Examining the Impact of Body Mass Index on Temperature Regulation During General Anaesthesia: A Prospective Observational Study

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Abstract

Objective: To evaluate the impact of body mass index (BMI) on core body temperature during general anesthesia. **Methods:** A prospective observational study was conducted on 69 patients divided into three groups based on BMI: Group A (<24 kg/m²), Group B (25-34.9 kg/m²), and Group C (≥35 kg/m²). Participants undergoing elective surgeries under general anesthesia were monitored for core body temperature at baseline, 1st, 15th, 30th, and 60th minutes. Hemodynamic parameters were simultaneously recorded. **Results:** Significant temperature variations were observed across BMI groups. Group A demonstrated the most pronounced temperature drop, with a mean decrease of 1.7°C compared to 1.2°C in Group C. Statistically significant differences were noted in temperature regulation ($p<0.001$), with progressive temperature decline correlated with lower BMI. Systolic and diastolic blood pressures showed a parallel increase across BMI categories. **Conclusion:** The study reveals a strong correlation between BMI and temperature dysregulation during general anesthesia, emphasizing the need for personalized thermal management strategies.

Keywords: Body Mass Index, Anesthesia, General, Body Temperature, Perioperative Care, Obesity

Introduction

Temperature dysregulation during surgical procedures is a significant clinical challenge that can lead to various perioperative complications. Body mass index (BMI) has emerged as a potential critical factor influencing thermoregulatory responses during general anesthesia, yet the precise mechanisms and extent of its impact remain incompletely understood.

Inadvertent perioperative hypothermia is a common phenomenon affecting approximately 20-60% of surgical patients under general anesthesia [1]. The physiological mechanisms underlying temperature regulation are complex, involving interactions between core and peripheral thermoregulatory systems that can be substantially altered during surgical interventions and anesthetic management [2].

Obesity, characterized by elevated BMI, represents a growing global health concern with potential implications for perioperative physiology. Existing literature suggests that individuals with higher BMI may experience differential thermoregulatory responses compared to individuals with normative body compositions [3]. However, the precise mechanisms by which BMI influences temperature regulation during anesthesia remain insufficiently characterized.

Several physiological factors potentially contribute to temperature dysregulation in patients with varying BMI, including altered metabolic rates, differences in body heat distribution, and modifications in peripheral vasoconstriction and vasodilation mechanisms [4]. These variations can significantly impact core body temperature maintenance during surgical procedures, potentially increasing risks of adverse perioperative outcomes.

Previous studies have demonstrated that patients with lower BMI might exhibit increased susceptibility to temperature fluctuations, but the evidence remains heterogeneous and lacks comprehensive systematic investigation [5,6]. Our prospective observational study aims to address this knowledge gap by systematically examining the relationship between BMI and temperature regulation during general anesthesia.

The primary objective of our research is to evaluate to evaluate the impact of BMI on body core temperature under general anaesthesia.

By providing a comprehensive analysis of these interactions, our study seeks to enhance understanding of perioperative thermoregulation and potentially inform targeted clinical strategies for temperature management across diverse patient populations.

Methodology

Study Design and Setting

This was a prospective observational study conducted over a six-month period at R.L. Jalappa Hospital and Research Centre, Tamaka, Kolar. The study aimed to examine the impact of body mass index (BMI) on temperature regulation during general anesthesia.

Participants

A total of 69 patients were recruited for the study. Participants were selected based on specific inclusion and exclusion criteria. The inclusion criteria comprised:

- Patients aged 20-60 years
- Patients undergoing elective surgeries under general anesthesia
- American Society of Anaesthesiologists (ASA) physical status classification of 1 or 2

The exclusion criteria included:

- Patients with seizure disorders
- Patients with electrolyte abnormalities
- Patients with psychiatric disorders
- Patients with known metabolic disorders affecting temperature regulation
- Patients with conditions interfering with temperature measurement
- Unconscious or uncooperative patients
- Patients with allergies to anesthetic agents

Sampling Procedure

Patients were divided into three groups based on their Body Mass Index (BMI):

- Group A: BMI < 24 kg/m²
- Group B: BMI 25-34.9 kg/m²
- Group C: BMI ≥ 35 kg/m²

A detailed patient history was obtained, and a comprehensive physical examination was conducted. Routine investigations were performed, and an intravenous line was secured.

Anesthesia Protocol

Prior to surgery, informed consent was obtained from all participants. The anesthesia induction followed a standardized protocol:

1. Premedication consisted of:
    - Intravenous midazolam (0.05 mg/kg)
    - Glycopyrrolate (0.005–0.01 mg/kg)
    - Fentanyl (2–3 µg/kg)
2. Induction was performed with intravenous propofol (1–2.5 mg/kg)
3. Muscle relaxation was achieved using vecuronium (0.1 mg/kg)
4. Tracheal intubation was performed
5. Anesthesia was maintained using isoflurane in oxygen-enriched air

Monitoring and Data Collection

Hemodynamic parameters were meticulously monitored and recorded:

- Blood pressure (systolic, diastolic, and mean arterial)
- Heart rate
- Body temperature

Measurements were taken at the following time points:

- Baseline
- 1st minute
- 15th minute
- 30th minute
- 60th minute

All measurements were recorded using a standardized proforma to ensure consistency and accuracy.

Statistical Analysis

Statistical analysis was performed using SPSS version 23.0. The analysis included:

- Descriptive statistics (frequency, percentage, mean, and standard deviation)
- Repeated measures ANOVA for comparing numerical variables at different time points
- One-way ANOVA for between-group comparisons

A p-value < 0.05 was considered statistically significant.

Sample Size Calculation

The sample size was determined using the standard deviation of temperature from a previous study by Philipp Groene et al.[7] The calculation considered:

- Power: 80%
- Level of significance: 5%
- Pooled standard deviation of temperature: 0.47
- Expected mean difference: 0.4

The estimated sample size was 22 in each group, with an additional 5% allowance for potential attrition, resulting in 23 participants per group.

Ethical Considerations

The study was conducted after obtaining appropriate institutional ethical approval. Informed consent was obtained from all participants, ensuring their voluntary participation and understanding of the study procedures.

Results

The demographic analysis revealed significant differences across the three BMI groups. The mean age progressively increased with BMI groups, with Group C (BMI ≥ 35) showing the highest mean age of 45.1 years. While gender distribution was relatively balanced, there were statistically significant differences in age and surgery duration across groups.

Table 1: Demographic and Baseline Characteristics of Study Participants

Characteristic	Group A (BMI < 24)	Group B (BMI 25-34.9)	Group C (BMI ≥ 35)	P Value
Number of Participants	23	23	23	-
Age (years), Mean ± SD	38.5 ± 6.2	42.3 ± 7.1	45.1 ± 6.8	0.023
Gender (Male/Female)	12/11	14/9	10/13	0.456
Average BMI, kg/m²	21.6 ± 1.5	29.7 ± 2.8	38.2 ± 3.5	<0.001
ASA Classification (1/2)	15/8	13/10	12/11	0.678
Surgery Duration (min)	85 ± 25	92 ± 30	105 ± 35	0.041

*Statistically significant differences

The most critical finding of our study was the progressive reduction in core body temperature across different BMI groups. At baseline, there were no significant temperature differences. However, as anesthesia progressed, a clear pattern emerged:

1. Group A (BMI < 24) exhibited the most significant temperature dysregulation.
2. Group B (BMI 25-34.9) demonstrated moderate temperature variations.
3. Group C (BMI ≥ 35) showed the most stable temperature profile with the least temperature drop.

The total temperature drop was most pronounced in Group A, with a mean decrease of 1.7°C, compared to 1.2°C in Group C. This suggests that higher BMI is associated with greater heat loss during general anesthesia.

Table 2: Core Body Temperature Variations across Different Time Points

Time Point	Group A (BMI < 24)	Group B (BMI 25-34.9)	Group C (BMI ≥ 35)	P Value
Baseline	36.5 ± 0.3	36.6 ± 0.4	36.7 ± 0.3	0.342
1st Minute	35.8 ± 0.4	36.0 ± 0.5	36.2 ± 0.4	**0.047***
15th Minute	35.3 ± 0.5	35.6 ± 0.4	35.9 ± 0.3	**0.012***
30th Minute	35.0 ± 0.4	35.4 ± 0.3	35.7 ± 0.4	**0.003***
60th Minute	34.8 ± 0.5	35.2 ± 0.4	35.5 ± 0.3	**0.001***
Total Temperature Drop	1.7 ± 0.5	1.4 ± 0.4	1.2 ± 0.3	**<0.001***

*Statistically significant differences

Hemodynamic parameters showed interesting correlations with BMI:

1. Systolic and diastolic blood pressures progressively increased with BMI groups.
2. Heart rate showed a slight increase across groups, though not statistically significant.

These findings indicate that BMI not only impacts temperature regulation but also influences cardiovascular responses during anesthesia.

Table 3: Hemodynamic Parameters across BMI Groups

Parameter	Group A (BMI < 24)	Group B (BMI 25-34.9)	Group C (BMI ≥ 35)	P Value
Mean Systolic BP (mmHg)	125 ± 10	132 ± 12	140 ± 15	0.018*
Mean Diastolic BP (mmHg)	78 ± 6	82 ± 7	86 ± 8	**0.045***
Mean Heart Rate (bpm)	72 ± 8	75 ± 10	78 ± 12	0.156

*Statistically significant differences

Discussion

General anesthesia significantly disrupts the body's thermoregulatory mechanisms, typically inducing hypothermia through a predictable progression. During the initial hour of anesthesia, core body temperature experiences a rapid decline of approximately 1-1.5°C. Subsequently, the temperature reduction transitions to a more gradual, linear descent before ultimately stabilizing at a plateau phase where core temperature remains relatively constant.[8]

Our prospective observational study provides compelling evidence of the significant impact of body mass index (BMI) on temperature regulation during general anesthesia. The findings reveal a complex interplay between body composition and thermoregulatory responses that warrant detailed examination and comparison with existing literature.

Temperature Dysregulation across BMI Groups

Our results demonstrate a progressive decline in core body temperature correlated with lower BMI, a phenomenon partially substantiated by previous research. Sessler et al. [2] similarly observed that patients with lower BMI experience more pronounced temperature variations during surgical procedures. Our study extends these observations by quantifying the temperature drop across different BMI categories, revealing a statistically significant difference of up to 0.9°C between low and high BMI groups.

A landmark study by Kurz and colleagues, involving 40 patients undergoing elective colon surgeries, investigated the relationship between body composition and temperature regulation. By categorizing patients based on body fat percentages and surface areas, they discovered an inverse correlation between body fat distribution and temperature decrease during surgical procedures. Specifically, individuals with higher body fat percentages and larger body surface areas demonstrated less pronounced temperature variations.[9]

Research consistently highlights the critical importance of proactive thermal management during surgical interventions. Studies have conclusively demonstrated that without implementing strategic interventions such as prewarming techniques, active temperature monitoring, and continuous core temperature control, patients are at substantially higher risk of developing perioperative hypothermia.[10-12] Adipose tissue's insulating properties might paradoxically contribute to impaired heat distribution during anesthesia. Our findings support this hypothesis, with Group C (BMI ≥ 35) demonstrating the most significant temperature dysregulation. The progressive temperature decline suggests that excess adipose tissue may interrupt normal thermoregulatory mechanisms, potentially compromising patient thermal homeostasis.

Hemodynamic Correlations

The observed increase in systolic and diastolic blood pressures across BMI groups aligns with research by Bernabe-Ortiz A et.al. [13], who documented similar cardiovascular responses in patients with higher body mass. The progressive elevation in blood pressure suggests that BMI not only affects temperature regulation but also influences cardiovascular parameters during anesthetic management.

Physiological Mechanisms

Our findings support the complex thermoregulatory mechanisms proposed by Matsukawa et al. [3], who highlighted the intricate interactions between core and peripheral temperature regulation. The study suggests that lower BMI might impair the body's ability to maintain thermal equilibrium, potentially due to:

1. Altered metabolic rates
2. Reduced peripheral vasoconstriction efficiency
3. Compromised heat distribution mechanisms

Clinical Implications

The results underscore the critical importance of:

- Implementing more aggressive temperature monitoring for low-BMI patients
- Developing specialized thermal management protocols
- Considering BMI-specific anesthetic approaches

Limitations and Future Research

While our study provides valuable insights, several limitations must be acknowledged:

- Relatively small sample size
- Single-center study design
- Potential uncontrolled confounding variables

Future research should focus on:

- Multicenter studies with larger sample sizes
- Exploring precise physiological mechanisms
- Developing targeted thermal management interventions

Practical Recommendations

Based on our findings, we recommend:

1. Enhanced thermal monitoring for patients with BMI< 24
2. Proactive warming interventions during surgical procedures
3. Individualized anesthetic protocols considering BMI variations

Conclusion

Our prospective observational study demonstrates a significant correlation between body mass index (BMI) and temperature regulation during general anesthesia. The findings reveal that patients with lower BMI experience more pronounced core temperature variations. These results underscore the critical importance of personalized thermal management strategies, highlighting the need for enhanced monitoring and targeted interventions for patients across different BMI categories during surgical procedures.

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