RESEARCH PAPER

Effect of theatre temperature on body temperature during anaesthesia for routine neutering of domestic rabbits (*Oryctolagus cuniculus*)

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Abstract

Objective To investigate the effect of theatre temperature on body temperature in rabbits undergoing castration or ovariohysterectomy surgery during general anaesthesia.

Study design Prospective, clinical study.

Animals A group of 88 rabbits presented for elective neutering.

Methods Rabbits were divided into male (31/54) and female (23/54) groups and assigned to one of two theatre temperatures via coin toss. Theatre temperature was 23 °C (±2 °C) for group A (n = 37/54) and 28 °C (±2 °C) for group B (n = 17/54). During anaesthesia and recovery, theatre temperature and rectal temperature were recorded every 5 minutes. Time to resumption of feeding and passing faeces were recorded. Data are presented as median (interquartile range) or mean (± standard deviation). Statistical analyses comprised a mixed-effects model, with Sidak's multiple comparison test for *post-hoc* testing and Fisher's exact test; $p < 0.05$.

Results A total of 54 rabbits completed the study, with median age 6 (4–9) months and median weight 1.53 (1.30–1.79) kg. In rabbits undergoing castration, theatre temperature did not significantly affect body temperature. Mean temperatures immediately after induction were 38.6 °C and 38.7 °C and at the end of the procedure 38.5 °C and 38.5 °C for group A and group B, respectively. In rabbits undergoing ovariohysterectomy, mean temperatures immediately after induction were 38.3 °C and 38.8 °C and at the end of the procedure 38.1 °C and 39.2 °C for group A and group B, respectively. Rabbits undergoing ovariohysterectomy at an ambient temperature of 28 °C had a significantly higher final temperature, mean ± 1.15 °C (95% confidence interval, 0.47–1.83), compared with 23 °C (p = 0.001). Theatre temperature did not affect return to feeding or defaecating.

Conclusions and clinical relevance During anaesthesia an ambient theatre temperature of 28 °C may reduce the risk of hypothermia in rabbits undergoing ovariohysterectomy or similarly invasive surgery.

Keywords anaesthesia, hypothermia, rabbit, temperature, theatre.

Introduction

Hypothermia is a common complication in animals during general anaesthesia and has been associated with a slower recovery from anaesthesia in dogs and cats (Pottie et al. 2007; Redondo et al. 2012a,b). Hypothermia increases the risk of postoperative infection in humans and guinea pigs (Sheffield et al. 1994; Frisch et al. 2016). It also delays surgical wound healing owing to the reduced levels of oxygen within the tissues that result from thermoregulatory vasoconstriction in humans (Kurz et al. 1996). Hypothermia can also inhibit immune function and the inflammatory response and will increase the risk of infection (Polderman 2012). During anaesthesia, heat loss and decrease in body temperature occur because of convection, conduction, evaporation and radiation, with radiation accounting for approximately 60% of heat loss (Díaz & Becker 2010). This is of particular significance in smaller mammals that have a high surface area to bodyweight ratio leading to rapid changes in temperature (Cantwell 2001).

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The largest study comparing anaesthetic morbidity across several species, found that rabbits are often at a higher risk of anaesthetic-related complications compared with larger animals such as dogs and cats (Brodbelt et al. 2008). Multiple predisposing factors probably play a role including subclinical disease and the increased stress response of prey species, but perioperative hypothermia was hypothesized as a key problem. Prevention of hypothermia is therefore important in avoiding anaesthetic complications in smaller animals. Standard practice would be the application of passive and active surface rewarming devices such as blankets, warm water bottles, circulating warm water heating pads and forced air warming blankets (Armstrong et al. 2005). A previous study showed that forced air warming blankets were superior to heat pads in limiting heat loss during anaesthesia in medium-sized dogs (Clark-Price et al. 2013), and a forced-air warming system outperformed both an infrared heat emitter and circulating-water blanket in providing active warming of laboratory rodents (Rembert et al. 2004). By contrast, a study of anaesthetized laboratory rabbits found that warm-water blankets slightly outperformed forced-air warmers. Both devices maintained body temperatures within the normal range and temperatures were significantly higher than in anaesthetized rabbits without the use of heating devices (Sikoski et al. 2007). Forced-air warming increases ambient temperature around the animal but consequently results in reduced humidity in the microenvironment, so unprotected eyes or viscera may be prone to drying during lengthy procedures (Rembert et al. 2004). Corneal ulceration is a common complication of anaesthesia in rabbits (Bedard 2019), so the ideal heating method would maintain body temperature without significantly reducing local humidity. Prewarming is another method of reducing the prevalence of hypothermia in anaesthetized animals. In a study performed in dogs weighing < 10 kg, prewarming in an incubator at 33 °C did not reduce the risk of hypothermia (Rigotti et al. 2015). However, prewarming rats with a forced air device maintained temperature for a longer period, although animals became hypothermic after approximately 19 minutes of anaesthesia (Rufiange et al. 2020). A previous study in rats found that body temperature was maintained during anaesthesia, but the animals also suffered a degree of hypothermia postoperatively (Schuster and Pang 2018).

Using the same concept of increasing ambient temperature, increasing theatre temperature reduced the incidence of hypothermia (Duryea et al. 2016). Recommended theatre temperatures for routine surgeries in adult humans range from 20 °C to 23 °C, but up to 27 °C for paediatric surgery (Katz 2017). Although hypothermia is a significant risk factor for anaesthetic mortality in humans undergoing anaesthesia (Akers et al. 2019), there have been no previous studies in small mammals investigating the effect of ambient theatre temperature on body temperature. Therefore, we hypothesized that maintaining the ambient theatre temperature at >25 °C would prevent hypothermia in rabbits undergoing anaesthesia for elective surgery — castration and ovariohysterectomy — and have a positive impact on their recovery.

Materials and methods

Ethical approval for the study was granted by the Royal Veterinary College Clinical Research Ethical Review Board (study number URN 2018 1806-3), and informed owner consent was obtained. All rabbits that were presented to the surgery for routine neutering between June 2018 and June 2019 were considered for inclusion in the study. A full clinical examination was performed prior to anaesthesia, including rectal temperature, and only animals categorized via the American Society of Anesthesiologists (ASA) physical classification system category (I or II) were included. Any animals that appeared anxious on admission to hospital were excluded, as the drug protocol was adapted for those individuals. Any rabbits in which surgery was expected to be non-routine (such as an abdominal approach to locate cryptorchid testes) were also excluded from the study.

Animals were allocated to one of two groups (A and B) by coin toss after admission to the hospital. Rabbits in group A were allocated a normal ambient theatre temperature of 23 °C (± 2 °C). This temperature was based upon measurements of average temperatures in several different closed-door theatres within a veterinary referral centre. This was measured by placing a digital temperature probe with maximum and minimum measurements on the anaesthesia machine for 8 hours during the working day. Measurements were made with the same thermometer used in our study (Exo terra digital thermometer, Exo Terra, QC, Canada) , which had been calibrated and had an accuracy of 0.2 °C. Rabbits in group B were allocated an ambient theatre temperature of 28 °C (± 2 °C). Thermostat-controlled air conditioning was used to maintain the theatre temperature at the target value for the duration of the surgery. Both groups of rabbits were placed on a heat pad in theatre (Double Faced Vet Heating Mat; Burtons Veterinary, UK), as per standard practice within this hospital.

Anaesthesia and surgical protocol

All rabbits were given an oral dose of meloxicam (0.6 mg kg^{-1}, Loxicom 1.5 mg mL^{-1} Oral Suspension Dogs; Norbrook Group, UK) and ranitidine (4 mg kg^{-1}, Zantac syrup 15 mg mL^{-1}; GlaxoSmithKline, UK) 2—4 hours before the procedure. Upon arrival in the preparation room, a combination of medetomidine (0.07 mg kg^{-1}, Domitor; Vetoquinol, UK Ltd, UK), buprenorphine (0.05 mg kg^{-1}, Buprecare; Animalcare Ltd, UK) and ketamine (Anaestamine, Animalcare Ltd) was administered by the intramuscular (IM) route. The dose of

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ketamine was 5 mg kg^{-1} for the rabbits undergoing castration (castrates) and 10 mg kg^{-1} for those undergoing ovariohysterectomy. The rabbit was then left for 10 minutes in theatre, which had been prewarmed to the appropriate temperature, prior to returning to the preparation room for intubation and surgical preparation. Rabbits were intubated using a 2.0−2.5 mm uncuffed Murphy endotracheal (ET) tube (Well Lead Medical Co Ltd, Guangzhou, China). This was achieved using a visualized otoscopic technique, using a 4 Fr urinary catheter (Henry Schein Medical, NY, USA) as a stylet. Placement confirmation was achieved using a side stream capnograph (Vetronic Impact III monitor; Veteronic Services Ltd, UK) with an aspiration flow rate of 50 mL $minute^{-1}$. This was attached to a dead space reduced ET tube connector (ACE Veterinary supplies Ltd, UK) and all were rabbits connected to an Ayre's T-piece circuit (ACE Veterinary supplies Ltd, UK) set at an average oxygen flow rate of 2 L $minute^{-1}$. Anaesthesia was maintained with isoflurane (Isofluran CP; CP Pharma, Germany) in oxygen during the period in the preparation room and then changed to sevoflurane (SevoFlo; Zoetis, UK) in oxygen in theatre, owing to vaporizer availability. Vaporizer concentration was adjusted as required during the procedure; the fraction of inspired oxygen (F_IO_2) was > 95% throughout anaesthesia. After surgical preparation, rabbits were returned to theatre and placed on a heat pad (Double Faced Vet Heating Mat; Burtons Veterinary, UK); the temperature of the heat pad was set at a standard manufacturer setting for animals less than 20 kg in weight. Surgery was performed by one of four exotic animal veterinarians, and anaesthesia was monitored by one of five registered veterinary nurses. The operators were not blinded to the theatre temperature. A standard scrotal surgical technique was used for castration and a standard midline technique was used for ovariohysterectomy.

Intraoperative and postoperative monitoring

Prior to moving to the theatre all rabbits had an intravenous (IV) catheter (26 gauge Zoetis Peripheral IV catheters, Zoetis, UK; or 24 gauge Jelco IV catheter, Smiths Medical, UK) placed in the marginal ear vein and were given a slow IV bolus of 10 mL kg^{-1} Hartmann's solution (Hartmanns solution for infusion, Aquapharm 11; Animalcare Ltd) during the procedure. The fluids administered during the procedure were administered at ambient room temperature and were stored in the preparation room before administration; the temperature of this room was not recorded. During the anaesthetic, the animal's rectal temperature was continuously monitored using the Vetronic Impact III monitor (Veteronic Services Ltd, UK). The rectal temperature probe was inserted to a depth of 3−5 cm, and the same thermometer probe was used for all rabbits in the study. The ambient room temperature was recorded using a digital thermometer placed on the anaesthetic machine; the same thermometer was used for all procedures in the study (Exo terra digital thermometer, Exo Terra, QC, Canada). Readings were recorded every 5 minutes during the procedure, starting immediately after the animal had been moved into theatre. Thermometers had standard manufacturer calibration. Heart rate, respiratory rate, mucous membrane colour, oxygen saturation and end-tidal partial pressure of carbon dioxide ($P_E'CO_2$) were monitored throughout the procedure (Vetronic Impact III).

At the end of the procedure, medetomidine was antagonized using atipamezole 0.35 mg kg^{-1} (Antisedan; Vetoquinol UK Ltd) administered IM and the rabbit extubated prior to the return of a swallowing reflex. All animals were monitored postoperatively in an incubator (Pet Brooder ICU incubator; Rcom Company, FL, USA) set at 30 °C until body temperature was maintained, and the animal was ambulatory. At this point, the rabbit was moved back to its kennel within the hospital ward and supplementary feeding was provided (Critical Care Formula, Oxbow, NE, USA) if they were not eating voluntarily. Times to resume feeding and defaecation were recorded overnight, and the animal was discharged to their owner the following day.

Sample size determination

Retrieving historical data from rabbits ovariohysterectomized using the same anaesthetic protocol, we identified average final temperatures of 38.25 °C (variance 0.209, six rabbits) *versus* 38.95 °C (variance 0.332, six rabbits) in theatres maintained at 23 °C or 28 °C, respectively. The corresponding difference in rectal temperature change (before and after anaesthesia) was +1.35 °C in favour of the 28 °C theatre environment. A sample size was computed using an online calculator (https://epitools.ausvet.com.au/twomeanstwo). In a prospective study to demonstrate a significantly higher final temperature in theatres maintained at 28 °C, with a p value of 0.05 and 80% power, seven rabbits were required per group.

Statistical analysis

Data distributions were tested for normality with the Kolmogorov−Smirnov test (Table 1). Weight, age, baseline respiratory rate and body condition score (BCS) were non-normally distributed and are presented as median (25−75% interquartile range). Rectal temperature data were normally distributed (for all time points/theatre temperatures), and they are presented as mean (± standard deviation).

The effect of two variables, theatre temperature and time, on the rectal temperature of the rabbits were analysed using a mixed-effects model (GraphPad Prism, version 8.0.1; GraphPad Inc., CA, USA), with Sidak's multiple comparison test for *post hoc* testing. The mixed-effects model allowed the inclusion of rabbits with partially missing data. The animal's

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Table 1 Distribution of variables using the Kolmogorov–Smirnov (KS) test to assess age, body weight, body condition score (BCS) and physiological data on admission of 54 rabbits of various breeds presented to a hospital for routine ovariohysterectomy or castration. IQ, interquartile; NS, nonsignificant; SD, standard deviation.

Continuous normally distributed data	KS test	Mean	SD	Lowest	Highest
Baseline temperature on admission (°C)	NS	38.88	0.50	37.6	39.9
Baseline heart rate on admission (beats minute^{-1})	NS	299	34	180	290
Continuous non-normally distributed data	KS test	Median	IQ range	Lowest	Highest
Weight (kg)	Non-normal	1.53	(1.30–1.79)	0.99	3.57
Age (months)	Non-normal	6.0	(4.0–9.0)	3	51
Baseline respiratory rate on admission (breaths minute^{-1})	Non-normal	180	(120–200)	40	300
Ordinal categorical data		Median	IQ range	Lowest	Highest
BCS		3	(3–3)	2	4

temperature was the dependent variable, with the animal as a random effect. The fixed effects were: 1) the recording time point (first time point: preanaesthetic temperature taken on admission; second time point: first temperature recorded in theatre; third time point: last temperature recorded during anaesthesia); 2) the theatre temperature; and 3) the interaction between these two factors. The effect of the surgical procedure itself on temperature was also tested at each time point. We tested for the effect of the procedure and temperature group on the postoperative incidence of anorexia and absence of defaecation using a Fisher's exact test. A p value of < 0.05 was taken to indicate statistical significance.

Results

Between June 2018 and June 2019, a total of 88 rabbits presented for neutering procedures, comprising 49 males (55.7%) and 39 females (44.3%). Out of the 88 rabbits, 70 rabbits met the inclusion criteria and were randomly allocated to group A or group B (Fig. 1). A total of 54 rabbits completed the study, and their data were available for statistical analysis. These included 17 rabbits in the 28 °C group (seven ovariohysterectomies and 10 castrations) and 37 in the 23 °C group (16 ovariohysterectomies and 21 castrations). Signalment and variables for baseline physiological are summarized in Table 1. The breed that presented most commonly was the Mini Lop ($n = 19$); the smallest breed of rabbit which was presented for neutering was the Netherland dwarf ($n = 6$) and the largest breed was a Belgian hare ($n = 1$). Other breeds included the Dwarf Lop ($n = 7$), Dutch ($n = 4$), Lionhead ($n = 3$), Mini Rex ($n = 1$) and Dwarf Hotot ($n = 1$), the remaining being cross breeds ($n = 12$).

From the initial IM injection to final surgical closure, the mean anaesthetic time of a castration was 52 (33–67) minutes. The mean time for an ovariohysterectomy was 76 (56–100) minutes. The average time spent in the preparation room from intubation to first theatre temperature was 20 (2–36) minutes. The time of year the rabbits presented to the hospital did not affect rectal temperature on admission. Although no rabbits were presented during the month of August, a mean of six rabbits presented in the other months. The number of rabbits seen and the average temperatures of each month were as follows; January ($n = 4$) 38.6 °C, February ($n = 6$) 38.4 °C, March ($n = 7$) 39.2 °C, April ($n = 7$) 38.6 °C, May ($n = 6$) 39.3 °, June ($n = 4$) 39.1 °C, July ($n = 1$) 39.1 °C, August ($n = 0$), September ($n = 2$) 39.3 °C, October ($n = 5$) 38.9 °C, November ($n = 4$) 38.7 °C and December ($n = 8$) 38.9 °C.

Effect of ambient theatre temperature on animals' perioperative temperature

There was no difference in temperature between the four groups at any time point, except for the difference in final body temperature between rabbits undergoing ovariohysterectomy of groups A and B.

The mean body temperatures on admission for ovariohysterectomy were 38.9 °C (± 0.54 °C) for group A and 38.9 °C (± 0.24 °C) for group B. There was a significant difference in body temperature between the different time points of the procedure ($p = 0.027$). A significant difference in mean body temperature was also found between the two groups regardless of the time point ($p = 0.007$) (Fig. 2). Finally, there was a significant effect of the interaction time point × theatre temperature ($p = 0.0001$).

For rabbits undergoing ovariohysterectomy in group A (23 °C), the first recorded rectal temperatures in the controlled theatre (38.3 ± 0.42 °C, $p = 0.002$) and the last temperature recorded at the end of anaesthesia (38.1 ± 0.59 °C, $p = 0.0002$) were significantly less than those at admission.

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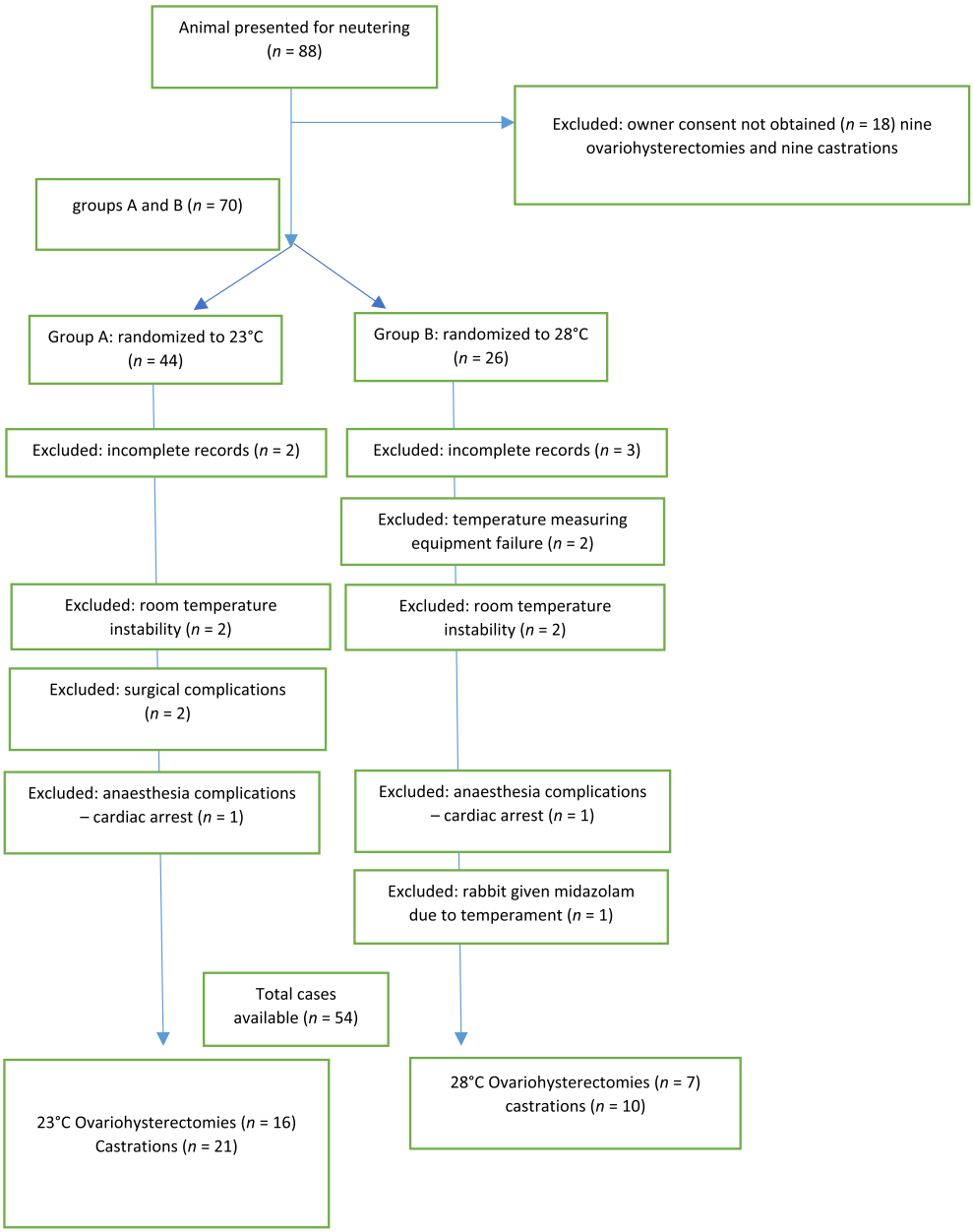

Figure 1 CONsolidated Standards of Reporting Trials (CONSORT) diagram showing animal enrolment, their allocation to a Group, disposition status and how they were analysed in the trial.

There was no significant difference between the first and the last temperature recorded during anaesthesia ($p = 0.25$). For the rabbits undergoing ovariohysterectomy in group B (28 °C), the first recorded rectal temperature after anaesthetic induction in the controlled theatre environment (38.8 ± 0.59 °C, $p = 0.98$) and at the end of anaesthesia (39.2 ± 0.53 °C, $p = 0.46$) did not differ significantly from the admission temperature.

Comparing ovariohysterectomies performed at 23 °C and 28 °C, there was no significant difference between admission temperatures and first temperatures recorded after induction. However, the rabbits undergoing surgery at 28 °C (group B) had significantly higher final body temperatures, by an average of 1.15 °C [95% confidence interval (CI), 0.47−1.83], compared to the 23 °C group (group A) ($p = 0.001$) (Fig. 2).

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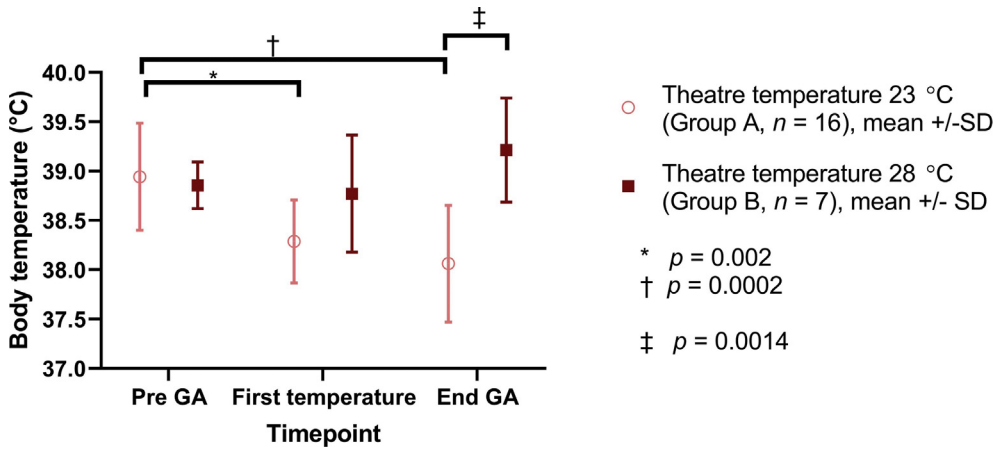

Figure 2 Body temperature at admission (pre GA), first temperature recorded after induction and final temperature (post GA) recorded at the end of anaesthesia for the two groups of rabbits that underwent ovariohysterectomy (OVHs) (group A 23 °C and group B 28 °C). Data are presented as mean and the error bars represent the standard deviations (SD). Differences within-group from baseline: $^{*}p = 0.002$, $^{\dagger}p = 0.0002$. Difference between groups at the end of anaesthesia, $^{\ddagger}p = 0.0014$. SD, standard deviation.

The mean body temperatures on admission for rabbits undergoing castration were 38.9 °C (±0.58 °C) in group A and 38.6 °C (±0.41 °C) in group B. There were no significant differences in body temperature between the two groups undergoing castration for the duration of the procedure ($p = 0.12$). The mean first recorded temperatures after induction were 38.6 °C and 38.7 °C and the mean body temperatures recorded at the end of the procedure were 38.5 °C and 38.5 °C for group A and group B, respectively. Body temperature did not vary significantly within each of the groups at the different time points of the procedure ($p = 0.74$) (Fig. 3).

Postoperative recovery

Of the 54 rabbits that completed the study, 47 (83.9%) were feeding and 53 (94.4%) had defaecated by the following morning (Table 2). A rabbit from group B had neither eaten nor defaecated the morning after castration; however, this animal was noted to be eating at 4 PM that day, which was approximately 24 hours after surgery.

The proportion of rabbits with postoperative anorexia did not differ significantly between those animals undergoing an ovariohysterectomy *versus* a castration ($p = 0.15$; relative risk = 0.81; 95% CI, 0.5852−1.049). There was also no

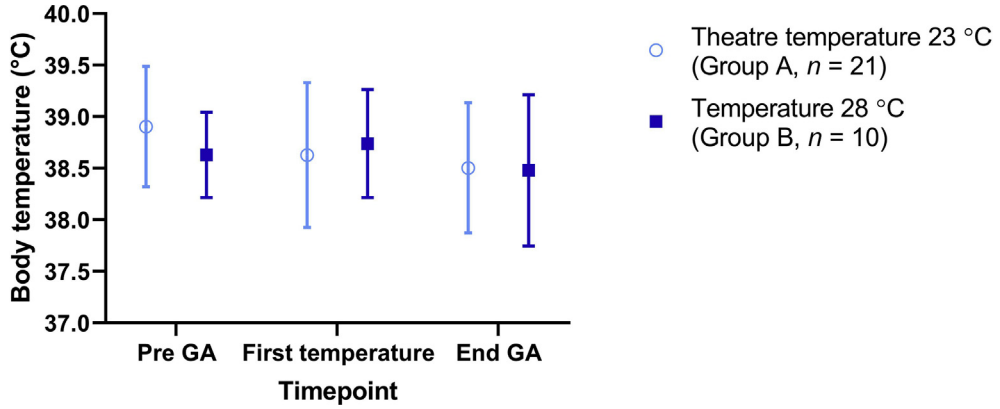

Figure 3 Body temperature at admission (pre GA), first temperature recorded after induction of anaesthesia and final temperature recorded at the end of anaesthesia (post GA) for the two groups of rabbit that underwent castration [group A (23 °C) and group B (28 °C)]. Data are presented as mean and the error bars are the standard deviations.

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Table 2 Postoperative recovery data of two groups of rabbits group A (in which theatre temperature was 23 °C) or group B (in which theatre temperature was 28 °C) the morning after routine neutering procedures. Chi-square test: no significant effect of procedure or theatre temperature on postoperative anorexia ($p = 0.15$ and $p = 0.12$, respectively) or on faecal output ($p = 0.57$ and $p = 1$, respectively). Data are presented as number of animals (n) and the percentage of the total within each group which had fed and defaecated.

	Total number self-feeding	Total number defaecated
Ovariohysterectomies ($n = 23$)	17 (73.9%)	21 (91.3%)
Castrates ($n = 31$)	28 (90.3%)	30 (96.8%)
Group A: 23 °C ($n = 37$)	33 (89.2%)	35 (94.6%)
Group B: 28 °C ($n = 17$)	12 (70.6%)	16 (94.1%)

significant difference in the proportion of rabbits with reduced faecal output between the two surgeries ($p = 0.57$; relative risk = 0.94; 95% CI, 0.7534−1.105). There was no significant difference between group A and group B in the proportion of rabbits with postoperative anorexia ($p = 0.12$; relative risk = 1.64; 95% CI, 0.9685−1.923) or those with reduced faecal output ($p = 1.00$; relative risk = 1.005; 95% CI, 0.8635−1.302).

All rabbits were discharged the day after surgery and re-examined 3 and 10 days postoperatively, except for five rabbits that were not presented by their owner for a postoperative check. Postoperative infections were detected in four rabbits (7.4%), one from each surgical and temperature group. Of these animals, three were noted to have self-traumatized their surgical incisions. All four were treated with oral antibiotics, and revision surgery was performed in one doe to debride and re-suture the ovariohysterectomy incision.

Discussion

Theatre temperature did not have a significant effect on rectal temperature of rabbits during anaesthesia for castration. Castration of rabbits is generally a short procedure that involves a small amount of fur clipping. Routine cases do not involve a laparotomy; therefore, there is a smaller risk of hypothermia when compared with rabbits undergoing a longer and more invasive procedure (Redondo et al. 2012b).

Body temperature initially decreased in rabbits undergoing an ovariohysterectomy in the period between induction of anaesthesia and the first temperature recorded in theatre. This is probably a result of the larger clipped area and the preparation for abdominal surgery. When compared with the smaller surgical site needed to perform a castration, this probably led to greater radiant and evaporative heat loss (Armstrong et al. 2005; Redondo et al. 2012b). Convective heat loss is also probably greater from a larger surgical site. Temperatures following induction of anaesthesia increased in rabbits undergoing an ovariohysterectomy at a theatre temperature of 28 °C. which probably resulted from active warming combined with the increased theatre temperature, thereby reducing radiant heat loss. However, temperatures remained within the normal range reported for rabbits, so although statistically significant, are probably not physiologically significant. However, an increase in body temperature with a higher ambient theatre temperature may be beneficial in animals with preoperative hypothermia − for example if emergency surgery were required. Still, care should be taken to avoid overheating.

The duration of anaesthesia and surgery, the amount of skin clipped and prepared for surgery and exposure of viscera all contribute to a reduction in body temperature. As shown in this study for group A rabbits, those animals undergoing ovariohysterectomy would be expected to have a greater reduction in temperature from the time of surgical preparation onwards. Ideally, the temperature of the preparation room should have been controlled in line with theatre temperature. Variations in preparation room temperature may have influenced our results. In clinical practice, however, where a preparation room may be in use for multiple animals this is not always practical.

A disadvantage of higher ambient theatre temperature is reduced physical comfort for anaesthetists and surgeons when wearing surgical attire. In one study, objective measurements of performance were not affected by warmer theatre temperatures during a 30 minute surgery. The surgeons, however, perceived that they performed more poorly, and their frustration levels were higher (Berg et al. 2015). This current study showed no difference between theatre temperature and surgical time.

Appropriate ambient temperatures must be balanced with humidity levels and air changes in theatre. These variables were not measured in the current study; however, no rabbits in the present study suffered corneal ulceration. There is a higher risk of this complication when circulating warm air heating devices are used (Rembert et al. 2004). There was no difference in recovery variables (time to feeding and defaecating) between subject groups, regardless of the procedure performed or the theatre temperature. This is unsurprising as all rabbits remained normothermic throughout the study, with variations within the normal temperature range, whereas post-anaesthetic complications were associated with mild

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hypothermia (Sheffield et al. 1994). Both pain and stress can reduce appetite and increase the risk of gastrointestinal stasis (Harcourt-Brown 2002; Da Silva et al. 2020). Study rabbits were housed in a quiet environment away from predatory species to reduce stress. Regular pain assessment using facial grimace and behaviour/activity was performed and compared to preoperative behaviour. No rescue analgesia was required, suggesting adequate pre-emptive analgesia. Opioid drugs such as buprenorphine decrease gastrointestinal transit time (Martin-Flores et al, 2017); however, this effect was not observed in our study rabbits. This may be because we used prokinetic drugs and assisted feeding by giving a high fibre diet in the recovery period. High fibre diets promote gastrointestinal motility in rabbits (Davies & Davies 2003).

Postoperative infections were seen in four rabbits in the study. The incidence of surgical wound infection appears unrelated to the type of surgery performed or to theatre temperature, as an equal number of infections were encountered in each of the four groups. Again, this is unsurprising because perioperative hypothermia was not observed in any rabbit in the study. Self-trauma was the cause of infection in all affected individuals. The single rabbit that required revision surgery had undergone an ovariohysterectomy and was in the lower theatre temperature group. However, perioperative hypothermia was not documented in any individuals in the study, so this is not considered a contributory factor.

The study population was limited by the number of animals that presented for surgery at the clinic during the time frame of the study. Operators were not blinded to the temperature setting in the room; however, objective variables were monitored to reduce the risk of operator bias. Assignment of rabbits to each study group was not blinded as the person tossing the coin knew the resulting intervention.

Although the injectable anaesthetic protocol was the same for all animals, the dose of ketamine varied between the male and female rabbits, as is standard practice in this hospital. The higher dose ketamine used in the female rabbits may have affected body temperature (directly or indirectly); however, the increased body temperature was only seen in group B, which is probably attributable to the higher theatre temperature. A study in dogs concluded that ketamine administration following xylazine did not alter body temperature in the 2 hours following administration (Ullah et al. 2017). Vaporiser settings varied between individual animals. Higher concentrations of volatile agent may have resulted in vasodilation although blood pressure was not monitored in all rabbits. This could have contributed to reduced body temperatures; however, no individuals in the study were hypothermic so this was probably not clinically significant. Finally, the study was not powered to evaluate mid-to long-term benefits of recovery when surgery was performed at a higher temperature. The animals returned home the day after surgery to continue recovery, and further data was not recorded.

Conclusions

This study showed that an ambient theatre temperature of 28 °C significantly increased body temperature of rabbits during anaesthesia for ovariohysterectomy, compared with rabbits in a theatre maintained at 23 °C. Theatre temperature had no effect on the body temperature of rabbits anaesthetized for castration. Therefore, for shorter procedures not involving a laparotomy, there appears to be no advantage to increasing ambient theatre temperature. For longer procedures and those involving an open abdominal cavity, an increased theatre temperature appears helpful in preventing hypothermia.

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Authors' contributions

AE: study design and proposal, implementation of study running, data collection and preparation of manuscript. LP: data analysis and preparation of manuscript. VB: data collection and preparation of manuscript. JH: data collection and preparation of manuscript.

Conflict of interest statement

The authors declare no conflict of interest.

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