"EFFECTS OF PRE-WARMING AND CO-WARMING IN PREVENTING INTRAOPERATIVE HYPOTHERMIA"

By

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DISSERTATION SUBMITTED TO SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH CENTER, KOLAR, KARNATAKA

In partial fulfillment of the requirements for the degree of

DOCTOR OF MEDICINE

IN

ANAESTHESIOLOGY

Under the Guidance of

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APRIL 2022

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ACKNOWLEDGEMENT

*First and foremost I thank the **"Lord Almighty"** for showering his blessings and giving me the strength during my post graduation and providing me everything that I required in completing my dissertation.*

I would like to acknowledge all those who have supported me, not only to complete my dissertation, but helped me throughout my post graduation course.

*I attribute the success of my dissertation and owe immense gratitude to my mentor and guide **Dr RAVI M,** Professor and Head , Department of Anaesthesiology, for being very helpful throughout the study, whose valuable guidance has helped me patch this dissertation and make it a complete dissertation book. His suggestions and his instructions have served as the major contribution towards the completion of this study. His dedication, keen interest, professional knowledge and overwhelming attitude to help students had been solely and mainly responsible for completing my work.*

*It gives me immense pleasure to extend my sincere thanks to my Professors **Dr.SURESH KUMAR N** and **Dr KIRAN N** for providing valuable suggestions and motivation throughout the course.*

*A special mention and gratitude to my Associate Professor **Dr SUJATHA M P** for being my moral support and an inspiration throughout the course. Plenty thanks for emboldening me .*

*I am also grateful to all my Associate Professors **, Dr LAVANYA K , Dr.THREJA C K** and **Dr VISHNUVARDHAN V** for their positivity and encouragement which has helped me in completing the study and throughout.*

*I am extremely thankful to all my Assistant Professors **Dr SUMANTH T, Dr.SHIVAKUMAR K M, Dr AHMEDI FATHIMA** and **Dr.NAGASESHU KUMARI VASANTHA, DR SINDHU J,** for their constant help and guidance throughout the course. They were source of encouragement, support and for patient perusal to which I am deeply obliged.*

*My heartfelt thanks to senior residents **DR GAJANAN BABU, Dr.HUCHAPPA ,Dr.ABHINAYA MANEM, Dr.LAKSHMI K SWAMY** and my super seniors **Dr ARPITHA MARY,Dr.NAGARAJ S K, Dr.SREENIDHI** and my seniors **Dr MANJULA DEVI S,Dr SARAVANTHI GNS and Dr.SANDEEP V D** for their practical tips, advice and constant encouragement.*

*I express my sincere thanks to my colleagues and dearest friends **Dr.JYOTSNA PRIYA MADANA , Dr SHRI EASWARI S, Dr PREETHI R, Dr.BALAJI J, Dr ISHITA RAJ, Dr SINCHANA B & Dr MAHIMA L N** for their co-operation and help in carrying out this study. I thank my **JUNIORS** for providing useful tips and clues in completing this vast work.*

*I extend my sincere thanks to all the **SURGEONS** who played an important role during the study.*

*I am also thankful to all the **OT, ICU** and **Paramedical Staff** for their valuable help while performing the study.*

*Thanks to my beloved **PARENTS Smt.RADHA K** and **Sri. KRISHNAMURTHY V** and my **SISTER smt. ARCHANA M** for giving me constant support, encouragement and unconditional love throughout my life*

*Last but not the least, I express my special thanks to all my **PATIENTS** and their families, who in the final conclusion are the best teachers and without whom this study would have been impossible.*

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ABBREVATIONS

Glossary	Abbreviations
°C	Degree Celcius
IV	Intravenous
ICU	Intensive Care Unit
RCT	Randomized Controlled Trial
PACU	Post Anaesthesia Care Unit
ASA	American Society of Anaesthesiologists
FAWs	Forced Air Warmers
NICE	National Institute for Health and Care Excellence
OT	Operation Theatre
ACC/AHA	American College of Cardiology/ American Heart Association
CO2	Carbondioxide
PVD	Peripheral Vascular Diseases
BMI	Body Mass Index
ASAPS	American Society of Anaesthesiologists Physical Status
Kg	Kilogram
HR	Heart rate
PR	Pulse rate
SBP	Systolic blood pressure
DBP	Diastolic blood pressure
NIBP	Non invasive blood pressure
MAP	Mean arterial pressure
ECG	Electrocardiogram
CVS	Cardiovascular system
PA	Per abdominal

RS	Respiratory system
CNS	Central nervous system
HB	Haemoglobin
BT	Bleeding time
CT	Clotting time
WBC	White blood count
RFT	Renal function tests
i.e.,	That is

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ABSTRACT

"EFFECTS OF PRE-WARMING AND CO-WARMING IN PREVENTING INTRAOPERATIVE HYPOTHERMIA"

BACKGROUND:

AIMS: The aim of this study was to see how effective co-warming and pre-warming are at reducing the risk of intraoperative hypothermia

MATERIALS & METHODS: Randomized prospective comparative clinical study conducted in a population of 60 participants. Participants were divided into two groups. Participants receiving pre-warming for 30 minutes at 40^0C before shifting to operation theatre and also receive co-warming before induction of anaesthesia as group A. Whereas, those receiving co-warming at 40^0C from the point of induction of anaesthesia as group B.

RESULTS: The mean age (years) of participants in the group A and B were identified as 43.3 ± 11.84 and 45.93 ± 15.87. Majority of the participants in the study population were males in group A and group B with 66.67% and 73.33% respectively. The median of core temperature and peripheral temperature at the baseline were identified as 36.80 (36.20 to 37.12) and 32.55 (32.38 to 32.72) in group A Similarly, it was observed as 36 (35.70 to 36.20) and 32 (31.60 to 32.02) in group B. The median of core temperature and peripheral temperature after the surgery were identified as 34.50 (34.20 to 35) and 32.65 (31.95 to 33) in group A. Similarly, it was identified as 34 (33.80 to 34.25) and 32 (32.10 to 32.25) in group B.

CONCLUSION: The importance of preventing hypothermia in patients undergoing surgery under general anesthesia is concluded through the study.

INTRODUCTION:

Hypothermia is a condition of having a lower body temperature. It takes place when the body is exposed to cold weather or water for a longer period of time. Acute hypothermia, exhaustion hypothermia and chronic hypothermia are the different types of hypothermia.[1]Excessive shivering, breathing difficulty, slurred speech, confusion, drowsiness, weak pulse and loss of consciousness are the symptoms related to hypothermia.

Anesthesia used, intraoperative warming practices, operating room temperature, and IV infusions of fluids or replacement of blood loss are the elements which can cause hypothermic condition during the surgery.[2]

Intraoperative hypothermia is termed as core temperature of less than 36 °C. It is a frequently occuring complication identified during any surgery.[3]The rate of intraoperative hypothermia in distal gastrectomy was identified as 54% while, in gastroenterological surgery and hip fracture fixation with 37% and 17%. [456] Shivering, slurred speech, clumsiness, weak pulse, lack of coordination, dizziness, redness of the skin and loss of consciousness are some of the complications with intraoperative hypothermia.[7–9]

Hypothermia starts its development within the first hour of surgery in 65% of patients even with the active intraoperative warming. Typically it occurs immediately after the induction of anesthesia and can cause a decrease of 1.6ºC in the core temperature. Of this reduction, 81% is attributed to the core-to-peripheral redistribution of the body heat. It is mainly due to the anesthetic-induced vasodilation and around 46 kcal of heat is redistributed. This can be halted by increasing the peripheral temperature and reducing the core-periphery temperature gradient through pre-warming.[10]

Most of the guidelines prefer at least 30 min of pre-warming. But, it is difficult to apply the recommended 30 minutes or more of pre-warming when there is inadequate preoperative holding area. Recently, it was reported that the pre-warming of less than 30 minutes of duration is effective. Brauer et al. [11]study suggested that ≤ 30 minutes of regular pre-warming can effectively reduce perioperative hypothermia.

In Horn et al.[12] study 10, 20 and 30 minutes of pre-warming groups as well as with the control group were compared, it has been concluded that 10 min of pre-warming can effectively decrease perioperative hypothermia.

NEED OF THE STUDY

Most studies on short-term pre-warming applied intraoperative warming in hypothermic patients only. Also, the effects on patients undergoing continuous intraoperative warming cannot be verified. Similarly, the effects of pre-warming on patients undergoing continuous intraoperative warming are still controversial, provided findings from the existing ≥ 30 min pre-warming cases only. This study was conducted to determine the effects of pre-warming and co-warming in preventing intraoperative hypothermia.

AIMS & OBJECTIVES

The aim of this study was to see how effective co-warming and pre-warming are at reducing the risk of intraoperative hypothermia.

REVIEW OF LITERATURE:

Intraoperative hypothermia is a frequently occurring condition seen in patients undergoing various surgery and all anaesthetics which are used for the surgical procedure will induce diminished regulatory body temperature control through the core to peripheral redistribution of body heat. Prewarming and other warming techniques were used to counter the hypothermic condition before and during the surgical interventions. We have conducted an extended literature review focused on the pre-warming and co-warming techniques used to reduce the morbidity of hypothermia during intraoperative procedure.

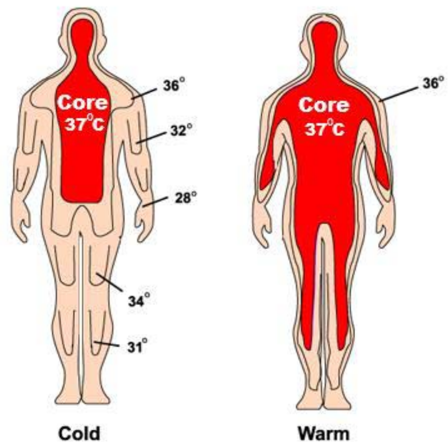
Regulation of Body temperature

Maintenance of human body temperature is a vital parameter, to maintain the optimal function of organ systems the temperature maintained in such way for all functioning also for enzyme activity in particular. The normal body temperature maintained through blood homeostasis, a body temperature of 36.0 to 37.5◦C, which is regulated by a negative feedback mechanism in the hypothalamus. The core of our body temperature maintained through two different compartments, either central compartment including viscera, central nervous system, blood vessels and through peripheral compartment including skin, fat and muscle protecting a barrier to the outside environment.[13,14]

Hypothermia and Intraoperative hypothermia

Hypothermia is the condition of having a lower body temperature due to the loss of body heat quicker than it can produce it. It occurs when body exposed prolonged period to cold weather or water. Hypothermia causes symptoms such as excessive shivering, breathing difficulty, slurred speech, confusion, drowsiness, weak pulse and loss of consciousness. It is a medical emergency and demands prompt medical attention and needs treatment includes first aid procedures. Further the body temperature measured at different parts explained the warm and cold temperatures (Figure 1).

Figure 1: the core temperature response to temperature changes



The hypothermia is when core body temperature becomes <36◦C.[14,15] The peripheral tissues act as a thermal buffer, absorbing or dissipating heat as necessary to protect the core and preventing activation of thermoregulatory defences in response to small changes in atmospheric temperature. This difference between peripheral body and core temperature is maintained by vasoconstriction of blood vessels leading to the peripheral tissues.

Intraoperative hypothermia

Definition: Intraoperative hypothermia is having a core temperature of less than 36 °C. During any surgery, It is one of the common complication.[3] As mentioned earlier the normal body temperature is kept at approximately 37 °C by neurohumoral regulation to attain stable physiological functions.[2]

Factors: There are multiple factors involved during surgery and leads to hypothermic conditions as a result of factors such as anesthesia used, intraoperative warming practices, the operating room temperature, IV infusions of fluids and replacement of blood loss.[2] In the past 2 decades it was noted that only vital signs were monitored such as respiratory rate, pulse and heart rate, blood pressure, , but body temperature has not been monitored, gradually the monitoring of hypothermia intraoperatively has become routine globally.[16,17]

Anaesthesia affects thermoregulatory responses and increases the inter-threshold range from 0.2 to 4◦C. The various phase of anesthesia and body core temperature reduction were explained in the Figure 2. Once induction of general anaesthesia started hypothermia sets in 3 phases different phases as follows:[18,19]

1. Phase 1/ Redistribution (1st hour)- Peripheral vasodilatation due to general anaesthetic drugs leading to transfer of heat from core to periphery.

2. Phase 2/ Linear (1st to 3rd hour)- Heat loss exceeds metabolic heat production.

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

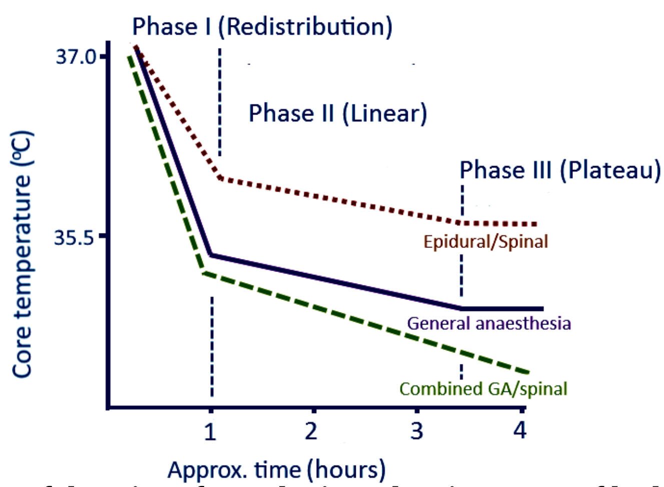


Figure 2. Illustration of duration of anesthesia and maintenance of body temperature.

Epidemiology and incidence of intraoperative hypothermia

Literature from the past has documented that the incidence of intraoperative hypothermia ranging from fifty to ninety percent[20]. The improved standard clinical practices of monitoring temperature during various surgical conditions reduced the incidences. Recently studies have shown that the intraoperative hypothermia rates of fifty four percent in distal gastrectomy [4], thirty seven percent in gastroenterological surgery [5], and seventeen percent in hip fracture fixation [6]and in China, an epidemiological survey-based study carried out and found that an incidence hypothermia of forty four percent.[16] The study found that study subjects who had intraoperative hypothermia did not report any complications such as a longer duration of intensive care unit (ICU) stay, surgical site infection, or a higher mortality rate compared with subjects who did not present with intraoperative hypothermia [16]. This finding was also similar by other similar study conducted in a randomized controlled trial (RCT) conducted in China showed a significantly lower incidence of intraoperative hypothermia in study participants who were given active intraoperative warming than in subjects who were given regular passive warming during the operation. There are several studies reported that the incidence of intraoperative hypothermia in various populations and in various surgical procedure during and post anaesthetic administration among patients underwent for various mild to moderate surgery.[4–6,20]

Causes of hypothermia

Hypothermia is caused by getting too cold, as the more heat loss in the body it can generate and body temperature drops below 35◦C.[1]

There are different types of hypothermia, depending on how quickly the body loses heat:

1. Acute or immersion hypothermia - occurs when a person loses heat very rapidly (exposure to cold water or cold weather)
2. Exhaustion hypothermia - occurs due to tiredness of the body and can no longer generate heat
3. Chronic hypothermia - where heat is lost slowly over time; this is common in elderly people who live in poorly heated accommodation or in people sleeping rough

Various complications of intraoperative hypothermia [7–9]

The Intraoperative Hypothermia effects can affect the patient during and after surgery. Some possible effects are:

- Shivering
- Slurred speech
- Clumsiness
- Weak pulse
- Lack of coordination
- Memory loss
- Dizziness
- Redness of the skin
- Loss of consciousness
- Delayed drug metabolism
- Peripheral vasoconstriction
- Wound infection
- Cardiac event
- Increased intra-operative blood loss or need for blood transfusion
- Shivering and increased metabolic demands post-operatively
- Need for re-warming therapy in recovery ward
- Increased stay in recovery ward, intensive care and overall hospitalization
- Reduced patient satisfaction

Perioperative hypothermia

Definition

Perioperative hypothermia is termed as a drop-in core body temperature to less than 36◦C due to excess pharmacological action of the used anaesthetics exposure of the body for long periods in the operative room during surgery this leads to impair the body's ability to maintain its normal temperature.[21]

Consequences of perioperative hypothermia[21]

The consequences of perioperative hypothermia include an impact on morbidity, mortality, and length of hospital stay. Most cellular functions are temperature dependent and hypothermia provokes systemic responses, some of which are potentially harmful. Although few patients are susceptible to all potential complications, most are susceptible to at least some. Furthermore, patients being cold and shivering in the PACU is the most distressing aspects of their surgery.

Consequences include [21–23]

- Surgical wound infection
- Duration of hospitalization
- Intraoperative blood loss
- Allogenic transfusion requirement
- Morbid cardiac events
- Postoperative ventricular tachycardia
- Urinary excretion of nitrogen
- Duration of vecuronium
- Duration of atracurium
- Postoperative shivering

- Duration of post anaesthetic recovery
- Plasma (norepinephrine)
- Thermal discomfort

Causes of hypothermia under anaesthesia

- Altered responses to heat loss due to anaesthesia (e.g. lack of shivering)
- Increased heat loss-environment exposure
- Cooling effect of cold anaesthetic gases and intravenous fluids
- Reduced heat production due to reduced metabolic activity.

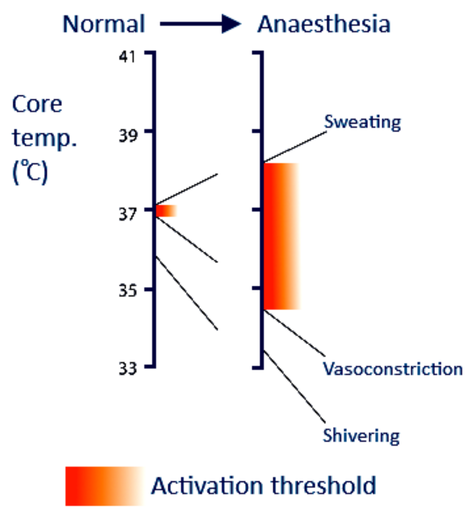
Table 1. Causes of hypothermia and possible mechanisms

Causes of hypothermia	**Mechanism**
OT Environment	Set OT temperature and humidity exposure of body surface cold irrigation fluid, skin preparation
Cold intravenous fluid	1 unit cold RBC can decrease body temperature by 0.25℃ to 0.35℃
Anaesthesia	Reduction of metabolic rate by 20-30% Dry anaesthetic gases, impair thermo regulatory vasoconstrictions, increases sweating threshold, vasodilators promote heat loss, hypothalamic heat regulation intact.
Surgical technique	Exposure of body cavity, duration of surgery

Thermoregulation under Anesthesia

During the surgery most patients are under general anesthesia, patients are frequently paralyzed and unconscious. The regulation of temperature only depends on autonomic defences and external thermal management.[24] Due to anaesthetic effect autonomic response also markedly diminished or impaired. The thermal regulation explained in the following charts (Figure 3).

Figure 3. Altered temperature during anesthesia



Further the threshold level for sweating and cold temperature were vary for various anesthetic agents and Midazolam slightly impairs thermoregulatory control. Painful stimulation can slightly increase vasoconstriction threshold, therefore, regional or local anesthesia decreases vasoconstriction threshold. In table 2. The various anaesthetics and threshold level explained.

Table. 2. Various general anaesthetic agents and temperature threshold variation[25]

General anaesthetic agent	Sweating threshold	Cold threshold
Propofol	Increase	Linear decrease
Alfentanil	Increase	Linear decrease
Dexmedetomidine	Increase	Linear decrease
Isoflurane	Slight increase	Nonlinear decrease
Desflurane	Slight increase	Nonlinear decrease
Enflurane	Slight increase	Nonlinear decrease
Halothane	Slight increase	Nonlinear decrease
Combination of nitousoxide and fentanyl	Slight increase	Nonlinear decrease
Clonidine	Slight increase	Decrease

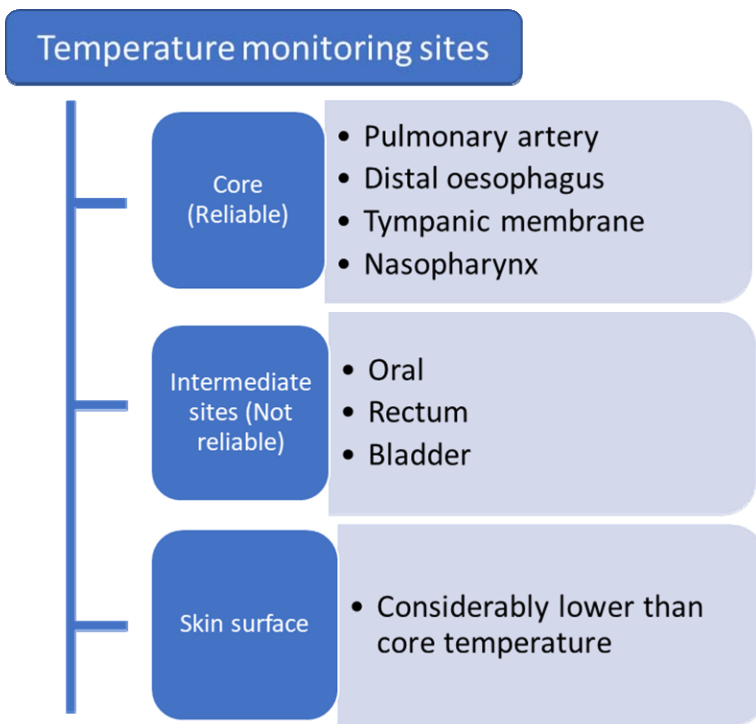
Measurement of Intraoperative Body Temperature

There are various techniques followed for measuring body temperature during the surgery, Combination of core and mean skin temperature measurement is required to accurately estimate body heat content. Temperature can be monitored at various sites as described in Figure 4. [26–29] None of the existing guidelines specify the best device or best site to monitor temperature. The site and device selection depend on the physician, type of surgery, and accessibility of monitoring sites.

The techniques are included:

- Mercury-in-glass thermometers
- Electronic thermometers use thermistors and thermocouples. They are sufficiently accurate (±0.5°C), but inexpensive
- Infrared monitors detect heat given off by radiation and can measure temperature from tympanic membrane and forehead skin but are less reliable.
- Thermotropic liquid crystals incorporated in disposable sheets are available but less accurate.

Figure 4. Various temperature monitoring sites during surgery



Cowarming in intraoperative hypothermia

In preventing or reducing the incidence of intraoperative hypothermia cowarming is as effective as prewarming. By comparing core body temperature patients were assessed on the day before surgery.

Methods used to prevent intraoperative hypothermia[30]

There are various methods proposed however they were classified into two major categories as Active and passive methods. The following table. Explains the various methods:

Table.3. Hypothermia prevention methods

ACTIVE METHODS	PASSIVE METHODS
Warm infusion fluids	Heat and humidity exchanger
Forced Warm air circulation	Isolation methods
Water mattress pads and blankets	
Electric mattress pads and blankets	

Active warming of the patient during surgery

Convective heating using a forced-air warming blanket is very effective, since most of the heat lost by the patient is lost through radiation and convection. Through the blanket, warmed air flows over the patient's skin.

The warming devices should be cleaned and used with filters according to their manufacturers' instructions, otherwise there is possibility of growth of microorganisms [31]. A further rise in warming efficacy can be achieved by combining intraoperative patient warming with prewarming [32].

Conductive warming methods (transfer of heat by direct contact) are used for heat retention as an alternative to convective methods. Blankets laid on top of the body should be used for this. Heating blankets laid under the patient's back should only be used to supplement those on top [33].

Warm infusion fluids

Administration of large volumes of cold infusion solutions or blood products reduces core body temperature, therefore intraoperative warming of infusions and blood products given at infusion rates above 500 mL/h should also be implemented. Warming infusion solutions in an infusion warmer ("in-line warming") is very effective and should be employed. In cases where there is little fluid exchange, the use of infusion warmers alone is not enough to maintain normothermia[34,35].

Several fluid warming devices are available.

- Dry warming systems
- Counter current heat exchanger
- Water bath
- Convective air systems
- Insulators.

Forced Warm air circulation

To prevent perioperative hypothermia, forced-air warming devices has shown their effectiveness. It is shown to minimize intraoperative hypothermia before the induction of anesthesia ("pre warming") as per the studies conducted in the past . In a previous study

It was reported that sixty eight percent of participants prewarmed with a Bair Paws warming system before anesthesia maintained an intraoperative temperature above 36°C compared with forty three percent in the control group. A smaller decrease in core temperature was seen between fourty and eighty minutes after induction in the prewarmed group.[34,36]

In set of previous studies,it was observed that patients who received a combination of preoperative warming and intraoperative skin surface warming had core temperatures significantly more elevated than those of other patients during the first two hours of anesthesia. Forced-air warming with the Bair Hugger for 30 minutes increased peripheral tissue heat content by more amount than normally redistributed during the first hour of anesthesia.[32,35,37]

Water mattress pads and blankets

When water is utilized as a carrier, the idea of a heat carrier in continuous motion is used in the warming system. Warm water filled mattresses have been used for many years, but their use has been linked to a slew of technical issues, and their efficacy in preventing hypothermia has been proven to be minimal. However, because they can be filled with both warm and cold fluids, these mattresses have found utility in particular situations where the body temperature is being dropped purposely.[35]

Electric mattress pads and blankets

Electric resistance heating systems are a viable alternative to forced air heating systems. These devices are part of a category devices whose efficiency is based on conduction. As a result, unlike warm airflow systems, in which a heat carrier departs the warming blanket and transfers heat to the body surface, the systems are only effective when the warm surface directly contacts the surface to be warmed.[38]

Passive warming

Thermal insulation is an external (passive), effective way of reducing radiating and convective heat loss via the skin. Various materials reduce heat loss by up to 30% [37]. In addition to active warming, the largest possible (not actively warmed) area of the body should be covered (insulated).

Insulation alone does not usually suffice to maintain normothermia intraoperatively. A recent Cochrane Review shows that only active warming increases body temperature by 0.5 to 1°C compared to warming by insulation [38].

Table.4. Comparison various devices used in prewarming and Cowarming methods

Device	Advantage	Disadvantage
Warming cabinets	Cheap, simple	Cooling of fluid with low flow rates
Counter current warming system	No loss of heat even with low flow rates, efficient	Infection, air embolism, dilutional electrolyte disturbances
Blood warmer	--	Haemolysis causing reduced oxygen carrying capacity, electrolyte disturbances
Dry heat technology	Rate of heating is controlled and adjusted as per flow rate, small temperature change can be sensed, no risk of contamination	--
Circulating water mattresses	No ambience warming	Take 2-3 times longer than forced air warmers, nearly ineffective, cover only posterior surface.
Circulating water garments	Can transfer large amount of heat, outperform forced air warmers	Bulky risk of water leakage
Forced air warmers	Readily available, completely eliminate heat loss, safe, reduce radiant heat loss, fast warmup time, high warming capacity	Can disrupt laminar airflow patterns, chance of microbial over growth
Resistance heating device	Reusable, energy efficient, easy to clean, good alternative for forced air warmers, do not interfere with surgical sites	Can cause burns, long warmup time
Negative pressure warming system	--	Can cause burns
Radiant heaters	Fast warmup time, good warming capacity	Bulky, warm ambience, risk of burns

Strategies for the prevention of hypothermia perioperatively [39,40]

Before surgery

- Identify patients at high risk of hypothermiaperioperatively. Active warming should begin prior to surgery in high-risk orhypothermic patients
- Measure the patient's core temperature
- Patient should not be transferred to theatre unless their core temperature is >36℃
- Patient should be encouraged to walk to theatre where possible (This causes increase in generation of heat by metabolism)

During anaesthesia and surgery

- Induction of anaesthesia should not be started until the patient's core temperature is >36℃ unless clinically urgent.
- Active warming is recommended for all high-risk patients regardless of the length of the procedure, and for all patients with total anaesthesia time >30 min.
- Ambient temperature should be >21℃ when the patient is exposed to reduce heat loss by convection and radiation. Thereafter, for staff comfort the ambient temperature can be reduced.
- Warm i.v fluids. (Prewarmed fluids are effective when given within 30 minutes after removing from warming cabinet).
- Humidification of respiratory gases. Despite the fact that only a tiny quantity of metabolic heat is lost through the respiratory tract, using a heat moisture exchanger filter or another humidification device is recommended.

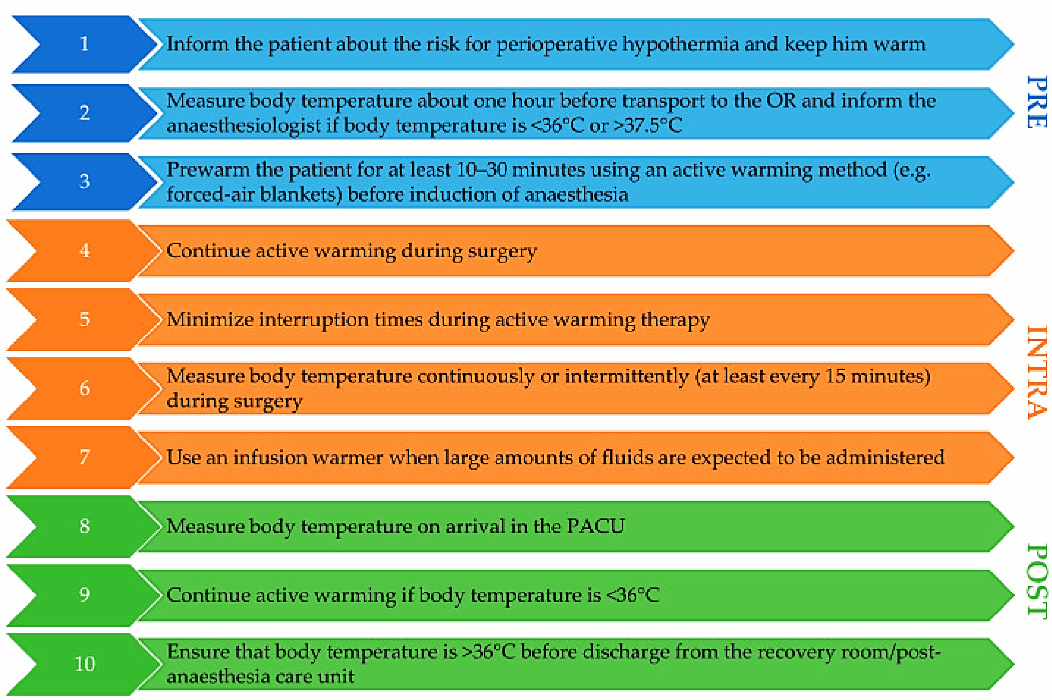
- The patient's temperature should be measured at least every 30 min and active warming titrated to effect. This can be used to keep an eye on both hypothermia and overheating. Patients who are undergoing regional anaesthesia are included in this category.

After surgery

- On admittance to PACU, the core temperature should be checked, and then every 15 minutes after that. If the patient is hypothermic, forced air warming should be continued (warm blankets provide comfort but do not actively warm the patient). The patient should remain in PACU until the core temperature is >36°C
- Patients should be kept comfortably warm for 24 h after surgery with a duvet and blankets.

Prevention of hypothermia

Figure 5. Steps to prevention of hypothermia during pre, intra and post-surgery



Inadvertent Intraoperative Hypothermia

The most common perioperative thermal disturbance is inadvertent intraoperative hypothermia (core temperature <36°C). Incidence varies from 6% to 90% depending on the surgical population and demographic characteristics of patients. Risk is higher with prolonged surgery, extremes of age, extensive burns, lower preoperative temperature, severe trauma, and major intraoperative fluid shifts. Besides prolonging anaesthetic drugs actions, hypothermia impairs coagulation and platelet function, increased blood loss and transfusion requirements, increases wound infections, prolongs hospital stay, causes postoperative discomfort, and increases heart rate, blood pressure, and plasma catecholamine levels. Mild hypothermia is related with threefold increase in morbid myocardial outcomes.[41–43]

Thermal Management Guidelines

ASA standards require every patient receiving anesthesia to have temperature monitoring when clinically significant changes in body temperature are intended, anticipated, or suspected. For office-based sedation, regional anesthesia, or general anesthesia, body temperature of pediatric patients shall be measured continuously. However, according to a European survey by the Thermoregulation in Europe Monitoring and Managing Patient Temperature Study group, temperature monitoring is done in 19.4% patients (24% in general anesthesia, 6% in regional anesthesia) and only 38.5% patients are actively warmed (43% during general anesthesia, 28% during regional anesthesia). Nasopharyngeal temperature under general anesthesia and tympanic temperature during regional anesthesia are most frequently measured and forced air warmers (FAWs) are used for warming.[44]

The Outcomes Research Consortium guidelines state as follows.

- In patients undergoing general anaesthesia for more than 30 minutes should have their body temperature checked before surgery.
- Body temperature might ideally be monitored continuously; however, 15 min intervals are probably sufficient in most patients
- Core temperature should be measured during spinal or epidural anesthesia in patients whom clinicians believe are likely to become hypothermic
- Intraoperative core temperatures should usually be maintained >36°C unless hypothermia is specifically indicated.

The NICE proposed Clinical Practice Guidelines for Management of Inadvertent Perioperative Hypothermia in Adults.[45] They recommend assessing patients for risk of developing perioperative hypothermia before transfer to the operation theatre (OT). Anesthesia should be induced only after core temperature is more than 36°C. IV fluids and blood products must be warmed to 37°C using fluid warming device. Use of FAWs is recommended to prevent and treat perioperative hypothermia.

The ACC/AHA 2007 Guidelines on Perioperative Cardiovascular Evaluation and Care for Noncardiac Surgery made Class I (Level of Evidence: B) recommendation to maintain body temperature in normothermic range for most procedures other than during periods, in which mild hypothermia is intended to provide organ protection.[46] However, 2014 ACC/AHA Guidelines on Perioperative Cardiovascular Evaluation and Management of Patients Undergoing Noncardiac Surgery makes Class I b recommendation that maintenance of normothermia may be reasonable to reduce perioperative cardiac events in patients undergoing noncardiac surgery.[47]

RELEVANT REVIEW OF LITERATURE

- A recent study was conducted as a prospective randomized control trial to evaluate the effectiveness of prewarming in prevention of inadvertent intraoperative hypothermia. The study reported 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. Hence report confirms that prewarming is effective in reducing the core to peripheral temperature gradient at induction stage.[48]
- In a recent prospective comparative study conducted among Sixty-two adult patients, those underwent major abdominal surgery, under general anesthesia. The comparisons between the co-warming and prewarming groups to prevent hypothermia, revealed that co-warming is as effective as prewarming to avoid intraoperative hypothermia.[49]
- A retrospective audit-based study conducted in Maharashtra, India, among patients who underwent cesarean were compared between three different fluid warming techniques in maintaining euthermia. The study results show that using the cabinet and inline fluid warmer proved as efficacious methods in maintaining euthermia and limited shivering after cesarean section.[50]
- A retrospective analysis of recorded perioperative temperature was noted among healthy volunteers, they were donors of hepatectomy under combined general anesthesia and neuraxial analgesia for liver donors. The study used a multimodal protocol for temperature management and evaluated the efficacy. They revealed that simultaneous use of the resistive heating mattress, forced-air warming blanket, and fluid warmer along with atmospheric temperature management is an effective method to prevent unintended perioperative variation in body temperature.[51]
- A comparative study conducted among patients who underwent under spinal anesthesia reported that infusion of warm intravenous fluids resulted in a lesser degree

of fall in core temperature (36 degrees C) as compared to patients receiving intravenous fluids at room temperature.[52]

- A retrospective cohort study was conducted to evaluate the length of hospital stay and intraoperative hypothermia among patients who underwent surgical elective open abdominal aortic aneurysm. The study revealed that there was no association between the length of hospitalization and hypothermia. However, the study emphasized that prewarming is needed during surgical interventions.[53]
- A comparative study on the prevention of hypothermia using pre and intra-operative forced-air warming with only intraoperative warming reported that forced-air warmer is effective in preventing hypothermia for the initial two hours of surgery.[54]
- Yoo, J. H., et al. (2021) conducted a RCT on the efficacy of active forced-air warming during anaesthesia induction toavoid perioperative hypothermia in intraoperative warming patients: Comparison with passive warming. The study evaluated the efficacy of peri-induction forced-air warming to prevent perioperative hypothermia. They have reported that simple, convenient peri-induction active forced-air warming was an effective method to prevent perioperative hypothermia in patients intraoperatively warmed to prevent hypothermia.[55]
- Xu, H., et al. (2020) conducted a meta-analysis of RCT and observational studies on the safety of intraoperative hypothermia. The study results revealed shreds of evidence from observational studies showed that intraoperative hypothermia did not result in higher risks in any of these adverse events. The study results were not changed even if the standard of hypothermia was reduced by 0.5-1.0 degrees C. Further, it was reported that hypothermia was overestimated.[56]
- Wittenborn, J., et al. (2019) conducted a pilot study on the prevention of Intraoperative Hypothermia by the Use of Body-Temperature and Humidified CO_2 in

Laparoscopy. The study results explained that if intraoperative prewarming measures are undertaken, a patient's temperature is reduced by 1 - 2 degrees C. The mild conditions of intraoperative hypothermia were led to a marked increase in morbidity and mortality. The percentage rate of hypothermia at the initial stage among the participants was reduced from 50 to 36%, than 36 to 42% in the control group. The study concludes monitoring body temperature and using humidified insufflation gas for laparoscopy much helped to prevent intraoperative hypothermia.[57]

- Okada, N., et al. (2020) conducted a study to study the efficacy of prewarming prophylaxis method in subjects who were admitted for thoracoscopic esophagectomy for the prevention of intraoperative hypothermia. They have observed that, intraoperative core temperature was significantly different between the two groups at each 30-min time point from the initial to end of the thoracic procedure. The incidence of infectious surgical complications observed was not significantly different between the control and active groups. However, it was emphasized that the prewarming prophylaxis method was effective for maintaining normothermia.[58]
- Yi, J., et al. (2015) conducted a prospective regional survey in Beijing for evaluating the incidence of intraoperative hypothermia and its risk factors in patients undergoing general anesthesia. The study results show that all patients were compared using different methods of prewarming and those warmed passively with surgical sheets or cotton blankets, whereas only 10.7% of patients underwent active warming with space heaters or electric blankets. In another group of patients (16.9%) pre-warmed intravenous fluid was administered, and irrigation of wounds with pre-warmed fluid was administered in 34.6% of patients. The study revealed that concern for the intraoperative hypothermia development is very high in patients undergoing major

operations and required long periods of anesthesia, and they have received un-warmed intravenous fluids. [59]

- Inoue, S., et al. (2011) reported a randomized trial and evaluated amino acid infusions initiated after the intraoperative hypothermia development do not affect rewarming but resulted in the reduction of incidence of postoperative anesthetic-induced shivering during major abdominal surgery. This survey was conducted to investigate the benefits of amino acid infusions started after the development of intraoperative core hypothermia can improve accelerated rewarming. The study concludes the use of amino acid infusions to reduce thermoregulatory vasoconstriction in emergencies might contribute to a decrease in the postoperative shivering development.[60]
- Kay, A. B., et al. (2020) conducted a study to find the preoperative warming reduces Intraoperative Hypothermia in Total Joint Arthroplasty Patients. They have reported that adding forced-air warming preoperatively to the existing warming protocol reduced the rate of postoperative hypothermia by approximately 30%. Further, they have recommended that the time from entry into the operating room to the start of surgery should be minimized this may prevent the patients become vulnerable to postoperative hypothermia during this interval.[61]
- Gupta, N., et al. (2019) conducted a prospective randomized comparative evaluation of forced-air warming and infusion of amino acid-enriched solution on intraoperative hypothermia in patients undergoing surgical removal of tumors in the head and neck cancer. The study results show that the amino acid infusion can be used in intraoperative hypothermia prevention under general anesthesia.[62]
- Granum, M. N., et al. (2019) conducted a nonrandomized controlled study to evaluate the preventing inadvertent hypothermia in patients undergoing major spinal surgery of two different methods of preoperative and intraoperative warming. They have

observed that patients using the FAU blanket reported a 72% lower incidence of hypothermia at initial. They have suggested having attention to thermal comfort during surgery is an important aspect.[63]

- Becerra, A., et al. (2019) conducted a prospective observational study to find the effectiveness of prewarming on perioperative hypothermia in surgical patients submitted to spinal anesthesia, the study revealed that prewarming for 15 or 30 min before surgery under spinal anesthesia prevents the development of hypothermia at post-surgery.[64]
- Lau, A., et al. (2018) conducted a RCT on the effect of preoperative warming on intraoperative hypothermia. The study results suggested that a minimum of 30 min of preoperative forced-air convective warming decreased the overall exposure to intraoperative hypothermia. They have also reported that redistribution hypothermia occurred despite pre-and intraoperative forced-air warming, however, their combined application of both methods resulted in greater preservation of intraoperative normothermia compared with intraoperative forced-air warming alone.[65]
- Oshvandi, K., et al. (2014) conducted a survey to study the effect of pre-warmed intravenous fluids on preventing intraoperative hypothermia in cesarean section. The study was conducted among sixty-two women undergoing elective cesarean section by general anesthesia they were randomly allocated to intervention and control groups. The intervention group women received pre-warmed serum (37 degrees C) and control group women received serum at room temperature (25.5 degrees C). During the study, the core body temperature and few hemodynamic parameters of the participants were assessed. The study results show that infusion of pre-warmed serum help to prevent intraoperative hypothermia.[66]

- Xu, H. X., et al. (2010) conducted a study to evaluate the prevention of hypothermia by infusion of warm fluid during abdominal surgery. The study indicated that perioperative hypothermia can lead to several complications among patients post-surgery. The study reported that core temperature decreased to 35.5 +/- 0.3 degrees C among the control group during the first 3 hours, and later stabilized. On the other hand, the core temperature decreased during the first 60 minutes but increased to 36.9 +/- 0.3 degrees C at the end of anesthesia in the test group. The study reported that the usage of infusion of warm fluid keep patients under normothermic and prevented post anesthetic associated shivering.[23]

LACUNAE IN LITERATURE

Several complications were reported during intraoperative procedure however, hypothermia is most common complication while using anaesthetics in various surgical methods. However, some patients over express these reactions and leads to significant morbidity and mobility. Hence, reducing the complications associated with intraoperative hypothermia, patients need to be undergone for prewarming and co-warming to bring the core body temperature to normothermic.

Several study reports were searched to find the various prewarming techniques to reduce the risk associated with intraoperative hypothermia in patients. However, there is a huge lacking in the correct selection of methods for the prewarming or co-warming. On other hand, we have noted that the techniques were used in different surgical conditions. It indicates that, an appropriate uniform technique is not followed for all the surgical procedures. However, prewarming using infusion of warm fluid is observed as one common method in many studies. Also, we have noted that which method of warming is better for intraoperative hypothermic condition is not clearly identified.

In the present study we have examined the comparisons of prewarming and co-warming methods to prevent or reduction in the incidence of hypothermia. Hence, this study may contribute to the evidence that selecting the appropriate method for preventing intraoperative hypothermia.

Several surveys were conducted among various populations and various regions all over the world, however there are few studies conducted to explain the same research question. Further, there were less studies conducted as comparative clinical trials for comparing various prewarming methods. But comparing the time of warming is not studies well.

MATERIALS & METHODS

Study site: This study was conducted in the department of Anaesthesiology at Sri Devaraj URS Medical College, Tamaka, Kolar.

Study population: All 60 Patients admitted for elective surgery done under the department of Anaesthesiology at Sri Devaraj URS Medical College, Tamaka, Kolar were considered as study population.

Study design: The current study was a Randomized prospective comparative clinical study

Sample size: 60 (divided into 2 groups of 30 patients each)

Sampling method: All the eligible subjects were recruited into the study consecutively by convenient sampling till the sample size is reached.

Study duration: The data collection for study was done between January 2020 to May 2021 for a period of 1 year 5 months.

Inclusion Criteria:

All patients who require Under Age 18 to 65 years**,** BMI of 18.5 – 25 kg/m2**,** ASAPS 1 and 2**,** Patients undergoing elective surgery under General Anaesthesia expected to last less than 2 hours.

Exclusion criteria:

Febrile patients, Patients who are having co-morbidities liked dysautonomia, thyroid disease, uncontrollable diabetes mellitus with autonomic neuropathy, cushings syndrome.

Patients affected with PVD like Raynaud's syndrome, Hemodynamically unstable patients who require large amounts of fluid resuscitation.

STATISTICAL ANALYSIS:

Two Means Hypothesis testing for two means(equal variances)

Standard deviation in group I-366.4

Standard deviation in group II-366.4

Mean difference = 267(to detect atleast 30% increase in mean reduction in ulcer area in study group)

Effect size=1.41375545851528

Alpha error(%)= 5

Power(%)= 80

Sided= 2

Sample size per group= 30

FORMULA:

$$n = \frac{2s_p^2[z_{1-\alpha/2}+z_{1-\beta}]^2}{\mu_d^2}$$

$$s_p^2 = \frac{s_1^2 + s_2^2}{2}$$

Where , s_1^2= Standard deviation in the first group

s_2^2= Standard deviation in the second group

μ_d^2= Mean difference between the samples

$\dot{\alpha}$ = Significance level

1-ß = Power

Ethical considerations: Study was approved by institutional human ethics committee. Informed written consent was obtained from all the study participants and only those participants willing to sign the informed consent were included in the study. The benefits and risks involved in the study and voluntary nature of participation were explained to the participants before obtaining consent. Confidentiality of the study participants was maintained.

Data collection tools: All the relevant parameters were documented in a structured study proforma.

Methodology:

- Detailed history of the patient was taken.
- Complete physical examination was done.
- Routine investigations were checked.
- Intravenous line was secured, and IV fluids were connected.
- Patients were divided into two groups randomly.
- **Group A :** Receiving pre-warming for 30 minutes at 40^0C before shifting to operation theatre and also receive co-warming before induction of anaesthesia.
- **Group B :**Receiving co-warming at 40^0C from the point of induction of anaesthesia.
- A skin probe was used to record the baseline peripheral(Thumb) temperature**.** A nasopharyngeal temperature probe was implanted into a length of tragus to philtrum after induction of anaesthesia to detect core body temperature.

PARAMETERS OBSERVED

- Core temperature base line
- Core temperature at the end of surgery
- Peripheral temperature base line
- Peripheral temperature at the end of surgery
- Core to peripheral temperature gradient base line
- Core to peripheral temperature gradient at the end of surgery

The study requires the following investigations:

1. Complete hemogram.
2. Bleeding time and clotting time.
3. Random blood sugar.
4. Blood urea and serum creatinine.
5. Serum sodium and potassium.
6. Urine analysis for sugar, albumin and microscopy.
7. ECG and chest X-ray.

Statistical Methods:

Core to peripheral temperature gradient (at baseline and at end of surgery) was considered as primary outcome variable.

Study Group (A v/s B) was considered as primary explanatory variable.

Normality distribution was cross verified by using statistical test like Shapiro-Wilk/ Kolmogorov's test and visual representation like Q-Q plot and histograms for all quantitative parameters.

For normally distributed Quantitative parameters the mean values were compared between study groups using independent sample t-test (2 groups) and non-normally distributed parameters were compared between study groups using Mann Whitney U test.

Data was also represented using clustered bar chart, error bar chart and box plot.

Categorical outcomes were compared between study groups using Chi square test /Fisher's Exact test (If the overall sample size was < 20 or if the expected number in any one of the cells is < 5, Fisher's exact test was used. P value<0.05 was considered to be statistically significant. IBM SPSS was used for statistical analysis

OBSERVATIONS AND RESULTS

RESULTS:

A total of 60 participants were included in the final analysis with 30 participants in group A and 30 participants in group B.

Table 5: Comparison of baseline parameters between study group (N=60)

Parameter	Study Group (Mean± SD)		P value
	A (N=30)	B (N=30)	
Age (in years)	43.3 ± 11.84	45.93 ± 15.87	0.469
Weight (in kg)	61.03 ± 5.01	60.2 ± 4.6	0.505

Among the study population, the mean age of participants was 43.3 ± 11.84 years in group A and 45.93 ± 15.87 years in group B. The mean weight of participants in group A was 61.03 ± 5.01 kg and in group B was 60.2 ± 4.6 kg. There was not any statistically significant difference in mean age and weight between study group (P Value>0.05). (Table 5)

Table 6: Comparison of gender between study group (N=60)

Gender	Study Group		Chi square	P value
	A (N=30)	B (N=30)		
Female	10 (33.33%)	8 (26.67%)	0.317	0.573
Male	20 (66.67%)	22 (73.33%)		

Among the study population, there were 10 (33.33%) female participants in group A and 8 (26.67%) in group B. There were 20 (66.67%) male participants in group A and 22 (73.33%) in group B. There was not any statistically significant difference in gender between study group (P Value>0.05). (Table 6)

Figure 6: Clustered bar chart for comparison of gender between study group (N=60)

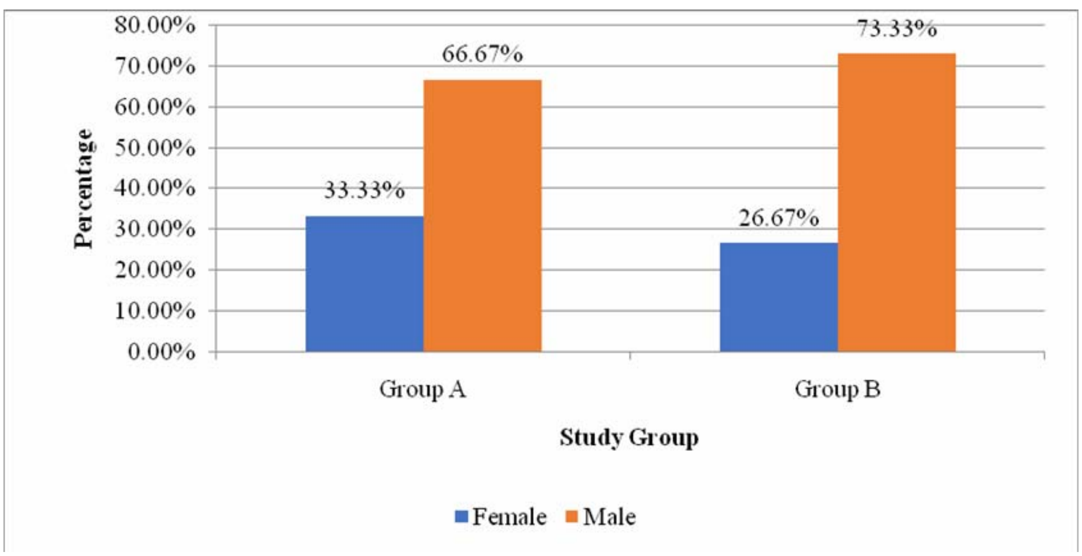


Table 7: Comparison of vital parameters at pre-operative stage between study group (N=60)

Parameter	Study Group		P value
	A (N=30)	B (N=30)	
Pulse Rate[Median(IQR)] (bpm)	87 (82.75 to 96)	93 (79.50 to 100)	0.300#
Systolic Blood Pressure (mm/hg)[Median(IQR)]	128.50 (120 to 135.25)	124.50 (118 to 130.25)	0.118#
Diastolic Blood Pressure (mm/hg)[Median(IQR)]	81 (77.75 to 89.50)	81.50 (78 to 86.50)	0.813#
Mean Arterial Pressure(Mean± SD)(mm/hg)	97.93 ± 9.41	95.63 ± 6.92	0.285$

#: Mann Whitney U test; $: IST

Among the study population, the median pulse rate was 87 (82.75 to 96) bpm in group A and 93 (79.50 to 100) bpm in group B, median SBP was 128.50 (120 to 135.25) mm/hg in group A and 124.50 (118 to 130.25) mm/hg in group B, median DBP was 81 (77.75 to 89.50) mm/hg in group A and 81.50 (78 to 86.50) mm/hg in group B and the mean arterial pressure was 97.93 ± 9.41 in group A and 95.63 ± 6.92 in group B. There was not any statistically significant difference in vital parameters at pre-operative stage between study group (P Value>0.05). (Table 7)

Table 8: Comparison outcome parameters at baseline between study group (N=60)

Parameter	Study Group		P value
	A (N=30)	B (N=30)	
Core temperature [Median (IQR)](in ºC)	36.80 (36.20 to 37.12)	36 (35.70 to 36.20)	<0.001 #
Peripheral temperature [Median (IQR)] (in ºC)	32.55 (32.38 to 32.72)	32 (31.60 to 32.02)	<0.001 #
Core to peripheral temperature gradient(Mean± SD)	4.21 ± 0.69	4.14 ± 0.42	0.620$

#: Mann Whitney U test; $:IST

Among the study population, the median core temperature at baseline was 36.80 (36.20 to 37.12) ºC in group A and 36 (35.70 to 36.20) ºC in group B, median baseline peripheral temperature was 32.55 (32.38 to 32.72) ºC in group A and 32 (31.60 to 32.02) ºC in group B and mean core to peripheral temperature gradient at baseline was 4.21 ± 0.69 in group A and 4.14 ± 0.42in group B. There was a statistically significant difference in median baseline core temperature and baseline peripheral temperature between study group (P Value<0.05) while it was not statistically significant for core to peripheral temperature gradient at baseline (P Value>005). (Table 8)

Figure 7: Box plot for comparison of core temperature (at baseline) between study group (N=60)

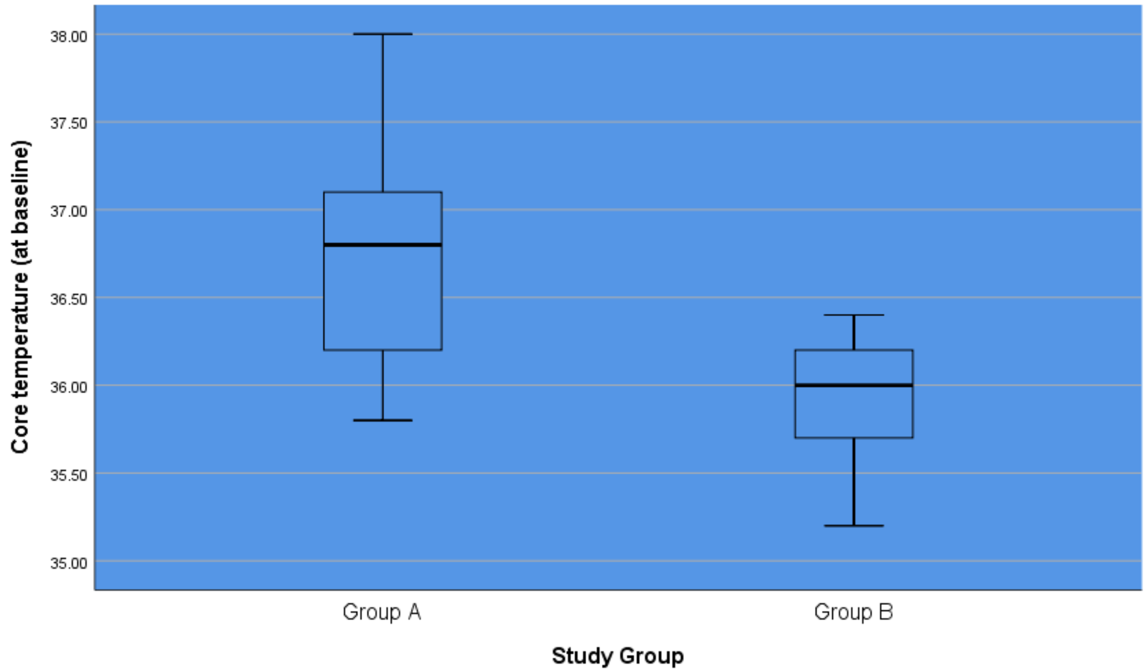


Figure 8: Box plot for comparison of peripheral temperature (at baseline) between study group (N=60)

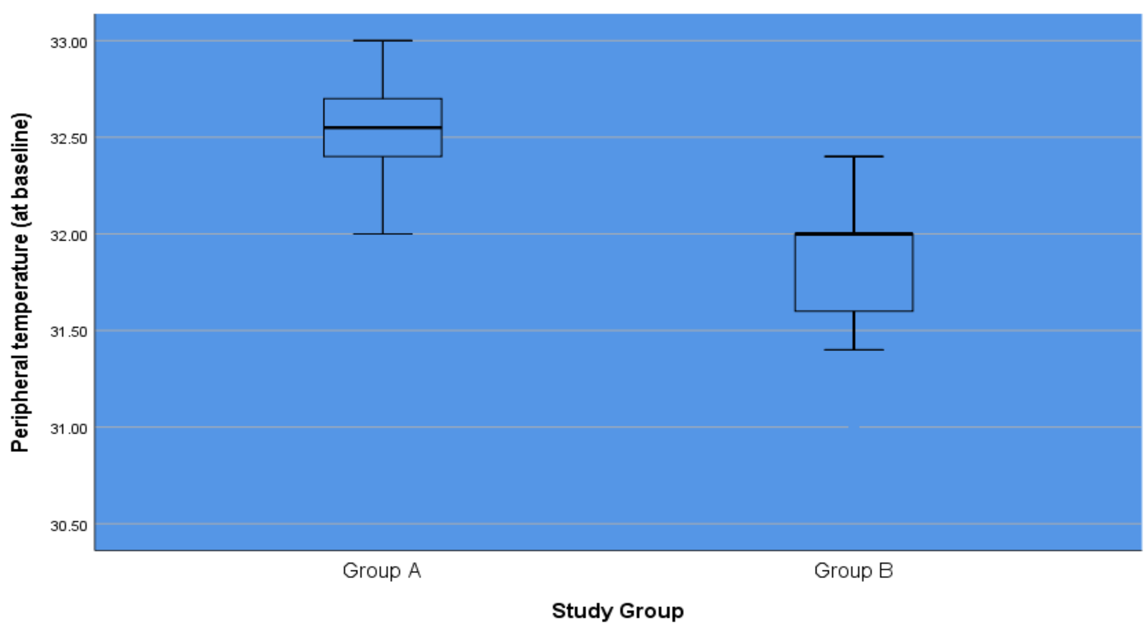


Figure 9: Box plot for comparison of core to peripheral temperature gradient (at baseline) between study group (N=60)

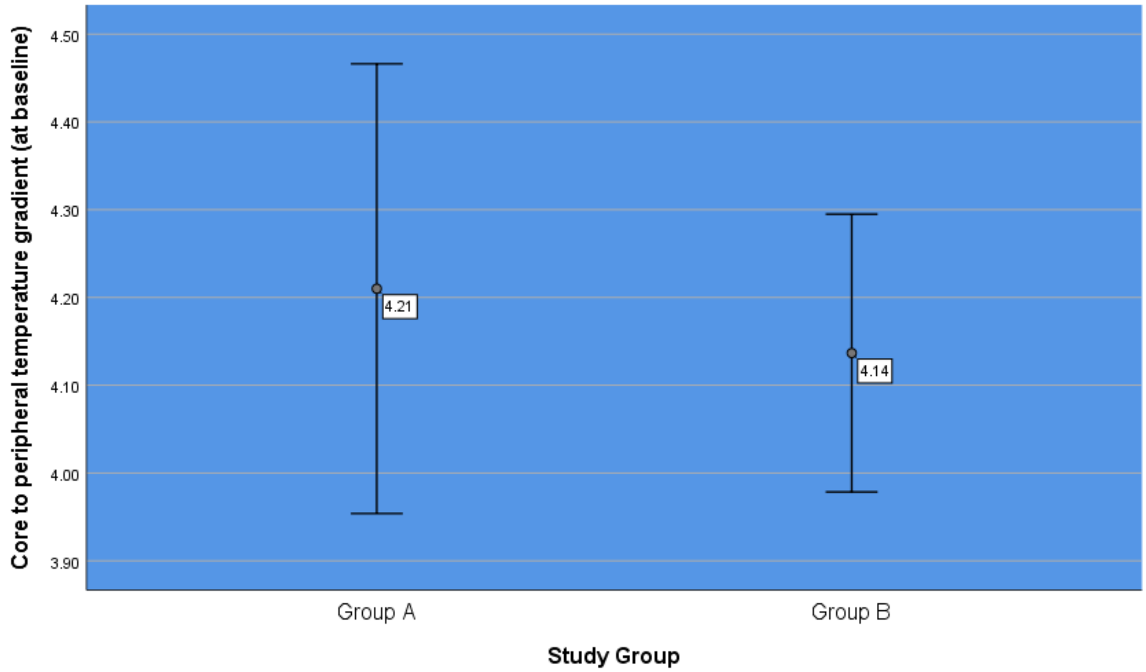


Table 9: Comparison outcome parameters at end of surgery between study group (N=60)

Parameter	Study Group (Mean± SD)		P value
	A (N=30)	B (N=30)	
Core temperature [Median (IQR)] (in ºC)	34.50 (34.20 to 35)	34 (33.80 to 34.25)	0.001#
Peripheral temperature [Median (IQR)] (in)	32.65 (31.95 to 33)	32 (32.10 to 32.25)	0.014#
Core to peripheral temperature gradient(Mean± SD)	2.07 ± 0.82	1.97 ± 0.49	0.582$

#: Mann Whitney U test; $: IST

Among the study population, the median core temperature at end of surgery was 34.50 (34.20 to 35.00) ºC in group A and 34 (33.80 to 34.25) ºC in group B, median peripheral temperature at end of surgery was 32.65 (31.95 to 33)ºC in group A and 32.10 (32.00 to 32.25) ºC in group B and mean core to peripheral temperature gradient at the end of surgerywas2.07 ± 0.82in group A and 1.97 ± 0.49 in group B. There was a statistically significant difference in median core temperature and baseline peripheral temperature at the end of surgery between study group (P Value<0.05) while it was not statistically significant for core to peripheral temperature gradient at the end of surgery (P Value>005). (Table 9)

Figure 10: Box plot for comparison of core temperature (at the end of surgery) between study group (N=60)

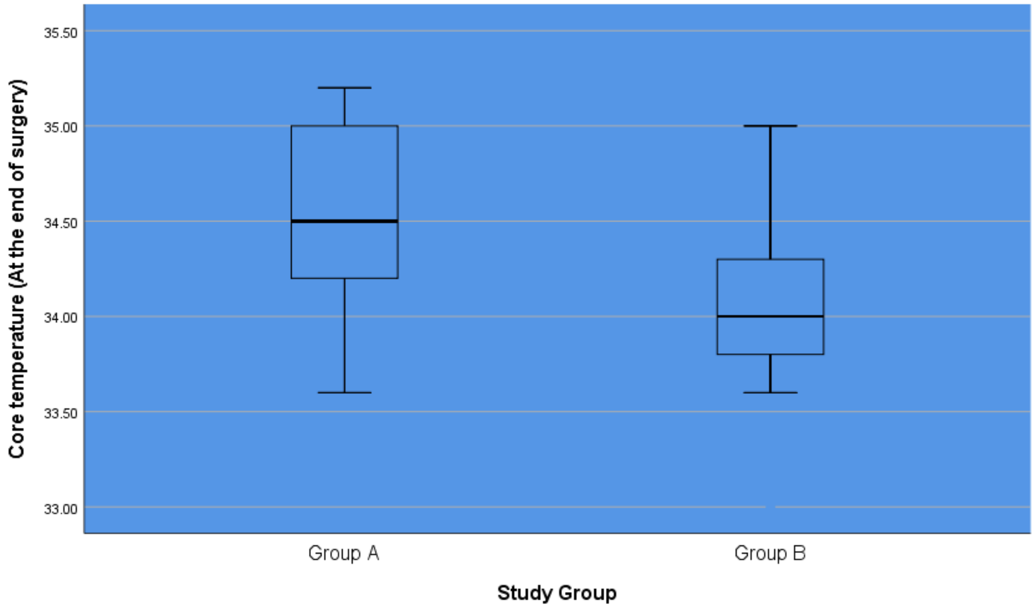


Figure 11: Box plot for comparison of peripheral temperature (at the end of surgery) between study group (N=60)

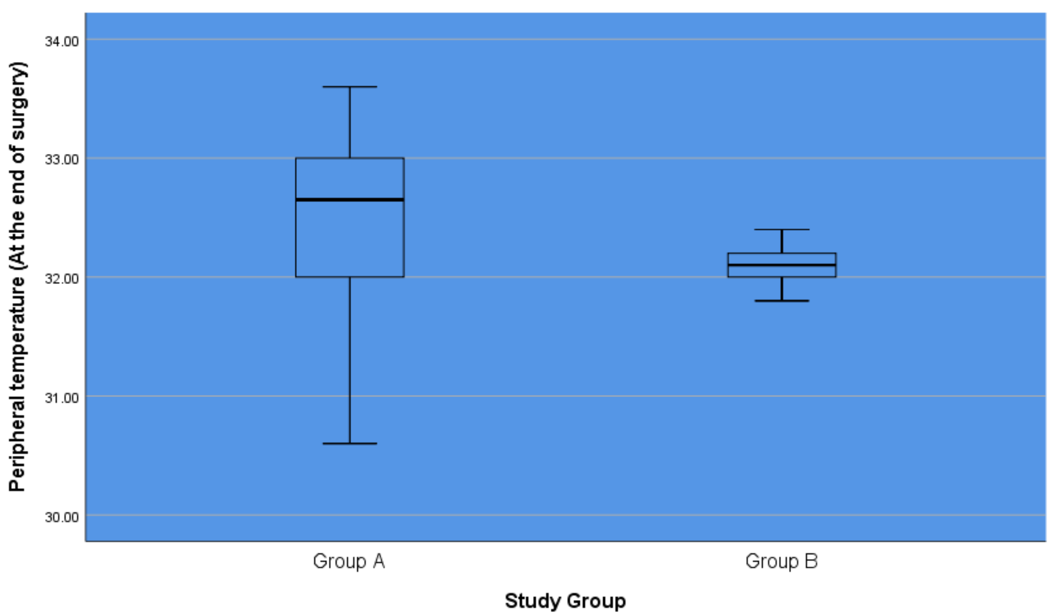
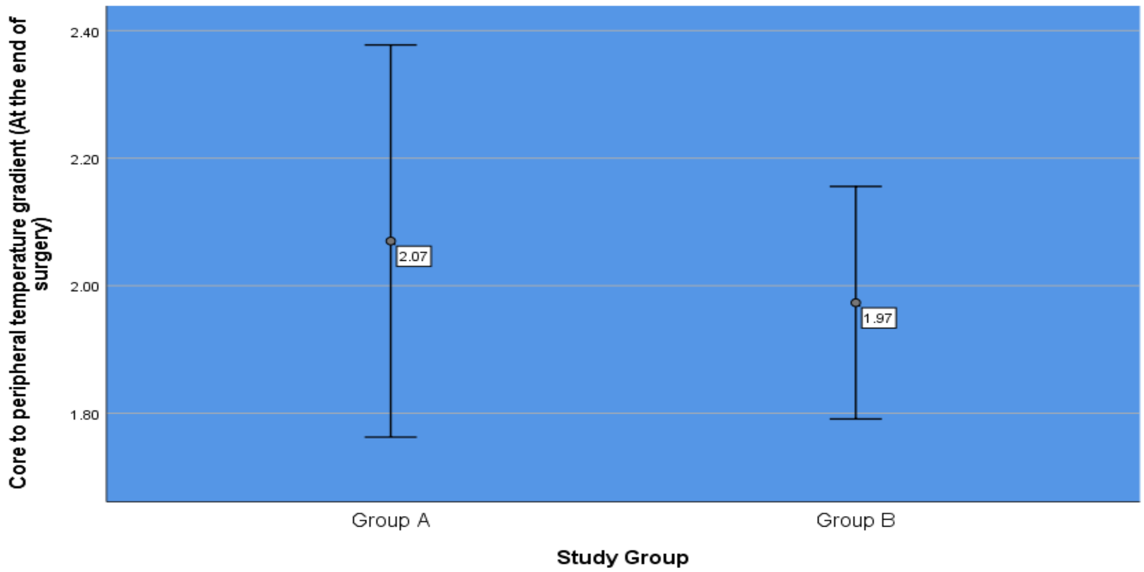


Figure 12: Error bar chart for comparison of core to peripheral temperature gradient (at the end of surgery) between study group (N=60)



DISCUSSION

Temperature is considered as one of the major parameter to be monitored in anaesthesia. Regional anaesthesia and also the general anesthesia impairs thermoregulation. There are studies comparing different techniques in order to prevent intraoperative hypothermia. The present study was carried out to determine the effectiveness of co-warming and pre-warming in intraoperative hypothermia incidence reduction.

A total of 60 participants were enrolled in the study in which 30 participants were belonged to group A and the remaining 30 participants to group B.

Participants receiving pre-warming for 30 minutes at 40^0C before shifting to operation theatre and also receive co-warming before induction of anesthesia was categorized into group A. Whereas, those receiving co-warming at 40^0C from the point of anaesthesia induction was categorized into group B.

In the present study, the mean age (years) of participants in the group A and B were identified as 43.3 ± 11.84 and 45.93 ± 15.87 respectively. While, the mean weight (kg) of participants in group A and group B were 61.03 ± 5.01 and 60.2 ± 4.6 respectively.

The mean age was higher in the co-warming group while, the mean weight was higher in the pre warming group.

In Melissa Bucci Adriani , et al., [67] study the mean age was identified as 49.43 ± 13.74 in the prewarming + intraoperative warming group while, 46.67 ± 15.02 in the intraoperative warming alone. Xiao, Yan MM, et al.,[68] study, conducted a study in which 53.81 ± 7.26 and 56.50 ± 6.71 years were identified as the mean of age in the prewarming and co-warming group.

Table 10: Comparison of mean of age between various studies

Study	Population	Mean of age (years)
Present study	**60**	**Prewarming (43.3 ± 11.84)** **Co-warming (45.93 ± 15.87)**
Melissa Bucci Adriani , et al., [67]	60	Prewarming (49.43 ± 13.74) Co-warming (46.67 ± 15.02)
Xiao, Yan MM, et al.,[68]	98	Prewarming (53.81 ± 7.26) Co-warming (56.50 ± 6.71)

Melissa Bucci Adriani , et al., [67] and Xiao, Yan MM, et al., [68] study showed an increased mean of age as compared to our study results

Jae Hwa Yoo, et al., [69] conducted a prospective randomized study on 60 patients in which the mean of age and weight were identified as 48.04 ± 17.42 years and 63.51 ± 10.89 kg in the prewarming group. In another study by So Young Lee, et al., [70] the mean of age and weight in the prewarming group were observed as 44.4 ± 9.5 years and 60.3 ± 8.5 kg respectively which resembles to our study results.

In the current study majority of the participants were identified as male in group A and group B with 66.67% and 73.33% respectively. TannaDhara B, et al., [71] conducted a prospective interventional study on 40 participants in which majority of the participants in the prewarming and co-warming group were males with 75% and 60% followed by females with 25% and 40% respectively. In Xiao, Yan MM, et al., [68] study most of the participants were males in the prewarming and co-warming group with 67.35% and 53.06% respectively.

In our study, TannaDhara B, et al., [71] and Xiao, Yan MM, et al., [68]study most of the participants were males.

Aaron Lau MD, et al., [72] performed a randomized control study on 200 participants in which 50.5% of the participants were females and the remaining 49.5% males. In another observational prospective study by Abhini Prabhakar, et al., [73] 50% of the participants were males.

Table 11: Comparison of gender between various studies

Study	Population	Gender (%)
Present study	**60**	**Prewarming group** **Males (66.67%)** **Females (33.33%)** **Co-warming group** **Males (73.33%)** **Females (26.67%)**
TannaDhara B, et al., [71]	40	Prewarming group Males (75%) Females (25%) Co-warming group Males (60%) Females (40%)
Xiao, Yan MM, et al., [68]	98	Prewarming group Males (67.35%) Females (32.65%) Co-warming group Males (53.06%) Females (46.94%)

In the present study, the median of pulse rate, systolic blood pressure and diastolic blood pressure were identified as 87 (82.75 to 96), 128.50 (120 to 135.25) and 81 (77.75 to 89.50) in group A while, it was identified as 93 (79.50 to 100), 124.50 (118 to 130.25) and 81.50 (78 to 86.50) in group B respectively. The mean arterial pressure found to be higher in group A with 97.93 ± 9.41 as compared to the group B with 95.63 ± 6.92.

In the current study, the median of core temperature and peripheral temperature at the baseline were identified as 36.80 (36.20 to 37.12) and 32.55 (32.38 to 32.72) in group A while, it was observed as 36 (35.70 to 36.20) and 32 (31.60 to 32.02) in group B. Similarly, the mean of core to peripheral temperature was identified as 4.21 ± 0.69 and 4.14 ± 0.42 in the group A and group B respectively.

Laxmi Shenoy, et al.,[74] conducted a study in 60 patients in which median of core temperature (°C), peripheral temperature (°C) and core to peripheral temperature gradient (°C) at the base line were identified as 36.1 (0.8), 32.9 (2.4) and 3.4 (1.7, 4.5) in the prewarming group while, it was identified as 36 (0.58), 32.1 (2.8) and 3.5 (1.8, 5.1) respectively in the co-warming group which was an increased median as compared to our study results.

Laxmi Shenoy, et al.,[74] study showed a similar results to our study.

B Just.et al .,[75] performed a study on 16 participants in which the mean of core temperature(°C) and peripheral temperature(°C) at the baseline were identified as 36.6±0.1 and 32.3±0.2 in the prewarming group.

Similarly, Ji Young Kim, et al.,[76] conducted a study on 40 patients in which 36.7±2.4, 30.5±0.2 and 6.2± 2.7 were identified as the mean of core temperature(°C), peripheral temperature (°C) and core to peripheral temperature (°C) at the baseline in prewarming group.

In the present study, the median of core temperature and peripheral temperature at end of the surgery were identified as 34.50 (34.20 to 35) and 32.65 (31.95 to 33) in group A while it was identified as 34 (33.80 to 34.25) and 32 (32.10 to 32.25) in group B.

Similarly, the mean of core to peripheral temperature was identified as 2.07 ± 0.82 and 1.97 ± 0.49 in group A and group B respectively.

In Laxmi Shenoy, et al., [74] study the core temperature (°C), peripheral temperature (°C) and core to peripheral temperature gradient (°C) at the end of the surgery were identified as 34.6 (1.2), 33.0 (2.4) and 2.8 (0.9, 6.4), Whereas, it was 34.3 (1.3), 32.1 (2.8) and 2.9 (0.6, 6.2) respectively which resembles to our study results.

In another study by B Just.et al ., [75] the mean of core temperature(°C) and peripheral temperature(°C) at the end of the surgery were identified as 36.3±0.1 and 33.3±0.3 in the prewarming group.

In Ji Young Kim, et al., [76] study the mean of core temperature(°C), peripheral temperature (°C) and core to peripheral temperature (°C) at the end period were identified as 35.6±0.5, 29.1±4.0 and 6.6±4.2 in the prewarming group.

CONCLUSIONS

Our study concluded the importance of preventing hypothermia in patients undergoing surgery under general anesthesia. Post-operative and intra operative warming showed a decrease in the rate of fall in core temperature. Hence, both the techniques are effective in reducing hypothermia.

SUMMARY

Intraoperative hypothermia is a common complication among patients undergoing various surgery and all anaesthetics used in the surgical procedure may induce diminished regulatory body temperature control via the core to peripheral redistribution of the body heat. Prewarming and other warming techniques were used to counter the hypothermic condition before and during the surgical interventions. The present study was conducted to determine the effectiveness of co-warming and pre-warming in reducing the incidence of intraoperative hypothermia.

A total of 60 participants were enrolled in the study in which 30 participants were belonged to group A and the remaining 30 participants to group B.

Participants receiving pre-warming for 30 minutes at 40^0C before shifting to operation theatre and also receive co-warming before induction of anaesthesia was categorized into group A. Whereas, those receiving co-warming at 40^0C from the point of induction of anaesthesia was categorized into group B.

The mean age (years) of participants in the group A and B were identified as 43.3 ± 11.84 and 45.93 ± 15.87. Whereas, the mean weight (kg) of participants in group A and group B were 61.03 ± 5.01 and 60.2 ± 4.6 respectively. Majority of the participants in the study population were males in group A and group B with 66.67% and 73.33% respectively. The median of pulse rate, systolic blood pressure and diastolic blood pressure were identified as 87 (82.75 to 96), 128.50 (120 to 135.25) and 81 (77.75 to 89.50) in group A while, it was identified as 93 (79.50 to 100), 124.50 (118 to 130.25) and 81.50 (78 to 86.50) in group B respectively. The mean of arterial pressure in group A and group B were identified as 97.93 ± 9.41 and 95.63 ± 6.92.

The median of core temperature and peripheral temperature at the baseline were identified as 36.80 (36.20 to 37.12) and 32.55 (32.38 to 32.72) in group A Similarly, it was observed as 36 (35.70 to 36.20) and 32 (31.60 to 32.02) in group B. The mean of core to peripheral temperature in group A and group B were identified as 4.21 ± 0.69 and 4.14 ± 0.42 respectively. The median of core temperature and peripheral temperature at end of the surgery were identified as 34.50 (34.20 to 35) and 32.65 (31.95 to 33) in group A. Similarly, it was identified as 34 (33.80 to 34.25) and 32 (32.10 to 32.25) in group B. The mean of core to peripheral temperature was identified as 2.07 ± 0.82 and 1.97 ± 0.49 in group A and group B respectively.

LIMITATIONS

Comparison of both warming group with a control group was not performed in the present, as it was not ethical to expose the patients to perioperative hypothermia. Patients waiting time in pre operative room increased because of the prewarming which may cause uncomfortable for some participants.

RECOMMENDATION

Future studies can be conducted in a larger population size thereby, statistical analysis can also be performed better.

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ANNEXURES

PROFORMA

EFFECTS OF PRE-WARMING AND CO-WARMING IN PREVENTING INTRAOPERATIVE HYPOTHERMIA.

Investigators: Dr Ravi M / Dr Chandramohan K

1.Name of the patient: **2. Age/Sex:** **3. IP No. :**

4.Ward: **5. ASA grade:**

- **General physical examination:**

Height: Weight: Pulse rate: BP:

Pallor/icterus/cyanosis/clubbing/lymphadenopathy/edema

- **Systemic examination:**

RS - **CVS -**

CNS - **P/A -**

- **Investigations :**

Blood group: Hb: WBC: Platelets:

RBS: Blood urea: Sr. Creatinine: Sodium: Potassium:

ECG:

- **Diagnosis :** **Surgery:**

- **Group A :**Receiving pre-warming for 30 minutes at 40°C before shifting to operation theatre and also receive co-warming before induction of anaesthesia.

- **Group B** :Receiving co-warming at 40°C from the point of induction of anaesthesia.

Baseline vitals:

HR: BP : MAP: SPO2:

Temperature Monitoring:

Core temperature baseline-

Core temperature at the end of surgery-

Peripheral temperature baseline-

Peripheral temperature at the end of surgery-

Core to peripheral temperature gradient baseline-

Core to peripheral temperature gradient at the end of surgery-

PATIENT INFORMATION SHEET

Study: "EFFECTS OF PRE-WARMING AND CO-WARMING IN PREVENTING INTRAOPERATIVE HYPOTHERMIA"

Investigators: Dr Chandramohan K / Dr Ravi M

Study location: R L Jalappa Hospital and Research Centre attached to Sri Devaraj Urs Medical College, Tamaka, Kolar.

Details - All Patients posted for surgery under general anaesthesia which lasts for less than 2 hours will be included in this study. Patients with co morbid conditions will be excluded from the study.

This study aims to reduce the incidence of intra operative hypothermia in patients undergoing surgeries under general anaesthesia . Patient and the attenders will be completely explained about the procedure being done i.e . use of a warmer.

Warming will be avoided in the patient in Febrile patients, Patients with co-morbidities like thyroid disease, dysautonomia, cushings syndrome, diabetes mellitus with autonomic neuropathy. Patients affected with peripheral vascular disease like Raynaud's syndrome. Hemodynamically unstable patients who may require massive rapid intravenous fluid resuscitation.

Please read the information and discuss with your family members. You can ask any question regarding the study. If you agree to participate in the study we will collect information . Relevant history will be taken. This information collected will be used only for dissertation and publication.

All information collected from you will be kept confidential and will not be disclosed to any outsider. Your identity will not be revealed. There is no compulsion to agree to this study. The care you will get will not change if you don’t wish to participate. You are required to sign/ provide thumb impression only if you voluntarily agree to participate in this study.

For further information contact

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INFORMED CONSENT FORM

EFFECTS OF PRE-WARMING AND CO-WARMING IN PREVENTING INTRAOPERATIVE HYPOTHERMIA

Date:

I, ____ aged _____________ ,after being explained in my own vernacular language about the purpose of the study and the risks and complications of the procedure, hereby give my valid written informed consent without any force or prejudice for using warmer.. The nature and risks involved have been explained to me to my satisfaction. I have been explained in detail about the study being conducted. *I have read the patient information sheet and I have had the opportunity to ask any question. Any question that I have asked, have been answered to my satisfaction. I consent voluntarily to participate as a participant in this research.* I hereby give consent to provide my history, undergo physical examination, undergo the procedure, undergo investigations and provide its results and documents etc to the doctor / institute etc. For academic and scientific purpose the operation / procedure, etc may be video graphed or photographed. All the data may be published or used for any academic purpose. I will not hold the doctors / institute etc responsible for any untoward consequences during the procedure / study.

A copy of this Informed Consent Form and Patient Information Sheet has been provided to the participant.

________________ ________________

(Signature & Name of Pt. Attendant) (Signature/Thumb impression of Patient)

(Relation with patient)

Witness 1:

Witness 2:

____

(Signature & Name of Research person /doctor)

KEY TO MASTER CHART

PR	Pulse Rate
SBP	Systolic Blood Pressure
DBP	Diastolic Blood Pressure
MAP	Mean Arterial Pressure
mmHg	Millimetre Of Mercury
IVDP	Intervertebral disc prolapse
PIVD	Prolapse of intervertebral disc
CP angle	Cerebello Pontine angle
LL	Lower Limb
CSOM	Chronic Suppurative Otitis Media
SOL	Space Occupying Lesion
EDH	Extra Dural Hemorrhage
SDH	Sub Dural Hemorrhage
D3	3^{rd} Thoracic Vertebra
D4	4^{th} Thoracic Vertebra
D5	5^{th} Thoracic Vertebra
D6	6^{th} Thoracic Vertebra
D7	7^{th} Thoracic Vertebra
D8	8^{th} Thoracic Vertebra
D9	9^{th} Thoracic Vertebra
D10	10^{th} Thoracic Vertebra
D11	11^{th} Thoracic Vertebra
D12	12^{th} Thoracic Vertebra
C3	3^{rd} Cervical Vertebra

C4	4^{th} Cervical Vertebra
C5	5^{th} Cervical Vertebra
C6	6^{th} Cervical Vertebra
C7	7^{th} Cervical Vertebra
L1	1^{st} Lumbar Vertebra
L2	2^{nd} Lumbar Vertebra
L3	3^{rd} Lumbar vertebra
L4	4^{th} Lumbar Vertebra
L5	5^{th} Lumbar Vertebra
S1	1^{st} Sacral Vertebra

MASTER CHART : GROUP A

S.No.	Group	Age	Sex	Wt.	R.No.	Diag.	Surg.	Pre-operative				Baseline			At the end of surgery		
								PR	SBP	DBP	MAP	Core temperature	peripheral temperature	peripheral temperature	Core temperature	peripheral temperature	peripheral temperature
1	A	45	Male	57	832726	C5 fracture	Decompression and fusion with implant	96	137	89	105	36.3	33	3.3	35	32.6	2.4
2	A	36	female	60	836373	L4-L5 Disc prolapse	Decompression and fusion with implant	86	127	70	88	36.7	32.8	3.9	34.6	33	1.6
3	A	37	Male	65	836318	L2-S1 Disc prolapse	Spinal fixation with implant+Lumbar decompression	86	122	80	94	37.1	32.2	4.9	34.2	31.8	2.4
4	A	40	Male	55	836952	L4-L5 Disc prolapse	Decompression and fusion with implant	100	136	100	115	36.1	33	3.1	34.6	32.5	2.1
5	A	60	Male	65	838835	Traumatic cervical spondylosis	Decompression and fusion with implant	83	134	93	107	36.8	32.5	4.3	35.2	33	2.2
6	A	21	Male	58	842678	Fracture dislocation of D8 D9 vertebra	Decompression with laminectomy	99	128	89	99	37.3	32.4	4.9	34.3	31.6	2.7
7	A	30	female	60	836718	L1 Compression fracture	Decompression with spinal fusion implant	98	135	82	100	37.2	32	5.2	35.1	32.1	3
8	A	38	Male	63	842811	Grade 2 spondylolisthesis of L5 over S1	Polyaxial pedicle screw fixation with laminectomy	96	136	95	109	35.9	32.6	3.5	35.1	32	3.1
9	A	58	Male	58	821092	L3 L4 Disc bulge	Decompression with spinal fusion	74	116	78	91	36.3	32.7	3.6	34.6	33.2	1.4
10	A	60	female	54	846218	CP angle tumor	Excision	84	140	96	111	36	32.6	3.4	35	32.9	2.1
11	A	53	female	57	844928	D6 compression fracture	Spinal fixation with implant	75	127	79	95	37.6	32.9	4.7	34.6	33.2	1.4
12	A	45	female	55	846988	L4- S1 PIVD with canal stenosis	Decompression with spinal fusion	94	134	92	112	36.9	32.3	4.6	34.4	31.4	3
13	A	31	Male	76	845288	L3 - L5 PIVD	Spinal fusion with implant	78	120	80	94	38	32.5	5.5	34.6	32	2.6
14	A	35	Male	64	848134	Frontal lobe tumor	Tumor excision	82	120	70	84	37	32.7	4.3	34.5	32.4	2.1
15	A	21	female	58	849082	Aneurysmal bone cyst	Excision	84	136	93	108	36.3	32.3	4	34.3	33	1.3
16	A	43	Male	58	849094	SOL in Rt occipital region	Excision	80	129	73	89	36.2	32.9	3.3	34.4	30.6	3.8
17	A	59	Male	65	850153	L5-S1 Listhesis	Spinal fusion with implant	78	130	80	94	35.8	32.4	3.4	35	32.4	2.6
18	A	39	Male	60	793805	L4 - L5 IVDP with canal stenosis	Spinal fusion with implant	100	136	91	107	36	32.5	3.5	33.8	30.9	2.9
19	A	50	female	60	851126	L4 - L5 Listhesis	Spinal fusion with implant	95	134	86	102	37	32.5	4.5	33.6	32.8	0.8
20	A	43	Male	66	835463	C5 - C6 Listhesis	Decompression with fusion implant	85	130	55	80	37.9	32.1	5.8	34.5	33	1.5
21	A	25	female	50	850021	Thyroid swelling	Total thyroidectomy	83	117	63	86	37.7	32.6	5.1	34.2	33.2	1.2
22	A	56	male	68	850807	Thoracic dorsal compression	Decompression with spinal fusion	83	122	82	95	36.6	32.7	3.9	34.1	33.1	1
23	A	43	Male	59	853902	Intradural tumor	Tumor excision	71	120	77	89	37	32.6	4.4	33.9	31.3	2.6
24	A	60	Male	63	852258	L3 - L5 PIVD	Decompression with spinal fusion	98	129	84	114	36.2	32.3	3.9	33.8	32.8	1
25	A	45	Male	60	854384	B/L CSOM	Left tympanoplast with mastoidectomy	88	115	79	96	36.1	32.1	4	35	33.2	1.8
26	A	51	Male	60	854748	Peritonitis	Exploratory laprotomy	90	121	81	92	37	32.4	4.6	34.3	33.6	0.7
27	A	30	male	65	853525	C5 compression fracture	Decompression with spinal fusion	104	140	80	100	36.6	32.5	4.1	34.3	32.4	1.9
28	A	35	female	63	858543	D3 - D5 intradural tumor	Tumor excision	88	126	89	98	37	32.6	4.4	34.1	33	1.1
29	A	55	female	65	856461	D12 wedge compression fracture	Spinal fusion with implant	90	116	81	97	37.2	33	4.2	34.9	31.6	3.5
30	A	55	Male	64	861948	EDH with SDH with midline shift	Decompressive craniotomy with evacuation of SDH and E	94	116	73	87	36.8	32.8	4	35	32.7	2.3

MASTER CHART : GROUP B

S.No.	Group	Age	Sex	Wt.	R.No.	Diag.	Surg.	Pre-operative				Baseline			At the end of surgery		
								PR	SBP	DBP	MAP	Core temperature	peripheral temperature	Core to peripheral temperature	Core temperature	peripheral temperature	Core to peripheral temperature
31	B	29	Male	62	803003	Blunt injury abdomen	Rt nephrectomy	98	134	86	102	35.9	31.8	4.1	33.6	32.1	1.5
32	B	31	Male	68	855221	D12 fracture with cord compression	Decompression with laminectomy	82	130	82	98	35.8	32	3.8	33	32	1
33	B	64	Male	56	862662	L4 - L5 PIVD	Decompression with fusion implant	105	127	90	99	36	32.2	3.8	35	32.2	2.8
34	B	21	Male	60	864022	L2 fracture with cord decompression	decompression with pedicle screw fixation	98	130	91	106	36.2	32	4.2	34.2	32	2.2
35	B	30	Male	58	865557	C5 - C6 root compression	Decompression with spinal fusion	120	130	90	105	35.8	30.9	4.9	33.8	32.1	1.7
36	B	58	Male	55	865611	cervical canal stenosis	spinal decompression with fusion	100	113	76	92	35.6	32	3.6	33.9	32.2	1.7
37	B	48	male	58	867212	C5 - C7 Traumatic disc PIVD	spinal decompression with fusion	90	120	80	93	36.2	32.1	4.1	34	32	2
38	B	35	Male	64	860741	oligodendroglioma	excision with craniotomy	102	108	77	87	36	31.4	4.6	35.1	32.6	2.5
39	B	38	female	65	870907	Thyroid swelling	Total thyroidectomy	74	117	78	89	36.3	32	4.3	34.1	32	2.1
40	B	35	female	63	865491	D11 - D12 PIVD	Decompresion with laminectomy	78	118	80	78	35.7	32.1	4.6	33.9	32.2	1.7
41	B	53	Male	58	871355	D9 extradural tumor	tumor decompression with pedicle screw fixation	75	130	90	102	35.8	32	3.8	33.6	32.4	1.2
42	B	25	Male	64	875275	D11 - D12 wedge compression fracture	Spinal fusion with implant	98	110	85	94	35.2	30.8	4.4	33.8	32	1.8
43	B	45	Male	57	877162	Severe cervical spondylosis	Spinal fusion with implant	99	118	78	96	36.4	31	5.4	34.2	31.8	2.4
44	B	60	Male	55	839289	Lt parietal glioma	Excision	94	121	70	88	35.2	31.7	3.5	35	32.6	2.4
45	B	64	female	50	883724	L3-L5 PIVD	Laminectomy with L3 - L4 stabilisation	100	127	86	99	36.4	32	4.4	33.9	32.1	1.8
46	B	30	Male	60	886923	C5 - C6 IVDP	Discectomy with fusion	78	119	81	96	35.4	31	4.4	34.3	32	2.3
47	B	63	female	65	864250	L4 - L5 PIVD	Spinal fusion with implant	98	131	88	102	36	32	4	34.2	32.2	2
48	B	60	female	60	888119	Lt occipital meningioma	Excision	90	120	80	93	36.1	31.8	4.3	34	32.4	1.6
49	B	62	Male	63	891102	C3 - C5 spondylosis	Spinal fusion with implant	92	126	81	102	35.6	32	3.6	33.6	32.6	1
50	B	59	female	62	890804	L4 - L5 IVDP	L4 - L5 Discectomy with pedicle screw fixation	100	135	88	100	35.7	32.2	3.5	33.8	31.9	1.9
51	B	64	Male	64	895515	Rt SDH with midline shift	Rt decompressive craniotomy	95	134	86	102	36	32.4	3.6	34.6	32	2.6
52	B	44	female	59	882231	craniopharyngioma	excision of tumor	100	127	83	98	36.1	32.2	3.9	34.2	32.2	2
53	B	51	Male	54	897520	L4 - L5 IVDP	Spinal fusion with implant	70	117	63	86	35.5	31.6	4.1	34.8	32.1	2.7
54	B	23	Male	58	898418	Cauda equina syndrome	L4 - L5 Discectomy with pedicle screw fixation	83	122	82	95	36	31.9	4.1	34	31.9	2.1
55	B	40	Male	50	900715	L4 - S1 PIVD	Microscopic discectomy	100	123	72	83	36.1	32	4.1	34.4	31.6	2.8
56	B	62	Male	63	920126	L4-L5 IVDP with Rt LL radiculopathy	L4 - L5 laminectomy with discectomy	78	122	80	93	36.2	32.4	3.8	33.9	32.4	1.5
57	B	38	Male	60	902709	L3 vertebral fracture	Spinal fusion with implant	75	132	78	96	35.7	31.4	4.3	33.8	32.3	1.5
58	B	64	Male	64	870526	Rt frontal meningioma	excision of tumor	90	136	90	105	36.2	32	4.2	34	32.1	1.9
59	B	25	Male	68	905549	L1 Compression fracture	Spinal fusion with implant	84	110	79	89	36	31.6	4.4	34.2	32.1	2.1
60	B	35	female	63	907924	L5 - S1 listhesis	Spinal fusion with laminectomy	80	131	84	101	36.3	32	4.3	34.4	32	2.4