Routine veterinary anaesthetic management practices in South Africa

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ABSTRACT

A survey of the routine anaesthetic management of dogs and cats during sterilisation by veterinarians in South Africa was conducted. This report describes the premedication, induction and maintenance agents most commonly used in dogs and cats. Information about monitoring of patients during the procedure and who is responsible for induction of anaesthesia and monitoring was obtained. Questionnaires were analysed with regard to demographic data, practice size, continuing education, the number of surgical procedures and sterilisations performed per week and an estimate of yearly mortality. Acetylpromazine is the most commonly used premedication in dogs and xylazine in cats. Thiopentone in dogs and alphaxalone/alphadolone in cats were the induction agents most commonly used. Alphaxalone/alphadolone in cats and halothane in dogs are the most commonly used maintenance agents. Records of anaesthesia are poorly kept and monitoring of patients is poorly performed. Respiratory rate is the parameter most commonly monitored (90.7 %), and in most cases is the sole parameter. On average 10.34 ± 8.25 cats were operated per week, of which 5.45 ± 5.60 were sterilised; 17.79 ± 11.61 dogs were operated per week, of which 8.65 ± 7.10 were sterilised. In total, 190 patients died under anaesthesia, a mortality rate of 1:1243. Just over 50 % of practitioners had attended continuing education courses during their careers.

Key words: anaesthetic survey, continuing education, mortality, mortality rate, South Africa, sterilisation.

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INTRODUCTION

Anaesthesia invariably carries a risk of morbidity and mortality. The risks associated with anaesthesia are multifactorial. Every anaesthetic agent and premedication carries an associated risk. This study was undertaken to determine the routine anaesthetic protocol used by veterinarians in South Africa for the sterilisation of small animals. The study included aspects of premedication, induction and maintenance of anaesthesia, anaesthetic machine usage and routine weighing of patients.

Veterinarians are faced with limited economic resources and professional help. Patients are seldom optimally monitored during anaesthesia, as the veterinarian is often the anaesthetist and the surgeon. Anaesthetic observation is often intermittent. Veterinary patients are statistically likely to be exposed to a higher anaesthetic risk than their human counterparts. An estimate of mortality under anaesthesia was made.

This information can be used to identify potential problem areas associated with anaesthetic practice and drugs. From an historical point of view it is invaluable to assess changes in anaesthetic practices over time. The appropriateness of current curricula can also be assessed in terms of routine anaesthetic practice. Comparisons can be drawn between anaesthetic practices in different countries.

MATERIALS AND METHODS

The sales representatives of a drug company on their routine visits delivered 600 questionnaires to practices in South Africa. The questionnaires were distributed between February and April 1999, completed by the veterinarian, and returned either *via* the drug company or by post to the author. The questionnaire covered aspects of demographic information (province, type of practice, size of practice, years in practice), continuing education (whether they have attended within the last 5 years or at all), the number of procedures performed on small animals (operations and sterilisation) and mortality (patients dying per year under anaesthesia). The type of practice was defined as small animal (>75 % of patients are dogs or cats), equine, mixed practice (production animals, companion animals), large animals (>75 % production animals) and specialists or referral practice. Practice size was defined in intervals of 5000 patients up to a practice greater than 25 000. The availability of anaesthetic machines and inhalation agents in private practice was assessed. The induction technique used with reference to intravenous anaesthesia, whether or not patients were weighed, and the premedication, induction and maintenance agents commonly used for the routine sterilisation of dogs and cats were requested. The induction techniques comprised administering the intravenous anaesthetic agent as a bolus dose, ⅔ bolus plus titration, ½ bolus plus titration or by titration alone. Information on the monitoring method and parameters monitored was obtained, as well as how often records were kept.

The data were entered onto a spreadsheet using Microsoft Excel 97 SR-1 (Microsoft Corporation). When a range was given as data, the mid-range value was used for analysis. When data were given as a 'less than or greater than' value, the number given was used for analysis. For mortality data, a value of <1 was entered as a mortality rate of 0.5. The number of procedures was requested on a weekly basis, and this was multiplied by 52 to obtain a yearly value when required. Global mortality rate was calculated from the total number of deaths reported divided by the number of anaesthetics given. Individual mortality rates were calculated for each practice to identify trends related to mortality. Kolmogorov-Smirnov was used to determine normality. The Mann-Whitney rank sum test and Spearman's rank order correlation were used to test for statistical difference when mortality rate was compared against variables such as practice size, continuing education, anaesthetic and premedication agents and procedural lengths. Statistical analysis was performed using SigmaStat for Windows, version 2.00 (Jandel Corporation, San Rafael, California). Tables and descriptive statistics are used to describe the data.

RESULTS

A total of 162 questionnaires was returned. This represents a response rate

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Table 1: **Distribution of type of practice by province** (*n* = 161)**. The percentages given are representative of the percentage in each province.**

Province/ type of practice	*n*	%
Eastern Cape		
Small animals	5	100.00
Free State		
Small animals	2	50.00
Mixed practice	2	50.00
Guateng		
Small animals	55	78.57
Mixed practice	13	18.57
Specialists and referral	1	1.43
Other	1	1.43
KwaZulu-Natal		
Small animals	38	79.17
Mixed practice	8	16.67
Specialists and referral	2	4.17
North West		
Small animals	1	100.00
Northern Province		
Small animals	1	50.00
Mixed practice	1	50.00
Western Cape		
Small animals	23	74.19
Mixed practice	6	19.35
Equines	1	3.23
Other	1	3.23

of 27 %. One questionnaire was rejected, as it was incomplete; 161 questionnaires were used for analysis.

The highest number of returns came from Guateng (*n* = 70, 43.5 %) followed by KwaZulu-Natal (*n* = 48, 29.8 %) and the Western Cape (*n* = 31, 19.25 %). The remaining 4 provinces were represented as follows: Eastern Cape (*n* = 5, 3.1 %), Free State (*n* = 4, 2.5 %), Northern Province (*n* = 2, 1.2 %) and North West (*n* = 1, 0.6 %). The provinces of Mpumalanga and Northern Cape were not represented.

Small animal practice (*n* = 125, 77.6 %) was the most common type of practice, followed by mixed practice (*n* = 30, 18.6 %). The remaining types of practices were equine (*n* = 1, 0.6 %), specialist and referral (*n* = 3, 1.9 %) and other types of practice (*n* = 2, 1.2 %). Four practices indicated that they had an avian interest, 2 were mainly involved in small animal practice and 2 indicated that most of their work was avian. Of the specialist and referral practices, 2 involved small animals and 1 was a mixed practice. No replies from large animal practices were received. A distribution of type of practice by province is given in Table 1.

Most practices were small, with 5000 or fewer clients per annum (*n* = 88, 54.7 %). The next largest was the 5001–10 000 client-base group (*n* = 46, 28.6 %), followed by the 10 001–15 000 client-base group (*n* = 13, 8.1 %). Practices with more than 15 000 clients made up fewer than 5 % (*n* = 8) of the respondents. Six practices did not indicate their client base, and as a result only 155 practices were analysed. These data are presented in Table 2.

Table 2**: Distribution of practice size by client base in each province** (*n* = 155)**. The percentages given are representative of the percentage in each province. A combined summary is given at the bottom of the Table.**

Province/ size of practice	*n*	%
Eastern Cape		
0–5000	3	60.00
10001–15000	1	20.00
Unknown	1	20.00
Free State		
0–5000	3	75.00
10001–15000	1	25.00
Guateng		
0–5000	31	44.29
5001–10000	27	38.57
10001–15000	9	12.86
15001–20000	1	1.43
20001–25000	1	1.43
>25000	1	1.43
KwaZulu-Natal		
0–5000	31	64.58
5001–10000	8	16.67
10001–15000	2	4.17
15001–20000	1	2.08
20001–25000	2	4.17
>25000	2	4.17
Unknown	2	4.17
North West		
5001–10000	1	100.00
Northern Province		
0–5000	2	100.00
Western Cape		
0–5000	18	58.06
5001–10000	10	32.26
Unknown	3	9.68
Summary		
0–5000	88	54.66
5001–10000	46	28.57
10001–15000	13	8.07
15001–20000	2	1.24
20001–25000	3	1.86
>25000	3	1.86
Unknown	6	3.73

The mean time in practice after qualification was 15.57 ± 8.67 years. The range was from 2 to 46 years in practice. One practitioner did not indicate length of time in practice, leaving 160 results for analysis. The distribution of practitioners in 5-year intervals in private practice is shown in Table 3.

The mean number of cats operated per week was 10.34 ± 8.25, with a range of 1–70. The mean number of cats sterilised per week was 5.45 ± 5.60, with a range of 0–60. The number of cats sterilised is skewed, with the 25 % quartile being 3, and the 75 % quartile 6. The standard error for cats sterilised was 0.441. The mean number of dogs operated per week was 17.79 ± 11.61, with a range of 2–70. The mean number of dogs sterilised per week was 8.65 ± 7.10, with a range of 0–50. By extrapolating to a year, 86 528 cats are operated, and 45 656 are sterilised. For dogs, 148 928 are operated, while 72 410 are sterilised. The surgical caseload data are presented in Table 4.

Table 3: **Distribution of practitioners by number of years in private practice** (*n* = 160)**.**

Number of years in practice	*n*	%
<5 years	20	12.50
6–10 years	31	19.38
11–15 years	35	21.74
16–20 years	25	15.53
21–25 years	27	16.87
>25 years	22	13.75

Most practitioners (93.8 %, *n* = 151), have an anaesthetic machine. Halothane was available in 91.3 % (*n* = 147) of practices while in 13.7 % (*n* = 22) of practices halothane was available in addition to another inhalation agent. Isoflurane was the second-most frequently used inhalation agent (15.5 %, *n* = 25). Isoflurane was the only agent used in 1.9 % (*n* = 3) of practices. Enflurane was used in 2 practices, and in both it was used in combination with halothane and isoflurane. Halothane and isoflurane were used in 12.4 % (*n* = 20) practices. One practice did not indicate which inhalation agent was used. Most practices had out-of-circuit vaporisers (78.3 %, *n* = 126), while 13 % (*n* = 21) had in-circuit vaporisers. Two practices had both types of vaporisers, and 6 practices did not indicate the type of vaporiser. A total of 160 practices provided information on inhalation agents used in their practices while 155 practices provided information on vaporisers.

Patients were weighed regularly in 20.5 % (*n* = 33) and occasionally in 21.7 % (*n* = 35) of practices. Most practices (57.76 %, *n* = 93), did not weigh their patients.

Most practitioners (41.6 %, *n* = 67), administered half the dose of the induction agent as a bolus and titrated the remainder to the required anaesthetic depth. The second-most popular method (26.7 %, *n* = 43), was to give ⅔ of the calculated dose as a bolus and titrate the remainder. This was followed by a titration-only technique in 26.1 % (*n* = 42) practices. In 3.7 % (*n* = 6) of practices the

Table 4: **Total number of surgical procedures performed on cats and dogs. SD = standard deviation.**

Procedures performed	Per week	±SD	Per year	±SD
Cats operated	1664	8.25	86 528	429.84
Dogs operated	2864	11.61	148 928	605.74
Total	4528	10.73	235 456	559.57
Cats sterilised	878	5.60	45 656	289.34
Dogs sterilised	1393	7.08	72 410	368.27
Total	2271	6.57	118 066	341.08

induction agent was given as a bolus, while 1.2 % (*n* = 2) did not indicate their choice of induction technique.

Premedication and anaesthetic protocols were different for dogs and cats and the results are presented separately below.

Cats

The premedication most commonly administered to cats was xylazine (43.5 %, *n* = 70), followed by acetylpromazine (31.7 %, *n* = 51) and medetomidine (8.7 %, *n* = 14). No premedication was administered in 12.4 % (*n* = 20) practices. The remaining premedications were used by fewer than 5 % of the practices (Table 5). Atropine was given in 21.7 % (*n* = 35) of practices and was combined with either acetylpromazine (60.0 %, *n* = 21) or xylazine (25.7 %, *n* = 9) or administered on its own (14.3 %, *n* = 5). Antibiotics in the form of penicillin were administered in 4.4 % (*n* = 7) of practices and pethidine was given by 1.9 % (*n* = 3) practices. One respondent gave both acetylpromazine and xylazine.

The induction agent used most commonly for anaesthesia of cats was alphaxalone/alphadolone (54.0 %, *n* = 87), followed by thiopentone (34.2 %, *n* = 55), ketamine (3.7 %, *n* = 6), halothane (3.1 %, *n* = 5) and propofol (3.1 %, *n* = 5). A xylazine-ketamine combination was used in 1.2 % (*n* = 2) of cases and pentobarbitone in 0.6 % (*n* = 1) cases. These results are presented in Table 5.

Maintenance of anaesthesia was most commonly carried out with alphaxalone/alphadolone in 40.4 % (*n* = 65), halothane in 35.4 % (*n* = 57) and thiopentone in 21.1 % (*n* = 34) of cases. Ketamine was used by 2.5 % (*n* = 4) respondents and isoflurane by 0.6 % (*n* = 1) (Table 5). Of the 151 respondents who had an anaesthetic machine, only 38.4 % (*n* = 58) used it to maintain anaesthesia for routine sterilisation of cats.

Table 5: **Premedication and anaesthetic agents used for the induction and maintenance of anaesthesia in cats** (*n* = 161)**.**

Medication	*n*	%
Premedication		
Xylazine	70	43.48
Acetylpromazine	51	31.68
No premedication	20	12.42
Medetomidine	14	8.70
Ketamine-xylazine	4	2.48
Alphaxalone/alphadalone	1	0.62
Ketamine-medetomidine	1	0.62
Xylazine & acetylpromazine	1	0.62
Use of atropine by respondents		
Atropine used	35	21.74
Atropine & acetylpromazine	21	13.04
Atropine & xylazine	9	5.59
Atropine alone	5	3.11
Other drugs used for premedication		
Penicillin	7	4.35
Pethidine	3	1.86
Induction agents		
Alphaxalone/alphadolone	87	54.04
Thiopentone	55	34.16
Ketamine	6	3.73
Halothane	5	3.11
Propofol	5	3.11
Ketamine-xylazine	2	1.24
Pentobarbitone	1	0.62
Maintenance agents		
Alphaxalone/alphadolone	65	40.37
Halothane	57	35.40
Thiopentone	34	21.12
Ketamine	4	2.48
Isoflurane	1	0.62

Dogs

The sedative/tranquilliser most commonly administered to dogs was acetylpromazine, by 83.2 % (*n* = 134) of respondents, followed by xylazine by 8.7 % (*n* = 14); 5.0 % (*n* = 8) of respondents did not premedicate their patients. Atropine was used in 39.8 % (*n* = 64) of cases, including 95.3 % (*n* = 61) used in combination with acetylpromazine and 3.1 % (*n* = 2) in combination with xylazine. One practice used atropine on its own. Other drugs used to premedicate patients were ketamine in combination with medetomidine (0.62 %, *n* = 1), medetomidine alone (2.5 %, *n* = 4) and penicillin (3.7 %, *n* = 6). These results are presented in Table 6.

Thiopentone was used by 97.5 % (*n* = 157) of respondents to induce anaesthesia in dogs. This was followed by pentobarbitone (1.9 %, *n* = 3) and halothane (0.6 %, *n* = 1) (Table 6).

Anaesthesia was maintained in dogs using halothane by 65.2 % (*n* = 105) and thiopentone by 34.8 % (*n* = 56) of respondents. These were the only 2 agents reported (Table 6). Of the 151 respondents who had an anaesthetic machine, only 69.5 % (*n* = 105) used it to maintain anaesthesia for routine sterilisation of dogs.

Table 6: **Premedication and anaesthetic agents used for the induction and maintenance of anaesthesia in dogs** (*n* = 161)**.**

Medication	*n*	%
Premedication		
Acetylpromazine	134	83.23
Xylazine	14	8.70
No premedication	8	4.97
Medetomidine	4	2.48
Ketamine-medetomidine	1	0.62
Use of atropine by respondents		
Atropine used	64	39.75
Atropine & acetylpromazine	61	37.89
Atropine & xylazine	2	1.24
Atropine alone	1	0.62
Other premedication given		
Penicillin	6	3.73
Induction agent		
Thiopentone	157	97.52
Pentobarbitone	3	1.86
Halothane	1	0.62
Maintenance agent		
Halothane	105	65.22
Thiopentone	56	34.78

Table 7: **Involvement of staff in the induction and monitoring of anaesthesia** (*n* = 161)**.**

Personnel responsible	Induction		Monitoring	
	n	%	*n*	%
Veterinarian only	138	85.71	43	26.71
Veterinary nurse only	5	3.11	16	9.94
Veterinarian and nurse	14	8.70	27	16.77
Lay staff only	1	0.62	21	13.04
Veterinarian and lay staff	3	1.86	47	29.19
Nurse and lay staff	0	0	2	1.24
All staff members	0	0	5	3.11
Relative contribution of each staff member				
Veterinarian	155	96.27	122	75.78
Nurse	19	11.80	50	31.06
Lay staff	4	2.48	75	46.58

Table 8: **An indication of how often anaesthetic records were kept** (*n* = 161)**. Parameters monitored in small animal patients under anaesthesia** (*n* = 161)**.**

	n	%
Records		
Always	41	25.47
Usually	12	7.45
Sometimes	20	12.42
Never	60	37.27
Difficult cases	28	17.39
Monitoring		
Respiratory rate	146	90.68
Heart rate	84	52.17
Mucous membranes	60	37.27
Neurological reflexes	17	10.56
ECG	11	6.83
Capillary refill time	10	6.21
SpO_2	2	1.24

The staff involvement in anaesthetic induction and monitoring of anaesthesia is described in Table 7. The frequency with which anaesthetic records are kept and the means and variables used to monitor patients are shown in Table 8.

In total, 190 patients were reported to have died under anaesthesia. Forty-two practices did not report any deaths, while 72 practices reported fewer than 1 death per year. This has resulted in a large standard deviation in the deaths reported. The standard error for deaths was 0.121. The range for deaths was 0–10. The mortality rate calculated for all practices was 1:1.243 (Table 9). No correlation was found between mortality and years in practice, duration of procedures, induction technique, any of the drugs used or continuing education received.

Of the 161 practitioners who replied, 50.3 % (*n* = 81) had participated in continuing education courses since qualifying, while 49.7 % (*n* = 80) had not. Only 34.2 % (*n* = 55) of the respondents had received continuing education within the last 5 years. Those who had received continuing education prior to the last 5 years amounted to 26.1 % (*n* = 42), and of these 38.1 % (*n* = 16) had received continuing education within the last 5 years. Thus, 16.2 % (*n* = 26) of respondents had only received continuing education prior to the last 5 years. Combined with those who had not received continuing education at all, 65.9 % (*n* = 106) of respondents had not received continuing education in the last 5 years. These data were split into 5-year intervals, and the results are given in Table 10. Only 160 results were analysed using 5-year intervals, as 1 practitioner did not indicate the number of years in practice.

DISCUSSION

All the data are based on the individual interpretation, experience and opinions of the veterinarians polled. The results depend on the integrity and honesty of the veterinarians who completed the questionnaire. Selective recall and forgotten cases may have an influence on mortality data. This renders the data less reliable, but by no means less interesting. It is always easier to criticise than perform; the aim of this study was to highlight problem areas and propose solutions, and not to malign practitioners.

In order for surveys to be comparative, it is important to establish whether or not the surveys are based on similar client bases. This survey is biased towards Gauteng, KwaZulu-Natal and the Western Cape, which represented 92.5 % (*n* = 149) of the respondents.

Most (96.2 %) practitioners were involved in small animal practice. This compares favourably with the 92.4 % reported for South Africa[24] and the 84 % reported for Canada[12]. Odendaal reported that 47.4 % of practitioners are involved in mixed practice[24]. Our survey indicates that only 18.6 % were involved in mixed practice. This difference may be the result of different definitions of mixed practice and small animal practice. The absence of large animal practices from this survey may be the result of a very small percentage of practitioners involved solely with production animals. It has been previously reported that only 7.6 % (*n* = 38) in a much larger study (*n* = 500) are solely involved in production animals in South Africa[24]. The absence of large animal and mixed practice may indicate that this survey has a bias against large animal practice.

A Canadian study showed that 48 % of veterinarians had graduated within the last 10 years[12]. Our data indicated that only 31.9 % of veterinarians had graduated within the last 10 years. The absence of younger veterinarians may be related the large number of newly-qualified graduates who seek employment in the United Kingdom and elsewhere.

A number of welfare institutions and practices involved in welfare were sampled. This resulted in the high number of sterilisation and operations reported in the ranges and the skewed results. An average of 15 dogs and 16 cats operated per week was reported in the Vermont study[9], and 8–60 dogs and cats are operated per week in the United Kingdom[6]. South African private practitioners have a similar case load to that of veterinarians in Vermont and the United Kingdom.

A high number of respondents (93.8 %) indicated that they had an anaesthetic machine in their practice, but it is interesting that it was only used in 35.4 % of cats and 65.2 % of dogs. The anaesthetic machine not only delivers an anaesthetic agent, but is also used to assess ventilation (through observation of the reservoir bag expanding and collapsing), to control ventilation when required, and to supplement oxygen. One of the primary respon-

Table 9: **Summary of mortality statistics.**

	Mortality
Number of practices reporting no death	42
Maximum number of deaths in a practice	10
Estimated mortality rate	1:1243
Total deaths per year	190
Highest individual mortality rate	1:130
Lowest individual mortality rate	1:10920
Practices with <1 death per annum	79

Table 10: **Attendance of continuing education** (*n* = 160)**. Continuing education is evaluated against the length of time in private practice.**

Years in practice	Attended CE in last 5 years		Attended CE at any time	
	n	%	*n*	%
<5 years	6	30.00	6	30.00
6–10 years	11	35.48	12	38.71
11–15 years	15	42.86	21	60.00
16–20 years	11	44.00	15	60.00
21–25 years	7	25.93	15	55.56
>25 years	5	21.74	12	54.55

sibilities of an anaesthetist is to maintain a patent airway. This provision remains true when total intravenous anaesthesia is performed. The reason for this is that the reflexes that protect the upper airway are abolished during anaesthesia. Intubation is considered to be the gold standard for maintenance of a patent airway. Because no question with regard to intubation was included, it is difficult to determine the number of patients actually intubated. If one assumes that all the patients that were maintained intravenously were not intubated, a significant number of patients are exposed to potential upper airway complications. Endotracheal tubes are invaluable if an anaesthetic crisis arises[8,9]. Possible complications are not sufficiently important to counter the benefits of routine endotracheal intubation[14]. Total intravenous anaesthesia is a common practice in cats in South Africa.

Halothane was the most frequently-used inhalation agent, and is currently the most cost-effective one available in South Africa. It is worth noting that isoflurane is not necessarily safer than halothane. Halothane sensitises the myocardium to adrenaline, potentially resulting in ventricular arrhythmias[23]. Acetylpromazine has been shown to reduce the sensitivity of the myocardium to halothane and adrenaline[23,25].

Few patients in South Africa (20.5 %) are weighed before anaesthesia. In Canada, 82 % of dogs and 71 % of cats are weighed before anaesthesia[14]. All anaesthetic agents, premedications and other drugs are administered according to body mass (mg/kg). It is very important to weigh patients before anaesthesia. Anaesthetic overdose is a commonly-reported cause of death[6,8]. An overdose can be either relative or absolute. Absolute overdoses may result from incorrect weighing, incorrect estimation of mass and failure to weigh patients before induction of anaesthesia. Accurate weighing can prevent an absolute overdose of anaesthesia. A relative overdose occurs when a patient requires less anaesthetic agent than the calculated dose. A decrease in the amount of anaesthetic required occurs as a result of premedication particularly with alpha$_2$-adrenergic agonists, and the systemic condition of the patient[6,14]. There is also a normal variation in anaesthetic requirements described by a standard bell curve. In practical terms, there is little clinical difference between a relative and an absolute overdose of an anaesthetic agent. Relative overdoses are prevented by the careful titration of an anaesthetic to the required depth of anaesthesia. Most practitioners in this survey did not use a bolus dose technique. The usual technique was to give ½ the required dose as a bolus and to titrate the remainder.

Acetylpromazine was used in 31.7 % of cats and 83.2 % of dogs as a premedication. Acetylpromazine was the most commonly-used premedication in cats and dogs in studies performed in Canada and Vermont[9,14]. Xylazine was used in 43.5 % of cats and 8.7 % of dogs. Xylazine is one of the few premedications that has been associated with an increase in mortality[6,14], but the cause has not been established. Atropine is commonly used as a premedication to prevent salivation and bradycardia during anaesthesia. Atropine was used in combination with xylazine in only a small number of cases; this practice is not encouraged with any of the alpha$_2$-adrenergic agonists[18,19,27]. It is interesting to note that a number of cats (12.4 %) and dogs (5 %) were not routinely premedicated. Premedication renders the induction and maintenance of anaesthesia safer, easier and more pleasant for the patient and anaesthetist[8], and should be based on an assessment of the patient preoperatively and not necessarily routinely performed. However, for practical purposes a standard premedication protocol is usually established in most practices for healthy patients undergoing routine procedures.

Thiopentone was used for induction in 34.2 % of cats and 97.5 % of dogs, and in 21.1 % of cats and 34.8 % of dogs for maintenance. In Canada, thiopentone was used in 52 % of dogs and was not used in cats for induction[14]. Recovery from anaesthesia occurs as the result of redistribution of the anaesthetic drug from the central nervous system to the peripheral compartments. Redistribution in cats is limited, and metabolism of thiopentone is delayed. The use of thiopentone in cats cannot be encouraged, and neither can the use of thiopentone for maintenance be encouraged. Prolonged recoveries lead to increased morbidity and mortality. Alphaxalone/alphadolone was the most commonly-used anaesthetic in cats for induction and maintenance. Alphaxalone/alphadolone is a non-accumulative anaesthetic agent and hence safe to use for the maintenance of anaesthesia[8]. Ketamine has been associated with fewer peri-operative complications than other induction agents[6,14].

From this survey, it is apparent that veterinarians are mainly responsible for the induction and monitoring of anaesthesia. It is also interesting to note that lay staff were more commonly involved in the monitoring of anaesthesia than veterinary nurses. The veterinarian is the most prominent professional staff member responsible for both the induction and monitoring of anaesthesia, and is also the person who performs the procedure. This is not an ideal situation, as the surgeon's concentration is split between 2 very critical procedures, surgery and anaesthesia. A 10-fold increase in mortality has been reported for infants anaesthetised by an inexperienced anaesthetist as opposed to an experienced anaesthetist[1]. Monitoring of patients by professional veterinary staff is associated with a reduction in anaesthetic morbidity[14]. Continual monitoring allows minor changes to be detected before a clinical problem develops[14]. Most problems occur when patients are not under direct supervision. Veterinary anaesthetic mortality could be reduced if dedicated professional staff were responsible for the peri-anaesthetic care and monitoring of patients[14].

Only ¼ (25.5 %) of practices kept anaesthetic records, although it is a legal requirement in South Africa to keep complete records. Records should be designed to enhance the recognition of adverse physiological trends[28], and should indicate the drugs administered, dose, route of administration and time as well as recording all variables monitored at regular intervals (not more than 10 minutes) from induction until an advanced stage of recovery is achieved[28]. A number of authors have underlined the importance of maintaining adequate records and of recording data at regular intervals[2–4,7,20,21,26,28,29,30], although it is tedious and time-consuming. The minimum parameters that should be monitored are: heart-rate through palpation of

a peripheral pulse or auscultation; ventilation, including an assessment of tidal volume and respiratory rate by observation of thoracic wall movements, movement of the rebreathing bag or auscultation of respiratory sounds; oxygenation by observation of mucous membranes, and anaesthetic depth by recording neurological signs associated with the stages and planes of anaesthesia[10,28]. The importance of monitoring well into the post-operative period can not be over-emphasised, as compromised patients tend to die in the post-operative period, when care is less optimal than during anaesthesia[6].

The most commonly-monitored parameter in this survey was respiratory rate (90.7 %) followed by heart rate (52.2 %) and mucous membranes (37.2 %). It is disappointing that so few respondents monitor heart-rate, as it is simple and cost-effective to monitor, requiring no specific equipment. Mucous membranes were also poorly monitored. Cyanotic membranes do indicate a life-threatening problem, but normally-coloured mucous membranes do not necessarily indicate that everything is normal. Neurological reflex monitoring is also simple and cost-effective, requiring no specific equipment, yet fewer than 11 % of respondents monitored this parameter. The reflexes enable one to determine the anaesthetic planes, and in effect should enable the anaesthetist to maintain a stable plain of anaesthesia, preventing the patient from becoming too deeply or lightly anaesthetised during a procedure. Capillary refill time also offers useful information.

Pulse oximetry is a device designed to determine the saturation of haemoglobin and is significantly better at determining hypoxia than observation of mucous membranes[17]. Pulse oximeters are not currently widely available in South Africa. Electrocardiographs are useful for the diagnosis of arrhythmias. These devices are also not commonly available in private practice. Adverse reactions tend to occur when patients are not monitored[6].

The general death rate reported for human anaesthesia is approximately 1:10 000[14]. The reported mortality at Colorado State University was 1:233 (0.43 %) under anaesthesia for dogs and cats[16]. This was a dramatic improvement from the results reported in 1957 when 1:84 (1.2 %) of dogs died under anaesthesia[16]. For Ontario, a mortality rate of 1:909 (0.11 %) for dogs and 1:1000 (0.1 %) for cats under anaesthesia is reported[14]. A Vermont study showed a similar mortality in dogs (1:909, 0.11 %) but a reduced mortality in cats (1:1500, 0.06 %)[9]. A survey of feline anaesthesia in the United Kingdom revealed a mortality rate of 1:334 (0.3 %)[8], while another survey revealed that 1:679 (0.15 %) of healthy dogs and 1:870 (0.11 %) of healthy cats died under anaesthesia[6]. Compromised patients have a higher incidence of mortality, dogs 1:31 (3.3 %) and cats 1:32 (3.12 %)[6]. This brings the overall mortality rate for the United Kingdom to 1:679 (0.15 %)[6]. The mortality rate (1:1243) reported in this study compares favourably with the results from other countries. There is nevertheless much scope for a reduction in peri-operative mortality in veterinary medicine. The death rate in this study may not be accurate, as nobody likes to report negative events.

The most commonly-reported causes for anaesthetic death are hypovolaemia, anaesthetic overdoses, ventilatory failure and anaesthetic machine malfunction[6]. Hypotension (7 % of dogs and 8.5 % of cats) was the most frequent complication associated with anaesthesia in a study at Colorado State University[16]. Hypovolaemia and hypotension are closely associated, and the critical maintenance of circulating volume and blood pressure cannot be over-emphasised. Unfortunately, accurate monitoring of blood pressure and circulating volume is dependent upon specific monitoring equipment. Ventilatory failure can result from too deep an anaesthetic plane, obstruction of the upper airways (laryngospasm in cats), failure to intubate (Pekinese and other brachycephalic breeds and cats, oesophageal intubation, endobronchial intubation), pleural disease (pneumothorax, haemothorax), and mechanical ventilatory failure (diaphragmatic hernia)[6,9,14,16]. Anaesthetic machine malfunctions commonly result in death in humans[5]. Malfunctions resulting in death reported by veterinarians include exhaustion of oxygen cylinders, delivery of hypoxic mixtures (nitrous oxide), and disconnection from the anaesthetic machine[6].

Death may occur during induction, maintenance or recovery from anaesthesia. A higher incidence of death is reported to occur during surgery for dogs[6]. More cats tend to die in the postoperative period but the incidence during surgery is nevertheless high[6]. Compromised dogs and cats have a significant incidence of mortality during surgery and recovery[6]. Peri-operative mortality can be reduced by correct and accurate dosing of drugs, maintenance of a patent airway, adequate ventilation, appropriate and diligent monitoring of the patient, record-keeping, and observation during the recovery period.

It is important to note that the question about continuing education was general. This immediately revealed that some practitioners had attended more than 1 event, while others had attended only 1. The question could have been misunderstood to exclude journal clubs, journal subscriptions and less formal continuing education. The aim of this study was not to formally investigate continuing education among South African veterinarians but merely to gain an insight into its status, and the results should be interpreted accordingly.

Two interesting trends in continuing education have been observed. The first is that more practitioners attended continuing education during the last 5 years than for the preceding period, which was longer ago than 5 years (34.2 % *vs* 26.1 %). This correlates with the increase in the number of continuing education opportunities offered by the Faculty of Veterinary Science, University of Pretoria, the South African Veterinary Association and the regional clinicians' groups. Animal feed and pharmaceutical companies regularly engage international speakers for congresses, short courses and product launches. It is also interesting to note that continuing education was poorly attended by those with less than 10 years experience (0–5 years 30 %, 6–10 years 38.71 %). Newly-qualified graduates are frequently employed as locums when senior partners are on leave or attending continuing education courses. If they are assistants, they may not be offered the opportunity to attend continuing education courses. If practices are newly established, considerable effort is required, allowing little opportunity to be away from the practice.

Participation in continuing education opportunities by veterinarians in South Africa appears to be poor. With the rapid rate of advancement in scientific knowledge, continuing education should be an integral part of veterinary practice. It is difficult to assess the impact of continuing education, because it is difficult to define the outcome objectively[15]. Continuing education, subjectively assessed, appears to impact on the nursing care of human patients[15]. The impact of continuing education has been assessed in production-animal medicine, where the mean age to 1st calving was reduced by 3 months[22]. The present study did not assess the financial impact of better production techniques emphasised by the continuing education programme[22]. Continuing education has been associated with an increased in awareness and treatment of pain by veterinarians and animal health technologists[11,13]. More effective pain management can only be regarded as

admirable. This indicates that continuing education improves the quality and standard of veterinary practice.

CONCLUSIONS

South Africa has a mortality rate under anaesthesia in small animals that is not dissimilar to the rest of the veterinary world. No significant positive or negative correlation could be identified in relation to mortality among small animal patients. Continuing education is generally poorly attended in South Africa. The large area of the country with centralised expertise may be a problem. Currently, there is an initiative to introduce a formally-legislated continuing-education programme for veterinarians, as exists for medical practitioners in South Africa.

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