Original Article

Multimodal temperature management during donor hepatectomy under combined general anaesthesia and neuraxial analgesia: Retrospective analysis

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ABSTRACT

Background and Aims: Unintended hypothermia (UIH) during surgery under general anaesthesia has adverse implications. A retrospective analysis of the perioperative temperature records of healthy voluntary liver donors was done to evaluate the efficacy of a multimodal protocol for temperature management. **Methods:** Records of 50 American Society of Anesthesiologists physical status Class 1 patients operated for Donor Hepatectomy lasting >2 h under combined general and epidural anaesthesia were analysed. Ambient temperature was maintained 24°C–27°C before induction of GA and during insertion of epidural catheter. Active warming was done using warming mattress set to temperature 38°C, hot air blanket with temperature set to 38°C and fluid warming device (Hotline™) with preset temperature of 41°C. Nasopharyngeal temperature was continuously monitored. After induction of GA and draping of the patient, ambient temperature was decreased and maintained at 21°C–24°C and was again increased to 24°C–27°C at the conclusion of surgery. During surgery, for every 0.1°C above 37°C, one heating device was switched off such that at 37.3°C all the 3 devices were switched off. Irrigation fluid was pre-warmed to 39°C. **Results:** Baseline temperature was 35.9°C ± 0.4°C. Minimum temperature recorded was 35.7°C ± 0.4°C. Mean decrease in temperature below the baseline temperature was 0.2°C ± 0.2°C. Temperature at the end of surgery was 37.4°C ± 0.5°C. **Conclusion:** Protocol-based temperature management with simultaneous use of resistive heating mattress, forced-air warming blanket, and fluid warmer along with ambient temperature management is an effective method to prevent unintended perioperative variation in body temperature.

Key words: Anaesthesia, epidural analgesia, hypothermia, perioperative, pre-warming

INTRODUCTION

Unintended hypothermia (UIH) during surgery is associated with adverse outcomes.[1] Patients undergoing long duration surgery under combined general and neuraxial anaesthesia are at higher risk for unintended perioperative hypothermia.[2,3] Maintenance of normothermia during perioperative period is desired, but there are no established protocols that may be followed.[4,5]

Living donor hepatectomies are long duration surgeries that are done under combined general anaesthesia (GA) and neuraxial analgesia and are thus at significant risk for UIH. A temperature management protocol consisting of active management of ambient operating room temperature and simultaneous use of 3 different warming devices in a predefined manner is followed at authors' hospital. An audit was undertaken to assess the efficacy of such temperature management protocol and is presented here with review of literature.

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METHODS

Patients aged 18–50 years without any co-morbidities and American Society of Anesthesiologists Physical Status (ASA) Class 1, who underwent elective donor hepatectomy between November 2014 and February 2016 were studied. The study was approved by the Ethical Committee of the Institute (IEC/IRB No. 41/5 dated 09th April 2016). The electronic database of patients was retrieved. The laboratory investigations, patient and procedure details were retrieved from the hospital information system and the scanned anaesthesia and clinical care files available in the hospital archives. Temperature management protocol included maintaining operation theatre ambient temperature between 24°C and 27°C before induction of anaesthesia. A warming mattress set to temperature 38°C was switched on before the patient was wheeled inside operation theatre. Intravenous fluid was connected to venous access through fluid warming device (Hotline™) with a preset temperature of 41°C. After induction of GA, the patient was scrubbed and covered in surgical drapes. Additional forced air warming blanket (Bair Hugger™) with temperature set to 38°C was switched on following which the ambient operation theatre temperature was allowed to decrease and was then maintained between 21°C and 24°C until the end of surgery. At conclusion of surgery, the patient was clothed, and then the ambient temperature was raised to 24°C - 27°C before termination of anaesthesia and tracheal extubation.

GA and epidural analgesia were administered according to a standardised institutional protocol. Injection thiopentone sodium or propofol was used for induction of anaesthesia. Anaesthesia was maintained using isoflurane or sevoflurane in air and oxygen. Injection rocuronium was used for neuromuscular blockade for tracheal intubation, and subsequently, either injection vecuronium or atracurium was used for maintenance of neuromuscular blockade. Intraoperative analgesia was provided using systemic fentanyl or morphine and epidural analgesia using 0.1% levobupivacaine which was continued into the post-operative period as patient-controlled epidural analgesia. The nasopharyngeal probe was inserted immediately after tracheal intubation and temperature was continuously monitored. The first reading thus obtained was labelled as the baseline temperature. Nasopharyngeal probe length to be inserted was determined by measuring the philtrum to tragus distance and subtracting 5 cm from the measured distance.[6] Epidural catheter was charged and used only after the GA was induced, the patient draped, and all the warming devices switched on. Restrictive fluid management was practiced and was guided by stroke volume variation which is targeted between 10% and 13%.

In case patient's nasopharyngeal temperature increased above 37°C, for every 0.1°C increase, one temperature maintenance device was switched off beginning with the fluid warmer, followed by warming blanket and in the end the warming mattress, such that at 37.3°C all the 3 devices were switched off. Fluid used for irrigation in the surgical field was pre-warmed to 39°C. If temperature decreased to 37.3 or less, the warming devices were again switched on one at a time in the reverse order starting with the warming mattress. Hot air blanket was continued in the recovery area.

Temperature monitoring was continued into the post-anaesthesia recovery area where armpit temperature was monitored and was equated to nasopharyngeal temperature by adding 1°C to the reading obtained. Patients were labelled as either hyperthermic or hypothermic in the recovery area if the temperature was more than 37.5°C or <36.0°C, respectively. Patients were watched for shivering in the post-anaesthesia recovery.

Patients requiring inotrope or vasopressor infusion for management of haemodynamics during the surgery and those requiring blood transfusion and the patients who had fever before surgery or had any known septic focus were excluded from the study.

Data were checked for normalcy of distribution. Parametric data are presented as mean with standard deviation. One-way ANOVA (Greenhouse-Geisser) test was used to test the significance of the difference in the observed mean values. $P \leq 0.05$ was considered statistically significant.

RESULTS

Sixty-one ASA Class 1 patients were identified. Eleven patients were excluded from the study (in two patients protocol was breached [ambient room temperature was not maintained within the decided range due to technical reasons], in six patients' blood was transfused during surgery, and three patients required inotropic supports). Data were analysed for fifty patients [Table 1].

Table 1: Observed temperature changes

	Number of patients	Baseline temperature (mean±SD)	Minimum baseline temperature	Maximum baseline temperature	Number of patients with basal temperature <36°C	Mean±SD		
						Minimum intraoperative temperature (observed at 1 h)	Temperature at 2 h	Temperature at end of surgery
Male	20	35.8±0.4	35.2	36.8	12	35.6±0.5*	36.1±0.3*	37.5±0.4*
Female	30	35.9±0.4	34.8	37.0	18	35.7±0.4*	36.2±0.4*	37.3±0.5*
Total	50	35.9±0.4	34.8	37.0	30	35.7±0.4*	36.1±0.4**	37.4±0.5***

*P=0.00 when compared with baseline temperature, **P=0.013 when compared with baseline temperature, ***P=0.029 when compared with baseline temperature. SD – Standard deviation

Females had a higher temperature at baseline and at 1 h into anaesthesia. The difference of temperature between males and females was however statistically insignificant at all-time points. Significant number of patients (30/50), males (12/20) as well as females (18/30), had baseline temperature below 36°C. Minimum temperature was recorded at 1 hour after induction of GA and charging of epidural catheter and the mean decrease in temperature below the baseline temperature was 0.2°C ± 0.2°C. Temperature recorded at the end of surgery was significantly higher than the baseline temperature and upon arrival in post-anaesthesia recovery temperature recorded was 36.6°C ± 0.3°C. No patient was labelled as hyper- or hypo-thermic in the post-anaesthesia recovery [Table 1 and Figure 1].

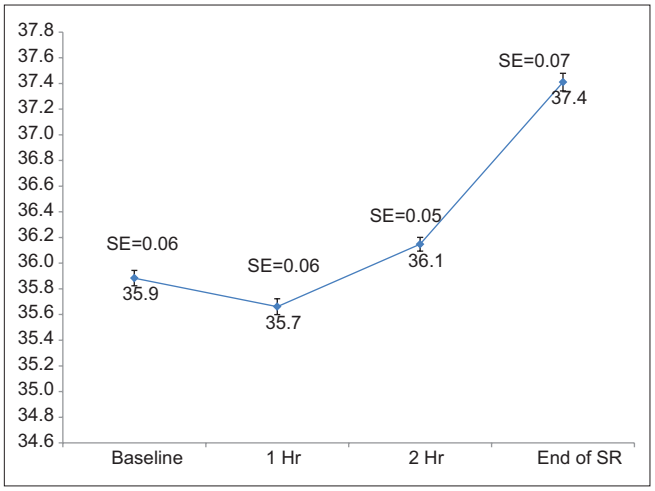

Figure 1: Temperature trend. SR-Surgery

Median operation room ambient temperature before induction of GA and following end of surgery was 24°C and was 21°C during surgery. Mean duration of surgery was 9 h 47 ± 21 min. Mean fluid volume transfused was 4500 ± 500 ml of Plasmalyte® and the Mean blood loss during the donor hepatectomy was 432 ± 129 ml.

DISCUSSION

The protocol-based temperature management strategy that includes ambient temperature management and simultaneous use of multiple temperature management devices was able to contain the unintended perioperative decrease in core body temperature to 0.2°C ± 0.2°C below the baseline temperature measured immediately after induction of anaesthesia and endotracheal intubation.

Unintended perioperative hypothermia is diagnosed when core body temperature decreases below 36°C.[7] However, review of literature has found a wide range of 33.2°C –38.2°C (91.8–100.8°F) for normal temperature in adults.[8] Factors like fasting with restriction of caloric intake are reported to decrease body temperature, a normal occurrence due to a simultaneous decrease in basal metabolic rate.[9] Body temperature also is known to exhibit diurnal variation with minimum temperature being in early morning hours.[10] The baseline temperature of our patients was 35.9°C ± 0.4°C which was recorded in the morning after overnight fasting and was within the range of normal body temperature described in the review[8] [Table 1 and Figure 1].

Maximum decline in core body temperature is known to occur within the 1st h of anaesthesia.[11] In this study, we also observed minimum core body temperature, 1 h after induction of general anaesthesia. Pre-warming is advocated as a temperature management strategy, but the concept of pre-warming is interpreted differently by different people as is evident from the difference in the reported details of practice and of the efficacy of pre-warming. While Andrzejowski *et al*. used pre-warming at 38°C for 72 min and reported mean fall of core temperature of 0.5°C ± 0.5°C at 1 h,[5] Erdling and Johansson in their study, pre-warmed their patients at 43°C after insertion of epidural catheter for undisclosed period of time and reported no decrease in body temperature.[4]

Higher body temperatures are reported for females compared to males.[10] We also found higher mean baseline temperature in females than in males [Table 1]. However, the difference in temperature between males and females was statistically insignificant. In addition to higher mean core body temperature, we also found lowest and highest recorded baseline temperature of 34.8°C and 37°C, both in two different female patients [Table 1]. The observed highest as well as lowest body temperature in female patients and higher mean core body temperature compared to males could probably be due to different phases of menstrual cycle which we did not record and probably due to better fat insulation in females.[10,11]

Warming devices such as resistive heating mattresses, forced-air warming blankets, or fluid warmers when used alone are insufficient to provide protection against UIH, whereas using them together, yields better results.[12] Furthermore, using either of the active warming devices when set to high delivery temperatures for maximum gain has the potential to cause harm to the patient.[13] We, therefore, use a combination of three different active warming devices, all set to near normal body temperature along with ambient temperature management. While the fluid warming device (Hotline™) delivers fluids warmed to near body temperature and protects against the cooling that may occur due to the administration of fluids colder than the body temperature, the resistive heating mattress transfers heat by conduction to the large underbody surface area that it is in contact with. The hot air blanket protects against the loss of body heat to the cooler ambient environment of the operation theatre. However, the efficiency of the hot air blankets is determined by the surface area of the body that it covers and is a limiting factor during abdominal surgeries wherein a significant area cannot be covered. While superiority of one method over the other has not been conclusively established, the use of several methods together is always advantageous.[14,15]

Ambient room temperature below 21°C is reported to significantly increase the incidence of hypothermia while it is seen less often with ambient room temperature of 23°C.[16] In this study, the ambient operating room temperature was actively managed, and the fall in core body temperature following induction of anaesthesia was contained to only 0.2°C, observed at 1 h after induction of anaesthesia, as compared to decrease in temperature of greater magnitudes reported in literature.

The core body temperature at 2 h after induction of GA, increased above the baseline temperature and thereafter continued to remain increased significantly above the baseline temperature until the end of surgery [Table 1 and Figure 1]. In 19 patients, temperature increased to more than 37.3°C and all the warming devices were switched off in accordance to the protocol. On switching off the warming devices, the temperature in five patients did not decrease to below 37.3°C. The release of thermogenic cytokines during surgery is known and could have contributed to the initial rise and then for maintenance of temperature in such cases.[17] While multimodal temperature management that we practice, successfully limited the fall in body temperature, such rise in body temperature as observed here in this study in some patients, also necessitates instituting protocol based checks to prevent hyperthermia, especially during long surgeries with the use of multimodal hyperthermia. In the protocol described here in this study, to protect against rise of temperature beyond 37.3°C one warming device was switched off for every 0.1°C rise in temperature above 37.0°C. Appropriate use of warming devices can, therefore, help to prevent and balance the risk of hypothermia as well as hyperthermia.[18]

The use of inotropes and vasopressors during surgery can possibly contribute to rise in body temperature because of their thermogenic property.[19] Similarly, allergic reaction to the transfused blood products is also known to cause fever. We, therefore, excluded those patients who required inotropes or vasopressors during surgery and also those who were transfused blood products during the conduct of surgery.

CONCLUSION

Protocol-based temperature management with simultaneous use of resistive heating mattress, forced-air warming blanket, and fluid warmer along with ambient temperature management is an effective method to prevent unintended perioperative hypothermia.

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Conflicts of interest

There are no conflicts of interest.

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