Papers

Retrospective study of the prevalence of postanaesthetic hypothermia in cats

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A retrospective study of 275 anaesthetic records of cats was undertaken to examine the prevalence of postanaesthetic hypothermia, its clinical predictors and consequences. Temperature was recorded throughout anaesthesia. The temperature reached at the end was classified as hyperthermia (>39.50°C), normothermia (38.50 to 39.50°C), slight hypothermia (38.49 to 36.50°C), moderate hypothermia (36.49 to 34.00°C) or severe hypothermia (<34.00°C). Statistical analysis consisted of multiple regression to identify the factors that affect the temperature at the end of the procedure. Before premedication, the mean (sd) temperature was 38.2 (1.0)°C. At 60, 120 and 180 minutes from induction, the temperature was 35.4 (1.4)°C, 35.0 (1.5)°C and 34.6 (1.5)°C, respectively. The prevalence of hypothermia was slight 26.5 per cent (95 per cent CI 21.7 to 32.0 per cent), moderate 60.4 per cent (95 per cent CI 54.5 to 66.0 per cent) and severe 10.5 per cent (95 per cent CI 7.4 to 14.7 per cent). The variables associated with a decrease in the temperature recorded at the end of anaesthesia were the duration of anaesthesia, the reason for anaesthesia (abdominal and orthopaedic surgeries significantly reduced the temperature when compared with minor procedures) and the anaesthetic risk (high-risk cats showed lower temperatures than low-risk cats). The temperature before premedication was associated with an increase in the final temperature.

THE combination of anaesthetic-induced impairment of thermoregulatory control and exposure to a cool operating room environment make most anaesthetised patients hypothermic (Sessler 2001). In human beings, about 28.3 to 57.8 per cent of patients admitted to intensive care units after a surgical procedure enter with a temperature below 35°C (Kongsayreepong and others 2003, Abelha and others 2005). However, the prevalence of hypothermia after anaesthesia in cats has not been documented clinically.

In human medicine, perioperative hypothermia is associated with a variety of adverse outcomes, including an increase in the prevalence of surgical wound infection (Kurz and others 1996), higher intraoperative blood loss (Schmied and others 1996), more frequent morbid cardiac events and postoperative ventricular tachycardia (Frank and others 1992), an increase in urinary nitrogen excretion (Carli and MacDonald 1996), and longer postoperative shivering (Just and others 1993), postanaesthetic recovery (Lenhardt and others 1997) and hospitalisation (Kurz and others 1996). Few studies have been undertaken in veterinary medicine. In dogs, hypothermia is a common complication of general anaesthesia and surgery, and is associated with a slower recovery from anaesthesia (Pottie and others 2007). Mild perioperative hypothermia is not a significant risk factor for postoperative wound infection with clean surgical wounds (Beal and others 2000).

The aims of this study were to estimate the prevalence of hypothermia in anaesthetised cats and to retrospectively identify its clinical predictors. A second objective was to evaluate the outcome measured in terms of the length of the time to extubation and mortality.

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Materials and methods

Patients

A retrospective study was performed on the anaesthetic records of cats anaesthetised at the Veterinary Clinical Hospital of Cardenal Herrera University (HCVUCH). The animals were anaesthetised in order to carry out various surgical or diagnostic procedures. Only cats with complete records, anaesthetised in the operating theatres, the x-ray room and the CT scan room, were studied. The environmental temperature at the hospital was controlled by air conditioning and maintained at between 20 and 25°C. Cats were placed on a plastic mat (Soporte quirúrgico colchón 50 x 100 cm; Henry Schein) during the procedures. Active methods were not used to heat the cats during anaesthesia. The only devices used were blankets.

Studied variables

The following data were recorded:

Signalment: sex (SEX); age in months (AGE); weight in kg (WEIGHT) of the cat; and body surface in m^2 (BS), calculated as (10 x WEIGHT$^{2/3}$)/100 (Rosenthal 1995).

Reasons for anaesthesia have been coded into five categories: minor surgery (MIN; ie, wound suture, mastectomy, orchidectomy, dental procedures, etc); orthopaedic and trauma surgery (ORTH; ie, fracture and luxation repair); abdominal surgery (ABD; ie, enterectomy, caesarean section, ovariohysterectomy, etc); and diagnostic techniques (DIAG; ie, endoscopy, computerised axial tomography, radiography, etc).

TABLE 1: Total prevalence of hypothermia among 275 cats in relation to sex, American Society of Anesthesiologists anaesthetic risk (ASA), reason for anaesthesia and recumbency

		Hyperthermia	Normothermia	Slight hypothermia	Moderate hypothermia	Severe hypothermia	Number of cats
Total		2	5	73	166	29	275
Sex	Male	0	4	41	116	15	99
	Female	2	1	32	50	14	176
ASA	I	0	3	38	69	2	112
	II	2	2	24	58	13	99
	III	0	0	7	32	7	46
	IV	0	0	4	7	7	18
Reason	MIN	2	2	29	14	3	50
	DIAG	0	0	4	6	0	9
	ORTH	0	1	8	53	15	77
	ABD	0	2	32	93	11	138
Recumbency	LR	1	2	23	59	16	101
	DR	0	3	47	105	13	168
	SR	1	0	3	2	0	6

MIN Minor surgery, ABD Abdominal surgery, DIAG Diagnostic procedures, ORTH Orthopaedic surgery, LR Lateral recumbency, DR Dorsal recumbency, SR Sternal recumbency

TABLE 2: Predictors of temperature (°C) at the end of the procedure in 275 cats by multiple regression analysis

Variable	β	P	95% CI for β Lower	Upper
Basal temperature	0.14	0.02	0.05	0.53
Duration of anaesthesia (minutes)	−0.10	0.01	−0.01	0.00
Reason				
ORTH	−0.45	0.00	−1.95	−0.97
ABD	−0.38	0.00	−1.53	−0.70
Anaesthetic risk				
High risk	−0.14	0.02	−1.10	−0.24

ABD Abdominal surgery, ORTH Orthopaedic surgery, β Standardised coefficients for the studied variables in the multiple regression model

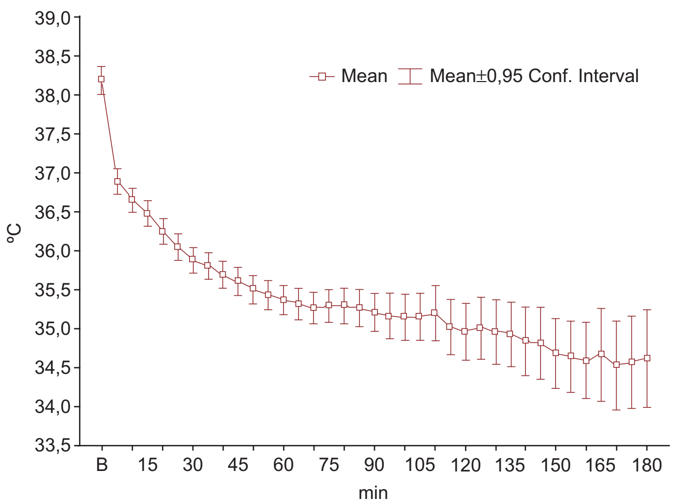

FIG 1: Mean (95 per cent CI) body temperature during the first three hours of anaesthesia in 275 cats

Based on the 'Anaesthetic Risk for the Patients according to American Society of Anesthesiologists (ASA)' criteria, the animals were grouped into low-risk subjects (LowR: ASA I and ASA II) and high-risk subjects (HighR: ASA III and ASA IV).

The recumbency during anaesthesia was recorded as dorsal (DR), lateral (LR) or sternal recumbency (SR). In animals with multiple recumbencies (eg, dorsal and lateral), the recumbency in which the cat spent the longest period of time was considered.

Basal temperature (TAB) is the rectal temperature that was measured before the premedication with a digital thermometer (Thermoval Classic; Hartmann International).

Oesophageal temperature was measured every five minutes after induction during anaesthesia (TA) with a multiparametric monitor (AS3 Haemodynamic and Respiratory Monitor; Datex-Ohmeda).

Final temperature (TAF) was defined as the temperature recorded at the end of the procedure, when the administration of the hypnotic (intravenous or volatile agent) was stopped. TAF was coded in a new ordinal variable called HYPOTH into five classes: hyperthermia (>39.50°C), normothermia (38.50 to 39.50°C), slight hypothermia (38.49 to 36.50°C), moderate hypothermia (36.49 to 34.00°C) and severe hypothermia (<34.00°C).

The duration of the procedure was classified in three phases: preanaesthetic time (TIND: time in minutes from the administration of the premedication to anaesthesia induction), anaesthetic time (TANES: time in minutes from the induction to the end of the administration of the hypnotic agent) and time to extubation (TEXT: time in minutes from the end of hypnotic agent administration to the recovery of voluntary swallowing). All cats were intubated.

Anaesthetic death was recorded if cats died in the time period between the administration of premedication and 72 hours after endotracheal extubation. Cats that were euthanased during the procedure because they had severe preexisting lesions were excluded from this study.

Statistical study

Statistical analysis was performed using a computer program (Statistica for Windows, version 6.0; StatSoft).

Coding the variables

Three types of predictor variables were coded in the model: variables coding values of continuous variables (such as age, weight, body surface, duration of the procedure, temperature, etc); those coding the sex (the variable was coded as 1 if the cat was female and 0 if it was male); and those coding categorical or ordinal items (such as anaesthetic risk, reason for anaesthesia and recumbency, where 'dummy' using k-1 indicator variables for k categories of the item is set up) (Wolters and others 1996). To simplify the model, the reference categories for anaesthetic risk, reason for anaesthesia and recumbency were, respectively, low-risk cats, minor surgery and lateral recumbency.

Statistical analysis

Data were examined for normality using the Kolmogorov-Smirnov test. When normal data distribution was found, parametric statistics were applied. When data were non-normally distributed, a non-parametric Fisher's exact test was used.

Three different statistical studies were performed. In all analyses, the differences were considered statistically significant if $P<0.05$.

The first analysis described the studied population, the temperature evolution during anaesthesia and the prevalence of hypothermia at the end of the procedure. The second analysis described the relationship between the temperature at the end of the procedure and sex, age, body surface, elapsed time from sedation to anaesthesia induction, the duration of anaesthesia, anaesthetic risk, reason for anaesthesia and recumbency, and was estimated using multiple regression. In this analysis, data greater than or less than three times the standard deviation were considered outliers and were excluded from this analysis. According to this, four cases (30.4°C, 31.7°C, 32.2°C and 32.2°C) were excluded in this analysis. Outliers are atypical (by definition), infrequent observations. Because of the way in which the regression line is determined (especially the fact that it is based on minimising not the sum of simple distances but the sum of squares of distances of data points from the line), outliers have a profound influence on the

TABLE 3: Time to extubation in minutes (mean (sd)), deaths and mortality index by ranks of hypothermia in 275 cats undergoing anaesthesia

	Time to extubation (minutes)	Number of cats	Deaths	Mortality index (%)
Hyperthermia	23 (0)	2	0	0
Normothermia	13 (11)	5	0	0
Slight hypothermia	12 (7)	73	2	2.73
Moderate hypothermia	13 (10)	166	2	1.20
Severe hypothermia	26 (25)	29	2	6.89
Total	14 (12)	275	6	2.18

slope of the regression line and consequently on the value of the correlation coefficient. A single outlier is capable of considerably changing the slope of the regression line and, consequently, the value of the correlation. Non-significant variables were removed one by one, removing the largest P value first, until all remaining variables in the model were significant.

The third analysis studied the relationship between the degree of hypothermia reached at the end of the procedure, the TEXT and the prevalence of death. For this, a linear regression between TEXT and the TAF was performed, as well as an analysis of variance and a post hoc Tukey's test for comparing TEXT of the five ranks considered in HYPOTH. Finally, a Fisher's exact test was performed to study the prevalence of the deaths by ranks of HYPOTH.

Results

A total of 275 anaesthetic records of cats were included in this study. Another 23 cats were excluded because they were not anaesthetised in the operating theatres, x-ray rooms or the CT scan rooms, and 17 cats were also excluded because they did not have complete records. Nine cats were euthanased during the procedure and they were also excluded from the study.

Four different breeds were registered: 237 domestic shorthair, 23 Siamese, 13 Persian and two Norwegian forest cats. Ninety-nine males and 176 females were recorded. The mean (sd) age of the cats was 32 (29) months (range 1.5 to 225 months) and their weight was 3.2 (1.0) kg (0.6 to 6.5 kg).

According to the ASA criteria, 112 ASA I, 99 ASA II, 46 ASA III and 18 ASA IV cats were recorded. The reason for performing anaesthesia was coded into four groups: MIN 50 animals, ORTH 77, ABD 138 and DIAG 10. The recumbency during the procedure was LR 101, DR 168 and SR 6. Mean (sd) TIND was 37 (18) minutes (one to 140 minutes). The mean TANES was 96 (57) minutes (five to 395 minutes).

Mean basal temperature was 38.2 (1.0)°C (range 32.6 to 40.0°C). A total of 5032 intraoperative temperature readings were taken (mean (sd) 35.6 (1.5)°C, range 32.6 to 40.0°C). The change in temperature during the procedure is presented in Fig 1. At five, 60, 120 and 180 minutes from induction, the mean (sd) temperature was 36.9 (1.3) (range 33.2 to 39.9), 35.4 (1.4)°C (32.3 to 39.6°C), 35.0 (1.5)°C (30.9 to 38.4°C) and 34.6 (1.5)°C (30.7 to 37.4°C), respectively. At the end of the procedure, two cats showed hyperthermia (0.73 per cent; 95per cent CI 0.2 to 2.6 per cent), five showed normothermia (1.8 per cent; 95 per cent CI 0.8 to 4.8 per cent), 73 slight hypothermia (26.5 per cent; 95 per cent CI 21.7 to 32.0 per cent), 166 moderate hypothermia (60.4 per cent; 95 per cent CI 54.5 to 66.0 per cent) and 29 severe hypothermia (10.5 per cent; 95 per cent CI 7.4 to 14.7 per cent). The prevalence of hypothermia in relation to sex, ASA, reason for anaesthesia and recumbency are shown in Table 1.

The multiple regression model showed that there were some clinical predictors of the temperature at the end of the procedure (Table 2). The variables that were associated with a decrease in the temperature recorded at the end of anaesthesia were the duration of anaesthesia, the reason for anaesthesia (abdominal and orthopaedic surgeries were associated with statistically significant reductions in the temperature when compared with minor procedures) and the anaesthetic risk (high-risk cats showed lower temperatures than low-risk cats). The basal temperature was the only variable that was associated with an increase in the final temperature (Table 2). On the other hand, sex, age, body surface and the time to induction were not significant predictors of the temperature at the end of the procedure.

The simple linear regression between TEXT and TAF showed a weak but significant relationship between these variables ($R=0.203$; $P=0.002$). Lower temperature was statistically associated with longer extubation times. TEXT of severely hypothermic patients was longer than the rest of the groups. Data are shown in Table 3.

Six cats died (2.2 per cent; 95 per cent CI 0.7 to 4.0 per cent): one ASA I, one ASA II, one ASA III and three ASA IV. All of them were female. Three died as a result of preexisting lesions, one due to glottis oedema, one as a consequence of oesophageal intubation and in one the cause of death was not established. At the time of death, two of these cats showed slight hypothermia, two moderate and two severe hypothermia. There were no differences in the prevalence of death after studying the different groups. Data are shown in Table 3.

Discussion

The normal feline temperature range is 37.8 to 39.2°C (Armstrong and others 2005). Hypothermia is defined as a core body temperature less than 37.0°C, and three classes are recognised in veterinary patients: mild (32 to 35°C), moderate (32 to 28°C) and severe (<28°C) (Armstrong and others 2005). Using this classification, most readings in this study would be included in the range of mild hypothermia. As only 36 readings (0.71 per cent) fell below 32°C, with none below 28°C, the categories were modified in this study. The definitions of mild, moderate and severe hypothermia were modified and based on the authors' own opinions to facilitate analysis.

In human medicine, hypothermia is a frequent complication (Kongsayreepong and others 2003, Abelha and others 2005, Kiekkas and others 2005). In cats, the prevalence of hypothermia has not been documented in clinical studies until now. This study shows a very high prevalence of this complication: 96.7 per cent of cats showed hypothermia at the end of the anaesthetic procedure.

There are a variety of causes associated with perioperative hypothermia. This study identified several factors associated with the evolution of body temperature during anaesthesia in the cat. These can be summarised in three groups: first, variables related to the animal's signalment (basal temperature); second, variables related to the anaesthetic risk and the intervention (reason for anaesthesia and the anaesthetic risk); and third, the duration of anaesthesia.

The basal temperature is a very important factor. In this study, a warmer preoperative body temperature was considered a significant protective factor for hypothermia, as has also been demonstrated in human medicine (Just and others 1993, Kongsayreepong and others 2003, Abelha and others 2005). These results support the suggestion that efforts should be made to maintain body temperature before surgery. Increasing the operating room temperature (Kongsayreepong and others 2003, Abelha and others 2005) and the use of devices to warm the patient (Machon and others 1999) may prevent heat loss during anaesthesia.

The reason for anaesthesia is a significant risk factor for core hypothermia at the end of the procedure. In human medicine, the magnitude of the surgical procedure is a well-known risk factor (Kongsayreepong and others 2003, Abelha and others 2005). In this study, orthopaedic and abdominal surgeries produce significantly lower body temperatures than minor surgeries or diagnostic tests. Orthopaedics requires major preparation of the surgical field, and thus increases the heat loss. In abdominal surgery, a body cavity is open and evaporative heat loss is increased. Anaesthesia for diagnostic tests produces less hypothermia as the cats' fur is not clipped and/or antiseptic cold solutions are not used.

As in human patients, the higher the ASA physical status, the greater the risk of hypothermia. High-risk patients have problems regulating their temperature, which increases the risk for core hypothermia (Kongsayreepong and others 2003). However, some of the association detected may result from the relationship between ASA and procedure, because sicker patients may on average have more invasive and/or longer procedures.

Finally, the duration of anaesthesia is a significant variable. In human medicine, surgery lasting longer than two hours increased the risk of core hypothermia (Kongsayreepong and others 2003, Abelha and others 2005). In this study, the data indicated that in the first hour the cats lost 1.2°C, during the second hour 0.7°C and in the third hour 0.4°C. It has previously been reported that the decrease in temperature takes place in three stages, not linearly (Armstrong and others 2005), as these observations confirm.

The relationship among hypothermia, time to extubation and anaesthetic death were also studied. In severely hypothermic patients, the time to extubation was significantly longer than the rest of the groups. Previously, a slower recovery from anaesthesia in hypothermic dogs was observed (Pottie and others 2007). Hypothermia reduces the anaesthetic requirements, since it delays the hepatic metabolism of the drugs, prolongs its action and delays recovery from anaesthesia (Haskins 1993). Six cats died (2.2 per cent). In five of them, the cause of death was related to the preexisting lesions or anaesthetic complications not directly related to hypothermia. However, one severely hypothermic cat died six hours after extubation and the cause could not be determined. This risk of death is high in relation to previous studies (Dyson and others 1998, Brodbelt and others 2008). This was consistent with the previous work in which the risk of anaesthetic-related death in referral centres was much higher than that of the practice-based centres (Gaynor and others 1999, Brodbelt and others 2008). It may well reflect the population and/or procedures undertaken. In human anaesthesiology, hypothermia is associated with significantly increased mortality during the postoperative period (Bush and others 1995). Hypothermia can produce alterations in cardiac (Orts and others 1992) and hepatic function (Cabell and others 1997), coagulation (Patt and others 1988), humoral and cellular immunity (Orts and others 1992, Kurz and others 1996) and wound healing (Beal and others 2000). Hypothermia may have contributed to exacerbation of the cat's condition and to its death. However, this study could not demonstrate a relationship between hypothermia and an increase in mortality. Clinical studies involving a larger number of cats may clarify this point.

In conclusion, hypothermia is a very frequent anaesthetic complication in cats. To reduce the prevalence, more efforts should be made to prevent before and during core hypothermia, especially in smaller animals with higher ASA physical status and in animals undergoing more-intensive and lengthy surgeries.

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