e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(8); 56-61

Original Research Article

Comparison of Thermal Insulation versus Active Cutaneous Warming in Prevention of Hypothermia among Critically Ill Patients Being Evacuated by Patient Transfer Unit (PTU)

Gp Capt. (Dr.) G. Rajaram[1], Gp Capt (Dr.) Atul Sharma[2], Lt Col (Dr.) Kiran Kalshetty[3]

[1]Associate Professor, Department of Anaesthesiology, Military Hospital, Bareilly, UP, India
[2]Assistant Professor, Department of Obstetrics & Gynaecology, Military Hospital, Bareilly, UP, India
[3]Assistant Professor, Department of Anaesthesiology, Military Hospital, Bareilly, UP, India

Received: 01-05-2026 / Revised: 15-06-2026 / Accepted: 21-07-2026
Corresponding author: Gp Capt. (Dr.) G Rajaram
Conflict of interest: Nil

Abstract

Background: Hypothermia is a frequent complication during aeromedical evacuation of critically ill patients because of low cabin temperatures, impaired thermoregulation, sedation, mechanical ventilation, and exposure during transport. Identification of an effective warming strategy is essential to improve patient safety during transfer.

Methods: This prospective randomized study was conducted at Airforce Hospital Jorhat, Assam, from November 2016 to September 2019. Sixty mechanically ventilated critically ill patients undergoing aeromedical evacuation were randomly allocated into three groups (20 patients each). Group A received an electrically heated blanket combined with a woollen blanket, Group B received a reflective blanket with a woollen blanket, and Group C received an electrically heated blanket alone. Core temperature and physiological parameters were recorded every 15 minutes for 120 minutes. Data were analysed using one-way ANOVA with post hoc comparisons.

Results: Baseline physiological characteristics were comparable among the three groups. Combined warming (Group A) maintained and progressively increased core temperature throughout transport, whereas Groups B and C demonstrated progressive reductions in temperature. Significant differences among the groups were observed from 30 minutes onward ($p<0.001$). Passive thermal insulation produced the greatest decline in core temperature, while active warming alone limited but did not completely prevent heat loss. The combined warming strategy showed significantly better thermal protection than both alternative methods.

Conclusion: Combined use of an electrically heated blanket with a woollen blanket was superior to passive thermal insulation or active warming alone for maintaining normothermia during aeromedical evacuation. A multimodal warming strategy should be considered the preferred approach for critically ill patients undergoing prolonged air transport.

Keywords: Aeromedical evacuation; Hypothermia; Active cutaneous warming; Thermal insulation; Critical care transport; Mechanical ventilation; Patient transfer unit.

DOI: 10.25258/ijcpr.18.8.10

Introduction

Hypothermia is a common and potentially life-threatening complication encountered during the aeromedical evacuation of critically ill patients. Exposure to low ambient temperatures within military transport aircraft, combined with reduced heat production and increased heat loss, predisposes these patients to inadvertent hypothermia. During air evacuation, cabin temperatures may fall to approximately 15°C within the first 60–90 minutes, creating a significant thermal challenge for mechanically ventilated patients receiving intensive care support. [1] Critically ill patients are particularly susceptible to hypothermia because of impaired thermoregulation, sedation, neuromuscular blockade, mechanical ventilation, administration of unwarmed intravenous fluids, and decreased metabolic heat production. Hypothermia has been associated with adverse physiological effects including coagulopathy, cardiac arrhythmias, impaired oxygen delivery, metabolic disturbances, increased infection rates, prolonged recovery, and increased morbidity and mortality. [2-4] Various warming strategies have been employed to minimize heat loss during patient transport. Passive thermal insulation using reflective or woollen blankets reduces heat loss by limiting radiation and convection, whereas active cutaneous warming devices supply external heat to maintain core body temperature. Studies have demonstrated that active warming techniques may be more effective than passive insulation alone; however, evidence regarding the optimal strategy for prolonged aeromedical evacuation remains limited. [5-7]

Considering the unique environmental conditions encountered during military aeromedical evacuation and the paucity of comparative clinical data, the present prospective randomized study was undertaken to compare the effectiveness of active cutaneous warming, passive thermal insulation, and combined warming strategies in preventing hypothermia among critically ill mechanically ventilated patients transferred by patient transfer unit.

We hypothesized that the combined use of active cutaneous warming with thermal insulation would be more effective in maintaining normal core body temperature during aeromedical evacuation than either passive thermal insulation or active cutaneous warming alone.

Materials and Methodology

Study Design: This was a prospective randomized comparative study conducted to evaluate different hypothermia prevention strategies during aeromedical evacuation of critically ill patients.

Study Setting: The study was conducted at Airforce Hospital Jorhat, Assam in collaboration with the Critical Care Air Transport Team (CCATT) during patient transfers using the Patient Transfer Unit (PTU).

Study Duration: The study was carried out over a period of 36 months from November 2016 to September 2019.

Study Population: A total of 60 critically ill patients requiring mechanical ventilation with or without vasopressor support and undergoing CASEVAC/MEDEVAC by PTU from Jorhat to Command Hospital (Eastern Command), Kolkata, with an anticipated transfer duration of more than 120 minutes, were enrolled.

Sample Size: The sample size was determined based on the availability of eligible critically ill patients undergoing aeromedical evacuation during the study period. A total of 60 patients meeting the inclusion criteria were enrolled and randomly allocated equally into three study groups (20 patients in each group).

- **Group A:** Electrically heated blanket combined with military woollen blanket (combined warming)
- **Group B:** Reflective blanket combined with military woollen blanket (passive thermal insulation)
- **Group C:** Electrically heated blanket alone (active cutaneous warming)

Inclusion Criteria: Adult critically ill patients undergoing aeromedical evacuation who required mechanical ventilation with or without vasopressor support, had an anticipated transport duration of more than 120 minutes, and a baseline core temperature of ≥36.5°C were eligible for inclusion. Written informed consent was obtained from the patient's next of kin prior to enrolment.

Exclusion Criteria: Patients with a baseline body temperature <36.5°C, febrile patients (body temperature >38°C), those with pre-existing hypothermia, patients undergoing surgery with anticipated massive blood transfusion, and those in whom continuous temperature monitoring could not be performed were excluded from the study.

Randomization: Eligible patients were randomized into one of the three study groups using sealed opaque envelope randomization.

Operational Definitions

Hypothermia: Core body temperature <36.0°C during transport.

Normothermia: Core body temperature between 36.5°C and 37.5°C.

Active cutaneous warming: External warming provided using an electrically heated blanket.

Passive thermal insulation: Prevention of heat loss using reflective and woollen blankets without an external heat source.

Combined warming: Simultaneous use of an electrically heated blanket with a woollen blanket.

Study Procedure

Before transport, all patients underwent routine stabilization according to standard critical care protocols. Intravenous fluids administered during transport were pre-warmed to approximately 38°C. Sedation was maintained using propofol, fentanyl, and midazolam as clinically indicated. Neuromuscular blockade with vecuronium was administered when required to eliminate shivering and facilitate mechanical ventilation. According to randomization, patients received one of the three hypothermia prevention strategies. The warming devices or insulation blankets were placed over the patient and tucked securely to minimize convective heat loss throughout transport.

Monitoring: Baseline measurements were obtained immediately before departure. During the 120-minute aeromedical transport, core (nasopharyngeal), rectal, and skin temperatures, along with heart rate, blood pressure, oxygen saturation (SpO_2), end-tidal carbon dioxide ($EtCO_2$), central venous pressure (where available), and cargo compartment temperature, were recorded at 15-minute intervals. Arterial blood gas analysis was performed hourly using an i-STAT portable analyzer. Patients whose core temperature decreased below 34.8°C during transport were withdrawn from the study and immediately managed with active rewarming measures.

Outcome Measures

Primary Outcome

- Maintenance of core body temperature during the 120-minute aeromedical transfer.

Secondary Outcomes

- Change in nasopharyngeal, rectal, and skin temperatures.
- Incidence of hypothermia.
- Changes in physiological parameters.
- Requirement for rescue warming interventions.
- Adverse events during transport.

Statistical Analysis: Data were entered into Microsoft Excel and analysed using SPSS version 22.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequency and percentage. Normality of continuous variables was assessed before analysis. Comparisons of baseline characteristics among the three groups were performed using one-way Analysis of Variance (ANOVA) for continuous variables and Chi-square test for categorical variables. A p-value <0.05 was considered statistically significant.

Ethical Considerations: The study protocol was approved by the Institutional Ethics Committee. Written informed consent was obtained from the patients' next of kin before enrolment. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Results

A total of 60 critically ill patients requiring aeromedical evacuation were enrolled in the study between 2016 and 2019.

Patients were randomly allocated into three equal groups (n = 20 each) according to the hypothermia prevention strategy employed during transport.

- **Group A:** Electrically heated blanket with woollen blanket (combined warming)
- **Group B:** Reflective blanket with woollen blanket (passive thermal insulation)
- **Group C:** Electrically heated blanket alone (active cutaneous warming)

Baseline physiological parameters were comparable among the three groups. Core temperature was monitored at 15-minute intervals during the 120-minute transport period.

Table 1: Baseline Physiological Characteristics of the Study Population

S. No.	Parameter	Group A (n=20)	Group B (n=20)	Group C (n=20)	p-value
1	Mean age (years)	44.06 ± 6.13	43.33 ± 10.91	43.53 ± 7.64	0.97
2	Baseline systolic BP (mmHg)	126.97 ± 4.88	124.50 ± 5.21	124.70 ± 5.27	0.59
3	Baseline diastolic BP (mmHg)	82.70 ± 5.52	85.10 ± 4.84	85.45 ± 2.67	0.39
4	Baseline heart rate (beats/min)	72.00 ± 9.95	74.78 ± 2.18	75.15 ± 2.06	0.33
5	Baseline core temperature (°C)	36.11 ± 0.10	36.10 ± 0.50	36.05 ± 0.30	0.92

There were no statistically significant differences in baseline demographic or physiological parameters among the three groups (p>0.05), indicating that the study groups were comparable before initiation of the warming interventions.

Table 2: Comparison of Mean Core Temperature During Aeromedical Transport

Time	Group A (°C)	Group B (°C)	Group C (°C)	Overall p-value
15 min	36.96 ± 0.90	36.56 ± 0.20	36.75 ± 0.10	0.19
30 min	37.48 ± 0.30	36.23 ± 0.20	36.77 ± 0.30	<0.001*
45 min	37.85 ± 0.10	36.01 ± 0.30	36.62 ± 0.40	<0.001*
60 min	38.12 ± 0.30	35.67 ± 0.10	36.40 ± 0.30	<0.001*
75 min	38.45 ± 0.40	35.43 ± 0.40	36.33 ± 0.30	<0.001*
90 min	38.67 ± 0.40	35.27 ± 0.30	35.93 ± 0.20	<0.001*
105 min	38.77 ± 0.30	34.97 ± 0.20	35.48 ± 0.50	<0.001*
120 min	38.90 ± 0.10	34.92 ± 0.26	35.47 ± 0.50	<0.001*

***Statistically significant.**

Core temperature remained stable and progressively increased in Group A, whereas a continuous decline in core temperature was observed in Groups B and C throughout the transport period. Statistically significant differences among the three groups became evident from 30 minutes onwards (p<0.001), demonstrating superior maintenance of normothermia with the combined warming strategy.

Table 3: Post-hoc Pairwise Comparison of Core Temperature

Time	Group A vs Group C	Group A vs Group B
15 min	NS	NS
30 min	<0.01*	<0.01*
45 min	<0.01*	<0.01*
60 min	<0.01*	<0.01*
75 min	<0.01*	<0.01*
90 min	<0.01*	<0.01*
105 min	<0.01*	<0.01*
120 min	<0.01*	<0.01*

NS = Not significant; *Statistically significant.

Post-hoc analysis demonstrated significantly higher core temperatures in Group A compared with both Group B and Group C from 30 minutes until completion of transport ($p<0.01$). The greatest temperature difference was observed between Group A and Group B, indicating that passive thermal insulation alone was the least effective strategy.

Table 4: Overall Trend of Temperature during 120-Minute Transport

Group	Baseline Temperature (°C)	Temperature at 120 min (°C)	Mean Change (°C)
Group A	36.11 ± 0.10	38.90 ± 0.10	**+2.79**
Group B	36.10 ± 0.50	34.92 ± 0.26	**−1.18**
Group C	36.05 ± 0.30	35.47 ± 0.50	**−0.58**

The combined warming strategy (electrically heated blanket with woollen blanket) produced a progressive increase in core temperature throughout transport. In contrast, passive thermal insulation (reflective blanket with woollen blanket) resulted in the greatest decline in core temperature, while active cutaneous warming alone limited temperature loss but was less effective than combined warming.

Discussion

Maintenance of normothermia during aeromedical evacuation of critically ill patients is challenging because of exposure to low ambient temperatures, impaired thermoregulation, sedation, neuromuscular blockade, mechanical ventilation, and administration of intravenous fluids. The present prospective randomized study compared three hypothermia prevention strategies during air evacuation and demonstrated that the combination of an electrically heated blanket with a woollen blanket was significantly more effective in maintaining core body temperature than either reflective insulation with a woollen blanket or an electrically heated blanket alone.

Accidental hypothermia during transport is associated with important physiological consequences, including coagulopathy, metabolic derangements, impaired tissue oxygenation, cardiac arrhythmias, and increased morbidity. Current recommendations emphasize that prevention of heat loss should be prioritized over treatment after hypothermia develops. Paal et al. highlighted that critically ill and trauma patients require early preventive warming measures because environmental exposure and impaired thermoregulation rapidly predispose them to hypothermia during transport. [8]

In the present study, patients receiving the combined warming strategy maintained normothermia throughout the 120-minute transport, whereas continuous decline in core temperature was observed in both the passive insulation and active warming-alone groups. These findings support the concept that minimizing heat loss while simultaneously providing external heat is more effective than either strategy alone. The updated review by Paal et al. similarly concluded that active warming combined with adequate insulation provides superior temperature preservation compared with passive insulation alone in high-risk patients. [9] Trauma and critically ill patients are particularly vulnerable to hypothermia during transport because reduced tissue perfusion, shock, sedation, and environmental exposure impair endogenous heat production. Vardon et al. reported that hypothermia adversely affects coagulation, increases transfusion requirements, and contributes to poorer clinical outcomes, reinforcing the importance of effective preventive strategies during patient transfer. [10] Likewise, Wang et al. demonstrated that admission hypothermia is independently associated with increased mortality following major trauma, emphasizing that prevention of temperature decline should remain an important component of critical care transport. [11] Our study demonstrated that passive thermal insulation using reflective and woollen blankets alone was the least effective strategy, with patients exhibiting the greatest reduction in core temperature during transport. Similar observations have been reported in large trauma registry analyses, where passive insulation alone was insufficient to maintain normothermia under prolonged cold exposure, particularly in critically ill patients with impaired thermoregulation. [12]

Although electrically heated blankets alone reduced the fall in core temperature compared with passive insulation, they did not maintain normothermia as effectively as the combined warming strategy. Smith et al. demonstrated that external active warming becomes considerably more effective when accompanied by additional measures aimed at reducing ongoing heat loss, supporting the physiological basis for combining insulation with active warming. [13]

Another important component of temperature management in the present study was the administration of warmed intravenous fluids at approximately 38°C. Campbell et al., in a Cochrane review, concluded that warming intravenous and irrigation fluids contributes significantly to the prevention of inadvertent hypothermia, particularly in patients receiving large volumes of fluid replacement. [14] Maintaining normothermia therefore requires a multimodal approach rather than reliance on a single intervention. Overall, the findings of the present study are consistent with the evidence synthesized in recent systematic reviews demonstrating that active body-surface warming significantly reduces inadvertent hypothermia and improves peri-transport thermal stability compared with passive warming methods alone. Madrid et al. concluded that active warming systems remain the most effective strategy for maintaining normothermia, especially when integrated with additional heat-conservation measures. [15] The present study extends these observations to the unique environment of military aeromedical evacuation, where equipment portability, power availability, and operational constraints are major considerations. The findings of the present study suggest that combining active external warming with passive thermal insulation provides better preservation of core body temperature than either strategy alone. This may be attributed to simultaneous reduction in heat loss and continuous external heat delivery, thereby maintaining thermal balance more effectively during prolonged aeromedical transport. These observations support the adoption of multimodal warming strategies in critically ill patients whenever operationally feasible.

Limitations: The present study has certain limitations. It was conducted at a single military tertiary care centre with a relatively small sample size, which may limit the generalizability of the findings. The duration of follow-up was limited to the transport period, and long-term clinical outcomes beyond the transport period were not assessed. In addition, cost-effectiveness of the different warming strategies and the influence of patient-specific factors such as disease severity and vasopressor requirement were not evaluated.

Future Recommendations: Further multicentric studies with larger sample sizes are recommended to validate these findings. Future research should evaluate long-term clinical outcomes, cost-effectiveness of different warming strategies, and their applicability in various aeromedical transport settings and patient populations.

Conclusion

The present study demonstrated that the combination of an electrically heated blanket with a woollen blanket was the most effective strategy for preventing hypothermia during aeromedical evacuation of critically ill mechanically ventilated patients. Combined warming maintained core body temperature significantly better than passive thermal insulation or electrically heated blankets used alone throughout the 120-minute transport period. Passive insulation alone resulted in the greatest decline in core temperature, while active warming alone provided intermediate protection. These findings support the routine use of combined active warming and thermal insulation during prolonged aeromedical transport of critically ill patients whenever operationally feasible. Adoption of this strategy may reduce transport-related hypothermia and its associated complications, thereby improving patient safety during evacuation.

References

1. Schmelz JO, Bridges E, Evers K, Sylvester JC. Comparison of three strategies for preventing hypothermia in critically injured casualties during aeromedical evacuation. Mil Med. 2007;172(3):322-326. doi: 10.7205/MILMED. 172.3.322.
2. Bridges E, Schmelz J, Evers K. Efficacy of the Blizzard Blanket or Blizzard Blanket plus Thermal Angel in preventing hypothermia in a hemorrhagic shock victim (Sus scrofa) under operational conditions. Mil Med. 2007; 172(1):17-23. doi: 10.7205/MILMED.1 72.1. 17.
3. Lundgren P, Henriksson O, Naredi P, Björnstig U. The effect of active warming in prehospital trauma care during road and air ambulance transportation—a clinical randomized trial. Scand J Trauma Resusc Emerg Med. 2011;19:59. doi: 10.1186/1757-7241-19-59.
4. Sookram SM, Barker S, Kelly KD, Patton W, Sosnowski T, Neilson D. Can body temperature be maintained during aeromedical transport? Can J Emerg Med. 2002;4(3):172-177. doi: 10.1017/S1481803500006352.
5. Haverkamp FJC, Giesbrecht GG, Tan ECTH. The prehospital management of hypothermia—

an up-to-date overview. Injury. 2018;49(2): 149-164. doi: 10.1016/j.injury.2017.11.001.

6. Zasa M, Flowers N, Zideman D, Hodgetts TJ, Harris T. A torso model comparison of temperature preservation devices for use in the prehospital environment. Emerg Med J. 2016;33(6):418-422. doi: 10.1136/emermed-2015-204769.
7. Thomassen Ø, Færevik H, Østerås Ø, Sunde GA, Zakariassen E, Sandsund M, et al. Comparison of three different prehospital wrapping methods for preventing hypothermia—a crossover study in humans. Scand J Trauma Resusc Emerg Med. 2011;19: 41. doi: 10.1186/1757-7241-19-41.
8. Paal P, Gordon L, Strapazzon G, Brodmann Maeder M, Putzer G, Walpoth B, et al. Accidental hypothermia—an update. Scand J Trauma Resusc Emerg Med. 2016;24(1):111. doi: 10.1186/s13049-016-0303-7.
9. Paal P, Pasquier M, Darocha T, Lechner R, Kosinski S, Wallner B, et al. Accidental hypothermia: 2021 update. Int J Environ Res Public Health. 2022;19(1):501. doi: 10.3390/ ijerph19010501.
10. Vardon F, Mrozek S, Geeraerts T, Fourcade O. Accidental hypothermia in severe trauma. Anaesth Crit Care Pain Med. 2016;35(5):355-361. doi: 10.1016/j.accpm.2016.05.001.
11. Wang HE, Callaway CW, Peitzman AB, Tisherman SA. Admission hypothermia and outcome after major trauma. Crit Care Med. 2005;33(6):1296-1301. doi: 10.1097/01.C CM.0000165965.31895.80.
12. Weuster M, Brück A, Lippross S, Menzdorf L, Fitschen-Oestern S, Behrendt P, et al. Epidemiology of accidental hypothermia in polytrauma patients: an analysis of 15,230 patients of the TraumaRegister DGU. J Trauma Acute Care Surg. 2016;81(5):905-912. doi: 10.1097/TA.0000000000001220.
13. Smith CE, Desai R, Glorioso V, Cooper A, Pinchak AC, Hagen KF. Preventing hypothermia: convective and intravenous fluid warming versus convective warming alone. J Clin Anesth. 1998;10(5):380-385. doi: 10.10 16/S0952-8180(98)00049-X.
14. Campbell G, Alderson P, Smith AF, Warttig S. Warming of intravenous and irrigation fluids for preventing inadvertent perioperative hypot hermia. Cochrane Database Syst Rev. 2015; (4):CD009891. doi: 10.1002/14651858.CD0 09891.pub2.
15. Madrid E, Urrútia G, Roqué i Figuls M, Pardo-Hernandez H, Campos JM, Paniagua P, et al. Active body surface warming systems for prev enting complications caused by inadvertent perioperative hypothermia in adults. Cochrane Database Syst Rev. 2016;4 (4):CD009016. doi: 10.1002/1465185 8.CD009 016.pub2.