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The use of forced air warmer for the prevention of inadvertent perioperative hypothermia under general anaesthesia - A prospective observational study

Abhini Prabhakar[1],*, Trupti Pethkar[1]

[1] *Dept. of Anaesthesiology, Kokilaben Dhirubhai Ambani Hospital and Medical Research Institute, Mumbai, Maharashtra, India*

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ABSTRACT

Background: Temperature is an important parameter which determines patient outcomes perioperatively. Iatrogenic hypothermia during surgery under general anaesthesia leads to significant side effects which can be corrected with the use of active body surface warming devices like the forced air warmer.
Materials and Methods: A prospective observational study was conducted with a sample size of 362 which included patients of either sex aged 18-65years posted for any elective surgery under general anaesthesia lasting >60 and ≤180minutes. Baseline oral temperature was recorded preoperatively. Patients were warmed with forced air warmer intraoperatively at 44°C with half hourly monitoring of nasopharyngeal temperature until extubation. Intravenous fluids were given at room temperature. Further, oral temperature was monitored at 15 and 60 minutes in post anaesthesia care unit and patients were warmed if hypothermic or shivering.
Results: The final mean intraoperative temperature (nasopharyngeal) was 36.01°C (n=362) with a range from 34.7°C to 37.1°C. 139 of 362(n) (38.4%) patients were hypothermic (<36°C) at the end of surgery. 61.6% of patients were normothermic. In 9 patients (2.5%, n=362) the forced air warmer was turned off due to over heating (temperature >37°C). 33 patients (n=362, 9.1%) had shivering postoperatively. Comparing the nasopharyngeal temperature (mean) at half hourly intervals post induction revealed statistically significant results (p<0.001).
Conclusion: The establishment of near constant temperature (36±0.03°C) following the initial fall in core body temperature can be attributed to the forced air warmer. However, it is imperative to continuously monitor core body temperature to detect temperature changes(hypo/hyperthermia) in order to use the device safely as chances of overheating is always present.

1. Introduction

Body temperature is a vital parameter, the maintenance of which is required for the normal and optimal function of organ systems; enzyme activity in particular. Humans being homeothermic maintain a core body temperature of 36.2 to 37.5°C[1,2] which is regulated by a negative feedback mechanism in the hypothalamus. The central thermal core of our body (viscera, central nervous system, blood vessels) is surrounded by a peripheral compartment (skin, fat, muscle) which acts like a buffer to the outside environment.[3]

Core body temperature <36°C is termed hypothermia.[3–6] Anaesthesia affects thermoregulatory responses and increases the inter-threshold range from 0.2 to 4°C (the range between sweating and vasocontriction where no thermoregulatory responses are triggered). On induction of general anaesthesia, hypothermia sets in 3 phases (Figure 1).[3,7,8]

1. Phase 1/ Redistribution(1^{st} hour)- Peripheral vasodilatation due to general anaesthetic drugs leading to transfer of heat from core to periphery.
2. Phase 2/ Linear (1^{st} to 3^{rd} hour)- Heat loss exceeds metabolic heat production.

* *Corresponding author.*
E-mail address: abhinisreeram@gmail.com (A. Prabhakar).

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3. Phase 3/ Plateau (3^{rd} to 4^{th} hour)- Heat loss equals heat production thereby restoring core to peripheral temperature gradient but at a hypothermic level.

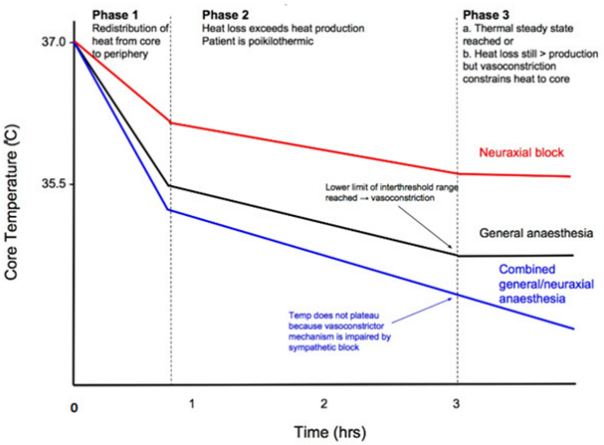

Fig. 1: Patterns of hypothermia under different types of anaesthesia.

Inadvertent perioperative hypothermia (IPH) occurs in nearly 50-70% of patients undergoing surgery[3,9] with a 1-3°C decrease in core temperature depending on the type of anaesthesia, dosage of drugs, ambient temperature and risk factors (children, elderly, hypothyroid, American Society of Anaesthesiologists {ASA} GradeIII- V patients at higher risk). Hypothermia is perhaps the most frequent undesirable event in elective surgery.[10] Peri-operative hypothermia leads to impaired drug metabolism and prolonged action of muscle relaxants, altered pharmacodynamics of inhalational anaesthetics, increased blood loss/coagulopathy(platelet dysfunction), prolonged post anaesthesia recovery time and prolonged hospital stay, increased surgical site infections and cardiac events(myocardial infarction, arrhythmias).[11] Temperature is part of the ASA basic standard anaesthesia monitoring.[12] Core body temperature is the best indicator of body temperature.[11] It can be measured reliably in the nasopharynx, oesophagus and pulmonary artery due to their close proximity to the brain.[13]

The National Institute for Health and Care Excellence (NICE) recommends the use of forced air warmer (FAW) and intravenous fluid warmers to prevent iatrogenic hypothermia.[6] The FAW is a body surface convective warming device which consists of a power unit that generates warmed air and a fan that blows the warmed air through a hose into a disposable blanket that has direct contact with the patient. In our study we determined the incidence of hypothermia at the end of surgery (primary objective) and the adverse effects of the FAW (secondary objective).

2. Materials and Methods

2.1. Study population

It was a prospective single centre observational study conducted after approval from the Institutional scientific and ethical committee. Study was registered on Clinical Trials Registry-India [URL- http://ctri.nic.in/Clinicaltrials/login.php] with number CTRI/2018/04/013113. All consecutive ASA I and II patients of either sex aged 18- 65 years undergoing elective surgery lasting >60minutes and ≤3 hours under general anaesthesia between 15^{th} July-2017 and 15^{th} December-2017 were included in our study. Patients presenting with oral temperature ≥ 38°C or < 36°C on arrival at preoperative hold, recent history of fever, emergency surgery, laparoscopic/robotic surgeries, previous history of malignant hyperthermia, hypo/hyperthyroid status and history of nasal surgery/ nasal trauma/recurrent epistaxis were excluded. Based on findings of Charles E. Smith et al[14] assuming an absolute precision of 5% at 95% confidence interval a total of 362 patients were enrolled in the study.

2.2. Study design and measurements

Written informed consent for the study was taken from all patients satisfying the eligibility criteria. No personal identifying information regarding the patient or anaesthesia provider was obtained, and therefore, patient and provider anonymity was maintained. All patients were subjected to a detailed pre-anaesthetic evaluation including physical examination with airway assessment, history of any medical conditions and laboratory investigations (haemoglobin, total white blood cell count, platelet count, and electrocardiogram) were recorded. Other investigations were individualized. All patients were kept nil by mouth for at least 6 hours prior to surgery.

On the day of surgery patients were shifted from ward wearing the operating room gown and a woollen blanket covering them. Oral temperature (sublingual) was recorded using a digital thermometer in the preoperative holding area before transferring the patient to operating room (T0). Operating room temperature was set at 20°C. Patients were shifted to the operating room with the same woollen blanket covering them.

On shifting the patient to the operating table WHO Surgical Safety checklist was followed. Electrocardiogram, electronic blood pressure monitor and pulse oximeter were applied and vitals recorded. A 20G intravenous (IV) cannula was secured and a crystalloid was started. Patients were covered with whole body Snuggle Warm forced air warming blanket. The forced air warmer hose was connected to it and temperature set at 44°C. Equator® level 1 convective warmer and Snuggle Warm® warming blankets by Smiths medicals (USA) were used (Figure 2). This is standard of care as per our institutional protocol.

Fig. 2: Equator Level 1 forced air warmer(left) and Snuggle Warm blanket(right) [Taken from product instruction manual]

Further, patients were premedicated with intravenous glycopyrolate 0.2mg, midazolam 1mg and fentanyl 1mcg/kg. General anaesthesia was induced with inj propofol IV 2mg/kg and airway secured with Laryngeal mask airway/Endotracheal tube following inj atracurium 0.5mg/kg IV. Patients were mechanically ventilated using closed anaesthesia circuit to maintain an end tidal carbon dioxide concentration of 35-40mm of Hg. Nasopharyngeal temperature probe (Philips) was inserted at approximately 10cm from one of the nares post induction.[15] Subsequently anaesthesia was maintained with 0.8 to 1MAC sevoflurane in oxygen: air of 1:1. Other measures to prevent inadvertent perioperative hypothermia like HME filters in breathing circuits and low flow anaesthesia were followed for all patients. Room temperature intravenous fluids were used as indicated. The Snuggle Warm blankets were placed covering the upper or lower body according to surgical exposure required. Over this the woollen blankets were placed followed by the surgical drapes. Active warming during the surgical procedure was continued at 44°C. Core body temperature was recorded at following intervals using nasopharyngeal probe-

1. 30 minutes post induction (T-30).
2. Every 30 minutes thereafter till end of surgery (T-60, T-90, T-120, T-150, T-180).
3. Prior to extubation (final intraoperative temperature-T-final).

Any patient in whom intraoperative core body temperature was >37°C, the FAW was turned off to avoid overheating. Patient vitals like heart rate, mean blood pressure and oxygen saturation were recorded. Anaesthesia time (time from the induction of general anaesthesia to extubation), surgery time (time from skin incision to last suture), total volume of fluids given (crystalloids and colloids) and intraoperative blood loss were recorded. At the end of surgery and anaesthesia, Snuggle Warm blanket was removed and the patient was covered with operating room gown and woollen blanket while shifting to the post anaesthesia care unit(PACU).

On entering the PACU vitals were monitored. Patients were covered with the same woollen blanket. Oral temperature was recorded at 15min and 60min after arrival in PACU (T-1 and T-2 respectively). Postoperatively, the occurrence of shivering was documented in the PACU. FAW was used to treat postoperative shivering and/or sublingual temperature <36°C. Patients were discharged from the PACU based on the Modified Aldrete score.

2.3. Statistical analysis

Descriptive and inferential statistical analysis was done using IBM SPSS statistics 20.0 (IBM Corporation, Armonk, NY, USA) software. Results on continuous measurements were presented as Mean ± SD and results on categorical measurement were presented as a percentage (%). Level of significance was fixed at p=0.05 and any value ≤ 0.05 was considered to be statistically significant.

Student t tests (two tailed, unpaired) were used to find the significance of study parameters on continuous scale between two groups. Analysis of variance (ANOVA) was used to find the significance of study parameters between the groups (Inter group analysis). Microsoft Word and Excel were used to generate graphs and tables.

3. Results

A total of 362 patients who satisfied the inclusion and exclusion criteria were included in the study. There were nearly equal males (50%) and females (49.7%) with one patient being a transgender. The mean age of the patients was 43.30±12.53 years (mean±SD). Average BMI (Body mass index) was found to be 26.98kg/m^2.

Majority of the patients (54.4%; n=362) belonged to ASA Grade I(i.e. a normal healthy patient) whereas the rest were ASA grade II (45.6%, n=362). Most of the patients recruited into the study underwent Orthopaedic surgery 33.7% (n=362), followed by Oncosurgery 26.5% (n=362), which was followed by General surgery at 10.2% (n=362). Thoracic surgery, gastrointestinal surgery, vascular surgery and gynaecological cases were nearly negligible. (Table 1)

All patients were given crystalloids (n=362, 100%). Only 2 patients required colloids (0.55%, n=362) and none were given blood. The average crystalloid used was 826.93 ml. Blood loss was minimal (47.99ml) during the surgeries.

All patients were normothermic in the preoperative hold. In all the 362 patients the baseline temperature dropped post anaesthetic induction (i.e. at 30 min) to a mean temperature of 36°C (range from 36.7 to 35.2°C). Further, during the course of anaesthesia and surgery, the mean core temperatures were 35.93°C, 35.98°C, 36°C, 36.04°C and 35.98°C at 60, 90, 120, 150 and 180 minute intervals respectively. Comparing the nasopharyngeal temperature (mean) at half hourly intervals post induction revealed statistically significant results (p<0.001). (Table 2)

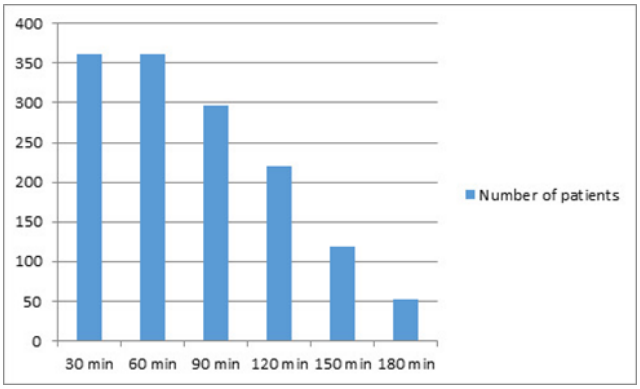

Fig. 3: Number of patients with respect to the duration of time their core body temperature was monitored intraoperatively (Anaesthesia time)- All patients' temperature was monitored for the first 60minutes as surgeries lasting 60minutes or more were only included in the study. It should be noted that only 53 patients' temperature was monitored half hourly till 180minutes, i.e. their anaesthesia and/or surgery lasted for 180minutes. The anaesthesia and surgery time lasted 130.12± 41.67 and 96.50±34.32 minutes respectively.

The mean final intraoperative core body temperature (nasopharyngeal) was 36.01±0.34°C i.e. normothermic (n=362) with a range from 34.7°C to 37.1°C. It was seen that 139 of 362(n) (38.4%) patients were hypothermic (<36°C) at the end of surgery despite using the FAW. 61.6 % of patients (n=362) were normothermic (Figure 4).

Further, in 9 patients (2.5%, n=362) the FAW was turned off due to over heating (temperature >37°C). This is one of the adverse effects of the FAW. No skin burns or fire accidents were documented with its use. T1 was 35.98°C (n=362) with a range of 34.7°C to 37°C and T2 was 36.25°C (n=362) with a range of 35°C to 37.1°C. 33 patients (n=362, 9.1%, mean T-final 35.5±0.18°C) had shivering in the PACU. These patients were warmed with FAW in the PACU as per protocol.

4. Discussion

Hypothermia is a common occurrence in the unwarmed surgical patient with significant morbidity and mortality. Forced air is by far the most commonly used and extensively tested intraoperative warming approach.[11,16] As FAW is

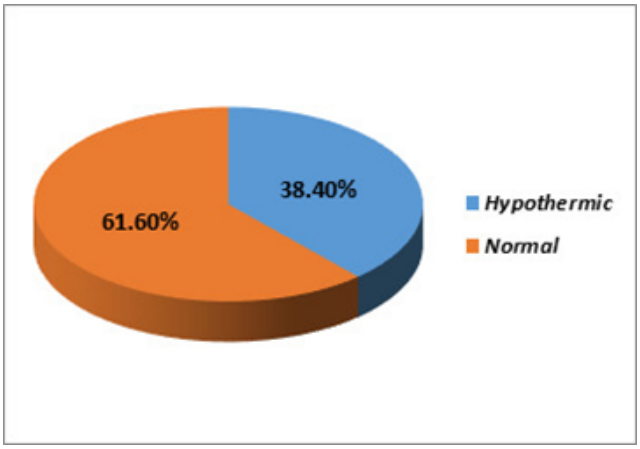

Fig. 4: Percentage of hypothermia at end of surgery

used routinely as standard of care in our institute, we examined its usefulness in preventing IPH in patients undergoing surgery under general anaesthesia.

Of the 362 patients, there were nearly equal males (50%) and females (49.7%) with one patient being a transgender who was posted for perineal urethrostomy. The mean age of the patients was 43.30 years. Average BMI was found to be 26.98±4.55kg/m^{2}in our study. L. A. Fernandes et al compared peri-operative core temperatures and the incidence of hypothermia in obese (30.0–34.9 kg/m2)(n=10) and non-obese(18.5–24.9 kg/m2)(n=10) women with active forced air warming and found the incidences of intra-operative hypothermia to be lower in the obese group (10%) compared with non-obese group (60%; p = 0.019).[17] But in our study, the average BMI of hypothermic patients(n=139) at the end of surgery was 26.61± 4.69kg/m^2 and that of normothermic patients was 27.21 ±4.45kg/m^2(n=223). As per ASPAN (American Society of Perianaesthesia Nurses), weight/BMI and age were the most common risk factors studied.[18]

While our study included ASA I and II patients, most of the other studies included ASA I -III patients.[19–22] The duration of anaesthesia and surgery was longer in other comparable studies.[14,19]

The initial fall in nasopharyngeal temperature during the first 60 minutes following induction of general anaesthesia was universal in our study. This was the time of skin incision and exposure of the body to cold operating room temperature of 20°C. This initial fall in temperature corresponds to the rapid redistribution of heat from core to periphery due to vasodilatation. In our study the mean temperature at 60minutes following induction was 35.93±0.28°C. This suggests that this redistribution hypothermia is possibly not prevented by FAW. Prewarming the patient with FAW preoperatively has been suggested as a strategy to decrease redistribution hypothermia with proven efficacy.[23–25] Further, the mean temperatures in

Table 1: Demographic and descriptive statistics (N=362)

Variables	Sub-groups	n	%	Mean ±SD
Gender	Male	181	50.0	
	Female	180	49.7	
	Undetermined(U)	1	0.002	
Age (years)				43.30 ± 12.53
BMI (kg/m^2)				26.98 ± 4.55
ASA	I	197	54.4	
	II	165	45.6	
Surgery	Ear, nose and throat	17	4.7	
	Gastrointestinal	3	0.8	
	General surgery	37	10.2	
	Gynaecology	3	0.8	
	Neurosurgery	35	9.7	
	Oncosurgery	96	26.5	
	Orthopaedics	122	33.7	
	Plastic surgery	10	2.8	
	Thoracic surgery	2	0.6	
	Urology	35	9.7	
	Vascular surgery	2	0.6	
Crystalloid (ml)		362	100.0	826.93 ± 328.68
Colloid		2	0.55	
Total blood loss (ml)		362	100	47.99 ± 81.33
Anaesthesia time (min)				130.12 ± 41.67
Surgery time (min)				96.50 ± 34.32
T-final (°C)	Hypothermic(<36°C)	139	38.4	36.01 ± 0.34
	Normal	223	61.6	
FAW turned off	Yes	9	2.5	
	No	353	97.5	
T1 (°C)				35.98 ± 0.33
T2 (°C)				36.25 ± 0.32
Shivering	Yes	33	9.1	
	No	329	90.9	

Table 2: Comparison of the nasopharyngeal temperature values in terms of Mean (SD) at half hourly intervals post induction of general anaesthesia using ANOVA test

Time interval	N	Mean temperature(in °C)	Std. Deviation	F value	P value
Baseline	362	36.95	0.13		
30 min	362	36.00	0.27		
60 min	362	35.93	0.28		
90 min	296	35.98	0.30	590.51	<0.001**
120 min	220	36.00	0.32		
150 min	118	36.04	0.38		
180 min	53	35.98	0.42		

($p < 0.05$ - Significant*, $p < 0.001$ - Highly significant**)

Table 3: Comparison of gender, age and type of surgery with T-final

Patient particulars			Temperature		Mean T-final(°C)
			Hypothermic	Normal	
Gender	Male	Count	75	106	36.01
		% within Gender	41.4%	58.5%	
	Female	Count	63	117	36.02
		% within Gender	35.0%	65.0%	
Age	18-30	Count	13	49	36.23
		% within Age	21.0%	79.0%	
	31-40	Count	24	68	36.04
		% within Age	26.1%	73.9%	
	41-50	Count	43	56	35.99
		% within Age	43.4%	56.6%	
	51-60	Count	33	38	35.91
		% within Age	46.5%	53.5%	
	61-65	Count	26	12	35.84
		% within Age	68.4%	31.6%	
Type of surgery	ENT	Count	13	4	35.86
		% within surgery	76.47	23.53	
	Gastrointestinal surgery	Count	3	0	35.77
		% within surgery	100	0	
	General surgery	Count	13	24	35.98
		% within surgery	35.14	64.86	
	Gynaecology	Count	2	1	35.77
		% within surgery	66.67	33.33	
	Neurosurgery	Count	26	9	35.76
		% within surgery	74.29	25.71	
	Oncosurgery	Count	24	72	36.07
		% within surgery	25	75	
	Orthopaedics	Count	25	97	36.22
		% within surgery	20.49	79.51	
	Plastic surgery	Count	4	6	35.87
		% within surgery	40	60	
	Thoracic surgery	Count	2	0	35.5
		% within surgery	100	0	
	Urology	Count	25	10	35.69
		% within surgery	71.43	28.57	
	Vascular surgery	Count	2	0	35.75
		% within surgery	100	0	

75 males (n=181, 41.4%) were hypothermic at the end of surgery. Whereas, 63 females (n=180, 35%) were hypothermic at the end of surgery. Therefore, males were more hypothermic than females in our study. Maximum patients (99 of 362) were aged between 41-50 years and the least number (38 of 362) were of the 61-65 age group. The incidence of hypothermia at the end of surgery was maximum in the 61-65 age group at 68.4% (n=38) with a mean temperature of 35.84°C. Hypothermia was minimal in the 18-30 age group at 21% (n=62). Therefore, elderly individuals were more prone for perioperative hypothermia. Apart from the patients who underwent orthopaedic and oncosurgical procedures, the rest of the patients were hypothermic at the end of surgery. 25%(n=96) and 20.49%(n=122) of oncosurgical and orthopaedic patients were hypothermic respectively.

the following 2 hours(60 to 180 minutes) at half hourly intervals were 35.98°C, 36°C, 36.04°C and 35.98°C. This near constant temperature maybe attributed to the use of forced air warmer.

A non-systematic literature review of 52 articles on hypothermia stated that 70–90% of patients were hypothermic 1h into surgery and it could take upto 4hours to restore normothermia if suitable measures were not taken.[10] Sheryl Warttig et al. conducted a Cochrane review of the various interventions(active and passive warming) to prevent IPH and concluded that active warming particularly with FAW showed a clinically significant reduction in mean time taken to achieve normothermia (normal body temperature between 36°C and 37.5°C) in patients with postoperative hypothermia.[26]

The incidence of hypothermia (<36°C) at the end of surgery was 38.4%(139 of 362) with a mean final intraoperative temperature of 36.01 ± 0.34°C in our study. Charles E. Smith et al.[14] found 38%(n=30, p<0.05) of the patients in the FAW group to be hypothermic with mean final intraoperative distal oesophageal temperatures of 36.1 ±0.1°C, while Abdallah Kabbara et al.[19] found 31%(n=39,

Table 4: Comparison of different variables in terms of {Mean (SD)} using unpaired t test (p< 0.05 - Significant*, p < 0.001 - Highly significant**)

Parameter	Variable	N	Mean	Std. Deviation	t value	P value
Temperature	T-final	362	36.01	0.34	1.2047	0.228
	T 1	362	35.98	0.33		
Temperature	T-final	362	36.01	0.34	9.780	<0.001**
	T 2	362	36.25	0.32		
BMI	Hypothermic	139	26.61	4.69	1.223	0.222
	Normal	223	27.21	4.45		
Anesthesia time	Hypothermic	139	127.66	44.38	0.887	0.376
	Normal	223	131.66	39.92		
Surgery time	Hypothermic	139	95.11	35.37	0.607	0.544
	Normal	223	97.36	33.70		
Total Blood loss	Hypothermic	139	63.42	99.742	2.877	0.004*
	Normal	223	38.39	65.805		
Crystalloid	Hypothermic	139	827.70	339.286	0.035	0.972
	Normal	223	826.46	322.671		

The comparison between the final intraoperative temperature (mean, 36.01°C) and the temperature in the PACU at 60minutes (mean, 36.25°C) & the total blood loss in hypothermic (mean 63.42ml) and normothermic(mean 38.39ml) patients was found to be statistically significant(p=0.001 and p=0.004 respectively).

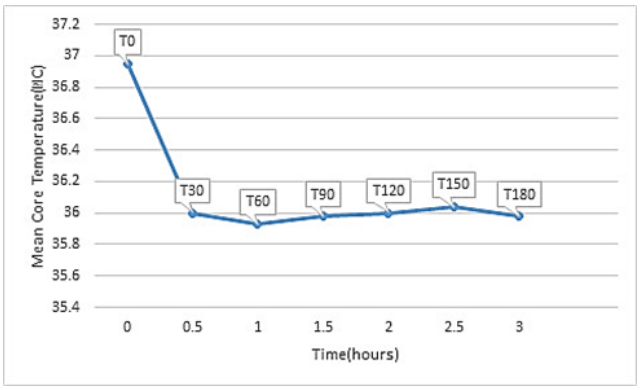

Fig. 5: Core temperature (mean, n=362) changes at half hourly intervals in patients warmed with FAW under general anaesthesia. After the initial redistribution phase (compare Figure 1) the temperature fluctuated around 36°C within a narrow range (±0.03°C) thereafter. The mean final intraoperative temperature (T-final) was just above 36°C. The linear phase is absent.

p= 0.81) of patients in the FAW group with commercial blankets to be hypothermic at the end of surgery with final oesophageal temperatures of 36.4 ±0.7°C. Intravenous fluids at room temperature were given in both the above studies in the concerned groups. About 9% of patients had shivering in the PACU. Although shivering increases metabolic heat production by 200% to 500%[3,5] it is not the primary etiology of cardiac events.

Most patients recruited into the study underwent Orthopaedic surgery 33.7% (N=362), followed by Oncosurgery 26.5% (N=362), which was followed by General surgery at 10.2% (N=362). Urosurgery and neurosurgery patients were at 9.7% (N=362) each. Of the 122 patients (n=362, 33.7%) who underwent orthopaedic surgeries, more than 90% were arthroscopic joint surgeries where the surgical exposure is bare minimal with minimal/no blood loss. The oncosurgical procedures in our institute constituted largely of breast surgeries which is considered a superficial surgery without opening any body cavities. The mean final intraoperative temperatures in both these surgical groups were 36.22°C and 36.07°C respectively. In practice, the ability of convective warming to maintain perioperative normothermia is dependent on many factors including amount of surface area covered, metabolic heat production, ambient temperature, patient temperature, length and type of surgical procedure, type and duration of convective warming, body heat content before induction of anaesthesia, and body habitus.[14]

All the urological cases were found to be hypothermic at the end of surgery (mean 35.69°C) which could be attributed to the cold irrigation fluids used during the procedures. These patients remained hypothermic in the PACU as well as the irrigation fluids were continued in surgeries like transurethral resection of prostrate. However, Campbell et al found no statistically significant difference in core body temperature or shivering between individuals given warmed and room temperature irrigation fluids.[27]

Our study was not designed to administer warm intravenous fluids. However, studies show that patients receiving warm intravenous fluids are 0.5°C warmer than those given room temperature fluids at the end of surgery.[27] They also further reduced the risk of shivering compared to room temperature intravenous fluids. IV fluids of 500ml or more should be warmed using a fluid warming device (in-line warmer).[6] Alternatively, prewarmed fluids can be given.

Although the total blood loss was statistically significant (p<0.004) (Table 4) it probably cannot be attributed to

the FAW because most of the surgeries were superficial and of short duration(96.50 ± 34.32 minutes). A meta-analysis of prospective studies on hypothermia and blood loss indicates that even mild hypothermia (<1°C) increases blood loss and the relative risk of transfusion by significant amounts.[28] A Europe-wide intraoperative temperature management study revealed that body temperature had been monitored in 19.4% patients and 38.5% patients were actively warmed in 8083 surgical procedures that were assessed.[29] Monitoring body temperature is mandatory to determine hypothermic patients. In our study temperatures were measured at the oral (preoperatively and post-operatively) and nasopharyngeal (intraoperatively) sites. Oral temperature reflects the core temperature as it is measured in the posterior sublingual pocket (close to the lingual artery which is a branch of the carotid artery) after closure of the mouth.[17] Nasopharynx is a commonly used temperature monitoring site during general anaesthesia due to its close proximity to the internal carotid artery (ICA) and can be accessed by anaesthetists.[15] Nasopharyngeal,[22] aural canal and skin surface,[30] oral and oesophageal[14,19] and tympanic membrane monitors[25] were used to record temperatures in other similar studies.

The NICE proposed Clinical Practice Guidelines for Management of Inadvertent Perioperative Hypothermia in Adults which further stresses temperature as an important entity.[6] They divide the perioperative period into preoperative (1h before induction of anaesthesia), intraoperative (total anaesthesia time) and postoperative (24h after entry into recovery area in the theatre suite) phases. Risk of developing perioperative hypothermia to be assessed before transfer to the operation theatre. Anaesthesia should be induced only after core temperature is more than 36°C. If the patient's temperature is <36.0°C FAW should be started preoperatively in the ward or emergency department unless there is a clinical urgency (bleeding or critical limb ischaemia) to expedite surgery. Patients should also be informed to bring additional clothing to keep themselves warm as the hospital is colder than their homes. The patient's temperature should be measured before induction of anaesthesia and every 30 minutes thereafter till the end of surgery. All patients under anaesthesia for longer than 30 minutes should be warmed intraoperatively from induction of anaesthesia using a FAW. IV fluids and blood products must be warmed to 37°C using fluid warming device. The patient's temperature should be monitored on admission to the recovery room and at 15-minute intervals thereafter. Ward transfer should be done only when the patient's temperature is ≥36.0°C. If the patient's temperature is <36.0°C, they should be actively warmed using FAW until discharge from the recovery room or until they are comfortably warm.

In our study, the FAW was turned off due to over heating (temperature >37°C) in 9 patients (2.5%, n=362). No thermal injuries were noticed in the immediate postoperative period. Charles E. Smith et al.[14] observed that the FAW was turned off in 11.5% of patients (n=30 p=0.052). This reaffirms the importance of routine core temperature monitoring to detect both intraoperative hypothermia and hyperthermia. Although there are concerns about FAW causing surgical site infections and airflow disturbances in the operating room there is no conclusive evidence.[31] Even though there was high heterogeneity among trials with limited data on adverse effects Madrid et al. concluded that nothing so far suggests that active body surface warming involves a significant risk to patients.[4]

5. Limitations

1. There was no control group(without warming) to compare the efficacy of the FAW.
2. The study did not address the use of convective warming systems during lengthier surgeries or during surgeries associated with more significant blood loss.
3. The study design did not include detection of the other side effects of hypothermia like PACU discharge times, length of hospitalization and wound infection in patients warmed with FAW.
4. Thermal comfort of patients was not assessed.
5. This study was not powered to evaluate the other proposed effects of the FAW like surgical site infections.

6. Conclusion

After the initial fall in the core body temperature, it remained nearly constant (36±0.03°C) till the end of surgery. From the present study we conclude that the forced air warmer which is an active body surface warming system with reasonable safety profile can be used to prevent inadvertent perioperative hypothermia in surgical patients under general anaesthesia. In addition to the side effects of hypothermia, there is also a danger of overheating the patient while using convective warming, as demonstrated. Therefore, temperature monitoring is a must while using the FAW.

7. Source of Funding

None.

8. Conflict of Interest

The authors declare that there is no conflict of interest.

References

1. Mackowiak PA, Worden G. Carl Reinhold August Wunderlich and the evolution of clinical thermometry. *Clin Infect Dis*. 1994;18(3):458–67.
2. Kelly G. Body temperature variability (Part 1): a review of the history of body temperature and its variability due to site selection, biological rhythms, fitness, and aging. *Altern Med Rev*. 2006;11(4):278–93.

3. Forstot RM. The etiology and management of inadvertent perioperative hypothermia. *J Clin Anesth*. 1995;7(8):657–74. doi:10.1016/0952-8180(95)00099-2.
4. Madrid E, Urrútia G, Figuls MR, Pardo-Hernandez H, Campos JM, Paniagua P, et al. Active body surface warming systems for preventing complications caused by inadvertent perioperative hypothermia in adults. *Cochrane Database Syst Rev*. 2016;2016(4). doi:10.1002/14651858.cd009016.pub2.
5. Torossian A. Thermal management during anaesthesia and thermoregulation standards for the prevention of inadvertent perioperative hypothermia. *Best Pract Res Clin Anaesthesiol*. 2008;22(4):659–68. doi:10.1016/j.bpa.2008.07.006.
6. Clinical Practice Guideline. The management of inadvertent perioperative hypothermia in adults. National Collaborating Centre for Nursing and Supportive Care commissioned by National Institute for Health and Clinical Excellence (NICE): April 2008. Available from: http://www.nice.org.uk/nicemedia/pdf/CG65Guidance.pdf.
7. Daniel I, Sessler. Temperature regulation and monitoring. *Anaesthesia*. 2015;1.
8. Sessler DI, Todd MM. Perioperative Heat Balance. *Anesthesiology*. 2000;92(2):578–96. doi:10.1097/00000542-200002000-00042.
9. Roberson MC, Dieckmann LS, Rodriguez RE, Austin PN. A Review of the evidence for active preoperative warming of adults undergoing general Anesthesia. *AANA J*. 2013;81(5):351–6.
10. Bayter-Marína JE, Rubio J, Valedón A, Macías A. Hypothermia in elective surgery: The hidden enemy. *Colombian J Anesthesiol*. 2017;45(1):48–53.
11. Kurz A. Thermal care in the perioperative period. *Best Pract Res Clin Anaesthesiol*. 2008;22(1):39–62.
12. American Society of Anesthesiologists (ASA). Standards, guidelines and statements(Updated October 28th, 2015). Available from: https://www.asahq.org/standards-and-guidelines/standards-for-basic-anesthetic-monitoring.
13. Stone GJ, Young WL, Smith CR, Solomon RA, Wald A, Ostapkovich N, et al. Do Standard Monitoring Sites Reflect True Brain Temperature When Profound Hypothermia Is Rapidly Induced and Reversed? *Anesthesiology*. 1995;82(2):344–51. doi:10.1097/00000542-199502000-00004.
14. Smith CE, Desai R, Glorioso V, Cooper A, Pinchak AC, Hagen JF. Preventing hypothermia: convective and intravenous fluid warming versus convective warming alone. *J Clin Anesth*. 1998;10(5):380–5. doi:10.1016/s0952-8180(98)00049-x.
15. Lee J, Lim H, Son K, Ko S. Optimal Nasopharyngeal Temperature Probe Placement. *Anesth Analg*. 2014;119(4):875–9. doi:10.1213/ane.0000000000000361.
16. John M, Ford J, Harper M. Peri-operative warming devices: performance and clinical application. *Anaesthesia*. 2014;69(6):623–38. doi:10.1111/anae.12626.
17. Fernandes LA, Braz LG, Koga FA, Kakuda CM, Módolo NSP, de Carvalho L, et al. Comparison of peri-operative core temperature in obese and non-obese patients*. *Anaesthesia*. 2012;67(12):1364–9. doi:10.1111/anae.12002.x.
18. Clinical guideline for the prevention of unplanned perioperative hypothermia. *J Perianesth Nurs*. 2001;16:305–14.
19. Kabbara A, Goldlust SA, Smith CE, Hagen JF, Pinchak AC. Randomized Prospective Comparison of Forced Air Warming Using Hospital Blankets versus Commercial Blankets in Surgical Patients. *Anesthesiology*. 2002;97(2):338–44. doi:10.1097/00000542-200208000-00009.
20. Egan C, Bernstein E, Reddy D, Ali M, Paul J, Yang D, et al. A Randomized Comparison of Intraoperative PerfecTemp and Forced-Air Warming During Open Abdominal Surgery. *Anesth Analg*. 2011;113(5):1076–81. doi:10.1213/ane.0b013e31822b896d.
21. Wagner K, Swanson E, Raymond CJ, Smith CE. Comparison of two convective warming systems during major abdominal and orthopedic surgery. *Canadian J Anesth*. 2008;55(6):358–63. doi:10.1007/bf03021491.
22. Leung KK, Lai A, Wu A. A randomised controlled trial of the electric heating pad vs forced-air warming for preventing hypothermia during laparotomy. *Anaesthesia*. 2007;62(6):605–8. doi:10.1111/j.1365-2044.2007.05021.x.
23. Andrzejowski J, Hoyle J, Eapen G, Turnbull D. Effect of prewarming on post-induction core temperature and the incidence of inadvertent perioperative hypothermia in patients undergoing general anaesthesia. *Br J Anaesth*. 2008;101(5):627–31. doi:10.1093/bja/aen272.
24. Yoshie T, Utsumi I. The efficacy of prewarming on post-induction core temperature and thermoregulatory response under general anesthesia. *Eur J Anaesthesiol*. 2012;29:30. doi:10.1097/00003643-201206001-00099.
25. Vanni SD, Braz JRC, Módolo NSP, Amorim RB, Rodrigues GR. Preoperative combined with intraoperative skin-surface warming avoids hypothermia caused by general anesthesia and surgery. *J Clin Anesth*. 2003;15(2):119–25. doi:10.1016/s0952-8180(02)00512-3.
26. Warttig S, Alderson P, Campbell G, Smith AF. Interventions for treating inadvertent postoperative hypothermia. *Cochrane Database Syst Rev*. 2014;(11):CD009892. doi:10.1002/14651858.cd009892.pub2.
27. Campbell G, Alderson P, Smith AF, Warttig S. Warming of intravenous and irrigation fluids for preventing inadvertent perioperative hypothermia. *Cochrane Database Syst Rev*. 2015;(4):CD009891.
28. Rajagopalan S, Mascha E, Na J, Sessler DI. Sessler; The Effects of Mild Perioperative Hypothermia on Blood Loss and Transfusion Requirement. *Anesthesiology*. 2008;108(1):71–7.
29. Torossian A, Temmp. Thermoregulation in Europe Monitoring and Managing Patient Temperature) Study Group. Survey on intraoperative temperature management in Europe. *Eur J Anaesthesiol*. 2007;24:668–75.
30. Bennet J, Ramachandra V, Webster J, Carli F. Prevention of hypothermia during hip surgery: effect of passive compared with active skin surface warming. *Br J Anaesth*. 1994;73(2):180–3. doi:10.1093/bja/73.2.180.
31. Kellam MD, Dieckmann LS, Austin PN. Forced-Air Warming Devices and the Risk of Surgical Site Infections. *AORN J*. 2013;98(4):353–69. doi:10.1016/j.aorn.2013.08.001.

Author biography

Abhini Prabhakar, DNB Trainee

Trupti Pethkar, Consultant

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