Forward aeromedical evacuation: A brief history, lessons learned from the Global War on Terror, and the way forward for US policy

LT Chris M. Olson, Jr., MSC, USN, COL Jeffrey Bailey, MC, USAF, LTC Robert Mabry, MC, USA, LTC Stephen Rush, USAF/ANG, MAJ Jonathan J. Morrison, RAMC (V), *and* **CAPT Eric J. Kuncir, MC USN**

The US Army pioneered air evacuation of casualties from the battlefield to a forward operating surgical treatment facility after the advent of the helicopter. This rotary-wing capability was initially used for casualty evacuation (CASEVAC) during the Korean War but evolved to the extent that lifesaving resuscitation was initiated en route by the US Army during the Vietnam War. More recently in Iraq and Afghanistan, medical evacuation (MEDEVAC) by platforms operating under a US and UK joint system has matured to the point where advanced medical capabilities are brought forward to the point of injury (POI).

Emerging data from the Afghanistan experience however indicate that clinical and doctrinal gaps exist in US forward aeromedical evacuation (FAME) capability. In this review article, we provide a brief history of military MEDEVAC centered on the evolution of FAME, describe the current FAME platforms in Afghanistan, discuss lessons learned from recent studies examining the performance of the current FAME platforms, and propose the way ahead for FAME in future conflicts.

FAME EVOLUTION: A BRIEF HISTORY

Early Application of Battlefield Evacuation

In the first century, the Byzantine Empire's army incorporated a system for battlefield CASEVAC using medics, called *Scribones*, who were stationed a hundred meters behind the battle and were paid a gold piece for each casualty they rescued. There is no record of organized CASEVAC again until late in the 18th century when during the French Revolution, Napoleon's surgeon, Baron Dominique-Jean Larrey, rode into battle on a horse-drawn carriage to evacuate injured soldiers to the rear of the battle where treatment could be delivered.[1] Before this, casualties were for the most part considered liabilities to the war effort and therefore were left where they fell with little-to-no care rendered. During the Civil War in 1862, Dr. Jonathan Letterman established the first military ambulance system for the US Army. The subsequent emergence of CASEVAC systems can in part be attributed to the advent of new technologies (enabling safe movement without sacrificing the overall war effort) coupled with increasing social activism (calling for care to the wounded soldiers), the latter of which was promulgated by the likes of Henry Dunant and led to the creation of the International Committee of the Red Cross and the first Geneva Convention. Until the mid-20th century, various forms of ground ambulances were used to clear battlefield casualties. The first, but isolated, report of CASEVAC accomplished via air ambulance occurred during World War I when the French used a fixed-wing craft to evacuate Serbian casualties retreating from Albania.[2]

Submitted: January 31, 2013, Revised: March 22 2013, Accepted: April 1, 2013.
From the Naval Research Laboratory (C.M.O.), Stennis Space Center, Mississippi; US Army Institute of Surgical Research (J.B., J.J.M.); and San Antonio Military Medical Center (R.M.), Fort Sam Houston, San Antonio, Texas; USAF Pararescue (S.R.), Westhampton Beach, New York; and Department of Surgery (E.J.K.), Naval Medical Center, San Diego, California; and Academic Department Military Surgery and Trauma (J.J.M.), Royal Centre for Defence Medicine, Birmingham, United Kingdom.
The viewpoints expressed in this article are those of the authors and do not reflect the official position of the US Department of Defense.
Address for reprints: CAPT Eric J. Kuncir, MC USN, Naval Medical Center San Diego, Department of Surgery, 34800 Bob Wilson Dr, San Diego, CA 92134; email: eric.kuncir@med.navy.mil.

DOI: 10.1097/TA.0b013e318299d189

The Korean War Experience

Soon after the first year of the Korean War, the Army sent 12 newly procured Bell H-13 Sioux helicopters to Korea for CASEVAC.[3] The H-13 had many shortcomings, limiting operational and clinical functions. Because of the aircraft's low power, short range (273 miles), and lack of interior lighting, operations were limited to daylight evacuation of no more than two patients. Furthermore, owing to the external placement of patient litters, in-flight treatment was not possible. CASEVAC was also hampered by a lack of standard operating procedures, lack of a dedicated communications network (the aircraft had no radios), and limited use because of maintenance problems. Despite these shortcomings, helicopter detachments evacuated as many as 190,000 casualties.

Most importantly, the Korean War experience established the role of the helicopter in CASEVAC and convinced the Army it needed a permanent organization dedicated to this mission.[4] Near the end of the conflict, helicopter evacuation detachments were incorporated into the Army Medical Service, and shortly thereafter, the Surgeon General (MG George E. Armstrong) created an organization within the Surgeon General's Office, capable of directing and administering aviation resources.[5] Additional planning, personnel staffing, operations and aircraft changes occurred after the cease-fire in 1953.

The Vietnam War Experience

The US Army's 57th Medical Detachment arrived in Vietnam in 1962 with the Bell UH-1 helicopter, which replaced the H-13 in 1955. The UH-1, colloquially known as *Huey*, had twice the speed and endurance of the H-13, carried patient litters in-board, displayed the Geneva Red Cross, and delivered en route care—a first for helicopter FAME. The enhanced flight crew included a pilot, copilot, crew chief, and flight medic. En route care included application of first aid, morphine

Copyright © 2013 Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.

Report Documentation Page

Report Documentation Page	*Form Approved* *OMB No. 0704-0188*

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

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

4. TITLE AND SUBTITLE **Forward aeromedical evacuation: a brief history, lessons learned from the Global War on Terror, and the way forward for US policy.**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) **Olson Jr. C. M., Bailey J., Mabry R., Rush S., Morrison J. J., Kuncir E. J.,**	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **United States Army Institute of Surgical Research, JBSA Fort Sam Houston, TX**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

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

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**7**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

administration for pain, intravenously administered fluid resuscitation, and surgical airway establishment. Typically, the aircraft commander transported casualties to the nearest definitive care facility unless redirected by the medical regulating officer. In 1963, the 57th adopted "DUSTOFF" [Dedicated Unhesitating Service To Our Fighting Forces] as their radio call sign, a name that has endured for 50 years.

During the Vietnam War, the Air Force performed rotary-wing combat search and rescue (SAR) and personnel recovery (PR). This was a continuation of the Air Rescue Service, which stood up in 1946, before the 1947 Air Force designation as a separate service, and continued until late 1965 as the Aerospace Rescue and Recovery Service. Pararescuemen (PJs) were best known for being lowered down a hoist to rescue isolated personnel. At about this time, tactical training ensued to permit operation in hostile environments (John Cassidy, personal communication, December 15, 2012).

In the 1950s and 1960s, the initial Air Force helicopter, the HH-43 Huskie, was used for local SAR missions around bases. In 1965, capabilities increased with the introduction of the Sikorsky HH-3E "Jolly Green Giant,"[6] and in 1966, "PEDRO" replaced the call sign "HUSKIE" (PEDRO was the call sign at Laredo Air Force Base). During this period, PJs received a basic medic course and provided only first aid.[7] Overall, PEDRO fulfilled CASEVAC function far less often than DUSTOFF because it was not their primary mission. PEDRO also differed from DUSTOFF by operating without a Red Cross; thus, aircrew were considered combatants.

The experience and confidence of DUSTOFF and PEDRO units increased throughout the conflict and were considered an unqualified success during the war; the DUSTOFF units alone would evacuate nearly 900,000 allied military personnel and Vietnamese civilians from the battlefield in Vietnam,[8] and PEDRO would rescue 4120.[9] However, in addition to demonstrating its value in the mountains, jungles, and flood plains of Vietnam, DUSTOFF also demonstrated its vulnerability. Astonishingly, a third of the DUSTOFF aviators, crew chiefs, and medics became casualties, and the loss of air ambulances to hostile fire was 3.3 times that of all other forms of helicopter missions in the Vietnam War.[3] This high loss rate led to questioning the value of openly declaring the vulnerability of these unarmed platforms with a Red Cross in asymmetrical conflict—a conflict between disparate military powers—in which the protection offered by the Geneva Conventions to the medical helicopters and personnel were/are not routinely afforded.[10]

Figure 1. FAME platforms operating in Southern Afghanistan—airframes (left) and interior working space (superimposed). Photo courtesy of Eric Kuncir, MD; interior PEDRO photo courtesy of Stephen Rush, MD; interior MERT photo courtesy of Jonathan Morrison, MD.

Copyright © 2013 Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.

TABLE 1. FAME Platforms Operating in Southern Afghanistan—Key Characteristics

Unit Call Sign	DUSTOFF	PEDRO	MERT
Service organization	US Army	US Air Force	UK Royal Air Force
Red Cross symbol	Yes	No	No
Combat search and rescue	No	Yes	No
Helicopter			
Air frame	UH-60 Blackhawk	HH-60 Pavehawk	CH-47 Chinook
Cruising speed	173 mph	183 mph	196 mph
Armaments	None	2 miniguns	2 miniguns and 1 M60
Patient litters	3–6*	2–3	8**–9
Medical crew			
Physician	0	0	1
Nurse	0	0	1
Paramedic	0	2	2
EMT-B	2	0	0
En route intervention			
Active warming	Yes	Yes	Yes
Intravenous access	Yes	Yes	Yes
Intraosseous access	Yes	Yes	Yes
Needle chest decompression	Yes	Yes	Yes
Cricothyroidotomy	Yes	Yes	Yes
Supraglottic devices	Yes	Yes	Yes
Chest tube placement	No	Yes	Yes
Blood products	No	Yes	Yes
RSI	No	Yes	Yes
ACLS	No	Yes	Yes
TXA Administration	No	Yes	Yes
Video laryngoscopy	No	Yes	Yes

*Three-litter configuration in OEF; maximum of six with carousel.
**As configured in OEF.
ACLS, advanced cardiac life support; TXA, tranexamic acid.

Post-Vietnam Era

MEDEVAC units were deployed several times in the post-Vietnam era in support of Operation Urgent Fury in Grenada, Operations Just Cause in Panama, and Desert Storm and Shield in Iraq. During each of the conflicts, combat operations were over quickly and resulted in few casualties transported by MEDEVAC units. The threat of war in Europe persisted until the Soviet Union dissolved in 1991. Large-scale war in Europe assumed massive numbers of casualties and continued to drive MEDEVAC's focus on evacuating casualties from the battlefield. With the historic focus being on battlefield "clearance," innovation in prehospital trauma life support and en route care has only recently began to emerge after 10 years of war in Afghanistan.[11]

In the 1980s, the US Army began phasing out the UH-1 Huey in favor of the faster and larger Sikorsky UH-60 Black Hawk helicopter. During Operation Desert Storm, US Central Command dedicated 220 helicopters for FAME; 75% of these were UH-1s, and 25% were UH-60As.[12] By the end of the 1990s, the UH-60A would completely replace the UH-1 with the exception of some reserve units. Although these units were assigned to the MEDEVAC mission for the 43-day Persian Gulf War of 1990 to 1991, they were lightly tasked because US Forces sustained less than 500 battle-related casualties during the conflict.[13]

Leveraging the success of FAME during the Vietnam era, US state and local governments began to look at using helicopters in civilian emergency medical service systems. Throughout the 1970s and 1980s, civilian helicopter emergency medical service (HEMS) agencies proliferated and became more sophisticated. Most adopted a dual provider model, most commonly a nurse-paramedic team. These providers are required to have advanced training and certifications and are expected to provide critical care in the helicopter to include advanced airway management, blood administration, and the use of a variety of pharmacologic agents.

With the anticipation of large numbers of casualties during a NATO Soviet conflict and with no prolonged conflict to force examination of the Vietnam era legacy model of a single medic without advanced training, Army MEDEVAC had no reason to adopt the lessons learned from the rapidly evolving civilian HEMS experience, which has demonstrated some evidence of improved outcomes with the use of advanced care practitioners.[14–17]

MODERN FAME PLATFORMS

Three FAME platforms have been operational in recent years of Operation Enduring Freedom (OEF) as shown in Figure 1. Each platform was borne out of unique requirements

© 2013 Lippincott Williams & Wilkins

Copyright © 2013 Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.

and therefore possesses a distinct combination of on-board medical and nonmedical capability, as outlined in Table 1. In 2009, Secretary of Defense Robert Gates mandated that US MEDEVAC deliver battlefield casualties to a field hospital with appropriate surgical care within 1 hour after the request for a MEDEVAC. This is known colloquially as the *Golden Hour Rule*.

US Army MEDEVAC: Call Sign ''DUSTOFF''

DUSTOFF has been the most widely used MEDEVAC unit throughout the history of US warfare, including during the recent Operation Iraqi Freedom (OIF) and the current OEF. The current airframe is a UH-60A Blackhawk, distinguished by the characteristic Red Cross symbol, and is not armed with offensive weapons unlike the other two platforms. The rationality of dispatching unarmed DUSTOFF helicopters with overt outward designation by a Red Cross to hostile fire zones in an era of asymmetrical warfare has been questioned since its debut in the Vietnam War, yet this important topic is beyond the scope of the current review. DUSTOFF units went to Iraq and Afghanistan, operating under the legacy model that had essentially changed little since the Vietnam era. These aircraft were still staffed by a single medic, now credentialed at the emergency medical technician-basic (EMT-B) level. Under the legacy training model, there was no requirement to participate in the care of a single critically injured or ill patient before deploying to combat as a flight medic, and therefore, advanced capabilities are limited as shown in Table 1. No standardized protocols exist across MEDEVAC units, and medical direction was provided in most cases by general medical officers (GMO) serving with aviation units. These GMOs generally completed internships and were awaiting placement into residency programs. Their primary job was to provide routine medical care to the aviators in that unit. No standardized system of patient documentation, chart review, or process improvement exists. Rotary MEDEVAC units are traditionally commanded by aviators with no clinical experience, and currently no formal clinical oversight of MEDEVAC by experts in trauma, emergency medical services, or critical care exists.

US Air Force Expeditionary Rescue Squadron: Call Sign ''PEDRO''

Throughout OIF and OEF, PJs performed their designated PR mission, occasionally conducted MEDEVAC missions in support of the Army, and provided on-scene support for special operations serving as both a tactical/technical rescue specialist and an emergency medical casualty care provider. Their combination of advanced rescue and medical capabilities define the Pararescue role; being a paramedic is only one of their skills. After initial paramedic certification, clinical skills maintenance is challenging and occurs at their home station while working to maintain other skill sets required for their mission. Despite this, during the course of these conflicts, PJ medical capability has evolved from providing tactical combat casualty care (TCCC) and paramedic care to a more advanced capability as shown in Table 1. Intubation is generally limited to strict indications and applied less aggressively than on the UK platform.

In 2007, PEDRO operating at Bagram Air Field, Afghanistan, flew MEDEVAC in lieu of DUSTOFF when weather conditions prevented launch of a DUSTOFF mission. That same year at Kandahar Air Field, Afghanistan, PEDRO was formally tasked with the FAME mission, ultimately flying with Guardian Angel Teams, the Air Rescue package that includes a Combat Rescue Officer and five PJs on a pair of HH-60s.

Based on these successes and to meet the Golden Hour Rule, in early 2009, a fragmentation order was given for Air Force Air Rescue assets to provide joint PR and MEDEVAC support going forward. The order added the use of the C-130 with a GMO-level flight surgeon and three PJs without critical care training with the call sign "FEVER." Fixed-wing missions included picking up patients at forward operating bases who were often immediately in a postoperative status and on ventilators with ongoing resuscitative and sedative requirements.

UK MEDEVAC: Call Sign ''MERT''

The UK medical emergency response team (MERT) was originally deployed in Southern Afghanistan in 2006; however, its genesis originates in OIF as part of an incident response team. This rotary-wing asset was designed to quickly deploy specialist personnel. The medical component consisted of a GMO delivering a forward extension of UK battlefield advanced trauma life support.

Following the UK deployment into Helmand Province in 2006, owing to the large battle space (58,000 km^2), forward critical care was required to reduce the time from wounding to the delivery of skilled resuscitation. Since a number of deployed clinicians were trained HEMS providers, a similar model of physician-led prehospital care, involving delivery of advanced clinical intervention, was instituted. The MERT has subsequently evolved into a scalable platform where the basic MERT configuration consists of an advanced paramedic or nurse, which can be enhanced as MERT-E with the addition of a physician and interventions such as prehospital blood and rapid sequence induction (RSI), as shown in Table 1. The MERT is not exclusively rotary-wing based, so it can also be littoral, sea, or land deployed

This "militarized HEMS" concept has proven controversial because the asset is of high value and requires significant logistic support and limited clinical evidence supporting its deployment exists. Most studies are either observational or editorial and lack a comparison population. Davis et al.[18] in 2007 reviewed the civilian literature and some unpublished military outcome data and concluded that a MERT physician improved outcomes in major trauma. Tai et al.[19] reviewed the importance of early, skilled resuscitation in critical battlefield trauma and postulated that the MERT-E may serve to extend the physiologic window of salvage in such cases.

Calderbank et al.[20] prospectively examined the quality of the physician's contribution to MERT over 5 months and 324 missions in 2008. A physician flew on 88% of MERT missions and was felt not to be clinically beneficial in 77% of missions. However, there were few critical casualties during the study, although RSI was specifically identified as an intervention that was lifesaving in a small number of casualties with compromised airways.

Following the deployment of US forces in Helmand in mid-2008, UK MERTs started to operate in parallel with PEDRO and DUSTOFF assets. Integration of interservice and multinational platforms has permitted the deployment of a unique

Copyright © 2013 Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.

prehospital system of care in Southern Afghanistan. For the first time, comparison of clinical outcomes between platforms, discussed in the next section, suggests that there is a survival benefit to an advanced clinical capability in certain patient groups.[21,22] However, MERT and MERT-E have only ever operated in combat theaters characterized by asymmetric warfare with air superiority. It is also unclear how such an asset would or could perform in a conventional war, where the loss of even a single MERT-E could significantly limit operational effectiveness.

LESSONS LEARNED IN IRAQ AND AFGHANISTAN

The killed-in-action and died-of-wounds rates in the recent Iraq and Afghanistan conflicts are the lowest in the history of armed conflict. Eastridge et al.[23] analyzing prehospital death on the battlefield noted that 88% of US combat fatalities occur in the prehospital phase of care and 92% of this group dies of hemorrhage. While evidence that advancements in tactical field and first responder care has contributed to improved battlefield survival has been forthcoming,[24] literature that documents the contribution of advances in evacuation and en route care to casualty mortality rates has only begun to emerge. The following discusses studies that illustrate lessons learned from FAME operations in Iraq and Afghanistan.

DUSTOFF Survival Rates Improve With Paramedic Training

Questioning the long-accepted DUSTOFF model, Mabry et al.[25] demonstrated in a recent study that casualty mortality was significantly lower when evacuation was performed by US Army National Guard DUSTOFF unit flight paramedics compared with the standard military air ambulance unit's staff by EMT-Bs. This study examined 671 casualties with an Injury Severity Score (ISS) of greater than 15 retrieved from POI by the Army Guard critical care flight paramedics (CCFP) compared with EMT-B flight medics or standard MEDEVAC. The unadjusted mortality was highest in casualties evacuated by the standard EMT-B flight medic platform (15% vs. 8%), and after adjusting for covariates including an observed interaction between evacuation system and patient category, the odds ratio for the association between evacuation system and mortality was lower for those transported by CCFP compared with standard MEDEVAC (odds ratio, 0.34; 95% confidence interval, 0.14–0.88). In response to this study, US Army policy shifted and now supports CCFP training for all flight medics, and training to that standard has commenced.

MERT Offers a Distinct Survival Advantage

Two recent combat trauma registry studies characterize mortality rates for casualties evacuated from the battlefield via the FAME platforms operating in Southern Afghanistan.[21]

The first study by Morrison et al.[21] uses both the UK and US combat trauma registries. The study of Morrison et al. characterizes MERT as an advanced capability platform and compares mortality and timelines with the conventional platform—DUSTOFF and PEDRO, wherein the study examines 1,093 MERT patients and 628 conventional transported patients during a 33-month period grouped into three ISS bins (1–15, 16–50, and 51–75). The study demonstrates that times from tasking to arrival in the emergency department were similar across all platforms, and a high percentage of the most severely injured patients evacuated with MERT underwent an advanced intervention. The largest proportion of patients were in the lowest ISS category, where there was no difference in mortality across the platforms. However, casualties in the middle ISS category were associated with a lower mortality if they were retrieved by MERT. The study of Morrison et al. also reports a reduced time from admission to surgery in the MERT group, attributed to a combination of patient preparedness and direct communication between the platform and receiving hospital. Overall, this report suggests that mortality from certain patterns and severity of trauma are decreased with the deployment of advanced medical capability as part of POI en route care capability. However, it does not present evidence on which component(s) of this capability contribute most to this survival advantage.

A second study by Apodaca et al.[22] is a US combat trauma registry performance improvement study currently submitted for publication. The study cohort consisted of 975 casualties evacuated by MERT (n = 543), PEDRO (n = 326), and DUSTOFF (n = 106) during the shorter period of June 2009 to June 2011. Results showed that MERT was preferentially tasked to transport polytrauma casualties and also casualties with single or multiple amputations. Not surprisingly, this study demonstrated that MERT casualties had on average more severe injuries and worse shock physiology manifested by lower systolic blood pressure and tachycardia compared with casualties transported by the either PEDRO or DUSTOFF. Overall crude mortality was equivalent for MERT and PEDRO (4.2% and 4.6%) but lower for DUSTOFF (0.9%). This was attributed, in large part, to the finding that DUSTOFF primarily was tasked to transport less severely injured casualties. When mortality was compared between MERT and PEDRO in four ISS groupings (<10, 10–19, 20–29, and 30–75), there was no difference in the lower (<10 and 10–19) and highest (30–75) ISS categories. However, mortality in casualties with an ISS of 20 to 29 was lower in the MERT compared with the PEDRO group (4.8% vs. 16.2%; $p = 0.021$). Using Trauma and Injury Severity Score (TRISS) methodology, the observed mortality for MERT was statistically lower than the predicted mortality for all ISS bins except for those with less than 10 demonstrating a high rate of unexpected survivors for MERT-transported casualties. PEDRO's observed mortality was as-expected with the exception of the bin ISS 20 to 29; here, the observed rate was higher than predicted.

The study of Apodaca et al. further demonstrates and confirms the effectiveness of MERT as an en route care capability during combat operations. Specifically, the study showed that despite higher predicted mortality, physician-led tactical evacuation achieved greater survival rates than paramedic-directed evacuation for battlefield casualties with life-threatening injuries. The authors discuss the limitations of the study, which include its lack of visibility on the tactical scenarios that may have affected these outcomes especially for PEDRO. Lastly, the authors discuss the medical regulation process that likely underlies the preferential selection of MERT for the polytrauma casualty. This has been described as intelligent tasking and recognized as a critical element in the process of assigning the right platform to the right mission to match clinical capability with clinical need. This is an

© 2013 Lippincott Williams & Wilkins

Copyright © 2013 Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.

exceptionally unique confluence of circumstances and may provide clues to addressing the way forward.

PEDRO Performs a Unique FAME Mission

The study Apodaca et al. is the first to document outcomes for PEDRO demonstrating a lower-than-predicted survival for a certain subset of severely injured casualties. These results, however, may not fully account for all factors contributing to survival in a combat setting because the PEDRO platform is traditionally reserved for SAR/PR missions, including offensive tactics and complex casualty extraction. In general, by virtue of its mission, PEDRO is more likely to be tasked to retrieve casualties when DUSTOFF and MERT are unable to owing to technical challenges and enemy fire. This tasking would presumably lead to prolonged evacuation times, which could explain a bias for PEDRO's lower observed survival rate.

Clarke and Davis[26] in a recently published largely descriptive analysis of MEDEVAC and triage of casualties in Helmond Province, Afghanistan, present comparative average transport time data for the three FAME platforms without offering any detail how the various times were derived. During a 6-month period ending in November 2010, Clarke and Davis examined times to response, scene, critical care, and Role 3 with critical care time ending for MERT upon arrival of the advanced care team at POI, whereas it coincides with Role 3 time for the other two platforms. Significantly, time to Role 3 was identical for MERT and PEDRO, while critical care time was only approximately 12 minutes to 15 minutes faster for MERT than for PEDRO. Taken together, the results from Clarke and Davis might suggest that tactical considerations, on average, did not impede PEDRO's time to surgical care. However, removed from considerations of the different airframe maximum air speeds and divergent response times shown by Clarke and Davis, these results at first glance do not allow a precise estimate of time spent on scene and best demonstrate that advanced care started earlier for MERT.

It is also worth noting that PJs onboard PEDRO, unlike MERT, were not administering blood products and tranexamic acid until December 2010, which corresponds to the end of the study period for the two aforementioned studies. This factor must also be considered in the final characterization of a physician-driven platform being associated with higher survival rates. None of the recent studies precisely determine if improved survival for the advanced care platforms was caused by early blood transfusions on MERT or physician action and judgment in treating trauma patients.

THE WAY FORWARD

The Army Surgeon General's Dismounted Complex Blast Injury Task Force Report[27] and a deployed MEDEVAC Medical Director's after-action report[28] both noted that that the UK's MERT has been used preferentially to evacuate the most severely injured casualties in Southern Afghanistan despite a lack of hard clinical evidence to any benefit.

Taking note, the Committee on Tactical Combat Casualty Care, which develops and recommends TCCC guidelines to the Defense Health Board (DHB),[29] made recommendations for improving US Department of Defense's (DoD) FAME capability. On August 8, 2011, the DHB approved and forwarded the TCCC guidelines to the assistant secretary of Defense for Health Affairs.[30] These recommendations called for extensive improvements to (1) platform, (2) provider skill level and oversight, (3) response time, and (4) standardization, documentation procedures, and quality assurance. Most prominently, the board recommended that DoD pursue the development of an advanced FAME capability led by an emergency or critical care physician for the transport of the most critical battlefield casualties that may be similar to MERT.

In response to the DHB on October 28, 2011, the assistant secretary of Defense for Health Affairs requested definitive evidence that would assist the DoD in meeting its critical objective to improve FAME care in theater.[31] Movement toward that goal has been heretofore hampered by the fact that the DoD "lack(ed) such data as documentation comparing casualty outcomes across the various FAME platforms currently in existence in Afghanistan that support piloting such a capability." Given the emergence of recent data demonstrating a survival advantage for severely injured casualties evacuated by critical care flight paramedics[25] and the MERT platform[21,22] for severely injured casualties, conditions seem to be in place for a paradigm shift to strongly favor fielding en route care POI FAME platforms with a range of scaled resuscitative capability as has been observed in Afghanistan. What the data and experience have shown is that the three platforms that represent different capabilities are complementary and bring something unique to the fight based on challenges presented in terms of weather/terrain, ongoing hostilities, and casualty severity of injury. The fundamental challenge then becomes one of recognizing and acknowledging these differences and working to appropriately task each platform to take full advantage of the differences to enable safe mission completion for both the casualty, the medical team, and air crew. It is critical to note that the possibility of tasking different medical platforms is unique to Southern Afghanistan.

A key logical question then becomes one of a discussion of degrees or provider credentials versus platform capabilities as the next generation advanced FAME platforms are designed, equipped, staffed, and deployed. It is clear from our point of view that FAME providers of the future should be capable of delivering a casualty from POI to the point of initial surgical intervention and skillfully perform lifesaving interventions and initiate advanced resuscitative measures. Simply stipulating that a doctor should be on board FAME missions could result in the deployment of the wrong skill set of providers who may not be trained and experienced in advanced evacuation trauma care and intervention, as is the case in medical direction of the legacy DUSTOFF. It is therefore best in our opinion to focus on capabilities and allow the Armed Forces to determine best how to achieve this capability while factoring in consideration of training and sustainment for FAME providers. Maintaining a force of medic/corpsmen/PJ and CCFP teams that could be augmented by nurses and physicians when needed might be more expedient and cost-effective to sustain compared with fielding fully augmented teams that include all breeds of advanced providers, or, with clear delineation of medical capabilities and scope of practice, training flight paramedics to advanced skills and facilitating ongoing real-world

Copyright © 2013 Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.

work in that capacity outside of the conflict may achieve the same goal. Alternatively, perhaps it would require the equivalent of a specialized new shock trauma paramedic or physician's assistant to staff FAME platforms for future conflicts because it may be easier to both train and sustain such a force of these providers in times of peace.

CONCLUSION

Many potentially preventable deaths in recent conflicts have occurred in the prehospital phase,[23] of which FAME casualty movement played a role. To address this, the FAME mission has evolved from rapid and efficient clearing of the battlefield to a relative extension of heretofore-fixed, facility-based resuscitative capability. Despite these recent advances, there remains convincing evidence that an opportunity to improve upon this record exists through further improvements in airframe, mission tasking, and clinical capabilities.

Active involvement of physician experts in battlefield medicine and forward lifesaving intervention and resuscitation is fundamental to the success of such a program.

Evolution of future FAME models and requirements must focus on saving lives while being survivable on the battlefield.

Factors not previously discussed such as the anticipated number and type of casualties, the area of contested terrain and distance between echelons of care, and air superiority also need to be carefully considered.

As a desired end state, FAME platforms of the future will represent a capability that will provide flexibility to the commander and optimize scalable state-of-the-art forward care that can initiate early damage-control resuscitation when called upon to do so for severely injured combatants. The lifesaving potential of such a capability would be difficult to undervalue in the chaotic, dynamic, and asymmetric battle spaces of the future.

AUTHORSHIP

C.M.O., J.B. and E.J.K. conceived and designed the study. C.M.O., J.B., R.M., S.R., J.J.M. and E.J.K. drafted the manuscript. C.M.O., J.B., and E.J.K. analyzed and interpreted the data. C.M.O., J.B., R.M., S.R., J.J.M., and E.J.K. critically revised the manuscript. E.J.K. provided administrative, technical, or material support. E.J.K. supervised the study.

DISCLOSURE

All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. There were no conflicts reported. There was no funding for this study. The United States Army Institute of Surgical Research (USAISR) supported this project. All authors are employed by the US Department of Defense.

REFERENCES

1. Lam DM. Medical evacuation, history and development—the future in the multinational environment. *Res Technol Organ*. 2001;19:1–7.
2. Green B. Challenges of aeromedical evacuation in the post-cold-war era. *Aerospace Power J*. 2001;15:14–26.
3. Dorland P, Nanney J. *DUSTOFF: Army Aeromedical Evacuation in Vietnam*. Washington DC: Department of the Army; 1982.
4. Neel, SH. Medical considerations in helicopter evacuation. *U S Armed Forces Med J*. 1954;5:220–227.
5. Ginn VN. *The History of the United States Army Medical Service Corps*. Washington, DC: Office of the Surgeon General and Center of Military History United States Army; 1997.
6. Mock S. PEDRO News Web site. Available at: http://users.acninc.net/padipaul/Pedronews/home.htm. 2012. Accessed September 18, 2012.
7. Cassidy J. PJ History Web site. Available at: www.specialtactics.com, 1999. Accessed September 18, 2012.
8. Department of the Army. *Vietnam Studies—Medical Support 1965–1970*. Washington, DC: US Government Printing Office. 1974:174–175.
9. Combat Search and Rescue in Southeast Asia Web site: Available at: http://www.nationalmuseum.af.mil/factsheets/factsheet.asp?id=15122. Accessed January 20, 2012.
10. Brady PH. *DUSTOFF Operations in Vietnam*. Army Logistician; July-August 1973;5:18–23.
11. Mabry RL, DeLorenzo RA. Sharpening the edge: paramedic training for flight medics. *US Army Med Dep J*. 2011;92–100.
12. *Final Report to Congress: Conduct of the Persian Gulf War*. 1991. Available at http://www.ndu.edu/library/epubs/cpgw.pdf.
13. Fischer H. *American War and Military Operations Casualties: Lists and Statistics*. Congressional Research Service Report for Congress; 2005.
14. Garner AA. The role of physician staffing of helicopter emergency medical services in prehospital trauma response. *Emerg Med Australas*. 2004;16:318–323.
15. Hamman BL, Cue JI, Miller FB, et al. Helicopter transport of trauma victims: does a physician make a difference? *J Trauma*. 1991;31:490–494.
16. Baxt WG, Moody P. The impact of a physician as part of the aeromedical prehospital team in patients with blunt trauma. *JAMA*. 1987;257:3246–3250.
17. Garner A, Rashford S, Lee A, Bartolacci R. Addition of physicians to paramedic helicopter services decreases blunt trauma mortality. *Aust N Z J Surg*. 1999;69:697–701.
18. Davis PR, Richards AC, Ollerton JE. Determining the composition and benefit of the pre-hospital medical response team in the conflict setting. *J R Army Med Corps*. 2007;153:269–273.
19. Tai NR, Brooks A, Midwinter M, Clasper JC, Parker PJ. Optimal clinical timelines—a consensus from the academic department of military surgery and trauma. *J R Army Med Corps*. 2011;155:253–256.
20. Calderbank P, Woolley T, Mercer S, Schrager J, Kazel M, Bree S, Bowley DM. Doctor on board? What is the optimal skill-mix in military pre-hospital care? *Emerg Med J*. 2011;28:882–883.
21. Morrison J, Oh J, Dubose J, O'Reilly D, Russell R, Blackbourne L, Midwinter MJ, Rasmussen TE. En-route care capability from point of injury impacts mortality following severe wartime injury. *Ann Surg*. 2012;257:330–334.
22. Apodaca A, Olson C, Bailey J, Butler F, Eastridge B, Kuncir E. Performance improvement evaluation of forward aeromedical evacuation platforms in Operation Enduring Freedom. *J Trauma Acute Care Surg*. [in press].
23. Eastridge BJ, Mabry R, Seguin P, Cantrell J, Tops T, Uribe P, Mallot O, Zubko T, Oetjen-Gerdes L, Rasmussen T, et al. Death on the Battlefield (2001–2011): Implications for the future of combat casualty care. *J Trauma Acute Care Surg*.2012;73:S431–S437.
24. Kotwal RS, Montgomery HR, Kotwal BM, Champion HR, Butler FK, Mabry RL, Cain JS, Blackbourne LH, Holcomb JB. Eliminating preventable death on the battlefield. *Arch Surg*. 2011;146:1350–1358.
25. Mabry R, Apodaca A, Penrod J, Orman JA, Gerhardt RT, Dorlac WC. Impact of critical care–trained flight paramedics on casualty survival during helicopter evacuation in the current war in Afghanistan. *J Trauma Acute Care Surg*. 2012;73(2 Suppl 1):S32–S37.
26. Clarke JE, Davis PR. Medical evacuation and triage of combat casualties in Helmand Province, Afghanistan: October 2010–April 2011. *Mil Med*. 2012:177:1261–1266.
27. Caravalho J. Dismounted Complex Blast Injury - Report of the Army Dismounted Complex Blast Injury Task Force. June 18, 2011. Available at: http://www.armymedicine.army.mil/reports/DCBI%20Task%20Force%20Report%20(Redacted%20Final).pdf. 44–47.
28. Mabry R. MEDEVAC Medical Director's After Action Report. APO, AE 09354: United States Central Command. Joint Trauma Theater System; 2011.
29. Butler FK, Giebner SD, McSwain N and Pons P, eds. *Prehospital Trauma Life Support Manual: Military Version*. 7th ed. St. Louis, MO: Mosby; 2010.
30. Dickey N, Jenkins D, Butler F. Tactical Evacuation Care Improvements Within the Department of Defense. Defense Health Board Memo; 2011.
31. Woodson J. Response to Defense Health Board Recommendation for Tactical Evacuation Care Improvements within the Department of Defense. Assistant Secretary of Defense for Health Affairs Memorandum. 2011.

© 2013 Lippincott Williams & Wilkins

Copyright © 2013 Lippincott Williams & Wilkins. Unauthorized reproduction of this article is prohibited.