Basrah Journal of Surgery

Original Article

Bas J Surg, September, 12, 2006

OESOPHAGEAL TEMPERATURE MONITORING DURING GENERAL ANAESTHESIA

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Abstract
This study aimed to demonstrate the oesophageal temperature changes with the time during general anaesthesia for the routine surgical work, and to see the effects of patient's gender or age, and the effects of neuromuscular blockade on these changes, also to compare oesophageal temperature changes with mean skin temperature changes during general anaesthesia, and to assess the problem of unintentional intraoperative hypothermia with its complications in the postanaesthetic recovery room.

Fifty three ASA (I-II) unpremedicated randomly selected patients (26 males and 27 females) undergoing different routine elective surgical operations under general anaesthesia in the University Hospital Medical College in Baghdad between August -September 2001.

Anaesthesia was induced by intravenous (iv) thiopentone 4-5 mg /kg and fentanyl 1-2 μg/kg, and maintained with either 2-3 % halothane in oxygen without neuromuscular blockade in spontaneously ventilated by mask (4 patients)or manually assisted ventilation through a tube in 17 patients, while it was maintained by 0.5-1% halothane in oxygen and the muscle paralysis was done by either suxamethonium 1 mg/kg bolus iv followed by infusion of 4-10mg\min. of 0.1% suxamethonium solution to 16 patients, or by iv pancuronium 0.1 mg /kg (16patients), then endotracheal intubation was done and ventilation was mechanically controlled. Neostigmine 40μg/kg and atropine 20 μg/kg were given iv at the ends of operation to reverse residual blockade of pancuronium where it was given.

Monitoring of the oesophageal and skin temperatures was started ten minutes after induction of anaesthesia as a baseline, repeated every ten minutes until the end of halothane administration and the last measurements were taken just before discharging the patient from the recovery room, other vital signs were also monitored like noninvasive blood pressure, ECG, and pulse oximetry at the perioperative periods. The means for the ambient temperature and the relative humidity of the operating theatre were also recorded.

Postanaesthetic shivering when observed, was scored (0-3), pulse oximetry was used to assess oxygenation status. The postanaesthetic recovery time was measured from the moment of closing the halothane vaporizer at the end of the operation until the patient got 10 degrees according to Aldrete &Kronlik postanaesthetic recovery score.

Oesophageal temperature increase above the baseline occurred in 7.54% (4/53) of the patients with mean increase was 1.035°C ± 0.797 (SD) range was 0.2-3.4°C, while the temperature decrease below the baseline occurred in 92.45 % (49/53) of the patients, with mean decrease was 1.7 °C ± 0.67 (SD), the range was 1 - 3.4 °C .The decrease became significant ($P < 0.05$) at 20-150 minutes after induction in oesophageal temperature and at 30-140 minutes in mean skin temperature. At all time periods after induction the oesophageal temperature readings were significantly ($P<0.05$) above those of the mean skin temperature. Changes in oesophageal temperature showed no significant difference between males and females, but there was significant ($P<0.05$) difference between different age groups up to 90 minutes after induction, however significant differences were seen between patients who had spontaneous or assisted ventilation with 2-3% halothane in oxygen, and those who received muscle relaxants in addition to 0.5-1% halothane in oxygen with controlled ventilation

The incidence of unintentional intraoperative hypothermia (decrease 1-3°C in core temperature) was 43.39% (23/53), and from the total hypothermic patients; females formed 69.56% (16/23), males were 30.43 % (7/23) .
Hypothermia was more frequent 39.13 % (9/23) in the age group 15 years and below. Postanaesthetic shivering was seen in 37.73 % (20/53) from total patients, and from total shivering patients; females formed 55% (11/20) , males were 45% (9/20). The highest percentage of shivering was 40% (8/20) and seen within the age 16-25 years, while the lowest was 5% (1/20), and found within the age group above 40 years. From the total shivering patients 50% (10/20) had ENT operations, 30% (6/20) who had orthopaedic operations, and 20%(4/20) who had general surgery operations. Severe shivering grade 3 occurred in 55% (11/20) of all the shivering patients causing hypoxaemia (SaO_2 < 90 %) diagnosed by pulse oximetry in 40% (8/20) of the total shivering patients. Irritable patients were seen in 60% (12/20) of these shivering where hypoxaemia occurred in 58.3% (7/12) of the irritable patients. The mean postanaesthetic recovery time in hypothermic patients was 31.47 minutes ± 15.41(SD), which was significantly (P<0.01) more than that in the nonhypothermic patients which was 18.76 minutes ± 9.16 (SD).
In conclusion, monitoring of oesophageal temperature during routine practice of general anaesthesia can early detect the body core temperature changes especially the intraoperative unintentional hypothermia, which should be prevented to avoid its complications

Introduction

Under normal conditions the temperature of the body is controlled within 0.4°C of its set-point (37°C) which is a condition necessary to maintain the vital cellular metabolic processes. The control center for temperature is located within the hypothalamus and operates via a negative feed back mechanism. This system may be susceptible to the action of certain pharmacological agents, in particular the inhalation and intravenous anaesthetic agents[1]. Afferent warm and cold thermal massages are relayed from compared to threshold temperatures for either heat or cold. If the detected temperature falls outside this narrow interthreshold range 36.5°C - 37.5°C, the efferent mechanisms are triggered to restore the body temperature for the cold responses like vasoconstriction, nonshivering thermogenesis, shivering and behavioral response while the warm responses like active vasodilatation, sweating and behavioral response[2].

Mild hypothermia occurring during general anesthesia (i.e a drop in core temperature of between 1°C and 3°C) is very common[3]. This is caused by (a) thermally sensitive cells located throughout the body, principally the skin, brain, spinal cord and certain central core tissues. The cold information is transmitted via A-delta fibers and warm influx via unmyelinated C-fibers which are also responsible for transmission of pain sensation. This explains why intense thermogenic stimulation cannot be differentiated from sharp pain. These thermal inputs are transferred by the ascending spinothalamic tracts to the hypothalamus to be integrated and internal redistribution of heat within the body[4]. (b) an approximately 30% reduction in heat production from metabolism[5].(c)increased environmental heat loss. (d) the effect of anesthetic agents on thermoregulatory mechanisms[3]. Hypothermia typically occurs in three phases[6]: [1] Internal redistribution of heat [2] thermal imbalance [3] thermal steady state. The first phase can be explained by peripheral vasodilation during inducting anaesthesia which leads to increase in size of the central compartment and subsequent decrease in the compartmental temperature because the amount of energy contained within the initial compartment is forced to distribute within larger volume. The first phase typically occurs over 30-60 minutes the phase of thermal imbalance occurs as heat production during anaesthesia is reduced lower than the environmental heat loss, this phase typically takes place over 2-3 hours. The reduction in temperature is linear in fashion and occurs at a rate of approximately 0.5-1°C per hour - Heat loss during anaesthesia is mainly the result of convector and radiation [85% of totally loss] from the patient to the environment[3]. The contribution of heat loss from conduction and evaporation accounts for less than 15%. Various methods were used to deliver heat to the patients like warming intravenous fluids[7], and using warming devices in paediatric anaesthesia[8].

Body temperature monitoring during anaesthesia and active warming measures are not done routinely in many operating theatres. Sessler[9] stated that "Temperature monitoring should be routine during general anesthesia" while Kaplan[10] on other hand stated "Temperature monitoring need not be done routinely during general anesthesia". The benefit of body temperature monitoring through the oesophagus during general anaesthesia where no routine active warming measures are taken, will be investigated in this study.

This study aimed to demonstrate oesophageal temperature changes with time during general anaesthesia in routine surgical operations and to see the effects of patent's age and gender and the neuromuscular blockade on these changes. To compare the oesophageal temperature changes with those of mean skin temperature during general anaesthesia and finely to assess the problem of intraoperative unintentional hypothermia and it's complications in the postanesthetic recovery room.

Patients and Methods

This is a prospective study was done on fifty three patients [26 males & 27 females] with physical status 1-II of the American society of anesthesiology [ASA] classification undergoing different elective surgical procedures under general anaesthesia in the operating theatres of University Hospital in Baghdad between August and September, 2001. Standardization of the conditions was not attempted as it was intended that the results should represent information obtained from routine theatre procedures, and should reflect realistic estimate of what can be expected in routine practice. The skin preparation used during the operation was an aqueous solution of 10% povidone iodine, draping of the patient was consistent with standard surgical procedures. The temperature of the theatre was measured by dry and wet bulb thermometer and the relative humidity was calculated using special tables. Temperature recording from the patients were made immediately before induction of general anaesthesia by using an oral mercury in glass thermometer kept sublingually for three minutes. While the oesophgeal and the skin temperatures were measured using temperature sensors manufactured by Yellow Springs instruments **CO.,O**hio, USA. These sensors have exclusive property of being interchangable within the tolerance of 0.1 C. In measuring range from 0-80 C (YSI patent number 2970411). Temperature sensors for oesophagus and skin were coupled to bedside monitor Trakmon (Kontron Medical Charter House Company) which is also used for monitoring noninvasive arterial blood pressure, electrocardiography and pulse oximetry.

All temperature sensors were calibrated previously against a mercury in glass total immersion thermometer in a stirred waterbath, in addition to automatic calibration to 37 C within the monitor was done during each surgical operation. The mean skin temperature was calculated from four probes situated on four sites; the lateral aspect of the mid calf, the ventral surface of the mid thigh, the nipple and the lateral aspect of the upper arm, using the formula of Ramanathan 1964[11] mean skin temperature = 0.3 (nipple +arm)+ 0.2 (thigh + calf).

Setting of the skin probes was started before induction of anaesthesia while an oesophageal probe lubricated with lidocaine 5% ointment, was inserted through the nose of the patient immediately after induction of anaesthesia. The lower fourth of the oesophagus is both the warmest and the most stable site and to reach this area, the thermocouple probe should be inserted at least 24 cm below the corniculate cartilages in the anaesthetized adult patient[12], while in paediatric patients the oesophageal probe should be inserted a distance of 10+ 2x age years/ 3 cm below the corniculate cartilages but that reading should be taken up to 2 cm above and below this point before fixing to confirm that the probe is below the area affected by ventilation[13]. Both the oesophageal and the skin temperatures were measured every 10 minutes after induction of anaesthesia and were taken as the baseline levels, then the measurements were repeated every 10 minutes until closing the halothane administration at the end of the operation. The last measurements were done before discharging the patient from the recovery room. The mean body temperature[14] was calculated as:

T body = (0.66 x T core) + (0.34 x T skin), where T body = mean body temperature, T core = core temperature (oesophageal temperature), T skin = mean skin temperature. The body mass index (BMI) was calculated as:

BMI = weight (Kg) \ height^2(m)^2

The accepted range is 18.5- 24.9 as mentioned by Frier etal[15].

Anaesthesia Technique: There was no routine premedication , and anaesthesia was induced intravenously (iv) by thiopentone 2.5% in a dose of 4-5 mg/kg body mass, fentanyl 1-2μg/kg, and anaesthesia was maintained by 0.5-1% halothane in oxygen, with the muscle relaxation was achieved by either intravenous (iv) pancuronium bromide 0.1 mg/kg (16 patients),or by (iv) suxamethonium 1mg/kg followed by infusion 4-10mg/min as 0.1% solution of suxamethonium (16 patients) and the remaining 21 patients were ventilated with oxygen supplemented by end tidal halothane 2-3% halothane without muscle relaxants and ventilated either spontaneously by mask in 4 patients, or assisted manually through endotracheal tube in 17 patients .

The ventilation was mechanically controlled after endotracheal intubation in patients who received pancuronium or continuos infusion of 0.1% suxamethonium after setting tidal volume at 10-12ml/kg and breathing rate of 10-14 breaths/minute using either Taema or Acoma anaesthesia machines. The intravenous fluids were given in the room temperature and there was no warming blanket or mattress during the operation. Perioperative Clinical monitoring was aided by Kontron bed side monitor which displays continuous ECG, pulse oximetry, body temperatures, inspired and expired CO2 tensions, inspired and expired halothane percentages, and intermittent noninvasive arterial blood pressure measurements were started before induction of anaesthesia, repeated every 10 minutes and continued until discharging the patient from the recovery room. At the end of the operation halothane administration was stopped, suxamethonium infusion was removed and residual pancuronium was reversed using neostigmen 40μg/kg and atropine 20μg\Kg. given iv slowly. The maximum adult dose was given as 2.5 mg neostigmine and atropine 1.2 mg iv. Endotracheal extubation was done after recovering the muscle power as assessed by asking the patient to open the eyes, protrude the tongue, lift the head up for 5 seconds. The patients were transferred immediately to the recovery room, where they were covered up to the shoulders with an ordinary wool blanket until they are fully awake. The time of recovery was measured between the period of closing halothane administration at end of surgery until discharging the patient after getting total score of 10, as shown in table I, as modified from Aldrete and kronlik[16].

In the recovery room the post-anaesthetic shivering[17] when observed visually was scored 0 = none, 1 = mild minimal fasciculation on face and neck; 2 = moderate, visible tremor involving head, neck, shoulders and/or extremities, and 3 = sever, generalized and visible shaking. The pulse oximetry recorded the arterial oxygen saturation(SaO2)during breathing room air in the recovery room, and the first reading was recorded immediately after admission the patient and the last reading was taken just before the discharge from the recovery room. Readings of SaO2 below 90% diagnosed as hypoxaemia and treated by oxygen mask breathing.

Unpaired Student t test was used to test the differences between two means and the analysis of variance test for differences among means when there are more than two variables. Difference was considered statistically significant when P value < 0.05. The data were coded, stored and processed by computer using EPI-6 system for statistical analysis.

Results

The demographic variables are presented in table 2, which shows the characters of the patients, types of surgical operations, the means of ambient temperature and the relative humidity of the operating theatre, the amount of intravenous fluid, and the duration of surgical operations.

Oesophageal temperature changes

Temperature increase: This occurred in 7.54% (4/53) of the patients with the mean was 0.25ºC±0.173 (SD), and the range between 0.1ºC-0.4ºC.

Temperature decrease: This occurred in 92.45% (49/53) of the patients with mean decrease was 1.035ºC±0.797 (SD), and the range was 0.2-3.4ºC.

Hypothermia (mild hypothermia where a decrease in core temperature was between 1-3ºC), occurred in 43.39% (23/53) of the patients with mean decrease was 1.704ºC±0.674 (SD) and the range of decrease was 1°C-3.4°C.

Table 3, show the changes in the means of esophageal, mean body, and mean skin temperatures in all the patients in the study.

There is general decrease from the baseline measurement at 10 minutes after induction of anaesthesia. The decrease in oesophageal temperature from its baseline becomes significant (P<0.05) between 20-150 minutes after induction while the mean skin temperature decreased significantly (P<0.05) in the periods between 20-60 minutes, and the mean body temperature decreased significantly between 30-140 minutes after induction from their baseline levels . The mean skin temperature changes were significantly (P<0.05) lower than those changes in oesophageal temperature in all time periods after induction of anesthesia. Oesophageal temperature changes in different groups

- Gender groups (table 4). There were no significant differences between males and females.
- Age group (table 5). There were significant differences (P<0.05) between different groups up to 90 minutes after the base line except in the time period 40 minutes after the induction.
- Neuromuscular blocker groups (table 6). There were significant differences (P<0.05) within 10-30 minutes after the between oesophageal temperatures of those who were ventilated with oxygen supplemented with 2-3% halothane and did not receive neuromuscular blocking agents and those who were ventilated with oxygen supplemented with 0.5-1% halothane and received either suxamethonium or pancuronium.
- Hypothermic and non-hypothermic groups (table 7). shows decreases in oesophageal temperatures of both groups after their baselines, and the hypothermic group shows lower temperature levels than the nonhypothermic group, however there was significant difference (P<0.05) both at the time period 60 minutes after the baseline, and at the recovery period.

Table (8) shows the characters of the 23 hypothermic patients, the incidence was 43.39% (23\53) , their age distribution was; 39.13% (9/23) within the age group up to 15 years, 26.08% (6/23) within the age group 16-25 years, 13.04% (3/23) within the age group 16-40 years and 21.73% (5/23) within the age group more than 40 years. From the total hypothermic patients, females were 69.56% (16/23), males were 30.43% (7/23). The calculated body mass index (BMI) was normal between 18.5-24.9 in 21.73% (5/23) of the hypothermic patients, while in 39.13 % of them (9/23) the BMI was either above or below the normal range in 30.4% (7/23) of them.

The mean decrease in oesophageal temperature of hypothermic patients was 1.70ºC±0.674 (SD), and the range was (1-3.4°C). There was no significant difference in the mean decrease of esophageal temperature within the groups when related to different factors like age, gender, BMI, and the type of neuromuscular blocking agents. However there is significant (P<0.01) difference between mean decrease in oesophageal temperature of patients who had ENT operations 2.2°C±0.711 (SD) when compared to patients who had operations in general surgery 1.18°C±0.144 (SD).

It was found that 52.17% (12/23) of hypothermic patients developed shivering table (9) shows feature of 20 patients who suffered from postanesthetic shivering. From the to total, females constituted 55% (11/20), moles were 45% (9/20).

The age distribution was, 35% (7/20) within in the age group up to years, 40% (8/20) within the age group 16-25 years and 20% (4/20) within the age group 26-40 years and 5% (1/20) within the age group more than 40 years. About 90% (18/23) of the shivering patients whose body mass index less than 28. There were 50% (10/20) of the shivering patients who had ENT operations, 30% (6/20) had orthopaedic operations, 20% (4/20) had general surgery operations. There were 50% (10/20) of the shivering patients who were mechanically ventilated using 2-3% halothane in oxygen, while 25% (5/20) were ventilated with 0.5-1% halothane in oxygen supplemented with either suxamethonium or pancuronium.

The mean duration of sever shivering grade 3, was 27-57 minutes ± 9.16 (SD), range 16-40 minutes. Sever shivering occurred in 55% (11/20) of all the shivering patients, produced low arterial oxygen saturation mean 79.42% ± 10.40% (SD), and the range was 62-97% when the patients were admitted to the recovery room. Shivering caused hypoxaemia (Sa O2 ≤ 90%) in 40% (8/20) of total shivering, patients and sever hypoxaemia (Sa O2 ≤ 85%) in half of these hypoxaemic attacks.

About 60% (12/20) of shivering patients become irritable and hypoxaemia was seen in 58.3% (7/12) of the irritable patients.

The mean time of recovery for hypothermia patients was 31.47 minutes ± 15.41 (SD), which is significantly (P< 0.01) more than the time of recovery for non hypothermic patients 18.76 minutes ± 9.16 (SD).

Discussion

The experience, gained in this work indicates that body core temperature monitoring can be introduced in the routine work during administration of general anaesthesia. The results confirmed earlier observations that during general anaesthesia the body core temperature usually decreases. Morris[18], observed that anaesthetized patients remained normothermic in environmental temperature of 24ºC and more. The mean ambient temperature of the operating theatre in the present study was 22.12ºC, ranged between (16.66ºC - 27.2ºC), and this can predict this decrease in body core temperature in the present study.

It is difficult to set the oesophageal temperature probe through the nose of a conscious patient before induction of general anaesthesia, because it is uncomfortable, therefore the baseline reading from the oesophageal site started 10 minutes after induction of anaesthesia. However the preoperative body temperatures were measured from sublingual sites using mercury in glass thermometer to exclude patients with abnormal body temperatures from the study. Cranstone et al[19] showed a little difference in temperature measurements in the sublingual and oesophageal sites.

The increase in oesophageal temperature was observed in 7.5% of the total patients, while Crocker et al[20], found this increase occurred in 10-20% of the patients, and explained this increase as body response to the lower initial body temperature. In the present study only 4 patients showed increases in their oesophageal temperatures, with their initial temperatures were (36°C, 36.1°C, 36.8°C, 37.2°C), and most of these were lower than the mean initial temperature recorded at the baseline from the total patients which was 36.97°C.

The mean decrease in oesophageal temperature was 1.035ºC, occurred at mean duration 72.25 minutes after induction while Morris (18) found the largest decrease in temperature occurred during the first hour with a mean of 1.3°C. Cohen[21] also reported an acute decrease in oesophageal temperature of 1°C on induction of anaesthesia.

The incidence of intraoperative unintentional hypothermia in this study was 43.39%, while it was reported that 60-80% of all admissions to the postanaesthetic recovery room suffered from hypothermia[22].

The cause of postanaesthetic shivering had been related to the administration of halothane[21] and particularly to the central body temperature[23]. Moir and Doyle[24], found a lower temperature (more than 0.5ºC less) in shivering compared to nonshivering patients, in the present study the difference reached 0.65ºC. The incidence of postanaesthetic shivering was 37.7% in the present study, while Zhang and Wong[25] reported an incidence between 5-65%.

Shivering occurred in 52.17% of the hypothermic patients while 40% of the shivering patients were normothermic and this may be explained by nonthermogenic cause for shivering[26].

The factors which were unrelated to the mean decrease in body temperature during anaesthesia in hypothermic patients were the age, gender, body mass index and those results are in agreement with those of Holdcroft and Hall[27].

Although body fat has classically been thought of as an insulation layer protecting the central core temperature from the environment. It is also highly active metabolic tissue and has been described as an "electric blanket" or heat producing organ, which is important in maintenance of body temperature[27]. However short studies of less than 2 hours may subject to large variations in the results. Lehard et al[28] found that mild intraoperative hypothermia prolonged the postanaesthetic recovery time 40 minutes longer than that after normothermia to reach fitness of the patients for discharge.

However in the present study hypothermia prolonged the mean recovery period by 12.71 minutes longer than that in normothermic patients. This difference may be related to the different score system for patient to reach fitness for discharge, that had been used by Lehard et al[27], which is composed from 13 points (80%), versus the 10 points score system described by Aldrete & Kronlic[16] which was used in the present study, in addition to that all the patients in Lehard work had major abdominal surgery,while in the present study there were different types of operations with some of them were major.

The postoperative hypoxaemia, was found in 17.39% of the hypothermic patients, as shown by low arterial oxygen saturation (less than 90%) measured by pulse oximetry.

Frank et al[29] reported higher incidence of postoperative hypoxaemia as shown by low arterial oxygen tension less than 80 mmHg in 52% of hypothermic patients undergoing lower extremity vascular surgery. This is suspected from the prolonged duration of vascular surgery with more exposure time to anaesthetic agents. Causing higher incidence of postoperative hypoxaemia.

Frank et al[29] also showed in their study that maintenance of the perioperative normothermia decreased the incidence of ischaemic ECG changes in normothermic patients 13% when compared to those in hypothermic 36% within the first postoperative day using continuous Holter monitoring.

In another study frank et al[30], demonstrated that perioperative normothermia decreased the morbid cardiac events and ventricular tachycardia in cardiac risk patients undergoing non cardiac surgery.

Many methods were used to prevent heat loss during anaesthesia which were reviewed by lmrie and Hall[31]; these include keeping the theatre`s temperature above 24°C, using humidified anaesthetic gasses, warming mattresses and blankets, warming the intravenous and irrigating fluids, using radiant heaters in the postoperative recovery rooms and oesophageal rewarmers.

In conclusion; There was statistically significant ($P<0.05$) decrease in oesophaeal temperature below the baseline level occurred between 20-150 minutes after induction of anaesthesia, this occurred in 92.45% of the patients. The incideuce of peroperative hypothermia was 43.39%.

There were significant ($P<0.05$) differences between oesophageal and mean skir temperature durig surgucal operation general anaesthesia.

The incidence of hypothermia was highest (39.13%) in the age group up to is years, and the lowest (13.04%) in the age group 16-40 years.

The incidence of postanaesthetic shivering was the highest (40%) among the age group 16-25 years, and the lowest (5%) in the age group more than 40 years.

Pulse oximetry showed that arterial hypoxaemia ($Sa O2 < 90\%$) occurred in 40% of the shivering palients, and 58.3% of the irritable shivering patients suffered from arterial hypoxaemia.

Recommendations: Oesophageal temperature monitoring can improve patients care during general anaesthesia administrative by early detection of the harmful changes in the body temperature.

The best method of preventing the post anaesthetic shivering and associated hypoxaemia is to avoid intraoperative hypo-thermia.

Applying the active warming measurs, to decrease body heat loss during suryical operations.

Monitoring the core body temperature like oesophageal temperature can improve patient care during general anaesthesia for routine surgical procedures by early detecting the harmful changes in body temperature. Prevention of postanaesthesia shivering and associated hypoxaemia is best done by avoiding the intraoperative hypothermia, through applying the active warming measures in the operating theatres.

Also it is concluded that; There is significant difference between skin temperature and oesophageal temperatures during general anaesthesia.

The most common intraoperative changes occurs during general anaesthesia is the temperature decrease which may lead to mild hypothermia.

The incidence of hypothermia is more common in patients within the age group below 15 years of age.

The incidence of postanaesthesia shivering is highest in the age group above 40 years.

Not all the shivering patients are hypothermic this may support a nonthermogenic cause for the shivering.

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Table I : criteria to determine patient readiness for discharge.

System	Observation	Score
Respiration	Patient is able to breath freely	2
	Respiratory effort limited (splinting or dyspnoea)	1
	Absence of spontaneous respiration	0
Blood pressure	Systolic pressure ± 20% of preoperative level	2
	Systolic pressure ± 20-50% of preoperative level	1
Consciousness	Fully alert and oriented	2
	Arousable only when called by name	1
	Auditory stimulus fails to produce response	0
Colour	Normal pink mucus membranes and nail beds	2
	Discolouration - any thing but pink or blue	1
	Frank cyanosis	0
Activity on command	Able to move all four limbs	2
	Able to move only two limbs	1

Table II **Characteristics of the patients and surgical operations(mean ± standard deviation**

Age(years) Mean±SD (Range).	30.44 ± 17.69 (3 – 75)
Gender Females	27
Males	26
Body Mass (Kg)Mean±SD(Range)	59.62 ± 23.31 (11- 100)
Height (cm) Mean±SD (Range)	157.83 ±22.76 (79 - 188)
Body mass index Mean±SD(Range)	36.18±13.19 (11.42-58.89)
Preoperative oral temperature(°C) Mean ±SD(Range)	37.05±0.561(36-37.8)
Preoperative mean skin temperature(°C) Mean ±SD (Range)	32.19±1.327(28.8-35.58)
Ambient temperature (°C) Mean ±SD range)	22.12 ± 2.64 (16.66-27.2)
Relative humidity (%) Mean ±SD (Range)	67.53±9.549 % (49-82 %)
Type of surgical operation	
General surgery	24
ENT surgery	14
Orthopaedic surgery	12
Gynecological surgery	3
Duration of surgical operation (minutes) Mean ±SD(Range)	72.25±36.2(25-150)
Amount of intravenous fluids(ml) Mean ±SD (Range)	881.92±572.42(250-2500)

SD = Standard Deviation

Table III: Changes in the Means for oesophageal, mean body and mean skin temperatures with Time in all the patients (Mean ± Standard Deviation)

Time period (minutes)	No. of patients	Oesophageal temperature °C	Mean skin temperature °C	Mean body temperature °C
10 Baseline	53	36.97 ± 0.564	32.96 ± 1.198	35.60 ± 0.523
20	53	36.65 ± 0.647*	33.23 ± 0.929*	35.49 ± 0.552*
30	53	36.44 ± 0.698*	33.21 ± 0.904*	35.33 ± 0.626*
40	47	36.31 ± 0.766*	33.14 ± 0.924*	35.25 ± 0.795*
50	39	36.22 ± 0.792*	33.05 ± 1.014*	35.15 ± 0.747*
60	34	36.17 ± 0.795*	32.83 ± 0.947	35.10 ± 0.894*
70	27	35.92 ± 0.892*	32.81 ± 0.884	35.00 ± 0.786*
80	22	35.83 ± 0.992*	32.99 ± 1.396	34.90 ± 0.877*
90	17	36.03 ±1.039*	33.03 ± 0.992	34.98 ± 0.903*
100	15	35.98 ± 1.201*	32.93 ± 1.070	34.94 ± 1.042*
110	10	36.26 ± 1.019*	32.94 ± 1.225	35.13 ± 0.972*
120	9	36.23 ± 1.140*	32.95 ± 1.495	35.11 ± 1.068*
130	8	36.24 ± 1.227*	32.69 ± 1.384	35.02 ± 1.1308*
140	5	35.34 ±1.584*	32.97 ± 1.126	34.93 ± 1.349
150	2	36.65 ± 1.202	33.82 ± 1.103	35.68 ± 1.174
Recovery	53	36.15 ±0.793	32.61 ± 1.097	34.94 ± 0.731

* P <0.05 (Change from its corresponding baseline), SD = Standard Deviation

Table IV: Oesophageal Temperature Mean Changes In Males And Females (Mean ± Standard deviation)

Time Period (Minutes)	Females		Males		P value
	Mean ± SD	No.	Mean ± SD	No.	
10 Baseline	37.08 ± 0.524	27	36.81 ± 0.596	26	0.088
20	36.74 ± 0.647	27	36.51 ± 0.637	26	0.207
30	36.52 ± 0.749	27	36.31 ± 0.607	26	0.290
40	36.36 ± 0.849	24	36.23 ± 0.651	23	0.573
50	36.32 ± 0.873	20	36.12 ± 0.708	19	0.452
60	36.21 ± 0.820	18	36.11 ± 0.785	16	0.722
70	36.16 ± 0.869	14	35.57 ± 0.840	13	0.091
80	36.09 ± 0.949	12	35.27 ± 0.899	10	0.071
90	36.26 ± 0.898	9	35.62 ±1.238	8	0.245
100	36.22 ± 1.025	8	35.5 ± 1.502	7	0.290
110	36.52 ± 0.445	6	35.88 ±1.567	4	0.359
120	36.54 ± 0.462	5	35.85 ± 1.682	4	0.403
130	36.60 ± 0.534	5	35.63 ± 1.955	3	0.316
140	35.00 ± 1.273	2	35.57 ± 2.003	3	0.752
150	35.80	1	37.50	1	-
Recovery period	36.16±0.820	27	36.13 ± 0.768	26	0.899

No. = Number of Patients, SD = Standard Deviation

Table V: Oesophageal Temperature Changes In Different Age Groups (Mean±SD)

<15 years	No.	16-25 years	N.	26-40 years	N.	>40 years	No.	P value
36.92 ±0.531	12	36.92±0.525	16	36.85 ±0.654	10	37.15 ± 0.583	15	0.544
26.28 ±0.654	12	26.64 ±0.472	16	36.54 ±0.757	10	37.03 ± 0.570	15	0.02*
35.98 ±0.752	12	36.42 ±0.571	16	36.34 ±0.660	10	36.88 ± 0.585	15	0.007*
35.98 ±0.810	12	36.19 ±0.754	13	36.25 ±0.730	9	36.76 ± 0.610	13	0.061
35.59 ±0.951	9	36.31±0.33	9	36.15 ±0.826	9	36.68 ± 0.603	12	0.013*
35.57 ±0.884	9	36.35 ±0.105	6	36.05 ±0.923	8	36.64 ± 0.516	11	0.02*
35.00 ±0.797	5	36.23 ±0.098	4	35.45 ± 0.863	8	36.57 ± 0.566	11	0.002*
34.73 ±0.998	3	36.20 ±0.100	4	35.25 ±0.782	6	36.58 ± 0.529	9	0.0008
34.90 ±1.044	3	36.20 ±0.173	3	35.75 ±1.118	6	36.92 ± 0.327	5	0.03*
34.70 ±1.212	3	36.20 ±0.265	3	35376 ±0.311	5	37.05 ± 0.351	4	0.053
36.20	1	36.20 ± 0.424	2	36.88 ± 1.567	4	36.83 ± 0.321	3	0.752
36.10	1	36.25 ±0.495	2	35.77 ±2.050	3	36.73 ± 0.404	3	0.849
35.8	1	36.25 ± 0.636	2	35.55 ±2.758	2	36.83 ±0.404	3	0.791
35.7	1	35.0 ±1.273	2	35.5 ±2.828	2	_	0	0.959
-	0	35.8	1	37.5	1	_	0	_
35.72±0.879	12	36.21 ±0.436	16	36.600 ±1.106	10	36.52 ±0.642	15	0.060

* p < 0.05 (Difference between the age groups), NO.= Number Of Patients.

Table VI: Oesophageal Temperature Mean Changes In Different Neuromuscular Blockade Groups (Mean ± Standard Deviation)

Time Period (Minutes)	Halothane 2-3%		Halothane 0.5-1% with Pancuronium		Halothane 0.5-1% with Suxamethonium		P Value
	Mean ± SD	No.	Mean ± SD	No.	Mean ± SD	No.	
10 Baseline	36.82±0.548	21	37.30±0.646	16	36.83±0.340	16	0.02*
20	36.49±0.667	21	36.99±0.730	16	36.53±0.386	16	0.04*
30	36.24±0.674	21	36.81±0.758	16	36.32±0.536	16	0.03*
40	36.09±0.791	15	36.63±0.827	16	36.18±0.596	16	0.102
50	35.82±0.823	9	36.50±0.882	16	36.16±0.557	14	0.112
60	35.87±0.770	7	36.41±0.892	15	36.04±0.637	12	0.271
70	35.40±0.819	3	36.04±1.084	13	35.93±0.652	11	0.554
80	35.30±1.273	2	35.97±1.123	12	35.75±0.786	8	0.676
90	35..25±1.202	2	36.26±1.211	10	35.86±0.428	5	0.444

100	35.05±1.485	2	36.29±1.437	8	35.86±0.498	5	0.444
110	36.20	1	36.43±1.320	6	35.93±0.252	3	0.824
120	36.10	1	36.38±1.411	6	35.85±0.071	2	0.877
130	35.8	1	36.38±1.416	6	35.8	1	-
140	35.7	1	35.03±2.157	3	35.90	1	-
150	-	0	37.5	1	35.8	1	-
Recovery	36.25±0.584	21	36.15±1.145	16	36.01±0.613	16	0.665

* P <0.05 Difference Between the Pancuronium and other two Groups

No. = Number of Patients SD = Standard Deviation

Table VII: Oesophageal Temperature Mean Changes In Nonhypothermic And Hypothermic Groups (Mean ± Standard Deviation).

Time Period (Minutes)	Non-hypothermic Group		Hypothermic Group		P Value
	Mean ± SD	No.	Mean ± SD	No.	
10 Baseline	36.83 ± 0.488	28	37.12 ± 0.612	25	0.063
20	36.67 ± 0.598	28	36.63 ± 0.710	25	0.825
30	36.51 ± 0.574	28	36.36 ± 0.821	25	0.460
40	36.49 ± 0.556	24	36.11 ± 0.911	23	0.094
50	36.41 ± 0.531	19	36.05 ± 0.961	20	0.159
60	36.49 ± 0.542	16	35.88 ± 0.887	18	0.03*
70	36.15 ± 0.773	12	35.74 ± 0.963	15	0.243
80	36.14 ± 0.817	9	35.61 ± 1.072	13	0.221
90	36.57 ±0.673	7	35.64 ± 1.105	10	0.067
100	36.63 ± 0.731	6	35.55 ± 1.288	9	0.085
110	36.62 ± 0.736	6	35.73 ± 1.255	4	0.190
120	36.68 ± 0.817	5	35.68 ± 1.352	4	0.208
130	36.80 ± 0.770	4	35.68 ± 1.441	4	0.218
140	36.60 ± 1.273	2	34.50 ± 1.294	3	0.165
150	37.5	1	35.8	1	_
Recovery	26.42 ± 0.573	28	35.85 ± 0.901	25	0.008*

P<0.05. Difference between Non-Hypothermic And Hypothermic Groups At The Corresponding Time Periods. No. = Number of Patients, SD = Standard Deviation

Table VIII: Oesophageal Temperature Mean Changes In Nonshivering And Shivering Groups (Mean ± Standard Deviation).

Time Period (Minutes)	Non Shivering Group		Shivering Group		P Value
	Mean ± SD	No.	Mean ± SD	No.	
10 Baseline	37.04±0.553	33	36.86±0.578	20	0.261
20	36.83±0.609	33	36.35±0.608	20	0.008*
30	36.69±0.592	33	36.03±0.676	20	0.0005*
40	36.52±0.713	30	35.92±0.720	17	0.008*
50	36.49±0.603	25	35.74±0.877	14	0.003*
60	36.46±0.592	22	35.64±0.869	12	0.003*
70	36.18±0.750	18	35.41±0.973	9	0.03*
80	36.21±0.764	15	35.014±0.975	7	0.005*
90	36.50±0.728	11	35.15±0.989	6	0.006*
100	36.60±0.798	9	35.05±1.136	6	0.008*
110	36.72±0.655	6	35.58±1.164	4	0.08
120	36.70±0.733	5	35.55±1.277	4	0.11
130	36.76±0.673	5	35.37±1.595	3	0.126
140	36.70±1.131	2	34.43±1.137	3	0.117
150	36.65±1.201	2	_	0	_
Recovery	36.37±0.635	33	35.79±0.905	20	0.009*

P<0.05. Difference Between Nonshivering And Shivering Groups At The Corresponding Time Periods. No.=Number of Patients, SD = Standard Deviation