15 Kgs. This observation may be attributed to the large surface area to volume ratio of small dogs compared to large dogs. This results in increased metabolic demands and hence higher oxygen consumption. The observed relatively higher desaturation in dogs weighing less than 15 Kgs in this study could also be attributed to hypothermia (Mwangi et al., 2014) that accompanies general anaesthesia and surgery, which is more pronounced in small size dogs.

5.5 Type of surgery

Dogs that underwent open cavity surgery recorded a relatively higher oxygen desaturation compared to those that underwent closed cavity surgeries. Open cavity surgeries have been shown to have a negative impact on arterial oxygen saturation in human patients (Knudsen, 1970; Canet et al., 1989; Xue et al., 1999). This is attributed to the fact that patients undergoing open cavity surgeries are at a risk of hypoventilation, ventilation-perfusion imbalance and atelectasis due to mechanical impairment of respiratory function (Bishop and McKeown, 1979). Further, in abdominal and thoracic surgeries the functional residual capacity is more depressed compared to that in superficial surgeries (Alexander et al., 1973; Ali et al., 1974; Meyers et al., 1975). The mechanism for the reduction in functional residual capacity after abdominal or thoracic cavity surgery is the combined effect of incisional pain and reflex dysfunction of the diaphragm. In addition, pleural effusion, cooling of the phrenic nerve, and mediastinal widening further reduces functional residual capacity in thoracic surgeries (Wahba, 1991). The observed higher levels of desaturation in open cavity surgeries compared to closed cavity surgeries in this study can also be attributed to hypothermia (Mwangi*et al.*, 2014) that accompanies general anaesthesia and surgery.

5.6 Duration

In this study, longer duration of surgery resulted in relatively higher oxygen desaturation compared to shorter surgeries. According to Houman (2010), duration of anaesthesia and positioning of the patient work in synergy to impact oxygen saturation perioperatively. In a study conducted by Ray *et al.,* (1974), when mongrel dogs were placed in a lateral decubitus position and were anesthetized for several hours and the extracellular space expanded with fluid, the partial pressure of oxygen of blood draining the dependent lung decreased abruptly to mixed venous levels (no O_2 uptake). Blood draining the nondependent lung maintained its partial pressure of oxygen for a period of time but in the face of the extracellular fluid expansion also suffered a decline in its partial pressure of oxygen after 5 hours. If the animals were turned every hour (and received the same fluid challenge), only the dependent lung, at the end of each hour period, suffered a decrease in oxygenation. If the animals were turned every half-hour and received the same fluid challenge, neither lung suffered a decrease in oxygenation. In patients undergoing surgery in the lateral decubitus position and who receive excessive intravenous fluids, the risk of the dependent lung becoming edematous is certainly increased. It is therefore beneficial to continuously turn the patient intra-operatively more so in critically ill patients (Houman, 2010).

5.7 Position

Dogs that were placed on dorsal recumbency had relatively higher oxygen desaturation compared to dogs placed on lateral recumbency. This observation agrees with studies in human patients that have reported hypoxemia caused by positioning of patients in supine position (Watanabe et al., 2000; Lane et al., 2005). This is caused by the reduction in the functional residual capacity as a result of pulmonary edema caused by accumulation of fluids in the dependant lung **(**Houman, 2010**).** It is possible that the volume of the dependant lung was significantly reduced in dogs placed on dorsal recumbency compared to those placed on lateral recumbency however, more studies need to be conducted to establish whether this is the case. This observation can also be attributed to reduced functional residual capacity caused by pulmonary vascular congestion and cranial displacement of the diaphragm consequent to pressure from the abdominal organs as seen in human patients placed in supine position **(**Houman, 2010**)**. It is also possible that most dogs placed in dorsal position during surgery underwent open cavity surgery compared to those placed in lateral position. This is very possible considering dogs undergoing ovariohysterectomy are placed in dorsal recumbency. Open cavity surgery is associated with hypoxia that is further aggravated by hypothermia.

CHAPTER SIX

6.1 CONCLUSION AND RECOMMENDATION

As established by this study, oxygen desaturation is a commonly encountered complication associated with anaesthesia and surgery in dogs. The physiological processes involved in maintaining oxygen saturation are interfered with during anaesthesia and surgery therefore predisposing dogs to hypoxemia.

From the study, it can therefore be concluded that:

a) Patient body size contributes greatly to development of oxygen desaturation with small sized dogs being at a high risk due to higher surface area to volume ratio.

b) Open cavity surgeries and prolonged duration of surgery predispose animals to oxygen desaturation.

c) Positioning patients on dorsal recumbency, as compared to lateral recumbency during surgeries is associated with higher oxygen desaturation in dogs due to higher ventilation / perfusion mismatch.

d) Premedicating patients with medetomidine as opposed to xylazine, results in higher oxygen desaturation. This is because medetomidine is a more potent cardiopulmonary depressant drug compared to xylazine.

e) Supplementing oxygen intra-operatively reduces the level of oxygen desaturation and is beneficial to the patient.

It is therefore recommended that supplemental oxygen be administered to all dogs under general anaesthesia and during surgery so as to mitigate hypoxemia and hence reduce anaesthesia related morbidity and mortality. In addition, surgical skills should be enhanced so as to keep the duration of anesthesia and surgery to the practical minimum.

CHAPTER SEVEN

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