Original Article

Pre-Operative Forced Air Warming and In Preventing Incidence of Perioperative Hypothermia in Patients Undergoing General Anaesthesia- a Randomised Comparative Prospective Study

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Abstract

Background and Aims: Inadvertent perioperative hypothermia (IPH) is defined as a peri-operative core temperature of less than 36°C. IPH is known to increase the risk of blood loss, prolonged and altered drug effects, post-operative shivering, and adverse cardiac events. Pre-operative warming with forced air reduces post-induction redistribution hypothermia and prevents complications associated with hypothermia. The present study was conducted to compare the effect of preoperative forced-air warming on the incidence of perioperative hypothermia in patients undergoing general anaesthesia, who are pre-warmed versus those who are not pre-warmed.
Material and methods: This randomized comparative prospective study was carried out on 170 adult persons of either sex, ASA (American Society of Anesthesiologists) physical status I -III scheduled for different surgeries under general anaesthesia who met eligibility criteria were randomly assigned either to group A in which pre-operative forced-air warming was done for 30 minutes or to group B in which pre-operative forced-air warming was not done. The incidence of hypothermia was compared between the two groups.
Result: The incidence of hypothermia was significantly higher in the non-pre-warmed group as compared to the pre-warmed group. The incidence of postoperative shivering was significantly higher in the non-pre-warmed group. However, the incidence of an adverse cardiac event and increased blood loss was insignificant between the two groups.
Conclusion-Based on observations and results of this study, the incidence of perioperative hypothermia was reduced in patients who were pre-warmed for 30 minutes before general anaesthesia in comparison to patients who were not pre-warmed.

Key-words: Hypothermia, Forced Pre Warming, recovery, adverse effects

Introduction:

Peri-operative hypothermia as defined by the American Society of Peri- Anaesthesia Nurses (ASPAN) is a core temperature below 36 °C and is known to increase the risk of surgical wound infections, poor wound healing, blood loss, prolonged and altered drug effects, increased duration of hospital stay, cardiac events, morbidity, and mortality.[1]

Hypothermia is associated with many detrimental physiological alterations and increased morbidity. These derangements include decreased cardiac output, decreased metabolic rate, metabolic acidosis, and prolonged recovery from anaesthesia, deranged clotting, and an increased incidence of post-operative infections. Postoperative shivering may also lead to increased oxygen consumption, norepinephrine release, and myocardial ischemia.[2]

Pre-operative forced-air warming (i.e., pre-warming) reduces the potential for heat loss that occurs during post-induction redistribution by cutaneously transferring heat to peripheral tissues, thereby decreasing the core-to periphery temperature gradient and in turn reducing the overall incidence of hypothermia.[3-5]

The present study was conducted to evaluate pre-operative forced-air warming in preventing the incidence of perioperative hypothermia in a patient undergoing general anaesthesia for various surgeries and also with a

secondary objective to study the effect of pre-warming on the Amount of intra-operative blood loss, Incidence of adverse cardiac event, Time of recovery from anaesthesia and Incidence of postoperative shivering

Material and Methods:

This randomized comparative prospective study was carried out over 10 months starting from August 2018 to May 2019. After approval by the institutional ethics committee(TS/MSSSH/BMDRC/ANES/IED/18-19,DATED 28/12/2018) 170 adult persons of either sex, ASA(American Society of Anesthesiologists) physical status I-III admitted in our hospital, and scheduled for different surgeries under general anaesthesia who met eligibility criteria were enrolled for the study after their voluntary consent.

The patients were randomly assigned using a computer-generated table of random numbers, either to group A (pre-warmed) or to group B (not pre-warmed). The randomization was done using the table of random numbers with the aid of the website randomization.com. Patients with ASA grade1-3, Age 18-75years, Undergoing general anaesthesia for surgeries of the duration of 1-3 hours were included in the study. Patients with h/o current infection, Intake of antipyretics within 24 hours, Hypo or hyperthyroidism, Preoperative temperature of more than 37.2 ° C, BMI > 35kg/m2 were excluded from the study. Axillary temperature, BP, SpO2, Heart rate were monitored during the Pre-operative, intra-operative, and post-operative period. During the intraoperative period, the nasopharyngeal temperature was also measured

Our study comprised of two groups, Group A: In this group, forced-air warming for 30 minutes was done pre-operatively. Group B: In this group, forced-air warming was not done pre-operatively. For forced Air Warming The Bair Hugger™ system, the original forced-air unit system that was introduced in 1987 was used.

It requires a patient-specific warming blanket and there are 3 temperature settings of low (32°C), medium (38° C), and high (45° C).

In our study, forced-air warming was done pre-operatively and intra-operatively in group A. In group B, forced-air warming was done intra-operatively only. After detailed pre-anesthetic evaluation, patients scheduled for different surgeries under general anaesthesia that fulfilled the inclusion criteria were explained about the pre-warming, and written informed consent was taken.

Pre-warming for 30 minutes was done in the preoperative care unit with a forced-air blanket positioned over the body of the patient with a temperature setting of 45 °C. The baseline axillary temperature of the patient was measured and noted. During the warming, procedure patients were asked every 10 minutes about their thermal comfort. When warming was stopped blanket was left on the patient's skin without blowing air. After warming the patient was transferred to O.T. (operation theatre) ambient temperature of the operating room was noted and maintained at around 18-20 °C. GA(General anaesthesia) was given using fentanyl 2-2.5 mcg/kg, propofol 1.5-2.5 mg/kg, atracurium 0.5 mg/kg. The patient was intubated with an endotracheal tube or laryngeal mask airway. Maintenance of anaesthesia was done with O2, N2O, and sevoflurane. After measuring the distance between the philtrum and tragus, the same length of the nasopharyngeal temperature probe was introduced after induction. Warming with forced-air warming blanket was started with a temperature setting of 45 °C and core temperature was recorded every 10 minutes till the end of surgery.

After the surgery patient was shifted to post anaesthesia care unit (PACU) and forced-air warming was the axillary temperature was measured every 15 minutes for 1 hour. Ambient temperature was maintained at 18-22 °C. The amount of blood loss, Recovery time from anaesthesia, Incidence of peri-operative adverse cardiac event and shivering in PACU was measured .grade of shivering was measured using the postoperative shivering grading scale. 0= No shivering, 1= Intermittent, low intensity shivering, 2= Moderate shivering, 3= Continuous, intense shivering.

The collected data was entered in Microsoft Excel and then analysed and statistically evaluated using the SPSS-PC-17 version. Quantitative data were expressed by mean, standard deviation, and while qualitative data was expressed in percentage. The difference between the proportions was tested by the chi-square test or Fisher's exact test while the difference between the quantitative variable between the two groups was tested by Student‘t’ test or Fisher Exact test. 'P' value of less than 0.05 was considered statistically significant.

Results:

The study population showed female preponderance in both groups. Patients in both groups were comparable for gender (P-value = 0.64). The mean BMI (Body mass index) in group A was found to be 24.71 kg/m^2 while the mean BMI in group B was found to be 24.97 kg/m^2. Patients in both groups were comparable for the BMI of the patients

(P-value = 0.65). Both groups were comparable for the type of surgery (p-value-0.75). The mean duration of surgery was 95.18 minutes in group A and 96.71 minutes in group B. Both groups were comparable to each other for the duration of surgery, (p-value-0.77) (Table 1).

Table 1: Demographic data of both groups

Variables	Group A (n=85), n (%)	Group B (n=85), n (%)	P value
Age in years (Mean ±SD)	45.44±14.38	43.72±15.17	0.42 *
BMI in kg/m^2 (Mean ±SD)	24.71±3.09	24.97±4.21	0.65*
Gender			
Male	39 (45.88)	36(42.35)	0.64**
Female	46(54.11)	49(57.64)	
Comorbidities			
Asthma	0(0.0)	3(3.5)	0.24**
CAD	6(7.1)	5(5.9)	0.99**
DM	19(22.3)	22(25.9)	0.59**
Hypertension	35(41.1)	26(30.6)	0.15**
Obesity	5(5.9)	5(5.9)	-
Post-chemotherapy	1(1.7)	1(1.7)	-
Post-CABG	0(0.0)	1(1.7)	0.99**

*Independent *t*-test, **Fisher's exact test. SD: Standard deviation

The mean ambient temperature in the pre-operative, post-operative area in group A and group B were comparable to each other (p-value- 0.99)

In the pre-operative area, axillary temperatures of patients were comparable to each other (p- 0.9). Before shifting into operation theatre axillary temperatures in both groups had no significant difference (p- 0.68). Just after induction, there was no significant difference between axillary temperatures of patients in group A group B. after 10 minutes of induction, there was a significant temperature difference between the two groups (p<0.001). mean axillary temperature at ten minutes was 36.07 ℃ in group A and 35.97 ℃ in group B. there was a significant temperature difference at T 20 , T 30 ,T 40, T 50, T 60 , T 70, T 80, T 90, T 100 , T 110, T 120 (P<0.001) . this difference remained significant at T 120, T 130, T 140, T 150 (p<0.01) and at T 160 , T 170, T180 (p-0.01).

At the end of the surgery, the mean axillary temperature was 36.08 °C in group A and 35.86 °C in group B and the temperature difference was significant (p<0.001). On arrival at PACU, the mean axillary temperature was 36.08-°C in group A and 35.86 °C in group B and the difference was significant (p<0.001)

Just after induction, there was no significant difference between the core temperatures of patients in group A group B. After 10 minutes of induction, there was a significant temperature difference between the two groups (p<0.001). Mean core temperature at ten minutes was 36.02 °C in group A and 35.85 °C in group B. There was significant temperature difference at T 20 , T 30 ,T 40, T 50, T 60 , T 70, T 80, T 90, T 100 , T 110, T 120 (P<0.001) . This difference remained significant at T 120, T 130, T 140, T 150 (p<0.01) and at T 160 , T 170, T180 (p-0.01). At the end of the surgery, the mean core temperature was 36.06 ℃ in group A and 35.84 ℃ in group B and the temperature difference was significant(p<0.001).(Table 2) Hypothermia occurred in 34.1% of patients in group A and 65.9% of patients in group B (Table 3).

Table 2: Intraoperative core temperature at different time period in study subjects

Core temperature (in degree Celsius)	**Group A**		**Group B**		**P value**
	Mean	**SD**	**Mean**	**SD**	
Just after induction	36.03	0.16	35.95	0.13	0.5
At 10 minutes	36.02	0.14	35.85	0.18	<0.001
At 20 minutes	36.00	0.17	35.83	0.19	<0.001
At 30 minutes	36.01	0.17	35.82	0.20	<0.001
At 40 minutes	36.02	0.19	35.82	0.23	<0.001
At 50 minutes	36.03	0.20	35.81	0.23	<0.001
At 60 minutes	36.04	0.21	35.82	0.23	<0.001

At 70 minutes	36.03	0.22	35.78	0.24	<0.001
At 80 minutes	36.03	0.23	35.77	0.25	<0.001
At 90 minutes	36.03	0.24	35.78	0.25	<0.001
At 100 minutes	35.98	0.26	35.76	0.27	<0.01
At 110 minutes	35.98	0.26	35.75	0.28	<0.01
At 120 minutes	35.97	0.26	35.76	0.26	<0.01
At 130 minutes	36.06	0.20	35.55	0.09	<0.01
At 140 minutes	36.06	0.20	35.55	0.07	<0.01
At 150 minutes	36.03	0.23	35.55	0.07	<0.01
At 160 minutes	36.02	0.23	35.54	0.05	0.01
At 170 minutes	36.02	0.23	35.54	0.05	0.01
At 180 minutes	36.05	0.23	35.54	0.05	0.01
At end of surgery	36.06	0.21	35.84	0.23	<0.001

Mean intraoperative blood loss in group A was 83.36 ml and group B was 99.36 ml in group B. p-value is 0.25, which is not statistically significant. The mean recovery time from anaesthesia was 12.64 minutes in group A and 15.55 in group B. p-value is <0.001 which is significant (Table 2).
In group A 20% of patients and 32.9% of patients in group B had grade 1 post-operative shivering (P-value-0.05) which is statistically significant.4.7% of patients in group A and 23.5% of patients in group B had grade 2 postoperative shivering. (P-value <0.001) which is statistically significant. No patient had grade 3 shivering in group A and one patient in group B had grade 3 shivering (Table 3).

Table 3: Ambient temperature, Incidence of hypothermia, Recovery time from anaesthesia and postoperative shivering in both groups

Variables	Group A (n=85), n (%)	Group B (n=85), n (%)	P value
Preoperative area	19.28±0.71	19.32±0.60	0.73*
Operation theatre	19.20±0.74	19.24±0.78	0.76*
Postoperative area	21.47±0.52	21.47±0.50	0.99*
Hypothermia			
Yes	29(34.1)	54(63.5)	<0.001**
No	56(65.9)	31(36.47)	<0.001**
Recovery time from anaesthesia(Mean ±SD)	12.64±4.49	15.55±5.87	<0.001**
Postoperative shivering grade			
0	64(75.13)	36(42.4)	<0.001*
1	17(20)	28(32.9)	0.05
2	4(4.7)	20(23.5)	<0.001
3	0(0)	1(1.2)	0.99

*Independent *t*-test, **Fisher's exact test. SD: Standard deviation

Discussion:

Intraoperative hypothermia represents a three-phase pattern. An initial rapid decrease in core temperature observed during the first hour of general anaesthesia is related to the anaesthesia -induced impairment of centrally mediated thermoregulatory control leading to the inhibition of thermoregulatory vasoconstriction and mainly the core-to-peripheral redistribution of heat, which is due to peripheral vasodilatation by anaesthetic drugs. A relatively slow, linear decrease follows in the subsequent 2 or 3 hours. It results from the thermal imbalance due to increased heat loss which exceeds metabolic heat production. Finally, core temperature reaches a plateau phase that remains constant, even during a prolonged duration of surgery.[6-8]
Forbes et al conducted a study and recommended using forced-air warming systems and increasing room temperature to 22 °C for surgical procedures with an expected duration of more than 30 minutes.[9] Various studies suggested duration varying from 10 to 60 min reduced shivering and largely prevented hypothermia during general

anesthesia in healthy adult patients.[10-12]

NICE, has defined a temperature difference of 0.2 degrees between any intervention and control groups as being of clinical significance in hypothermic patients. It recommends using the maximum setting of the forced air warming unit from the beginning of surgery.[13] In our study, the temperature of the forced-air warming unit was set to 45 °C from the beginning of the surgery. The mean core temperature difference in our study at 40, 60, 70, 80 100, and 120 minutes exceeded 0.2 °C.

In a similar study by Shin et al, the patients in the pre-warmed group were warmed 30 minutes before induction with a forced-air warming device. Core temperatures in the pre-warmed group were significantly higher than the control group from 20 minutes after the induction until the end of surgery.[14] Similarly in a study conducted by Horn et al, forced-air skin surface pre-warming was done for 10, 20, and 30 min.[10]

Studies have suggested an optimal time of 30 min pre-warming reduced intraoperative hypothermia in patients. There were significant differences in changes in core temperature between the non-pre-warmed group and all the pre-warmed groups.[15,16]

In our study, at the end of the surgery, core body temperature was higher in group A ($p<0.001$). On arrival at PACU, the axillary temperature was higher in group A ($p<0.001$). 34.1% of patients in group A and 65.9 % of patients in group B ($p<0.001$) were hypothermic which was significant.

In surgeries of one-hour duration, 57.5 % of patients in group B and 16.6% of patients in group A were hypothermic ($p < 0.001$) which was significant. In surgeries of 60 to 120 minutes duration, 65.9% of patients in group B and 27.4% in group A were hypothermic ($p<0.001$) which was significant. In surgeries of 120 to 180 minutes duration, 83.3% in group B and 14.2% in group A were hypothermic ($p<0.001$) which was significant. It is difficult to treat intraoperative hypothermia because the heat applied to the skin surface requires considerable time to reach the core thermal compartment.

In our study, 24.7% of patients in the pre-warmed group had postoperative shivering, and 57.6% of patients in non -pre-warmed had post-operative shivering which was significant ($p <0.001$). Grade 2 shivering was observed in 23.5% of patients in the non-pre-warmed group ($p<0.001$) while grade 3 shivering occurred only in one patient who was not pre-warmed.

Two different studies by Park B et al and Lopez MB showed that the incidence of shivering was significantly less in the pre-warmed groups compared with the non-pre-warmed group.[17,18]

Although postoperative cutaneous warming decreases thermal discomfort, shivering intensity, and maximum oxygen consumption during shivering, it does not stop or affect the duration of shivering.[5] however in our study preoperative forced-air warming reduced the incidence of postoperative shivering.

Hypothermia is not only uncomfortable for patients. It is also physiologically stressful, elevating blood pressure, heart rate, and plasma catecholamine concentrations. These factors lead to a threefold increase in morbid myocardial events. The mechanism behind the increased postoperative cardiac risk with mild hypothermia is still unclear. But the study showed perioperative maintenance of normothermia is associated with a reduced incidence of morbid cardiac events and ventricular tachycardia. In a study conducted by Frank et al in patients with a high risk of coronary artery disease, those patients who were hypothermic had an increased incidence of postoperative cardiac events. While post-operative norepinephrine, epinephrine, and cortisol concentrations increased in all patients, norepinephrine was significantly higher in the hypothermic group compared to the normothermic group.[19,20]

In a systemic review by Sajid et al, there was insufficient data in the trials available to assess hypothermia induced myocardial dysfunction.[21] In the present study, there was no incidence of adverse cardiac events in both pre-warmed and non-pre-warmed groups.

In our study, the mean intraoperative blood loss in group A was 83.36 ml and group B was 99.36 ml which was not significant. In a study by Tedesco NS et al, no effect was found on perioperative blood loss from hypothermia. They interpreted that the effect of temperature on blood loss can be explained by a strong relationship with the confounders of operating time and surgery type.[22] In a recent large retrospective study by Sun z et al, transfusion requirements increased in proportion to the decrease in temperature and the increased duration of hypothermia.[23]

In our study, mean blood loss between pre-warmed and non-pre warmed groups when compared did not give significant results and this could be attributed to the confounding factors of operating time and surgery type.

Another complication attributed to a typical mild intraoperative hypothermia is the prolonged duration of post-anesthetic recovery. In our study, the mean recovery time from anaesthesia was 12.64 minutes in group A and 15.55 minutes in group B. p-value is <0.001 which is significant. Studies have concluded that mild hypothermia increases the duration of action of and time for spontaneous recovery from vecuronium-induced neuromuscular blockade.[24,25]

Our study supports the previous findings that peri-operative hypothermia prolongs the recovery time from anaesthesia Pre-warming the patients for 30 minutes at 45 °C before general anaesthesia reduced the incidence of hypothermia in comparison to patients who were not pre-warmed. Pre-warming also reduced the incidence of postoperative shivering and reduced the time of recovery from anaesthesia.

Conclusion:

Based on observations and results of this study, we conclude that the incidence of perioperative hypothermia was reduced in patients who were pre-warmed for 30 minutes before general anaesthesia in comparison to patients who were not pre-warmed. Our study was done with the limitation of time and a larger subset of cases would give more conclusive findings.

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