Veterinary Anaesthesia and Analgesia, 2008, **35**, 365–373 doi:10.1111/j.1467-2995.2008.00397.x

RESEARCH PAPER

The risk of death: the Confidential Enquiry into Perioperative Small Animal Fatalities

David C Brodbelt* MA, VetMB, PhD, DVA Diplomate ECVAA, MRCVS, **Karen J Blissitt†** BVSc, PhD, DVA, Diplomate ECVAA, MRCVS, **Richard A Hammond‡** BSc (Hons), BVetMed, PhD, DVA, Diplomate ECVAA, ILTM, MRCVS, **Prue J Neath§** BSc, BVetMed, Diplomate ACVS Diplomate ECVS, MRCVS, **Lestey E Young*** BVSc, PhD, DVA, DVC, MRCVS, **Dirk U Pfeiffer‡** Dr.med.vet, PhD, MACVSc, Diplomate ECVPH & **James L N Wood*** BSc, BVetMed, MSc, PhD, MRCVS, Diplomate ECVPH

*Animal Health Trust, Lanwades Park, Kentford, Newmarket, Suffolk, UK

†Royal (Dick) School of Veterinary Studies, Easter Bush Veterinary Centre, Roslin, Midlothian, UK

‡Royal Veterinary College, Hawkshead Lane, North Mymms, Herts, UK

§Northwest Surgeons, Delamere House, Sutton Weaver, UK

Correspondence: D. C. Brodbelt, Royal Veterinary College, Hawkshead Lane, North Mymms, Herts, AL9 7TA, UK.
E-mail: dbrodbelt@rvc.ac.uk

Present addresses:

D. C. Brodbelt & D. U. Pfeiffer, Royal Veterinary College, Hawkshead Lane, North Mymms, Herts, AL9 7TA, UK

K. J. Blissitt, Royal (Dick) School of Veterinary Studies, Easter Bush Veterinary Centre, Roslin, Midlothian, EH25 9RG, UK

R. A. Hammond, The School of Veterinary Medicine and Science, The University of Nottingham, Sutton Bonington, Leicestershire, LE12 5RD, UK

P. J. Neath, Northwest Surgeons, Delamere House, Sutton Weaver, WA7 3FW, UK

L. E. Young, Specialist Veterinary Cardiology Services, Moat End, Dunstall Green, Suffolk, CB8 8TZ, UK

J. L. N. Wood, Department of Veterinary Medicine, Cambridge University, Madingley Road, Cambridge CB3 OES, UK

Abstract

Objective To estimate the risks of anaesthetic and sedation-related mortality in companion animals in the UK. (The Confidential Enquiry into Perioperative Small Animal Fatalities, CEPSAF).

Study design A prospective cohort study with nested case–control study.

Animal population All small animals anaesthetized and sedated at participating centres between June 2002 and June 2004.

Methods Patient outcomes at 48 hours (alive, dead and killed) were recorded. Anaesthetic and sedation-related death was defined as death where surgical or pre-existing medical causes did not solely cause death. Species-specific risks of anaesthetic-related death and 95% confidence intervals (95% CI) were calculated. Risks were also estimated in the sub-sets of dogs, cats and rabbits that were either healthy or sick (ASA 1–2 and 3–5, respectively).

Results One hundred and seventeen veterinary practices participated in the study and 98 036 dogs, 79 178 cats and 8209 rabbits were anaesthetized and sedated. Overall risks of anaesthetic and sedation-related death in dogs were 0.17% (1 in 601, 95% CI 0.14–0.19%), in cats 0.24% (1 in 419, 95% CI 0.20–0.27%) and in rabbits 1.39% (1 in 72, 95% CI 1.14–1.64%) within 48 hours of the procedure. In healthy dogs, cats and rabbits, the risks were estimated to be 0.05% (1 in 1849, 95% CI 0.04–0.07%), 0.11%, (1 in 895, 95% CI 0.09–0.14%) and 0.73% (1 in 137, 95% CI 0.54–0.93%), respectively. In sick dogs, cats and rabbits, the risks were 1.33%, (1 in 75, 95% CI 1.07–1.60%), 1.40% (1 in 71, 95% CI 1.12–1.68%) and 7.37% (1 in 14, 95% CI 5.20–9.54%), respectively. Postoperative deaths accounted for 47% of deaths in dogs, 61% in cats and 64% in rabbits. Most

other small animal species had higher mortality risks.

Conclusions and clinical relevance Small animal anaesthesia appears to be increasingly safe. Greater patient care in the postoperative period could reduce fatalities.

Keywords anaesthetic-related, cat, complications, death, dog, mortality, perioperative, rabbit, risk, small animal.

Introduction

The risk of anaesthetic-related death in small animals has not been studied in the UK since the mid 1980s (Clarke & Hall 1990). In the last UK study, 0.11% (1 in 870) of healthy dogs (American Society of Anesthesiologists, ASA physical status 1–2), 0.18% (1 in 552) of healthy cats and approximately 3.3% (1 in 30) of sick dogs and cats (ASA grade 3–5) were reported to have died during or shortly after anaesthesia (Clarke & Hall 1990). In subsequent international studies, the risk in general practice in dogs and cats was estimated at nearer 0.1–0.05% (1 in 1000) of patients (Dodman & Lamb 1992; Rintasalo & Vainio 1995; Dyson et al. 1998; Joubert 2000). Although better than the risk of anaesthetic-related death in horses, 0.9% of non-emergency anaesthetics (Johnston et al. 2002), it was substantially higher than the 0.02–0.005% reported in human anaesthesia (Lunn & Mushin 1982; Tikkanen & Hovi-Viander 1995; Eagle & Davis 1997; Suan et al. 1997; Biboulet et al. 2001; Jones 2001; Kawashima et al. 2001; Braz et al. 2006). Risks of anaesthetic-related death have been poorly documented for other small animal species. Since the previously reported small animal studies were undertaken, new drugs, monitoring and techniques have been introduced into UK practice, making it an appropriate time to re-evaluate the risks of anaesthetic-related death in practice in the UK. The aims of this study were to estimate the risk of anaesthetic and sedation-related death in small animal species in the UK and to describe common characteristics of these deaths.

Methods

A prospective multi-centre cohort study of small animals undergoing anaesthesia and sedation at participating centres was undertaken between June 2002 and June 2004 (The Confidential Enquiry into Perioperative Small Animal Fatalities, CEPSAF). A convenience sample of interested UK practices and referral institutions was recruited to take part in the study. The study was publicized and volunteer practices requested, by publishing letters (Brodbelt et al. 2002) and short articles in the veterinary press and with oral presentations at a number of UK veterinary meetings. Additionally, after the pilot study, a further 49 veterinary hospitals were recruited following a postal and subsequent telephone request of 72 registered veterinary hospitals (RCVS 2001). The study was endorsed by the Association of Veterinary Anaesthetists, the British Small Animal Veterinary Association and the British Veterinary Hospital Association.

Practice characteristics of participating centres were recorded on pre-tested questionnaires and included questions relating to species commonly dealt with, practice standard (BSAVA standard, RCVS hospital status or neither) and per cent referred work. This practice survey was undertaken with face-to-face interviews by the primary investigator (DCB) at the participating centre, except where geographical or time considerations made it difficult to attend the centre. In these latter cases, the questionnaire was posted to the centres and was self-administered. Of 118 centres that participated, one was excluded (outside the UK), 73 were visited (62% of 117 centres) and 44 were not visited (38%). There were no significant differences between centres visited and not visited for practice type (small animal, mixed, veterinary institution), number of veterinary surgeons and nurses, number of postgraduate qualifications or number of fatalities recorded.

Participating centres recorded details of all companion animals anaesthetized and sedated in case diaries supplied. Procedure date, patient identification, species, whether the patient had an anaesthetic or sedation and outcome at 48 hours (alive, dead or killed) were recorded on one line entries for each animal. Anaesthesia was defined as chemical restraint sufficient to allow endotracheal intubation. Sedation was defined as chemical restraint insufficient to allow endotracheal intubation. Anaesthetic- or sedation-related death (a case) was defined as a perioperative death (including killing) occurring after pre-medication and within 48 hours of termination of the procedure, except where death or killing was due solely to inoperable surgical or pre-existing medical conditions. A death was considered

anaesthetic- or sedation-related if anaesthesia or sedation could not be reasonably excluded as a contributory factor.

Anaesthetic- and sedation-related deaths were identified by the participating centres in the first instance and subsequently by the primary investigator from the case diaries of anaesthetics and sedations recorded by each practice. A detailed case–control questionnaire was requested for all deaths unless the practice had no doubt that the death was not related to anaesthesia or sedation. Details of patient, procedure, anaesthetic management, personnel involved and characteristics of death were recorded (questionnaire available from the authors on request). The classification of dog and cat cases was undertaken by an independent review panel (KB, RH, PN, LY) of RCVS Diploma/European College Diplomate level veterinary anaesthetists and surgeons based on the case definition. The panel also used available information to state the cause of death against a specified list of criteria. When the panel could not be confident of the cause of death, the cause was classified as unknown. Case classification and cause of death for other small animal species were classified by the primary investigator (DCB). The panel was unaware of what anaesthetic agents were administered.

Species-specific risks of anaesthetic- and sedation-related death within 48 hours of the procedure (cumulative incidence) were calculated by dividing the total number of cases by the total number of patients anaesthetized and sedated for each species and 95% confidence intervals (95% CI) were calculated by standard methods, with exact confidence intervals reported if <10 deaths were recorded in a species (Kirkwood 1988). In dogs, cats and rabbits, the risks and 95% CI were adjusted for clustering at the clinic level and were compared with the likelihood ratio test (Kirkwood 1988; Levy & Lemeshow 1999). Species-specific risks of anaesthetic- and sedation-related death were additionally compared between general practices and veterinary institutions (five veterinary schools and the Animal Health Trust) using the chi-squared test followed by a *post-hoc* normal test for comparison of proportions (Kirkwood 1988).

Within the cohort study, a case–control study was undertaken to establish risk factors for anaesthetic-related death, although these aspects are not reported here. Detailed questionnaires were completed for all cases as described above, and for a random selection of dogs and cats and for a selection of rabbits matched to each rabbit case, that did not die (the controls). Amongst other things, the health status [healthy (ASA physical status 1–2) and sick (ASA physical status 3–5)] of the animals was reported on these forms. This allowed the estimation of health status-specific risks for dogs, cats and rabbits. Health status-specific risks were calculated from the number of actual cases in each health status category divided by the estimated number of patients anaesthetized and sedated in that health status category. The number of patients anaesthetized and sedated in each health status stratum was estimated from the proportion of the controls recorded from the case–control study with the specific health status, multiplied by the total number of anaesthetics and sedations undertaken in that species during the study period. Ninety-five per cent confidence intervals were calculated and within species differences in risk by health status were compared with the normal test for proportions (Kirkwood 1988). Statistical significance was set at the 5% level.

Results

One hundred and seventeen UK centres participated in the study. During the study, 98 036 dogs, 79 178 cats and 8209 rabbits were anaesthetized and sedated during the 2-year study period (Table 1). The cumulative incidences of anaesthetic and sedation-related death were approximately 0.17% in dogs, 0.24% in cats and 1.39% rabbits within 48 hours of the procedure (Table 1). Risks of anaesthetic- and sedation-related death for other small animal species ranged from 0.33% in ferrets to 16.33% in budgerigars within 48 hours of the procedure (Table 1). Risks of sedation-related death were significantly lower than risks of anaesthetic-related death in dogs, cats and rabbits ($p = 0.007$, $p = 0.012$, $p = 0.048$, respectively) (Table 2).

Estimated risks for healthy patients (ASA 1–2) were 0.05% for dogs, 0.11% for cats and 0.73% for rabbits within 48 hours of the procedure (Table 3). Risks for sick patients (ASA 3–5) were 1.33% for dogs, 1.40% for cats and 7.37% for rabbits within 48 hours of the procedure, which were significantly higher than in healthy dogs, cats and rabbits, respectively ($p < 0.001$). The risks were significantly greater in rabbits than cats or dogs ($p < 0.001$) and the risk in cats was significantly higher than in dogs ($p < 0.001$). The risks of anaesthetic-related death in dogs and cats were

Table 1 Anaesthetic- and sedative-related risks of death in small animals

Species	Number at risk	Number of anaesthetic- and sedative-related fatalities	Risk of anaesthetic/ sedative-related death (%)	95% CI (%)
Dog	98 036	163	0.17	0.14–0.19
Cat	79 178	189	0.24	0.20–0.27
Rabbit	8209	114	1.39	1.14–1.64
Guinea pig	1288	49	3.80	2.76–4.85
Ferret	601	2	0.33	0.04–1.20*
Hamsters	246	9	3.66	1.69–6.83*
Chinchilla	334	11	3.29	1.38–5.21
Rat	398	8	2.01	0.87–3.92*
Other small mammals	232	4	1.72	0.47–4.36*
Budgerigar	49	8	16.33	7.32–29.66*
Parrot	127	5	3.94	1.29–8.95*
Other birds	284	5	1.76	0.57–4.06*
Reptiles	134	2	1.49	0.18–5.29*
Other	50	0	0	0–7.11*

*Exact 95% confidence interval.

Table 2 Risks of anaesthetic- and sedative-related death in dogs, cats and rabbits

Species	General anaesthesia or sedation	Deaths	Number of anaesthetics and sedations	Risk (%)	95% CI (%)
Dog	General anaesthesia	154	85 827	0.18	0.15–0.21
	Sedation	9	12 209	0.07	0.03–0.12
	Overall	163	98 036	0.17	0.14–0.19
Cat	General anaesthesia	177	69 234	0.26	0.22–0.29
	Sedation	12	9944	0.12	0.05–0.19
	Overall	189	79 178	0.24	0.20–0.27
Rabbit	General anaesthesia	107	7211	1.48	1.20–1.76
	Sedation	7	998	0.70	0.18–1.22
	Overall	114	8209	1.39	1.14–1.64

Table 3 Risks of anaesthetic- and sedation-related death in healthy and sick dogs, cats and rabbits

Species	Health status*	Number of anaesthetic-related deaths	Estimated number of anaesthetics	Risk of anaesthetic- and sedation-related death (%)	95% CI (%)
Dog	Healthy	49	90 618	0.05	0.04–0.07
	Sick	99	7418	1.33	1.07–1.60
	Overall†	163	98 036	0.17	0.14–0.19
Cat	Healthy	81	72 473	0.11	0.09–0.14
	Sick	94	6705	1.40	1.12–1.68
	Overall†	189	79 178	0.24	0.20–0.27
Rabbit	Healthy	56	7652	0.73	0.54–0.93
	Sick	41	557	7.37	5.20–9.54
	Overall†	114	8209	1.39	1.14–1.64

*Healthy (ASA 1–2) no/mild preoperative disease, sick (ASA 3–5) severe preoperative disease. †Overall risks include additional deaths for which insufficient information was available (including health status) to exclude them from being classified as anaesthetic-related.

Table 4 Risks of anaesthetic- and sedation-related death in dogs and cats by type of veterinary centre

Species	Health status*	Veterinary practice		Veterinary institution		*p*-value
		Risk (%)	95% CI (%)	Risk (%)	95% CI (%)	
Dog	Healthy	0.054	0.038–0.070	0.057	0.007–0.106	0.911
	Sick	1.32	1.04–1.61	1.22	0.68–1.77	0.754
	Overall	0.15	0.13–0.18	0.29	0.19–0.39	0.001
Cat	Healthy	0.11	0.09–0.13	0.16	0–0.34	0.540
	Sick	1.51	1.20–1.82	0.75	0.01–1.40	0.116
	Overall	0.23	0.19–0.26	0.58	0.30–0.88	< 0.001

*Healthy (ASA 1–2) no/mild preoperative disease, sick (ASA 3–5) severe preoperative disease.

significantly lower for veterinary practices than veterinary institutions ($p < 0.001$), although when stratified by ASA grade there were no significant differences (Table 4).

The postoperative period was the most common time for dogs, cats and rabbits to die. Over 60% of cats and rabbits and nearly 50% of dogs died during this time period (Table 5). Most postoperative deaths occurred within 3 hours of termination of the procedure ($p = 0.034$).

Deaths were classified by the independent review panel as primarily because of cardiovascular and respiratory causes in dogs and cats, accounting for 74% (109/148) and 72% (126/175), respectively, of deaths. Approximately, 20% were of unknown cause (Table 6). In contrast, most rabbit deaths were recorded as of unknown cause, with <40% classified as of cardio-respiratory causes. Cardiovascular causes included clinical descriptions of apparent cardiac arrest often on induction or during anaesthesia and cardiovascular collapse, frequently involving the poorer health status patients. Respiratory causes included cases where clinical signs of airway obstruction, hypoventilation and failure of gas exchange were described. Two dogs died after the adjustable pressure-limiting (APL) valve was left closed. Neurological causes included uncontrolled seizures and failure to regain consciousness postoperatively resulting in cardiopulmonary arrest or killing. Renal causes represented postoperative renal failure resulting in death or killing.

Table 5 Timing of anaesthetic- and sedation-related deaths in dogs, cats and rabbits

Timing of death	Dogs (%)	Cats (%)	Rabbits (%)
After pre-medication	1 (1)	2 (1)	0
Induction of anaesthesia	9 (6)	14 (8)	6 (6)
Maintenance of anaesthesia	68 (46)	53 (30)	29 (30)
Postoperative death*	70 (47)	106 (61)	62 (64)
0–3 hours postoperative	31	66	26
3–6 hours postoperative	11	9	7
6–12 hours postoperative	12	7	13
12–24 hours postoperative	13	12	9
24–48 hours postoperative	3	10	3
Unknown time	0	2	4
Total	148 (100)	175 (100)	97 (100)

*Postoperative deaths were additionally categorized by time after anaesthesia. The per cent values are given within parenthesis.

Table 6 Primary causes of death in dogs, cats and rabbits

Cause of death	Dogs (%)	Cats (%)	Rabbits (%)
Cardiovascular cause	34 (23)	11 (6)	3 (3)
Respiratory causes	20 (13)	16 (9)	13 (13)
Either cardiovascular or respiratory	55 (37)	99 (57)	22 (23)
Neurological cause	7 (5)	8 (5)	2 (2)
Renal	1 (1)	6 (3)	0
Unknown	31 (21)	35 (20)	57 (59)
Total	148 (100)	175 (100)	97 (100)

Deaths are expressed as number of animals (per cent of total). Only cases where a case–control questionnaire was received are included.

Discussion

The risks of anaesthetic-related death appear to have decreased from those reported in the last UK

study and were comparable with more recent international studies (0.1–0.05%) (Clarke & Hall 1990; Dodman & Lamb 1992; Rintasalo & Vainio 1995; Dyson et al. 1998; Joubert 2000). Both sick animal (ASA grade 3–5) and healthy animal (ASA grade 1–2) risks have approximately halved since the last UK study in the mid 1980s. The risks in small animal species other than dogs and cats appear higher and the anaesthesia of these species merits greater attention. More than half of all anaesthetic-related mortalities occurred in the postoperative period and closer monitoring, particularly in the first 3 hours of the postoperative period might aid a further reduction in mortality rates.

It is difficult to compare the different studies of risks of anaesthetic-related death as case definitions, case ascertainment methods and lengths of follow-up vary between studies. The definition of anaesthetic-related death used in the current study aimed at reflecting deaths where anesthesia played a role but may not have been the only cause, and was defined to include all deaths unless it was reasonable to exclude them. The inclusive definition, such that all deaths were considered cases unless it was reasonable to exclude them, attempted to provide a clear and objective cut-off. The use of an independent review panel, to classify the dog and cat cases, was undertaken to increase objectivity of a potentially subjective classification. Comparing the case definition with previous work suggested it was most similar to the definition used for healthy animals (ASA grade 1–2) in the last UK study (Clarke & Hall 1990), where deaths were classified as cases if the underlying disease/surgery could not explain the death. However, in sick animals (ASA 3–5) all deaths independent of cause were included in the last study (Clarke & Hall 1990), reflecting a broader definition for the sick animals than in the current study and this may in part have contributed to the reduction in risk reported here in the poor health status group. Comparisons with international practice-based work were more difficult as the definition of anaesthetic death was not stated in some work and in other studies, it referred to death as a result of cardiac arrest only (Dodman & Lamb 1992; Dyson et al. 1998; Joubert 2000).

Methods used for case ascertainment and length of follow-up also varied between studies and it is likely this too would have affected the risks of death recorded. Two of these reports (Dodman & Lamb 1992; Joubert 2000) relied on practitioners' recall over an extended time period (previous 1–2 years) and given unclear case definitions, these studies may have only identified deaths primarily because of anaesthesia and lower risks would be expected. The 48-hour follow-up period in the current study was elected to minimize losses to follow-up. Longer periods such as 7 days, as used in the recent equine study (CEPEF) (Johnston et al. 2002, 2004), were considered more likely to increase losses to follow-up (Hennekens & Buring 1987). This concern was considered more important than the loss of a small number of anaesthetic-related deaths occurring after 48 hours. In the previous small animals studies described, the durations of patient follow-up were not specified; hence, close comparisons of risks between studies remains difficult. However, the results from the current study suggest standards have improved since the last UK study and were generally comparable with risks of death reported in recent international studies.

Although the risks of death reported suggest improved standards of anaesthesia, the risk of anaesthetic-related death in human anaesthesia appears consistently lower. Recent studies evaluating deaths where anaesthesia played a contributory role in human anaesthesia, documented risks of approximately 0.02–0.005% (Tikkanen & Hovi-Viander 1995; Eagle & Davis 1997; Suan et al. 1997; Biboulet et al. 2001; Kawashima et al. 2001). Differences in standards of anaesthesia, including the level of training of those involved and the facilities available, are more likely to explain these substantially lower results in human anaesthesia than species differences. Hence, although standards of anaesthesia in small animal practice appear to have substantially increased, additional improvements are merited to reduce fatalities further.

Sedation and anaesthesia were studied as both were considered relevant to a practice-based study of risks. Risks of death were significantly greater for patients undergoing anaesthesia than sedation. However, the data were sparse for sedated patients (approximately 12% of all dogs, cats and rabbits studied and 6% of deaths were sedated as opposed to anaesthetized) and when adjusted for patient health status these differences were reduced, suggesting confounding by health status. Hence, conclusions of reduced risk with sedations may not be valid. For the reporting of other risks sedations and anaesthetics were combined as there were relatively few sedations (as discussed above), it was thought that

they represented different ends of a spectrum of chemical restraint in animals, and risks of death for sedation compared with anaesthesia when adjusted for health status were not sufficiently different.

Sick animals had a substantially higher risk of anaesthetic- and sedation-related death compared with healthy patients, as previous studies have reported (Clarke & Hall 1990; Dyson et al. 1998; Hosgood & Scholl 1998, 2002; Brodbelt et al. 2006), suggesting this group of animals remain a particular concern. Risks of greater than 1% in the ASA 3–5 animals highlight a population at substantial risk and greater care is required in the perioperative management of these animals.

Risks of death reported for veterinary institutions within the current work were higher than the risk reported by veterinary practices. This was consistent with previous work in which the risk of anaesthetic-related death in referral centres was much higher than that of practice-based centres (Hosgood & Scholl 1998, 2002; Gaynor et al. 1999; Brodbelt et al. 2006). However, when stratified by health status, the risks were not significantly different suggesting much of the difference in risk was due to a higher risk population being treated by the referral institutions. Only cats and dogs were reported in this section as insufficient other species were anaesthetized at the referral institutions.

The significantly increased risk reported in cats compared with dogs, particularly in healthy patients (ASA 1–2) was of note. This agrees with the results of Clarke & Hall (1990) and Hosgood & Scholl (1998, 2002), but contrasts with work by Dodman & Lamb (1992) and Dyson and Pettifer (1997). These latter studies had smaller sample sizes and the lack of difference may have been due to insufficient statistical power. That apparently healthy cats (ASA 1–2) had a twofold higher risk of death than healthy dogs, would suggest either preoperative assessment is poorer and more cats are misclassified as healthy when harbouring significant disease, or cats are at a greater risk of anaesthetic-related death. Cats are smaller than dogs in general and hence would be more prone to hypothermia, pre-disposing to prolonged recoveries and increased morbidity (Waterman 1981; Dhupa 1995; Kurz et al. 1996). The reduced size could predispose to overdosing of anaesthetics administered, particularly in patients that were not weighed. Endotracheal intubation has been associated with increased risk of death in cats but not dogs (Clarke & Hall 1990; Dyson et al. 1998; Brodbelt 2006; Brodbelt et al. 2007). The technique is technically more difficult and laryngospasm more likely in cats than dogs, pre-disposing to perioperative complications (Hall & Taylor 1994).

Rabbits were the third most commonly anaesthetized species, and the risk of death was approximately seven times greater than that reported for dogs. Rabbits may exhibit stress on induction of anaesthesia, have a high-surface area to volume ratio predisposing to perioperative hypothermia, and have a predilection to preoperative diseases involving respiratory, digestive and fluid balance disorders (Aeschbacher 1995; Flecknell 1996b). Many rabbits presenting for anaesthesia have been reported to carry *Pasteurella multocida* respiratory infections (Flecknell 1996b). They have fewer easily accessible veins for venous catheterization and endotracheal intubation is more technically demanding than in dogs and cats (Aeschbacher 1995). Combined with a perceived increased sensitivity to the respiratory depressant effects of anaesthetics and a narrow therapeutic index for many of the anaesthetic agents (Aeschbacher 1995), a higher risk of anaesthetic death could be anticipated. There are no other large-scale studies of anaesthetic death risks to compare with; hence, it is difficult to conclude whether there has been improvement in the anaesthesia of rabbits over the last 20 years. However, it is clear there is scope for a substantial reduction in mortality.

The large proportion of deaths in dogs, cats and rabbits that were postoperative, representing 50–60% of deaths, was of note. This contrasts with previous work where around 40% of dogs and cats died postoperatively (Clarke & Hall 1990). However, both studies highlight the importance of the risks in the postoperative period. That nearly 50% of the postoperative deaths in this study occurred within 3 hours of the end of anaesthesia suggested that if closer monitoring and management of patients in this early postoperative period were instituted, then mortality might be reduced. The large number of postoperative deaths that were classified as of unknown cause probably reflected that patients were less closely monitored postoperatively.

The cause of death was only broadly classified in the current study. This reflected the available information, such that it was not always possible to confidently state the specific cause, for example whether respiratory compromise proceeded cardiovascular demise or vice versa. The independent review panel aimed to state the cause of death they were confident of, based on the available

information, and in many cases this allowed only a broad classification. Additionally, in only approximately 10% of patients was a post-mortem undertaken, making exact classification of death more difficult. Nonetheless, the presence of the independent review panel and their classification of deaths against a specified list of criteria should have provided a consistent and valid classification of the general cause of death.

Cardiovascular and respiratory causes of death were similarly important in dogs and cats although unknown causes were pre-eminent in rabbits. Cardiac arrests and cardiovascular collapse were comparably described in dogs and cats and occurred throughout the perioperative period. Respiratory causes were also similar, although respiratory obstruction tended to be more frequently reported in cats. Many deaths were of unknown cause postoperatively, as discussed above, and this was particularly so in rabbits. Some of this large unknown category for cause was likely to reflect that most rabbits died postoperatively when less closely monitored, but additionally the standards of intra-operative monitoring were generally lower in rabbits than dogs and cats, with only respiration being observed for many rabbits.

Mortality risks in other small animal species were generally higher again than those reported in rabbits. Birds appeared to be at particularly high risk, as were small mammals such as hamsters, chinchillas and mice. It is likely that small body size contributed to these high risks, with all these species having high surface area to volume ratios, again pre-disposing to hypothermia during anaesthesia (Flecknell 1996b). Additionally, they generally have high metabolic rates and would be prone to perioperative hypoglycaemia until they resumed eating postoperatively (Flecknell 1996a). Because of their small size, their tracheas were less commonly intubated, therefore maintaining a patent airway and adequate ventilation would be more difficult. Only a small number of each species were anaesthetized or sedated and the relative inexperience of veterinary surgeons with these patients was likely to have contributed to the high perioperative mortality risks.

Given that the data were collected prospectively within a large-scale multi-centre cohort, it is likely the overall risks reported for dogs, cats and rabbits were representative of the population studied. The health status stratum-specific risks reported for dogs, cats and rabbits could only be estimated. Based on the proportion of each health status group in the control population derived from the case–control study, these estimates were dependent on an accurate reflection of the control population by the controls selected. The ASA grade 3–5 risks were inherently less precise than the ASA 1–2 risks, as a small error in the proportion of controls estimated would have had a large effect on the relatively small denominator of sick patients anaesthetized. In contrast, the low risks for the ASA 1–2 group would be only minimally affected by errors in the estimates of the proportion of healthy patients being anaesthetized, as the denominator would be less affected by small errors in the proportion of healthy controls. Hence, assuming an unbiased selection of the controls, these estimates are likely to be reasonably reflective of the populations anaesthetized.

In conclusion, the risks of anaesthetic-related death appear to have substantially decreased in dogs and cats over the last 20 years in the UK and are comparable with risks reported internationally. Animals undergoing sedation may be at a lower risk of death than those undergoing anaesthesia, although further work is required to confirm this. Sick animals remain particularly at risk of perioperative death and should be targeted for improvements in anaesthetic management. Cats, rabbits and other small animal species appear to be at greater risk of anaesthetic-related death than dogs and particular attention to these species could reduce mortality substantially. The postoperative period represented a particularly high risk and greater patient monitoring and management during this time period is recommended.

Acknowledgements

The authors would like to acknowledge Drs J. Brearley, G.M. Johnston and P.M. Taylor for their contribution to the development of the project. Particular thanks are due to the practices and veterinary referral centres and their staff who provided all the data on which this study is based. CEPSAF was funded by Pfizer Animal Health.

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Received 21 December 2006; accepted 12 March 2007.