

# Risk Factors for Hypothermia After General Anesthesia in Abdominal Surgery: A Three-Year Retrospective Analysis

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**Introduction:** Postoperative hypothermia is a common complication following abdominal surgery under general anesthesia. It is associated with delayed recovery, increased postoperative complications, and prolonged hospitalization. However, comprehensive research on its risk factors remains limited. This study aimed to identify key perioperative factors associated with postoperative hypothermia to guide prevention strategies.

**Methods:** This retrospective cohort study included 256 patients who underwent abdominal surgery under general anesthesia. Patients were categorized into a hypothermia group (core temperature < 36°C, n = 66) and a normothermia group (n = 190) based on postoperative core temperature measured upon PACU admission. Demographic data, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, anesthesia details, surgical duration, ventilation time, warming measures, baseline temperature, blood loss, and postoperative surgical site infection were collected. The hypothermia group was further divided into mild ( $\leq 2$  episodes) and severe ( $> 2$  episodes) subgroups based on hypothermia frequency within 24 hours postoperatively. Univariate and multivariate logistic regression analyses were performed to identify independent risk factors.

**Results:** Age, BMI, duration of anesthesia and surgery, absence of prewarming, blood loss, transfusion, and surgical site infection were significantly associated with postoperative hypothermia in univariate analysis. Multivariate analysis confirmed that BMI, lack of prewarming, and blood loss were independent predictors of postoperative hypothermia.

**Conclusion:** Postoperative hypothermia after abdominal surgery is influenced by multiple perioperative factors. Strategies targeting modifiable risk factors-particularly prewarming, temperature monitoring, and optimization of intraoperative blood loss-may reduce hypothermia incidence and support improved postoperative recovery.

**Keywords:** abdominal surgery, anesthesia, general, hypothermia, risk factors, retrospective studies

## Introduction

Postoperative hypothermia, defined as a core body temperature below 36°C,<sup>1</sup> is a frequent complication following abdominal surgery under general anesthesia. It is associated with a range of adverse effects, including increased risk of surgical site infection,<sup>2-4</sup> prolonged metabolism of anesthetic drugs,<sup>5</sup> extended recovery time,<sup>6,7</sup> elevated risk of cardiovascular events,<sup>8</sup> hypoxia,<sup>9,10</sup> and shivering.<sup>11</sup> Hypothermia may also lead to prolonged stays in the post-anesthesia care unit (PACU) or intensive care unit (ICU), and is correlated with higher morbidity and mortality.<sup>12,13</sup> Therefore, identifying risk factors for postoperative hypothermia is of significant preventive importance.

Postoperative hypothermia remains a significant concern in adult abdominal surgeries. Patients undergoing such procedures are particularly susceptible to hypothermia, which may be attributed to prolonged surgical duration, extensive visceral exposure, substantial intraoperative fluid infusion, and blood loss.<sup>14</sup> General anesthesia further exacerbates this risk by impairing hypothalamic thermoregulation, reducing heat generation, and promoting heat loss. Although preventive measures such as intraoperative warming<sup>15</sup> and the use of thermal blankets are routinely employed, interindividual variability means some patients remain vulnerable. According to related studies, advanced age,<sup>16</sup> low body mass

index (BMI),<sup>17</sup> lack of prewarming,<sup>18</sup> and significant blood loss<sup>14</sup> are important risk factors for postoperative hypothermia.

However, despite these previous findings, evidence focusing specifically on abdominal surgery under general anesthesia remains limited. Existing studies often examine individual factors in isolation and rarely integrate patient characteristics, intraoperative variables, and perioperative warming strategies into a comprehensive risk-factor model. As a result, the overall contribution and interaction of these factors in postoperative hypothermia are still not fully understood.

This study aims to explore the potential risk factors for postoperative hypothermia following general anesthesia in abdominal surgery through a retrospective analysis, and to evaluate their impact on patient outcomes. By elucidating these influencing factors, we hope to contribute to the development of more effective interventions that may reduce the incidence of postoperative hypothermia, enhance recovery, and improve the quality of life for patients.

## Materials and Methods

This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Institutional Review Board and Ethics Committee of the Second Affiliated Hospital of Anhui Medical University (Approval No. USC-202128). Written informed consent was obtained from all participants or their next of kin if patients were unable to provide consent due to medical or cognitive reasons.

This study was designed as a retrospective cohort study. The study was conducted from 1 February 2021 to 1 February 2024 in the operating theaters of the Second Affiliated Hospital of Anhui Medical University. We included patients scheduled for elective major abdominal surgery classified as American Society of Anesthesiologists (ASA) physical status I–III.

## Research Subjects

A total of 256 patients who underwent abdominal surgery under general anesthesia at our hospital between February 2021 and February 2024 were selected. Based on postoperative core temperature, the patients were divided into two groups: a hypothermia group ( $< 36^{\circ}\text{C}$ ,  $n = 66$ ) and a normothermia group ( $n = 190$ ). A retrospective analysis was conducted on the clinical data of both groups. The hypothermia group was further categorized into mild ( $\leq 2$  episodes) and severe ( $> 2$  episodes) groups based on the number of hypothermic events within 24 hours post-surgery. Univariate and multivariate analyses were carried out to identify factors associated with hypothermia.

Inclusion criteria: ① General anesthesia via endotracheal intubation or laryngeal mask airway; ② ASA class I to III; ③ Age between 18 and 85 years; ④ No recent use of dopaminergic drugs.

Exclusion criteria: ① Presence of preoperative hypothermia or fever; ② History of thermoregulatory disorders; ③ Surgery performed under intentional hypothermia; ④ Incomplete temperature records; ⑤ Emergency surgeries.

## Methods

All patient data were retrieved from the hospital's electronic medical record (EMR) system. Patients were categorized into the hypothermia group (postoperative core temperature  $< 36^{\circ}\text{C}$ ,  $n = 66$ ) and the normothermia group ( $n = 190$ ) based on the occurrence of postoperative hypothermia. Postoperative core temperature was measured using a sublingual digital thermometer, which is routinely employed in our institution. Measurements were taken immediately upon admission to the Post-Anesthesia Care Unit (PACU) to ensure consistency across patients. All temperature readings were obtained by trained PACU nurses following standardized institutional protocols. Prewarming was defined as the application of a forced-air warming device for 30 minutes in the preoperative holding area before induction of anesthesia. Univariate and multivariate analyses were conducted to explore the associations between clinical data and postoperative hypothermia in these two groups. Additionally, within the hypothermia group, patients were further divided into mild ( $\leq 2$  episodes) and severe ( $> 2$  episodes) subgroups based on the number of hypothermic episodes occurring within the first 24 hours after surgery. The clinical data of these subgroups were analyzed to assess their associations with postoperative hypothermia.

## Statistical Analysis

Statistical analysis was performed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA). Normally distributed continuous data were expressed as mean  $\pm$  standard deviation and compared using the *t*-test. Non-normally distributed continuous data were presented as median (minimum, maximum) and compared with the Mann–Whitney *U*-test. Categorical data were expressed as n (%), with comparisons performed using the chi-square ( $\chi^2$ ) test, and correlations were assessed with Spearman's rank correlation coefficient. For the multivariate logistic regression analysis, variables with a *P* value  $< 0.05$  in univariate analysis were eligible for inclusion. All selected variables were entered simultaneously using the Enter method in SPSS to construct the final model. *P*  $< 0.05$  was considered statistically significant.

## Results

### Analysis of General Data

Demographic and clinical characteristics of the included patients are summarized in Table 1.

### Factors Associated with Postoperative Hypothermia

Age, BMI, duration of anesthesia and surgery, absence of prewarming, blood loss, transfusion, and surgical site infection were significantly associated with the occurrence of postoperative hypothermia in abdominal surgery under general anesthesia (*P*  $< 0.05$ ). There were no significant differences in baseline body temperature or intraoperative fluid volume between the two groups (*P*  $> 0.05$ ). See Table 2.

Multivariate logistic regression analysis indicated that lack of prewarming and blood loss were significant risk factors for postoperative hypothermia in abdominal surgery under general anesthesia (*P*  $< 0.05$ ). Notably, the confidence interval for “Blood Loss” was relatively wide, suggesting limited stability of this variable in the multivariate model. This may reflect heterogeneity in intraoperative bleeding or insufficient event numbers for this predictor. See Table 3.

**Table 1** Analysis of General Data

Indicator	Patients (n = 256)
Gender (Male/Female)	159/97
Age (Years)	54.02 $\pm$ 11.51
BMI ( $kg/m^2$ )	22.62 $\pm$ 1.93
Hypothermia Occurrence (Yes/No)	66/190
Recurrent Hypothermia (Yes/No)	18/48

**Abbreviation:** BMI, body mass index.

**Table 2** Univariate Analysis of Factors Affecting Postoperative Hypothermia in Abdominal Surgery Under General Anesthesia

Factor	Normothermia Group	Hypothermia Group	<i>t</i> / $\chi^2$ / <i>z</i>	<i>P</i>
Age (Years)	54 (18, 73)	62.50 (29, 73)	4.34	$< 0.001$
BMI ( $kg/m^2$ )	22.5 (17.8, 26.8)	21.3 (16.5, 26.2)	4.19	$< 0.001$
ASA Classification	1 (1, 3)	1 (1, 3)	1.36	0.17
Anesthesia Type	General Anesthesia	34	2.28	0.13
	General + Nerve Block	72		
Anaesthetic Duration (h)	4.05 $\pm$ 1.27	4.55 $\pm$ 1.28	2.75	0.01
Surgical Duration (h)	2.65 $\pm$ 1.03	3.50 $\pm$ 1.24	5.45	$< 0.001$

(Continued)

**Table 2** (Continued).

Factor		Normothermia Group	Hypothermia Group	$t/x^2/z$	P
Patient Position	Supine	72	18	3.03	0.22
	Prone	49	23		
	Lateral	69	25		
Prewarming	Yes	116	24	12.05	0.01
	No	74	42		
Baseline Temperature (°C)		36.5 (36.1, 37)	36.6 (36.1, 37)	0.67	0.51
Blood Loss (mL)		90 (50, 610)	425 (130, 810)	10.38	< 0.001
Transfusion Status	Yes	21	37	45.08	< 0.001
	No	169	29		
Surgical Site Infection	Yes	6	7	5.64	0.02
	No	184	59		
Fluid Volume (L)		2.0 (1.1, 2.8)	2.0 (1.1, 2.8)	0.30	0.76

**Abbreviations:** BMI, body mass index; ASA, American Society of Anesthesiologists.

**Table 3** Multivariate Logistic Regression Analysis of Risk Factors for Postoperative Hypothermia in Abdominal Surgery Under General Anesthesia

Factor	$\beta$	SE	Wald $\chi^2$ Value	P	OR
Age (Years)	0.28	0.49	0.32	0.57	1.32 (0.51–3.42)
BMI ( $kg/m^2$ )	0.12	0.48	0.05	0.82	0.90 (0.35–2.30)
Anaesthetic Duration (h)	1.09	0.76	2.03	0.15	2.96 (0.67–13.19)
Surgical Duration (h)	1.34	0.85	2.48	0.12	3.82 (0.72–20.26)
Prewarming	1.96	0.62	9.98	0.01	0.14 (0.04–0.47)
Blood Loss (mL)	5.53	0.81	46.51	< 0.001	252.10 (51.45–1235.20)
Transfusion Status	0.66	0.55	1.45	0.23	0.52 (0.18–1.52)
Infection	0.66	0.92	0.52	0.47	1.94 (0.32–11.77)

**Abbreviations:** BMI, body mass index; SE, standard error; OR, odds ratio.

## Factors Associated with Recurrent Hypothermia (Mild vs Severe)

Age, BMI, prewarming, blood loss, transfusion, and surgical site infection were significantly associated with postoperative recurrent hypothermia in patients undergoing abdominal surgery under general anesthesia ( $P < 0.05$ ). See Table 4.

Multivariate logistic analysis indicated that lack of prewarming and surgical site infection were significant risk factors for postoperative recurrent hypothermia in patients undergoing abdominal surgery under general anesthesia ( $P < 0.05$ ). See Table 5.

**Table 4** Univariate Analysis of Factors Affecting Postoperative Recurrent Hypothermia in Patients Undergoing Abdominal Surgery Under General Anesthesia

Factor	Mild Group	Severe Group	t	P
Age (Years)	57.38 ± 8.75	68.94 ± 3.32	5.44	< 0.001
BMI ( $kg/m^2$ )	23.35 ± 1.77	21.96 ± 1.69	2.88	0.01
ASA Classification	1 (1, 3)	1 (1, 3)	0.03	0.98

(Continued)

**Table 4** (Continued).

Factor		Mild Group	Severe Group	t	P
Anesthesia Type	General Anesthesia	25	8	0.02	0.89
	General + Nerve Block	23	8		
Anaesthetic Duration (h)		4.47 ± 1.29	4.76 ± 1.25	0.80	0.43
Surgical Duration (h)		3.42 ± 1.26	3.70 ± 1.21	0.80	0.43
Patient Position	Supine	11	7	1.72	0.42
	Prone	18	5		
	Lateral	19	6		
Prewarming	Yes	11	13	13.75	< 0.001
	No	37	5		
Baseline Temperature (°C)		36.56 ± 0.26	36.55 ± 0.24	0.09	0.93
Blood Loss (mL)		382.29 ± 175.24	588.33 ± 172.77	4.27	< 0.001
Transfusion Status	Yes	21	14	6.09	0.01
	No	27	4		
Surgical Site Infection	Yes	1	6	13.48	< 0.001
	No	47	12		
Fluid Volume (L)		1.92 ± 0.48	2.02 ± 0.55	0.76	0.45

**Abbreviations:** BMI, body mass index; ASA, American Society of Anesthesiologists.

**Table 5** Multivariate Logistic Analysis of Risk Factors for Postoperative Recurrent Hypothermia in Patients Undergoing Abdominal Surgery Under General Anesthesia

Factor	$\beta$	SE	Wald $\chi^2$ Value	P	OR
Age (Years)	1.79	0.91	3.90	0.48	5.97 (1.01–35.15)
BMI ( $kg/m^2$ )	0.89	0.83	1.14	0.29	2.43 (0.48–12.35)
Prewarming	2.75	0.90	9.43	<0.01	15.69 (2.71–90.99)
Blood Loss (mL)	1.78	1.80	0.97	0.32	0.17 (0.01–5.78)
Transfusion Status	3.58	1.87	3.65	0.06	35.81 (0.91–1405.21)
Surgical Site Infection	3.54	1.59	4.92	0.03	34.28 (1.51–778.29)

**Abbreviations:** BMI, body mass index; SE, standard error; OR, odds ratio.

## Discussion

This retrospective study aimed to explore the risk factors associated with postoperative hypothermia in patients undergoing abdominal surgery under general anesthesia and to assess their impact on patient outcomes. Postoperative hypothermia is a common complication with a multifactorial etiology and often leads to multiple adverse effects, such as coagulopathy, increased transfusion requirements, surgical site infections, delayed drug metabolism, prolonged recovery, shivering, and patient discomfort.<sup>5</sup> Through univariate and multivariate analyses, we identified several independent risk factors for postoperative hypothermia, including advanced age, low BMI, prolonged duration of anesthesia and surgery, absence of prewarming, and significant intraoperative blood loss. The following discusses these risk factors in detail.

### Age and Postoperative Hypothermia

Advanced age was a significant predictor of postoperative hypothermia, with patients aged 60 years and older being particularly susceptible. This increased risk is largely attributable to age-related declines in physiological function,

including a reduced basal metabolic rate,<sup>19</sup> diminished heat conservation capacity, and impaired thermoregulatory responses. Older patients also exhibit reduced cutaneous blood flow, which exacerbates heat loss. Moreover, the presence of multiple comorbidities can compromise metabolic reserve and stress adaptability, further increasing vulnerability to postoperative hypothermia.<sup>20</sup> Cardiovascular impairment in older adults may also diminish the ability to respond to thermal challenges, complicating perioperative temperature management.<sup>21,22</sup> Therefore, enhanced preoperative assessment and targeted monitoring are essential for this population.

## BMI and Postoperative Hypothermia

Low BMI was also significantly associated with hypothermia. This finding is consistent with previous research by Groene et al<sup>17</sup> indicating that patients with a lower BMI experience more pronounced temperature declines during abdominal surgery, whereas Özer et al<sup>23</sup> noted that obesity was an important protective factor for core temperature. Reduced adipose tissue limits insulation and facilitates heat loss, increasing the susceptibility to hypothermia postoperatively.<sup>24</sup> Additionally, although individuals with a low BMI typically have a higher basal metabolic rate to maintain a stable body temperature, they often lack sufficient metabolic reserve to compensate for heat loss during prolonged exposure, especially in the absence of active intraoperative warming measures.

## Duration of Anesthesia and Surgery

Prolonged duration of anesthesia and surgery were identified as additional risk factors. Chen et al<sup>25</sup> similarly reported that inadvertent hypothermia during laparoscopic surgery was significantly correlated with the duration of surgery. Prolonged anesthesia can suppress the body's thermoregulatory centers and reduce heat production, increasing the likelihood of hypothermia during surgery. Anesthetic agents' effects on the central nervous system can also interfere with thermoregulation, leading to decreased body temperature.<sup>26</sup> Furthermore, longer surgical procedures typically involve greater visceral exposure, which increases heat loss and may cause a continuous decline in core temperature due to substantial fluid use and the open surgical environment.<sup>27</sup> Thus, streamlining surgical and anaesthetic management and minimizing unnecessary delays may effectively lower the incidence of hypothermia.

## Prewarming and Intraoperative Warming

Prewarming and intraoperative warming measures were strongly protective against postoperative hypothermia. Prewarming helps establish adequate thermal reserve, thereby reducing core temperature decline during surgery.<sup>28,29</sup> Intraoperative warming devices, such as forced-air blankets<sup>30</sup> and fluid warmers, are essential for maintaining core temperature and decreasing the incidence of hypothermia. These measures can not only improve patient comfort, but also reduce postoperative complications and enhance overall recovery. Therefore, integrating a multimodal warming strategy across the perioperative period can significantly improve thermal stability and enhance recovery.

## Blood Loss and Transfusion

Significant intraoperative blood loss was another independent factor affecting postoperative hypothermia. Research indicates that major blood loss can lead to hypovolemia and substantial heat dissipation, resulting in hypothermia.<sup>31</sup> Blood loss not only diminishes the blood's oxygen-carrying capacity but also causes rapid temperature decline, especially if warm fluids are not promptly administered during the surgery. Additionally, transfusion of cold blood or intravenous fluids can precipitate rapid core temperature reduction, exacerbating hypothermia.<sup>32</sup> Consequently, minimizing unnecessary blood loss during surgery and administering warm blood and fluids when necessary are essential for maintaining blood volume and temperature. Moreover, effective control of intraoperative bleeding through hemostatic agents and meticulous surgical techniques is crucial for reducing the incidence of hypothermia.

## Hemodynamic Management and Anaesthetic Blood Pressure Targets

Beyond blood loss and transfusion, intraoperative hemodynamic management is also closely linked to thermal homeostasis. Marked hypotension can impair tissue perfusion and oxygen delivery, and may exacerbate the adverse physiological effects of hypothermia, particularly in elderly and high-risk patients. Recent work on bone cement implantation

syndrome has highlighted how abrupt hemodynamic instability during orthopedic procedures can precipitate severe hypoxia, hypotension, and even cardiovascular collapse, underscoring the importance of proactive blood pressure management throughout anesthesia.<sup>33</sup> In the context of major abdominal surgery, maintaining adequate arterial pressure, optimizing circulating volume, and avoiding excessive hypotension may help reduce intraoperative blood loss, limit the need for transfusion of cold fluids, and thereby indirectly mitigate the risk of postoperative hypothermia. Integrating temperature management with individualized blood pressure targets could therefore represent a key component of comprehensive perioperative care.

## Surgical Site Infection and Recurrent Hypothermia

Finally, surgical site infection was associated with recurrent hypothermia, possibly due to dysregulated inflammatory responses involving a large number of cytokines, such as interleukin-1 (IL-1), interleukin-6 (IL-6), and tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ).<sup>34</sup> While these cytokines often lead to fever in the early stages of infection, in cases of severe infection, the immune system may become compromised, potentially resulting in recurrent hypothermia. Additionally, severe infection may cause metabolic disturbances, and persistent infection can lead to inadequate energy supply, resulting in an imbalance in thermoregulation and subsequent recurrent hypothermia. Moreover, infection may trigger systemic inflammatory response syndrome (SIRS), which can lead to microcirculatory dysfunction and inadequate tissue perfusion. In such cases, the body may reduce its temperature to decrease energy expenditure and oxygen demand, manifesting as recurrent hypothermia.

## Interpretation of Differences Between Univariate and Multivariate Results

Several variables, such as age, showed significance in the univariate analysis but did not remain independent predictors in the multivariate logistic regression model. This discrepancy is expected, as univariate analysis evaluates each variable in isolation, without accounting for interactions or confounding influences. Once factors such as BMI, blood loss, and prewarming were simultaneously included in the multivariate model, the independent contribution of age diminished, suggesting that its apparent association with hypothermia may be partially mediated or overshadowed by these perioperative factors.

These findings highlight the importance of interpreting univariate results with caution, as they may overestimate associations that do not persist when clinically relevant confounders are controlled. Clinically, this means that while older patients may appear more susceptible to hypothermia, age alone is not a sufficient predictor after accounting for modifiable perioperative variables. Therefore, targeted interventions should prioritize factors shown to be independently significant—such as blood loss and prewarming—rather than relying on demographic characteristics alone.

## Limitations

Several limitations of this study should be acknowledged. First, the analysis was conducted as a single-center retrospective cohort study based on electronic medical record data, which may have introduced selection bias and limits the generalizability of the findings to other institutions and surgical settings. Second, core temperature was assessed at a specific postoperative time point rather than continuously, so we were unable to capture the full intraoperative temperature trajectory or the total “hypothermia burden” over time. Third, although we adjusted for multiple perioperative variables, residual confounding from unmeasured factors—such as ambient operating room temperature, detailed characteristics of warming devices, and anesthetic drug dosing—cannot be excluded. Finally, the number of patients with recurrent hypothermia was relatively small, which may have contributed to wide confidence intervals for some predictors in the multivariate models. These limitations should be taken into account when interpreting our results, and they highlight the need for larger prospective multicenter studies with more granular perioperative temperature monitoring.

## Conclusion

Postoperative hypothermia after abdominal surgery under general anesthesia is driven by multiple perioperative factors, including patient characteristics, surgical duration, blood loss, and inadequate warming. Recognizing these risk factors

and optimizing perioperative temperature management may help reduce hypothermia and improve recovery. Further prospective studies are needed to validate these findings.

## Ethics Statement

This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Institutional Review Board and Ethics Committee of the Second Affiliated Hospital of Anhui Medical University (Approval No. USC-202128). Written informed consent was obtained from all participants or their next of kin if patients were unable to provide consent due to medical or cognitive reasons.

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## Disclosure

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## References

1. Rauch S, Miller C, Brauer A, Wallner B, Bock M, Paal P. Perioperative hypothermia-A narrative review. *Int J Environ Res Public Health*. 2021;18(16):8749. doi:10.3390/ijerph18168749
2. Simegn GD, Bayable SD, Fetene MB. Prevention and management of perioperative hypothermia in adult elective surgical patients: a systematic review. *Ann Med Surg Lond*. 2021;72:103059. doi:10.1016/j.amsu.2021.103059
3. Siddiqui T, Pal KMI, Shaikat F, et al. Association between perioperative hypothermia and surgical site infection after elective abdominal surgery: a prospective cohort study. *Cureus*. 2020;12(10):e11145. doi:10.7759/cureus.11145
4. Ribeiro JC, Bellusse GC, Martins de Freitas IC, Galvao CM. Effect of perioperative hypothermia on surgical site infection in abdominal surgery: a prospective cohort study. *Int J Nurs Pract*. 2021;27(4):e12934. doi:10.1111/ijn.12934
5. Sessler DI. Perioperative thermoregulation and heat balance. *Lancet*. 2016;387(10038):2655–2664. doi:10.1016/S0140-6736(15)00981-2
6. Garceau C, Cosgrove MS, Gonzalez K. Inadvertent perioperative hypothermia. *AANA J*. 2023;91(4):303–309.
7. Wang L, Chen B, Liu T, Luo T, Kang W, Liu W. Risk factors for delayed neurocognitive recovery in elderly patients undergoing thoracic surgery. *BMC Anesthesiol*. 2023;23(1):102. doi:10.1186/s12871-023-02056-6
8. Soar J, Becker LB, Berg KM, et al. Cardiopulmonary resuscitation in special circumstances. *Lancet*. 2021;398(10307):1257–1268. doi:10.1016/S0140-6736(21)01257-5
9. Bang YJ, Park IH, Jeong H. Frequency and risk factors for failed weaning from supplemental oxygen therapy after general anesthesia at a postanesthesia care unit: a retrospective cohort study. *BMC Anesthesiol*. 2023;23(1):231. doi:10.1186/s12871-023-02192-z
10. Haller K, Trauzeddel RF, Treskatsch S, Berger C. Risk factors for postoperative hypoxemia during transport to the postanesthesia care unit and influence of transport monitoring: a retrospective propensity score-matched databank analysis. *Anaesthesiologie*. 2023;72(7):488–497. doi:10.1007/s00101-023-01296-y
11. Dinges HC, Al-Dahna T, Rucker G, et al. Pharmacologic interventions for the therapy of postanesthetic shivering in adults: a systematic review and network meta-analysis. *Minerva Anesthesiol*. 2023;89(10):923–935. doi:10.23736/S0375-9393.23.17410-4
12. Wang YC, Huang HH, Lin PC, Wang MJ, Huang CH. Hypothermia is an independent risk factor for prolonged ICU stay in coronary artery bypass surgery: an observational study. *Sci Rep*. 2023;13(1):4626. doi:10.1038/s41598-023-31889-x
13. Du W, Yang J, Lou Y, You J. Hypothermia on the first day of ICU admission leads to increased in-hospital mortality in patients with subarachnoid hemorrhage. *Sci Rep*. 2024;14(1):9730. doi:10.1038/s41598-024-60657-8
14. Sun L, Gao Q, Wang G, et al. Risk factors for hypothermia in patients undergoing general anesthesia in the postanesthesia care unit. *Zhonghua Yi Xue Za Zhi*. 2021;101(1):52–56. doi:10.3760/cma.j.cn112137-20201013-02828
15. Lee Y, Kim K. Optimal application of forced air warming to prevent peri-operative hypothermia during abdominal surgery: a systematic review and meta-analysis. *Int J Environ Res Public Health*. 2021;18(5):2517. doi:10.3390/ijerph18052517
16. Sagioglu G, Ozturk GA, Baysal A, Turan FN. Inadvertent perioperative hypothermia and important risk factors during major abdominal surgeries. *J Coll Physicians Surg Pak*. 2020;30(2):123–128. doi:10.29271/jcpsp.2020.02.123
17. Groene P, Zeuzem C, Baasner S, Hofmann-Kiefer K. The influence of body mass index on temperature management during general anaesthesia-A prospective observational study. *J Eval Clin Pract*. 2019;25(2):340–345. doi:10.1111/jep.13064
18. Horn EP, Bein B, Broch O, et al. Warming before and after epidural block before general anaesthesia for major abdominal surgery prevents perioperative hypothermia: a randomised controlled trial. *Eur J Anaesthesiol*. 2016;33(5):334–340. doi:10.1097/EJA.0000000000000369
19. Pontzer H, Yamada Y, Sagayama H, et al. Daily energy expenditure through the human life course. *Science*. 2021;373(6556):808–812. doi:10.1126/science.abe5017
20. Cramer MN, Gagnon D, Laitano O, Crandall CG. Human temperature regulation under heat stress in health, disease, and injury. *Physiol Rev*. 2022;102(4):1907–1989. doi:10.1152/physrev.00047.2021
21. Millyard A, Layden JD, Pyne DB, Edwards AM, Bloxham SR. Impairments to thermoregulation in the elderly during heat exposure events. *Gerontol Geriatr Med*. 2020;6:2333721420932432. doi:10.1177/2333721420932432
22. Gravel H, Chaseling GK, Barry H, Debray A, Gagnon D. Cardiovascular control during heat stress in older adults: time for an update. *Am J Physiol Heart Circ Physiol*. 2021;320(1):H411–H416. doi:10.1152/ajpheart.00536.2020

23. Ozer AB, Yildiz Altun A, Erhan OL, et al. The effect of body mass index on perioperative thermoregulation. *Ther Clin Risk Manag.* 2016;12:1717–1720. doi:10.2147/TCRM.S122700
24. Morishige S, Ohya T, Fujita N, et al. Risk factors for intraoperative hypothermia during holmium laser enucleation of the prostate. *Urol Int.* 2023;107(7):672–677. doi:10.1159/000528721
25. Chen HY, Su LJ, Wu HZ, Zou H, Yang R, Zhu YX. Risk factors for inadvertent intraoperative hypothermia in patients undergoing laparoscopic surgery: a prospective cohort study. *PLoS One.* 2021;16(9):e0257816. doi:10.1371/journal.pone.0257816
26. Hara K, Kaneko S, Ishioka T, et al. Relationship between perfusion index and central temperature before and after induction of anesthesia in laparoscopic gastrointestinal surgery: a prospective cohort study. *Medicine.* 2023;102(9):e33169. doi:10.1097/MD.00000000000033169
27. Stewart BT, Stitz RW, Tuch MM, Lumley JW. Hypothermia in open and laparoscopic colorectal surgery. *Dis Colon Rectum.* 1999;42(10):1292–1295. doi:10.1007/BF02234217
28. Recio-Perez J, Miro Murillo M, Martin Mesa M, et al. Effect of prewarming on perioperative hypothermia in patients undergoing loco-regional or general anesthesia: a randomized clinical trial. *Medicina.* 2023;59(12). doi:10.3390/medicina59122082
29. Carella M, Beck F, Piette N, Lecoq JP, Bonhomme VL. Effect of preoperative warming on intraoperative hypothermia and postoperative functional recovery in total hip arthroplasty: a randomized clinical trial. *Minerva Anesthesiol.* 2024;90(1–2):41–50. doi:10.23736/S0375-9393.23.17555-9
30. Yin L, Wang H, Yin X, Hu X. Impact of intraoperative hypothermia on the recovery period of anesthesia in elderly patients undergoing abdominal surgery. *BMC Anesthesiol.* 2024;24(1):124. doi:10.1186/s12871-024-02509-6
31. Wee J, Tan XR, Gunther SH, et al. Effects of medications on heat loss capacity in chronic disease patients: health implications amidst global warming. *Pharmacol Rev.* 2023;75(6):1140–1166. doi:10.1124/pharmrev.122.000782
32. Donizetti E, Perini FV, Dos Reis Rodrigues R, et al. Consensus of the Brazilian association of hematology, hemotherapy and cellular therapy on patient blood management: inadvertent intraoperative hypothermia. *Hematol Transfus Cell Ther.* 2024;46 Suppl 1(Suppl 1):S53–S59. doi:10.1016/j.htct.2024.02.021
33. Moldovan F. Bone cement implantation syndrome: a rare disaster following cemented hip arthroplasties-clinical considerations supported by case studies. *J Pers Med.* 2023;13(9):1381. doi:10.3390/jpm13091381
34. Lamkanfi M, Dixit VM. Mechanisms and functions of inflammasomes. *Cell.* 2014;157(5):1013–1022. doi:10.1016/j.cell.2014.04.007

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