Hypothermia prevention in long-standing equine dental procedures

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Summary
Hypothermia is a common, detrimental post-operative complication in man and veterinary medicine. Active warming strategies are paramount for prevention and treatment. Duration of operations, administered drugs and their adverse effects put horses undergoing procedures requiring long-standing sedation at risk of hypothermia. The aim of this study was to investigate whether an air warming device would be helpful to avoid severe hypothermia in adult horses. Twenty client-owned horses undergoing dental/sinusoidal procedures were divided into two equal groups. The treatment group was covered with a warming blanket connected to the warming device with the temperature set to 43°C. Horses in the control group were not blanketed. Temperature was monitored at the time of first sedation (T0) and every hour throughout the length of the procedure. Use of the warming blanket was straightforward and caused no adverse reactions. The mean decrease in body core temperature in the treatment group was significantly less than the mean temperature decrease in the control group, beginning at the second hour of the procedure. No horse in the treatment group reached a body core temperature in the treatment group was

Introduction
Hypothermia is a decrease in body core temperature (BCT) below physiological values. It is considered to be a common finding in humans, small animals and horses undergoing general anaesthesia (Janicki et al. 2002; Mayerhofer et al. 2005; Moola and Lockwood 2011). Even though hypothermia has various negative effects on living organisms, a decrease in body core temperature below 36°C (Moola and Lockwood 2011). As previously published in horses, reduction in BCT not only causes vasoconstriction and increased risk of ventricular dysrhythmias, but also influences the coagulation cascade impairing platelet function as well as coagulation factors, while enhancing fibrinolysis. Because of decreased oxygen partial pressure in tissues and impaired function of neutrophils and macrophages, the risk of bacterial wound infection is increased (Pietsch et al. 2007). With every Celsius degree loss of temperature, metabolic rate slows down as well as metabolism of medication which can cause inadvertent overdose (Frank 2001; Pietsch et al. 2007). Unfortunately, hypothermia was found in all equine cases undergoing general anaesthesia for greater than 45 min (Mayerhofer et al. 2005). Horses undergoing long-standing sedation are also in danger of hypothermia due to reduced muscle tone, and thereby heat production. All sedation protocols for adult horses are based on use of alpha-2 agonists, whose influence on thermoregulation directly impacts heat production and perception in other species (Szreder 1993; Madden et al. 2013). In human medicine active warming systems with either warm water or air are routine management of perioperative hypothermia (Janicki et al. 2002; Moola and Lockwood 2011; Adderley 2015). To the best of the authors’ knowledge, there are no published trials to prevent hypothermia in equine cases undergoing long-standing sedation procedures. The aim of this study was to investigate whether an air warming device would be helpful to avoid severe hypothermia in adult horses.

Materials and methods
Horses
The study was conducted in 20 horses admitted to the Equine Hospital of University of Veterinary Medicine in Vienna for diagnosis and treatment of dental or sinusoidal problems. All horses were considered healthy at clinical examination, apart from the localised dental/sinusoidal problem.

Sedation and warming protocol
The study was designed as prospective and randomised. All horses were sedated with 0.01 mg/kg detomidine hydrochloride (Equidorm) and 0.01 mg/kg butorphanol (Alvagesic) prior to catheter placement (12 gauge) in one jugular vein; sedation to effect was maintained with detomidine-butorphanol constant rate infusion titrated to a dose which allowed continuation of the procedure. Infusions of lactated ringer’s solution at the rate of 5 mL/kg bwt/h were given throughout the entire procedure. In all cases local anaesthesia was performed with mepivacaine hydrochloride (Mepinaest purum 2%) (infiltration, splash and/or nerve block). Room temperature was recorded and maintained between 20 and 22°C. As previously published in horses, rectal temperature of all horses was controlled at T0-time of initial sedation and then every hour until the end of the procedure (Tomasic and Nann 1999). Temperature measurements in all horses were performed with an identical thermometer designed for use in veterinary medicine. Minimum procedure duration of 3 h was based on the authors’ opinion that the longer the procedure, the greater the likely corresponding loss of BCT. In the treatment group (n = 10), horses were covered with the warming blanket.
immediately after sedation and warm air flow was initiated with the highest possible temperature setting of 43°C. In order to minimise movement of the warming blanket on the horses, a stall blanket was placed over the warming air blanket. The Air Warming Device used in the current study is one of the routinely used at our small animal anaesthesia department and consists of a paper blanket with small openings to blow warm air in the direction of patient, horses and the device itself which can blow air at two speeds and three possible temperature settings. Both blankets were re-adjusted as needed during the procedure upon movement of the horse. Horses in the control group underwent the same protocol but no blankets were applied after the animal was sedated. For each horse: age, weight, sex, procedure length and BCT were recorded and compared. The warming blanket set-up is shown in Figures 1 and 2.

Data analysis
Data were analysed by one-way ANOVA in order to minimise type 1 errors. Each time point analysis was confirmed by T-test and all variables were analysed by F-test for equal variance. The study power was calculated to be 91.7%. A P value of <0.05 was used to set statistical significance.

Results
Twenty horses (6 mares, 2 stallions and 12 geldings) weighing 477 ± 128 kg with a mean age of 12 ± 7 years were included. Breeds that were represented were Warmblood-8, Pony-3, Noriker-2, Icelandic Horse-2, Haflinger-1, Quarter Horse-1, Standardbred-1, Arabian-1, Pura Raza Espanola-1. The warming blanket was easy to apply and keep in place for use throughout the entire sedation period in all horses for dental/sinusoidal procedures. Minimal dislocations of the blanket were easily corrected. No adverse reactions were observed. Results are summarised in Table 1. The decrease in BCT in the study group was significantly less from the second hour of the procedure (P = 0.04) onward. No horse in the study group reached a BCT less than 36°C. Mean loss of temperature in the control group was more than twice that in the study group (1.5°C and 0.7°C respectively).

Discussion
This study is, to the best of the authors’ knowledge, the first trial to effectively use an air warming blanket designed for human medicine in sedated horses and proves that it can minimise heat loss. Sedated horses are in danger of hypothermia which occurs due to decreased heat production and impaired temperature perception, especially during long procedures. As all sedative protocols...
for adult horses are based on the use of alpha-2 agonists, their influence on thermoregulation was examined in other species showing their effect on the central nervous system and direct influence on regulation of heat production (Szreder 1993; Kendall et al. 2010; Madden et al. 2013). BCT lower than 36°C triples the rate of SSI in human surgery (Kurz 2008). No horses in our treatment group crossed this threshold. The current study does present some limitations. Duration of the procedure was not equally long for all patients. In the treatment group, three horses’ procedures lasted only 3 h making it impossible to disprove that the temperature would not fall below 36°C if the procedure was continued for 1 h longer. However, the last temperature measurement was high enough that even accounting for the mean heat loss between third and fourth hour of the procedure, BCT was unlikely to decrease below 36°C. Another limitation of the study is the relatively low number of cases and lack of case follow-up and comparison of the groups for development of post-procedural complications and treatment costs. Nevertheless, the use of an active air warming device in sedated equine cases is easy and it has a positive influence on the owners. All owners in our study displayed positive attitudes and expressed the feeling that their horse was well cared for; this may also be connected with their personal experiences as one of the most common complaints in post-operative wards in hospitals is being cold and shivering. In this study, the statistically significant effect of the warming blanket on decreasing heat loss began during the second hour of the procedure and lasted the entire length of the procedure. It was previously published in human medicine that passive warming-blankets are not effective and in order to avoid and treat hypothermia active warming strategies are needed (Bennett et al. 1994). That is why control horses were not covered with a stable blanket during the procedure. Dental cases were chosen for the study as they are often presented in our clinic and time of procedure was the easiest to estimate.

In conclusion, the use of an active air warming blanket in horses is an easy method to decrease the heat loss in horses undergoing long-standing sedation procedures. Further studies are needed to evaluate the influence of hypothermia on complication rates and treatment costs.

Authors’ declaration of interests
No conflicts of interest have been declared.

Ethical animal research
Not applicable.

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None.

Authorship
A. Florczyk contributed to study design, study execution, and data analysis and interpretation. H. Simhofer contributed to study design, J. Rosser contributed to study design, and data analysis and interpretation. All authors contributed to preparation of the manuscript and gave their final approval of the manuscript.

### TABLE 1: Temperature measurement (°C) for each time point: T0-T4 for every horse: 1-10 in treatment and control group. Last verse for each group is the mean temperature for each time point with standard deviation calculation. Marked verse shows P value after comparison the individuals in both groups at each time point

| No- horse\ Time point | T0      | T1      | T2      | T3      | T4      |
|-----------------------|---------|---------|---------|---------|---------|
| Study group           |         |         |         |         |         |
| 1                     | 38.5    | 38.4    | 38.4    | 38.1    | 37.9    |
| 2                     | 37.7    | 37.6    | 37.5    | 37.3    | 37.0    |
| 3                     | 37.6    | 37.4    | 37.2    | 37.1    | 37.1    |
| 4                     | 37.9    | 37.6    | 37.6    | 36.3    | 36.1    |
| 5                     | 37.5    | 37.3    | 37.0    | 36.8    | 36.6    |
| 6                     | 37.5    | 37.0    | 37.0    | 36.8    | 36.6    |
| 7                     | 37.2    | 37.0    | 36.5    | 36.5    | 36.5    |
| 8                     | 37.7    | 37.7    | 37.5    | 37.1    | 37.1    |
| 9                     | 37.9    | 37.8    | 37.8    | 37.6    | 37.5    |
| 10                    | 37.4    | 37.4    | 37.3    | 37.2    | 37.1    |
| Mean temperature      | 37.7 ± 0.36 | 37.5 ± 0.41 | 37.4 ± 0.52 | 37.2 ± 0.55 | 37.0 ± 0.58 |
| Control group         |         |         |         |         |         |
| 1                     | 37.8    | 37.6    | 37.3    | 37.4    |         |
| 2                     | 37.9    | 37.9    | 37.8    | 37.5    | 37.4    |
| 3                     | 37.6    | 37.0    | 36.8    | 36.4    | 36.1    |
| 4                     | 37.4    | 37.2    | 36.8    | 36.6    | 36.6    |
| 5                     | 38.0    | 37.6    | 37.1    | 36.8    | 36.6    |
| 6                     | 37.2    | 37.1    | 36.9    | 36.5    | 36.1    |
| 7                     | 37.5    | 36.0    | 36.4    | 36.0    | 35.7    |
| 8                     | 37.9    | 37.5    | 37.0    | 36.5    | 36.6    |
| 9                     | 37.5    | 37.0    | 36.7    | 36.3    | 35.9    |
| 10                    | 37.7    | 37.1    | 36.5    | 35.8    | 35.8    |
| Mean temperature      | 37.7 ± 0.25 | 37.2 ± 0.52 | 36.9 ± 0.40 | 36.6 ± 0.54 | 36.2 ± 0.55 |
| P value               | 0.78    | 0.14    | 0.04    | 0.03    | 0.01    |
Manufacturers’ addresses

1Equidor, Richter Pharma, Muuria, Finland.
2Alvagesic, Alvetra u. Werfft GmbH, Vienna, Austria.
3Vetifundin 5 Salzammergut Kl., Bad Ischl, Austria.
4Mepinaest purum 2%, Gebro Pharma GmbH, Fieberbrunn, Austria.

References

Adderley, C.S. (2015) The use of an intraoperative forced air warming device alone versus warmed intravenous fluid infusion and forced air warming versus warmed intravenous fluid alone in patients undergoing open intra-abdominal surgery. The University of Southern Mississippi.

Bennett, J., Ramachandra, V., Webster, J. and Carli, F. (1994) Prevention of hypothermia during hip surgery: effect of passive compared with active skin surface warming. Br. J. Anaesth. 73, 180-183.

Frank, S.M. (2001) Consequences of hypothermia. Curr. Anaesth. Crit. Care 12, 79-86.

Janicki, P.K., Stoica, C., Chapman, W.C., Wright, J.K., Walker, G., Pai, R., Walla, A., Prefeur, M. and Pinson, C.W. (2002) Water warming garment versus forced air warming system in prevention of intraoperative hypothermia during liver transplantation: a randomized controlled trial. BMC Anesthesiol. 2, 7.

Kendall, A., Mosley, C. and Bröjer, J. (2010) Tachypnea and antipyresis in febrile horses after sedation with α2-agonists. J. Vet. Intern. Med. 24, 1008-1011.

Kurz, A. (2008) Thermal care in the perioperative period. Best Pract. Res. Clin. Anaesthesiol. 22, 39-62.

Madden, C.J., Tupone, D., Cano, G. and Morrison, S.F. (2013) α2 Adrenergic receptor-mediated inhibition of thermogenesis. J. Neurosci. 33, 2017-2028.

Mayerhofer, L., Scherzer, S., Gabler, C. and van den Hoven, R. (2005) Hypothermia in horses induced by general anaesthesia and limiting measures. Equine Vet. Educ. 17, 53-56.

Moola, S. and Lockwood, C. (2011) Effectiveness of strategies for the management and/or prevention of hypothermia within the adult perioperative environment. Int. J. Evid. Based Healthc. 9, 337-345.

Pietsch, A.P., Lindenblatt, N. and Klar, E. (2007) Perioperative hypothermia. Der Anästhesist. 56, 936-939.

Szreder, Z. (1993) Comparison between thermoregulatory effects mediated by α1-and α2-adrenoceptors in normothermic and febrile rabbits. Gen. Pharmacol. 24, 929-941.

Tomasic, M. and Nann, L.E. (1999) Comparison of peripheral and core temperatures in anesthetized horses. Am. J. Vet. Res. 60, 648-651.