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Dr. Lakshmikanth Charan
Consultant Intensivist, Royal Care Superspeciality Hospital, Coimbatore, Karnataka, India

Dr. Shwethapriya R
Associate Professor, Department of Critical Care, Kasturba Medical College, Manipal, Karnataka, India

Dr. Manjunath Prabhu
Professor, Department of Anaesthesiology, Kasturba Medical College, Manipal, Karnataka, India

Dr. Souvik Chaudhuri
Associate Professor, Department of Critical Care, Kasturba Medical College, Manipal, Karnataka, India

Corresponding Author:
Dr. Shwethapriya R
Associate Professor, Department of Critical Care, Kasturba Medical College, Manipal, Karnataka, India

Effectiveness of prewarming in prevention of inadvertent intraoperative hypothermia

Dr. Lakshmikanth Charan, Dr. Shwethapriya R, Dr. Manjunath Prabhu and Dr. Souvik Chaudhuri

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Abstract

Background: Inadvertent perioperative hypothermia (IPH), defined as a perioperative core temperature < 36 °C is attributable to redistribution of body heat from the core to peripheries during the initial phase of anaesthesia and is difficult to treat. We conducted this study to find the effectiveness of pre-warming in preventing the occurrence of hypothermia intraoperatively in adult patients undergoing elective laparotomy under general anaesthesia.
Material and Methods: Forty-four adult patients undergoing elective laparotomy were randomized into two groups of 22 each. Patients in Group P were prewarmed for 60 minutes prior to induction and those in Group C did not receive prewarming.
Results: Patients in Group P had a significantly higher peripheral temperature at induction compared to those in Group C (p = 0.025), whereas the core temperature at induction was found to be comparable between the 2 groups. The core to peripheral temperature gradient was found to be lower in group P when compared to group C and the difference was statistically significant (p = 0.042). The core temperature dropped to less than 35 °C in the first two hours following induction in 2 patients in Group P and in 14 patients in group C (p < 0.001). The rate of drop in the core temperature was higher in group C compared to group P (p=0.002). The mean peripheral temperature as well as the core temperature in group P was significantly higher than in group C from induction to 60th minute, and it was statistically significant.
Conclusion: In the first 2 hours post induction, prewarming is effective in preventing the drop in core temperature and reduces the rate of drop in core temperature. Prewarming is effective in reducing the core to peripheral temperature gradient at induction.

Keywords: inadvertent perioperative hypothermia, prewarming, core to peripheral temperature gradient, core temperature

Introduction

Inadvertent perioperative hypothermia (IPH), refers to core temperature of <36 ˚C, is a common problem in day to day anaesthesia practice [1]. IPH has been attributed to several complications such as adverse myocardial events, increased blood loss intraoperatively, thermal discomfort, delayed recovery from general anesthesia, prolonged length of hospitalization and even increased probability of surgical site infections [1, 2, 3, 4, 5]. Even though perioperatively body warmers are frequently administered to prevent hypothermia, such forced air warmers are ineffective to prevent a core temperature drop [1, 6, 7].
Anaesthetic induced vasodilation, however allows core heat to flow peripherally, warming the peripheries, but at the expense of the core [1]. Apart from pre warming of patient, warming of intravenous fluids and blood products have been proposed [8]. Abdominal surgery is known to cause hypothermia, especially because of large incision, long duration and frequent peritoneal lavage [9].
We conducted this study to find the effectiveness of this method of prewarming in preventing the occurrence of hypothermia intraoperatively in adult patients undergoing elective laparotomy under general anesthesia.

Material and Methods

This study was a prospective, randomized control trial. Approval was obtained from the Institutional Ethics committee. Based on the pilot study done in 10 patients, with 5 in each group, and power of study of 80%, the sample size was calculated to be 44.

Study population included adult patients of either gender aged 18 to 65 years belonging to ASA physical status I and II with BMI of 16 - 25 kg/m², undergoing elective laparotomy under general anaesthesia with expected duration of more than 2 hours.

Patients suffering from thyroid disease, dysautonomia, Raynaud's syndrome, peripheral vascular disease, Cushing's syndrome and diabetes mellitus with autonomic neuropathy were excluded from the study.

Patients were evaluated the day prior to surgery, the nature of study was explained and an informed written consent was taken from the patients. Fasting and premedication were as per the concerned anaesthesiologist's orders.

Patients were randomized into Group P (those who received prewarming prior to induction) or Group C (those who did not receive prewarming prior to induction) of 22 each by a computer generated block randomization table.

There were two observers in the study. Observer 1 was an anaesthesiology resident who performed the preoperative evaluation, got the informed consent and facilitated in prewarming the patient prior to induction and Observer 2 was an anaesthesiology resident posted for that particular case, who monitored the temperature intraoperatively.

On the day of surgery, patients were shifted to premedication area about one hour prior to the proposed time of surgery. Patients in group P were covered with full body warming sheet connected to warming unit (EQUATOR^{TM} Convective body warmer) and were prewarmed with the temperature output of the warming unit set to 40 ^{0}C for 60 minutes.

After prewarming for 60 minutes, warmer was disconnected and patients were shifted to the operating room and induced as per the concerned anaesthesiologist's discretion. Patients in group C were not prewarmed during preoperative period. In case if there was a delay of more than 15 min from the time of completion of prewarming to shift the patient to operating room, those patients were excluded from the study.

Immediately post-induction, patient's core and peripheral temperatures were measured using a central temperature probe (Datex Ohmeda 16561, 400 series) placed in the nasopharynx and a skin temperature probe (Datex Ohmeda 16560, 400 series) placed in the plantar surface of great toe respectively. During the conduct of general anaesthesia, fresh gas flows were maintained at 2 litres/min (N2O - O_2 - isoflurane on circle system).

Heat loss was minimised with heat and moisture exchanger (HME), fluid warmers and cotton sheets covering most of the body except the surgical site in all the patients. The warmer sheet was placed over the patient's chest and upper limbs, and was connected to the warming unit but was used only as a rescue measure. Patient's core and peripheral temperatures and the OR temperature were monitored every 15 minutes from the time of induction by observer 2. No active external warming of the patient was done intra-operatively with forced air warmer till the core temperature of the patient dropped to 35 ˚C.

Once the core temperature dropped to 35 ˚C, warmer was switched on with the temperature output of 44 ˚C. The time taken for the core temperature to drop to 35 ˚C from the time of induction was noted down.

We also noted the estimated blood loss and transfusion requirement, intra-operative fluid volume infused, and the use of regional anaesthesia.

The primary outcomes were the number of patients whose core temperature dropped to 35 ˚C in the first 2 hours post induction in each group and the rate of drop in core temperature in the first 2 hours post induction or till core temperature reached 35 ˚C, whichever was the earliest, in each group.

Results

The demographic variables of age, gender and body mass index (BMI) were comparable between the two groups P and C (Table 1).

Table 1: Demographic Data

	Group P	Group C	p value
AGE (years) Mean ± SD	48.80 ± 10.98	46.59 ± 13.31	0.668* (NS)
SEX (M/F)	11/11	6/16	0.122**(NS)
BMI (kg/m²) Mean ± SD	22.09 ± 2.19	20.97 ± 2.47	0.118* (NS)

S.D.: Standard Deviation
NS: Not statistically significant
* Students t-test
** Chi square test

The operating room temperature, amount of intravenous fluids used and duration of surgery were comparable between the two groups P and C (Table 2).

Table 2: Perioperative Variables

	Group P	Group C	p value
Operating room temperature (°C) Median (IQR)	23.35 (22.87, 23.60)	23.45 (22.70, 24.15)	0.517* (NS)
Total intravenous fluids used (ml) Median (IQR)	2500 (1875, 4050)	2000 (1500, 3625)	0.429* (NS)
Total duration of surgery (mins) Median (IQR)	217.50 (161.25,348.75)	210.00 (176.25,247.50)	0.588* (NS)

IQR: Inter quartile range
NS: Not statistically significant
* Mann Whitney U test

The mean and standard deviation (SD) of peripheral temperature of group P at induction was 30.20 ± 4.41 °C and that of group C was 27.29 ± 3.83 °C ($p = 0.025$ Student's t test), whereas the core temperature at induction was found to be comparable between the 2 groups (Table 3).

Table 3: Temperatures at Induction

	Group P	Group C	p value
Core Temperature (°C) Mean ± SD	36.27± 0.48	36.07 ± 0.26	0.105* (NS)
Peripheral Temperature (°C) Mean ± SD	30.20 ± 4.41	27.29 ± 3.83	0.025* (S)
Core To Peripheral Temperature Gradient (°C) Median (IQR)	4.65 (2.70, 10.75)	12.45 (4.40, 12.68)	0.042** (S)

S.D.: Standard Deviation, IQR: Inter quartile range,
NS: Not statistically significant, S: Statistically significant.
* Students t-test
** Mann Whitney U test

The core to peripheral temperature gradient at induction was found to be lower in group P, with median and interquartile range (IQR) 4.65±8.05 °C when compared to group C (median and IQR 12.45 ±8.28 °C) and the difference was statistically significant (p = 0.042, Mann Whitney U test) (Table 3). The core temperature dropped to less than 35 °C in the first two hours following induction in 2 patients in Group P and in 14 patients in group C and the difference was statistically highly significant (*p* < 0.001 Chi Square test). The rate of drop in the core temperature in the first 2 hrs post induction or till it dropped to 35 ˚C whichever was the earliest to occur was compared between the 2 groups and was found to be higher among the patients in group C (median and IQR 0.84± 0.93 ˚C /hour) when compared to group P (0.41± 0.23 ˚C /hour) and the difference was found to be statistically significant (p=0.002 Mann Whitney U test). The mean and SD of core temperature at 60th minute in group P (35.89 ˚C ± 0.46) was significantly higher than in group C (35.43 ˚C ± 0.29) (Table 4). The difference was statistically significant, with a p value 0.002 (Student's t test).

Table 4: Core temperature variations in every 15 min during the first 2 hours of post induction

Time From Induction (MINS)	Core Temp (°C) Mean ± SD		Significance p Value
	Group P	Group C	
0	36.27 ± 0.48	36.07 ± 0.26	0.105**
15	36.26 ± 0.26	35.87 ± 0.37	0.003*
30	36.10 ± 0.46	35.62 ± 0.31	0.000*
45	36.01 ± 0.43	35.45 ± 0.29	0.000*
60	35.89 ± 0.46	35.43 ± 0.29	0.002*
75	35.81 ± 0.48	35.46 ± 0.29	0.041*
90	35.73 ± 0.51	35.49 ± 0.20	0.182**
105	35.69 ± 0.55	35.46 ± 0.12	0.272**
120	35.65 ± 0.57	35.41 ± 0.15	0.271**

S.D.: Standard Deviation *: Statistically significant
Students t- test **: Not statistically significant

The mean and SD of peripheral temperature at 60th minute in group P (32.97 ± 1.81 ˚C) was significantly higher than in group C (31.13 ± 2.60 ˚C) (Table 5). The difference was statistically significant, with a p value 0.018 (Student's t test). There was no significant difference between the core to peripheral temperature gradient between the two groups at 60 minutes or at 120 minutes post induction.

Table 5: Peripheral temperature variations in every 15 min during the first 2 hours of post induction

Time from Induction (MINS)	Peripheral Temp (°C) Mean ± SD		Significance p value
	Group P	Group C	
0	30.20 ± 4.41	27.29 ± 3.83	0.025*
15	32.87 ± 1.90	30.23 ± 3.51	0.003*
30	33.48 ± 1.70	30.43 ± 3.88	0.002*
45	33.40 ± 1.52	31.37 ± 3.22	0.014*
60	32.97 ± 1.81	31.13 ± 2.60	0.018*
75	32.44 ± 2.03	31.40 ± 2.04	0.178**
90	32.03 ± 2.23	31.00 ± 1.78	0.230**
105	31.65 ± 2.47	30.46 ± 1.91	0.231**
120	31.43 ± 2.55	30.01 ± 2.00	0.173**

S.D.: Standard Deviation *: statistically significant
Students t- test **: Not statistically significant

Discussion

IPH is quite common in anesthesia practice and has an incidence of upto 70% [10, 11].
Pre-operative warming decreases heat redistribution. In a classic study, Camus and colleagues, found that core body temperature decreased at a rate of 0.6ºC per hour in prewarmed patients, but decreased 1.1ºC per hour in patients who were not pre-warmed [12]. Perioperative hypothermia has multiple deleterious effects [11]. It may lead to a decrease in metabolic rate, reduction in cardiac output, accentuation of metabolic acidosis, increased duration of action of muscle relaxants, abnormal coagulation functions and higher incidence of infection [10, 11]. Hypothermia also leads to postoperative shivering, with an increase in oxygen consumption, noradrenaline release, and a higher chance of myocardial ischemia [10, 11]. Ultimately, it may lead to an

increase in morbidity as well as cost of the treatment [11]. This hypothermia during general anaesthesia predominantly occurs during the initial phase following induction of anaesthesia and has been attributed to redistribution of body heat [10, 11]. Due to the vasodilation occurring post anesthetic induction, the core heat dissipates to the peripheries. Thus there is warming of the peripheries, but a drop in core temperature [10, 11]. There are conflicting reports in literature which says prewarming is as good as co-warming to prevent intra-operative hypothermia [1, 11].

Sessler *et al*. Conducted a study to find out the optimal duration and temperature of prewarming and in accordance with the results of that study, we prewarmed the patients in our study group for 1 hour with the temperature output of the warmer set at 40 °C, and has also been done in similar studies [11, 13, 14, 15]. However, prewarming from 15 minutes to 2 hours has been commonly done in previous studies [16, 17, 18]. Some studies have even concluded that pre-warming was not necessary to prevent intraoperative hypothermia [19, 20]. So, in our study we intended to check for the effectiveness of prewarming with forced air warmer as a sole measure in preventing intraoperative hypothermia.

Analyzing the results of our study, we found that the core temperature dropped to < 35 °C in the first two hours post induction in 2 among 22 patients in the prewarmed group and 14 among 22 in the control group and the difference in the number was statistically highly significant and hence prewarming was found to be effective in reducing the number of patients who drop their core temperature in the first two hours of surgery. Similar results were obtained in previous literature [1, 11, 12, 21, 22].

In the study by Kim *et al*. On 40 patients undergoing off-pump coronary artery bypass surgery, at 60 and 90 minutes, only one patient in prewarming group had core temperature below 35.8 °C, compared to six (30%) and seven patients (35%) in control group, who had their core temperatures reduced. The findings were similar to that of our study [23].

The rate of drop of core temperature was much less in the prewarmed group in our study 0.41(0.28, 0.51) °C/hr than in the control group 0.84 (0.40, 1.33) °C/hr, which was similar to the study done by Camus *et al*. [12]. However, the results of our study was different than that of Shenoy L *et al*., where the rate of drop of core temperatures was not significant between the prewarming and co-warming groups [11]. In that study however, the investigators had continued intra-operative warming in both the prewarmed and not prewarmed groups, and thus this could have led to different results.

The core to temperature gradient at induction, which we had analysed in our study, was significantly lower in the prewarmed group. Similarly, it was also significantly less in the prewarmed group at two hours post induction. Our results were different from a previous study, where the authors found no significant difference in core to peripheral temperature gradient, either at induction or at the end of surgery, which could again be explained by the continuation of warming intra-operatively in all the patients [11]. However, in another study done by Vanni *et al*. On 30 patients posted for abdominal surgery under general anesthesia, who were warmed both pre-operatively and intra-operatively, patients had higher core temperatures in the first two hours after induction [24].

We also studied some of the perioperative variables such as the total intravenous fluids used intraoperatively, the total blood loss and the transfusion requirements of the patients intraoperatively and found that they were all comparable between the two groups. We also studied and compared the rate of drop in core temperatures in the first two hours post induction, and found that those prewarmed had a significantly lesser rate of drop. This rate of drop of core temperatures has not been analysed in many studies, where only the absolute core temperatures were analysed.

Our study had few limitations. First was the use of epidural anaesthesia in addition to general anaesthesia in some patients. As our study was done in patients undergoing major abdominal surgeries, it would have been unethical to ask the concerned anaesthesia team not to use the epidural anaesthesia. As such the no of patients in whom the epidural was activated with local anaesthetic in the first 2 hours post induction was found to be six in both groups.

But the level at which epidural was put and the dose of local anaesthetic used for epidural activation were not standardised. So the effect of epidural was considered as a confounding factor. In order to evaluate whether the confounding factor affects the primary objective (number of patients who dropped their core temperature to <35 ˚C in the first 2 hrs post induction) Mantel – Haenszel test of conditional independence was used. When applied, p value of the primary objective which was < 0.001 initially came to 0.00. As the p value is still significant, it indicates that the primary objective is not affected by the confounding factor.

The other limitation was the use of nasopharyngeal probe for monitoring the core temperature. As it would be very uncomfortable for use in awake patients, the core temperature could not be measured before commencement of prewarming.

Conclusion

We conclude that in the first 2 hours post induction, prewarming is effective in preventing the drop in core temperature and reduces the rate of drop in core temperature. Prewarming is effective in reducing the core to peripheral temperature gradient at induction.

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