The Incidence of Fever in US Critical Care Air Transport Team Combat Trauma Patients Evacuated From the Theater Between March 2009 and March 2010

Authors: Joanne M. Minnick, DNP, APRN, ACNP-BC, Lt Col Vikhyat S. Bebarta, MD, USAF, MC, Marietta Stanton, PhD, RN, C, NEA-BC, CMAC, CCM, CNL, Lt Col (Retired) Julio R. Lairet, DO, USAF, MC, Col James King, MD, USAF, MC, Pedro Torres, BSN, RN, James Aden, PhD, and Rosemarie Ramirez, PhD, MPH, Ft. Sam Houston, TX and Lackland AFB, TX, Tuscaloosa, AL, Atlanta, GA

Introduction: Most critically ill injured patients are transported out of the theater by Critical Care Air Transport Teams (CCATTs). Fever after trauma is correlated with surgical complications and infection. The purposes of this study are to identify the incidence of elevated temperature in patients managed in the CCATT environment and to describe the complications reported and the treatments used in these patients.

Methods: We performed a retrospective review of available records of trauma patients from the combat theater between March 1, 2009, and March 31, 2010, who were transported by the US Air Force CCATT and had an incidence of hyperthermia. We then divided the cohort into 2 groups, patients transported with an elevation in temperature greater than 100.4°F and patients with no documented elevation in temperature. We used a standardized, secure electronic data collection form to abstract the outcomes. Descriptive data collected included injury type, temperature, use of a mechanical ventilator, cooling treatment modalities, antipyretics, intravenous fluid administration, and use of blood products. We also evaluated the incidence of complications during the transport in patients who had a recorded elevation in temperature greater than 100.4°F.

Results: A total of 248 trauma patients met the inclusion criteria, and 101 trauma patients (40%) had fever. The mean age was 28 years, and 98% of patients were men. The mechanism of injury was an explosion in 156 patients (63%), blunt injury in 11 (4%), and penetrating injury in 45 (18%), whereas other trauma-related injuries accounted for 36 patients (15%). Of the patients, 209 (84%) had battle-related injuries and 39 (16%) had non–battle-related injuries. Traumatic brain injury was found in 24 patients (24%) with an incidence of elevated temperature. The mean temperature was 101.6°F (range, 100.5°F-103.9°F). After evaluation of therapies and treatments, 80 trauma patients (51%) were intubated on a mechanical ventilator ($P < .001$). Of the trauma patients with documented fever, 22 (22%) received administration of blood products. Nineteen patients received antipyretics during their flight (19%), 9 received intravenous fluids (9%), and 2 received nonpharmacologic cooling interventions, such as cooling blankets or icepacks. We identified 1 trauma patient with

Joanne M. Minnick is Clinical Research Nurse, Air Force Enroute Care Research Center, US Army Institute of Surgical Research, San Antonio, Military Medical Center, Ft. Sam Houston, TX.

Vikhyat S. Bebarta, Lt Col, is Director, Enroute Care Research Center, USAF, and Chair, Medical Toxicology, Department of Emergency Medicine, San Antonio Military Medical Center, Ft. Sam Houston, TX.

Marietta Stanton is Dean and Faculty, Capstone College of Nursing, The University of Alabama, Tuscaloosa, AL.

Julio R. Lairet, Lt Col (Retired), is EMS Director, Department of Emergency Medicine, Emory University, Atlanta, GA.

James King, Col, is Chief, Department of Emergency Medicine, Air Force Enroute Care Research Center, US Army Institute of Surgical Research, San Antonio, Military Medical Center, Ft. Sam Houston, TX.

Pedro Torres is Research Nurse, Air Force Enroute Care Research Center, US Army Institute of Surgical Research, San Antonio, Military Medical Center, Ft. Sam Houston, TX.

James Aden is Statistician, US Army Institute of Surgical Research, Ft. Sam Houston, TX.

Rosemarie Ramirez is Senior Scientist/Epidemiologist, 59th MDW Office of the Chief Scientist, Wilford Hall Ambulatory Surgical Center, Lackland AFB, TX.

There is no prior publication, conflict of interest, or copyright constraints. The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the US Air Force, Department of the US Army, Department of the US Navy, Department of Defense, or the US Government.

For correspondence, write: Joanne M. Minnick, DNP, APRN, ACNP-BC, Enroute Care Research Center, Attn: Jacob Minnick, Program Manager, 3698 Chambers Pass, Ft. Sam Houston, TX 78234; E-mail: jodymm13@yahoo.com.

J Emerg Nurs 2013;39:e101-e106.

Available online 16 May 2013.

0099-1767/$36.00

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http://dx.doi.org/10.1016/j.jen.2013.02.001

Report Documentation Page

Form Approved
OMB No. 0704-0188

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1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 NOV 2013	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
The Incidence of Fever in US Critical Care Air Transport Team Combat Trauma Patients Evacuated From the Theater Between March 2009 and March 2010.	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
Minnick J. M., Bebarta V. S., Stanton M., Lairet J. R., King J., Torres P., Aden J. K., Ramirez R.,	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
United States Army Institute of Surgical Research,JBSA Fort Sam Houston, TX	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**6**	

neurologic changes (1%), 6 with hypotension (6%), 48 with tachycardia (48%), 33 with decreased urinary output (33%), and 1 with an episode of shivering or sweating (1%). We did not detect any transfusion reactions or deaths during flight.

Conclusion: Fever occurred in 41% of critically ill combat-injured patients evacuated out of the combat theater in Iraq and Afghanistan. Fewer than 20% of patients with a documented elevated temperature received treatments to reduce the temperature. Intubation of patients with ventilators in use during the transport was the only factor significantly associated with fever. Serious complications were rare, and there were no deaths during these transports.

Key words: Fever; Flight medicine; Critical care transport; Trauma; Military medicine; Combat

The use of a Critical Care Air Transport Team (CCATT) in the transportation of our critically injured military men and women has played a vital part in the rapid evacuation of patients during Operation Iraqi Freedom and Operation Enduring Freedom. The purposes of this study are to identify the incidence of documented fever in patients managed in the CCATT environment and to describe the coinciding complications reported and the treatments used in these patients. Fever, or elevation in temperature, was defined for the purpose of this study as a temperature higher than 100.4°F (38°C). The elevation in temperature had to be documented on the flight record, and no time restraints were imposed.

Aims included (1) identifying the incidence of fever (temperature > 100.4°F [> 38°C]) in any traumatically injured patient transported by the CCATT within the defined time frames, (2) describing the initial specific mechanism of injuries involved in the traumatic event of the patient, (3) further investigating any interventions with treatment modalities used to address the fever noted by the flight team, and (4) identifying complications coinciding with a documented temperature.

The environment that the CCATT presents is unique and challenging and can impact the clinical outcomes and mortality rates of severely injured patients.[1] The CCATT program was founded in 1994 because of the unmet need for evacuation of traumatically injured and critically ill patients for long-range air transport.[2] The concept of the CCATT program is to manage casualties that require further resuscitation, stabilization, and critical care as necessary until they can reach a higher level of care at another facility.[1] Flights average 2 to 6 hours in length. The CCATT is made up of a physician, registered nurse, and respiratory therapist who have a critical care background.[1]

There are no previous publications on fever and aeromedical evacuation of combat-injured patients. Fever is an identified complication with implications for the progression of a patient's injuries, disease, and death.[3] Past research has been performed by pioneers in immunology and neurophysiology and identified fever as an adaptive physiologic response to some threat.[3] Trauma patients who sustain devastating injuries have a higher incidence of systemic inflammatory response syndrome (SIRS) that occurs as a result of these injuries.[2] SIRS to some degree is beneficial in clearing organisms that would hinder recovery, but overactivation can lead to increased mortality rates and complications, such as vital organ failure that leads to multisystem organ failure and/or death.[2] The incidence of wound infections, blood transfusion requirements, and critical care in trauma patients has also been noted in research, supporting the need for the critical care team to address these threats in a timely and efficient manner.[2] Simply stated, fever (elevated temperature) can often be the first sign of SIRS and sepsis, which needs to be identified, treated, and re-evaluated to prevent the life-threatening complications that accompany it in trauma patients.[4]

Thus, to improve care and outcomes in the previously described patient population, critical evaluation of the incidence of fever needs to be addressed. Our research objectives were to identify the incidence of fever in patients managed in the CCATT environment and to describe the complications reported and the treatments used in the care of these patients. We also investigated the current therapeutic, evidence-based treatment modalities for the management of fever that are used during flight in CCATT transports.

Methods

We performed a retrospective review and analysis of all available flight medical records of all charts from all trauma patients transported by the CCATT from theater base locations to Landstuhl Regional Medical Center (LRMC) between March 1, 2009, and March 31, 2010 (Figures 1-3). Inclusion criteria included all patients who had trauma-related injuries during this period that occurred at bases in Iraq and Afghanistan and who were transferred to LRMC, a tertiary care receiving point in Germany. All patients were adults (aged ≥ 17 years) and included active-duty military personal, coalition forces, civil service employees, government contractors, and residents of Iraq or Afghanistan. We excluded children,

FIGURE 1

Evacuation of injured soldiers in a C-17 Globemaster III. (Photo courtesy of Lt Col Julio Lairet MD [retired].)

FIGURE 2

The team loading an injured solider from the theater for transport to Germany from the rear end of the plane. (Photo courtesy of Lt Col Julio Lairet, MD [retired].)

pregnant women, and patients on non-trauma medical flights with no trauma-related injuries. Demographic data were extracted to include age, weight, and sex of the patient.

We also abstracted the following demographics and outcomes, the nature of the injury (blast, blunt and penetrating, and other trauma-related injuries). The 3 categories were further divided into subcategories as combat-related injury (battle injury) versus non–combat-related injury (non-battle injury). Blast injuries included those that occurred as a result of trauma related to rockets, improvised explosive devices (IEDs), mortars, shrapnel metal fragments, and rocket-propelled grenades, as well as other devices causing blast injuries. Blunt injuries included motor vehicle collisions, falls, helicopter crashes, and other injuries from blunt force trauma.

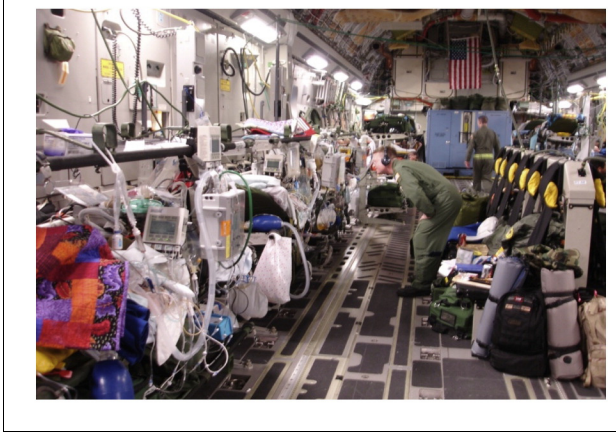

FIGURE 3

Inside view of the C-17 Globemaster III, 1 of the aircrafts used to evacuate traumatically injured patients from Operation Iraq Freedom and Operation Enduring Freedom. (Photo courtesy of Lt Col Julio Lairet, MD [retired].)

Penetrating trauma injuries included those resulting from gunshot wounds and stabbings.

Other data searched in the treatment records included trauma care, including the use of mechanical ventilation in intubated patients, cooling treatment modalities, antipyretics, nonpharmacologic therapies, blood, and intravenous fluids. Complications experienced during the transport were also closely evaluated and extracted from the charts. Complications considered during the transport by the CCATT included death, temperature greater than or equal to 100.5°F, change in neurologic status such as shivering or seizure activity, hypotension (systolic blood pressure <90 mm Hg), tachycardia (pulse rate >100 beats/min), transfusion reactions from blood administration, decreased urinary output of less than $0.5\ mL^{-1} \cdot kg^{-1} \cdot h$, and other related complications. We divided the trauma patients into 2 cohorts, those with hyperthermia during flight with the CCATT and those without incidence of hyperthermia during flight.

Data were placed in a Microsoft Excel 2007 spreadsheet (Microsoft, Redmond, WA), and SAS version 9.2 (SAS Institute, Cary, NC) was used for statistical analysis. All factors were evaluated to determine whether there was a possible relationship with the incidence of hyperthermia. Categorical variables were compared by use of χ^2 tests, and continuous variables were compared by use of a t test. Factors marginally associated ($P < .20$) with fever were then used in a logistic regression to predict fever during transport. Backward elimination was used to remove factors 1 by 1 in the logistical regression model so that only factors significantly associated with fever were left. Odds ratios and their corresponding 95% confidence intervals, as well as their P values, are

TABLE 1
Type of injury and incidence of fever in trauma patients moved by CCATT

Type of injury	Trauma patients without fever	Trauma patients with fever	Total
Blast	92	64	156
Blunt	6	5	11
Penetrating	25	20	45
Other	24	12	36
Total	147	101	248

reported for all factors in the logistic regression model. Statistical significance was established at $P < .05$.

TABLE 2
Mechanism of injury and incidence of fever in trauma patients moved by CCATT

Mechanism of injury	Trauma patients without fever	Trauma patients with fever	Total
IED	70	56	126
GSW	20	16	36
Rocket	18	7	25
Other	17	9	26
Fall	8	2	10
MVC	6	8	14
Shrapnel	4	1	5
Helicopter crash	3	1	4
Crush	1	9	10
Total	147	101	248

GSW, Gunshot wound; *MVC*, motor vehicle collision.

Results

A total of 248 trauma patients met the inclusion criteria from initial data collection, resulting in 101 trauma patients with an incidence of hyperthermia documented during their CCATT flight from the theater to LRMC. The mean age was 27.8 years (range, 17-58 years), and 98% of patients were men. The mechanism of injury was explosion in 156 trauma patients (63%), blunt injury in 11 (4%), and penetrating injury in 45 (18%), whereas other identified injuries accounted for 36 trauma patients (14%) (Table 1). Further analysis identified 126 IED injuries (51%), 36 gunshot wound injuries (14%), 25 rocket-related injuries (10%), 14 injuries from motor vehicle collisions (6%), 10 fall-related injuries (4%), 5 injuries related to shrapnel (2%), 4 injuries from helicopter crashes (2%), 2 crush injuries (1%), and 26 other injuries (10%) (Table 2). Of these injuries, 209 (84%) were battle-related injuries and 39 (16%) were non–battle-related injuries. However, no statistical significance was found in this specific cohort of trauma patients with fever with regard to age, weight, sex, type of injury, or mechanism.

A detailed analysis of the 101 trauma patients who met the inclusion criteria were evaluated by a trained abstractor to identify the data, variables, and research information sought and identified in the Wilford Hall Medical Center Investigational Review Board–approved protocol (FWH20120037H). Of these 101 trauma patients moved by the CCATT, the highest fever documented was 103.9°F (range, 100.5°F-101.6°F) (Tables 1 and 2). For type of injury, blast injury showed the highest incidence, at 63% (Table 1), and for mechanism of injury, IED explosions accounted for 55% (Table 2). After evaluation of therapies and treatments used during flight by the CCATT, patients transported on a mechanical ventilator had a higher incidence of fever as well ($P < .001$). This indicated that there were more patients with a documented fever on a mechanical ventilator (66 patients) than patients without a documented incidence of fever and not on a mechanical ventilator (91 patients). It was also noted that trauma patients with fever were 1.5 times more likely to receive blood transfusions, although the difference was not significant statistically (59% vs 39%, $P = .07$).

Of the trauma patients with documented fever, 22 were administered blood products, 19 received antipyretics during their flight, 9 received intravenous fluids, and 2 were given nonpharmacologic interventions, such as cooling blankets and ice (Table 3). Of 101 patients with documented fever, 63% received no therapy or treatment for their episode of elevated temperature.

Eighty-eight occurrences of complications in concurrence with fever were detected (Table 4). One trauma patient had an episode of neurologic changes resulting in intubation from mental status changes, 6 had hypotension, 48 had tachycardia, 33 had decreased urinary output ($<0.5\ mL^{-1} \cdot kg^{-1} \cdot h$), and 1 had shivering or sweating. No patient had transfusion reactions or died during flight.

Finally, another statistical analysis, logistic regression, was performed to predict fever. All factors with $P < .20$ were used. Of the patients considered, those who received or used ventilators during transport. The P value for blood was .24; therefore it was removed from the analysis. Significance remained only for trauma patients intubated

TABLE 3
Treatment and therapies used for fever in trauma patients moved by CCATT from March 1, 2009, to March 31, 2010

Treatment and therapies used during flight	Trauma patients with fever
Mechanical ventilation	80
Blood administration	22
Antipyretics	19
Nonpharmacologic	2
IVF	9

IVF, Intravenous fluid.

TABLE 4
Complications documented in association with incidence of fever in trauma patients moved by CCATT

Complications	Trauma patients with fever
Tachycardia (110-160 beats/min)	48 (24%)
Decreased urinary output ($<0.5\ mL^{-1} \cdot kg^{-1} \cdot h$)	33 (38%)
Hypotension (systolic blood pressure <90 mm Hg)	6 (7%)
Neurologic changes	1 (1%)
Transfusion reactions	0
Death	0
Total	88

on a ventilator (odds ratio, 3.9 [95% confidence interval, 2.1-7.1]; $P < .001$).

Discussion

In this study we found that fever is common during the transport of trauma patients moved by the CCATT out of the theater during the examined time frame. Approximately 41% of patients moved sustained a temperature of 100.5°F or greater during their flight. Fewer than 63% of these patients received no therapy or treatment to reduce their temperature during the flight. The highest incidence of type of injury and mechanism of injury was blast with the involvement of IEDs. This is suggestive and supportive of a higher incidence of blood loss, tissue damage, and inflammatory response that is followed by fever, SIRS, and increased mortality rate.[1]

In this study patients with a documented fever were 1.5 times more likely to receive blood transfusions during air transport. This is noted to be a risk factor for extended morbidity and/or mortality in association with blood transfusion administration not dependent on the environment. It would be interesting to take the research a step further to evaluate this finding. Another significant factor identified was that the trauma patients on a mechanical ventilator were more likely to have an incidence of elevated temperature, and of these, only 27% received some documented form of therapy or treatment related to the elevation in temperature. In another recent research study on fever risk factors and outcomes, the authors concluded that prolonged fever was associated with severe infections, ventilator-associated pneumonia, and other mixed infectious causes.[1] The findings also suggest the need to further examine the correlation between type of injury and body location such as abdomen, chest, head, and other areas for possible relationships to elevation in temperature.

This research study provides opportunities for improving the care and training of our CCATT providers that will allow us to modify the equipment and tactics to achieve better patient outcomes in the management of fever. Some examples include different probes to monitor temperature in the aircraft environment, such as bladder probes and esophageal probes instead of oral and axillary monitors, monitors that simultaneously monitor temperatures along with other vital signs, and establishment of protocols for nurses to address fever, to name a few. Research needs to be performed to identify the correlation between the 2 variables to determine further significance. This study does not conclude that if a trauma patient is intubated or receives a blood transfusion, he or she will incur a state of elevated temperature. It only identifies a possible correlation, and further research needs to be performed to investigate the relationships, if any, to the incidence of fever in trauma patients moved by CCATTs.

Further research and analysis of the data including a 30-day mortality rate and Injury Severity Score will be important factors to consider and identify further areas of study needed. The 30-day mortality rate will identify the use of antibiotics, blood culture results, presence of infectious states such as sepsis, progression of patient status and acuity during hospitalization, and mortality rates. The Injury Severity Score will provide the location of injury according to the percentage and extent of body areas affected, such as the trunk, extremities, and abdomen.[5] These important factors could influence the risk of fever and associated complications that are caused by states of elevated

temperature. As mentioned previously, injury location and type might also have an influence on the presence of elevated temperature.

Limitations

Limitations to the research included the retrospective data collection. However, we used predefined outcomes and a trained abstractor. In addition, the CCATT records were brief, and outcomes after CCATT transport were not available; however, for this particular study and for our short-term outcomes, the records provided sufficient data for outcomes.

Implications for Emergency Nurses

Implications for emergency nurses include a heightened awareness to trauma patients who are having episodes of fever. Current standards for emergent treatment and stabilization of trauma patients according to the sixth edition of the Trauma Nursing Core Course curriculum are to identify, treat, and manage hypothermic states in trauma patients,[6] but no clinical practice guidelines are established for the treatment of fever. Emergency nurses and critical care nurses possess excellent assessment and critical thinking skills that can be used to identify the increase in temperature quickly and collaborate with the medical team to administer quick and effective care. Many of these interventions are nursing care interventions that do not require a medical order, such as the use of cooling therapies such as ice bags and removal of clothing to reduce temperature. These simple preventative measures and therapies can in turn prevent complications and increased acuity in these trauma patients.

CCATT nurses also have opportunities to investigate relationships in this unique environment because of their experience and opportunity to work in this environment as flight nurses. CCATT nurses are familiar with equipment currently used to monitor fever in the aircraft, the flight environment itself, any possible flight stressors, the acuity of patients flown, and the documentation currently used during flight missions. CCATT and flight nurses in the military are also familiar with the different aircrafts used and variables such as aircraft size and temperature stabilization during flight (ambient temperature) on each aircraft that would be important variables to consider in future research related to fever. Their vast knowledge and experience make them ideal for developing research, implementing research, and evaluating outcomes to identify the needs and areas of improvement in the CCATT environment.

Conclusions

In this study it is noted that fever, or elevated temperature, is common in combat-injured service members transported by CCATTs. We detected fever in 41% of the critically ill combat-injured patients evacuated out of the combat theater. Ventilator use in transport was the only factor noted to coincide with elevation in temperature in trauma patients. Fewer than 20% of patients received treatments to reduce their temperature, serious complications were rare, and no patients died.

The purpose of this research study was to identify the incidence of fever, and in conducting the study, we developed further research questions: further exploration of the aircraft environment is needed, and temperature monitoring and mechanism of injury are further areas of research and interest to be investigated in relation to fever. This research study provided a foundation for further research to be developed.

Acknowledgment

We recognize the US Air Force CCATT and all of the staff involved in the care of the critically injured service men and women without whom this study would not have been possible.

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