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Casualty Evacuation (CASEVAC) Platform Review and Case Series of US Military Enroute Critical Care Team With Contract Personnel Recovery Services in an Austere Environment

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ABSTRACT

In a rapidly changing operational environment, in which there has been an emphasis on prolonged field care and limited evacuation platforms, military providers must practice to the full scope of their training to maximize outcomes. In addition to pushing military providers further into combat zones, the Department of Defense has relied on contracted personnel to help treat and evacuate servicemembers. This article is a retrospective review on the interoperability of the expeditionary resuscitative surgical team (ERST) and a contracted personnel recovery (CPR) team in a far-forward austere environment and will discuss actual patient transport case reviews that used multiple evacuation platforms across thousands of miles of terrain. To effectively incorporate CPR personnel into a military transport team model, we recommend including cross-training on equipment and formularies, familiarization with CPR evacuation platforms, and mass casualty (MASCAL) exercises that incorporate the different platforms available.

Keywords: *patient transport; air evacuation; prolonged field care; Special Operations; expeditionary resuscitative surgical team; contract personnel recovery; austere*

Introduction

During the past 19 years, battlefield injuries have necessitated urgent resuscitation and rapid transport to a surgical team across multiple dynamic environments. Military medicine has adapted by placing surgical capabilities farther forward, thus increasing casualty survival.[1] As many battlefronts – and subsequent injuries – have moved into more austere environments, the need for patient movement via nontraditional platforms has become relevant.[2]

A highly efficient patient evacuation system has been developed in the US Central Command (CENTCOM) theater over nearly two decades.[3,4] Unlike these environments, the US Africa Command (AFRICOM) theater poses distinct patient transport challenges. With an area exceeding 11 million square miles, over a patchwork of territory ranging from hostile to permissive, distances between levels of medical care make it impossible to implement the type of medical evacuation (MEDEVAC) system in place in mature and heavily resourced battlefields of CENTCOM.[5] Given the varying nature of the topography and the distances required for transport, alternative ground and air platforms have been repeatedly called upon for patient transport to maintain resuscitative and surgical capabilities throughout the AFRICOM.[2,6] Special Operations Forces (SOF) operate within numerous austere environments throughout AFRICOM, in which nonstandard evacuation platforms may be the best, or only options, for patient evacuation. Therefore, medical teams supporting these units, including those like ERST, must also adapt to the environment to best support the mission.

Methods

This is a retrospective case series review of CASEVAC transports via contracted nonstandard air platforms by ERST and CPR during their deployment to AFRICOM from August to December 2020. This review compares both units' training, capabilities, and consideration for future evacuations. The two CPR CASEVAC platforms reviewed include the Bell 412 and Pilatus PC-12.[7,8] We describe each aircraft, its capabilities, and the care rendered during transport through data collected by the authors.

ERST, as discussed in this article, is a highly modular surgical team that supports AFRICOM (Figure 1). This unique team possesses flexible capabilities, cubic weight, and personnel to meet mission requirements.[1] This team can provide initial resuscitative care at the point of injury (POI) by the damage control resuscitation (DCR) element, provide damage control surgery, move forward on nonlinear battlefronts, and perform prolonged field care for up to 72 hours. Another subset of this team is the critical care evacuation team (CCET), which can immediately evacuate multiple patients after surgical stabilization, using platforms of opportunity, including ground vehicles and aircraft.[1,6] This transport team can be stationed at a casualty collection point or outstation, has an extensive critical care medication formulary, carries a minimum of four units of stored whole blood, and can continue resuscitation through the tactical evacuation (TACEVAC) phase of Tactical Combat Casualty Care.

The ERST DCR and CCET used multiple air evacuation platforms for transport to higher levels of care immediately following an injury on the battlefield and after surgical stabilization during their deployment. These transports were completed in conjunction with a CPR team onboard their aircraft.

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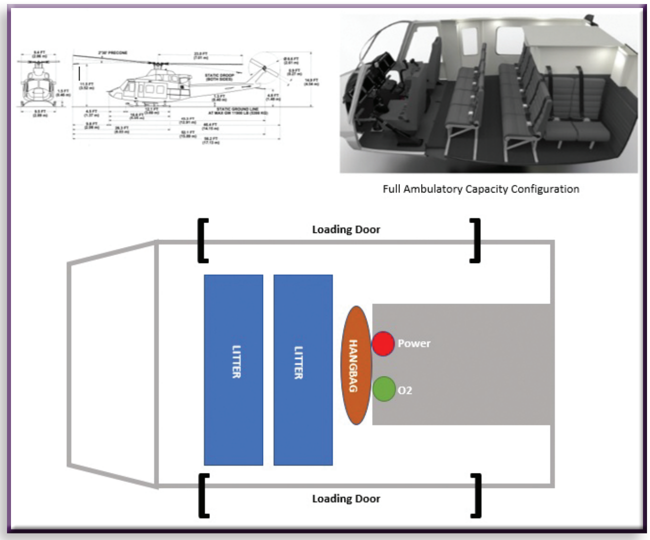
FIGURE 1 *ERST composition.*

FIGURE 2 *Bell 412 layout.*[7]



Familiarization, training, and coordination with both the layout of these platforms and loading protocols before patient transport were vital in providing optimal care during transport. This article will (1) review two platforms used by ERST and CPR; (2) discuss the configurations, capabilities, and care rendered on these platforms; (3) differentiate the two units' training and capabilities; and (4) offer recommendations to prepare future austere surgical and evacuation teams for operating alongside CPR personnel.

Results

ERST and CPR transported ten patients over a multiday operation in September 2020: nine partner force individuals and one US Servicemember. The mechanisms of injury for all ten casualties included both blunt and penetrating blast injuries from improvised explosive devices. The ten transports on the Bell 412 were from POI to the ERST medical facility, with transport times under 20 minutes. The Pilatus PC-12 flight was utilized as a transport platform to a tertiary partner force medical facility, with an inflight time of approximately 80 minutes for one US military casualty (Tables 1 and 2). Care of patients utilizing both transport platforms required medication administration, oxygen use, peripheral intravenous catheter placement, and ventilator management (Table 3).

TABLE 1 *Platform 1: Bell 412*

Platform Description	Platform Capabilities	Patient Transports (10)
• ***Litter capacity:*** 2 • ***Ambulatory capacity:*** 14 (not including medical providers).[7] • The Bell 412 by Bell Textron is a utility helicopter of the Huey family. • It has a max carrying weight of 5,398kg and cabin space of 6.2m^3. • The aircraft measures 3.69m long and 3.52m tall.[8]	• Two litters can be placed across the platform widthwise, allowing for the medical providers to care for both patients simultaneously (Figure 2). • The Bell 412 used by the ERST included a hoist, adding the capability to extract patients from dense terrain. • The platform has oxygen, power outlets, and communications.	• Male (10) • Military age [18–30] (10)* • Partner Force (9) • US military personnel (1) • Urgent-Surgical (5) • Priority (5) • Blast injuries (10) • Flight time (< 20 minutes) • Ten patients were transported from POI to the ERST in the following configurations: • Two urgent-surgical litter with two priority ambulatory patients • One urgent-surgical litter with three priority ambulatory patients • Two urgent-surgical litter patients. *Note:* Two CPR medical providers were present on the platform for all evacuations, and one evacuation included an ERST registered nurse from POI in addition to the two CPR personnel.

*Exact ages of partner force soldiers were unknown.

TABLE 2 *Platform 2: Pilatus PC-12*

Platform Description	Platform Capabilities	Patient Transport (1)
• ***Litter capacity:*** 2 • ***Ambulatory capacity:*** 10 (not including medical providers).[8] • The Pilatus PC-12 is a single-engine turboprop airplane capable of traditional passenger travel, medical assistance, cargo transport, and search and rescue missions. • The PC-12 cabin is 5.16m long, 1.52m wide, and the internal cabin height is 1.47m (Figure 3).	• The aircraft is capable of traversing paved, grass, gravel, or dirt airfields. • The PC-12 is equipped with a pallet-sized side cargo door, allowing for the loading of litters (Figure 4).[8] • There are two beds, each with its own oxygen H-class cylinder, suction regulator, and power supply allowing for two critically ill, vent-dependent patients at once (Figure 3). • The two beds are positioned along the aircraft's side, allowing for adequate working space for multiple medical providers (Figure 3).	• One urgent-surgical US servicemember who sustained multiple penetrating blast injuries was transported on the PC-12 from an outstation to a regional tertiary care center. • Flight time (80 minutes) • The patient was positioned in the rear litter bed allowing for easier access to medical supplies in the rear of the platform and proximity to the cargo door for loading and unloading. • The team included two CPR providers, an ERST critical care physician, an ERST critical care nurse, and a Special Operations combat medic.

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FIGURE 3 *PC-12 layout.*

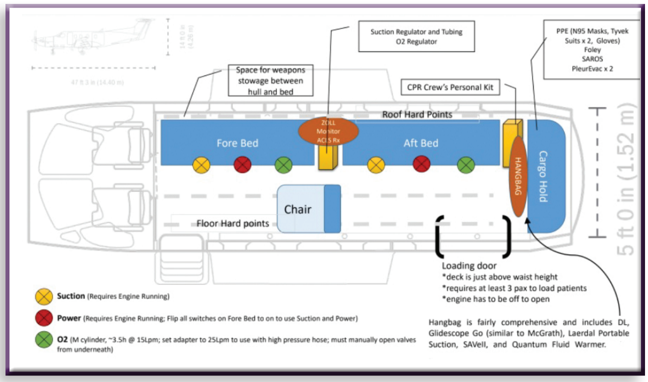

FIGURE 4 *Litter personnel training on loading a litter casualty into the PC-12.*

TABLE 3 *Medications/Therapies and Supplies/Equipment Used During Transport*

Platform	Medication/ Therapies	Supplies/Equipment
Bell 412	• Ketamine • Hydromorphone • Ondansetron • Whole blood	• Peripheral intravenous catheter insertion (1) • SAVeII Ventilator (5) • EMMA Capnograph (5) • Philips IntelliVue Monitor (5) • Oxygen via simple face mask (5) • Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) system management (1)*
Pilatus PC-12	• Ketamine • Propofol* • Midazolam • Fentanyl • Rocuronium* • Ondansetron	• Zoll Impact Uni-Vent 731 EMV+ (1)* • SAVeII Ventilator (1) • Philips IntelliVue Monitor (1) • EMMA Capnograph (1)

*Unique to ERST formulary/load-out.

Discussion

ERST versus CPR Training and Experience

Before deployment, ERST undergoes rigorous training over a 2-week period in prolonged field care in a limited-resource environment, under both day and night operations. The predeployment training incorporates seamless transition from prolonged field care to tactical evacuation care by implementing transport scenarios on ground CASEVAC platforms. These platforms include pick-up trucks, box trucks, and others to simulate providing care in a moving vehicle. This training differs from standard aeromedical evacuation training through the Joint Enroute Care Course (JECC) at the School of Army Aviation Medicine at Fort Rucker, AL, which trains joint military providers on static UH-60 Blackhawk simulators throughout a 2-week course.[9] We believe deploying transport teams should train on moving vehicles as it is critical to providing effective enroute care.

The experience of the CPR providers ranged from career civilian flight paramedics to former US Air Force pararescuemen. Unlike the ERST providers, CPR providers are certified in conducting hoist operations to extract causalities from dense terrain. ERST filled this gap in training by conducting hoist training operations with CPR personnel. The CPR personnel embedded with ERST were not advanced practitioners, so the addition of a critical care physician enhanced the medical capabilities during transports. Garne et al. showed that adding a critical care physician to flight paramedic teams can decrease trauma patients' mortality due to a vaster skillset and training experience.[10] Therefore, based on this previously cited data and personal experience, the authors recommend including physicians on critical care air transport whenever possible to augment enroute care.

Individual Platform Discussion – Bell 412

The Bell 412 is suitable for all patients, from convenience to urgent-surgical. Routine training and pre-mission rehearsals are imperative to identify logistical issues loading and unloading casualties into the aircraft (Figure 5). Teams should prioritize litter positioning depending on the level of illness and positioning of medical providers to maximize patient care. When transporting one casualty, we recommend placing the litter closest to the bulkhead where most medical supplies, including electrical and oxygen connections, are located for ease of access. When transporting two patients, we recommend that the more critically ill patient be placed closer to the bulkhead, for the same reason, with the medical providers located between the litters. Having ambulatory, or less ill, patients located proximal to the bulkhead and litter patients farther from the medical supplies may force the DCR attendant to move around these patients. This can make care of the litter patient more challenging. All litters and medical personnel should be secured before flight by any of the numerous D-rings fixed to the cabin floor.

ERST can position the DCR element far-forward with the ground forces because of its modularity, enabling advanced resuscitative capabilities at the POI and enroute back to the operating room. If tactically and logistically feasible, we recommend one DCR provider, either the trauma nurse or emergency medicine physician, accompany the patient from POI to support the CPR medical providers on the Bell 412. During one ERST patient transport, the DCR nurse remained with the patient from POI, performed enroute care on the Bell 412, and provided patient handoff upon arrival to the surgical facility. This allowed for continuity of care from the battlefield to the operating room.

An urgent medical evacuation from the POI requires significant coordination, involving ground medical providers, command and control personnel in multiple locations, and security personnel. Therefore, we recommend regularly occurring,

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FIGURE 5 *Litter team unloading a casualty from the Bell 412 after being evacuated from the battlefield.*

realistic rehearsals involving all parties before combat operations that focus on loading/unloading procedures, hoist operations as instructed by CPR personal, and roles of all providers on the aircraft. Teams should train with increasing intensity until members are familiar and capable in all phases from POI to evacuation outside of theater.

CPR medical providers render advanced life support-level care and serve as the subject matter experts for the onboard equipment, medical supply loadout, and flight crew functions. Additionally, the CPR medical personnel are certified to operate the hoist for patient extraction, which provides vital capability in restrictive terrain and can be a valuable option when no hasty landing zone is available. When a DCR provider remains with a casualty from POI, he or she must be competent in performing hoist operations, securing the litter in the aircraft, and being comfortable with hoisting in both day and night operations. We recommend engaging in progressive and challenging hoist training before any combat operation.

Coordination of patient loading and verbal handoff before transport was paramount as rotor noise and chaos on the battlefield make communication challenging. The addition of the DCR nurse on the CPR flight allows for a face-to-face patient handoff upon arrival to the surgical facility, increases the number of capable medical personnel on board and at the receiving facility, and potentially offers a broader scope of practice in-flight. If tactically feasible, we recommend allowing DCR personnel to remain with critically ill casualties transported from POI.

Transporting additional providers, along with critically injured patients, requires judicious space management. Medical teams and CPR personnel must coordinate and train to load only those supplies, medications, and pieces of equipment that effectively augment capabilities while avoiding unnecessary redundancy. Loading redundant equipment from the POI reduces working space within the aircraft. It also deprives the remaining ground personnel of that equipment with no added benefit to the patient in-flight.

The main limitation of the Bell 412, in comparison to other medical rotary wing aircrafts, is space available for medical care. Two litter patients on the aircraft leave little room for medical providers. This contrasts with the more spacious UH-60 Blackhawk, with which most rotary wing enroute military medical personnel are familiar with.

Individual Platform Discussion – Pilatus PC-12

The PC-12 contained two removable stretchers. However, litters can also be loaded and placed on top of the stretchers via the side cargo door. We recommend that the more critically ill litter patient be loaded into the rear of the PC-12, allowing for more rapid egress via the cargo door once at the intended destination. ERST uses the North American Rescue Talon Collapsible Litters (https://www.narescue.com/talon-ii-model-90c-litter.html) for transport. However, the PC-12 removable litters have an eight-point harness and adjustable headrest. While this has some advantages for enroute transport, such as raising the head of the bed for ventilator-associated pneumonia prevention and intracranial pressure precautions, it would require the ERST to transfer the patient from a Talon litter to the PC-12 litter. As an alternative, the transport team removed the PC-12 litter, placed it on the ground, and fixed the Talon litter to the PC-12 stretcher using standard litter straps. The team elevated the stretcher's head of the bed, placing the Talon litter in a reverse Trendelenburg position (Figure 6).

FIGURE 6 *ERST CCET and CPR transporting a patient via the PC-12.*

The PC-12 is ideal for remote patient transport because of the large cargo door for patient loading and the ability to utilize small airfields and non-traditional landing strips due to its short take-off and landing distance. Casualty rehearsals before missions are imperative to identify logistical issues in loading casualties into the PC-12. Teams should prioritize litter positioning depending on the level of illness, mechanism of injury, and positioning of medical providers to maximize patient care. Also, unlike rotary medical aircraft, the pressurized cabin allows for stethoscope auscultation, communication between team members without special equipment, and operation without ear protection while inflight.

Litter teams of three or four personnel should rehearse loading and unloading of litters, as once they are in the aircraft, there is little room to manipulate patients due to low overhead clearance. This training should help to minimize time spent loading and unloading, maximizing time spent caring for patients. When loading two casualties, the more critically ill patient should be loaded second. The two patients can be oriented multiple ways in the platform. Ideally, teams will position medical bags in the rear and place the patient's head toward the back of the plane to allow quick access to supplies (Figure 3). Other orientations include keeping the head of both patients toward the middle so that one medical provider can manage both airways without moving through the

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platform. Patients with a suspected neurologic injury should orient head-forward to maximize venous return since the aircraft's nose will be elevated during flight.

During the PC-12 critical care transport, the transport team used two different ventilators due to equipment failure. Initially, the team used the Zoll Impact Uni-Vent 731 EMV+ (https://www.zoll.com/products/ventilators/emv-plus). However, due to a high-pressure ventilator alarm on the Zoll Impact ventilator, the team switched to the SAVeII (AutoMedX, https://automedx.com/products/save-iiplus/). The high-pressure alarm was related to the PC-12 lacking an oxygen pressure regulator, thus triggering the automatic shut-off feature. Because the SAVeII ventilator does not require an oxygen pressure hose, the team managed the patient on the SAVeII with the corrugated tubing adapter connecting the ventilator's oxygen intake valve to the PC-12 oxygen regulator. It was critical that the medical personnel were able to troubleshoot and resolve ventilator issues, and thus future training and preparation should reflect this.

We identified three limitations of the PC-12:

1. With only one ingress or egress, the team must decide patient orientation before loading.
2. Although four medical providers fit into the platform, the more personnel present leads to decreased mobility and may necessitate kneeling to care for patients.
3. With the medical supplies and equipment positioned in the rear of the platform, it could be challenging to respond to emergencies for a forward-positioned patient. The height of the internal cabin, 4ft 10 in, makes moving around the aircraft difficult. Therefore, communication and teamwork amongst medical providers are critical.

An overall limitation of this retrospective case review is a lack of detailed documentation for the transports. This was due to limited access to the CPR personnel's documentation and the privacy of the patients involved. However, we did not believe it necessary to include documentation of all vital signs and interventions to fulfill the article's purpose. Since there are limited papers on joint flight operations in AFRICOM, we suggest further research on team dynamics between civilian contract flight paramedics and military transport teams to further identify training and equipment gaps. We also recommend including hoist training familiarization to deploying military medical transport providers.

Conclusion

We found that incorporating CPR personnel with forward austere military medical units during joint training and operational planning allows for continuity of care and increased interoperability in support of the warfighter. Ways to increase interoperability include cross training on equipment and formularies, familiarization with CPR evacuation platforms, and MASCAL exercises that include transporting multiple patients on the different platforms available.

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Disclosures

The authors have no financial relationships relevant to this article to disclose.

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Author Contributions

NB and JM conceived the study concept. All authors collected data. All authors read and approved the final manuscript.

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