Improved adherence to best practice ventilation management after implementation of Clinical Practice Guideline (CPG) for United States military Critical Care Air Transport Teams (CCATTs)

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Background: Critical Care Air Transport Teams (CCATTs) play a vital role in the transport and care of critically ill and injured patients in the combat theater, to include mechanically ventilated patients. Previous research has demonstrated improved morbidity and mortality when lung protective ventilation strategies are used. Our previous study of CCATT trauma patients demonstrated frequent non-adherence to the Acute Respiratory Distress Syndrome Network (ARDSNet) protocol and a corresponding association with increased mortality. The goal of our study was to examine CCATT adherence with ARDSNet guidelines in non-trauma patients, compare the findings to our previous publication of CCATT trauma patients, and evaluate adherence before and after the publication of the CCATT Ventilator Management Clinical Practice Guideline (CPG).

Methods: We performed a retrospective chart review of ventilated non-trauma patients who were evacuated out of theater by Critical Care Air Transport Teams (CCATT) between January 2007 and April 2015. Data abstractors collected flight information, oxygenation status, ventilator settings, procedures, and in-flight assessments. We calculated descriptive statistics to determine the frequency of compliance with the ARDSNet protocol before and after the CCATT Ventilator CPG publication and the association between ARDSNet protocol adherence and in-flight events.

Results: We reviewed the charts of 124 mechanically ventilated patients transported out of theater via CCATT on volume control settings. Seventy percent (n=87/124) of records were determined to be Non-Adherent to ARDSNet recommendations predominately due to excessive tidal volume settings and/or high FiO_2 settings relative to the patient's PEEP setting. The Non-

Adherent group had a higher proportion of in-flight respiratory events. Compared to our previous study of ventilation guideline adherence in the trauma population, the Non-Trauma population had a higher rate of non-adherence to tidal volume and ARDSNet table recommendations (75.6% versus 61.5%). After the CPG was rolled out, non-adherence decreased to 59% (p=0.0496) from 76%.

Conclusions: CCATTs had low adherence with the ARDSNet guidelines in non-trauma patients transported out of the combat theater, but implementation of a Ventilator Management CPG was associated with improved adherence.

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Introduction

The United States Air Force's Critical Care Air Transport Teams (CCATTs) play a vital role in the transport and care of critically ill patients[1,2] both within the combat theater and out of theater to higher echelons of care. Each CCATT consists of an emergency medicine or critical care trained physician, an emergency or critical care nurse and a respiratory therapist, and can transport up to six non-ventilated patients or 3 ventilated patients.[1-3] Our previous research has demonstrated that over half (56%) of CCATT patients suffer critical illnesses unrelated to combat trauma.[4,5] There has been a consistent burden of disease and non-battle related injuries that dominates clinical care in the combat setting since WWII.[6-8] In a recent 10-year trend of CCATT missions, while mission numbers of non-trauma transports have remained relatively consistent, proportions of non-trauma missions have increased from 24% to 54%, many of which required airway and/or ventilation support. Mechanical ventilation during transport supports critically ill patients with respiratory failure, cardiac failure, stroke, and other indications.[9-12] However, providing mechanical ventilation in the resource constrained transport environment can present challenges.

Inappropriately managed mechanical ventilation can worsen Acute Lung Injury (ALI), Acute Respiratory Distress Syndrome (ARDS), and morbidity.[13-17] Protective ventilation methods are associated with improved patient outcomes.[15,17] To prevent ventilator-induced lung injury, the National Institutes of Health (NIH) and National Heart Lung and Blood Institute (NHLBI) provides a mechanical ventilation protocol summary, ARDSNet, with established criteria for ventilator setting management.[18] Previous research supports the efficacy of ARDSNet in reducing ALI, ARDS, ventilator days, and death.[13-17] Our previous study evaluated CCATT adherence to the ARDSNet protocol in trauma patients revealed that a deviation of protocol recommendations was associated with increased lung injury and mortality.[19]

This study was conducted to determine CCATT ARDSNet adherence during aeromedical evacuation of mechanically ventilated non-trauma patients. We hypothesized that CCATT's ARDSNet compliance is greater with non-trauma patients than trauma patients.

Methods

This study is an analysis of a subset population from a previous a retrospective chart review study evaluating patients without traumatic injuries transported from Iraq or Afghanistan to Germany between January 2007 and April 2015.[4] The subset population comprised of patients without traumatic injuries that were transported by CCATT and required mechanical ventilation en route. To achieve our study objective of determining CCATT ARDSNet adherence in the patient population without traumatic injuries, we used similar methodology as that performed in our previous study evaluating CCATT ARDSNet adherence in the traumatic patient population.[19] This study was approved by the US Army Military Research Materiel Command Institutional Review Board.

We screened CCATT flight medical records to identify patients that did not sustain traumatic injuries and required mechanical ventilation during transport out of the combat theater to Landstuhl Regional Medical Center (LRMC) in Germany. We excluded patients who were ventilated using pressure control mode.

Using a study specific electronic database (Microsoft Excel 2010; Microsoft Corporation, Redmond, Washington) with pre-defined fields we abstracted data from records to include demographics, injury description, departure and arrival locations, clinical parameters, medications, procedures, laboratory measures, dates, and timestamps as available for pre-flight and in-flight data points. We included all available ventilator-related data such as mode, tidal volume, positive end-expiratory pressure (PEEP), fraction of inspired oxygen (FiO_2), and subject oxygenation measures along with timestamps. Using documented height, we calculated ideal body weight and tidal volume. Abstractors were trained to interpret CCATT medical records and used standardized tools to determine medical events of interest.[4] Data collected were based on provider documentation on the CCATT medical record (Air Force Form 3899). Routine quality control measures were implemented to ensure accuracy and consistency of data collection.[20,21] In our previous study, we obtained outcome data from the Department of Defense Trauma Registry (DoDTR). Since a registry for patients without traumatic injuries that necessitated care in theater does not exit, we used inpatient and outpatient data medical records (Essentris and AHLTA computer systems, respectively) to determine post-flight disposition of our study subjects. Post-flight data included oxygenation measures and complications as available. Complications and adverse events were determined based on standards set by our previous study.[19] When available, outcome data included total number of ventilator days, total number of intensive care unit days, total number of hospital days, and mortality through 30 days. To compare length of hospitalization, we calculated the number of days subjects were not on ventilator (vent-free), not in the ICU (ICU-free), and not in the hospital (hospital-free) during a 28-day period following arrival at LRMC. For the non-surviving subjects vent-free, ICU-free, and hospital-free days defaulted to a value of zero. During our study window, a standardized CCATT Mechanical Ventilation Clinical Practice Guideline based upon the ARDSNet protocol was implemented in March of 2012;[19] therefore, we identified the records that were Pre- and Post-CPG implementation.

Statistics

Subjects were categorized based on ventilator setting compliance to ARDSNet recommendations with respect to tidal volume and PEEP-to-FiO_2 settings according to the low PEEP table.[18] Subjects whose tidal volumes were ≤8 cc/kg ideal body weight (IBW) and PEEP-to-FiO_2 ratios were in accordance with the ARDSNet table recommendations were considered Adherent. Non-Adherent with either parameter was considered Non-Adherent for this study.

We conducted statistical analysis using JMP version 10 (SAS Institute Inc., Cary, NC). Initial descriptive analyses were performed followed by comparative tests such as t-tests (or Wilcoxon for non-parametric data) for continuous variables and chi-square (or Fisher's Exact when appropriate) for categorical variables. Regression model analysis was limited to the records for which outcomes were available. As previously mentioned, a registry that integrates in-theater care with outcomes does not exist and there is greater heterogeneity in the trajectory of care following transport out of theater to include the transfer of a patient to a civilian healthcare system.

Results

Of the 672 non-trauma patients transported by CCATT, 21% (n=141) were documented as necessitating mechanical ventilation; however, for this analysis we only included records with flow sheets documenting ventilator settings during flight (n=130). We excluded six of the subjects that were ventilated on pressure control setting; therefore, our final study sample of non-trauma, ventilated patients was n=124. Seventy percent (n=87/124) of records were determined to be Non-Adherent to ARDSNet recommendations, predominately due to excessive tidal volume settings and/or high FiO_2 settings relative to the patient's PEEP setting (providers tended to use increases in FiO2 over PEEP to increase oxygenation). A third (33%) of PaO2 values were within a reference range (80-105 mmHg)—a third below (<80 mmHg) and a third above (>105 mmHg). More than three quarters (77%) of SpO2 values were above target range of 92-96% (Figure 1). Demographics were similar between Adherent and Non-Adherent groups (Table 1). The majority were active duty service members (57%) with the following primary diagnosis: neurologic, 31%; pulmonary, 29%; cardiac, 12%. Thirty-four percent had documentation indicating an existing infection. The Non-Adherent group had more patients with a neurologic diagnosis. We calculated proportions of records with diagnoses of more than one body system and determined that there was no difference between the Adherent and Non-Adherent groups.

Pre-flight, the Non-Adherent group had higher tidal volume and FiO_2 settings yet had equivocal oxygenation status compared to the adherent group (Table 2). In-flight, the Non-Adherent group continued to have higher tidal volume and FiO_2 settings with a lower PaO_2/FiO_2 ratio. Correspondingly, the Non-Adherent group had a higher proportion of in-flight respiratory events (Table 2). Temporal order of respiratory events suggested that non-adherence was not secondary to a respiratory event. Documentation in records indicated that 67% of the Non-Adherent group had pre-flight tidal volume settings higher than recommended prior to flight. Fifty-five percent of records did not have any documentation of tidal volume changes made in-flight. Of the records with documented tidal volume changes (45%, n=56), almost half (48%, 27/56) had only one documented change in-flight. About 60% (74/124) of the Non-Trauma population had at least one change made to their PEEP or FiO_2 settings; of those, more than half (51%, 38/74) had only one change in-flight.

The Non-Adherent group had a higher proportion of patients receiving paralytics. Over 40% (10/23) did not have any documentation detailing explicit reason for the use/administration of a paralytic during flight. Six records documented the use of paralytic en route as part of sedation management. Fifty-four percent (7/23) of the in-flight administrations of a paralytic was related to a respiratory event.

At end of flight and arrival to LRMC, there were no differences in oxygenation status. For the subjects with hospitalization outcomes available (n=72), there was no difference in incidence of respiratory events, ventilator days, ICU days, or hospitalization days. Two did not survive to 30-days following flight to LRMC (Adherent, n=1; Non-Adherent, n=1).

Trauma versus Non-Trauma

Compared to our previous study of ventilation guideline adherence in the trauma population,[19] the Trauma population was younger (median age of 25 versus 38 years, p<0.0001). In the Trauma population, the Non-Adherent group had a higher injury severity score yet did not differ in proportions of head- or inhalation-injury. The Non-Trauma population had a higher rate of non-adherence to tidal volume and ARDSNet table recommendations (Figure 2). While the median tidal volume was higher in the Trauma population compared to the Non-Trauma (575 versus 550; p=0.0040), PEEP (p<0.0001) and FiO_2 (p<0.0001) settings were higher in the Non-Trauma population. However, both populations had the same modal PEEP-to-FiO_2 setting (5 cm H_2O to 40%). The Non-Trauma population had a higher proportion of PaO_2 values below reference range (chi-square=7.6224, p=0.005765; Figure 3a) but a higher proportion of SpO_2 values within the ARDSNet recommended range of 92-96% (chi-square=9.07441, p=0.002592; Figure 3b). The Trauma population had a higher proportion of values above PaO_2 reference range (chi-square=9.82143, p=0.001725; Figure 3a); and, respectively, a higher proportion of SPO_2 values above the ARDSNet recommended range of 92-96% (chi-square=8.58943, p=0.003381; Figure 3b).

Post-CPG

A total of 41 subjects were transported following CPG implementation (Post-CPG). Post-CPG, adherence increased to 41% (p=0.0496) and of the non-adherent records, over 80% had only one time point that was not within CPG recommendations. Non-adherence persisted to be associated with the relative PEEP-to-FiO_2 settings.

Discussion

In our study of non-trauma CCATT mechanically ventilated patients, we found a decreased adherence to the ARDSNet protocol compared to our previous study of CCATT trauma patients.[19] Patients on non-adherent ventilator settings were more likely to have an in-flight respiratory event. However, following the implementation of a JTS CPG, adherence to the ARDSNet protocol improved. Based on previous civilian research[13-17] and our prior study of CCATT trauma patients,[19] ventilator management per the ARDSNet protocol may improve patient morbidity and mortality. Use of a standardized CPG during CCATT missions has the potential to improve non-trauma patient care.

As in our previous study of CCATT trauma patents, our study found a substantial rate of non-adherence with the ARDSNet protocol. This finding is similar to civilian studies evaluating ARDSNet compliance. In a study of patients with acute lung injury, Needham et al found that less than half of ventilator settings adhered to lung protective ventilation.[20] Similarly, compliance with 6 – 8 cc/kg IBW tidal volumes was less than 40% in patients enrolled in three large ARDS trials.[21] We were surprised to find even lower compliance in non-trauma CCATT patients than in trauma CCATT patients since the majority of research demonstrating ARDSNet protocol benefit has been in civilian non-trauma patients.[15-17]

There are several potential explanations for the low adherence rate. First, the ARDSNet protocol was developed to manage patients with ARDS/ALI. Most patients in our study did not have a primary pulmonary diagnosis and providers may have been less concerned with the potential for ventilator induced ARDS/ALI; however, several studies have shown the use of the ARDSNet protocol aids in preventing ARDS/ALI.[15-17] Second, non-adherence was commonly due to an elevated FiO2-to-PEEP ratio. Presumably, this is due to providers' predominate reliance on increases in FiO2 instead of PEEP to maintain adequate oxygenation. Since medical personnel rely on increasing oxygen administration to manage hypoxia when using nasal cannulas and non-rebreathing masks, they may become habitually comfortable using only increases in oxygen to maintain saturation. Theoretically, relying on FiO2 increases over increases in PEEP may result in excessive free radical generation, inflammatory changes, and lung injury.[25,26] However, in contrast to our study of CCATT trauma patients, patients in this study less frequently had oxygen saturations above 96%, indicating that CCATTs were appropriately limiting oxygen levels within recommended parameters,[18] and thereby potentially preventing lung injury. Additionally, two thirds of patients in the non-adherence group were on non-adherent ventilator settings prior to the CCATT assuming care of the patient. Our findings serve to highlight the importance of adjusting ventilator settings as needed to appropriate parameters within ARDSNet protocol during transfers of care.

We found a statistically significant improvement in ARDSNet protocol adherence following the publication of the CCATT Ventilator CPG in 2012[22] indicating CPGs may be an effective tool to improve patient care. The Air Force has implemented multiple efforts to further improve ARDSNet protocol adherence. Following the publication of our previous study evaluating ventilator management of CCATT trauma patients in 2018,[19] the CCATT Pilot Unit implemented a process improvement (PI) project in which the CCATT pilot unit reviews CCATT medical records and generates reports documenting ARDSNet adherence. These reports are provided to CCATTs and Air Force leadership. Just as the CPG was associated with an improvement in ARDSNet protocol adherence, we anticipate similar success with the PI project. Additionally, the CCATT training platforms increased their emphasis of ARDSNet adherence during initial and refresher CCATT training. We are currently abstracting CCATT medical records from 2015 to present to evaluate the efficacy of the PI project and will publish our findings upon completion. In the future, reference cards attached to the ventilator or handheld device applications may assist improving adherence. Finally, the Air Force is engaged in ongoing efforts to develop automated closed loop and decision support ventilator systems which will adjust PEEP and FiO2 per the ARDSNet protocol thereby freeing CCATT personnel to focus efforts on other aspects of critical care.[11]

Our study has several limitations, the most significant of which is the lack of outcome data. While our study found an increase in in-flight events in those patients non-adherent to the ARDSNet protocol, the clinical significance of this finding is unknown. Since non-trauma CCATT patients are frequently not active duty military personnel, they are often transferred to the civilian medical system resulting in a lack of outcome data. Additionally, while the Joint Trauma System manages the Department of Defense Trauma Registry, there is no equivalent for non-trauma casualties. Given the historical propensity of disease and non-battle injury (DNBI) to account for the majority of casualties,[27,28] current involvement of the US military in the COVID-19 pandemic response efforts,[29] and the anticipated future prolonged field care environment[30] where casualties will be at greater risk of harm from infection and multi-organ dysfunction syndrome (MODS), the establishment of a non-trauma registry or expansion of the current DoDTR to include all casualties (trauma and non-trauma) may be prudent. An additional limitation of our study is its retrospective design. The data was abstracted from the CCATT record creating the potential for missing data due to a lack of documentation. Additionally, while data abstractors were trained and periodic quality reviews occurred, the potential for subjectivity in data abstraction remains.[20,21]

Conclusions

CCATT adherence with the ARDSNet guidelines in non-trauma patients was 20% and was lower compliance than in the CCATT trauma patients. Implementation of a Clinical Practice Guideline was associated with improved adherence to the ARDSNet guideline.

Author Contributions

J.M. provided study oversight. J.M., A.M., & C.P. designed the study. J.M performed the literature review. K.M. and J.P. performed the chart abstraction. A.M. performed the data analysis. C.P. and A.M. performed quality assurance review. All authors were involved in data interpretation, writing, and critical revisions.

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Table 1: Demographics and Diagnoses of Ventilated Non-Trauma CCATT Patients

	Overall Mean±SD; Median [IQR] or % (95% CI) n=124	**Tidal Volume and ARDSNet Table Adherent** Mean±SD; Median [IQR] or % (95% CI) n=37	**Tidal Volume and ARDSNet Table Non-Adherent** Mean±SD; Median [IQR] or % (95% CI) n=87	**p-value***
Age	38±13.3; 35 [26-51]	37±13.0; 35 [26-47]	38±13.6; 35 [25-51]	0.9455
Gender, % male	88% (81-93%)	86% (72-94%)	89% (80-94%)	0.7545
Active Duty	57% (48-65%)	49% (33-64%)	60% (49-69%)	0.2542
Contractor	32% (24-41%)	32% (20-49%)	32% (23-43%)	0.9784
Diagnoses				
Cardiac	12% (8-19%)	5% (1.5-18%)	15% (9-24%)	0.1476
Pulmonary	30% (23-39%)	19% (9-34%)	34% (25-45%)	0.0823
Neurologic	31% (23-40%)	49% (33-64%)	24% (16-34%)	0.0068
Other	28% (21-36%)	27% (15-43%)	28% (20-39%)	0.8910
Infection	34% (26-43%)	30% (17-46%)	35% (26-46%)	0.5474
>1 Diagnosis	12% (8-19%)	5% (2%-18%)	15% (9-24%)	0.1476
Flight				
Hours En route	7.7±2.12; 7.8 [6.5-9]	7.8±1.85; 7.7 [6.7-9.0]	7.7±2.24; 7.7 [6.3-9.0]	0.9366
Altitude Restrictions	6% (3-11%)	5% (2-18%)	5% (2-11%)	1.0000

*Comparison of characteristics between ARDSNet adherent and non-adherent subjects.

SD, standard deviation; IQR, interquartile range; CI, confidence interval

Table 2: Pre-flight and In-flight of Ventilated Non-Trauma CCATT Patients

	Overall Mean±SD; Median [IQR] or % (95% CI) n=124	**Tidal Volume and ARDSNet Table Adherent** Mean±SD; Median [IQR] or % (95% CI) n=37	**Tidal Volume and ARDSNet Table Non-Adherent** Mean±SD; Median [IQR] or % (95% CI) n=87	**p-value**
Pre-flight Ventilator Settings				
Ventilator Rate	17±4.0; 18 [14-20]	18±4.0; 18 [16-21]	17±3.8; 16 14-19]	0.0598
Tidal Volume, ml	555±90; 550 [500-600]	525±76; 520 [500-552]	567±93; 550 [500-600]	0.0107
FiO_2, %	51±18; 45 [40-60]	44±12; 40 [40-50]	54±20; 50 [40-60]	0.0018
PEEP, cm H_2O	7±2.8; 5 [5-8]	7±3.5; 5 [5-10]	6±2.3; 5 [5-8]	0.0687
Pre-flight Oxygenation Status				
SPO_2, %	97±6.8; 98 [96-100]	98±2.3; 98 [97-100]	97±8.0; 98 [96-100]	0.5916
PaO_2, mmHg	107±45; 94 [76-127]	103±38; 95 [76-124]	109±49; 95 [76-134]	0.8176
PCO_2, mmHg	42±8.5; 41 [37-45]	42±9; 41 [36-48]	42±8.3; 41 [37-45]	0.3823
HCO_3, mEq/L	24±4.0; 24 [22-26]	24±3.5; 25 [23-26]	24±4.1; 24 [22-26]	0.1901
Base Deficit/Excess, mEq/L	-1.5±4.7; -1.0 [-4.0-1.5]	-0.4±4.1; -0.5 [-2.8-1.8]	-2.0±4.8; -2.0 [-5.0-1.5]	0.1324
PaO_2/FiO_2	231±107; 203 [153-298]	243±112; 236 [157-309]	227±104; 200 [154-298]	0.4449
Pre-flight Event				
Respiratory Event*	57% (48-65%)	43% (29-59%)	62% (51-72%)	0.0570
Cardiac Event	26% (19-35%)	16% (8-31%)	31% (22-42%)	0.0806
Neurologic Event	40% (32-49%)	47% (33-64%)	37% (27-48%)	0.2272
Infection Event	25% (19-34%)	24% (13-40%)	25% (17%-35%)	0.9367
In-flight Medications				
Paralytic	19% (13-26%)	5.4% (1.5-17.7%)	24% (16-34%)	0.0199
Cardiac Drip**	27% (20-35%)	32% (20-49%)	24% (16-34%)	0.3100

Vasopressor	20% (14-28%)	19% (9.5-34.2%)	20% (13-30%)	0.8899
In-flight Ventilator Settings				
Num. of timestamps	7.7±2.3; 8 [6-9]	7.8±1.6; 8 [7-9]	7.7±2.5; 8 [6-10]	0.7657
Ventilator Rate	18±3.4; 18 [16-20]	18±3.5; 18 [16-20]	17±3.4; 17 [16-19]	0.2868
Tidal Volume	553±77; 550 [500-600]	526±70; 542 [473-550]	565±77; 553 [501-601]	0.0123
FiO_2, %	52±13; 50 [40-60]	44±8.6; 40 [40-50]	55±14; 51 [45-64]	<0.001
PEEP, cm H_20	7±2.7; 50 [40-60]	7.6±3.2; 6.5 [5-9.5]	6.7±2.5; 5 [5-8]	0.2278
In-flight Oxygenation Status				
SPO_2, %	98±1.9; 98 [97-99]	98±2.0; 99 [97-99]	98±1.9; 98 [97-99]	0.5399
PaO_2, mmHg	104±65; 89 [75-113]	100±33; 96 [83-108]	105±75; 86 [74-114]	0.5075
PCO_2, mmHg	42±15; 41 [37-45]	46±26; 40 [37-45]	41±5.8; 41 [38-44]	0.8321
HCO_3, mEq/L	24±4.0; 24 [21-27]	24±4.1 24 [21-27]	24±3.9; 24 [21-26]	0.4196
Base Deficit/Excess, mEq/L	-1.2±4.6; -1.0 [-4.5-2.0]	-0.4±4.3; -0.7 [-3.6-2.7]	-1.4±4.6; -1 [-4.5-1.4]	0.3497
PaO_2/FiO_2	213±146; 179 [132-259]	235±117; 225 [171-263]	202±158; 165 [123-238]	0.0080
In-flight Event				
Respiratory Event†	19% (13-26%)	2.7% (0.5-13.8%)	25% (17-35%)	0.0038
Cardiac Event	72% (63-79%)	64% (49-78%)	75% (65-83%)	0.2434
Neurologic Event	6.5% (3.3-12.3%)	2.7% (0.5-13.8%)	8% (4-16%)	0.4328
Renal/Urinary Event	17% (11-25%)	14% (5.9%-28%)	18% (12-28%)	0.6053

*Pre-flight respiratory events inclusive of acute hypoxemia, desaturation, patient ventilator dysynchrony, acidosis, mucous plug

**Cardiac drips includes intravenous vasopressors, antihypertensives, and antiarrhythmics.

†In-flight respiratory events inclusive of acute hypoxemia, desaturation, patient ventilator dysynchrony, acidosis, mucous plug

SD, standard deviation; IQR, interquartile range; CI, confidence interval; positive end-expiratory pressure, PEEP

Table 3: Outcomes

	Overall Mean±SD; Median [IQR] or % (95% CI) n=72	**Tidal Volume and ARDSNet Table Adherent** Mean±SD; Median [IQR] or % (95% CI) n=18	**Tidal Volume and ARDSNet Table Non-Adherent** Mean±SD; Median [IQR] or % (95% CI) n=53	**p-value**
Post-flight Events				
Respiratory Event*	46% (35-57%)	39% (20-61%)	49% (36-62%)	0.4531
ARDS	17% (10-27%)	22% (9-45%)	15% (8-27%)	0.4845
ARF	36% (26-48%)	28% (12-51%)	40% (28-53%)	0.4116
VAP	1% (0.2-7%)	0% (0-0%)	2% (0.3-10%)	1.0000
ARDS/ARF/VAP	46% (35-57%)	39% (20-61%)	49% (36-62%)	0.4549
Hospitalization†				
Vent-free Days	23±4.6; 25 [22-25]	21±8.4; 23 [22-25]	24±2.0; 25 [23-26]	0.0748
ICU-free Days	22±5.9; 24 [22-25]	20±8.3; 22 [22-24]	23±5.1; 24 [21-25]	0.2489
Hospital-free Days	19±8.1; 22 [16-24]	20±8.6; 23 [22-24]	18±8.0; 20 [16-24]	0.2095

*Post-flight respiratory events obtained from Essentris and AHLTA; pulmonary edema, pleural effusion, ARDS, ARF (acute respiratory failure not specified), and VAP.

†Aggregate of LRMC and CONUS hospital stays as available.

SD, standard deviation; IQR, interquartile range; CI, confidence interval; ARDS, acute respiratory distress syndrome; ARF, acute respiratory failure; VAP, ventilator-acquired pneumonia; ICU, intensive care unit