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Assessment of global warming potential of isoflurane at different fresh gas flow rates in canine anaesthesia

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ABSTRACT

Inhaled anaesthetics are recognized greenhouse gases. The study was conducted to assess the total mass of isoflurane at different FGF rate (1, 1.5 and 2 L/min) scavenged into the atmosphere in the canine anaesthesia. The total mass of isoflurane scavenged into atmosphere was measured by employing infrared absorption technique using Schiller Argus Multigas Monitor. The total quantity of isoflurane used in 1 MAC-hour basis was then multiplied by the GWP_{20} of isoflurane, and expressed as CDE_{20} in gram. The mean ±SE (g/h) of isoflurane scavenged into the atmosphere during canine anaesthesia was 12.07±0.04, 13.13±0.30 and 15.26±0.29 at FGF rate 1, 1.5 and 2 L/min, respectively. The mean ± SE CDE_{20} (g/h) of isoflurane at FGF rate 1, 1.5 and 2 L/min was 16,912.41±49.42, 18,394.87±422.81 and 20,087.63±410.27, respectively. From this study, it was concluded that, isoflurane at 1 L/min could be better FGF rate in canine surgical anaesthesia to reduce the environmental global warming impact of isoflurane.

Key words: CDE_{20}, Isoflurane, Fresh gas flow, Global warming potential

The currently used volatile anaesthetics are halogenated organic compounds that are recognized as an important category of greenhouse gases. But little consideration has been given to the ecotoxicological properties of gaseous anaesthetics. The halogenated anaesthetics (isoflurane, sevoflurane and desflurane) are eliminated through exhalation with little degradation in the body, and most anaesthesia systems transfer the unchanged gases as medical waste directly and into the atmosphere (Ishizawa 2011). The organic anaesthetic gases remain for a long time (1.2, 3.6 and 10 years for isoflurane, sevoflurane and desflurane, respectively) in the atmosphere and act as greenhouse gases (Ryan and Nielsen 2010). It has been calculated that isoflurane has 1401 times the warming potential of carbon dioxide (Christidis *et al.* 1997, Sellevaag *et al*. 2005).

Anaesthetic vapours and gases are widely used in veterinary clinics and laboratories for animal research. Data on the production or emission of these potential greenhouse gases and vapour are not available in the veterinary health care system. The high warming potentials of the inhaled anaesthetics warrant a detailed study for their impact in ecology. Fresh gas flow (FGF) rate may determine the relative impact of individual drugs on the environment (Anderson *et al.* 2010). Hence, this study was carried to assess the optimal FGF rate to evolve an eco-friendly anaesthetic protocol, to find the total mass of isoflurane scavenged into the atmosphere and to calculate the global warming impact of isoflurane during canine anaesthesia.

MATERIALS AND METHODS

Dogs (30) presented to Veterinary College and Research Institute Hospital, Namakkal for surgical interventions during the year 2012, were used for the study. They were randomly divided into groups 1, 2 and 3. All the dogs were premedicated with atropine sulphate @0.04 mg/kg body weight subcutaneously and 15 min later xylazine hydrochloride was administered @ 1.0 mg/kg body weight intramuscularly. At the onset of sedation, anaesthesia was inducted with ketamine hydrochloride @ 10 mg/kg body weight intravenously and oro-endotracheal intubation was carried out. Anaesthesia was maintained with isoflurane employing different fresh gas flow (FGF) rate of 1.0, 1.5 and 2.0 litre/ min in groups 1, 2 and 3, respectively, with a variable vapourizer settings to maintain uniform plane of surgical anaesthesia. These calculations assumed no degradation or metabolism of anaesthtic agent. All the trials were conducted at an ambient temperature of 25°C. The FGF was calculated on 1 MAC-

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hour basis. The inspired and end tidal concentration of isoflurane was measured using infrared absorption technique using multigas monitor. The data obtained were used to calculate the total mass and carbon dioxide equivalent (CDE_{20}) of isoflurane scavenged into the atmosphere.

Twenty years carbon dioxide equivalent (CDE_{20}) (g/h) of isoflurane was calculated using the global warming potential factor of isoflurane (GWP_{20}) as stated in the Intergovernmental Panel on Climate Change (IPCC) Report 2007.

The total mass of isoflurane scavenged was derived based on the formula as described by Ryan and Nielsen (2010), employing Avogadro's principle. First, the amount of isoflurane released into the atmosphere was calculated for a given period. Then, the quantity of isoflurane was multiplied by the GWP_{20} of isoflurane. Because, by definition, CO_2 has a GWP of 1, the product of the isoflurane quatity and the GWP_{20} express the CO_2 equivalent impact of isoflurane.

Total isoflurane vapour scavenged (litre/h) } = FGF (litre/min) on 1 MAC basis ×60 min

Total mass isoflurane scavenged (g/h) } = Isoflurane vapour scavenged (litre/h) × molecular weight of isoflurane /(24 litre/mol)

The CDE_{20} (g/h) of isoflurane scavenged was calculated as follows,

CDE_{20} (g/h) of isoflurane } = Total mass of isoflurane scavenged×GWP_{20} of isoflurane

The data obtained were analyzed by analysis of variance (ANOVA) using SPSS computer software 17.00 (SPSS 1999).

RESULTS AND DISCUSSION

The total mass of isoflurane (g) scavenged into atmosphere and its carbon dioxide equivalent (CDE_{20}) values at FGF rates of 1, 1.5 and 2 litre/min are presented in Table 1. The mean ± SE (g) isoflurane scavenged into the atmosphere during anaesthesia at FGF rates of 1, 1.5 and 2 litre/min was 12.05±0.49, 13.06±0.45 and 14.39±0.36, respectively. The differences between the groups were significant ($P \leq 0.05$). The mean ± SE carbon dioxide equivalent (CDE_{20}) (g/h) of isoflurane was 16883.17±68.60, 18291.39±634.59 and 20159.27±508.62 at FGF rates of 1, 1.5 and 2 litre/min, respectively. The CDE_{20} of isoflurane showed significant (Pd"0.05) difference between the groups 1, 2 and 3.

Table 1. Comparison of global warming impact of isoflurane anaesthetic per MAC-hour use at different fresh gas flow (FGF) rates (mean ±SE)

FGF (L/min)	Total mass of isoflurane scavenged (g) during surgery	Total mass of isoflurane scavenged (g) per hour	GWP_{20}	CDE_{20}
1 (n=10)	9.90±0.31	12.07±0.04*	1401	16,912.41± 49.42*
1.5(n=10)	10.28±0.45	13.13±0.30*	1401	18,394.87 ±422.81*
2(n=10)	11.12±0.49	15.26±0.29*	1401	20,087.63 ±410.27*

* Means in column are significant different (P<0.05); figures in the parentheses indicates numbers; MAC, minimum alveolar concentration; $GWP_{20,}$ 20 year global warming potential; CDE_{20}, 20 year carbon dioxide equivalent.

Ryan and Nielsen (2010) recorded the CDE_{20} value of isoflrane 7, 762 and 15, 551 g/h at FGF rate 1 and 2 litre/min, respectively, which was lesser than the CDE_{20} of isoflurane recorded in the present study. Higher vapourizer setting employed to achieve quick surgical plane of anaesthesia could be the reason for the higher values in the present study.

Langbein *et al*. (1999) concluded that the influence of inhaled anaesthetics on global warming was small, based on 1980s anaesthetic use pattern. However, in the last 30 years, the expanded use of inhalation anaesthetics dictates evaluation of warming potentials of anaesthetics.

Inhaled anaesthetics were contributory greenhouses gases in clinical cases and they varied substantially in their contribution by drug and by FGF rates (Ryan and Nielsen 2010). The FGF rates vary both within, and among, institutions, based on practice and surgical procedures. Bosenberg (2011) informed that the isoflurane had significantly larger global warming impact at higher FGF rate and reduction in volatile anaesthetic usage of up to 80 per cent could be achieved by employing low flow technique. Ryan and Nielsen (2010) suggested that the reduction of FGF to 0.5 to 1 litre/min would be the best approximations of ideal FGF rates, unless particular anaesthesia machines characteristics dictates higher flows.

In the present study, higher vaporizer setting (5% for 5 min) at the beginning with lowest FGF rates (1 litre/min) produced quick surgical plane of anaesthesia. This lowest FGF rate could minimize isoflurane anaesthetic scavenged into atmosphere. Based on the results of this study, isoflurane at 1 litre/min would be the ideal FGF rate in canine surgical anaesthesia in order to reduce environmental global warming impact of isoflurane.

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REFERENCES

Anderson M P S, Sander S P, Nielsen O J, Wagner D S, Sanford T J and Wallinton T J. 2010. Inhalation anaesthetics and climate change. *British Journal of Anaesthesia* **105**(6):760–66.

Bosenberg M. 2011 Anaesthetic gases: environmental impact and alternatives. *South African Journal of Anaesthesia and Analgesia* **17(5)**:345–48.

Christidis N, Hurley, M D, Pinnock S, Shine, K P and Wallington T J. 1997. Radiative forcing of climate change by CFC-11 and possible CFC replacements. *Journal of Geophysical Research* **102**:19597–609.

Ishizawa Y. 2011. General anesthetic gases and the global environment. *Anesthesia and Analgesia* **112 (1)**: 212–17.

Intergovernmental Panel on Climate Change (IPCC). AR4–Climate change 2007. Available at http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#.UIYC78Vy2rk.

Langbein T, Sonntag H, Trapp D, Hoffmann A, Malms W, Roth E P, Mors V and Zellner R. 1999. Volatile anaesthetics and the atmosphere: atmosphere lifetimes and atmospheric effects of halothane, enflurane, isoflurane, desflurane and sevoflurane. *British Journal of Anaesthesia* **82**:66–73.

Ryan S M and Nielsen C J. 2010. Global Warming Potential of Inhaled Anesthetics: Application to Clinical Use. *Anaesthesia and Analgesia* **111 (1)**: 92–98.

Sellevaag S R, Stenstrom Y, Helgaker T and Nielsen C J. 2005. Atmospheric chemistry of CHF2CHO:study of the IR and UV-Vis absorption cross sections, photolysis, and OH^-, Cl^- and NO^{3-} initiated oxidation. *Journal of Physical Chemistry* **109**:3652–62.

Statistical Package for the Social Sciences. 1999. Computer software 10.00 SPSS Inc., Chicago, Ilinois-60606, USA.