

# A Retrospective Cohort Study of Burn Casualties Transported by the US Army Burn Flight Team and US Air Force Critical Care Air Transport Teams

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## ABSTRACT

### Introduction:

The US Army Burn Center, the only burn center in the Department of Defense provides comprehensive burn care. The Burn Flight Team (BFT) provides specialized burn care during transcontinental evacuation. During Operations Iraqi and Enduring Freedom, burn injuries accounted for approximately 5% of all injuries in military personnel. To augment BFT capacity, US Air Force Critical Care Air Transport Teams (CCATTs) mobilized to transport burn patients. The purpose of this study was to describe critically ill, burn injured patients transported to the US Army Burn Center by BFT or CCATT, to compare and contrast characteristics, evacuation procedures, in-flight treatments, patient injuries/illnesses, and outcomes between the two groups.

### Materials and Methods:

We conducted a retrospective cohort study of CCATT and BFT patients, admitted to the burn ICU between January 1, 2001 and September 30, 2018. Patients with total body surface area burned (TBSA) >30% were evacuated by BFT, while CCATT evacuated patients with ≤30% TBSA.

### Results:

Ninety-seven patients met inclusion criteria for this study. Of these, 40 (41%) were transported by the BFT and 57 (59%) were transported by CCATTs. Compared with patients transported by CCATTs, patients transferred by the BFT had higher median TBSA and full-thickness burn size, higher prevalence of chest, back and groin burns, and higher prevalence of inhalation injury. BFT patients had increased hospital days (62 vs. 37;  $P = .08$ ), ICU days (29 vs. 12;  $P = .003$ ) and ventilator days (14 vs. 6;  $P < .001$ ). TBSA was the only variable significantly associated with ARDS (aOR = 1.04; 95% CI: 1.01, 1.08;  $P = 0.04$ ), renal failure (aOR = 1.07; 95% CI: 1.03, 1.11;  $P = .002$ ), and mortality (aOR = 1.08; 95% CI: 1.03, 1.13;  $P = .001$ ).

### Conclusions:

Evacuation by the BFT was associated with increased ICU and ventilator days, increased mortality, and a greater risk for developing renal failure. The severity of injury/TBSA likely accounted for most of these differences.

## BACKGROUND

The evidence related to burn care indicates that burn patients experience better outcomes when their care is provided by a specialized team that is trained in and dedicated to the provision of burn care, such as at a burn center.<sup>1,2</sup> The US Army Burn Center (USABC) has provided comprehensive burn care since 1949 and is the only burn center in the Department of Defense (DoD). As such, DoD beneficiaries and veterans throughout the world are transported to the USABC for comprehensive burn care. In addition, the USABC serves as the tertiary referral center for civilian burn patients in south Texas.<sup>3</sup>

Due to the need for specialized critical care, the long-range aeromedical evacuation of critically injured burn patients presents unique challenges for military medical providers and leadership. To achieve this mission for burn patients, the USABC developed the Burn Flight Team (BFT) in 1951, which was designed to provide specialized burn care during transcontinental evacuation. The Army BFT consists, at a minimum, of a critical-care physician or surgeon (with

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additional burn training), a critical-care registered nurse, a licensed vocational nurse, and a respiratory therapist. Members of the BFT all work in the USABC, affording them the opportunity to maintain currency in the care of critically injured burn patients.<sup>4</sup> In addition, BFT members began attending pre-deployment Critical Care Air Transport Team (CCATT) training in 2003.<sup>5</sup>

During Operations Iraqi and Enduring Freedom, burn injuries accounted for approximately 5% of all injuries in military personnel.<sup>6</sup> Initially, the BFT provided the majority of long distance burn patient transports. However, between 2003 and 2011, the tempo of these military operations stretched the limits of the BFT transport capacity, as 895 military burn patients required transport during this time period.<sup>3</sup> To augment BFT capacity, US Air Force Critical Care Air Transport Teams (CCATTs) were mobilized to transport burn patients of intermediate acuity.<sup>6</sup> Each CCATT is composed of an intensive-care-capable physician, nurse, and respiratory therapist.<sup>7</sup> The CCATT course provides less than two days training on the care of burn patients, and CCATT members are not currently assigned to duty in the USABC. Burn patients were transported out of theater by CCATTs to Landstuhl Regional Medical Center, Germany. Those with severe (>30% total body surface area; TBSA) burns were subsequently transported by the BFT to the USABC. Patients with moderate (10–30% TBSA) burns were transported by CCATTs to the USABC.<sup>6</sup>

Maintaining readiness in military health care providers is a priority for the Military Health System (MHS). The up-and-down tempo inherent in military operations can be a barrier to maintaining clinical currency.<sup>8</sup> In the case of CCATT providers, there is an opportunity to enhance clinical competence in the care of critically injured burn patients. Due to the different composition of transport teams and the associated burn training each team possesses, the purpose of this study was to describe critically ill, burn injured patients transported to the USABC by BFT or CCATT, and to compare and contrast characteristics, evacuation procedures, in-flight treatments, patient injuries/illnesses and outcomes between the two teams. A secondary objective was to identify the provider knowledge and skill sets required to establish proficiency in initial stabilization and en route burn care.

## METHODS

We conducted a retrospective cohort study of CCATT and BFT burn patients. The Institutional Review Board granted expedited approval for the study (19-0006H). The USABC registry provided the initial patient list, which included all patients ( $n = 587$ ) flown by CCATT or BFT from any point of origin outside of Texas, who was 18 years or older, and admitted to the Burn ICU between January 1, 2001 and September 30, 2018. Patients were excluded if they were less than 18 years old or a detainee. Patients were also excluded if the in-flight record was not available from local medical

records. Ninety-seven patients, 40 BFT and 57 CCATT, were included in the final analysis (see [Supplementary Fig. 1](#)). Of the 140 unavailable patient records (any chart), 80 (57%) were BFT evacuations; and of the 228 patients excluded due to the absence of the in-flight record, 224 (98%) were BFT records.

## Data

Using a study-specific electronic database (Microsoft Excel 2016 and Microsoft Access 2016; Microsoft Corporation, Redmond, WA) with pre-defined fields, data were abstracted from CCATT and BFT records (3899L and TRAC2ES) to include demographics, description of burn injury, vital signs, labs, procedures, medications, and in-flight events. A single nurse abstractor, trained to abstract CCATT medical records, used standardized definitions to determine relevant medical events of interest. In addition to the CCATT or BFT record, the USABC hospital discharge summary was abstracted for outcomes. If the summary was not included in the scanned patient care record, the record was retrieved from the hospital electronic health record. Meetings were held with the primary investigator for purposes of clarification and review of non-conformant data. The chart of each enrolled study subject was reviewed by a second research coordinator for quality assurance, to include errors in data entry, and inadvertent omission of data. Feedback was provided to the original abstractor who reviewed feedback and made corrections to the database as appropriate.

## Measures

At the onset of Operation Iraqi Freedom hostilities, the following policy was established by the Department of Defense: patients with total body surface area burned (TBSA) >30% were evacuated by BFT, while CCATT evacuated critical patients with ≤30% TBSA. Patients were assigned to study cohorts based on which team was responsible for transport to the USABC, CCATT vs. BFT. We described burn injuries using TBSA, presence of inhalation injury (yes/no), injury type (battle/non-battle), the body location of the burns (head, face, neck, chest, back, groin, buttocks and extremities), and the depth of burns. TBSA was assessed for partial and full-thickness burns. We recorded patient characteristics, including age in years, sex (female/male), and service branch (Air Force, Army, Marines, Navy, Other). We also measured transport data, including the precedence level of the evacuation (Regular, Priority or Urgent) and the number of days from injury to admission to the Burn ICU.

In-flight treatments were also measured for BFT and CCATT patients, including the use of blood products, intravenous (IV) fluids, analgesics, sedatives, antibiotics, anticoagulants and vasopressors. The use of blood products was indicated as yes/no. The use of IV fluids were documented as yes/no by type (albumin, lactated Ringers', normal saline, and other), and total volume of fluids administered in ml.

Analgesics were measured as yes/no for fentanyl, morphine or other. Medications for sedation were measured as yes/no for propofol and midazolam. Antibiotic use was categorized by type (cefazolin, doxycycline, levofloxacin, vancomycin, and other). Anticoagulant use was categorized as enoxaparin or other. Use of vasopressin was recorded as yes/no. Pre-flight and post-flight patient vital signs (temperature, heart rate, oxygen saturation, systolic and diastolic blood pressure and mean arterial pressure) and laboratory values (base excess, pH, hemoglobin, hematocrit, sodium and potassium) are reported in [Supplementary Table 1](#).

Outcomes of interest in this study included the number of hospital, ICU and ventilator days, as well as complications and mortality. Complications were measured as yes/no for patients who developed infections, acute respiratory distress syndrome (ARDS), renal failure, multi-system organ failure, gastritis/ulcer/gastrointestinal bleeding, and coagulopathy. We also generated a composite variable to account for the presence of any of these complications. Mortality was based on the patient discharge status. Outcomes and complications were abstracted from the hospital discharge summary and thus pertain to the index hospitalization.

**Statistical Analysis**

Continuous data are presented as median and interquartile range (IQR) and categorical data are presented as number and percent. Bivariate comparisons were analyzed using the Mann–Whitney *U* test for continuous variables, and Fisher’s exact test for categorical variables<sup>a</sup>. Multivariable regression models were used to analyze outcome data while controlling for potential confounders. Multivariable models were used for outcome variables with unadjusted differences between BFT and CCATT that were at least marginally significant (*P* < .10). Negative binomial regression models were used to analyze over-dispersed count variables (hospital, ICU and ventilator days) and logistic regression models were used to analyze binary morbidity and mortality outcome variables (ARDS, renal failure and mortality). Results of negative binomial models are reported as exponentiated coefficients, generally referred to in the literature as adjusted incidence rate ratios (aIRR), with 95% confidence intervals (CI) and *P* values. The IRR provides a straightforward interpretation of the negative binomial model as a percent increase in the dependent variable associated with each 1-unit increase in a predictor variable. Results of logistic regression models are reported as adjusted odds ratios (aOR) with 95% CI and *P* values. Data were analyzed using IBM SPSS Statistics, version 27 (Chicago, IL).

**RESULTS**

A total of 97 patients admitted to the burn ICU between January 1, 2001 and September 30, 2018 met inclusion criteria for this study. Of these, 40 (41%) were transported by the BFT and 57 (59%) were transported by CCATTs ([Table I](#)).

**TABLE I.** Patient, Injury and Transport Characteristics for Burn Flight Team and CCATT (*N* = 97)

| Variables   | Total<br>( <i>N</i> = 97) | Burn Flight<br>Team<br>( <i>n</i> = 40) | CCATT<br>( <i>n</i> = 57) | <i>P</i> value <sup>a</sup> |
|---|---------------------------|---|---------------------------|-----------------------------|
| Age, median (IQR)                                       | 23 (21–31)                | 23 (21–29)                              | 24 (21–31)                | .46                         |
| Male, <i>n</i> (%)                                      | 93 (95.5)                 | 37 (92.5)                               | 56 (98.2)                 | .39                         |
| Missing, <i>n</i> (%)                                   | 1 (1.0)                   | 1 (2.5)                                 | 0 (0.0)                   | .39                         |
| Service branch, <i>n</i> (%)                            |                           |   |                           |                             |
| Air Force   | 2 (2.1)                   | 1 (2.5)                                 | 1 (1.8)                   | .999                        |
| Army  | 66 (68.0)                 | 23 (57.5)                               | 43 (75.4)                 | .08                         |
| Marines   | 22 (22.7)                 | 13 (32.5)                               | 9 (15.8)                  | .08                         |
| Navy  | 1 (1.0)                   | 0 (0.0)                                 | 1 (1.8)                   | .999                        |
| Other   | 3 (3.1)                   | 2 (5.0)                                 | 1 (1.8)                   | .57                         |
| Missing   | 3 (3.1)                   | 1 (2.5)                                 | 2 (3.5)                   | .999                        |
| Battle injury, <i>n</i> (%)                             | 80 (82.5)                 | 35 (87.5)                               | 45 (78.9)                 | .43                         |
| Missing, <i>n</i> (%)                                   | 2 (2.1)                   | 1 (2.5)                                 | 1 (1.8)                   | .43                         |
| TBSA%, median (IQR)                                     | 25 (10–48)                | 47 (22–62)                              | 18 (6–33)                 | <.001                       |
| Missing, <i>n</i> (%)                                   | 4 (4.1)                   | 3 (7.5)                                 | 1 (1.8)                   | .30                         |
| Full thickness TBSA%, median (IQR)                      | 9 (0–37)                  | 38 (7–55)                               | 3 (0–19)                  | <.001                       |
| Body regions with burn injuries, <i>n</i> (%)           |                           |   |                           |                             |
| Head  | 74 (76.3)                 | 33 (82.5)                               | 41 (71.9)                 | .33                         |
| Face  | 3 (3.1)                   | 0 (0.0)                                 | 3 (5.3)                   | .27                         |
| Neck  | 50 (51.5)                 | 28 (70.0)                               | 22 (38.6)                 | .004                        |
| Chest   | 56 (57.7)                 | 29 (72.5)                               | 27 (47.4)                 | .02                         |
| Back  | 49 (50.5)                 | 25 (62.5)                               | 24 (42.1)                 | .06                         |
| Groin   | 23 (23.7)                 | 15 (37.5)                               | 8 (14.0)                  | .01                         |
| Buttocks  | 39 (40.2)                 | 21 (52.5)                               | 18 (31.6)                 | .06                         |
| Extremities   | 87 (89.7)                 | 36 (90.0)                               | 51 (89.5)                 | .999                        |
| Inhalation injury, <i>n</i> (%)                         | 33 (34.0)                 | 21 (52.5)                               | 12 (21.1)                 | .002                        |
| Non-burn injury, <i>n</i> (%)                           | 46 (47.4)                 | 14 (35.0)                               | 32 (56.1)                 | .06                         |
| Precedence, <i>n</i> (%)                                |                           |   |                           |                             |
| Regular   | 10 (10.3)                 | 0 (0.0)                                 | 10 (17.5)                 | .005                        |
| Priority  | 46 (47.4)                 | 12 (30.0)                               | 34 (59.6)                 | .007                        |
| Urgent  | 9 (9.3)                   | 5 (12.5)                                | 4 (7.0)                   | .48                         |
| Missing   | 32 (33.0)                 | 23 (57.5)                               | 9 (15.8)                  | <.001                       |
| Days from injury to admission to burn ICU, median (IQR) | 3 (2–4)                   | 3 (2–4)                                 | 3 (2–4)                   | .69                         |
| Missing (%)   | 18 (18.6)                 | 15 (37.5)                               | 3 (5.3)                   | <.001                       |

<sup>a</sup>Continuous variables analyzed with Mann–Whitney *U* test, and categorical variables analyzed with Fisher’s exact test.

Compared with patients transported by CCATTs, patients transferred by the BFT had higher median TBSA and full-thickness burn size, higher prevalence of chest, back and groin burns, higher prevalence of inhalation injury, lower rates of regular or priority precedence, and a higher rate of missing precedence. Nearly half (47.4%) of all patients suffered concomitant non-burn injuries, with CCATT patients experiencing the most (56% vs. 35%) ([Table I](#)).

Documented use of in-flight blood products was low in both BFT and CCATT patients ([Table II](#)). A significantly greater percentage of BFT patients received albumin (62.5% vs. 29.8%) and fentanyl (92.5% vs. 64.9%) in-flight, compared with CCATT patients. Conversely, a significantly

**TABLE II.** In Flight Treatments for Burn Flight Team and CCATT (N = 97)

| Variables                  | Total (N = 97)      | Burn Flight Team (n = 40) | CCATT (n = 57)      | P value <sup>a</sup> |
|----------------------------|---------------------|---------------------------|---------------------|----------------------|
| Blood products, n (%)      | 4 (4.1)             | 1 (2.5)                   | 3 (5.3)             | .64                  |
| Fluids, n (%)              |                     |                           |                     |                      |
| Albumin                    | 42 (43.3)           | 25 (62.5)                 | 17 (29.8)           | .002                 |
| Lactated ringers           | 53 (54.6)           | 26 (65.0)                 | 27 (47.4)           | .10                  |
| Normal saline              | 32 (33.0)           | 9 (22.5)                  | 23 (40.4)           | .08                  |
| Other                      | 8 (8.2)             | 3 (7.5)                   | 5 (8.8)             | .999                 |
| Total volume, median (IQR) | 2,810 (1,820–4,130) | 2,857 (1,784–3,770)       | 2,516 (1,803–4,263) | .77                  |
| Analgesic, n (%)           |                     |                           |                     |                      |
| Fentanyl                   | 74 (76.3)           | 37 (92.5)                 | 37 (64.9)           | .002                 |
| Morphine                   | 9 (9.3)             | 0 (0.0)                   | 9 (15.8)            | .01                  |
| Other                      | 29 (29.9)           | 7 (17.5)                  | 22 (38.6)           | .04                  |
| Sedation, n (%)            |                     |                           |                     |                      |
| Propofol                   | 20 (20.6)           | 7 (17.5)                  | 13 (22.8)           | .62                  |
| Versed                     | 51 (52.6)           | 26 (65.0)                 | 25 (43.9)           | .06                  |
| Antibiotic, n (%)          |                     |                           |                     |                      |
| Ancef                      | 12 (12.4)           | 1 (2.5)                   | 11 (19.3)           | .01                  |
| Doxycycline                | 17 (17.5)           | 1 (2.5)                   | 16 (28.1)           | .001                 |
| Levaquin                   | 8 (8.2)             | 2 (5.0)                   | 6 (10.5)            | .46                  |
| Vancomycin                 | 11 (11.3)           | 4 (10.0)                  | 7 (12.3)            | .999                 |
| Other                      | 29 (29.9)           | 9 (22.5)                  | 29 (35.1)           | .26                  |
| Anticoagulant, n (%)       |                     |                           |                     |                      |
| Lovenox                    | 43 (44.3)           | 4 (10.0)                  | 39 (68.4)           | <.001                |
| Other                      | 2 (2.1)             | 1 (2.5)                   | 1 (1.8)             | .999                 |
| Vasopressors, n (%)        |                     |                           |                     |                      |
| Vasopressin                | 1 (1.0)             | 0 (0.0)                   | 1 (1.8)             | .999                 |

<sup>a</sup>Continuous variables analyzed with Mann–Whitney *U* test, and categorical variables analyzed with Fisher’s exact test.

lower percentage of BFT patients received in-flight morphine (0% vs. 15.8%), cefazolin (2.5% vs. 19.3%), doxycycline (2.5% vs. 28.1%) and enoxaparin (10.0% vs. 68.4%), compared with CCATT patients. Data summarizing pre-flight and post-flight vital signs and laboratory values indicated a large amount of missing data, particularly for post-flight assessments, which prevented comparisons between BFT and CCATT patients for post-flight data (Supplementary Table I). However, none of the pre-flight vital signs or laboratory values differed significantly between BFT and CCATT patients where comparisons could be made (Supplementary Table I).

The median length of hospital stay was 62 (18–91) days for patients transported by the BFT, compared with 37 (20–56) days for CCATT, which was not statistically different ( $P = .08$ ) (Table III). However, median days in the ICU (29 vs. 12;  $P = .003$ ) and on a ventilator (14 vs. 6;  $P < .001$ ) were significantly higher for BFT patients compared with CCATT patients. The percentage of patients diagnosed with renal failure (25% vs. 7%;  $P = .02$ ) and the percentage of patients who died (40% vs. 7%;  $P < 0.001$ ) was significantly higher for BFT patients compared with CCATT patients. The percentage of patients diagnosed with ARDS (27.5% vs. 10.5%) approached but did not meet statistical significance ( $P = .06$ ). No other

**TABLE III.** Unadjusted Outcomes for Burn Flight Team and CCATT (N = 97)

| Variables                         | Total (N = 97) | Burn Flight Team (n = 40) | CCATT (n = 57) | P value <sup>a</sup> |
|-----------------------------------|----------------|---------------------------|----------------|----------------------|
| Hospital days, median (IQR)       | 42 (19–69)     | 62 (18–91)                | 37 (20–56)     | 0.08                 |
| ICU days, median (IQR)            | 16 (8–42)      | 29 (10–66)                | 12 (7–23)      | 0.003                |
| Ventilator days, median (IQR)     | 7 (4–15)       | 14 (6–40)                 | 6 (3–10)       | <0.001               |
| Infection, n (%)                  | 68 (70.1)      | 27 (67.5)                 | 41 (71.9)      | 0.66                 |
| ARDS, n (%)                       | 17 (17.5)      | 11 (27.5)                 | 6 (10.5)       | 0.06                 |
| Renal failure, n (%)              | 14 (14.4)      | 10 (25.0)                 | 4 (7.0)        | 0.02                 |
| Multi-organ system failure, n (%) | 5 (5.2)        | 4 (10.0)                  | 1 (1.8)        | 0.16                 |
| Gastritis/ulcer/GI bleed, n (%)   | 7 (7.2)        | 2 (5.0)                   | 5 (8.8)        | 0.70                 |
| Coagulopathy, n (%)               | 12 (12.4)      | 7 (17.5)                  | 5 (8.8)        | 0.22                 |
| Any complication, n (%)           | 72 (74.2)      | 30 (75.0)                 | 42 (73.7)      | 0.99                 |
| In-hospital mortality, n (%)      | 20 (20.6)      | 16 (40.0)                 | 4 (7.0)        | <0.001               |

<sup>a</sup>Continuous variables analyzed with Mann–Whitney *U*, and categorical variables analyzed with Fisher’s exact test.

morbidity outcomes differed significantly between BFT and CCATT patients.

In multivariable negative binomial models, adjusting for age, sex, TBSA and inhalation injury, the number of ventilator days (aIRR = 1.90; 95% CI: 1.11, 3.24;  $P = .02$ ) was significantly higher for BFT patients compared with CCATT patients (Table IV). Each 1-point increase in TBSA was associated with a 2% increase in the number of ventilator days. Hospital days (aIRR = 1.16; 95% CI: 0.70, 1.93;  $P = .56$ ) and ICU days (aIRR = 1.07; 95% CI: 0.63, 1.84;  $P = .80$ ) did not differ significantly between BFT and CCATT patients. TBSA was the only variable that was significantly associated with the number of hospital days (aIRR = 1.01; 95% CI: 1.00, 1.03;  $P = 0.02$ ), ICU days (aIRR = 1.03; 95% CI: 1.02, 1.04;  $P < 0.001$ ) and ventilator days (aIRR = 1.02; 95% CI: 1.01, 1.03;  $P < 0.001$ ). Age, sex and inhalation injury variables were not significantly associated with hospital, ICU or ventilator days.

The odds of developing ARDS, renal failure or dying were not significantly different between BFT and CCATT patients in multivariable logistic regression models (Table IV). TBSA was the only variable that was significantly associated with ARDS (aOR = 1.04; 95% CI: 1.01, 1.08;  $P = 0.04$ ), renal failure (aOR = 1.07; 95% CI: 1.03, 1.11;  $P = 0.002$ ) and mortality (aOR = 1.08; 95% CI: 1.03, 1.13;  $P = 0.001$ ) outcomes after adjustment. Each 1-point increase in TBSA was associated with a 4% increase in the odds of ARDS, a 7% increase in the odds of renal failure, and an 8% increase in the odds of death. Age, sex and inhalation injury variables were not significantly associated with ARDS, renal failure or mortality.

**TABLE IV.** Results of Multivariable Adjusted Negative Binomial Regressions for Hospital, ICU and Ventilator Days, and Logistic Regressions for ARDS, Renal Failure and Mortality (*N* = 97)

| Variables   | Negative binomial regression             |   |  |
|-------------|--|---|--|
|             | Hospital days<br>aIRR (95% CI); <i>P</i> | ICU days<br>aIRR (95% CI); <i>P</i>     | Ventilator days<br>aIRR (95% CI); <i>P</i> |
| Group       |  |   |  |
| BFT         | 1.16 (0.70, 1.93); 0.56                  | 1.07 (0.63, 1.84); 0.80                 | 1.90 (1.11, 3.24); 0.02                    |
| CCATT (ref) |  |   |  |
| Age         | 1.01 (0.99, 1.04); 0.35                  | 1.02 (0.99, 1.05); 0.08                 | 1.04 (0.99, 1.06); 0.09                    |
| Sex         |  |   |  |
| Female      | 0.99 (0.30, 3.29); 0.98                  | 0.90 (0.26, 3.05); 0.86                 | 0.49 (0.13, 1.81); 0.28                    |
| Male (ref)  |  |   |  |
| TBSA%       | %1.%2 (1.00, 1.03); 0.02                 | %1.%2 (1.02, 1.04); <0.001              | %1.%2 (1.01, 1.03); <0.001                 |
| Inhalation  |  |   |  |
| Yes         | 0.94 (0.58, 1.54); 0.82                  | 1.06 (0.65, 1.73); 0.82                 | 1.34 (0.82, 2.19); 0.25                    |
| No (ref)    |  |   |  |
| Variables   | Logistic regression                      |   |  |
|             | ARDS<br>aOR (95% CI); <i>P</i>           | Renal failure<br>aOR (95% CI); <i>P</i> | Mortality<br>aOR (95% CI); <i>P</i>        |
| Group       |  |   |  |
| BFT         | 1.15 (0.20, 6.48); 0.88                  | 1.14 (0.19, 6.80); 0.88                 | 3.19 (0.56, 18.10); 0.19                   |
| CCATT (ref) |  |   |  |
| Age         | 1.09 (0.99, 1.19); 0.06                  | %1.%2 0.97, 1.17); 0.17                 | 1.02 (0.95, 1.15); 0.38                    |
| Sex         |  |   |  |
| Female      | 2.39 (0.10, 55.38); 0.59                 | N/A                                     | N/A  |
| Male (ref)  |  |   |  |
| TBSA%       | 1.04 (1.01, 1.08); 0.04                  | 1.07 (1.03, 1.11); 0.002                | 1.08 (1.03, 1.13); 0.001                   |
| Inhalation  |  |   |  |
| Yes         | 1.75 (0.42, 7.32); 0.44                  | 0.80 (0.17, 3.74); 0.77                 | 0.94 (0.20, 4.31); 0.93                    |
| No (ref)    |  |   |  |

<sup>a</sup>Sex removed from renal failure and mortality models due to complete separation of data points.

## DISCUSSION

To our knowledge, this is the first article to compare and contrast global characteristics of burn critical care provided by BFT or CCATT during international transport. One previous article described analyses of anemia in critically ill burn patients transported by CCATT and identified that hemoglobin levels <10 g/dL were not a significant predictor of mortality among included patients.<sup>9</sup> Another article assessed analgesia provided to non-intubated patients during CCATT missions and identified that 3% of the included patients were burn-injured.<sup>10</sup> Piper and Mueller each describe separate instances of CCATT and BFT personnel working together in single situations to provide burn and trauma care during long range transport of patients.<sup>11,12</sup> Renz et al twice described care of burn patients during evacuation from a combat theater. The first was a descriptive article of all burn patients evacuated by CCATT or BFT, but the article included no analysis of the differences in care provided by the two transport teams.<sup>13</sup> The second article described in detail the BFT and made no mention of CCATT.<sup>3</sup>

Our analysis identified that patients transported by the BFT were more critically ill than those transported by CCATT. The severity of injury likely accounted for most of the differences

we identified between the BFT- and CCATT-transported patients. For example, the BFT transported patients had a higher median TBSA and a higher prevalence of inhalation injuries, both of which are significant contributors toward burn mortality in most series.<sup>14</sup> Additionally, patients transported by the BFT remained in the ICU and on a ventilator significantly longer than patients transported by CCATT. This is likely a reflection of the greater inflammatory response experienced by patients with larger burns, particularly when complicated by inhalation injury, and the longer time to wound closure.<sup>15</sup> Others have identified that the presence of inhalation injury was associated with an increased incidence of ARDS; however, our findings indicated that only TBSA was associated with ARDS.<sup>16</sup> Also associated with increased injury severity (represented by TBSA), BFT patients were at greater risk for developing renal failure.<sup>17</sup>

There were some medication-use differences between the groups. For example, patients transported by the BFT received more albumin during flight than those transported by CCATT. Albumin has been identified as a key component of burn resuscitation, aimed at mitigating the effects of fluid creep via oncotic pressure.<sup>18</sup> While use of albumin is common at burn centers and among those trained in burns, non-burn clinicians

may be unfamiliar with albumin use in burn resuscitation. However, wider dissemination of the Burn Care Clinical Practice Guideline as published by the Joint Trauma System<sup>19</sup> affords the knowledge of the use of albumin during acute burn resuscitation. Historically, CCATT personnel do not complete clinical rotations, as part of training or regular clinical practice. As such, they may be unfamiliar with the use of albumin in burn resuscitation. The lack of burn clinical experience, or provider preference, also may account for the identified difference in pain medication use. Fentanyl is often an analgesic of choice at the USABC due to its short half-life; limited hemodynamic effect of the medication that is short-lived. Morphine has a longer half-life and requires a greater dose in order to achieve the same analgesic effect as fentanyl.<sup>20</sup>

This study identified significant gaps in pre- and post-flight vital signs or laboratory data among patients transported by both evacuation teams. As a result, we were unable to make patient condition comparisons before and after the evacuation flight. Ideally, only stable patients are evacuated using long-range, fixed-wing aircraft because the physiologic effects of long-range evacuation can alter the patient's condition in flight.<sup>21</sup> This is particularly true of severely burned patients, who are physiologically volatile for several weeks after injury. Without the vital signs and laboratory data, it was impossible for us to generalize across the included sample our findings of patient stability or condition before and after transport.

During the process of conducting this study, we identified what was not known earlier: BFT transport records were not consistently recorded in the patient's long term medical record. As soon as we identified this, the medical director implemented a process to scan all BFT in-flight records into the medical record. Missing records and data may also be attributed to the fact that the BFT did not have specific protocols for documentation in the earlier years. The BFT started using the same record (3899L) as the CCATT in 2012. The USAF En Route Critical Care Pilot Unit has a quality assurance program in place to track and monitor in-flight documentation, which contributes to the increase in data collection from CCATT missions.

After accounting for TBSA, we did not find significant differences in patient outcomes between the BFT- and CCATT-evacuated patients. However, given the small patient sample included in this study, the absence of differences should not be construed as license to forego burn-specific training for evacuation teams. Burn patients have been called the "universal trauma model," owing to the dose-dependent, local and systemic responses to injury they experience.<sup>22</sup> Burn patients are complex and are routinely some of the sickest patients in the hospital, providing military health care personnel of all experience levels the opportunity to care for patients requiring aggressive fluid resuscitation, developing multiple organ dysfunction, to include ARDS, and requiring meticulous wound care—all of which were present in combat trauma patients of the last 20 years.<sup>23–25</sup>

Two teams collaborated during a time of war to provide optimal care and evacuation of casualties with burn injuries. As a result of the judicious selection of the right team for the right patient, burn-specific training was not required for safe transport of burn patients of lower acuity, and CCAT-specific training was not required for safe transport of burn patients of higher acuity. However, military leaders looking to future wars predict that burn injury will become more prominent on the battlefield.<sup>26,27</sup> As such, in order to adequately prepare to provide care on the future battlefield, it is important for military health care team members to obtain significant burn care experience.

## LIMITATIONS

Due to the retrospective nature of our study and small sample size, we were able to identify associations but not causation. A prospective study may help compliment the data reported to assist in understanding the implications of assigned transport team and associated training. Additionally, the data were extracted from medical records that had missing data secondary to incomplete documentation, lack of standardization in documentation requirements, difficulty accessing certain parts of the records, and/or illegibility. Such missing data could have implications on the interpretation of the data in regards to Type I and Type II errors. Comparison of the two cohorts was also limited by an increase in missing BFT documentation. Selection bias is likely in this study, due to the fact that selection into exposure groups (BFT vs. CCATT) was dependent on the likelihood of having the outcome of interest (i.e., sicker patients transported by BFT). These limitations were considered in the analysis and interpretation of results.

## CONCLUSIONS

Evacuation by the BFT was associated with increased ICU and ventilator days, increased mortality, and a greater risk for developing renal failure. The severity of injury/TBSA likely accounted for most of these differences. The lack of burn clinical experience and limited burn training available to CCATTs may lead to less-than-optimal choices in fluid resuscitation, pain management, or other processes. Further research and evaluation of training, readiness, and sustainment platforms for proficiency in the care of critically injured burn patients is warranted.

In order for the impact of care to be studied and evaluated, complete and accurate documentation is crucial. We identified an opportunity to improve documentation and maintain records of in-flight care. The BFT may benefit from establishment of a quality assurance program similar to the CCATT process.

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## SUPPLEMENTARY MATERIAL

Supplementary material is available at *Military Medicine* online.

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## CONFLICT OF INTEREST STATEMENT

None declared.

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