Original Research

Induction and Recovery Characteristics of Isoflurane and Sevoflurane Anaesthesia for Ovariohysterectomy in Dogs

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Abstract

A study was carried out to evaluate induction and recovery characteristics of isoflurane and sevoflurane inhalant anaesthesia for ovariohysterectomy in young and healthy female dogs. All the animals were premedicated with Atropine sulphate and Diazepam. Induction of anaesthesia was achieved by using Isoflurane (5%) in group A and Sevoflurane (5%) in group B along with oxygen (1.5L/min) using close fitting face mask with rubber diaphragm. Anaesthesia was maintained in group A and B by using Isoflurane and Sevoflurane respectively by endotracheal intubation till effect using small animal anaesthesia machines of rebreathing or circle system with vaporizer outside the circuit. Quantitative parameters like average induction time, average dose volume of maintenance and average time of reappearance of various reflexes during recovery were recorded. Quality of induction was compared by assessing subjective parameters like degree of various reflexes and scored accordingly during surgical plane. Also qualitative parameters during recovery phase were assessed based on video recordings obtained during the recovery phase and were scored using simple descriptive scale (SDS) and visual analog scale (VAS). Results indicated that Sevoflurane (group B) animals were having significantly faster induction and recovery rates than Isoflurane (group A) which may be attributed to its least blood gas solubility of Sevoflurane. Mean ± SE values for average maintenance dose volume (Vol %) were 3.16 ± 0.16 for group A and 2.04 ± 0.16 for group B. There was no significant difference in quality of induction and qualitative parameters of recovery between the groups. There was no significant difference in SDS and VAS scales between the groups and the values were within acceptable levels. Thus the quality of recovery and analgesia in both the groups was satisfactory. We do not conclude both the agents have significant analgesic effects though best results can be achieved with opiod analgesic pre medication. It was concluded though induction and recovery characteristics of sevoflurane anaesthesia are faster than

isoflurane, both isoflurane and sevoflurane are advantageous inhalant anaesthetics in terms of ease of administration, excellent maintenance quality and rapid and smooth recovery with minimal adverse effects on healthy female dogs subjected for ovariohysterectomy procedure. Although sevoflurane is associated with faster induction and recovery there is no clinical significance in usage with this finding except sevoflurane having low pungency and airway irritation.

Key words: Anaesthesia, Dogs, Isoflurane, Induction and Recovery, Sevoflurane

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Introduction

Isoflurane is a highly stable, non-explosive, potent volatile inhalation anaesthetic. Isoflurane is more potent with the MAC value of 1.31 in dogs but low blood gas solubility of 1.40 at 37^{o}C (Mutoh *et al*., 1995). Similar to other anaesthetics isoflurane causes hypothermia, dose dependent respiratory and cardiovascular depression (Meyer *et al*., 1984). Isoflurane is a popular anaesthetic agent in veterinary practice because of its cardiovascular stability, low blood solubility, resistance to hepatic metabolism and more of patient safety (Mutoh *et al*., 2001).

Sevoflurane is a non-inflammable halogenated inhalant anaesthetic with a MAC of 2.36 in dogs and blood gas partition coefficient of 0.68, since it has fluorine atoms only, it is more stable and less soluble in blood than isoflurane and hence sevoflurane possesses chemical properties that should produce more rapid induction of anaesthesia in comparison to halothane or isoflurane. Sevoflurane appears to have some advantages over isoflurane, including faster and smoother mask induction (Johnson *et al*., 1998). Similar to isoflurane, sevoflurane also causes similar dose related cardiovascular depression, but less at higher exponent anaesthetic doses and also much safer on hepatic function than halothane anaesthesia in dogs (Galloway *et al*., 2004). Sevoflurane produces anaesthesia of excellent quality, undergo limited biotransformation and has little or no systemic toxicity (Holaday *et al*., 1981). Concentrations of compound A, a degradation product of sevoflurane with sodalime in anaesthetic circuits was less than reported values to produce renal toxicosis in rats (Muir and Gadawski, 1998). In the view of above facts, a comparative study on isoflurane and sevoflurane anaesthesia in dogs was carried out to study the efficacy of isoflurane and sevoflurane as inhalant anaesthetics in dogs and to evaluate and compare two anesthetics in terms of induction, duration of surgical anaesthesia and recovery patterns.

Materials and Methods

The study was conducted on 12 clinical cases of young female dogs, which were presented for ovariohysterectomy to Department of Surgery and Radiology, Veterinary College Hospital, Bangalore.

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Dogs were randomly divided into two groups viz., Group A (Isoflurane) and Group B (Sevoflurane) comprising six dogs each. The animals were administered with atropine sulphate 0.04 mg/kg i/m and diazepam 1mg/kg i/v, at 30 minutes and 20 minutes, respectively prior to induction with inhalant anaesthesia and animals were not disturbed for at least 15 minutes from the point of administration of atropine sulphate. Twenty minutes after premedication with diazepam, anaesthesia was induced with isoflurane (for Group A) and sevoflurane (Group B) using close fitting face mask with rubber diaphragm with maximum vaporizer settings available for both i.e. 5%. Dogs were pre oxygenated for 2 minutes before induction using close fitting face mask.

Isoflurane (SOSRANE, Metrex Pharmaceuticals Pvt. Ltd., Mumbai) in group A and Sevoflurane (SEVORANE, Abbott India Ltd., Mumbai) in group B were administered in combination with oxygen (1.5 L/min) during induction as well as maintenance of anaesthesia. Surgivet small animal anaesthesia machines (Smith Medical PM. Inc., Veterinary Division, Wisconsin, USA) of rebreathing or circle system with vaporizer outside the circuit for isoflurane and sevoflurane were used for the study. The dose for induction of anaesthesia was calculated on the basis of total time required by an animal to attain the plane of surgical anaesthesia, which was marked by absence of pedal reflex, ventromedial deviation of eyeball and deep abdominal breathing with decrease in respiratory rate. The time required for induction, average maintenance dose volume of inhalant anaesthesia, duration of surgery and recovery parameters were recorded. Ovariohysterectomy procedure was carried out in all the female dogs for an average time of (Mean ± SE minutes) in both the groups. Average maintenance dose volume of anaesthesia (Vol %) of inhalant anaesthetic required to maintain surgical plane of anaesthesia was calculated by monitoring the reappearance of pedal reflex and central upward movement of eyeball from state of ventromedial deviation and finally through mathematical formula as summation of time in minutes multiplied by respective vaporizer setting of maintenance divided by total time of maintenance in minutes. Surgical plane of anaesthesia was marked as the duration of anaesthesia between abolition of pedal reflex and completion of surgical procedure. Completion of surgery was marked as point of completion of last skin suture.

Assessment of subjective parameters for various reflexes during surgical plane for quality of induction was done and graded as following. Salivation was graded on 0 to 2 scale, with score 0 (present), score 1 (sluggish) and score 2 (absent). Vomition was graded on 0 to 2 scale, with score 0 (present), score 1 (sluggish) and score 2 (absent). Skeletal muscle relaxation was graded from scale of 1 to 2, with score 1 (good) and score 2 (moderate). Jaw relaxation was graded from scale of 1 to 2, with score 1 (moderate) and score 2 (good). Anal relaxation was graded from scale of 1 to 2, with score 1 (moderate) and score 2 (good). Palpebral reflex was graded on 0 to 2 scale, with score 0 (present), score 1 (sluggish) and score 2 (absent). Pupillary reflex was graded on 0 to 2 scale, with score 0 (present), score 1 (sluggish) and score 2

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(absent). Pain pick reflex (flank region) was graded on 0 to 2 scale, with score 0 (present), score 1 (sluggish) and score 2 (absent). Tail prick reflex was graded on 0 to 2 scale, with score 0 (present), score 1 (sluggish) and score 2 (absent). Pinna reflex was graded on 0 to 2 scale, with score 0 (present), score 1 (sluggish) and score 2 (absent). Position of eyeball was graded from scale of 1 to 2, with score 1 (centre) and score 2 (ventromedial). Cutaneous analgesia was graded on 0 to 2 scale, with score 0 (present), score 1 (sluggish) and score 2 (absent).

At the end of the surgery, marked by placing of the last skin suture, the vaporizer was set off and the animals were allowed to breathe fresh oxygen for three additional minutes. Animals were shifted to recovery room and video recording was performed to study the qualitative (non-interactive) and quantitative recovery parameters. During recovery period, dogs were left undisturbed until they were able to stand up and walk on their own. The point at which the animal stood up was the last piece of data recorded for qualitative parameters for recovery phase of inhalation anaesthesia. Quantitative parameters like the average time for return of swallowing reflex, pedal reflex, head righting reflex, time taken for voluntary leg movement, time taken for sternal recumbency and time taken for animal to ambulate after cessation of anaesthesia during recovery period were recorded. Qualitative parameters during recovery phase were assessed directly on observations and later based on video recordings obtained during recovery phase by three different observers starting directly after extubation till the time animal walked unassisted. Recovery was scored based on simple descriptive scale (SDS) of 0-4 and visual analogue scale (VAS) defined one extreme at 0 mm as perfect recovery whilst the other end 100 mm was defined as worst recovery imaginable as described in Table 1.

Table 1: Comparative mean ± SE values of different parameters recorded during study period in Group A (Isoflurane) and Group B (Sevoflurane) dogs

S. No.	Parameters (minutes)	Group A	Group B
1	Time taken for induction (min)	7.16 ± 0.21	6.01 ± 0.11*
2	Duration of anaesthesia for surgical procedure (min)	35.33 ± 1.58	32.00 ±0.66
3	Average maintenance volume of anaesthesia for group (Volume %)	3.16 ± 0.16	2.04 ± 0.16*
4	Time taken for regain of swallowing reflex from the point of termination of anaesthesia (min)	3.33 ± 0.05	1.98 ± 0.09*
5	Time of return of pedal reflex from the point of termination of anaesthesia (min)	6.04 ± 0.10	3.19 ± 0.04*
6	Time of head righting reflex from the point of termination of anaesthesia (min)	7.33 ± 0.04	3.94 ± 0.12*
7	Time taken for voluntary leg movement from the point of termination of anaesthesia (min)	7.88 ± 0.13	4.38 ± 0.05*
8	Time taken for sternal recumbency from the point of termination of anaesthesia (min)	11.83 ± 0.50	5.54 ± 0.10*
9	Time taken for attempt to stand from the point of termination of anaesthesia (min)	17.87 ± 0.13	8.69 ± 0.12*

**Significant ($p<0.05$)*

The quality of recovery was considered unacceptable (SDS score 4 and VAS > 70 mm). Medication for post operative analgesia as butorphanol 0.2 mg/kg IV was administered in all cases immediately after animal walked unassisted. Recovery parameters as start position (starting position of the body), position

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change (change of body position), end position (last position of body before attaining a recumbency or standing procedure), head position, ear position, eyeball position, tail carriage, vocalizations and others (arched back, stretching, rigid back, licking of snout and drawing legs up) were observed.

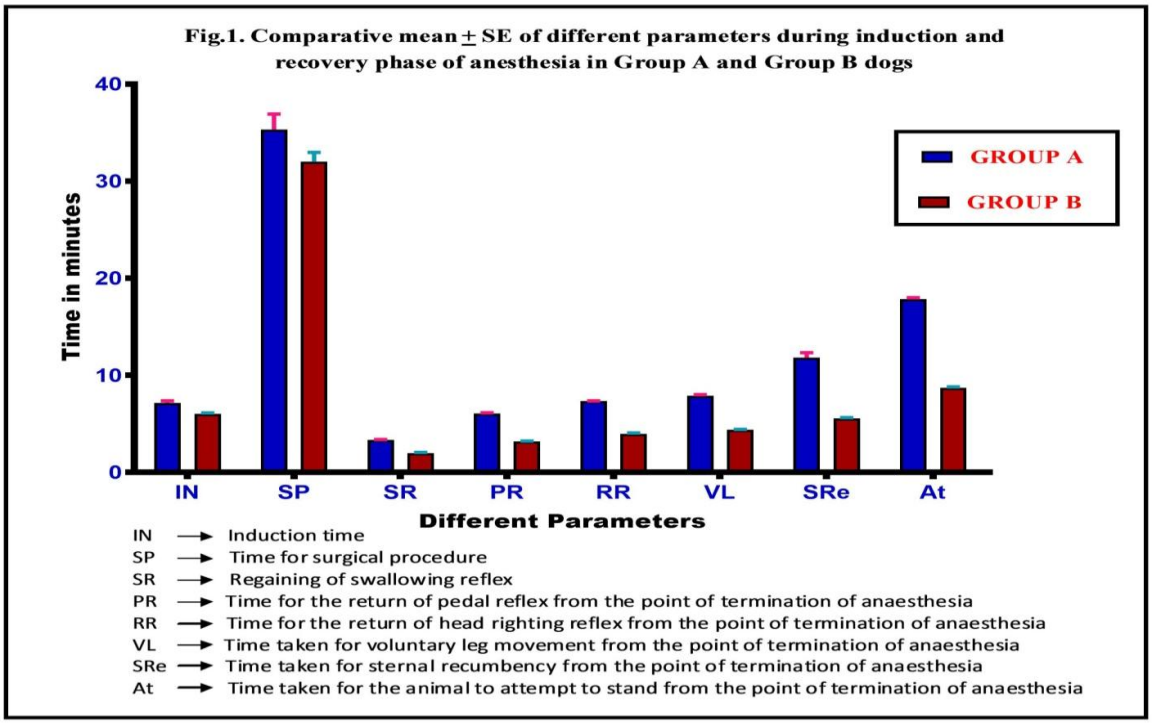
Statistical Analysis

The data was analyzed for statistical significance using computer based statistical program Graph pad prism and interpreted as per the procedure described by Snedecor and Cochran (1996) to arrive at a conclusion. The mean and standard error for all the data were computed. The variations during and after anaesthesia at different time intervals for both within and between treatments were analyzed by single tailed unpaired 't' test. The test of significance was fixed at five per cent for all the comparisons ($p \leq 0.05$). The subjective data generated from the scoring were analyzed using Kruskal-Wallis test (Snedecor and Cochran, 1996). In each analysis, the differences were considered significant at a value of $p<0.05$ and very significant at a value of $p<0.01$.

Results

Quantitative parameters observed during recovery phase are as indicated in (Table 1, Fig.1).

Fig.1. Comparative mean ± SE of different parameters during induction and recovery phase of anesthesia in Group A and Group B dogs



Induction Time of Inhalation Anaesthesia

The mean duration to attain optimal level of induction for isoflurane anaesthesia (Group A) was 7.16 ± 0.21 minutes and for sevoflurane anaesthesia (Group B) was 6.01 ± 0.11 minutes. In group A dogs, time

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taken for induction was significantly longer compared to group B however, animals in group A showed resistance during initial uptake of mask induction of isoflurane.

Average Maintenance Dose Volume (Vol%)

Average maintenance dose volume of isoflurane Group A (Isoflurane) and Group B (Sevoflurane) anaesthesia required during ovariohysterectomy were 3.16 ± 0.16 and 2.04 ± 0.16 (Vol %), respectively. The values were significantly higher in Group A animals.

Assessment of Subjective Parameters for Various Reflexes during Surgical Plane for Quality of Induction

There was no significant difference with the scoring system in monitoring of various reflexes during surgical plane of anaesthesia between groups.

Quantitative Values of Regaining of Reflexes during Recovery

In Group A animals the duration of return of swallowing reflex, head righting reflex, voluntary leg movement attainment of sternal recumbency and duration of animals to ambulate were significantly faster in group B animals compared to Group A animals (Table 1).

Qualitative Parameters Recorded During Recovery

In group A animals, recovery phase was relatively a smooth transition from anaesthesia to the state of full consciousness. No struggling, tremors or other unconscious movements were found except for one instance of slight pedaling. Vocalization was observed in one case. Moderate attempts of licking of snout, licking of floor, legs and bandage were evident but at lesser frequency. In group B animals, also recovery was relatively much smoother and rapid than the group A. No struggling, pedaling, tremors or other unconscious movements were observed. Very few attempts of licking of snout, licking of floor, legs and bandage were seen. Three observers each (P, Q and R) were assigned to score SDS and VAS scales for the evaluation of quality of recovery. There were no significant differences between groups for SDS and VAS scores for quality of recovery for any of the observers (Table 2).

Discussion

Time of induction of inhalation anaesthesia: During mask induction, average time taken for mask induction in group B animals was significantly faster than that of group A animals. Similar findings were observed by Johnson *et al.* (1998) and Jadon *et al*. (2008) while Mutoh *et al.* (1995) and Pottie *et al.* (2008) found no significant difference in speed of induction between these two inhalant agents. This could be due to the special chemical properties of sevoflurane *viz.*, low blood gas partition coefficient that produces rapid increase in alveolar anaesthestic concentration (Kubota, 1992). Faster mask induction of anaesthesia is advantageous in point of view of minimal struggling, minimizing likelihood of aspiration of

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stomach contents and rapid access to intubation and airway maintenance. Resistance to initial uptake of isoflurane in Group A may be due to its pungent odour. Sloan *et al.* (1999) found similar induction times in human patients receiving isoflurane and sevoflurane in single-breath induction. However, coughing occurred more frequently in patients receiving isoflurane and patients receiving sevoflurane had fewer complications. The maximal vaporizer settings used in this study of 5% in both the groups corresponds to 3.8 MAC and 2.1 times MAC for isoflurane and sevoflurane respectively (Steffy and Mama, 2007).

Table 2: Quality of recovery as assessed with SDS (Simple descriptive scale) and VAS (Visual analog Scale) by observers P, Q and R in Group A (Isoflurane) and Group B (Sevoflurane) dogs

	Group A	Group B	P value
SDS			
Observer P	2.333	1.5	0.06
Observer Q	2	1.5	0.17
Observer R	2.167	1.667	0.29
VAS in mm			
Observer P	34.67	32	0.55
Observer Q	32.67	27.67	0.21
Observer R	39.83	34.67	0.17

**Significant ($p<0.05$)*

Average Maintenance Dose Volume (Vol%)

The average maintenance volume of anaesthesia for group A (isoflurane) and group B (sevoflurane) animals were 3.16 ± 0.16 and 2.04 ± 0.16 (Vol%), respectively. Surgical anaesthesia is normally achieved at 1.5 times of MAC. With sevoflurane having higher MAC value, group B dogs should have consumed more anaesthetic agent with higher vaporizer settings theoretically when fresh gas flow rate being the same in both the groups. This significant difference in average maintenance dose volume between group A and B animals may be attributed to resistance offered by group A animals during mask induction and partial loss of anaesthetic gas at face mask junction, thus consuming higher maintenance dose via endotracheal intubation during maintenance than group B animals. Values obtained during present study were lower in overall may be because of usage of rebreathing or circle system in this study. Jadon *et al.* (2008) used 3 % isoflurane and 2.5 % sevoflurane for maintenance.

Assessment of Subjective Parameters for Various Reflexes during Surgical Plane for Quality of Induction

Animals in both the groups had rapid transition from consciousness to anaesthesia with minimal resistance in terms of movement, sufficient muscle relaxation, good jaw relaxation, sufficient cutaneous analgesia and negative tail clamp reflex with no significant difference between groups in scoring system. Similarly Pottie *et al.* (2008) did not find any significant difference in quality of induction in both the

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agents. Johnson *et al.* (1998) reported sevoflurane was associated significantly better quality of induction compared to isoflurane.

Quantitative Parameters Observed During Recovery Phase (Table 1, Fig.1)

In group B animals the regaining of reflexes was significantly faster than group A animals. Quick recovery from anaesthesia in Isoflurane can be attributed to the low solubility of the isoflurane which facilitated fast elimination from the body. Significantly faster recovery in Group B could be due to least blood gas solubility of sevoflurane. Johnson *et al.* (1998) did not find any significant difference in recovery parameters using isoflurane and sevoflurane in adult dogs.

Qualitative Parameters Recorded During Recovery (Table 2)

In terms of qualitative characteristics there was no significant difference in SDS and VAS scales between groups. Thus the quality of recovery and analgesia in both the groups was satisfactory and within acceptable levels. We do not conclude both the agents have significant analgesic effects though best results can be achieved with opiod analgesic pre medication. Group B animals had non significantly lower values in SDS and VAS with smoother recovery and limited movements. Hence group B animals seem to have slightly better recovery quality. Love *et al.* (2007) found subjectively better quality of recovery in dogs that received sevoflurane than in those that received isoflurane, also did not found any much difference in time to recover. Johnson *et al.* (1998) opined recovery quality in usage of isoflurane and sevoflurane in adult dogs is comparable. Sloan *et al.* (1996) used isoflurane and sevoflurane for human patients for single-breath induction with nitrous oxide and oxygen mixture and found patients receiving sevoflurane were less clumsy and less confused but had higher pain scores. Further they also opined sevoflurane is more suitable than isoflurane in single breath-induction, because it produces smoother induction and lower incidence of complications and better patient acceptance.

Speed of anaesthesia induction with inhalant anaesthetics is determined by the agent's blood solubility, airway irritation, alveolar concentration and rate of which the concentration is achieved (a function of cardiac output, alveolar ventilation, regional distribution and inspired anaesthestic concentration). Anaesthesia recovery depends not only on blood:gas solubility, but on alveolar ventilation, cardiac output and venous-to-alveolar anaesthestic partial pressure differences (Eger, 1974). However speed of recovery and quality of recovery must be considered as separate criteria for assessment of recovery. Further rapid recovery may not be always indicative of better quality of recovery. But considering limited movements, number of attempts made to stand, degree of ataxia and limited vocalizations during recovery period sevoflurane may be having slight advantage. Although sevoflurane is associated with faster induction and recovery there is no clinical significance in usage with this finding except sevoflurane having low pungency and airway irritation.

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Conclusion

In conclusion, though induction and recovery characteristics of sevoflurane anaesthesia are faster than isoflurane, both isoflurane and sevoflurane are advantageous inhalant anaesthetics in terms of ease of administration during induction, excellent maintenance quality with rapid and smooth recovery without any significant adverse effects on healthy female dogs subjected for ovariohysterectomy procedure.

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