Patient Transportation Part III: Prehospital Transport and Critical Care

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Intended Learning Outcomes

Patient Transportation Part III: Prehospital Transport and Critical Care

1. Understand specific safety considerations in prehospital care
2. Explain environmental and situational impact on providing clinical interventions in the prehospital environment
3. List effective elements of prehospital patient report and hand-off
4. Review key elements of effective communication before, during, and after transportation
5. Understand important aspects of prehospital triage
6. Discuss appropriate prehospital care based on an assessment of the patient's condition
7. List important changes and controversies in modern prehospital care
8. Identify principal elements of training hospital physicians to perform effectively in the prehospital realm
9. Review different forms of military medical transport
10. Explain the role of military transport in support of civilian operations

eModule Information

Relevant Competencies from CoBaTrICE

Patient Transportation Part III: Prehospital Transport and Critical Care

- **10.1** Undertakes transport of the critically ill patient outside the ICU (prehospital)
- **12.2** Communicates effectively with members of the health care team
- **12.3** Maintains accurate and legible records/documentation

1. Introduction

Providing emergency and critical care outside the hospital has unique challenges. Part I and Part II primarily focused on transporting patients either between facilities or within a facility. Under both circumstances, the patient has already been evaluated by a physician, has undergone diagnostic testing, and care has been initiated. Part III will discuss civilian and military care outside the walls of the hospital and the transportation of patients to definitive care.

2. Prehospital and Retrieval Medicine

Prehospital care refers to patients that are being recovered or retrieved from the field. These are sometimes referred to as primary missions or scene flights (in the air medical world). The challenge with these flights is that patients present from the field with little or no diagnostic workup. Occasionally, the critical care retrieval team are the first medical personnel to make contact with the patient.

The environment is particularly challenging in that the patients can present in austere environments or, at best, in the back of an ambulance. Providing swift and effective resuscitation and critical care under these circumstances can be challenging without the infrastructure and additional personnel found in a hospital. Successful prehospital care depends on early recognition of clinical problems, provision of immediate interventions to address life threats, triage of other interventions, and rapid transport to a higher level of care. Specifically, some of the most challenging decisions are choosing what needs to be done on scene, what can be done in flight, and what can be deferred until arrival at a primary receiving hospital.

2. 1. Dispatch

Early access to emergency medical services (EMS) is important for rapid management of the critically ill or injured patient. Short, standardized numbers such as 112 in most countries in the European Union, 999 in the UK, and 911 in the USA are the simplest way to provide rapid access. The dispatcher may then alert additional services, such as the police, fire service, helicopter service or specialists in assessment of dangerous substances such as chemicals or oil. Some dispatch centers around the world staff specially trained physicians that can be of particular help for efficient distribution of patients in case of multiple victims.

Note

If you are the responding physician receiving the initial notification of an emergency, try to get as much information as possible from the alerting person. Use the transfer time to mentally prepare possible interventions (e.g.: size of tracheal tube or dosages of medications for pediatric victims) and rehearse critical procedures.

Imagine you are the dispatcher receiving the call for help. What should you ask the person calling from the accident site? Six items of information are suggested here.

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

The more information you have, the better you can react. Important information includes:

1. Who is calling and how this person can be reached in case additional questions arise.
2. Where the accident happened and how to get there.
3. What happened (i.e.: type of incident).
4. The number of victims and their type of illness or injuries.
5. Kinds of victims (e.g.: children, pregnant women)
6. Whether additional rescuers are needed in addition to medical help (e.g.: to extricate persons trapped in a car, to extinguish a fire, to secure the site). Additional helpful information includes weather and road conditions and obstacles to air rescue.

2. 2. Prehospital Teams and their Skills

Provision of pre-hospital care differs greatly between countries. Different specialists with different levels of training may be involved, such as emergency medical technicians (EMTs), paramedics, nurses, physicians and, in some systems, emergency clergy workers, psychologists and others. These responders have different levels of skill and licensure. While some systems employ retrieval physicians that can perform very invasive procedures at the road, other systems in less developed areas of the world are only capable of delivering the most basic first aid services. It is important that in a given region physicians understand what the emergency response framework is and the level of care delivered by different services.

It is important to recognize that not only does the skill level vary by provider, but delivery of interventions is highly dependent on circumstance. Even the most capable, high-functioning, physician-led transport service might elect to not perform procedures or interventions due to compounding logistic or scene safety issues. Providing care in the field is dynamic and challenges not seen in hospitals (i.e.: scene safety or weather) may preclude certain interventions. Hospital providers must understand that there may be deviations from in-hospital standards to care due to challenging circumstances in the field.

To function in the field prehospital teams require skills not necessary in the hospital such as radio communication and coordination between multiple services (police, fire, and technical rescue teams). Fundamental communication skills needed during any in-hospital resuscitation become even more important in uncontrolled environments where noise, wind, or lack of light can hamper typical resuscitation operations. Prehospital teams also need to balance their ability to communicate with family members and loved ones with the time on scene to get patients to hospital.

A six-year-old boy was watching a rotating slicing machine cutting cabbage at a farm when the arm of his jacket got caught, pulling his arm into the machine. When you arrive at the scene, you determine that the boy has no serious A, B, or C problems, but his hand has been severely injured. The boy's mother is standing by. Would you take the mother along for the 50 km ambulance ride? Explain your decision.

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

Providing the mother is reasonably calm and cooperative and there is sufficient room in the ambulance, it is advisable to take her along. Separation of the child from the family will cause additional stress for the child and the mother. A family member may be the best analgesic and sedative for the boy. Further, the mother can provide important information on the child's health status, and she will understand that all efforts have been undertaken to save her child's hand.

In Text References

(Studnek, Ferketich and Crawford. 2007; Maddock et al. 2020; Rehn and Krüger. 2014; von Vopelius-Feldt and Benger. 2014; Rosenberger et al. 2021; Roth and Cone. 2021)

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2. 3. Patient Assessment and Care on the Scene

The first step is to determine the patient's status using the ABCDE system from the advanced life support algorithm. The most important initial question is: 'Is there any serious A, B or C problem (i.e.: is the cardiorespiratory situation stable or unstable)?' If the patient demonstrates no evidence of major life threat and no immediate intervention is needed, prehospital teams can move on to assess for and treat any D (neurologic disability, including pain) and E (exposure or environmental injuries) problems.

If the patient is unstable, the second step is to decide if the problem can be solved with simple means on the scene (e.g.: extrication of a foreign object from the pharynx or relief of a tension pneumothorax with a drain). Any life sustaining intervention that can be performed on scene should be performed immediately. If there is no immediately reversible treatment (e.g.: blunt abdominal trauma with hemorrhagic shock), it is imperative to minimize time to definitive care in hospital and attempt as much as possible en route to an appropriate trauma center.

Again, the goal of initial evaluation and care at the scene is to, as quickly as possible, determine what interventions be done immediately on scene, what interventions can be performed in transit, and what interventions can be deferred to the receiving hospital. However, this can be challenging on scene in the face of diagnostic uncertainty. With minimal diagnostic tools on hand, certain clinical problems may not be immediately apparent or may be obscured by environmental conditions. In some instances, decisions are made intuitively and treatments applied empirically, out of necessity, when a high degree of clinical suspicion exists.

It is also important to recognize that a key role for the prehospital team is to obtain a clear picture of the clinical history and sequence of events. Often, the prehospital team provides crucial information to the hospital team that can drive very important diagnostic tests and therapeutic interventions. One example might be that several family members are involved in a low-speed, motor vehicle accident. A co-occupant of the vehicle explains that prior to drifting off the road, the driver started to experience difficultly speaking and hemiparalysis. This might lead to additional workup for stroke. Another example would be a prehospital team collecting information on the quantity and dose of various medications taken during a polysubstance overdose. These important details might not be immediately available to the team treating the patient in hospital unless the prehospital team takes an appropriate history and relays the information during bedside report.

Consider the following serious emergencies: 1) a toddler with third degree burns from a portable heater; 2) a factory worker with alkali liquid splashed in her eye; 3) a motorcyclist with a crush injury. What crucial treatment would you perform before transporting each of these patients to the hospital?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

1. In burn injuries immediate cooling of the burned body area is more important than transport. However, beware of hypothermia.
2. Immediate and extensive flushing of the eye with plain water is the single most important therapeutic intervention; examination by an ophthalmologist can follow later.
3. In crush injuries with extensive destruction of muscle tissue, generous and early administration of crystalloids is needed to prevent acute kidney injury.

Challenge

Review the prehospital care report for the last five patients admitted to your ICU. Check if a decision was made concerning cardiorespiratory stability and note the procedures performed at the scene and the time spent out of the hospital. Evaluate the strategy adopted in light of later events in hospital and the final diagnoses.

What is the minimum acceptable blood pressure in a patient following myocardial infarction compared to that in a patient who has suffered an acute ischemic stroke?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

A mean blood pressure of 65 mm Hg may be sufficient in the first patient, however, a mean blood pressure goal of at least 100 mm Hg may be considered in a patient with stroke. The acceptable goals for vital parameters (e.g.: blood pressure) during transport are determined on an individual basis for each patient.

In Text References

(Haas and Nathens. 2008; Salomone et al. 2005; Seamon et al. 2007; Stiell et al. 2008)

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2. 4. Prehospital Triage

In cases of multiple casualties, it is imperative to triage patients quickly to do the most good for the greatest number of patients. Triage is a structured process used to recognize those victims in acute danger and those most likely to benefit from acute care. If the resources available are sufficient, triage will result in those who have the most serious conditions being treated first. If resources are limited and the facility is overwhelmed, triage may target those who need only simple or short interventions for treatment and those with severe injuries may only receive comfort care. The principles of triage apply not only to trauma victims but also to those with medical emergencies as well (e.g.: myocardial infarction or diabetic ketoacidosis with decreased mentation). Similar principles apply to allocation of ICU resources as to allocation of resources in the pre-hospital setting or in the emergency room.

It is worth mentioning that different countries utilize different triage tools and no international standard exists. In general, most triage tools used in the field assess physiologic parameters such as pulse, mental status, and respiratory rate. The Simple Triage and Rapid Treatment (START) triage model is widely used in North America. SMART Triage is a modified START algorithm with emphasis on hemorrhage control for patients with abnormal perfusion or altered mental status. JumpSTART, another modified START algorithm, is used for pediatric casualties appearing <8 years of age. The Triage Sieve algorithm, sometimes referred to as the Priority Triage system, is used in the United Kingdom and Australia. Part of this triage system makes recommendations for disposition of patients based on their priority; for example, Priority 1 (P1) patients should be directed to a major trauma center. The four-category CareFlight algorithm, intended for adult and pediatric patients, was developed in Australia. This method uses simplified parameters to categorize patients (walking, obeying commands, breathing, without the need for numerical measurements).

No single method has been proven to significantly outperform others in a real-world setting. Hospital providers from different services should be aware of what triage system is used locally as it will determine the manner in which patients are treated and transported to a particular facility.

Challenge

Imagine a bus accident with ten seriously injured patients. They will be admitted to your hospital within the next 15–120 minutes. On which criteria would you admit a patient to your ICU or send him on to the next institution. Would you transfer any of your presently admitted patients to another institution or to a normal ward in order to make room for one of the new patients?

In Text References

(Aylwin et al. 2006; de Ceballos et al. 2005; Postma et al. 2013; Frykberg. 2002; Pepper, Archer and Moloney. 2019; Disaster Med Public Health 2011; Randolph, Morsch and Chacko. 2019; Jenkins et al. 2008)

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2. 5. Developments in Prehospital Procedures and Interventions

Although immobilization of the spine after trauma is an integral part of ATLS, there is debate over how much stabilization is appropriate. The effect of spinal immobilization on mortality, neurological injury, and spinal stability remains uncertain. Under no circumstances should spinal immobilization (more commonly referred to as spinal motion restriction), especially of the cervical spine, lead to compromise of airway patency, increase in intracranial pressure or agitation and panic due to claustrophobia with too tight an immobilization. Furthermore, it is unnecessary in the setting of isolated penetrating trauma.

Armed conflict in recent history has led to substantial developments in trauma management that have impacted civilian prehospital practice. Directly addressing the coagulopathy of trauma by rapidly achieving hemostasis, minimizing administration of crystalloid, and “permissive, low normotension” until definitive surgical management are becoming common practice. Many critical care transport programs (and even some ground emergency response agencies) carry blood products, which seems both feasible and efficacious at improving survival.

The use of tranexamic acid (TxA) to treat hyperfibrinolysis and manage the acute coagulopathy of trauma is common around the world. In North America in particular, TxA is being carried and administered by prehospital teams with increased frequency.

Tourniquets have been a major, life-saving intervention in conflicts in Iraq and Afghanistan. Data from these conflicts as well as civilian databases demonstrate that tourniquet are safe and effective intervention to improve mortality from life-threatening hemorrhage. Many civilian organizations have adopted the use of tourniquets as routine part of their trauma care. Hemostatic dressings have also been adopted into civilian prehospital use. Although early hemostatic products posed significant safety concerns, several products have emerged as safe and effective. Although no robust data exist that definitively suggest a survival benefit, many systems consider it reasonable to implement these dressings when pressure dressings alone fail or a wound is not amenable to tourniquet placement.

Hypothermia is one of three parameters, along with coagulopathy and acidosis, that compose the lethal triad and is associated with poor outcome. Many factors contribute to hypothermia in severe trauma patients. Monitoring of temperature, prevention of hypothermia or restoration of normothermia must be performed in all patients using insulating blankets, infusion warming systems and other devices.

Airway management in the prehospital world remains controversial. The question remains whether or not definitive airway management using an endotracheal tube (with or without the use of anesthetic and paralytic medications) provides clear benefit in patient-centered outcomes. The benefit seems to be predicated on a number of variables. For example, in large metropolitan areas with very short transport times and non-physician emergency care providers several studies suggest no benefit. Likewise in the setting of cardiac arrest management in the prehospital setting. Physician-staffed prehospital critical care transport teams have demonstrated that prehospital medication facilitated airway management (commonly referred to as rapid sequence intubation or RSI) can be done safely and efficiently. Furthermore, although there is no conclusive evidence, it stands to reason that for prolonged prehospital transportation endotracheal intubation may be reasonable.

As mentioned in Part I in the discussion about transport team equipment, use of point of care prehospital ultrasound is on the rise. Prehospital physicians that are trained and facile with ultrasound have used it to improve diagnostic capabilities when faced with clinical uncertainty in the field. In addition, non-physicians have been effectively trained to quickly obtain and accurately interpret certain exams such as the extended Focused Assessment Sonography in Trauma (eFAST) and abdominal aorta exams. While its efficacy and patient benefit remain unclear at this time, as the use of ultrasound expands it seems like it will prove a valuable tool in the prehospital realm.

You are about to start a 50 km transfer of an obese patient with acute coronary syndrome. The patient is sleepy and nauseated but cooperative, following intravenous morphine. His blood pressure is stable with a mean pressure of approximately 75 mmHg. In which situations would you consider securing the patient’s airway before departure?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

- Difficulty keeping the airway open (e.g.: obesity and increased sleepiness following morphine). Airway protection deserves special consideration in case of increased nausea or vomiting.
- Difficulty ventilating (e.g.: heavy snoring, worsened sleep apnea with obesity and morphine).
- Difficulty oxygenating (e.g.: pulmonary oedema in left ventricular failure).

What are the disadvantages of orotracheal intubation?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

Intubation may render the situation more difficult: the patient will need sedative medication with the risk of increased cardiovascular instability. In the case of accidental extubation, the situation may really get out of hand, as airway control is even more difficult outside the safe confines of the ICU. It is worth noting that non-invasive ventilation may be an effective strategy that could support ventilation and oxygenation under certain circumstances.

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2. 6. Selection of a Receiving Hospital

The choice of the receiving hospital may be just as important as prehospital care. There is some evidence that patients referred to centers with higher numbers of emergency admissions have better outcomes than those referred to smaller hospitals. This evidence is particularly robust in the setting of trauma. However, stabilization of vital parameters at a smaller institution with secondary transfer to a (larger) receiving hospital may be appropriate when the total transfer distance or time is great.

Be particularly suspicious if a patient does not present with the signs and symptoms you would consider appropriate to the injury (e.g.: insufficient rise in heart rate in a patient with substantial bleeding or minimal pain with obviously severe injuries). There may be serious underlying or accompanying conditions or injuries. When in doubt, suspect the more serious differential diagnosis of illness or injury and transfer the victim to a large, tertiary center with a full spectrum of specialty care, rather than a small hospital. This is particularly important since delays in definitive care are associated with increased mortality. Specifically, when patients are taken to facilities with fewer resources initially, but secondary transfer to a tertiary center is required, there is evidence to suggest such a delay increases mortality.

Contacting the receiving unit early and providing extensive information helps them prepare for patient admission and activate appropriate services (e.g.: the trauma team or stroke unit). In addition, the CT suite or other invention areas may be reserved that needs emergent diagnostics studies or procedures.

You arrive at the scene of an accident approximately 60 minutes after it has occurred. A 66-year-old previously healthy woman has suffered a closed head injury. Now she has a GCS of 14 and is fully alert and cooperative. However, she does not remember the accident and has since vomited twice. As she feels fine, the patient demands to go home, rather than being transferred to a trauma center. Will you admit the patient? Where? How do you justify your decision?

COMPLETE TASK THEN CLICK TO REVEAL THE ANSWER

This patient with a closed head injury and amnesia together with repeated vomiting has an increased likelihood of intracranial injury requiring neurosurgical intervention. You may have to insist that she to be taken to the trauma center to rule out any serious injury.

Challenge

Question the local EMS dispatcher about the protocol currently used for the referral of trauma patients to hospitals in your area. Note if 'Trauma Centers' are formally designated. Assess if a physician is involved in the choice of hospital and how the receiving unit is informed.

In Text References

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2. 7. Prehospital Report and Patient Handoff

The handover of the patient at the receiving unit deserves special attention. It is a point at which information may be transferred accurately, inaccurately or lost. Even though written information (vital signs, medications, other interventions) is imperative for correct documentation and later reference, an oral report is faster and allows for emphasis of specific findings. It also allows the crew to provide critical, nuanced information about a scene or bystander narrative of events that may be important regarding next steps and diagnostic tests.

Structured communication that is brief (less than 30-60 seconds) and contains pertinent information in a certain order is important. During times of high-stress and in time-sensitive situations, presentation of clear and concise information is crucial if listeners are expected to hear and process the information presented. The handoff report should not include vague or unclear language. In fact, standard words, phrases, and abbreviations should be used so everyone understands. Furthermore, the order of the information should always be the same to the listeners know what to expect. An example of this type of report is referred to as the "MIST Report", sometimes referred to as the "D-MIST Report". The acronym stands for the following report elements

- DEMOGRAPHICS - "This is a 56-year-old female…
- MECHANISM - …who was a restrained driver involved in a head-on motor vehicle crash at approximately 65 mph (105 kph), prolonged extrication was required...
- INJURIES - …she presented to us responsive only to pain with a significant laceration and hematoma to the right forehead, lacerations to the face, bruising/crepitus and subcutaneous emphysema on the right hemithorax consistent with pneumothorax…
- SIGNS/SEVERITY - …her vital signs demonstrated hemodynamic instability with a heart rate initially of 134 and a blood pressure of 88/56. Her GCS was 6. Respirations were being supported via bag valve mask by local responders on our arrival.
- TREATMENTS - The right hemithorax was emergently decompressed, blood and TxA were administered. Her blood pressure improved and she was intubated with ketamine and rocuronium. En route to hospital she was given hypertonic saline as there was concern for increasing intracranial pressure."

Full documentation of patient data and interventions is obligatory and an integral part of patient care. Future development will hopefully simplify documentation using patient data management systems. However, electronic monitoring equipment outside the hospital may malfunction due to mechanical damage or weather conditions. Today paper documentation is still standard, see the sample record sheets in the Appendix.

In Text References

(Kanki, Lozito and Foushee. 1989; Brindley 2010; Cyna et al. 2010; Kanki and Smith. 2001; Gaba, Fish and Howard. 2014; Gaba. 1992; Jentsch and Smith-Jentsch. 2001; Foushee and Helmreich. 1998; Maddry et al. 2021; Meisel et al. 2015; Picinich, Madden and Brendle. 2019; Maddry et al. 2021)

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2. 8. Prehospital Training for Hospital Providers

In many jurisdictions physicians who also work in hospital-based specialties or who are engaged in specialist (residency) training also train and work in the prehospital environment. This is the so-called Franco-German model, which also extends to nurses from critical care (ED/ICU) background. The physician/paramedic model is often the team configuration chosen for high acuity aeromedical/HEMS models in the UK, Europe and Australia. In North America, nurse/paramedic staffing models are common with a growing number of transport services that incorporate physicians.

Induction training of physicians to thrive and add value in the prehospital environment is critical to the success of this model. Competency in skills such as rapid sequence intubation, finger thoracostomy should already be acquired skills but specific training should focus on performance of these and other skills under pressure and in a new environment. Furthermore, low-frequency high yield eye, life and limb saving procedures need to be embedded into that training and work-flow to maximize the chance of success. Those procedures may include lateral canthotomy, resuscitative hysterotomy and thoracotomy, REBOA, escharotomy and surgical airway. In addition to technical skills training, non-technical skills such as scene management, communication, crew resource management, and safety are of paramount importance.

2. 8. 1. Training

One example of embracing high-performance culture and approach to education is the induction training at Sydney HEMS, NSW Ambulance Aeromedical Operations. The initial training at Sydney HEMS for retrieval physicians and paramedics is formed around a number of key tenets:

1. Flipped classroom with a virtual learning environment (VLE) that details work flow, specific operating procedures (e.g.: resuscitative thoracotomy, traumatic cardiac arrest, neuroprotection). This is associated with MCQ/SBA assessment and occurs in advance of new doctors/paramedics entering the induction programme.
2. Train as you fight: doctors are paired with paramedics from the very beginning and through the entire 2-week induction. This allows for rapid development of a flattened hierarchy, shared mental model and human factors training, using operational packs for all simulations with responsibility for resetting and maintaining those packs for the entire induction period. Knowing the equipment well is key to a high-performance culture. This leads to implicit or non-verbal coordination within the team.
3. Overtraining and stress inoculation. High reality in-situ simulations, grading up scene perturbation over the course of the induction period is an excellent way to build performance under pressure and resilience. Underpinning this is the concept of overtraining, or training beyond what will be expected/required to that in the event of cognitive overload/bandwidth saturation the team still performs to a very high level. Scenarios must be realistic and believable. To avoid 'simulitis', observers should be remote to the scene but able to see and hear everything that is occurring by audiovisual link, in order to aid group debrief, learning and fidelity. Doing the basics to a very high level under all types of stress underpins all stress inoculation training.
4. Workflow (Figure 1). This concept is critical to the performance of the prehospital team and includes key rapid work-ons for the paramedic and doctor on the scene following integration to the crew already on scene. Where practicable and feasible, both the paramedic and physician may delegate certain aspects of the workflow to other paramedics on scene whilst the HEMS team set up for specific procedure/intervention or to lessen bandwidth saturation.
5. Zero Point Survey (ZPS). The ZPS is optimal for the prehospital environment. Pre-resuscitation and post-resuscitation steps (STEP-UP) can be seen in Figure 2. This provides a structured and reproducible approach to optimizing preparedness and hence performance of the team in the domains of the individual (self check), the team (team brief, shared mental model) and the environment, prior to commencing the primary survey. The prehospital environment is one that needs to be controlled as best as possible to improve chance of success (e.g.: 360-degree access). The primary survey involves the patient assessment, thereafter followed by an update (shared mental model) and priorities (team goals and mission trajectory).

6. Marginal gains or 1%ers. Marginal gains or as often mentioned in elite sport as “1%ers”, or small incremental improvements in processes, skills, training and systems that over time leans to large improvement. The corollary is also true, where stagnation, no regular development, training or system improvements leads to marginal decline over time (Figure 3). Sydney HEMS has developed an internal on-line 1%er Register where any physician or paramedic can register that small gain he/she has noted that will eke out small improvements. This leads to iterative improvement over time.

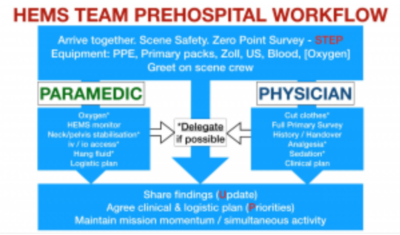

Figure 1: Prehospital Workflow (Sydney HEMS, NSW Ambulance, Australia).

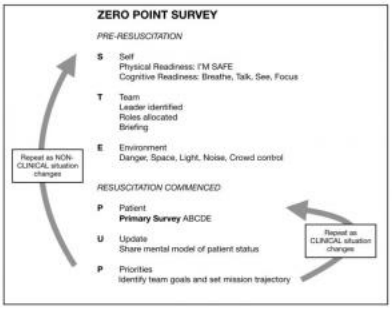

Figure 2: Zero Point Survey (Reid, C et al).

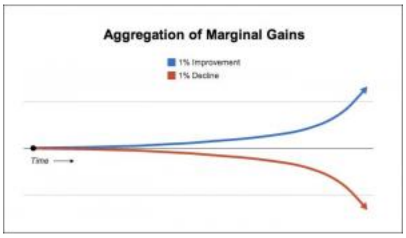

Figure 3: Aggregation of marginal gains.

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2. 9. Prehospital and Retrieval Medicine Clinical Governance

The prehospital and retrieval/transport medicine (PHRM) literature has been lacking in high-quality evidence up until recently. PHRM is increasingly becoming recognized as a medical subspeciality in various countries. It behooves organizations and clinicians working in this area to participate in and perform high quality audits and research. EMS and PHRM organizations should develop high quality audits in the first instance, and key to this is detailed and reliable data collection. Software upload capability from prehospital monitors and an electronic database that includes key mandatory variables should be seen as minimum standard. Integration of data to and from the hospital system is also a requirement for high quality research and clinical quality assurance.

Coupled to this should be an expectation that working for an organization entails collection of reliable data, meeting the expected standard of data entry and participation in research activities. Research standards will need to approach in-hospital critical care research standards in order to produce meaningful output and evidence base. This includes formation of a research committee, operating procedures, strategy and plan. Good prehospital research can drive change in practice away from accepted dogma and develop the scientific rigor of prehospital care.

There are many current and future domains of high-quality prehospital research that are rapidly accelerating on a global level. This includes blood product resuscitation, traumatic brain injury, cardiac arrest, sepsis, diagnostics and technology.

3. Military and Global Transport

The use of an aircraft to transport patients ill or injured during war was first described in the early 20th century and has evolved into the concept of aeromedical evacuation (AE). The advances of modern AE as an integral and sophisticated part of military medical systems were demonstrated during international conflicts in the 1990s such as Operation Desert Storm and the Implementation Force and Stabilization Force in Bosnia. In response to the complexity of combat casualties, the United States Air Force (USAF) developed the capability to transport critically ill or injured patients. These Critical Care Air Transport Teams (CCATT), which are highly specialized medical teams composed of physicians, nurses and technicians that ensure inflight ICU-level care on board of military aircraft.

The USAF showcased their critical care aeromedical evacuation capability during the Afghanistan and Iraq theaters of conflict in the early 2000s where approximately 500 critically ill or injured patients were evacuated from Southwest Asia to Europe. Many other military forces have also developed their own AE capability providing basic to advance life support while transporting patients across the world. In this section, we will elaborate on the concept of AE and its subtypes such as forward AE, tactical AE, and strategic AE, with a focus on the global transportation of critically ill and injured patients.

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3. 1. Aeromedical evacuation

According to the North Atlantic Treaty Organization (NATO), AE is defined as the air transportation of patients under medical supervision from the point of injury to a medical treatment facility or between medical treatment facilities. There are three types of AE: forward AE, tactical AE, and strategic AE. Forward AE describes the transport of patients from the point of injury to the initial medical treatment facility. In forward AE, medical care is aimed at transporting patients as quickly as possible to the nearest and/or most appropriate medical treatment facility while providing damage-control resuscitation. Considering the environmental constraints of retrieving patients at the point of injury, forward AE normally involves helicopters and other vertical and/or short take-off and landing (V/STOL) aircraft.

Forward AE medical crew composition is determined based on the operational requirements, available medical personnel, aircraft, and medical equipment. The scalable capability of forward AE can range from basic life support crews involving only medical technicians to advanced life support crews composed of physicians, nurses, and technicians. For example, the United States Army DUSTOFF is a UH-60 Blackhawk helicopter-based medical evacuation platform. The DUSTOFF medical crew is composed of two emergency medical technicians - basic (EMT-B) and can provide care to a maximum of 3 to 6 patients depending on aircraft configuration. Interventions in flight are based on tactical combat casualty care principles and include IV and IO access, needle chest decompression, cricothyroidotomy and supraglottic airway device insertion. Another forward AE example is the British Forces Medical Emergency Response Team (MERT) CH-47 Chinook helicopter-based medical evacuation platform. The MERT medical crew is composed of one physician, one nurse and two paramedics, and can provide care to a maximum of 8-9 patients depending on aircraft configuration. Due to the presence of more advanced healthcare providers on board, MERT has critical care capabilities and can offer additional interventions such as chest tube placement, blood products, rapid sequence intubation, advanced cardiac life support, tranexamic acid administration and video laryngoscopy.

Further along the chain of evacuation, tactical and strategic AE involve the medical transportation of patients on aircraft between medical treatment facilities within a theater (intra-theater) and outside the area of operations (inter-theater), respectively. Considering the long distances between medical treatment facilities, tactical and strategic AE normally involve fixed wing aircraft that are capable of long-haul flights. Similar to forward AE, medical crew composition is determined based on the operational requirements, available medical personnel, aircraft, and medical equipment.

The scalable capability of tactical and strategic AE can also range from basic life support crews involving only medical technicians to advanced life support crews composed of physicians, nurses, and technicians. It’s important that the level of medical care is maintained during patient transport. Accordingly, if a patient requires ICU-level care, then it is expected that a critical care air transport asset is available prior to making the decision to transport the patient. For example, the European Air Transport Command (EATC) is a multinational collaborative strategic AE program between the French, Dutch, Belgian, German, Spanish, Luxembourgish, and Italian Air Forces. Created in 2010, the EATC coordinates and controls the AE operations among the participating countries. In other words, they can task AE assets such as fixed wing aircraft and medical crews from different nations to meet operational requirements. The EATC has coordinated the transport of approximately 1,100 patients per year, for a total of more than 8,000 patients since its creation. The unique feature of the EATC is that it can turn to civilian air assets if there is a lack of a suitable military air asset. This example illustrates not only the flexibility and effectiveness of multinational cooperation, but also the interoperability of medical personnel.

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3. 2. Critical Care Aeromedical Evacuation

The transportation of critically ill or injured patients is essential to military operations. The aim for special critical care AE is to enable the movement of critical ill or injured patients over long distances from areas of operations to higher-level centers that are often located in different countries and continents. For example, the French Armed Forces launched the Module de Réanimation pour Patient à Haute Élongation d'Évacuation (MoRPHEE) that allows for the long-distance transportation of critically ill or injured patients. The French MoRPHEE system is based on the operational equipment of the Airbus A330 MRTT platform that has a maximum range of 14,800 km. The advantage to the MorPHEE system is that it does not require dedicated aircraft and can be installed in an A330 MRTT within a few hours to be able to transport patients. The MoRPHEE has two possible configurations that can accommodate 6 to 12 patients, with 4 to 6 mechanically ventilated patients. The MoRPHEE medical team includes two anesthetists, two doctors trained in aerospace medicine, three nurse anesthetists, two aeronautical unit nurses and two air transport nurses. More recently, the French Armed Forces have also developed the ModulE de Réanimation pour les OPÉrations (MEROPE), a system that enables patient transport using the Airbus A400M ATLAS. In fact, the MEROPE was specifically designed for the transport of COVID-19 patients with ARDS. The MEROPE is based on the operational equipment of the Airbus A400M ATLAS platform that has a maximum range of 4,500 km with a 30-ton payload. Considering the range differences between the A330 MRTT and the A400M, the MEROPE system is normally utilized to transport critically ill or injured patients for domestic operations or intra theater missions.

On the cutting edge of critical care transport, military forces have developed the capability to offer Extracorporeal Life Support (ECLS) on board aircraft. ECLS involves the use of extracorporeal membrane oxygenation (ECMO) as a life-saving measure to support patients with severe lung or cardiac failure that do not respond to lesser invasive interventions. During the combat theaters in Afghanistan and Iraq in the 2000s, the United States Armed Forces established the Acute Lung Rescue Team (ALRT) based at Landstuhl Regional Medical Centre (LRMC), Germany, augment their CCATT to allow for the transport of critically ill or injured patients that required ECMO aboard aircraft platforms such as the Boeing C-17 Globemaster III and the Lockheed Martin C-130 Hercules. The ALRT was later consolidated and became the ECMO Team based at Brooke Army Medical Center at Joint Base San Antonio-Fort Sam Houston, Texas. The combination of ECMO and CCATT teams with long-haul capable aircraft like the C-17 enables the United States Armed Forces to conduct global transportation of critically ill or injured patients requiring ECLS level care.

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3. 3. Aeromedical Evacuation of Highly Infectious Patients

Recent world events, such as the ongoing Coronavirus disease 2019 (COVID-19) pandemic and the 2014-2016 Ebola virus disease (EVD) outbreak in Western Africa, have resulted in AE systems to adapt to safely transport patients with highly communicable infectious diseases. Examples of highly contagious diseases that require special considerations for AE mission planning are Human Influenza caused by a novel serotype or SARS. Further safety measures should be taken into account for contagious diseases that require biosafety level (BSL) 4 in a laboratory such as smallpox, Lassa fever, New World arenaviral Viral hemorrhagic fevers (VHF), filoviral VHFs (Ebola, Marburg), flaviviral diseases with a hemorrhagic diathesis, Omsk VHF, Kyasanur Forest Disease and Crimean-Congo Hemorrhagic Fever. Recent advances in biosafety capability have facilitated the transport of highly infectious patients on military and civilian aircraft. Examples of these biosafety units are the Air Transportable Isolator (ATI), the Aeromedical Biological Containment System (ABCS), the Containerized Biocontainment System, and the Transportation Isolation System (TIK). These biosafety systems have been indispensable to AE missions during the COVID-19 pandemic.

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3. 4. Global Repatriation of Civilian Patients

The global repatriation of patients often requires civilian-military cooperation (CIMIC) in order to overcome geographical and logistical barriers. Examples of CIMIC in AE capability can vary from the use of civilian aircraft with military medical crews to military aircraft with civilian medical crews to military aircraft with mixed civilian-military medical crews. Regardless of the circumstances, AE mission planning should ensure that the necessary medical personnel, equipment, and resources are available while medico-legal responsibilities and liabilities are established. Considering the international nature of these missions it is imperative that the medical equipment and drugs be cleared by the appropriate authorities to avoid legal issues that can negatively impact patient care. The sending medical facility physician should be responsible for coordinating with the AE crew and the receiving medical facility physician to ensure that the required level of care is provided during patient transfer including the ground transfer between medical treatment facilities and the aircraft. Examples of a CIMIC approach to AE missions have been witnessed recently throughout the COVID-19 pandemic.

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4. Conclusion

Transporting critically ill or injured patients from out of hospital, and sometimes very austere locations has very unique challenges. Military and civilian medicine have adapted their practice over the years to better incorporate evidence-based therapies and incorporate cutting edge technology. While much has been learned, the field of Prehospital and Retrieval Medicine is still young and more research needs to be done to refine practices.