Air Transport Of The Critically Ill Emergency Department Patient

Abstract

Critically ill patients often require the specialized care offered only at tertiary care centers and must frequently be transferred from referring emergency departments. This transportation often occurs by air. Currently, there are no widely accepted or mandated guidelines regulating critical care transport, and regional medical transport systems have disparate models of performing this service. It is essential for practicing emergency physicians to be aware of the current evidence supporting critical care transport as well as federal laws regarding transfer of patients. With the variability in medical systems, each region has diverse resources and protocols, and emergency physicians should be aware of these prior to needing to transfer a patient. Select populations should be considered for air transport, and certain patients will require resources beyond typical helicopter transport teams. This review highlights the indications for helicopter transport of critically ill emergency department patients, the capabilities of many critical care transport teams, and current controversies in the field.

Case Presentation

A 54-year-old man presents to your community ED complaining of abdominal pain and numbness in his right leg. Shortly after arrival to the ED, he complains of pain extending to his chest. He describes the pain as a “tearing” sensation that rips through his chest and back between his shoulder blades. The pain is constant, and he has never experienced it before. On physical exam, his blood pressure is 208/110 mm Hg, and his pulse is 110.
beats per minute. He is diaphoretic with tenderness to palpation in his upper abdomen that is most prominent in the epigastrium. The chest and cardiac exams are normal, but he has 4/5 strength and decreased sensation in his left leg. Lab results are all within normal limits. ECG demonstrates sinus tachycardia without ischemic changes. A CT scan demonstrates a dissection from the aortic root to the level of the common iliac arteries. IV esmolol and nitroprusside are started, and bilateral radial arterial lines are placed to monitor blood pressures. The diagnosis is obvious, and the correct emergency treatment has been initiated. This patient needs life-saving surgery, but cardiothoracic surgical support is not available at your hospital. You need to transfer this critically ill patient.

Introduction

Motor vehicle collisions, myocardial infarctions, drownings, childbirth, and gunshot wounds are all examples of acute presentations that require immediate medical attention. Emergency medical services (EMS) personnel provide vital care while they treat and transport the sick or injured to appropriate medical facilities.1 EMS providers are also accustomed to transferring patients from the emergency department (ED) of one facility to another for tertiary or definitive care that is not available at the sending facility.

While variability exists from state to state, many EMS options are available in most areas, including basic life support (BLS), advanced life support (ALS), and critical care transport (CCT) services. BLS ambulances can provide rapid ground transport, oxygen therapy, and fracture or spinal immobilization. ALS ambulances can provide additional cardiac monitoring, advanced airway management, and intravenous (IV) therapy with limited pharmacologic intervention, typically by maintaining continuous infusion rates. ALS services, however, cannot titrate medications, cannot provide invasive monitoring or intervention, and transport primarily by ground.

CCT teams consist of a small cadre of highly trained EMS professionals who travel by air or ground and are regularly called upon to transport critically ill patients. Not only are CCT teams able to travel by air via rotor or fixed-wing aircraft, they can also provide invasive monitoring, advanced ventilator support, cardiac pacing, defibrillation, central line access, needle thoracostomy, and advanced airway management (including surgical approaches). Additionally, CCT teams typically have a substantial pharmacy, including vasoactive agents, volume expanders, sedatives, analgesics, paralytics, antiarrhythmics, and anticonvulsants.2 A typical CCT team in the United States will consist of specially trained nurses and paramedics, but they may also include a respiratory therapist, perfusionist, or physician.3,4 Although scene transfers are commonly studied, almost 80% of CCT missions are interfacility transfers.5,6

Despite the expertise of CCT teams, the transfer of critically ill patients is not without risk. Even transportation of critically ill patients within the hospital is associated with increased adverse events when patients are not accompanied by appropriate staff.7,8 The risk of adverse events is increased when interhospital transport is considered,7 as EMS transport is performed around the clock, at high speeds, and with short response times on an unscheduled basis. Mitigating this risk by adequately stabilizing a patient and employing the correct resources is essential. The potential benefit of emergent transfer must outweigh the potential risk.

Unfortunately, there are significant regional disparities in CCT services as there are no uniform national requirements or mandated skill sets for CCT providers. The Commission on Accreditation of Medical Transport Services (CAMTS) has evolved as an accrediting body for air CCT; however, CAMTS accreditation is not required for organizations providing air CCT.

It is important for any physician needing to transfer a critically ill patient to be aware of available regional EMS and CCT resources. While occasionally a CCT service medical director or transport physician will accept “shared responsibility” for a patient in transport, the Emergency Medical Treatment and Active Labor Act (EMTALA) stipulates that a transferring physician remains responsible for the patient’s care until the patient has arrived at the receiving institution.9,10 Familiarization with regional EMS capabilities and the transfer policies of local tertiary care facilities is imperative to provide patients with the highest level of care.

This issue of EMCC will discuss the advantages and disadvantages of air CCT, describe techniques for initiation of CCT, and discuss contraindications to air CCT.

Critical Appraisal Of The Literature

The data for helicopter transport of the critically ill ED patient have limitations similar to much of the EMS literature. Due to the emergent nature of patient presentations and variability in transport systems, performing high-quality, broadly generalizable studies is challenging. There are no randomized trials of helicopter transport, and, as such, the majority of the literature for helicopter transport consists of observational studies, case series, and expert opinion.

Many studies attempt to control for variability in patients by using the Injury Severity Score (ISS) or the Trauma Related Injury Severity Score (TRISS).11 A commonly noted limitation of these scoring systems is that they require clinical information that is only
obtained after transport, thereby limiting their use in a prospective manner. These studies are further limited by insufficient reporting of transport times, transport distances, and patient data. Studies often lack a control group, or, in the case of air versus ground transport, the ground cohort is used as the control. Many authors use multiregression analyses to account for differences in the subsets of patients transported by each mode, but these may leave some factors unaccounted for, leading to selection bias and reporting bias. Despite well-designed meta-analyses of helicopter transport, the diverse patient populations, variability of trauma systems, and inconsistent reporting of outcomes in the primary studies preclude strong evidence-based guidelines.

Due to the homogeneity of trauma patients, studies on helicopter transport are commonly centered around these patients. Studies of trauma patients benefit from substantial local and national trauma registries as well as a uniform trauma scoring system (ie, TRISS). The majority of these studies have evaluated outcomes associated with transporting patients from the scene of the trauma to a trauma center rather than interfacility transport. Although not directly applicable to the interhospital transport of critically ill ED patients, the best available data support the efficacy of CCT for improving outcomes for trauma patients.

Many of the studies and guidelines regarding CCT and helicopter transport are from Australia, the United Kingdom, and other areas of Europe. While some studies and their outcomes are applicable to the United States, the differences in healthcare systems (such as hospital design, geography, etc) may limit broad application. The Intensive Care Society published guidelines regarding CCT in 2002, 2007, and 2011. The American College of Critical Care Medicine published guidelines for the interhospital and intrahospital transport of critically ill patients in 1993; these guidelines were revised in 2004 but have not been updated since.

**Considerations For Critical Care Transport**

**Decision To Transfer**

The decision to transfer a patient from one hospital to another is ultimately determined by weighing the potential benefits of transport to the patient against the potential risks. There are little data available about how clinicians make the decision to transfer patients, or how clinicians determine patients’ suitability for transport; these decisions have been described as an ad hoc process. Transfer should only occur if it is likely to improve the patient’s clinical outcome. Financial considerations should not be a factor when considering transferring a patient. The indications for interhospital transfer from the ED should be primarily clinical. Potential indications include the need for tertiary care services not available at the referring hospital, such as specialist care, advanced diagnostics, or specialized procedures. Nonclinical reasons for transfer occur in a minority of cases and include lack of a critical care bed or repatriation to a patient’s local hospital. These transports should be avoided, if possible, as the transfer of a critically ill patient for a reason other than medical necessity is an undue risk for both the patient and the crew. All practitioners should be aware of federal and state laws regarding patient transfers, including EMTALA, which defines the legal responsibilities regarding initiation of patient transfer. EMTALA was enacted to prevent patient “dumping,” and it states that a hospital must provide a medical screening examination and stabilization to the best of the hospital’s capability prior to transfer.

A discussion of the risks and benefits of transfer must be held with, and informed consent must be obtained from, a competent patient or the patient’s legally authorized representative prior to transfer. Documentation of this conversation should be placed in the medical record. In the case of a life-threatening emergency, if informed consent is not obtained, the indications for the transfer and the rationale for not obtaining consent must be documented. The referring physician must write an order for transfer in the medical record. Although transfers from EDs constitute a significant proportion of interhospital transports, data indicate that there are significant deficiencies in providing adequate equipment, patient monitoring, staff training, and documentation of the transfer. In one survey, only 56% of EDs in the United Kingdom had established departmental transfer guidelines. Emergency physicians should review their institution’s resources and policies prior to encountering a situation in which a patient requires transport.

The ultimate decision to transfer rests with the referring physician. Once the decision is made to transfer the patient, the referring physician must find an accepting institution. This can be a difficult and time-consuming process unless the physician has access to a local centralized referral center. An Australian study found that transferring a patient required an average of 4.7 phone calls per patient and a mean time of 1 hour from the time of the decision to transfer until the patient was accepted at a receiving facility. Once a receiving institution is found, the referring physician must confirm that appropriate higher-level services are available. The receiving physician should be given a full report of the patient’s condition, with an opportunity to ask questions. While the receiving institution may provide guidance and medical recommendations, the patient remains the responsibility of the referring hospital until arrival at a receiving institution.
Decisions Regarding Mode Of Transport

In most instances, the determination of how to transport the patient — whether by helicopter or ground — is that of the referring physician. Only in rare circumstances, such as when the transport is to be provided by the receiving institution, does the receiving physician make this decision.\(^7\) When selecting a mode of transport, the referring physician must consider the patient’s illness, clinical stability, urgency of transfer, availability of various transport modalities, geography, traffic, and weather conditions.\(^7,17,18\) The referring physician must also understand the benefits and risks of helicopter transport.

While some authors assume that the primary benefit of helicopter-based transport is the decreased time to arrival at the receiving hospital,\(^19\) this is not necessarily the case. The interval from the time the decision is made to transport a patient until the patient arrives at the receiving facility may be extended due to organizational issues that cause delays in helicopter dispatch.\(^20\) Many transports also entail long ground legs if the helicopter must land at a helipad remote from either facility.\(^18,21\) In addition, the air CCT team may have to spend more time preparing the patient for transport than a ground ALS team.\(^22-24\) However, despite the potentially increased total time until arrival at the receiving institution, the helicopter offers the advantage of decreasing the time the patient spends in transit.\(^20\) This may be of particular benefit in unstable patients, for whom the time in the out-of-hospital setting should be minimized.

Some authors and guidelines have recommended that air transport be considered for travel distances greater than 50 miles or transfer times greater than 90 minutes.\(^18,25\) A study of scene trauma transports found that if the patient was located 45 miles from the referring hospital, the patient’s transport was faster by air even with nonsimultaneous dispatch of the ground crew and helicopter crew.\(^26\) Others note, however, that defining a universal distance beyond which the helicopter is faster is difficult.\(^21\) A study from Canada found that even for long distances, due to variability in helipad placement, geography, and overall systems, ground transport may actually be faster.\(^21\) Therefore, determining when one should choose a helicopter based on distance alone is difficult. Selection will vary depending upon aspects of the local healthcare system as well as individual patient factors.

Although flying does not necessarily decrease time to arrival at the receiving facility, helicopter transport does have benefits.\(^27-34\) A review of the National Trauma Data Bank, including nearly 260,000 patients, about 42,000 of which were transported by helicopter, was published in 2010. While patients undergoing interhospital transport by helicopter were more severely injured than patients transported by ground, multiregression analysis demonstrated that helicopter transport was a predictor of survival.\(^32\) Though subject to the limitations of any retrospective database review, this study is the only large, nationwide survey of transport practices in the United States.

Patients with moderate injuries (as determined by the ISS) are more likely to benefit from helicopter transport than those with scores at either extreme, as mildly injured patients will likely do well regardless,\(^33\) and moribund patients are not likely to benefit from either air or ground transport. A study in 2011 found that while air transport made no difference for patients with lesser injuries (an ISS < 15), patients with an ISS > 15 did benefit from helicopter transport.\(^31\)

A recent systematic review of helicopter transport literature demonstrated improved survival with the use of air CCT, although the review was limited by inconsistent methodology in many of the studies. When the 4 reliable studies in the review were examined, an overall mortality reduction of 2.7 additional lives saved per 100 helicopter deployments was found.\(^35\)

Although helicopter transport likely confers benefit for a subset of patients, this mode of transport may incur additional risks to the patient and the crew. A significant increase in the number of air ambulance crashes in recent years, out of proportion to the number of providers, has prompted more scrutiny from regulators and media. The rate of EMS helicopter crashes has increased over the last decade, from a rate of 1.7 per 100,000 in 1997 to 4.8 per 100,000 in 2004. In 2008, 9 crashes killed 35 people.\(^36\) Crashes with fatalities most commonly occur at night or in bad weather.\(^37\) Individual trauma systems must develop triage criteria that maximize the benefits of helicopter transport while minimizing the risks of flying patients who are least likely to benefit from air transport.\(^38\)

Once the decision is made to transport a patient by helicopter, the transport team should be contacted to confirm availability and coordinate the timing of the transport.\(^7\) Some systems provide a central dispatch center to streamline the referral process by communicating with receiving institutions and arranging an accepting physician if the sending physician has not already found one. In one region where multiple tertiary care centers are located, a “roster” system has been established that allows a CCT dispatch center to activate a transport team and assign a receiving hospital on a rotating “next-up” basis. One study has shown that this type of system allows for timely transport both to EDs and directly to operating rooms and that patients have similar outcomes as those transported to predesignated facilities.\(^39\) Unfortunately, this system is not available in all areas.

**Patient Selection**

Specific populations that should warrant consideration for activation of a CCT team include multi-

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Trauma and burn patients, cardiac patients, and stroke patients.

**Trauma And Burns**

Most research on the benefit of CCT and air transport has evolved from trauma patients. Patients with multisystem trauma or burns whose injuries exceed the capacity of a referring facility should be transferred to a trauma center. Approximately 42 million people in the United States live in rural areas without immediate access to specialist care, and 60% of all fatal motor vehicle crashes occur in these rural areas. As such, trauma patients are one of the largest patient groups to undergo interfacility transport.

Helicopter transport has been found to improve outcomes for this population. A recently published retrospective study of trauma patients transported from the scene by either air or ground to Level I or Level II trauma centers assessed for an association between mode of transport and 14-day mortality rates. These authors found a 33% reduction in death when the patients were transported by helicopter, although they noted that patients with normal vital signs had no mortality benefit associated with air transport. Other studies have shown that for patients with an ISS associated with a 10% or greater risk of dying, there was a 25% reduction in mortality among patients transported by air versus traditional ground services.

Time to intervention is one of the most important factors in the care of hypotensive trauma patients. CCT’s benefit in traumatic hypotension may be as much due to advanced medical resuscitation as it is due to timely delivery to definitive surgical therapy. CCT services bring critical care experts to the patient and offer capabilities that traditional EMS cannot always provide, including the ability to intubate in transport with neuromuscular blockade, the ability to obtain intraosseous (IO) access, and the ability to provide narcotic analgesia. Furthermore, aircraft launched from a base hospital can often bring uncrossmatched blood, an essential nonsurgical intervention.

**Cardiac: Time Is Muscle**

As time-sensitive interventions have become the standard of care for cardiac patients; the use of CCT teams for transport of these patients has increased. Percutaneous coronary intervention (PCI) has proven to be superior to fibrinolysis, and transferring patients to PCI-capable hospitals has become a major mission of CCT teams. The goal of emergency care providers is to obtain emergent revascularization within 90 minutes of ST-segment elevation myocardial infarction (STEMI) — or, if this not be possible, to initiate thrombolysis within 30 minutes. EMS protocols have been developed for rapid interfacility transport of STEMI patients to PCI centers; in one study, these protocols were shown to improve outcomes. Since most of the United States population does not live near a 24-hour PCI center, transfer to a PCI center is often done by air CCT. Transport of cardiac patients is not without risks. One study of STEMI patients requiring transport demonstrated that 79% of patients required an ALS intervention during transport (most commonly antiarrhythmic administration).

Unfortunately, other studies have identified that the majority of STEMI patients transported by helicopter had a transfer time that exceeded 2 hours and did not receive thrombolysis. The average patient transport time in one system was only 15 minutes by air, but the hidden times of CCT transport are commonly not taken into account when a sending physician is arranging transport.

The time taken to get to the patient’s bedside and package them for transport is commonly the longest time lag. Incompatibility of pump tubing and monitoring cables and the need for additional patient stabilization prior to lift-off are common reasons for this delay. Beyond early activation, one strategy to streamline care is to eliminate heparin and IIb/IIIa inhibitor infusions after bolus, as these medications have durations of action that exceed the average transport time of most CCT agencies. This eliminates the need to transfer pumps and IV tubing as well as the need to set up infusions. This single change can significantly cut the time needed to package the patient for transport.

CCT also plays a role in the transport of comatose survivors of cardiac arrest. Therapeutic hypothermia to a temperature of 32°C to 34°C (89.6°F to 93.2°F) has been shown to improve neurological outcomes and is now recommended as part of the American Heart Association (AHA) guidelines for the care of out-of-hospital cardiac arrest. While no current consensus exists on how quickly to initiate postarrest hypothermia, most believe benefit is obtained when it is employed as early as possible. Studies have suggested that infusion of 2 to 4 L of normal saline at 4°C can drop core body temperature by 1.5°C to 4°C. While this does not result in maintenance of hypothermia, this technique employed by CCT services is a practical way to initiate therapeutic hypothermia while transporting such critically ill patients. (For a more detailed discussion of therapeutic hypothermia, see the April 2011 issue of *Emergency Medicine Practice*, “Current Evidence In Therapeutic Hypothermia For Postcardiac Arrest Care.”)

**Neurologic: Time Is Brain**

Thrombolytic therapy for ischemic stroke has been used since 1996, and acute stroke is a time-sensitive diagnosis that commonly requires transport to specialty centers. CCT services have played an increasingly important role in transporting patents to stroke centers for definitive evaluation and thrombolytic therapy. CCT plays a key role in programs...
that allow a specialist, via teleconference, to provide expert opinion regarding the initiation of thrombolysis and subsequent transport of patients to specialty centers where services such as intra-arterial thrombolysis, endovascular clot retrieval, and post-tissue plasminogen activator (t-PA) care can be obtained. 

CCT teams can closely monitor a patient’s blood pressure, oxygenation, and evolution of neurological status to allow for early intervention to help prevent secondary brain injury. These critically ill patients often require advanced therapies, including ventilator and airway management as well as monitoring of end-tidal CO₂. Increased intracranial pressure can also be monitored and treated accordingly. Traditional EMS agencies are not trained or experienced enough to provide this level of care.

**Practical Considerations For Critical Care Transport**

**Staffing**

A principal concept in helicopter transport of critically ill patients is that they must continue to receive the same level of care they were receiving at referring hospitals up to and during transport. Studies have reported that standards of care during transport may be suboptimal, due to lack of monitoring and lack of appropriately trained staff. Patients should be accompanied by a minimum of 2 providers specifically trained in principles of CCT and emergency medical procedures. In many countries, 1 provider is always a physician; however, in the United States, specialty trained nurse and paramedic teams are the most common crew configuration. While many regions have dedicated CCT teams, their availability is not universal.

Data show that specialist CCT teams provide better medical care. A study compared 168 transfers performed by specialized transport teams with 91 transfers performed by teams comprised of staff from the referring facility. Patients transported by the specialist transport team were less likely to be acidotic and hypotensive on arrival to the receiving facility. While some studies have shown worse outcomes for head trauma patients intubated in the field by paramedics, studies specifically examining intubations performed by CCT teams demonstrate improved outcomes. Although some of these studies involved physicians, similar studies in the United States involving highly trained paramedic-based CCT teams have shown comparable results to physician-led teams. These findings support the notion that focused education and training of CCT personnel are associated with improved outcomes.

**Equipment**

Necessary equipment for patient monitoring during transport includes a portable monitor with an illuminated display of the heart rhythm, blood pressure, oxygen saturation, and (ideally) end-tidal CO₂. Given significant ambient noise within the aircraft, alarms should be visible as well as audible. When not deployed, vehicles should be connected to shore-power to ensure all equipment is fully charged and secured. The National Patient Safety Agency (NPSA) of England and Wales reports that there were 55 CCT equipment failures between August 2006 and February 2007, including loss of battery power for monitors in 6 cases.

Additional required equipment includes defibrillation and suction capabilities. A warming blanket is useful, especially in colder climates. Syringe pumps with a long battery life are required, as use of gravity drips during helicopter transport is discouraged due to potential unreliability when flying. All appropriate medications that the patient requires or is likely to require en route should be available.

Equipment for establishing and maintaining a safe airway is essential. The CCT team should have a portable mechanical ventilator that can provide multiple modes of ventilation, variable oxygen concentrations, respiratory rates, and positive end-expiratory pressure. The vehicle should carry sufficient oxygen to last the duration of the transfer, plus a reserve of 1 to 2 hours.

**Clinical Course In The ED**

**Stabilization**

Prior to transport, patients should be stabilized as much as possible to minimize the risks of transport. Patients may not be able to be completely stabilized without the tertiary care services they are being transported to receive; in select cases, this may be acceptable. The referring physician must make the determination that the benefits of transfer outweigh the risks for such unstable patients. Nonessential tests or procedures that may delay transport should be avoided. Several societies and authors have published pretransport checklists. (See Figure 1.)

On arrival at the referring institution, the transport team must be given a thorough report regarding the patient’s presentation and hospital course. The team should perform a physical examination, including an airway assessment, prior to transport. If there is risk of airway deterioration, the airway must be secured prior to the patient leaving the referring hospital. Though success rates for CCT intubation are generally excellent, intubation in the helicopter is more challenging than intubation at the referring institution. If the patient is intubated, adequate sedation must be provided. In appropriate instances, paralytics should be provided to maximize oxygenation and ventilation and to facilitate safe transport.
Figure 1. Pretransport Checklist

Decision to Transfer:
Indication for transfer (specialist services, diagnostics, procedures): ________________________________________________________________

Does the benefit of transport outweigh the risks? □ Yes □ No

Accepting institution and physician: ________________________________________________________________

Does the accepting institution have the capability and capacity to care for this patient? □ Yes □ No

Has informed consent for transfer been obtained from patient or family? □ Yes □ No

If not, the reason for not obtaining consent: __________________________________________________________

Mode of Transport:
Has the appropriate level of EMS service (BLS, ALS, CCT) been called? □ Yes □ No

Considering distance, geography, patient factors, need for a CCT team, and other factors, should this patient be transported by air? □ Yes □ No

Does this patient require specialized services? □ IABP □ Isolette □ Pediatric Team □ ECMO □ Other: ____________________

Who will accompany the patient? □ EMS providers □ CCT team □ Staff from referring or receiving institution □ Other: ____________________

Equipment:
□ Portable, lighted monitor
□ Portable ventilator
□ Oxygen source with 1-2 hours of additional reserves
□ Airway equipment, including LMA or other rescue device
□ Defibrillator
□ Suction
□ Syringe pumps
□ Additional battery supplies
□ All medications the patient is likely to require, including sedatives, paralytics, and vasoactive medications
□ All resuscitative fluids the patient may require, including crystalloid and blood products, as indicated

Stabilization Prior to Transport:
Is the patient likely to require airway management en route? □ Yes □ No

If yes, has the airway been secured? □ Yes □ No

Does the patient have 2 routes of IV (or IO) access? □ Yes □ No

Have appropriate vasoactive medications been initiated? □ Yes □ No

Are trauma patients properly immobilized, with cervical-spine collars, backboards, and splinting of long-bone fractures, as indicated? □ Yes □ No

Have chest tubes been placed for all pneumothoraces, and has gastric decompression been initiated for all bowel obstructions? □ Yes □ No

Is the patient being monitored with:
• Continuous cardiac rhythm (ECG) monitoring □ Yes □ No
• Noninvasive blood pressure □ Yes □ No
• Oxygen saturation (SaO₂) □ Yes □ No
• End-tidal CO₂ (in ventilated patients) □ Yes □ No
• Temperature □ Yes □ No

Is the patient as well stabilized as possible? □ Yes □ No

Do all providers agree that the patient is ready to travel? □ Yes □ No

Communication:
Has the transport team been given a full report? □ Yes □ No

Has the receiving facility been updated of any new findings or clinical changes? □ Yes □ No

Has the referring nurse called the receiving nurse to give a nurse-to-nurse report? □ Yes □ No

Have copies been made of all clinical documentation? □ Yes □ No

Have images of radiographic studies been copied, and are they being sent with the patient? □ Yes □ No

If lab or radiographic data is not available at the time of transport, what is the plan to convey that information to the receiving hospital? ________________________________________________________________

Abbreviations: ALS, advanced life support; BLS, basic life support; CCT, critical care transport; ECMO, extracorporeal membrane oxygenation; ECG, electrocardiogram; EMS, emergency medical services; IABP, intra-aortic balloon pump; IO, intraosseous; IV, intravenous; LMA, laryngeal mask airway.
Adequate IV access should be established, ideally with 2 IVs, a central venous line, or an IO line. The patient’s underlying diagnosis will guide resuscitation goals, such as whether hypotensive resuscitation should be pursued, but the provider should be aware that resources such as blood products or large volumes of crystalloid may not be available in transport unless provided to the transport team in advance. All appropriate hemodynamic agents for heart rate and blood pressure modification should be started prior to transport in order to monitor the patient’s response.

Trauma patients should be maintained in cervical-spine immobilization, and other fractures should also be immobilized. Orogastric or nasogastric tubes and Foley catheters should be placed, as indicated.

Published guidelines recommend the following as minimum standards of monitoring during air CCT:

- Continuous cardiac rhythm monitoring via electrocardiogram
- Noninvasive blood pressure
- Oxygen saturation (SaO₂)
- End-tidal CO₂ (in ventilated patients)
- Temperature

Intermittent noninvasive blood pressure cuffs may be unreliable due to motion artifact. If available, indwelling arterial lines are preferable. A central venous line may be of benefit, as it allows for monitoring central venous pressures and administration of centrally acting medications.

Deterioration

Critically ill patients tend to become unstable during transport, and helicopters are often cramped and not conducive to active intervention. In the helicopter, if a patient deteriorates, there are few options for obtaining additional help. As compared to ground transport, where the vehicle may reroute to a closer hospital if the patient deteriorates, altering the flight plan en route can be dangerous and is not routinely recommended.

In addition to the constrained environment of the helicopter, several factors specific to air transport warrant consideration. Close monitoring of a critically ill patient’s oxygenation during transport is essential, as patients may become hypoxic. As the decreased barometric pressure associated with altitude expands gas-filled cavities in the patient, untreated pneumothoraces can cause clinical deterioration. Flying is associated with a decrease in temperature, and critically ill patients may require additional interventions to maintain body temperature. Noise and vibration can cause nausea, pain, and motion sickness. Antiemetic medications should be available for patients, and ear protection should be provided.

Unfortunately, deterioration in transport is not uncommon. A recent review of incidents that occurred in transport of critically ill patients in Australia found that 59% of critical incidents (including both system-based and human-based errors such as transport operations, haste, equipment malfunction, failure to check pressure, etc) resulted in direct patient harm. This study also found that 91% of the incidents were preventable. Additionally, a report from the Netherlands showed that 34% of patients had an adverse event during transport, 70% of which were considered to be avoidable. A study from Canada found that critical events occurred in 5.1% of air transports and were independently associated with prior hemodynamic instability, assisted ventilation, and female gender.

Special Circumstances

Most CCT teams are available 24 hours a day with a standard crew configuration that is able to handle most emergencies and calls for service. Clinical situations may arise when a patient’s needs require additional or specialty personnel. When given notice, many CCT services can deploy specialty transport teams for specific patient populations. Such teams include pediatric, neonatal, intra-aortic balloon pump (IABP), and extracorporeal membrane oxygenation (ECMO) transport teams.

Neonates And Pediatric Patients

Very few hospitals are equipped to manage complex developmental and metabolic diagnoses or to care for critically ill children. Neonates require a disproportionate number of interfacility transports for this reason. These transports often require specialized equipment such as transport islettes, low-volume ventilators, and medications specific to pediatric and neonatal care (ie, surfactant and prostaglandin). Given the complexities and cost of this specific equipment, many regional pediatric centers have their own CCT vehicles and staff. Other CCT services are able to modify standard set-ups to provide this service.

Patients With IABPs

While many 24-hour PCI centers have cardiac surgical services available, some hospitals that offer this service do not have surgical support. Some unstable patients may require emergent cardiac surgical intervention; IABPs and other ventricular assist devices offer a bridge to augment cardiac output until a surgical treatment is available. While uncommon, the capacity to transfer IABP-dependent patients is available in many areas, and transport IABPs are available. Although not standard equipment on most CCT vehicles, IABPs can easily be added. Management of these patients and devices usually requires adding a perfusionist to the transport team, although studies...
have shown that cross-trained critical care paramedics can often perform this transport safely.\textsuperscript{3,66-68}

**Patients Requiring ECMO**

Other specialty teams have been developed specifically for the transfer of patients requiring ECMO. Patients requiring ECMO are among the most critically ill and the most difficult to transfer. CCT programs have developed protocols to transport such patients to ECMO centers.\textsuperscript{69} In some cases, ECMO must be started prior to transport, and a surgical team must be transported to the referring facility for cannulation and initiation of ECMO. While few programs have developed specific protocols or dedicated multidisciplinary healthcare teams prepared to transport such complex patients, transport ECMO circuits have been developed, and successful transport has been performed with both veno-arterial and veno-venous circuits.\textsuperscript{70} Patients receiving ECMO are at increased risk for significant complications during transport, including the risk of decannulation and membrane lung thrombosis.\textsuperscript{70} The most common complication for interfacility transport of these patients is a loss of power, resulting in the need for manual hand cranking of the ECMO circuit until power is restored.\textsuperscript{70} Close medical oversight of transport teams and coordination of care is essential for the success of programs that transfer patients receiving ECMO.\textsuperscript{70} (For an in-depth review of ECMO in the ED, see EMCC’s research report, *Extracorporeal Cardiopulmonary Resuscitation In The Emergency Department.*)

**Contraindications**

Not all critically ill patients who require transport to specialty centers are appropriate for helicopter transport, even with a CCT team. Profoundly unstable or coding patients are not candidates for transport. A patient in cardiac arrest will receive no benefit from rapid transport during resuscitation, and CCT services do not offer any additional therapy that is not already available at a local ED. Furthermore, while resuscitation does occur when needed in transport vehicles, choosing to do so in a dimly lit, cramped, and moving space is not in the patient’s best interest. In fact, it is the policy of many EMS agencies to not transport patients in cardiac arrest to a local hospital and to simply perform the resuscitation at the scene. Patients are only transported if return of spontaneous circulation is obtained.\textsuperscript{71}

Active labor is also a contraindication for CCT. Many CCT programs have protocols prohibiting transport of women in active labor, as helicopters are not equipped to provide simultaneous maternal and neonatal resuscitation. It is recommended that delivery or tocolysis be achieved at the sending facility prior to transport, and, if needed, an additional neonatal CCT team should be dispatched for neonatal care and transport.

Patients with injuries or conditions that would be made more severe with altitude should not be transported by CCT aircraft until these conditions are appropriately stabilized. CCT aircraft typically fly at altitudes less than 5000 feet, and, although this is a lower altitude than commercial aircraft, most aeromedical helicopter cabins and patient compartments are not pressurized. This can lead to alterations in normal physiology via Boyle’s and Dalton’s laws.

Boyle’s law states that at a constant temperature, the volume of a gas varies inversely with pressure. Therefore, as altitude increases and atmospheric pressure decreases, the volume of gas increases. This effect is seen on all gas-containing compartments of the body, including ears, sinuses, and (most importantly) the gastrointestinal tract and lungs.\textsuperscript{72} Pneumothoraces or bowel obstructions must be managed prior to flight. To prevent development of tension pneumothorax, patients with any pneumothorax should have a chest tube(s) placed. Chest tubes should not be clamped during transport. For patients with bowel obstructions, nasogastric tube decompression should be performed to minimize the risk of visceral expansion, worsening bowel ischemia, or perforation.\textsuperscript{73} The endotracheal tube cuff pressure should be monitored closely in intubated patients. While some guidelines suggest that pneumoperitoneum and pneumocephalus are relative contraindications to air transport,\textsuperscript{7,17} these must be considered in the context of the individual patient’s clinical circumstances and other transport options available. Soft tissues may also swell, and plaster casts should be bivalved to prevent compartment syndrome.\textsuperscript{17} Air transport is not absolutely contraindicated for other gas-containing devices such as esophageal tamponade (eg, Blakemore) tubes; however, helicopter crews must pay close attention to pressures maintained in these devices during flight.

Dalton’s law states that the pressure of a gas mixture is equal to the sum of the partial pressures of all the gases contained in the mixture. Therefore, with increasing altitude and increasing volume of a gas mixture (Boyle’s law), the percentage of an individual gas in the gas mixture does not change. As a gas mixture’s volume increases with altitude, the gas molecules within the mixture spread farther apart. One consequence of this is that alveolar gas exchange becomes less efficient, resulting in lower hemoglobin saturation and hypoxia.\textsuperscript{72} During flight, this effect can be mediated with supplemental oxygen and cabin pressurization; however, even when passenger compartments are pressurized, it is only to the equivalent of 5000 to 8000 feet — enough to cause hypoxia in patients with poor reserve.\textsuperscript{73}
Controversies

While the advanced care of CCT teams has been shown to provide benefit in some subsets of patients, the use of this expensive service is not always appropriate or feasible, as the evidence reviewed here has shown. An increasing number of patients who could be transferred by ground services are being taken by air. A recent review of hospital-based helicopter CCT services led to recommendations that Medicare recover overpayments due to inadequate justification of medical necessity for air CCT. One specific metric assessed by payers is the proportion of patients discharged within 23 hours of CCT. Some feel that this metric is particularly unreasonable given that definitive imaging and expert consultations, which are available only through transport, may ultimately rule out significant disease in an undifferentiated trauma patient, allowing timely discharge. In addition, there are concerns for over-triage of patients with non-life-threatening injuries where the use of the helicopter may not make a difference in outcomes. The United States has seen a dramatic increase in the number of aeromedical CCT providers; however, there is significant variability of air CCT organizations’ qualifications or capabilities. In 2005, there were 753 rotor-wing aeromedical units in operation; in 1990, there were only 231. Along with this growth, there has also been a disproportionate rise in helicopter crashes. Due to safety concerns and the increase in competition, groups such as CAMTS have developed standards for medical care and safety for the air medical industry. CAMTS accreditation is voluntary but is considered the “gold standard” for the industry.

Despite generally being more expensive than ground transport, a number of studies have found helicopter transport to be cost effective. However, given the variation inherent in the health systems in which helicopter transports operate, generalization of such findings across differing health environments is problematic. The most thorough cost-benefit study found that helicopter transport resulted in a $2500 cost per life-year, compared to a cost per life-year of $41,000 for zidovudine prophylaxis for HIV exposure. Another study found helicopter transport for thrombolysis in stroke patients to be associated with a cost of $35,000 per additional good outcome and $3700 per quality-adjusted life-year of $41,000 for zidovudine prophylaxis for HIV exposure. A recent study in the United Kingdom found helicopter transport to be well below cost-effectiveness ratios described as generally acceptable by healthcare economists and policy makers.

Summary

Critically ill patients in the ED often require transfer to tertiary care centers for specialized care. The decision to transfer the patient lies with the referring physician, who must weigh the potential benefits of transport against the risks. All emergency physicians must be familiar with federal laws regarding the transfer of ED patients as well as locally available resources and protocols. The referring physician is responsible for selecting the most appropriate method of transporting the patient as well as for the patient’s care until arrival at the receiving institution.

Helicopter transport does not always decrease the total time until arrival at the receiving facility, but it often decreases the time in the out-of-hospital setting. Helicopter transport is usually performed by CCT teams that specialize in the transport of critically ill patients. Patients should be stabilized as much as possible, with special attention to the airway and hemodynamics. If the patient is not able to be stabilized without tertiary care, the referring physician must carefully weigh the risks and benefits of transport. Select patients may benefit from CCT, including severely injured trauma patients, cardiac patients, and stroke patients. Additionally, highly specialized teams are often available to transport critically ill neonates and children, patients with IABPs, and patients requiring ECMO.

Disposition

After the CCT team arrives and completes an assessment, and the patient has been stabilized, preparations should be made for departure. The equipment should be rechecked, ensuring compatibility and sufficient reserves of battery power and oxygen. Adequate supplies of medications, fluids, and blood products, as indicated, should be verified. If using a pretransport checklist, as is recommended, it should be filled out at this time. Once the referring physician and the CCT team agree that the patient is ready to travel, the CCT team can depart.

The importance of communication cannot be over emphasized. Although the CCT team will give a report to the receiving institution on arrival, the referring institution is still responsible for ensuring that all clinically relevant information is communicated. In addition to the physician-to-physician discussion, a nurse-to-nurse report between the 2 hospitals should also be completed. If the patient has had any clinical change since the initial discussion between the 2 physicians, the referring physician should notify the receiving physician. Copies of all medical records, including laboratory values and images of radiographic examinations, should be provided to the CCT team prior to departure. If some information is not available at that time, departure should not be deferred; instead, the referring institution should send the data to the receiving institution as soon as possible.
Patients with pneumothoraces and bowel obstructions must have these issues addressed prior to flying. Furthermore, patients in cardiac arrest should not be transported. Prior to departure, the equipment and medications should be rechecked, and a transport checklist should be completed. The patient should not leave until both the CCT team and the referring physician agree that the patient is ready for transport.

Although flying incurs additional risk, data support the use of helicopters to improve outcomes in critically ill and injured patients. While expensive, the best available data suggest that helicopter transport provides cost-effective care.

**Case Conclusion**

You recognize that your patient is in need of close blood pressure control and monitoring and will need to be transferred for emergency surgery. Your regional CCT service operates a roster system and will facilitate the designation of a receiving facility. You call their central dispatcher, who requests that a medical helicopter be launched as soon as possible. After 2 additional calls, you are able to connect with the receiving hospital’s vascular surgeon. Within 40 minutes, the helicopter lands on your hospital’s helipad. As the CCT crew begins assessing and moving the patient onto the transport stretcher, he becomes unresponsive and is intubated by the CCT team. His esmolol drip is titrated as he is placed on a transport ventilator and moved to the waiting aircraft. A short flight later, he arrives in the OR where the vascular surgeon you spoke to is scrubbed and ready, waiting for the patient.

**Must-Do Markers Of Quality ED Critical Care**

- Emergency physicians must be familiar with federal laws as well as local resources and recognize that the decision to transfer, as well as the responsibility for the patient, rests with the referring physician until the patient arrives at the receiving hospital.
- Communication with the receiving facility is critical, including adequate physician-to-physician and nurse-to-nurse reporting. All pertinent medical records, including imaging studies, should be copied and provided to the receiving institution.
- The patient should be stabilized as much as possible prior to departure, including airway assessment and management. Pneumothoraces must be treated with chest tubes, and bowel obstructions should be decompressed with nasogastric or orogastric tubes. Patients in cardiac arrest should not be transported.

**References**

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study, will be included in bold type following the reference, where available. In addition, the most informative references cited in this paper, as determined by the author, will be noted by an asterisk (*) next to the number of the reference.


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1. The primary benefit of helicopter transport is:
   a. Decreasing the time to arrival at the accepting hospital
   b. Decreasing the time the patient spends in transit
   c. More specialized team of transport
   d. Better equipment than land transfers

2. One strategy to streamline care of STEMI patients is to:
   a. Eliminate administration of thrombolytics.
   b. Minimally stabilize the patient prior to transfer.
   c. Eliminate heparin and t-PA therapy from the treatment algorithm.
   d. Eliminate heparin and IIb/IIIa inhibitor infusions after bolus.

3. If there is a risk of airway deterioration, the airway should be secured:
   a. En route to the accepting hospital by the CCT team during the early phase of transport
   b. During transport when the patient requires a crash airway
   c. Prior to air transport by the referring team
   d. At any point before or during transport

4. All of the following are recommended as a minimum standard of monitoring during air CCT EXCEPT?
   a. Continuous cardiac rhythm (electrocardiogram)
   b. Noninvasive blood pressure
   c. Capillary blood glucose
   d. Oxygen saturation (SaO₂)
   e. Temperature

5. Contraindications for helicopter transport include all of the following EXCEPT?
   a. Patients in cardiac arrest
   b. Women in active labor
   c. Patients with chest tubes for pneumothorax
   d. Patients with bowel obstruction

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Optimizing Initial Antibiotic Delivery For Adult Patients With Severe Sepsis And Septic Shock In The Emergency Department

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Severe sepsis and septic shock account for one-fifth of all admissions to the intensive care unit (ICU) and remain the leading cause of death. There are more than 500,000 emergency department (ED) visits annually in the United States due to suspected severe sepsis, and the average length of stay in the ED is approximately 5 hours. In addition, many more patients present to the ED with infection-related conditions without signs of tissue hypoperfusion and, therefore, may be considered to have sepsis. Approximately 25% of these patients progress to severe sepsis or septic shock within 72 hours of presentation to the ED. Because of the high mortality associated with severe sepsis and septic shock, early identification, monitoring, and management of septic patients in the ED are imperative. This issue of EMCC will answer the following questions:

1. Does the choice of antibiotic matter, as long as it “covers” the suspected bugs?

2. Do we have to adjust the first dose of antibiotic for patients with sepsis in the ED?

3. Does the timing of antibiotic administration matter in patients with septic shock?

Cardiocerebral Resuscitation: An Evidence-Based Review

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Cardiac arrest is the third most common cause of death in North America, resulting in approximately 300,000 deaths per year. Following restoration of pulses, multiple organ systems demonstrate varying degrees of injury or failure. This postarrest syndrome demonstrates features of systemic inflammatory response (the postarrest state has been likened to a “sepsis-like syndrome”) along with diffuse anoxic injury to the brain. Aggressive titration of care to optimize cerebral resuscitation has improved outcomes. Multiple strategies are used to prevent secondary neuronal injury, including therapeutic hypothermia, aggressive revascularization, titrated blood pressure goals, careful control of ventilator parameters, and monitoring for seizure activity. An in-depth review of the literature to determine the evidence supporting present postarrest guidelines is presented in this issue of EMCC, with a primary focus on treatment of the postarrest patient to improve survival and neurologic outcomes.

Upon completion of this article, you should be able to:

1. Describe indications and contraindications for postresuscitation care.
2. Describe organ system strategies for optimizing postresuscitation care.
3. Describe techniques for optimizing organ system resuscitation during the postresuscitation phase.
4. Discuss current controversies in postarrest care.
5. Summarize the evidence for postresuscitation care.
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Dr. Joe Bellezzo and Dr. Zack Shinar have pioneered an ED ECPR (ECMO) service at Sharp Memorial Hospital in San Diego. This groundbreaking program — and the research behind it — are discussed in detail in their latest article: Extracorporeal Cardiopulmonary Resuscitation In The Emergency Department.

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