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En route Care Research Center

SCIENTIFIC AND TECHNICAL REPORT

M-10373: An evaluation of TACEVAC pre-hospital care and its effect on clinical outcomes: Evidence to support future clinical practice guidelines (CPGs)

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September 2018

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14. ABSTRACT
Background: Medical evacuation (MEDEVAC) is the movement and en route care of injured and medically compromised patients by medical care providers via helicopter. Military MEDEVAC platforms provide life-saving interventions that improve survival in combat. There is limited evidence to support decision making related to en route care and allocation of resources. The association between provider type and en route care is not well understood. Our objective was to describe MEDEVAC providers and identify associations between provider type, procedures performed, and outcomes. Methods: We conducted an IRB approved, retrospective record review of patients traumatically injured in combat, evacuated by MEDEVAC from the point of injury POI, between 2011 and 2014. Data abstracted included injury description, provider type, procedures performed, medications administered, survival, and 30-day outcomes. Subjects were grouped according to provider type: Medics, Paramedics, and ADV (advanced providers to include nurses, physician assistants, and physicians). Groups were compared. Analyses were performed using chi-square tests for categorical variables and ANOVA tests (Kruskal-Wallis tests) for continuous variables. A p-value < 0.05 was considered significant. Results: MEDEVAC records were reviewed and data were abstracted from 1,237 subjects. The providers were comprised of Medics 76%, Paramedics 21%, and ADV 4%. Patient and injury demographics were similar among groups. ADV were most likely to perform intubation,

chest needle decompressions ($p < 0.0001$), and hypothermia prevention ($p = 0.01$). Paramedics were most likely to administer blood en route ($p < 0.0001$). All other procedures were similar between groups. Paramedics were most likely to administer ketamine ($p < 0.0001$), any analgesic ($p < 0.0001$), or any medication en route ($p < 0.0001$). Incidence rates of en route events (pain, hypoxia, abnormal hemodynamics, vital signs) were similar between provider types. In theatre and 30-day survival rates were similar between provider types. Conclusion: Providers with higher level training were more likely to perform more advanced procedures during en route care. Our study found no significant association between provider type and in theater or 30-day mortality rates. Upon subgroup analysis, no difference was found in patients with an ISS > 16. More evidence is needed to determine the appropriate level of MEDEVAC personnel training and skill maintenance necessary to minimize combat mortality.

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SUMMARY

The “golden-hour policy” was implemented in 2009 to decrease mortality. As part of this policy, the Air Force Pararescuemen (PJs) with paramedic training were fully integrated to support the MEDEVAC mission in theater. This change provided the United States with two primary rotary MEDEVAC platforms: the US Army emergency medical technician (EMT)–led DUSTOFF and the US Air Force paramedic–led PEDRO. Previous studies have compared patient outcomes between evacuation platforms and/or provider type during en route care. The results are mixed and do not definitively answer the questions related to best practices for provider level during en route care. The goal of our study was to compare outcomes and procedures performed by provider type, based on direct data abstraction from the MEDEVAC patient care record (PCR).

We conducted a retrospective review of MEDEVAC patient care records (PCRs) for US military personnel injured in the Operation Enduring Freedom theater of operations between January 2011 and March 2014. Patients killed in action were excluded from the study. Patient data from the point of injury (POI) to the first military treatment facility (MTF) were abstracted from PCRs by trained research team members. Data were analyzed based on study group categorization as medic (EMT-B, EMT-I), paramedics (EMT-P, Special Ops, PJs), and ADVs (nurses, physicians, physician assistants).

Results:

- 1,237 MEDVAC records reviewed; Medics (76%, n = 940) were the predominant provider type followed by paramedics (21%, n = 257) and ADVs (3%, n = 40).
- The MEDEVAC records were of males (99%), 24 (SD, 5.1) years of age with blast-related injuries (69%), and an average ISS of 14.
- There were no differences when demographics, injury type, and severity were compared across the three study groups.
- The average time of care provided by en route care team (team arrival to MTF arrival) was 22 minutes, and the average time from dispatch call to arrival to MTF was less than 50 minutes.
- Provider type was not associated with a difference in number of ventilator days, ICU days, or hospital days.
- Survival to discharge from theater and final survival rates were similar across all provider types.
- Similar findings were identified when a subset of patients (ISS \geq 16) was compared.

Conclusions: Overall, the outcomes of our groups are similar between provider types.

The similarity may be due to the fact that all transports were within the “Golden Hour.”

Note: Our findings are limited to injured US military personnel (likely protected with body armor, thereby decreasing thoracic-abdominal injury), with an average evacuation time of less than 50 minutes.

Evidence Based Recommendations: In future military conflicts, longer transport times and prolonged field care scenarios may have a significant impact upon required en route care and ultimately survival. Under these circumstances, a greater benefit of advanced medical personnel may become more evident.

2.0 INTRODUCTION

Medical evacuation (MEDEVAC) involves the movement and en route care of injured and medically compromised patients via helicopter. Prior to 2009, the Army was primarily responsible for in theater MEDEVAC operations. In 2009 per the directive of the Secretary of Defense Robert M. Gates the “golden hour policy” was implemented to decrease mortality. As part of this policy, the Air Force Pararescuemen (PJs) with paramedic training were fully integrated to support the MEDEVAC mission in theater. (1) This change in policy and reallocation of resources provided the US with two primary rotary medical evacuation platforms during the Afghanistan conflict; the US Army emergency medical technician (EMT)-led DUSTOFF and the US Air Force paramedic-led PEDRO. (2,3)

Mabry et. al. (2012) completed one of the earliest studies evaluating outcomes related to the level of provider rendering en route care in theater in Afghanistan. The National Guard teams were staffed with critical care trained flight paramedics (CCFP), while the Army MEDEVAC teams were staffed with EMTs trained at the basic level. The 48 hour mortality rate in the group treated by CCFPs was almost half that of the group treated by EMTs (8% vs 15%, $p = 0.011$). The overall analysis included two categories of patients, US/NATO military ($n= 215$) and Afghan military and civilians ($n=456$). A subgroup analysis of patient category revealed no difference in mortality between evacuation systems in the US/NATO military group. However, the mortality rate in the Afghan patients transported by Army MEDEVAC was significantly higher than those transported by the CCFP team. The authors report the military patients who died under the care of the CCFP team trended to a greater severity of injury (mean ISS 36 vs. 22), but the difference was not statistically significant.(4) It is also likely that the US military personnel had more protective gear and combat first aid training than their Afghan counterparts.

Through the efforts of Mabry, Gerhardt, and others, paramedic-level training was incorporated into the initial flight medic training of DUSTOFF medics 2012. (5) Prior to this, the minimum requirement to begin Army flight medic (AFM) training was one year of experience. It was possible for a flight medic to be deployed with little to no experience beyond what had been simulated during training. (5) A new program course at Fort Sam Houston started in February of 2012 provided additional paramedic and critical care training to promote all skill competencies at EMT-Intermediate/Paramedic level and led to Critical Care Flight Paramedic (CCFP) certification. (6)

The impact of the initiation of paramedic level training of DUSTOFF medics combined with the increased utilization of PEDRO paramedics requires scientific evaluation. Prior studies evaluating provider type compared platforms because the provider type consistently matched the platform: DUSTOFF = EMT and PEDRO = Paramedic. (2,12,13). Since the change in training and the deployment of paramedics on some DUSTOFF platforms, that premise is no longer true. Our study includes patients transported between 2011 and 2014. The first class from the advanced training program graduated in December 2012, however there is no way of knowing the exact timing and rate of deployment of Army paramedics to the field. Examination of en route care documentation is necessary to determine the type of en route care provider on a DUSTOFF mission.

The goal of our study was to compare outcomes and procedures performed by provider type, based on direct data abstraction from the MEDEVAC patient care record. In addition, this is the first study to evaluate 30-day outcomes, including mortality, based upon provider type.

3.0 METHODS

3.1 Study Design and Setting

Our study was approved by the Medical Research and Materiel Command (MRMC) Institutional Review Board (IRB). We conducted a retrospective review of MEDEVAC patient care records (PCRs) for US military personnel injured in Operation Enduring Freedom (OEF) between January 2011 and March 2014.

3.2 Selection of Participants

A list of potential subjects for the study was obtained from the Joint Trauma System (JTS) and evaluated for inclusion in the study. Patients killed in action were excluded from the study. An additional 65 patients were excluded due to incomplete records.

3.3 Measurements

Patient data from the point of injury (POI) to the first military treatment facility (MTF) was abstracted from PCRs by trained research team members and entered into an electronic database (Microsoft Excel 2010, Redmond, WA). Data points included demographics, injury description, provider type, procedures, medications administered, clinical events, analgesics administered, and in-theater and final survival. Additionally, procedure and medication data were differentiated by whether they were performed at the POI, en route to the MTF, or at an unknown time. Clinical events were identified from provider narrative and descriptions of events documented in the PCR. Missing or unavailable data was reconciled through the use of the Theater Medical Data System (TMDS). A quality assurance (QA) process was implemented to ensure consistency among abstractors to include secondary abstractors to review 100% of records. (7)

3.4 Outcomes

Outcome data were obtained from the Department of Defense Trauma Registry (DoDTR). Data obtained included vital signs, complications, ventilator days, intensive care unit (ICU) days, hospital days, mortality, and disposition at discharge from each MTF and up to 30 days.(8)

3.5 Analysis

Based on input from our research working group and review by subject matter experts from the three military branches, subjects were placed into one of three groups based on the type of provider rendering care en route. Subjects treated by a provider with the designation EMT-B or EMT-I were placed in the Medic group; EMT-P, Special Ops, and PJ were designated as Paramedics; Registered Nurses, Physicians, and Physician Assistants were grouped as ADV. The provider type groups were compared utilizing subject mechanism of injury and injury severity scores (ISS), transport details, procedures performed, en route events, and analgesics administered.

We conducted a descriptive review of the data. Statistical analysis was performed with JMP version 10 (SAS Institute Inc., Cary, NC). Data were analyzed based on study group categorization as Medic, Paramedics, and ADV. Data were reported as either percentages or mean±standard deviation (SD) and median [interquartile range (IQR)]. Analyses for categorical data were performed using the chi-square test or Fisher's Exact test for small counts. Following Shapiro-Wilks test for normality, continuous variables were analyzed using ANOVA or the nonparametric equivalent, Kruskal-Wallis test. We considered a $p < 0.05$ as significant.

4.0 RESULTS

4.1 Characteristics of Study Participants

We reviewed 1267 MEDEVAC records of U.S. casualties. We could not identify the level of provider in 30 records and thus removed the records from our study analysis. We included 1,237 MEDEVAC records in our study. Medics (76%, n=940) were the predominant provider type followed by Paramedics (21%, n=257) and ADV (3%, n=40). The MEDEVAC records were of males (99%), 24±5.1 years of age with blast-related injuries (69%) and an average ISS of 14. There were no differences when demographics and injury type and severity were compared across the all three study groups (Table 1).

Table 1. Demographics

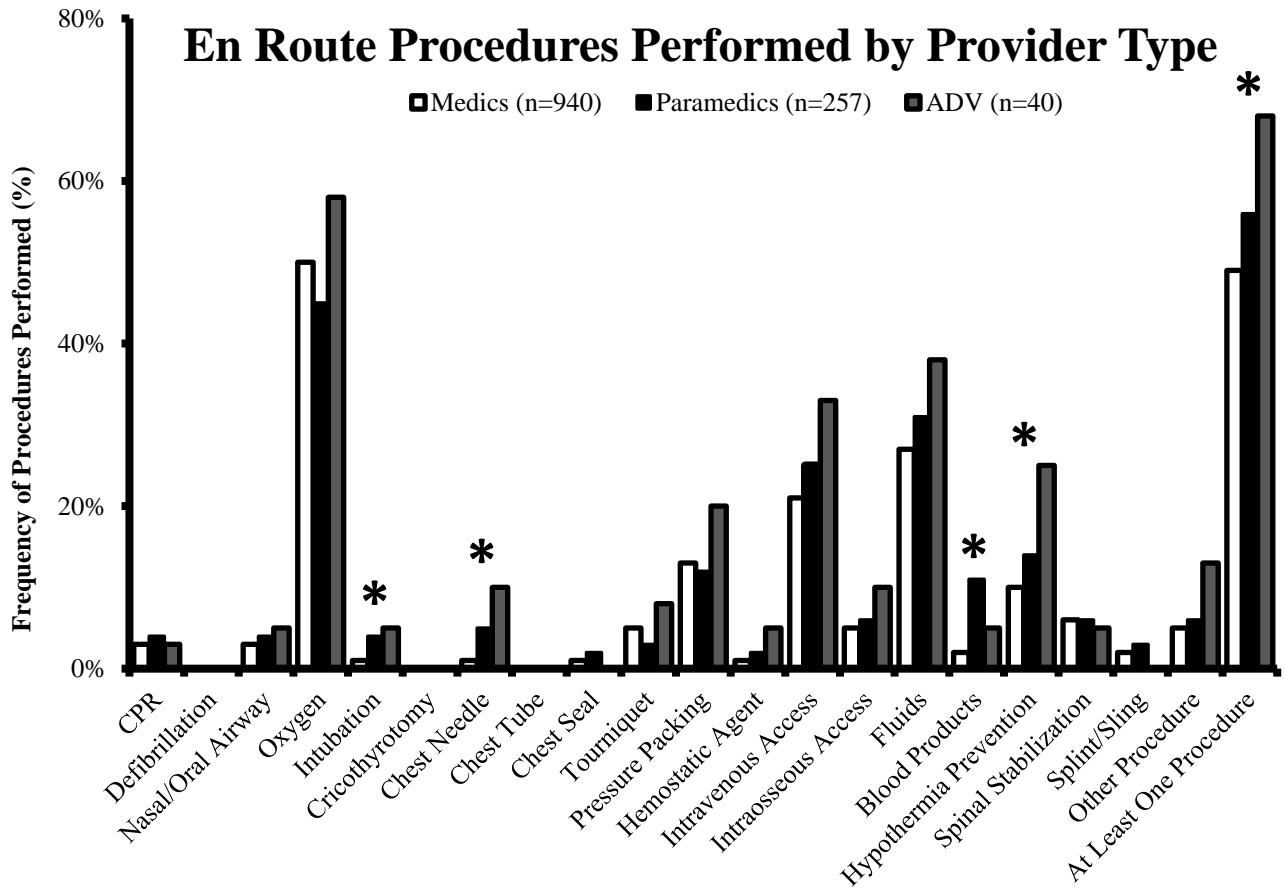
	Medics Mean±SD, Median [IQR]; n=940	Paramedics Mean±SD, Median [IQR]; n=257	ADV Mean±SD, Median [IQR]; n=40	p-value
Age	25±5.1, 24 [21-27]	25±4.9, 24 [22-28]	26±6.6, 26 [22-29]	0.49
Gender (male)	99%	98%	100%	0.46
Injury Description				
ISS	14±13.8, 10 [5-19]	14±13.2, 9 [5-10]	17±17.1, 10 [5-22]	0.89
<10	49%	52%	49%	0.76
11-19	26%	23%	13%	0.11
20-29	14%	12%	23%	0.22
30-75	11%	13%	15%	0.53
Blast	71%	65%	60%	0.09
Penetrating	26%	32%	40%	0.05
Blunt	2%	2%	0%	0.39
Burn	<1%	<1%	0%	0.85
Transport				
DUSTOFF	100%	36%	85%	<0.0001
PEDRO	0%	64%	15%	<0.0001
POI to MTF Arrival (minutes)	23±55.5, 15 [11-21]	18±10.9, 15 [11-20]	18±11.1, 16 [12-19]	0.25
Dispatch Call to MTF Arrival (minutes)	49±60.1, 37 [29-49]	44±22.6, 44 [32-55]	50±33.8, 41 [32-46]	<0.001
Transport to Role II	60%	31%	65%	<0.0001
Transport to Role III	40%	69%	35%	<0.0001

ADV, advanced level providers; ISS, injury severity score; POI, point of injury; MTF, military treatment facility.

4.2 Main Results

The average time of care provided by en route care team (Team arrival to MTF arrival) was 22 minutes and the average time from dispatch call to arrival to MTF was less than 50 minutes. Almost 50% of patients received oxygen support en route. ADV were most likely to intubate, perform chest needle decompression, and provide hypothermia prevention en route (Figure 1). Paramedics were most likely to administer blood en route. There were no differences between groups with regards to chest tube, chest seal, tourniquets, CPR, cricothyrotomies, intravenous fluids, oxygen support, spinal stabilization, vascular access, pressure packing. Medics were least likely to administer ketamine, any analgesic, or any medication en route (Table 2). In contrast, Paramedics were most likely to administer ketamine, any analgesic, or any medication en route.

Figure 1



	 Medic Mean±SD, Median [IQR] n=940	 Paramedic Mean±SD, Median [IQR] n=257	 ADV Mean±SD, Median [IQR] n=40	p-value
Number of Procedures	1.1±1.3, 0 [0-2]	1.4±1.7, 1 [0-3]	1.8±1.9, 1 [0-2]	0.002

ADV, advanced level providers; CPR, cardiopulmonary resuscitation; SD, standard deviation; IQR, interquartile range.

Other Procedures, pelvic binder, suction, eye protection, and wound dressing.

*p<0.05

Table 2. Medications

	Medics % of Patients n=940	Paramedics % of Patients n=257	ADV % of Patients n=40	p-value
Morphine	7%	6%	3%	0.38
Hydromorphone	<1%	0%	0%	0.58
Fentanyl	12%	12%	25%	0.10
Ketamine	3%	28%	13%	<0.0001
Any Analgesic*	22%	46%	40%	<0.0001
Sedative†	<1%	2%	0%	0.10
Other Medications‡	6%	7%	5%	0.18
Any Medication§	24%	48%	43%	<0.0001

ADV, advanced level providers; CPR, cardiopulmonary resuscitation.

*Any Analgesic defined as the administration at least one of the following: morphine, hydromorphone, fentanyl, or ketamine.

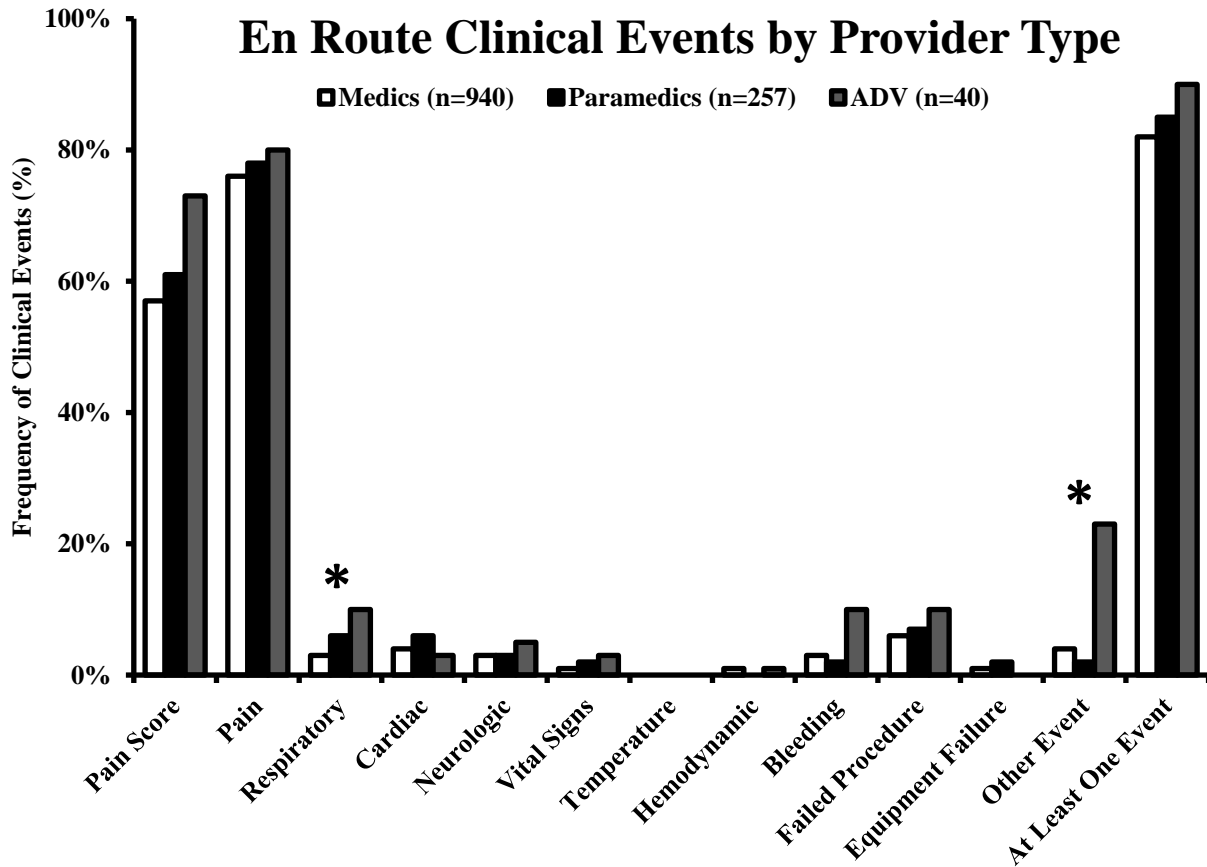
†Versed was the only sedative administered in this study population.

‡Other Medications defined as the administration of at least one of the following: induction agent, antibiotic, acetaminophen, or antiemetic.

§ Any Medication defined as the administration of at least one of the following: morphine, hydromorphone, fentanyl, ketamine, versed, paralytic, induction agent, antibiotic, acetaminophen, or antiemetic.

Respiratory and Other en route events were documented more frequently in the MEDEVAC records of patients transported by ADV (Figure 2). Incidence rates of en route events such as reported pain, hypoxia, abnormal hemodynamics, or vital signs were similar between provider types. Pain score was documented in 58% of all MEDEVAC records.

Figure 2



	□ Medic Mean±SD, Median [IQR] n=940	■ Paramedic Mean±SD, Median [IQR] n=257	▒ ADV Mean±SD, Median [IQR] n=40	p-value
Number of Events	1±0.7, 1 [1-1]	1±0.8, 1 [1-1]	1±1.1, 1 [1-2]	0.02

ADV, advanced level providers; SD, standard deviation; IQR, interquartile range. Other Event, combative patient, nausea, vomiting, pulled IV, priapism. *p<0.0

Provider type was not associated with a difference in number of ventilator days, ICU days, or hospital days (Table 3). Survival to discharge from theater and final survival rates were similar across all provider types. Similar findings were identified when a subset of patients (ISS ≥16) were compared.

Table 3. Outcomes

	Medics Mean±SD, Median [IQR], n; Total % (95% CI), (n/Total n)		Paramedics Mean±SD, Median [IQR], Total n; % (95% CI), (n/Total n)		ADV Mean±SD, Median [IQR], Total n; % (95% CI), (n/Total n)		Overall p- value	ISS ≥16 p-value
	Overall n=940	ISS ≥16 n=310	Overall n=257	ISS ≥16 n=81	Overall n=40	ISS ≥16 n=16		
Ventilator Days	3±6.2, 0 [0-3], n=855	6±9.1, 3 [1-8], n=302	2±4.6, 0 [0-3], n=233	6±6.2, 4 [1-10], n=77	2±5.4, 0 [0-3], n=36	6±7.3, 4 [1-8], n=14	0.6205	0.8359
ICU Days	5±9.6, 1 [0-7], n=855	12±13.1, 8 [4-15], n=302	5±7.7, 0 [0-8], n=233	11±9.4, 9 [6-16], n=77	6±9.8, 1 [0-9], n=36	14±11.8, 12 [4-23], n=14	0.7385	0.5737
Hospital Days	20±22.6, 11 [5-28], n=855	35±28, 32 [13-47], n=302	18±20, 9 [5-27], n=233	33±25.0, 32 [10-48], n=77	14±13.4, 8 [4-19], n=36	22±16.2, 16 [7-36], n=14	0.4159	0.2176
Survival								
In-Theater Survival	95% (93-96%), (888/937)	96% (94-98%), (298/310)	93% (89-95%), (237/256)	96% (90-99%), (78/81)	93% (80-97%), (37/40)	88% (64-97%), (14/16)	0.3858	0.1977
30-Day Survival	94% (92-95%), (839/897)	93% (90-95%), (287/308)	92% (88-95%), (230/250)	95% (88-98%), (76/80)	89% (78-96%), (34/38)	80% (55-93%), (12/15)	0.4980	0.3750

ADV, advanced level providers; IQR, interquartile range; CI, confidence interval; ISS, injury severity score; ICU, intensive care unit.

5.0 DISCUSSION

This is the first study conducted to compare 30-day outcomes between US military MEDEVAC provider types. Survival rates and 30-day outcomes were similar between medics, paramedics, and ADV. Similar findings were identified when a subset of patients (ISS ≥ 16) were compared. While ADV was most likely to intubate, perform intubations, and provide hypothermia prevention, paramedics were most likely to administer blood and ketamine en route.

Medics may be least likely to administer an analgesic due to lack of availability of any analgesic or limited analgesic options with the patient exhibiting contraindications to that medication. For example, a medic may only have access to morphine and may be reluctant to administer it to a hypotensive patient. During data abstraction, we noted that several medics recorded reluctance to administer an analgesic due to the patient's condition. It is likely that the patients' vital signs and responsiveness affected their decisions. Ensuring the availability of ketamine (less hypotension), or a drug with a similar adverse effect profile, to medics may increase the use of analgesics. Medics are also least likely to administer any medication en route. Medics are less likely to administer fluids, possibly due to a lack of availability or due to knowledge of increasing evidence of the benefit of hypotensive resuscitation.(9,10) Paramedics are most likely to administer blood products and ketamine en route. Again, this may be due primarily to an availability of the blood products or drugs. The ADV are least likely to administer morphine at POI but are most likely to administer Fentanyl at POI. This may be due to an increased availability of medications as well as the advanced providers experience with the common practice of using fentanyl over morphine in trauma patients due to its less significant effect on blood pressure.

Per Table 1, medics were more likely to take patients to a Role 2 facility (military treatment facility with forward resuscitation and surgical assets) and Paramedics were more likely to take patients to a Role 3 (combat surgical hospitals providing receipt, resuscitation, surgery & stabilization of casualties). This is likely due to the fact that many paramedics (especially PEDRO) operate out of bases at which the Role 3 is located. Given the implementation of the "golden hour rule" in 2009, this may potentially bias the results since patients injured at a location within one hour of a Role 3 facility may have better outcomes due to proximity to a higher level of care.

Medics are least likely to intubate the patient en route, and the ADV are most likely to intubate en route. This may be expected since the military medic curriculum does not include training to perform intubation. Therefore, maintaining skills to perform a cricothyrotomy is easier for medics given the lack of intubation practice. (11)

Several studies have compared MEDEVAC platforms including the UK physician-led medical emergency response team (MERT), PEDRO (paramedic) and DUSTOFF (EMT). (2,11,13) Apodaca, et al (2013) conducted a performance improvement study to compare in hospital mortality in patients transported via these three platforms in Southern Afghanistan from June 2009 to June 2011. However, this study did not compare DUSTOFF (medic providers) to PEDRO (paramedic based). A secondary analysis of this data compared shock indices between DUSTOFF and PEDRO and found only one difference; in the middle range Injury Severity Score (ISS) bin (10-25), the PEDRO group showed greater improvement from pre-hospital to admission. (10). Morrison, et al (2013) compared 30-day mortality in patients transported by US

MEDEVAC platforms to those transported by UK MERT but did not compare 30-day outcomes between DUSTOFF and PEDRO.

The paramedics in Dr. Mabry's study were civilian, critical care-trained flight paramedics with an average of nine years' experience who were compared to EMT-B trained medics. While DUSTOFF medics are currently being trained to the level of paramedic, it is unclear if they receive adequate refresher training or clinical experience outside the combat environment to maintain sufficient skills. Our study found no difference between provider type and outcomes. While Mabry found improved survival with the paramedic providers, this was only in the overall analysis when including medical and non-American patients. Within the subgroup of US/NATO trauma patients, his study found no significant difference in short-term outcome. As a result of the establishment of the DoDTR, we are able to compare 30 day mortality overall and across provider types. Our study found no significant difference in 30 day mortality among provider types. Non-American and non-trauma patients are not included in the registry; therefore our study may have failed to detect a difference in 30 day outcomes for all patient types.

Overall, the outcomes of our groups are similar between provider types. The similarity may be due to the fact that the confined space and limited payload of a Blackhawk/Pavehawk helicopter limits providers' capabilities. Advanced procedures that require a physician (central venous access, tube thoracostomy, rapid blood product transfusion) are not commonly performed in a closed space during brief transport periods. Furthermore, the golden hour policy limits the need for some life-saving interventions during transport. (14) In future conflicts, prolonged transport times and prolonged field care may result in one or both of two scenarios. The first may include the utilization of forward deployed, mobile surgical units. In this scenario, aeromedical assets may be transporting patients following surgical procedures which require more advanced care than typically provided by medics and paramedics. Such post-operative transport of ventilated patients with wound vacs, chest tubes, etc., may benefit from critical care trained nurses and physicians. The second scenario would involve providing advanced resuscitation in the aircraft. The UK has utilized the MERT team with good results to provide this care. Studies conducted in Australia, where prolonged transports are more common, have found benefit with more advanced clinical providers. (15) The ability to perform advanced resuscitation in a UH-60 or HH-60 helicopter is limited. The MERT team overcame this obstacle utilizing the Chinook. While the USAF has the Tactical Critical Care Evacuation Team TCCET team consisting of an emergency/critical care physician and nurse, this team currently lacks a designated airframe with sufficient space and equipment to enable it to reach its full potential. Military leaders should consider the development of specific units with the appropriate aeromedical platform in the event future conflicts result in prolonged transport times.

Our study found no difference in 30 day outcome between provider types, therefore one could argue against the need for advanced medical providers. However, it should be noted that our findings are limited to injured, US military personnel (likely protected with body armor thereby decreasing thoracic-abdominal injury), with an average evacuation time of less than 50 minutes. In future military conflicts, longer transport times may have a significant impact upon survival. The limited space and cargo capacity of MEDEVAC helicopters restricts the procedures performed; regardless

of the medical training of personnel onboard, larger evacuation platforms may be necessary. Under these circumstances, a greater benefit of advanced medical personnel may become more evident.

Limitations

Our study has several limitations. First, due to the logistical complexities of performing prospective combat MEDEVAC research, our study is retrospective. As such, we found no association between provider type and survival; however, we cannot assert causality. There is a potential for more critically injured patients to be selectively transported by advanced skilled providers; however, there was no significant difference in ISS between the provider types. Furthermore, the data was abstracted from the MEDEVAC record creating significant potential for missing data due to a lack of documentation by the en route care teams. While all data abstractors were trained and periodic quality reviews occurred, there remains the potential for subjectivity in data abstraction from the MEDEVAC patient care records. (7,8) In addition, during the period of our study there was no standardized DoD MEDEVAC chart. Variations in documentation practices between MEDEVAC units may impact the data extracted. The inability to conduct a prospective randomized trial for ethical and logistical reasons means our study may not account for differences in patient types between provider and unit types. Also, this study focused on military trauma patients and our results may not be generalizable to the civilian community. Civilian patients have significantly different traumatic injuries and medical ailments than those discussed in our study.

Conclusion

In our study of MEDEVAC flights, Medics were the most common provider type in the pre-hospital setting. ADV performed more chest needle decompressions, intubations, and hypothermia prevention. Paramedics were most likely to administer blood, ketamine, any analgesic, and any medication en route. Clinical outcomes for the patients in theater and at 30-days were similar among provider type. Similar findings were identified when a subset of patients (ISS \geq 16) were compared.

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APPENDIX A: Publications and Presentations

A.1 Publications

Maddry JK, Mora AG, Savell S, Reeves LK, Perez CA, Bebartá VS. Combat MEDEVAC: A comparison of care by provider type for en route trauma care in theater and 30-day patient outcomes. *J Trauma Acute Care Surg.* 2016 Nov;81(5 Suppl 2 Proceedings of the 2015 Military Health System Research Symposium):S104-S110. PMID: 27768659 DOI: 10.1097/TA.0000000000001119
<https://www.ncbi.nlm.nih.gov/pubmed/27768659>

Savell S, Mora AG, Perez CA, Bebartá VS, Maddry JK. En route intraosseous access in the combat setting. *Am J Disaster Med* 2016;11(4):225-231.
doi:10.5055/ajdm.2016.0243. PMID: 28140436
<https://www.ncbi.nlm.nih.gov/pubmed/28140436>

Hardy G, Maddry JK, Ng PC, Savell SC, Arana AA, Kester A, Bebartá VS. Impact of prehospital airway management on combat mortality. *Am J Emerg Med.* 2018;36:1032-1035. <https://doi.org/10.1016/j.ajem.2018.02.007>

A.2 Presentations

Reeves LK, Mora AG, Maddry JK, Bebartá VS. Analysis of Medevac Providers and Procedures Performed En Route from Point of Injury to a Military Treatment Facility in Combat. Poster. SURF, 2015

Maddry JK, Ervin AT, Perez CA, Ganem VJ, Mora AG, Nnamani NS, Russell SS, Medrano A, Bebartá VS. Analysis of MEDEVAC providers and procedures performed en route from point of injury to a military treatment facility in combat. Oral. MHSRS, 2015

Savell SC, Mora AG, Perez CA, Bebartá VS, Maddry JK. En Route Intraosseous Access Performed in the Combat Setting. Podium & Poster. TSNRP August 2016

Savell SC, Mora AG, Perez CA, Bebartá VS, Maddry JK. En Route Intraosseous Access Performed in the Combat Setting. Poster. MHSRS, August 2016

Kester AE, Ng P, Hardy G, Arana AA, Savell SC, Maddry JK. MEDEVAC Cricothyrotomy, Endotracheal Intubation, and Supraglottic Airway Outcomes for Operation Enduring Freedom: A Descriptive Analysis. Poster, Oral. SURF, 2017

Savell SC, Mora AG, Perez CA, Lear JD, Kester AE, Bebartá VS, Maddry JK. En Route Intraosseous Access Performed in the Combat Setting. Poster, Oral. SURF, 2017

Araña AA, Kester AE, Ng P, Hardy GB, Savell SC, Maddry JK. MEDEVAC Cricothyrotomy, Bag Valve Mask, and Supraglottic Airway Outcomes for Operation Enduring Freedom. Poster. MHSRS, 2017

Araña AA, Kester AE, Ng P, Hardy GB, Savell SC, Maddry JK. MEDEVAC Cricothyrotomy, Bag Valve Mask, and Supraglottic Airway Outcomes for Operation Enduring Freedom. Poster. GSACEP, 2018

Appendix B Brief Reports on Subanalysis

B.1 Impact of prehospital airway management on combat mortality

Hardy G, Maddy JK, Ng PC, Savell SC, Arana AA, Kester A, Bebartha VS. Impact of prehospital airway management on combat mortality. *Am J Emerg Med*. 2018 Feb 8. Pii:S0735-6757(18)30127-X doi: 10.1016/j.ajem.2018.02.007 [Epub ahead of print]

Background: Airway management is a potentially life-saving intervention in the resuscitation of critically ill trauma patients. Prehospital interventions to provide adequate ventilation and oxygenation in trauma patients has been linked to increased survival to hospital discharge. In the combat setting, airway compromise is the second leading cause of preventable death after hemorrhage. Combat medics can perform several prehospital lifesaving interventions to manage casualty airways; including cricothyrotomy, bag-valve-mask (BVM) ventilation, and supraglottic airway (SGA) placement. Despite multiple airway management options, the optimal prehospital airway intervention in the combat setting has not been well defined. **The purpose** of this study was to compare outcomes and 30-day survival between patients receiving cricothyrotomy, BVM, and SGA interventions in the prehospital combat setting.

Methods: The current study dataset (n=1267) was obtained from a previous study that included MEDEVAC patient information from point of injury to arrival at the first military treatment facility (MTF). We conducted a retrospective review of MEDEVAC patient care records (PCRs) for US military personnel injured in the Operation Enduring Freedom theater of operations between January 2011 and March 2014. We evaluated patients who received airway interventions prior to MTF arrival and compared outcomes among airway types. Ventilator-free, ICU-free, and hospital-free days were defined as the number of days from injury (day 1) to day 30 on which the patient did not require a ventilator, was not in the ICU, and was not in the hospital; patients who did not survive were assigned a score of 0.

Results:

- 1,267 MEDVAC records were reviewed of which 617(49%) required some form of pre-MTF airway intervention.
- Interventions included nasal/oral airway (n=535), ETI (n=4), BVM (n=28), SGA (n=22), and surgical cricothyrotomy (n=28).
- 77% of these procedures were performed by military medics
- Over half of all patients were completely unresponsive, and nearly half had an airway placed while in cardiac arrest.
- Patients who received a surgical cricothyrotomy had a higher military ISS than SGA patients, whereas BVM patients did not significantly differ from the other groups.

- Those with SGA placed experienced fewer vent-free days, ICU-free days, and hospital-free days compared to BVM and cricothyrotomy patients, though the groups did not significantly differ in survival rates.
- No difference in the odds for survival existed for BVM vs. SGA patients (OR 1.5, 95% CI 0.2-9.8), or cricothyrotomy vs. SGA patients (OR 3.9, 95% CI 0.6-24.9) in a logistic regression model adjusting for GCS.

Conclusions: SGA patients had higher morbidity demonstrated by fewer ventilator, hospital, and ICU free days than those receiving cricothyrotomy or BVM ventilation. There was no difference in survival between the airway groups.

Evidence Based Recommendations:

- Our data supports BVM ventilation as a possible alternative, as there was no difference in measured outcomes between the groups. Civilian studies further support the use of BVM over less invasive prehospital airway interventions.
- The use of SGAs should be reserved for patients who are unconscious, in cardiac arrest or after failed intubation with rapid sequence induction.
- Consider rather the space consumed by SGAs would be better reserved for other equipment with proven effectiveness in preventing combat mortality.
- It would be beneficial to perform prospective studies evaluating the use of various airway interventions on combat casualties.

B.2 En route intraosseous access performed in the combat setting

Savell S, Mora AG, Perez CA, Bebartá VS, Maddry JK. En route intraosseous access in the combat setting. *Am J Disaster Med* 2016;11(4):225-231. doi: 10.5055/ajdm.2016.0243. PMID: 28140436
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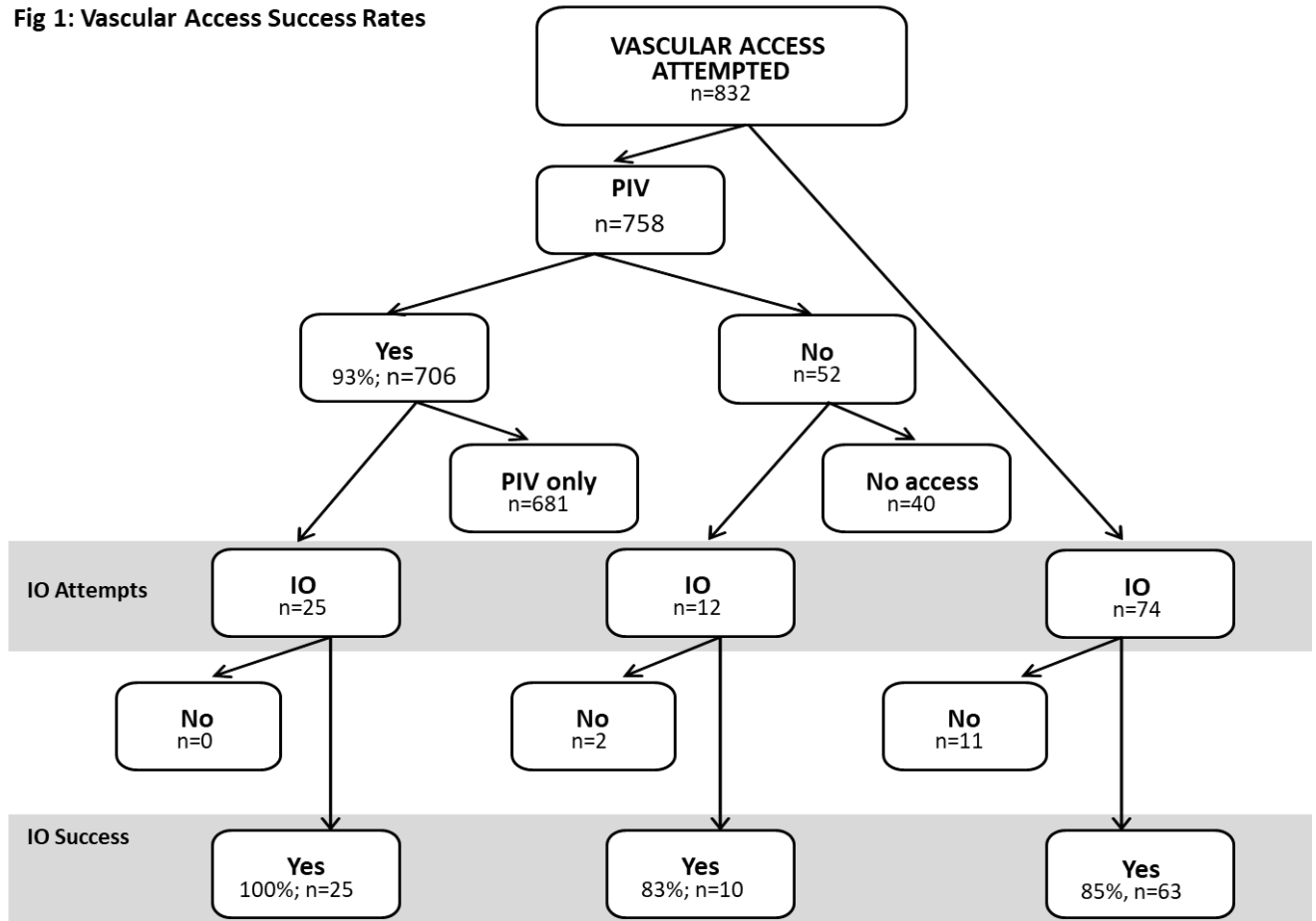
Background: Peripheral intravenous (PIV) access can be difficult to achieve in patients who have compromised venous circulation secondary to cardiopulmonary arrest, shock, sepsis, burns, or major trauma. Intraosseous (IO) access has become accepted as an immediate option for vascular access in emergent care, when intravenous access cannot be rapidly established. The current Tactical Combat Casualty Care (TCCC) guidelines state “If resuscitation is required and IV access is not obtainable, use the intraosseous (IO) route.” In the US Army MEDEVAC Critical Care Flight Paramedic Standard Medical Operating Guidelines (SMOG), providers are instructed to make two IV attempts prior to inserting an IO catheter. **The purpose** of this study was to describe vascular access practices used by en route care providers during MEDEVAC. In addition, our objective was to compare the use of PIV and IO insertion by reporting attempts, success rates, and associated factors.

Methods: We conducted a retrospective review of MEDEVAC patient care records (PCRs) for US military personnel injured in the Operation Enduring Freedom theater of operations between January 2011 and March 2014. Patients killed in action were excluded from the study. Patient data from the point of injury (POI) to the first military treatment facility (MTF) were abstracted from PCRs by trained research team members. This was a subanalysis of data collected from the previously described MEDVAC provider study. Overall vascular access attempts and success rates were reported for PIV and IO. For comparative analysis, subjects were grouped by type of vascular access: None, PIV, IO, and PIV + IO (combination of PIV and IO) and by vascular access (PIV or IO) success (No vs Yes).

Results:

- 93% overall vascular access success rate
- Zero success rate with repeated PIV attempts
- Vascular access was not achieved in 53 subjects due to placement failure, nonfunctional/nonpatent, and dislodgment
- Combative behavior was documented in 27 of these subjects
- **Failure to achieve vascular access was associated with lower survival rates, more in-flight events, and more in-flight cardiac arrests**
- The most common site for attempted IO insertion was in the sternum (n = 46, 47%), followed by the tibia (n = 29, 30%), and the humerus (n = 22, 23%).
- The military IO success rate (88%) was slightly below civilian reported success rates.
 - The challenging combat environment may account for the difference.

Fig 1: Vascular Access Success Rates



Conclusions:

- IO access accounts for 12% of vascular access in the MEDEVAC population we studied.
- IO placement in the humerus and sternum is more frequent in combat casualties than in civilian care.
- MEDEVAC providers may benefit from more training in the insertion of IO catheters.
- The failure to rapidly achieve vascular access may lead to undesirable outcomes.

Evidence Based Recommendations:

- In the event the initial IV access attempt fails, avoid subsequent attempts at IV access and move directly to IO access.
- Evaluate IO placement best practices – should IO be first access attempt in some patients?
- Consider administration of IM sedation to combative patients to assist in placement of IV or IO access

LIST OF SYMBOLS, ABBREVIATIONS, AND ACRONYMS

ADV	Advanced providers – Nurses, Physicians Assistants, Physicians
AFM	Army Flight Medic
AIS	Abbreviated Injury Severity
ANOVA	Analysis of Variation
CCFP	Critical Care Flight Paramedics
CI	Confidence Interval
CPR	Cardiopulmonary Resuscitation
DOD	Department of Defense
DODTR	Department of Defense Trauma Registry
EMT	Emergency Medical Technician (Basic, Intermediate, Paramedic)
H	Hospital
ICU	Intensive Care Unit
IH	In-Hospital
IQR	Interquartile Range
IRB	Institutional Review Board
ISS	Injury Severity Score
JTS	Joint Trauma System
MEDEVAC	Medical Evacuation
MERT	Medical Emergency Response Team
MTF	Medical Treatment Facility
MRMC	Medical Research Materiel Command
NATO	North Atlantic Treaty Organization
QA	Quality Assurance
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
OND	Operation New Dawn
PCR	Patient Care Record
PH	Pre-Hospital
PJs	Air Force Pararescuemen
POI	Point of injury
SD	Standard Deviation
TACEVAC	Tactical Evacuation
TCCC	Tactical Combat Casualty Care
TC CET	Tactical Critical Care Evacuation Team
TMDS	Theater Medical Data System