Veterinary
Anaesthesia and Analgesia
Formerly the Journal of Veterinary Anaesthesia

Veterinary Anaesthesia and Analgesia, 2013 doi:10.1111/vaa.12015

RESEARCH PAPER

A comparison between the v-gel supraglottic airway device and the cuffed endotracheal tube for airway management in spontaneously breathing cats during isoflurane anaesthesia

Hugo van Oostrom*, Maximillian W Krauss* & Robert Sap*

*Department of Clinical Sciences of Companion Animals, Faculty of Veterinary Medicine, Utrecht University, Utrecht, The Netherlands

Correspondence: Hugo van Oostrom, Department of Clinical Sciences of Companion Animals, Faculty of Veterinary Medicine, Utrecht University, P.O. Box 80-154, NL 3508 TD Utrecht, The Netherlands. E-mail: h.vanoostrom@uu.nl

Abstract

Objective To compare airway management using the v-gel supraglottic airway device (v-gel SGAD) to that using an endotracheal tube (ETT), with respect to practicability, leakage of volatile anaesthetics and upper airway discomfort in cats.

Study design Prospective, randomized clinical trial.

Animals Twenty European Shorthair cats (9 males, 11 females), weighing 3.3 ± 0.7 kg.

Methods Cats were randomly allocated to one of two groups, in which the airway was managed by either the v-gel SGAD or a cuffed ETT, and anaesthetized for neutering procedures. The dose of propofol necessary to insert the ETT or v-gel SGAD; time from the first injection of propofol to the first clinically acceptable reading on the capnograph; leakage of isoflurane around the airway device; and upper airway discomfort scores during recovery and during the first 24 hours after anaesthesia were recorded. Continuous and discrete variables were analyzed with the Mann–Whitney *U*-test and the Pearson chi-squared test, respectively. Results were considered statistically significant if $p < 0.05$.

Results Time from the first injection of propofol to the first clinically acceptable reading on the capnograph was significantly shorter in the v-gel group. The ETT group showed significantly more stridor during recovery. No other significant differences were found.

Conclusions and clinical relevance Airway management with the v-gel SGAD is a sound and practicable alternative to endotracheal intubation with an ETT. However, larger prospective trials will be needed to draw firm conclusions on the benefits and/or drawbacks of the use of v-gel SGAD for airway management in cats.

Keywords airway management, cat, endotracheal tube, isoflurane, v-gel supraglottic airway device.

Introduction

Airway management is paramount during general anaesthesia and at present, intubation with an endotracheal tube (ETT) is considered the 'gold standard' in veterinary anaesthesia. In cats, however, endotracheal intubation is not without risk, as it may result in arytenoidal tears and tracheal rupture (Mitchell et al. 2000; Hofmeister et al. 2007). In humans, the laryngeal mask airway (LMA) was developed as an alternative means of airway management (Brain 1991) and there are many reports of its use in a number of animal

species (Cassu et al. 2004; Bateman et al. 2005; Wiederstein et al. 2006; Fulkerson & Gustafson 2007; Wiederstein & Moens 2008; Sideri et al. 2009). However, the design of the human LMA does not directly conform to the specific anatomy of the oro- and laryngo-pharynx in different animal species, which might lead to leakage of volatile anaesthetics and/or inadvertent damage to the soft tissues of the pharyngo-laryngeal area of these animals.

Recently a supraglottic airway device (SGAD) designed specifically to conform to the anatomy of the cat was developed and introduced to the veterinary market under the name v-gel (Crotaz 2010). This v-gel SGAD contains a dedicated soft, non-inflatable cuff that rests over the laryngeal inlet. In addition, it possesses a dorsal pressure adjuster which can be inflated to depress the cuff over the laryngeal inlet. It conforms closely to the anatomy of the cat's oro- and laryngo-pharynx and therefore might be a reliable alternative to an ETT or a human LMA for airway management during general anaesthesia in cats.

In this prospective, randomized clinical trial, we compared the v-gel SGAD to endotracheal intubation for airway management in spontaneously breathing cats during general anaesthesia.

Materials and methods

The experimental procedures were approved by the Faculty of Veterinary Medicine, Department of Clinical Sciences of Companion Animals, Utrecht University, Utrecht, The Netherlands.

Animals

Twenty client-owned European Shorthair cats, nine males and 11 females, weighing 3.3 ± 0.7 kg, were randomly allocated to one of two groups, by draw of envelopes. Those in the ETT group were intubated with a cuffed ETT of internal diameter 3.0–3.5 mm (Rüsch; Teleflex Medical, The Netherlands) for airway management, while in the v-gel group, the v-gel SGAD (Docsinnovent Ltd, UK), size C1–C3, was used. The cats were found to be healthy upon clinical examination, and classified as ASA 1. All cats underwent general anaesthesia for elective neutering procedures. Food, but not water, was withheld for 12 hours before anaesthesia.

Owners were informed about both the procedure and aims of the study and provided formal consent by signing a form. The owners were not informed about the type of airway management used for their cat.

Procedure

All anaesthetic and surgical procedures were executed by the same experienced anaesthetist (RS) and surgeon (MK), respectively. All animals were premedicated with dexmedetomidine (Dexdomitor; Pfizer Animal Health BV, The Netherlands) 20 μg kg^{-1} and buprenorphine (Buprecare; ASTfarma, The Netherlands) 15 μg kg^{-1}, both administered intramuscularly (IM). After adequate sedation was observed, an intravenous (IV) catheter (Vasofix; B.Braun, Germany) was placed in a cephalic vein and an IV infusion of a crystalloid solution (Sterofundin ISO; B.Braun, Germany) was started at 5.0 mL kg^{-1} $hour^{-1}$. Time from premedication to induction of anaesthesia was recorded. Anaesthesia was induced with propofol (Propofol-Lipuro; B. Braun, Germany) given as a slow IV bolus of 2 mg kg^{-1}. When necessary, propofol was given in additional boluses of 1 mg kg^{-1} until either the ETT or v-gel SGAD could be inserted. Immediately after desensitizing the larynx with topical lidocaine spray (Xylocaine 10%; AstraZeneca, The Netherlands), the ETT was inserted with the aid of a laryngoscope whilst the cat was in sternal recumbency. After correct placement, the ETT was fixed to the mandible with adhesive tape (Leukoplast; BSN Medical, Germany) and the cuff inflated until there was no audible leak during application of positive airway pressure by squeezing the reservoir bag. The v-gel SGAD was inserted while the tongue of the cat was pulled slightly forward, with the opening of the cuff facing ventrally, until the device could not be inserted further. At this point, the shoulder of the device touches the pharyngeal arch and deeper insertion is not possible without excessive force. After placement, the v-gel SGAD was fixated by tying a bandage from the wing sections of the device behind the ears of the cat and the dorsal cuff was inflated with 1 mL of air. In both the surgical preparation area and the operating theatre, cats were attached to a modified Ayre's T-piece breathing system (Mapleson D).

The total dose of propofol needed for induction, and the time from injecting the first dose of propofol to the first clinically acceptable reading on the capnograph were recorded. All cats received 0.1 mg kg^{-1} meloxicam (Metacam; Boehringer

Ingelheim, The Netherlands) subcutaneously (SC) before being transported to the operating theatre.

Anaesthesia was maintained by isoflurane vaporized in an oxygen/air mixture (FiO2 targeted at 0.3–0.4) at a flow of 2.2 L minute^{-1}. The electrocardiogram (ECG), respiratory gas concentrations and end-tidal isoflurane concentration (FE'ISO) were monitored continuously. Depth of anaesthesia, judged by eye position, palpebral reflex, jaw tone, respiratory rate and heart rate, was adjusted by changing the FE'ISO at the anaesthetist's discretion. An initial FE'ISO of 1.0% was targeted. Body temperature was maintained at 38–39 °C by a hot water blanket and/or forced warm air blanket (Bair Hugger; Arizant Healthcare Inc., MN, USA).

During the maintenance phase, isoflurane concentrations (mg m^{-3}) were also measured at a fixed 2 cm distance from the animal's mouth by an ambient air analyser (Miran Sapphire series 205B; Foxboro Co., MA, USA).

At the end of surgery, the cats were immediately disconnected from the anaesthesia machine and observed continuously; the ETT or v-gel SGAD was removed before coughing or swallowing reflexes had returned. The total time of anaesthesia maintenance varied with the duration of surgery as this was a clinical study.

Following the removal of the ETT or v-gel SGAD, the breathing pattern and presence of respiratory stridor were evaluated and documented by one of the investigators (HvO), who was unaware of the airway management device used. In addition, dexmedetomidine was antagonized by atipamezole (Antisedan; Pfizer Animal Health BV, The Netherlands) at a dose rate of 100 μg kg^{-1}, administered SC. Time from removal of the ETT or v-gel SGAD until the animal was able to sit was recorded as the time for recovery. After full recovery from anaesthesia, the cats were returned to their owners, who received a questionnaire (see Appendix 1) with several questions regarding signs which might be associated with upper airway discomfort during the first 24 hours after surgery. These included coughing, retching, vomiting, hoarseness, reluctance to eat and a general impression of upper airway discomfort.

Post-operative analgesia was provided by the buprenorphine and meloxicam administered before surgery and by meloxicam (Metacam; Boehringer Ingelheim, The Netherlands) 0.05 mg kg^{-1} per os, given for four subsequent days.

Statistical analysis

All data were analysed using Microsoft Office Excel 2003 (Microsoft Corp., WA, USA) and SPSS 16.0 (IBM Corp., NY). Continuous variables were analyzed with the non-parametric Mann–Whitney-*U* test as data were not normally distributed. Discrete variables were analyzed using the Pearson chi-squared test. Differences were considered statistically significant if $p < 0.05$.

Results

Data and results of statistical analysis are shown in Tables 1 and 2. The response rate of the owners to

Table 1 Values [median (interquartile range)] of continuous variables and statistical outcome

Parameter (unit)	v-gel group	ETT Group	Mann–Whitney *U*-test
Age (year)	0.65 (1.1)	0.65 (0.84)	ns
Weight (kg)	3.2 (1.18)	3.2 (1.5)	ns
Time between premedication and induction (minutes)	17.5 (10)	17 (3.75)	ns
Duration of intubation (minutes)	24 (27.7)	23.5 (17.5)	ns
Dose of propofol (mg kg^{-1})	2.0 (1.3)	2.8 (1.0)	ns
Time to first clinically acceptable capnograph (seconds)	44.4 (21.4)	109.0 (46.2)	7.0; $p = 0.001$
Peak concentration isoflurane (mg m^{-3})	10.5 (45.2)	8.0 (11.5)	ns
Time weighted mean concentration of isoflurane during procedure (mg m^{-3} minute^{-1})	0.15 (0.27)	0.29 (0.74)	ns
Time for recovery (minutes)	10 (3)	11 (2.75)	ns
General impression of upper airway discomfort during first 24 hours post surgery	1.0 (0.0)	1.0 (2.2)	ns

Table 2 Distribution of discrete variables and statistical outcome. Scores for the recovery parameters (stridor, dyspnea and coughing; 0 and 1) mean 'no' and 'yes'. The parameters scored on the 3-point scale refer to the questionnaire filled out by the owners

	Stridor during recovery		Dyspnea during recovery		Coughing during recovery		Coughing			Hoarseness			Retching/vomiting			Reluctance to eat		
Score	0	1	0	1	0	1	1	2	3	1	2	3	1	2	3	1	2	3
V-gel Group	10	0	10	0	10	0	10	0	0	8	2	0	10	0	0	9	1	0
ETT Group	4	6	8	2	10	0	10	0	0	5	2	3	9	0	1	8	2	0
Pearson's chi-squared	8.571; $p = 0.003$		ns		ns		ns			ns			ns			ns		

the questionnaires was 100%. The groups did not differ in composition with respect to age and weight. Placement of all v-gel SGADs was successful at the first attempt; in one animal in the ETT group, a tube of smaller diameter than the one chosen at first attempt was needed for correct intubation. The time between pre-medication and induction of anaesthesia, and the time needed for recovery, did not differ between the two groups. The time between injection of the first dose of propofol to the first clinically acceptable reading on the capnograph was significantly shorter in the v-gel group. During the recovery period, the ETT group showed significantly more stridor, although the owner scores did not show any further differences with respect to upper airway discomfort.

Discussion

This study investigated whether the v-gel SGAD was a practicable and reliable alternative to endotracheal intubation for airway management in spontaneously breathing cats during isoflurane anaesthesia.

The time from injecting the first dose of propofol to the first clinically acceptable reading on the capnograph was significantly shorter in the v-gel group, which suggests that a secure airway is obtained faster with the v-gel SGAD than with an ETT. According to the subjective impression of the anaesthetist involved in this study, placement of the v-gel SGAD was indeed faster and seemed easier than endotracheal intubation. In swine, securing the airway with an LMA is also reported to be faster and easier than endotracheal intubation (Fulkerson & Gustafson 2007). In humans, however, there is no statistically significant difference between the LMA and ETT regarding success of insertion on the first attempt, when an experienced anaesthetist is securing the airway (Yu & Beirne 2010). In conclusion, securing the airway of the cat with a v-gel SGAD is faster than endotracheal intubation with an ETT.

The total dose of propofol needed for induction of anaesthesia did not differ between the two groups. This is in contrast with a previous report in dogs (Wiederstein et al. 2006), where insertion of an LMA was first attempted in dogs that had received only premedication drugs; when unsuccessful, a 1 mg kg^{-1} propofol bolus was given over 30 seconds and a further attempt to place the LMA was made. Additional boluses of propofol were administered until the LMA could be placed successfully. In contrast, in the present study, the first attempt was

made after induction with a 2 mg kg^{-1} bolus of propofol, which in most cats appeared sufficient to secure the airway with either the v-gel SGAD or ETT. It is possible also that lower doses of propofol may have been sufficient for placement of the v-gel SGAD, although due to the study protocol we could not confirm this. In addition, it must be noted that securing an airway with an LMA can also result in laryngeal spasm when an insufficient depth of anaesthesia is present (Wiederstein et al. 2006). Therefore, we recommend achieving a sufficient depth of anaesthesia before securing the airway with either an SGAD or ETT and therefore do not consider the potentially lower dose of induction agent needed to be an advantage of the SGAD over the ETT.

No significant differences were found between groups with respect to isoflurane concentrations in the vicinity of the mouth: in both groups, the mean and maximum values remained well below the maximum acceptable limits recommended by Dutch governmental guidelines (153 mg m^{-3}, time-weighted average over 8 hours). Based on these measurements, it can be concluded that the v-gel SGAD secures the airway sufficiently to prevent exposure of operating room personnel to unacceptably high concentrations of isoflurane, although it must be emphasized that all cats were breathing spontaneously in this study and that no data were obtained on isoflurane leakage during positive airway pressures, e.g. during manual or mechanical ventilation. Previous studies suggest that in several veterinary species, including cats, positive airway pressures of up to 10–23 cm H_2O can be safely applied without leakage from an LMA (Cassu et al. 2004; Bateman et al. 2005; Fulkerson & Gustafson 2007; Wiederstein & Moens 2008). These studies, however, used audible measures of leakage, rather than the highly sensitive detection of volatile anaesthetic concentrations, as was done in the present study. Further studies will be needed to evaluate leakage of volatile anaesthetics from the v-gel SGAD during application of positive airway pressures.

The v-gel group showed significantly less stridor during recovery than the ETT group, although the owner scores for upper airway discomfort in the first 24 hours post-operatively did not differ between groups. A systematic review of the human literature has shown that hoarse voice, laryngeal spasm during emergence, coughing and sore throat had a significantly lower incidence when managing the airway with an LMA, compared to airway management with an ETT (Yu & Beirne 2010). It may be argued whether the descriptor 'reluctance to eat' that we used in this study is indicative of upper airway discomfort, as post-anaesthetic complications such as oesophagitis due to gastro-oesophageal reflux might also lead to reluctance to eat. Other parameters such as coughing and hoarseness of voice are relatively straightforward and can be scored objectively by the owner. It was striking that we encountered rather a high incidence of respiratory stridor during recovery in the ETT group. In general, we feel that stridor is relatively low in cats undergoing general anaesthesia in our clinic, where endotracheal intubation with an ETT after desensitization of the larynx with lidocaine spray is standard practice. In this study, the larynx of the cats in the ETT group was sprayed with Xylocaine spray, whereas the larynx of the cats in the v-gel group was not sprayed. This might have created bias in the upper airway discomfort scores as Xylocaine spray is described to have adverse effects on the laryngeal mucosa of cats (Taylor 1992; Brearley 2010; Fisher 2010). Xylocaine spray, therefore, might have induced the significantly higher incidence of stridor during the recovery. However, we have used Xylocaine spray in cats for desensitization of the larynx for decades in our clinic, without observable problems. Furthermore, it seems that lidocaine itself, irrespective of the type of spray, has an effect on the laryngeal mucosa of cats (Rex et al. 1983). For this study, we decided to adhere as closely to the clinical situation as possible and since desensitization of the larynx of cats before intubation with an ETT and not doing so before placement of a v-gel SGAD is general practice in our clinic, we decided to include this bias in our study design. The episodes of stridor that were observed were only short-lived and resolved as soon as the animals had fully recovered. We cannot conclude, therefore, whether the ETT, spraying of the larynx with Xylocaine, or both led to the high incidence of stridor in the recovery period.

Another observation was the suggestion of an overall higher incidence of hoarseness of voice (7/20 animals). Normally we do not follow up on such signs, but it would appear that there may be a high incidence of affected vocal cords in cats undergoing general anaesthesia with active airway management. In conclusion, the better recovery scores (no stridor) with respect to upper airway function in the v-gel group suggest that airway management with a v-gel SGAD causes less upper airway discomfort than an ETT. We attribute the insignificant findings in

owner scores to the low number of animals included in this study and the inter-observer variability between owners. Therefore, we suggest studying the effect on upper airway discomfort more closely in a larger number of animals.

In this study we detected no signs of aspiration of gastric content in either group. Previous investigations in both cats and humans suggest that oesophageal reflux can be present but that aspiration of gastric content is seldom seen and that the incidence of the latter is no higher in patients in which the airway is secured with an LMA, compared to patients in which an ETT is used (Cassu et al. 2004; Sideri et al. 2009; Yu & Beirne 2010).

In conclusion we feel that airway management with the v-gel SGAD is a sound and practicable alternative to endotracheal intubation with an ETT. However, we suggest that large prospective (multicentre) trials are needed to determine: 1) whether the v-gel SGAD is also safe with respect to leakage of volatile anaesthetics when positive pressure ventilation is employed; 2) whether airway management with a v-gel SGAD indeed reduces upper airway discomfort after general anaesthesia compared to an ETT; and 3) whether the incidence of adverse events such as aspiration of gastric contents when using a v-gel SGAD is indeed similar to when using an ETT.

Acknowledgements

The authors kindly thank Rob Vollmer of Delta Medic BV for the isoflurane leakage measurements and Peter Jassel of Docsinnovent Ltd. for providing us with the v-gel supraglottic airway device.

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Received 4 July 2012; accepted 13 September 2012.

Appendix: Questionnaire to be completed by the owners

1. Did your cat cough within the first 24 hours after surgery?
   1. no.
   2. yes: once or twice.
   3. yes: often.
2. Was the vocal sound of your cat abnormal during the first 24 hours after surgery, e.g. was your cat hoarse?
   1. no.
   2. yes, but only mildly.
   3. yes, severely.
3. Did your cat retch, gag or vomit during the first 24 hours after surgery?
   1. no.
   2. yes, once or twice.
   3. yes, often.
4. Did your cat show abnormalities in food intake?
   1. no.
   2. yes, it showed difficulties in swallowing and/or refused hard kibbles.
   3. yes, it did not eat at all.
5. On a scale from 1 to 10, with 1 indicating no discomfort and 10 indicating very severe discomfort, what is your general impression of the upper airway discomfort of your cat in the first 24 hours after surgery?

