World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Comparison of anesthetic potency and cardiopulmonary effects of halothane and isoflurane anesthesia in dogs

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World Journal of Advanced Research and Reviews, 2026, 31(01), 709–722

Publication history: Received on 28 May 2026; revised on 04 July 2026; accepted on 06 July 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.31.1.1745

Abstract

The study was conducted at SAQ Teaching Veterinary Hospital (SAQTVH), Chattogram and Teaching & Training Pet Hospital and Research Center (TTPHRC) Dhaka, CVASU, to evaluate anesthetic potency and cardiopulmonary effects of isoflurane and halothane anesthesia in dogs. Fourteen dogs were randomly selected that were admitted to these hospitals for different surgical interventions like ovariohysterectomy, castration, correcrtion of cryptorchidism, umbilical hernia, fracture management through bandage (Modified Robert Johns), docking and caesarian section etc. . They were allocated into two anesthesia groups (n = 7 in each group). Dogs were premeditated with xylazine hydrochloride (1 mg/kg) intramuscularly and anesthesia was induced by propofol (2 mg/kg, IV). Inhalation anesthesia was maintained for a routine surgical procedure using 2% isoflurane (ISO) and 2.5% halothane (HAL). Cardiopulmonary parameters [heart rate (HR), respiratory rate (RR), systolic arterial pressure (SAP), diastolic arterial pressure (DAP), mean arterial blood pressure (MAP), oxygen saturation (SpO2), body temperature] were monitored and recorded during routine surgery for every 5 minutes interval up to completion of surgery. No significant difference was found between HAL and ISO groups in SPO_2 ($p>0.1$). Pulmonary indices during isoflurane anesthesia caused a significant increase (44.7±7.8 breath/min) in the respiratory rate in comparison to halothane anesthesia. There was no significant difference in HR between the two anesthetic groups. Systolic arterial pressure (SAP), diastolic arterial pressure (DAP), mean arterial blood pressure (MAP) were almost the same in both groups. Body temperature decreased gradually during ISO and HAL anesthesia without significant difference. Therefore, it is concluded that, halothane and isoflurane, both can be safe anesthetics for dogs with minimum side effects on cardiovascular and respiratory systems during routine surgical treatment in veterinary hospital. The result from this research may help the practitioners to increase awareness of anesthetic management in practices.

Keywords: Cardiopulmonary effects; Halothane; Isoflurane; Dogs

1. Introduction

Very impressive progress has been developed in small animal practice in the last decades. Majority of companion animals will undergo general anesthesia at least once in their lifetime for routine diagnostic procedures or surgery. General anesthesia is highly required in canine patients to facilitate advanced diagnostic and therapeutic interventions (Bille et al., 2012). Inhalation anesthetics are very useful for this purpose. Inhalation anesthetics are considered over

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injectable agents because of their rapid induction and recovery with better control over the depth and duration of anesthesia with desirable physiologic responses (Breck et al., 2003).

Anesthetic protocol included pre-anaesthetics drugs that have major importance under clinical circumstances. It reduces stress before induction of anesthesia, facilitates manipulations and also contributes to a smooth induction and recovery from anesthesia. Either inhalant or injectable anesthetics are used alone or in combination for induction of anesthesia in dogs.

Among the anesthetic drugs, inhalation anesthetics are unique because a large part of the anesthetic is removed from the body via lungs after anesthesia (Steffey and Mama 2007). The inhaled agents are supplied to the patients through a special apparatus having a source of oxygen (O2) and a patient breathing circuit with an endotracheal tube or face mask are attached with this apparatus with proper elimination of carbon dioxide (CO2).

Halothane induces dose-dependent depression of CNS. It Increases cerebral blood flow with bradycardia at clinical concentration. Hypotension is depended on the depth of anesthesia and decreased myocardial contractility at low concentration and also causes vasodilatation at high concentration (Muir et al., 2013). Halothane sensitizes the heart to catecholamine-induced arrhythmias. Halothane is contraindicated in patients with malignant hyperthermia or significant hepatotoxicity (Plumb and Pharm, 2011). Complications have been reported in halothane anesthesia, especially halothane causes hepatitis (Kumar et al., 2005). In developing countries, halothane is even considered for use due to its least expensive and less minimum alveolar concentration (MAC) (0.89) compare to the other inhalation anaesthetics (Harper, 2004).

In veterinary medicine, isoflurane is generally preferred as the most widely used inhalation anesthetic (Steffey and Mama, 2007). It is a less reactive, more potent and non-inflammable volatile anaesthetic agents. It is rapidly absorbed and distributed into the CNS and crosses the placenta and is primarily eliminated unchanged via the lungs alveoli; only about 0.17% is metabolized in the liver and very little biodegradation and formed inorganic fluoride (trifluoroacetic acid), excellent muscle relaxation, in the gastrointestinal system, it decreased smooth muscle tone and motility; no hepatotoxicity and renal blood flow is dose-dependently (Muir et al., 2013).

Isoflurane is contraindicated in patients with a history of malignant hyperthermia increased CSF or head injury, or myasthenia gravis and irritating for respiratory system and not recommended for mask induction (Clarke, 2008). Isoflurane causes hypotension; secondary to vasodilation is considered to be dose-dependent. Dose-related respiratory depression, and GI effects like nausea, vomiting have been reported in Isoflurane anesthesia of the dog (Plumb and Pharm, 2011).

To facilitate clinical anesthesia, xylazine HCL is used as premedication. Induction with propofol is recommended in dogs followed by maintenance with isoflurane or halothane. Xylazine HCl can cause changes in heart rate and blood pressure and Propofol may cause hypotension, bradycardia followed by reflex tachycardia, dose-dependent decreases in arterial blood pressure and arrhythmias in the cardiovascular system (Muir et al., 2013). The use of isoflurane and halothane as inhalation anesthetics can be potential use for the dog and also helpful to reduce anesthetics risk during surgery as well as in postoperative management. As per our knowledge, there is a limited study on inhalation anesthetics and a large number of surgery has been performed in dogs in our country now a days.

Therefore, the study was conducted to evaluate and compare the anesthetic effects of halothane and isoflurane anesthesia on certain cardiopulmonary parameters along with anesthetic potency in dogs.

2. Materials and Methods

2.1. Study period and area

The study was conducted through the period of January 2021 to December 2021 at Shahidul Alam Quadery Teaching Veterinary Hospital (SAQTVH) & Teaching and Training Pet Hospital and Research Center (TTPHRC) of Chattogram Veterinary and Animal Sciences University (CVASU), Chattogram Bangladesh.

Figure 1 Geographical location of SAQ Teaching Veterinary Hospital,Chattogram, CVASU.

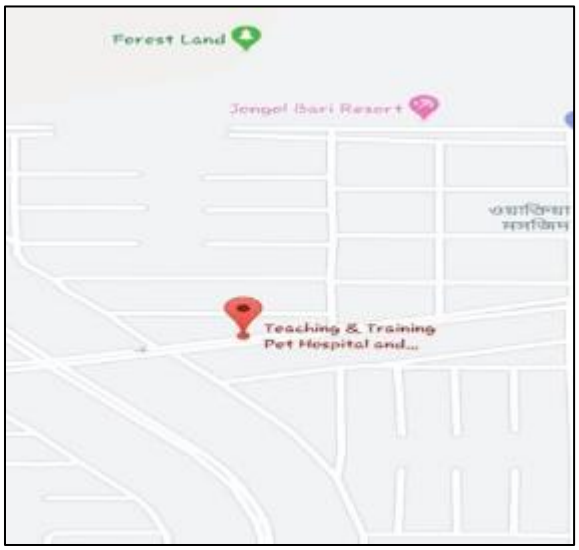


Figure 2 Geographical location of Teaching and Training Pet Hospital and Research Center, Dhaka, CVASU

2.2. Study design

A total of fourteen (n=14) crossbreed dogs of both sexes weighing from 11 to 28 kg and age between 2 to 8 years were included in this experiment. A preoperative anamnesis was taken and a routine pre-anesthetic physical observation was performed on each patient. Total samples were randomly allocated into two groups (n = 7 in every group; Halothane Group &Isoflurane Group) for this study.

2.2.1. Preanesthetic procedures

Xylazine HCl @ 1 mg/kg was given intramuscularly (IM) 30 minutes before induction of anesthesia as a preanesthetic.

2.2.2. Fluid therapy

All dogs were administered 0.9% sodium chloride solution at a flow rate of 10 mL/kg/hr. through a 22-gauge catheter or 21 gauge butterfly needle placed in the left cephalic vein by using an infusion pump.

2.2.3. Anesthetic procedures

Induction of anesthesia was performed by using propofol @ 2 mg/kg intravenously over 50- 60 seconds. The onset of anesthesia was accomplished when the eyeball position was rotated down and absent of palpebral reflex (examined by

lightly tapping the medial or lateral canthus of the eye and observing whether the animal blinks or not in response) and pedal (tested by pinching a digit and observing whether the animal flexes the leg and withdrawing the paw or not) reflexes and there were no jaw tone (assessed by attempting to open the jaws wide and estimating the amount of passive resistance).

2.2.4. Intubation

After the loss of the swallowing reflex and jaw tone, dogs were orally intubated with cuffed endotracheal tube (ET tube) according to body weight. Oxygen flow rate was maintained at 25 to 50 ml/kg/min.

2.2.5. Maintenance of anesthesia

A circle semi-open rebreathing anesthesia system was used throughout the study with a calibrated halothane (HAL) and isoflurane (ISO) vaporizer. For group A (n=7) anesthesia was maintained with halothane vaporizer for induction (3.5% to 4%) and group B (n=7) anesthesia was maintained with isoflurane vaporizer for induction (3% to 4%). HAL and ISO vaporizer setting was adjusted from 1.5% to 2.5% according to the depth of anesthesia. The dial of the vaporizers was progressively reduced or increased to the percentage required to maintain the plane of anesthesia according to a clinical response to the pain, and changes in heart rate (HR), respiratory rate (RR) and blood pressure. The entire study was finished after 60 minutes for different surgical intervention like ovariohysterectomy, castration, correcrtion of cryptorchidism, umbilical hernia, fracture management through bandage (Modified Robert Johns), docking and caesarian section etc.

2.3. Measurements and monitoring:

A pre-structured anesthesia record sheet was used for patient monitoring throughout the anesthesia period. Heart rate (HR), saturation of hemoglobin with oxygen (SpO2), respiratory rate (RR), rectal temperature, noninvasive systolic (SAP), diastolic (DAP) and mean arterial blood pressures (MAP) were monitored using a veterinary patient monitoring system. Capillary refill time (CRT), reflexes (palpebral, pedal), jaw tone, and eye position (straight, down) were also assessed to determine the depth of anesthesia. The first measurement of parameters was taken at one min after the loss of consciousness with HAL or ISO and the others were recorded every 5 minutes interval up to the completion of the study (60 min).

Rectal temperature was measured using an electric thermometer probe placed into the rectal mucosa. HR and RR were monitored by placing the electrodes at the level of the right and left elbows and the left patella and also ventral abdomen skin. Systolic and diastolic arterial blood pressures were measured by using standard oscillometry blood pressure measurement. The cuff was placed on the left antebrachium. SpO2 was measured by a pulse oximeter (with the infrared sensor probe placed on the dog's tongue). A warm heating pad was used to maintain the temperature between 101˚F and102.5˚F. The dogs were extubated when they were awake from anesthesia and the swallowing reflex appeared.

2.4. Statistical analysis

To compare the cardiopulmonary parameters with each inhalation anesthetics group, all complied data were imported in Microsoft Excel- 2010 and transferred to STATA 13.0 version for statistical analysis. All data were expressed as mean ± standard error (SE). Descriptive statistics of general parameters like – temperature, HR, RR, SpO2, SAP, DAP and MAP were analyzed by using paired t-test ($p \leq 0.1$) to determine the significance.

Anesthetic procedure and patient monitoring during anesthesia

Figure 3 Intubation in dog

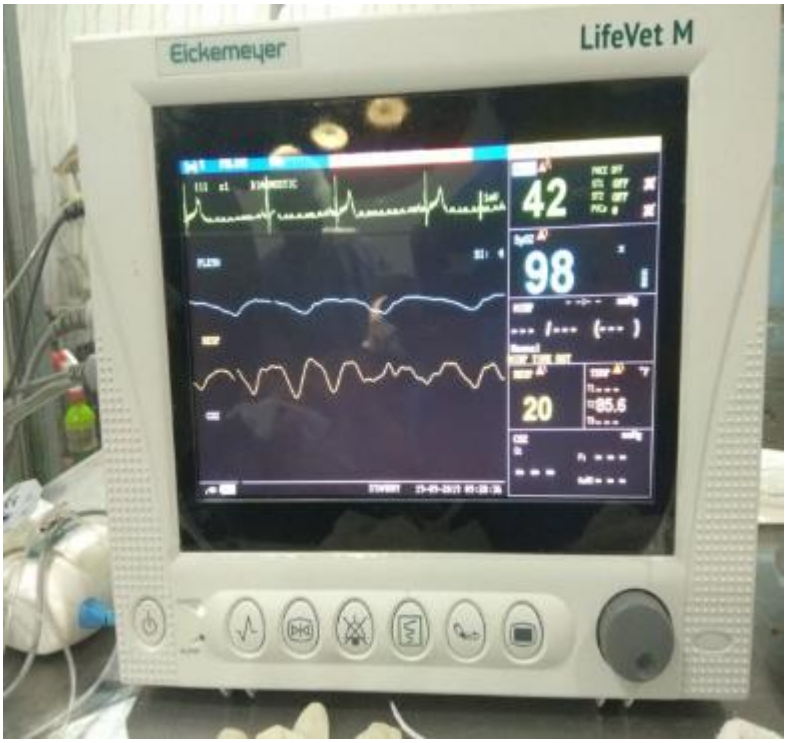


Figure 4 Monitoring the vital signs on monitor (Temperature, RR, HR, SpO_2, SAP, MAP, DAP)

Figure 5 Maintenance of anesthesia in dog using halothane during castration**.**

Figure 6 Maintenance of anesthesia in dog using Isoflurane during caesarean section.

Figure 7 Monitoring of patient using Halothane anesthesia during docking in a German Shepard at CVASU

Figure 8 Monitoring of patient using Isoflurane anesthesia during castration in a Lhasa Apso at TTPHRC.

3. Results

The measurements of the cardiopulmonary parameters of the dogs in each anesthesia group were recorded after induction of anesthesia (0 min) to completion of the surgery for every 5 minutes interval.

3.1. Measurements of Body Temperature

Body temperature decreased gradually in both groups during the 15, 30, 45 and 55 minutes when compared to the first measurement values. But there was no significant difference in body temperature between the HAL and ISO groups ($p>0.1$) (Figure 9).

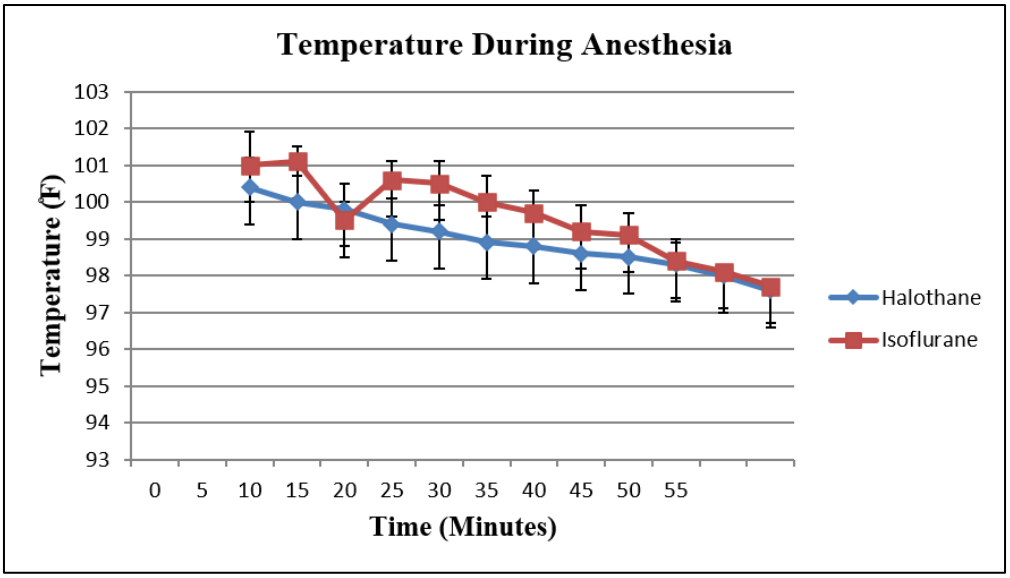
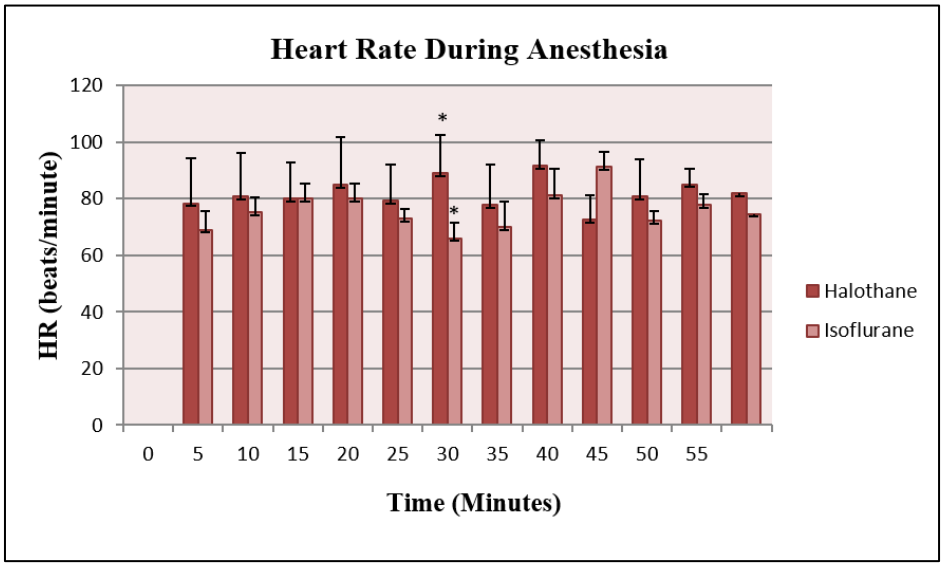


Figure 9 Values of temperature (F)during halothane and isoflurane maintenance anesthesia in dogs. Each point and vertical bar represents the mean±SE (n=7).

3.2. Measurements of Heart rate (HR)

There was no significant difference in HR between the anesthetic groups (p>0.1). HR did not significantly change when compared with the different anesthetic times (p≥0.1) except 25 minutes of anesthesia period (Figure 10).

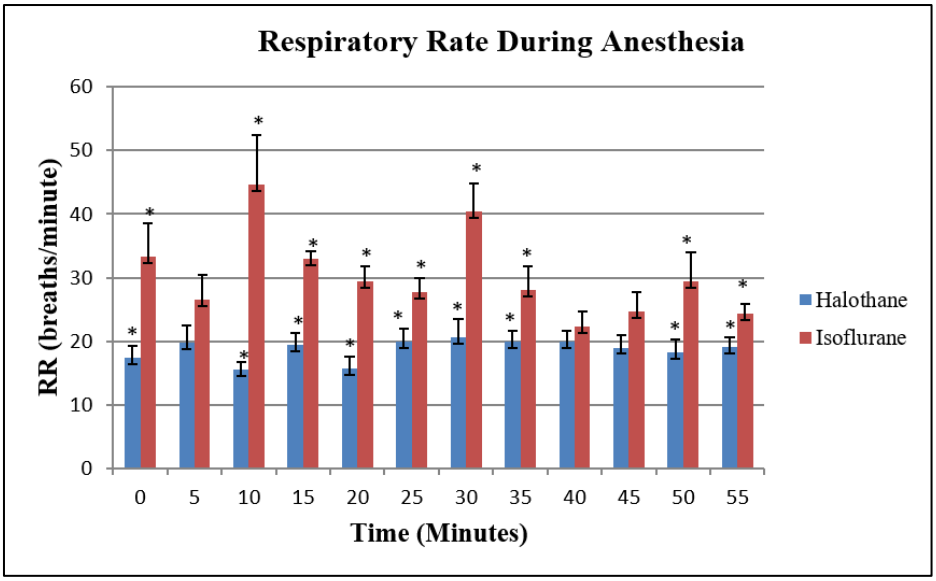


*: Significantly different between HAL and ISO group at corresponding interval (p≤0.1)

Figure 10 Values of heart rate (HR) during halothane and isoflurane maintenance anesthesia in dogs. Each point and vertical bar represents the mean±SE (n=7).

3.3. Measurements of Respiratory rate (RR)

Isoflurane caused a significant increase in respiratory rate when compared with the halothane anesthesia group (p≤0.1). There was a significant increase of RR in ISO anesthesia when compared with different anesthetics times at 0, 10, 15, 20, 25,30 35 min of maintenance of HAL anesthesia (p≤0.1) (Figure 11).



*: Significantly different between HAL and ISO group at corresponding interval (p≤0.1)

Figure 11 Values of respiratory rate (RR) during halothane and isoflurane maintenance anesthesia in dogs. Each point and vertical bar represents the mean±SE (n=7).

3.4. Measurements of Oxygen saturation (SpO2)

In this study, all data were expressed as mean±SE. No significant difference was found between HAL and ISO groups in SPO2 (p>0.1). Time had no significant influences on the SPO2 value in different anesthetics times (p>0.1) (Figure 12).

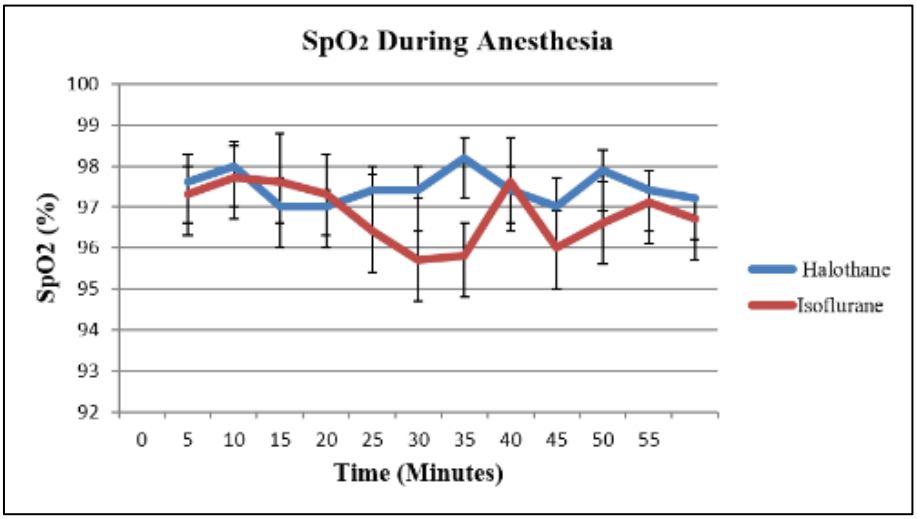


Figure 12 Values of Oxygen saturation (SpO2) during halothane and isoflurane maintenance anesthesia in dogs. Each point and vertical bar represents the mean±SE (n=7).

3.5. Measurements of Arterial blood pressure

The mean±SE value of Systolic (SAP), diastolic (DAP), and mean (MAP) arterial pressures in 14 dogs are presented in figure 13, 14 & 15 respectively.

3.5.1. Systolic arterial pressures (SAP)

There was no significant difference between HAL and ISO groups in SAP (p>0.1) (Figure 13).

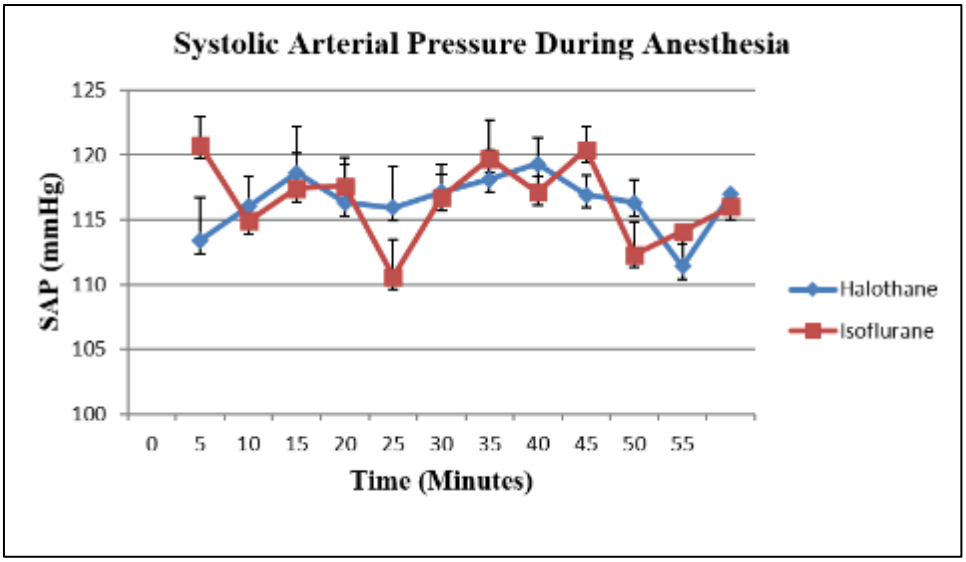
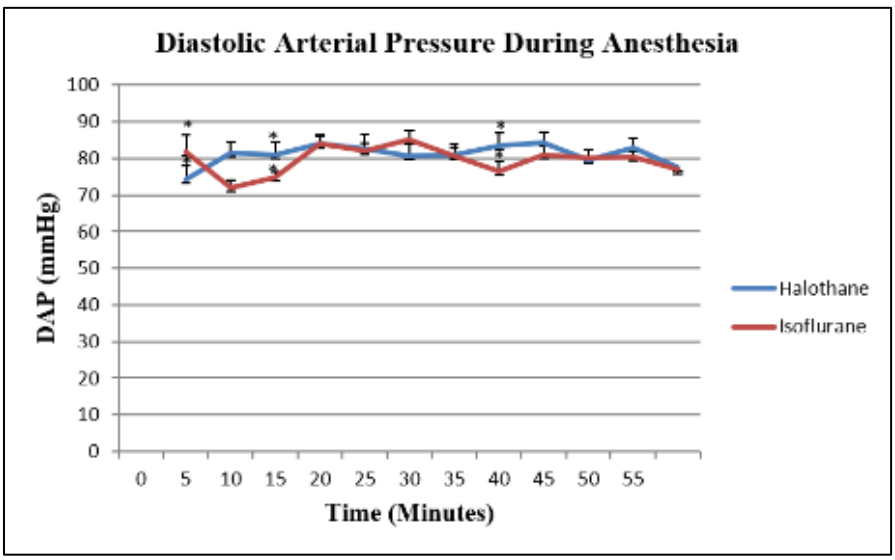


Figure 13 Values of systolic arterial pressure (SAP) during halothane and isoflurane maintenance anesthesia in dogs. Each point and vertical bar represents the mean±SE (n=7).

3.5.2. Diastolic arterial pressures (DAP)

In DAP value no significant difference was found in HAL and ISO groups. But time had a significant difference at the beginning of the anesthesia time, 10 and 35 min of maintenance of anesthesia period and when p value was (p=0.1, p= 0.09, p= 0.1) respectively (Figure 14).

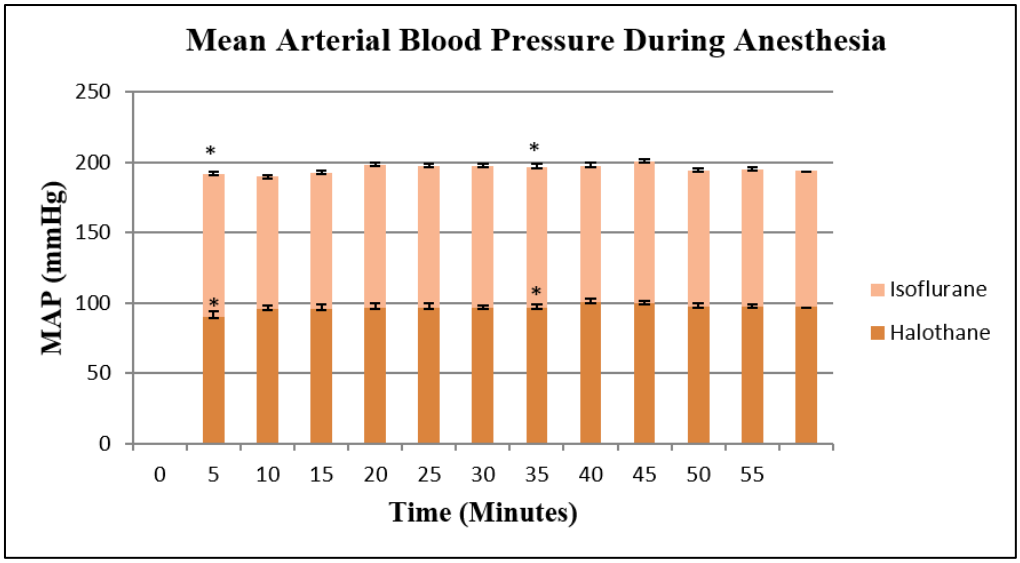


*: Significantly different between HAL and ISO group at corresponding interval (p≤0.1)

Figure 14 Values of diastolic arterial pressure (DAP) during halothane and isoflurane maintenance anesthesia in dogs. Each point and vertical bar represents the mean±SE (n=7).

3.5.3. Mean arterial pressures (MAP)

There was a significant difference documented at the beginning of anesthesia and 30 min of the maintenance of anesthesia (p≤0.1) (Figure 15).



*: Significantly different between HAL and ISO group at corresponding interval (p≤0.1).

Figure 15 Values of mean arterial pressure (MAP) during halothane and isoflurane maintenance anesthesia in dogs. Each point and vertical bar represents the mean±SE (n=7).

4. Discussion

Inhalation anesthetics are used extensively for their rapid induction, rapid recovery with better control over the depth and duration of anesthesia (Stewart et al., 2003). In this study, we found both inhalation anesthetics to be safe and reliable for use in dogs.

Both anesthetics responsible for falling the body temperature below the physiological limits. Time had influence on body temperature and significantly decreased during HAL and ISO anesthesia. This condition may be due to peripheral vasodilator properties of inhalation anesthetics and their effects depressed on heat regulation (Topal, 2005). Within the first 20 minutes of anesthesia the greatest loss in body heat occurs. HAL anesthesia causes hypothermia in buffaloes (Bodh et al., 2014). Rectal temperature significantly decreased during halothane anesthesia was reported in adult water buffaloes (Malik, 2010).

The mean HR was lower in ISO anesthesia group compared to HAL anesthesia at 0, 25 and 30 min but was still within the reference limits in our study. The effect of both anesthetics on the heart rate was examined, the difference between them was not significant ($p>0.1$). HR did not significantly change when compared with the different anesthetic times ($p\geq0.1$). In our study, under general anesthesia we managed to maintain HR within the physiological limits but our study results not supported to Göksen et al. (2009) study where during HAL anesthesia heart rate was lower compare to during ISO and SEV anesthesia. There was a significant decrease in the heart rate in HAL group than ISO group in water buffalos at Bodh et al. (2014) study. The changes in heart rate during maintenance of anesthesia might be due to few potential causes like level of anesthesia, differences in the amount of sympathetic stimulation within the anesthetics group Bodh et al. (2014).

In this study, the respiratory rate showed a statistically significant increase ($P \leq 0.1$) at the 10^{th} to 35^{th} min of anesthesia in the isoflurane group. These increases cross the physiological limits (10 to 20 breathe/min) (Hall and Clarke, 2014). Hyperventilation act as an indicator that the CO2 is not being adequately expelled from the breathing circuit through the CO2 absorber and an elevated respiratory rate may indicate a progression from moderate to light anesthesia and is often one of the first signs of arousal from anesthesia (Muir et al., 2013). The respiratory rate did not change significantly in the group receiving halothane anesthesia and the recorded data were within the physiological limit. The function of the respiratory system depressed by all volatile anesthetic agents (Steffey and Mama, 2007). Inhalation anesthetics cause dose-related respiratory depression in dogs (Juodzente et al., 2018). In Sen and Kilic(2018)study at the 15th min of propofol-isoflurane anesthesia causes a statistically significant decrease ($P < 0.001$) of respiratory rate not supported our study, because in our study we reported increased respiratory rate. The higher respiratory rate was noticed during isoflurane anesthesia in water buffaloes (Bodh et al., 2014) which is similar to our study results.

In our study, we managed to maintain SpO2 values within the reference limits (95-100%) during general anesthesia (West et al., 2014). No significant difference found in SpO2 values (p>0.1) between HAL and ISO anesthesia group might be due to the anesthetic-induced depression occurred of central respiratory center and ventilation/perfusion of oxygenation take place in the lungs properly during general anesthesia in both group. Time had no significant influences on the SPO2 values in different anesthetics times (p>0.1).Due to a high inspired oxygen fraction SpO2 values were normal during general anesthesia and no significant different noticed between the anesthetic groups in Göksen et al. (2009) study. However, administration of 100% oxygen along with either halothane or isoflurane anesthesia led to higher values of SpO2 in water buffalos observed by Bodh et al. (2014). Sen and Kilic(2018)showed that a peripheral oxygen saturation (SpO2) was decreased significantly during anesthesia which was not supported our study because during general anesthesia SpO2 values were within the reference limits.

In our study, no significant difference was found between HAL and ISO groups in SAP and DAP value (p>0.1). But time had a significant difference at the beginning of the anesthesia time, 10 and 35 min of maintenance of anesthesia period (p=0.1, p= 0.09, p= 0.1) in case of DAP, but was still within the physiological limits. The significant difference was documented in MAP at the beginning of surgery and 30 min of the maintenance of both anesthesia groups (p≤0.1) within the physiological limit. Juodzente et al.(2018) said that SAP and DAP were within the reference limits which were supported by our study. A significant decrease was reported in MAP values during ISO anesthesia Göksen et al. (2009) which was conflicts with our study because we documented significant difference in MAP but it was within the physiological limits. In another study, HAL anesthesia significantly decreased SAP, DAP, and MAP values in water buffalos Bodh et al. (2014). The most common cause of hypotension is the excessive anesthetic depth and other causes include hypovolemia due to intra-operative bleeding or pre-operative dehydration, hypothermia or hypoxia (Hall and Clarke, 2014). To overcome hypotensive effects in anesthetized patients, anesthetic depth should be reduced, need to increase the intravenous fluids administration or a vasoactive drug such as dopamine, dobutamine, or ephedrine can be used and if the patients keep in untreated conditions, it may cause cardiac arrest during anesthesia or neurological deficits, blindness or renal failure after recovery from anesthesia (Hall and Clarke, 2014).

From this study, we found a significant conclusion on the use of inhalation anesthetics during surgery. The present findings indicate that the respiratory effects of halothane were less suppressive than isoflurane anesthesia in dogs. On the cardiovascular system, there was no suppressive effect in dogs during surgery. A routine surgical treatment procedure, isoflurane and halothane ensure the stable plane of anesthesia with minimum side effects on the cardiovascular and respiratory systems. However, halothane and isoflurane both can be safely used in dogs.

5. Conclusion

This research was conducted at Shahidul AlamQuadery Teaching Veterinary Hospital (SAQTVH) & Teaching and Training Pet Hospital and Research Center (TTPHRC), Chattogram Veterinary and Animal Sciences University (CVASU), Chattogram, Bangladesh from January 2019 to December 2019 to evaluate and compare the anesthetic effects of halothane and isoflurane anesthesia on certain cardiopulmonary parameters (Heart rate, respiratory rate, oxygen saturation, arterial blood pressure) along with anesthetic potency in dogs. The present findings indicate that the respiratory effects of halothane were less suppressive than isoflurane anesthesia in dogs. On the cardiovascular system, there was no suppressive effect in dogs during surgery. A routine surgical treatment procedure, isoflurane and halothane ensure the stable plane of anesthesia with minimum side effects on the cardiovascular and respiratory systems. However, halothane and isoflurane both can be safely used in dogs. Till now, the gaseous anesthesia is not popular for animal anesthesia in our country. Therefore the result of this research will be helpful to increase awareness of anesthetic management in anesthesia practices, improve the safety of canine anesthesia and provide a foundation for further research in this area in Bangladesh.

Compliance with ethical standards

Acknowledgments

The authors would like to thank all faculties and staffs of Department of Medicine and Surgery, S. A. Quadary Teaching Veterinary Hospital and Teaching and Training Pet Hospital and Research Center, CVASU for their support and effort to conduct this study. The authors also thank to University Grant Commission, Bangladesh and Diroctorate of Research and Extension, CVASU for finanacial assistance.

Disclosure of conflict of interest

The authors declare no conflict of interest, financial, or otherwise.

Data availability statement

The data supporting the findings of the study are available within the article and its supplementary material.

Authors Contribution

BCS reviewed, designed and planed the study. AD was involved in sample collection, data analysis and initially drafted the manuscript. SB and JC were involved in sample collection. BCS supervised the whole work. MR was involved further reviewed the paper. The manuscript was read and approved by each authors prior to submit.

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