Can body temperature be maintained during aeromedical transport?

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ABSTRACT

Background: Aeromedical transport in northern areas may be associated with hypothermia. The objective of this study was to determine whether significant hypothermia (core temperature <35°C) occurs in severely injured or ill intubated patients during transport by rotary wing aircraft.

Methods: In this prospective cohort study, all intubated patients over 16 years of age who were transported by rotary wing aircraft from rural hospitals or trauma scenes in northern Alberta to regional hospitals in Edmonton were eligible for study. Esophageal thermometers were used to measure core temperature at 10-minute intervals during transport.

Results: Of 133 potentially eligible patients, 116 were enrolled; 69 (59%) had esophageal thermometers inserted, and 47 (41%) had other temperature measurements. Severe hypothermia occurred in only 1% to 2% of cases, but 28% to 39% of patients met criteria for mild hypothermia prior to transport. Core temperatures did not fall during transport, despite the fact that warming techniques were documented in only 38% of cases.

Conclusions: During brief (<225 km) rotary wing aeromedical transport of severely injured or ill patients, significant hypothermia is uncommon and body temperature is generally well maintained with the use of simple passive measures. These findings do not justify recommendations for more aggressive core temperature monitoring during this type of aeromedical transport.

Key words: hypothermia, air ambulance, trauma, emergency medical services system, transportation of patients

RÉSUMÉ

Contexte : Le transport aéromédical dans les régions nordiques peut être associé à l'hypothermie. La présente étude avait comme objectif de déterminer si une hypothermie importante (température centrale <35°C) se manifeste chez des patients intubés gravement blessés ou malades lors du transport par aéronef à voilure tournante.

Méthodes : Dans cette étude de cohorte prospective, tous les patients intubés âgés de plus de 16 ans qui avaient été transportés par aéronef à voilure tournante à partir d'hôpitaux ruraux ou de scènes de trauma dans la région du nord de l'Alberta vers des hôpitaux régionaux à Edmonton étaient admissibles à l'étude. On eut recours à des thermomètres oesophagiens pour prendre la température centrale à des intervalles de 10 minutes pendant le transport.

Résultats : Parmi 133 patients potentiellement admissibles, 116 furent inclus dans l'étude; on inséra un thermomètre oesophagien chez 69 de ces patients (59 %) et on eut recours à d'autres

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types de mesures de la température chez 47 autres (41 %). Une hypothermie sévère se manifesta dans seulement 1 % à 2 % des cas, mais de 28 % à 39 % des patients répondaient aux critères d'hypothermie bénigne avant le transport. Les températures centrales ne chutèrent pas pendant le transport, malgré le fait qu'on ait documenté des techniques de réchauffement dans seulement 38 % des cas.

Conclusions : Pendant le transport aéromédical par aéronef à voilure tournante des patients gravement blessés ou malades, l'apparition d'une hypothermie importante est peu usitée et la température corporelle est généralement bien maintenue avec l'aide de simples mesures passives. Ces constatations ne justifient pas des recommandations de surveillance plus étroite de la température centrale pendant ce type de transport aéromédical.

Introduction

Aeromedical transport poses many unique challenges, including difficulty performing procedures, working in confined spaces, and dealing with noise, pressure and temperature change.[1–3] In northern climates and during winter, hypothermia is a common concern, but its significance remains controversial.[4–9]

Shock, hypotension and hypovolemia impair thermoregulation. Critically ill patients are typically disrobed, most receive cold crystalloid infusions and many undergo neuromuscular blockade, which inhibits heat generation. Hypothermia has deleterious effects on physiology and patient outcomes;[6] therefore, temperature monitoring and prevention of hypothermia are key components of critical care.

Winter temperatures in many northern regions descend to –40ºC. Despite this, little is known about the incidence and magnitude of hypothermia in patients exposed to these cold environments. Our objectives were to determine the incidence and severity of hypothermia (core temperature <35ºC) in patients undergoing aeromedical transport, and to identify characteristics of patients at risk for developing hypothermia in a cold weather environment.

Methods

Setting and patients

The Capital Health Region, located in Edmonton, Alta., has a population of 870 000 and is surrounded by many rural communities of fewer than 10 000 people. The region has 2 acute care hospitals that accept most patients who are transferred from rural emergency departments (EDs) and injury scenes within a 225-km radius of Edmonton by rotary wing aircraft. This prospective observational cohort study was performed in the Edmonton region from Jan. 7, 1998 to Jan. 7, 1999. All intubated patients over 16 years of age who were transported by rotary wing aircraft to a regional referral hospital were included in the study. Non-intubated patients and children were excluded. This study was approved by the University of Alberta Ethics Review Committee, and a waiver of informed consent was permitted.

Study procedures

A typical aeromedical transport crew in this region includes one paramedic and one nurse; an on-call physician is available to ride along when medically necessary. Flight paramedics were trained in the use of esophageal probes and asked to place an esophageal thermometer, via the oropharynx, in all intubated patients undergoing transport. Core temperature readings were initiated as soon as possible after the transport crew reached the patient and concluded upon arrival at the referral centre. Temperatures were displayed continuously and recorded at 10-minute intervals using the ProPak™ monitor (Peak Sensor Systems, Albuquerque, NM). In cases where an esophageal probe was not placed or initial temperature was not recorded by the transport paramedic, we used the first ED rectal temperature as a baseline. This decision was based on data showing high correlation between esophageal and rectal temperatures ($r = 0.77$) when both were available from the same patient. The study protocol did not specify any patient warming protocols during transport. Conventional warming modalities, including "Rescue Wrap®" blankets (Doctor Down, Inc., Polson, Mont.), the helicopter heating system and warmed intravenous fluid were used at the aeromedical crew's discretion.

Data collection

Aeromedical crews recorded flight information, date, destination, patient problem and warming measures employed on specific data extraction forms. A nurse researcher blinded to study intervention abstracted hospital charts to capture demographic data, illness description (e.g., medical, surgical, trauma), medical history, comorbidity, transport information, and relevant patient outcomes (mortality, length of in-patient stay, and complications) using a standardized audit form. A second reviewer (S.B.) assessed all charts to determine reliability of data extraction. Physi-

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cians and other clinical staff were unaware of the study at the time of patient presentation.

The primary outcome measure was core temperature change (ºC) during the transport period. Secondary outcomes included prevalence and severity of hypothermia, admission status and hospital length of stay.

Statistical analysis

Descriptive statistics, including percentages, means, standard deviations (SDs), medians, and interquartile ranges (IQRs) were used to describe study data. The statistical significance of observed differences in categorical outcome variables was determined using chi-squared analysis. The statistical significance of observed differences in continuous outcome variables was determined using unpaired *t*-tests or non-parametric tests (Wilcoxon rank sum) where appropriate. All tests were 2-tailed unless otherwise specified. In assessing secondary outcomes, to adjust for multiple comparisons, a p value of <0.01 was used as the threshold for statistical significance. Logistic regression analysis was used to assess the association of potential predictor variables with the occurrence of hypothermia. Predictor variables in the regression model included age, type of injury, scene-vs.-interhospital transport, and other factors associated with moderate hypothermia (temperature <35ºC) on univariate analyses ($p < 0.10$). Data were analyzed using the SPSS-PC program (SPSS, Inc.; Chicago, Ill.).

Results

During the study period, 133 intubated patients were identified; 116 met eligibility criteria, and 17 were excluded for lack of any temperature recording. Overall, 69 (59%) had esophageal thermometers inserted, and 47 (41%) had rectal temperature measurements (Fig. 1). Compliance with probe placement was more likely for non-trauma than trauma victims (67% vs. 49%) but did not vary with season (summer/winter), patient gender, type of transport (i.e., scene-vs.-interhospital), patient intoxication, or pre-existing respiratory disease.

Table 1 summarizes patient demographics, showing that most patients were male and most transports were interhospital. The proportions of trauma transports and medical/surgical transports were similar. Table 2 summarizes temperature changes that occurred between patients' initial assessment and their arrival at the receiving facility, showing no difference (35.4°C vs. 35.4°C; $p = 0.99$). There was minimal change in air temperature outside the aircraft during the transport period; the aircraft's inside cabin temperature also did not change during transport.

Table 3 summarizes the degree of hypothermia based on 2 classification scales.[6] Mild hypothermia was documented prior to transport in 39% and 28% of patients, according to the Gentilello Trauma and Traditional scoring systems, respectively.[6] Severe hypothermia occurred in

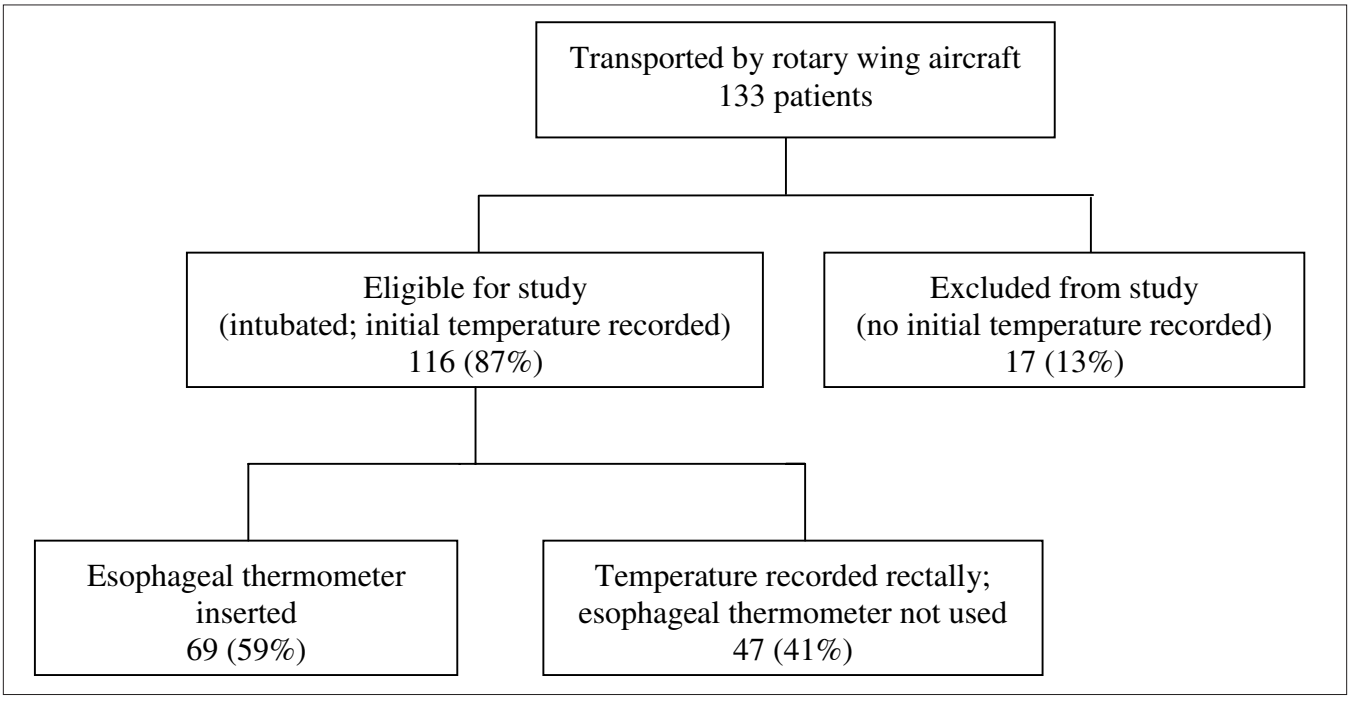

Fig. 1. Distribution of 133 intubated patients transported by rotary wing aircraft from rural hospitals or a trauma scene to a regional hospital during the study period

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only 2% and 1% of patients, respectively.

Warming practices varied widely among crews, and specific warming modalities were seldom used during transport. Use of the Rescue Wrap® blankets (commonly known as "Doctor Down" blankets) was documented in 38% of trips, and warmed intravenous fluid in 5% of trips. Our assessment of data extraction reliability showed that the research assistant and chart abstracters demonstrated excellent agreement for the recording of key demographic and event details ($\kappa > 0.8$).

Table 4 displays *p* values for univariate association of predictor variables with the occurrence of hypothermia. None of the associations were statistically significant. In particular, hypothermia was not statistically associated with age, gender, scene (vs. interhospital) pick-up, transport time, comorbidity, alcohol use, use of paralytic agents or season.

Table 1: Characteristics of 116 patients transported by rotary wing aircraft, the procedures used en route, flight specifics, and outcome.

Factors	Finding
Patient characteristics	
Median age, yr (IQR)	47.5 (29–68)
Range	18–72
Male, *n* (%)	74 (64)
Primary problem, *n* (%)	
Trauma	55 (47)
Sepsis	15 (13)
Other	46 (40)
Comorbidity, *n* (%)	
Cardiovascular	37 (32)
Acute alcohol intake	25 (22)
COPD	16 (14)
Diabetes	11 (9)
Renal disease	8 (7)
CVA	6 (5)
Procedures en route	
Esophageal probes used, *n* (%)	69 (59)
Paralytic agents administered, *n* (%)	83 (72)
Flight specifics	
Type of flight, *n* (%)	
Interhospital	95 (82)
Scene calls	21 (18)
Median air time, min (IQR)	27 (19–34)
Prehospital Index (IQR)	11 (10–13)
Outcomes	
Mean (and range) arrival temperature, °C	35.5 (32.0–40.8)
Deaths (%)	5 (4)
Admitted (%)	111 (96)

IQR = interquartile range; COPD = chronic obstructive pulmonary disease; CVA = cerebral vascular accident

Discussion

This is the first prospective Canadian cohort study describing the incidence and severity of hypothermia in intubated patients undergoing aeromedical transport. We describe a sample of 116 critically ill patients transported from a variety of rural settings to Edmonton referral centres. Despite hypothermic environmental conditions and limited use of warming modalities, we found that core temperatures did not fall during transport. This suggests that the simple measures in common use are sufficient to prevent hypothermia during brief transport by rotary wing aircraft.

Aeromedical crews must resuscitate (or at least maintain) severely ill patients, manage hemodynamic and cardiorespiratory status and rapidly transfer patients to referral centres capable of dealing with their problems. Aeromedical transport is increasingly common, and rotary wing aircraft, in particular, pose a threat to thermoregulatory stability. Given the importance of body temperature, its monitoring should be an integral component of the vital signs assessment.

In this study, severe hypothermia occurred in only 1% to 2% of cases, but 28% to 39% of patients met criteria for mild hypothermia prior to transport. These patients were often not recognized by the sending facility, and transport

Table 2. Initial (pre-flight) and final (upon arrival at destination) body temperatures for patients transported by rotary wing aircraft

Temperature	Mean initial temperature, °C	Mean final temperature, °C
Body	35.4	35.4
Outside air	6.3	6.7
Aircraft cabin	15.0	15.0

Table 3. Incidence of hypothermia in 116 patients transported by rotary wing aircraft during the study period

Degree of hypothermia	Type of hypothermia scale used, °C (and % of patients)	
	Trauma	Traditional
Normal	36–38 (47)	>35–38 (67)
Mild	<36–34 (39)	>32–35 (28)
Moderate	<34–32 (11)	>28–32 (1)
Severe	<32 (2)	<28 (1)
Hyperthermia	>38 (2)	>38 (2)

Note: Percentages do not total 100% due to rounding.

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crews found that many intubated patients had no temperature monitoring in progress prior to their arrival, suggesting that this important vital sign is too often forgotten.

Other studies have concluded that significant hypothermia is rare during aeromedical transport;[4,7–9] however, these studies were conducted in warmer climates and used less sensitive measuring equipment. Previous evidence suggests that esophageal thermometry is the most valid measure of core temperature.[10] We used this modality to identify hypothermia that may have gone undetected in previous studies.

We found that, even in the context of a study, paramedic compliance with probe insertion was lower than expected. In addition, significant hypothermia was rare, and core temperatures did not fall during transport — despite the cold northern environment. Given these findings, it is unrealistic to recommend esophageal probe placement as a routine method of temperature monitoring. It does seem appropriate to recommend that core temperatures be obtained prior to transport, perhaps using more readily available rectal thermometry, and patients with moderate to severe hypothermia at the referring hospital may benefit from aggressive rewarming techniques during transport. However, while the simple rewarming measures used in this study seemed to prevent temperature deterioration, our data do not show that they would successfully increase body temperatures in hypothermic patients.

Table 4. Univariate analysis comparing 116 hypothermic and nonhypothermic patients

Criteria	Hypothermia (<35°C) *n* = 34	Normothermia *n* = 82
Patient characteristics		
Age, yr (SD)	50 (23.2)	48 (21.1)
Male, %	56	67
Primary problem		
Trauma, %	55	45
Sepsis, %	6	16
Other, %	94	84
Comorbidity, %		
Cardiovascular	35	30
Acute alcohol intake	21	22
COPD	12	15
Diabetes	6	11
Renal disease	9	6
CVA	6	5
Mean ISS	31	29
Flight specifics		
Interhospital transport, %	79	83
Air time, min (SD)	25.5 (11.1)	26.7 (10.4)
Winter season, %	50	44
Prehospital Index, PHI (SD)	11.4 (4.5)	10.9 (3.6)
Outcomes		
Died in transport or ED, %	9	2
Admitted, %	91	98
Mean ICU length of stay, d (SD)	6.7 (10.0)	8.5 (12.9)
Mean overall length of stay, d (SD)	15.2 (16.8)	15.2 (19.4)

Note: no logistic regression results were significant (p = >0.1 for all comparisons. ED = emergency department; SD = standard deviation; ISS = Injury Severity Score; ICU = intensive care unit; COPD = chronic obstructive pulmonary disease; CVA = cardiovascular accident

Limitations

In this study, paramedics placed the required esophageal probes in only 59% of cases, despite many attempts by the investigators to promote protocol compliance. Poor compliance was not related to failed attempts or procedural complications; rather, it was because crews were too busy with patient care and did not have time to perform the procedure. Other studies have also shown disappointing compliance with temperature monitoring protocols. One study reported 55% compliance with esophageal thermometry in ground transported patients,[4] and another found only 75% compliance with a tympanic technique.[9]

Conclusions

Mild and moderate hypothermia are common in critically ill and traumatized patients, but severe hypothermia is rare, and core temperatures do not decrease significantly during aeromedical transport, even in a harsh northern environment. The variability in rewarming practice suggests that rewarming guidelines for transport crews may be required. Further research is needed to assess the influence of mild and moderate hypothermia on patient outcomes, to identify patient subgroups at greater risk, and to determine the most appropriate and cost effective treatments.

Competing interests: The authors are not affiliated with any pharmaceutical company that manufactures agents for use in the emergency department treatment of hypothermia. Dr. Rowe has received research funding in the past from the following companies: Abbott Pharmaceuticals, Aventis, AstraZeneca Pharma, GlaxoSmithKlein, Pharmacia, Trudell, Janssen-Ortho, but is not a paid consultant to any of these companies.

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