Original Contribution

Body temperature change and outcomes in patients undergoing long-distance air medical transport

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1. Introduction

Air medical transport is common in emergency settings and is now the global standard. Although ambient air temperature decreases with altitude, several studies showed that the body temperature of most adult patients did not decline significantly during air medical transport [1-6]. Studies also show that body temperature change is not associated with flight duration [1,2,5,6] and outside air temperature [1-4]. However, the flight duration in previous studies was relatively short (range, 18–35 min) [1-4,6]. Also, the evaluated outcome in previous studies was body temperature change between before and after air transport. It can be reasonably assumed that patients transported via aircraft over longer distances are more prone to develop hypothermia and unfavorable outcomes. To our knowledge, no studies have addressed the relationship between body temperature change and mortality in patients undergoing long-distance air medical transport. For example, one emergency medical center in our region conducts air medical transport for approximately 250 patients a year from isolated islands. Distances range from 100 to 1000 km, and transport usually takes from 30 min to 5 h. These flights cover longer distances and require longer duration than those in previous studies [1-4,6].

The present study aimed to determine whether flight duration and outside air temperature influence body temperature change, and the
relationship between body temperature change and mortality in adult patients undergoing long-distance air medical transport.

2. Method

2.1. Setting and patients

This was a retrospective cohort study based on data from the medical charts of inpatients admitted to our hospital between April 1, 2010, and December 31, 2016. We enrolled consecutive patients transferred via aircraft to our hospital. We defined long-distance air flight as >100 km or >30 min' duration. All patients underwent first-aid care by primary care physicians at a local clinic on each island before air transport; no islands were without clinics and physicians. We had no specific patient-warming protocols during air transport; blankets, ice packs, and cabin heating or cooling systems were used at the discretion of the transport team, but we used no active patient-warming devices.

We excluded patients under 16 years of age and patients with cardiac arrest at admission.

2.2. Data collection

We collected the following data for each patient: age; sex; date of admission (flight date); diagnoses; duration of flight (minutes); body temperature (°C) measured at the local clinic before air transport (Tbefore); body temperature at arrival at our hospital after air transport (Tafter); severity of illness; and in-hospital death.

Season at admission was divided into spring (March–May), summer (June–August), autumn (September–November), and winter (December–February). Diagnosis was categorized into cerebrovascular disease, infectious disease including sepsis, cardiovascular disease, gastrointestinal disease, respiratory disease, trauma, post-cardiac arrest, drowning, consciousness disturbance without intracranial lesion (e.g., seizure and epilepsy), and others (e.g., renal disease and metabolic disease).

Body temperature was measured during examination in the local clinic and at arrival at our hospital. We usually use an eardrum thermometer (M30, Terumo Corporation, Shibuya, Japan) or an axillary thermometer (MC-680, Omron Healthcare, Kyoto, Japan) to measure body temperature after flight. These devices differed from those used in each island’s clinic to measure before-flight temperature.

We divided Tbefore and Tafter into three groups: hyperthermia (>38.0 °C), normothermia (36.0–37.9 °C), and hypothermia (<36.0 °C) [4]. The following patient categories described body temperature change: hyperthermia both before and after air transport (“hypo to hypo”); hyperthermia both before and after air transport and normothermia after air transport (“hypo to normo”); hypothermia before air transport and hyperthermia after air transport (“hypo to hyper”); hypothermia before air transport and normothermia after air transport (“normo to hypo”); normothermia before and after air transport (“normo to normo”); normothermia before and after air transport (“normo to hyper”); hypothermia before air transport and normothermia after air transport (“hyper to hypo”); hyperthermia before air transport and normothermia after air transport (“hyper to normo”); and hyperthermia both before and after air transport (“hyper to hyper”). The “normo to hypo” and “hypo to hypo” groups were combined to create a single group (“normo or hyper to hypo”). The “hypo to hyper”, “normo to hyper” and “hyper to hyper” groups were combined to create a single group (“any to hyper”) (Fig. 1).

We also calculated the body temperature change between before and after air transport (ΔT = Tbefore − Tafter).

Illness severity was evaluated according to the acute physiology and chronic health evaluation (APACHE) II score [7]. Because the APACHE-II score includes body temperature and age parameters, we calculated this score without body temperature and age parameters (APACHE II − Tafter − age) on the day of admission to our hospital after air transport.

2.3. Outcome

The outcome was all-cause in-hospital mortality.

2.4. Statistical analysis

We performed complete case analysis. Continuous variables are presented as means with standard deviations (SD) and medians with interquartile ranges (IQR), and categorical variables are reported as count and percentage. Differences in variables between Tbefore and Tafter were compared using a paired t-test. Pearson’s correlation was used to determine the relationship between flight duration and body temperature change (ΔT). ΔT among seasons was compared using one-way analysis of variance. Multivariable logistic regression analysis was performed to evaluate factors associated with in-hospital mortality. We included the following clinically important independent variables: sex; age as a categorical variable; season; body temperature change between before and after air transport as a categorical variable; diagnosis; and APACHE-II score without body temperature and age parameters (APACHE II − Tafter − age).

We performed three further analyses to evaluate the effect of the diagnosis. First, we conducted a sub-group analysis that included only non-trauma patients. Second, we conducted a multivariable logistic regression analysis that included diagnosis category divided into trauma and non-trauma because a previous study was conducted for trauma patients only [3], and hypothermia is a risk factors for trauma patients [8]. Third, we conducted a sub-group analysis that included patients not experiencing post-cardiac arrest because post-cardiac arrest patients can have high mortality regardless of body temperature change.

![Fig. 1. Flow diagram for selecting the study population.](image-url)
The threshold for significance was a p-value < 0.05, and all statistical analyses were performed using SPSS version 23.0 (IBM Corp., Armonk, NY).

2.5. Ethics

This study was approved by the Institutional Review Board of our hospital. Because this study was based on secondary analyses of medical charts, the requirement for informed consent was waived.

3. Results

3.1. Patients’ characteristics

During the study period, 1518 patients were transferred and admitted to our hospital via helicopter or plane. We excluded 265 patients who met the exclusion criteria or who had incomplete data, which left 1253 patients for inclusion in the study.

Patients’ characteristics for each body temperature change category are shown in Table 1. Overall, the median patient age was 72 years (IQR, 60–82 years), and median flight duration was 71 min (IQR, 54–93 min). The median APACHE-II was 9 (IQR, 6–14) and APACHE II – ΔT after – age was 4 (IQR, 2–8). Overall in-hospital mortality was 8.5% (107/1253).

3.2. Main analysis

The mean (SD) body temperature before air transport (Tbefore) was 36.7 (0.94) °C and 36.3 (0.90) °C after air transport (Tafter). The difference between Tbefore and Tafter was −0.36 °C, which was statistically significant based on the paired t-test (95% confidence interval (CI), −0.30 to −0.42; p < 0.001) (Fig. 2).

Fig. 3 shows the relationship between body temperature change (ΔT = Tbefore – Tafter) and flight duration. There was no significant correlation between ΔT and flight duration (r = 0.025, p = 0.371). Analysis of variance results showed no significant difference in ΔT among the four seasons (p = 0.255).

In multivariate analysis (Table 2), a body temperature category change was significantly associated with an increased risk of in-hospital death. With reference to the “normo to normo” group, the odds ratio (95% CI; p-value) for in-hospital mortality was 2.08 (1.20–3.63; p = 0.009) in the “normo or hyper to hypo” group. Winter was significantly associated with an increased risk of in-hospital death compared with spring. Compared with patients with cardiovascular disease, those experiencing post-cardiac arrest were significantly more likely to die. Age and APACHE II – ΔT after – age was also significantly associated with mortality.

3.3. Additional analysis

Multivariable logistic regression analysis that included only non-trauma patients (n = 1064) showed similar results to the main analysis. The “normo or hyper to hypo” group, winter season, post-cardiac arrest, age, and APACHE II – T after – age were significantly associated with increased in-hospital death. In the multivariable analysis that included diagnosis category divided into trauma and non-trauma, “normo or hyper

Table 1

Patients’ characteristics for each body temperature change category

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Overall (n = 1253)</th>
<th>Normo to normo (n = 669)</th>
<th>Normo or Hyper to hypo (n = 266)</th>
<th>Any to hyper (n = 42)</th>
<th>Hypo to normo (n = 121)</th>
<th>Hypo to hypo (n = 77)</th>
<th>Hyper to normo (n = 78)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>777 (62.0)</td>
<td>413 (61.7)</td>
<td>165 (62.0)</td>
<td>30 (71.4)</td>
<td>70 (57.9)</td>
<td>51 (66.2)</td>
<td>48 (61.5)</td>
</tr>
<tr>
<td>Season</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>288 (23.0)</td>
<td>164 (24.5)</td>
<td>58 (21.8)</td>
<td>10 (23.8)</td>
<td>25 (20.7)</td>
<td>16 (20.8)</td>
<td>15 (19.2)</td>
</tr>
<tr>
<td>Summer</td>
<td>344 (27.5)</td>
<td>201 (30.0)</td>
<td>64 (24.1)</td>
<td>10 (23.8)</td>
<td>34 (28.1)</td>
<td>16 (20.8)</td>
<td>19 (24.4)</td>
</tr>
<tr>
<td>Autumn</td>
<td>334 (26.7)</td>
<td>153 (22.9)</td>
<td>84 (31.6)</td>
<td>12 (28.6)</td>
<td>35 (28.9)</td>
<td>23 (29.9)</td>
<td>27 (34.6)</td>
</tr>
<tr>
<td>Winter</td>
<td>287 (22.9)</td>
<td>151 (22.6)</td>
<td>60 (22.6)</td>
<td>10 (23.8)</td>
<td>27 (22.3)</td>
<td>22 (28.6)</td>
<td>17 (21.8)</td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>243 (19.4)</td>
<td>134 (20.0)</td>
<td>65 (24.4)</td>
<td>2 (4.8)</td>
<td>26 (21.5)</td>
<td>14 (18.2)</td>
<td>2 (2.6)</td>
</tr>
<tr>
<td>Infectious disease, sepsis</td>
<td>239 (19.1)</td>
<td>110 (16.4)</td>
<td>41 (15.4)</td>
<td>22 (52.4)</td>
<td>8 (6.6)</td>
<td>10 (14.0)</td>
<td>50 (64.1)</td>
</tr>
<tr>
<td>Gastrointestinal disease</td>
<td>217 (17.3)</td>
<td>122 (18.2)</td>
<td>41 (15.4)</td>
<td>7 (16.7)</td>
<td>20 (16.5)</td>
<td>15 (19.5)</td>
<td>12 (15.4)</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>212 (16.9)</td>
<td>117 (17.5)</td>
<td>45 (16.9)</td>
<td>3 (7.1)</td>
<td>28 (23.1)</td>
<td>18 (23.4)</td>
<td>1 (1.3)</td>
</tr>
<tr>
<td>Trauma</td>
<td>189 (15.1)</td>
<td>110 (16.4)</td>
<td>34 (12.8)</td>
<td>3 (7.1)</td>
<td>25 (20.7)</td>
<td>11 (14.3)</td>
<td>6 (7.7)</td>
</tr>
<tr>
<td>Respiratory disease</td>
<td>39 (3.1)</td>
<td>21 (3.1)</td>
<td>9 (3.4)</td>
<td>2 (4.8)</td>
<td>4 (3.3)</td>
<td>1 (1.3)</td>
<td>2 (2.6)</td>
</tr>
<tr>
<td>Disturbance of consciousness</td>
<td>37 (3.0)</td>
<td>22 (3.3)</td>
<td>9 (3.4)</td>
<td>1 (2.4)</td>
<td>2 (1.7)</td>
<td>2 (2.6)</td>
<td>1 (1.3)</td>
</tr>
<tr>
<td>Post-cardiac arrest</td>
<td>17 (1.4)</td>
<td>0 (0)</td>
<td>10 (3.8)</td>
<td>0 (0)</td>
<td>2 (1.7)</td>
<td>4 (5.2)</td>
<td>1 (1.3)</td>
</tr>
<tr>
<td>Drowning</td>
<td>13 (1.0)</td>
<td>5 (0.7)</td>
<td>1 (0.4)</td>
<td>1 (2.4)</td>
<td>3 (2.5)</td>
<td>2 (2.6)</td>
<td>1 (1.3)</td>
</tr>
<tr>
<td>Other</td>
<td>47 (3.8)</td>
<td>28 (4.2)</td>
<td>11 (4.1)</td>
<td>1 (2.4)</td>
<td>3 (2.5)</td>
<td>2 (2.6)</td>
<td>2 (2.6)</td>
</tr>
<tr>
<td>In-hospital death</td>
<td>107 (8.5)</td>
<td>34 (5.1)</td>
<td>45 (16.9)</td>
<td>5 (11.9)</td>
<td>6 (5.0)</td>
<td>13 (16.9)</td>
<td>4 (5.1)</td>
</tr>
<tr>
<td>Age, years</td>
<td>72 (60–82)</td>
<td>72 (58–82)</td>
<td>76 (65–83)</td>
<td>64 (51–78)</td>
<td>68 (59–79)</td>
<td>72 (63–83)</td>
<td>70 (58–82)</td>
</tr>
<tr>
<td>Duration of fright, minutes</td>
<td>71 (54–93)</td>
<td>73 (53–98)</td>
<td>73 (55–90)</td>
<td>71 (56–91)</td>
<td>71 (56–92)</td>
<td>66 (50–86)</td>
<td>66 (55–90)</td>
</tr>
<tr>
<td>APACHE II</td>
<td>9 (6–14)</td>
<td>9 (6–13)</td>
<td>11 (8–17)</td>
<td>12 (6–17)</td>
<td>8 (6–11)</td>
<td>12 (8–20)</td>
<td>10 (8–16)</td>
</tr>
<tr>
<td>APACHE II – T after – Age</td>
<td>4 (2–8)</td>
<td>4 (2–8)</td>
<td>5 (2–11)</td>
<td>6 (2–11)</td>
<td>4 (2–7)</td>
<td>7 (2–13)</td>
<td>5 (3–10)</td>
</tr>
</tbody>
</table>

Data for categorical variables are shown as n (%). Data for continuous variable are shown as median (interquartile ranges). APACHE II–T after – Age: the acute physiology and chronic health evaluation score without temperature and age component.
to hypo* group, winter season, post-cardiac arrest, age, and APACHE II
− T after — age were significantly associated with increased in-hospital
death. However, diagnosis divided into trauma or non-trauma catego-
ries was not associated with mortality. The sub-group analysis that ex-
cluded patients with post-cardiac arrest (n = 1236) also showed
similar results to the main analysis.

4. Discussion

We demonstrated that patients’ body temperature decreased signif-
ically during long-distance air transport; however, flight duration was
not associated with body temperature change. In-hospital death was
significantly associated with (i) normothermia or hyperthermia before
air transport and hypothermia after air transport and (ii) winter season.

Contrasting with previous observational studies [1-6], body temper-
ature change during air transport decreased significantly in our study.
The mean difference of −0.36 °C appears clinically unimportant; how-
ever, this value was based on data from patients whose body tempera-
ture increased, decreased, or did not change. Therefore, the value was an
average of all cases. Body temperature change in each patient is more
important than mean body temperature change.

Several previous studies stated that body temperature before air
transport was the most significant risk factor [5,6]. Our study showed
that the “normo or hyper to hypo” group was associated with higher
in-hospital death, indicating that body temperature monitoring during
long-distance air transport is important for patients with not only hypo-
thermia before air transport but also normothermia or hyperthermia
before air transport.

In our study, hyperthermia at admission and “hypo to hypo” group
were not associated with mortality. Previous studies demonstrated
that hyperthermia was not associated with mortality, whereas hypo-
thermia was associated with that in critically ill patients [9,10]. In our
study, the number of patients in the “any to hyper” group (n = 42)
and “hypo to hypo” group (n = 77) may have been too small to detect
significance.

Our results demonstrated no significant difference in ΔT among the
seasons; however, winter was significantly associated with an increased
risk of in-hospital death in the multivariate analysis. Disease type and
severity in winter may have affected this association. Post-cardiac arrest
was significantly associated with higher mortality, but trauma was not
associated with higher mortality even though hypothermia is part of
the “deadly triad” for trauma patients [8]. Clinicians should pay atten-
tion to body temperature for both non-trauma and trauma patients.

Several limitations of this study should be acknowledged. First, this
was an observational study, and we had no standard protocol to measure
body temperature. Information regarding additional blankets, iced pads,
and cabin heating or cooling were lacking. We also had no data for air temperature in the aircraft cabin or outside; however, a previous
prospective observational study showed that body temperature change
was not significantly associated with air temperature in the aircraft
cabin or outside [4]. Second, patients are exposed to outside air separate from the flight, including transfer from the scene to the airport
and waiting for the flight; our data also lacked this information. Third,
our records recorded only the primary disease and included no comor-
bidity data. Fourth, we used the APACHE II score to adjust for disease se-
verity, which is based on several parameters within 24 h after admission in
the intensive care unit and may not reflect disease severity before
hospitalization. Finally, we had no information on the use of neuromus-
cular blockades or blood transfusions, which are reported risk factors
[6,11]. However, several studies showed that these factors were not asso-
ciated with body temperature change during air transport [1,4,5]. We
also had no information on the use of vasopressors, vasodilators, and
sedatives. Each of these factors may have influenced body temperature
change.

5. Conclusion

Our analysis suggests that body temperature may decrease during
long-distance air transport. Physicians should consider body tempera-
ture during long-distance air transport in patients with not only hypo-
thermia but also normothermia or hyperthermia before air transport
especially in winter.

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Declarations of interest

None.

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References