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To Fly or Not to Fly: The Role of Helicopter Transport in Trauma Systems

by Joshua B. Brown, MD, MSc

Helicopter emergency medical services (HEMS) have become an integral component of modern trauma systems. As with many advances in trauma care, HEMS arose from military experience.

The first medical evacuation by helicopter occurred in April 1944 during World War II, less than five years after the inaugural flight of the modern rotorcraft.

The Korean War brought the first large-scale implementation of helicopter transport for injured troops, reducing the casualty evacuation time from six hours to two hours, and mortality from 5.8% to 2.4% when compared to World War II.

Helicopter transport of the injured was expanded in the Vietnam War with care initiated en route, further reducing evacuation times to one hour and mortality to 1.7%. The first civilian HEMS programs were developed in the late 1960s and early 1970s. Today, there are more than 1,000 medical helicopters in service in the United States.

Why Do We Use Helicopters For Transport?

There are several reasons why HEMS might be used to transport a patient to the trauma center, which generally fall into one of three mechanisms (see Figure 1).

(Continued on Page 4)

Influencing Factors and Mechanisms of Potential HEMS Benefits to Trauma Patients

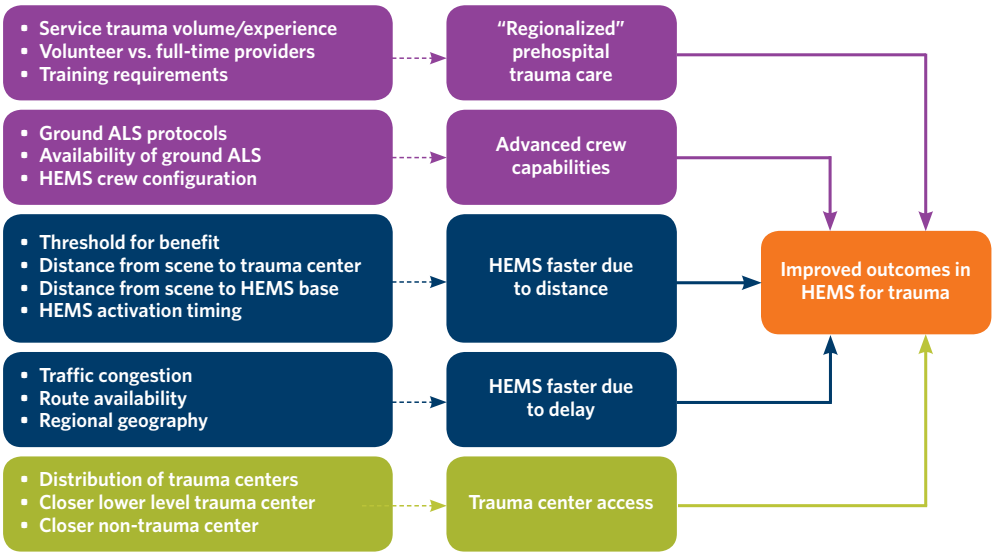

Figure 1. Influencing factors and mechanisms of potential benefit of helicopter emergency medical services (HEMS) to trauma patients through advanced care (purple), speed (blue), or trauma center access (green).

Trauma in Pregnancy

by Alain Corcos, MD, FACS, and Kevin Train, MD

Trauma patients are a unique population for first responders, and managing a pregnant trauma patient can be especially fraught. An estimated 7-10% of all pregnancies are affected by trauma.[1] Aside from obstetric causes, trauma is the highest cause of maternal morbidity and mortality, responsible for up to 45% of maternal deaths.[1] Although there are ostensibly two patients to consider, one must take the approach of "save the mother, save the baby" to ensure the best outcomes for both patients.

Epidemiology

While traumatic injuries during pregnancy occur across the entire spectrum of mechanisms, motor vehicle crashes and falls make up the majority of presentations.[2] Unfortunately, this is followed closely by domestic violence and intimate partner assault.[2] Studies have shown that both traumatic injury in general and mortality resulting from trauma are more common in pregnant women than non-pregnant women. Although the vast majority of traumas during pregnancy are considered minor, most fetal deaths associated with traumatic injury to the mother occur as a result of these "minor" traumas, and 38% of all fetal mortality is associated with a blunt traumatic mechanism.[2] Penetrating trauma in pregnancy is rare, with gunshot wounds more common than stab wounds.

Maternal Physiology

Physiologic changes associated with pregnancy affect virtually every organ system and can contribute to unique risks and complications, particularly in the third trimester. From a cardiovascular standpoint, there is an increase in both circulating blood volume and overall cardiac output to meet the increased demands in uterine blood flow to what is essentially an additional organ system: the fetus.[2] Although this adaptation can serve as a protective mechanism, it can also mask a significant blood loss.

Most pregnant women have well-developed cardiovascular compensatory mechanisms for acute blood loss and can often maintain adequate cardiac output and blood pressure for up to a 40% hemorrhage (2.5 liters). Therefore, once the typical "shock" physiology we associate with hemorrhage is apparent, the mother is already in severe distress, as is the child. Respiratory rate and oxygen requirements are increased at baseline in pregnancy and are associated with a decrease in functional residual capacity (reserve lung volume). This becomes important, as the mother and fetus are at increased risk for hypoxia.[4] Additionally, decreased gastric motility, an elevated diaphragm, and decreased lower esophageal sphincter tone lead to increased risk of aspiration.[4] Finally, as pregnancy progresses, the enlarging uterus becomes an intra-abdominal organ while the uterine lining thins, making the uterus more susceptible to injury.[2]

Fetal Physiology

Fetal physiology is unique, as the utero-placental unit does not have the ability to undergo autoregulation. Therefore, it relies exclusively on maternal blood flow while being extremely sensitive to vaso-pressors and catecholamines; any changes in maternal circulation can have vast consequences on the fetus. This will manifest as either tachycardia or brady-cardia in the fetus, which underscores the importance of fetal monitoring and why it becomes such an integral part of the secondary survey for trauma patients. Abnormal fetal heart rate is often the first clinical sign of maternal hemorrhage.[3] Preterm labor may result from a sudden release of numerous biochemical mediators, including endogenous catecholamines, leading to uterine contractions.

Trauma Management

As mentioned previously, despite having two patients, the management of a pregnant trauma patient starts with stabilizing the mother, following the dictum: "save the mother, save the baby." An approach based on appreciating and accommodating for the physiologic changes associated with pregnancy is best. Immediate oxygen supplementation is essential, as is aggressive fluid administration.

In the second and third trimesters of pregnancy (beyond 20 weeks), the uterus is an abdominal organ and is large enough to decrease venous return to the heart by compression of the inferior vena cava.[3] Patients should immediately be positioned with their right side elevated, while maintaining spine precautions, to relieve this compression and maximize venous return.[3] This can be accomplished by placing a roll, or "bump" under the right flank or backboard if the patient is fully immobilized. In addition to the standard history questions, a full obstetric history should be obtained, which includes an estimation of gestational age. Finally, given the high morbidity and mortality associated with uterine rupture and placental abruption, special attention must be paid to the signs and symptoms associated with these conditions, including vaginal bleeding, abdominal pain, contractions, uterine rigidity/tenderness and/or a bulging perineum.[3] Once the mother is stabilized, providers can then focus on the fetus, as the fetus has the greatest chance at survival if the mother is healthy.

Fetal Monitoring

The obstetrical service has an integral role in the evaluation of a pregnant trauma patient, as the importance of fetal monitoring cannot be overstated. While fetal viability is a contested issue, it is generally accepted to begin at 23 or 24 weeks although there have been anecdotal reports of survival prior to this.[3] The gold standard for fetal assessment is continuous cardiotocographic monitoring, which should be initiated immediately in any pregnant patient with a potentially viable pregnancy, even after minor trauma. Patients should have at least six hours of continuous monitoring. If there are no concerning findings, such as variations in heart rate, the patient can be discharged.[3] Any abnormality or concern, however, necessitates a 24-hour in-patient stay.

Screening

Unfortunately, domestic violence and intimate partner assault affects up to 20% of pregnancies, and a significant number of these go unreported with only a small number of patients actually seeking medical attention.[1] Advanced Trauma Life Support® recommends asking the following validated screening questions:

- Have you been kicked, hit, punched, or otherwise hurt by someone within the past year?
- Do you feel safe in your current relationship?
- Is there a partner from a previous relationship who is making you feel unsafe now?

First responders play an important role in these scenarios, as it may be the only time a patient can be adequately assessed.

Conclusion

While only 7-10% of all pregnancies are affected by trauma, there is significant morbidity and mortality associated with any trauma. It is important to understand that there is no such thing as a "minor" trauma while pregnant, as the majority of fetal deaths occur as a result of minor traumas. First responders must have a solid understanding of the physiologic changes associated with pregnancy and the significant impacts that these have. With this understanding and appropriate monitoring comes the greatest chance of survival for both the mother and the fetus.

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The Role of Helicopter Transport in Trauma Systems *(Continued from Page 1)*

The primary reason for using HEMS is speed. The goal is to get the patient to definitive care at the trauma center as quickly as possible, which may reduce mortality in select patients. This requires the patient be far enough from the trauma center that the travel speed of the helicopter overcomes the additional time to notify, respond to a safe landing zone, and transfer care of the patient. Where this distance threshold lies is debatable and can be anywhere from five miles to 45 miles based on local geography.

Other factors for EMS providers to consider are traffic and weather patterns. Research at UPMC has shown that during peak traffic hours, helicopter travel time becomes faster than ground transport even if moved over one mile closer to the trauma center.[1] Local EMS resources must also be considered, as leaving an area uncovered or dependent on mutual aid for EMS responses while transporting long distances to a trauma center may be detrimental to the EMS system.

HEMS may also provide trauma center access to patients who would otherwise be taken to non-trauma centers initially. Even with transfer to a trauma center after stabilization, some studies have shown that initial treatment at a trauma center increases survival.[2] A national analysis demonstrated that approximately 25% of the U.S. population has access to a trauma center within 60 minutes only because of HEMS transport.[3]

A third reason HEMS may benefit patients is the ability to provide advanced care. A growing body of literature suggests that early transfusion of blood products improves outcomes in severely injured patients.[4] A study at UPMC of patients receiving blood transfusion by a STAT MedEvac care team demonstrated higher rates of early survival, less risk of shock, and fewer blood transfusions at the trauma center.[5] There is also evidence that availability of rapid sequence intubation techniques may lead to better outcomes in patients with Glasgow Coma Scale (GCS) ≤8. Even if the helicopter is slower than ground transport,[6] patients transported via HEMS have better outcomes, as HEMS providers tend to have more experience and offer a higher level of care.[7] This benefits patients in need of critical early interventions from the flight crew before they can get to a trauma center.

Does It Work?

There has been significant debate about the effectiveness of HEMS transport of trauma patients. The cost and risk of this intervention must be outweighed by the benefit, given that HEMS operating costs are more than five times that of ground emergency medical services (GEMS) and are more likely to have fatalities in the event of a crash. Critics cite several studies that showed no survival benefit for HEMS transport of injured patients, while a number of authors have demonstrated improved survival. A systematic review examined 25 of these studies, concluding that there was some benefit in severely injured patients.[8] However, even studies that demonstrated survival benefits reported high over-triage rates of minimally injured patients to HEMS. Based on this data, the issue is no longer whether we should be using HEMS transport for trauma patients, but how we can best identify the patients who would most likely benefit from it.

Picking the Right Patients

Identifying patients for helicopter transport remains challenging, particularly at the scene of injury. EMS providers have limited resources and information on which to make this decision quickly. Previous research has classified severely injured patients based on information that is not available in the field. Furthermore, there are a number of both logistical and medical considerations. In Pennsylvania, protocol states that HEMS transport should be considered in category one trauma patients if HEMS will be faster than ground transport or if the patient has a GCS≤8 and the helicopter would arrive before the patient could be at a trauma center via ground transportation (see Figure 2).

Considerations for Helicopter Transport from Pennsylvania EMS Protocols

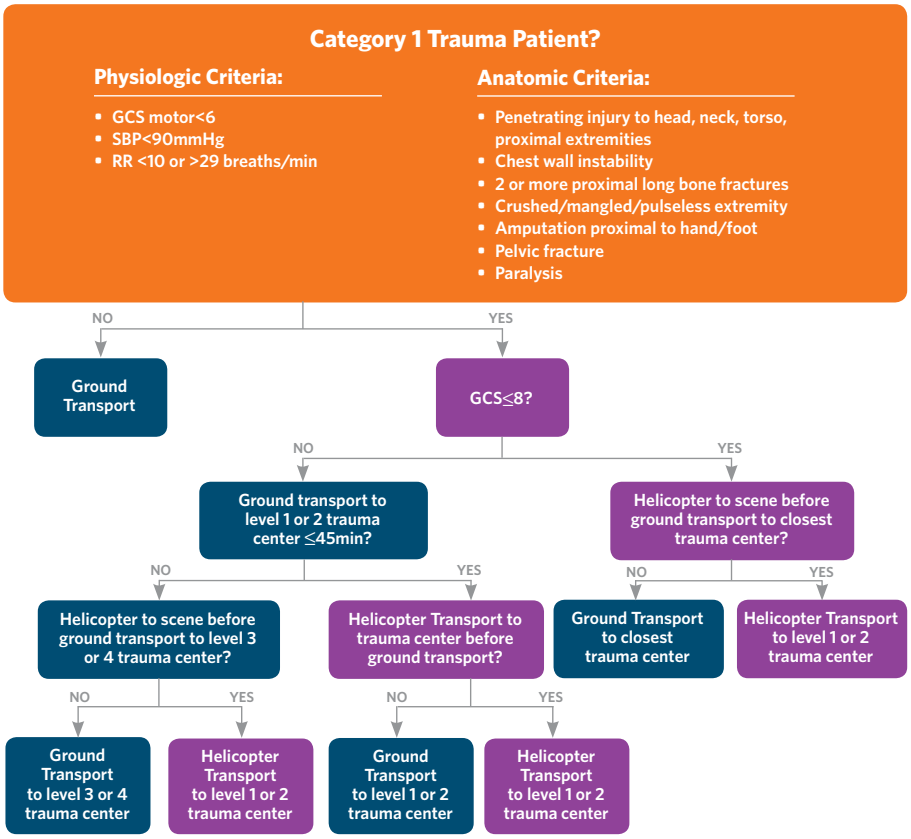

Figure 2. Considerations for helicopter transport from Pennsylvania EMS protocols. All transport decisions must be based on EMS provider judgment including other mitigating factors that may make helicopter transport more or less favorable.

Air Medical Prehospital Triage (AMPT) Score

AMPT Score Criteria	Points
Glasgow Coma Scale <14	1
Respiratory Rate <10 or >29 breaths/min	1
Unstable chest wall fractures*	1
Suspected hemothorax or pneumothorax†	1
Paralysis	1
Multisystem trauma ‡	1
PHY+ANA §	2

Consider Helicopter Transport if AMPT score ≥2 points

* Any chest wall instability or deformity including flail chest or multiple ribs fractures on physical exam

† Absence of breath sounds on affected hemithorax PLUS objective signs of respiratory distress (cyanosis, SpO_2<92%, signs of tension physiology)

‡ 3 or more anatomic body regions injured

§ Any 1 physiologic criterion plus any 1 anatomic criterion present from American College of Surgeons Committee on Trauma national field triage guidelines

Table 1. Used with permission from Wolters Kluwer: Brown, Joshua B. MD; Gestring, Mark L. MD; Guyette, Francis X. MD, MPH; Rosengart, Matthew R. MD, MPH; Stassen, Nicole A. MD; Forsythe, Raquel M. MD; Billiar, Timothy R. MD; Peitzman, Andrew B. MD; Sperry, Jason L. MD, MPH. "Development and Validation of the Air Medical Prehospital Triage Score for Helicopter Transport of Trauma Patients." *Annals of Surgery.* Volume 264, Issue 2: 378-385. https://journals.lww.com/annalsofsurgery/Fulltext/2016/08000/Development_and_Validation_of_the_Air_Medical.28.aspx.

This protocol is similar to other evidence-based guidelines, largely based on criteria from the national field triage guidelines. However, it is important to remember that trauma triage and air medical triage are fundamentally different questions. Put another way: needing to go to the trauma center is not the same as needing to *fly* to the trauma center. Extrapolating trauma triage criteria for air medical triage can lead to over-triage and limit the potential benefits of HEMS based on the mechanisms noted above.

Researchers at UPMC have been interested in developing specific criteria for air medical triage. We began by using a national database of trauma patients to evaluate if a subset of trauma triage criteria can identify patients who have increased survival when transported by HEMS. Out of this, we developed the Air Medical Prehospital Triage Score (see Table 1).[9] We have subsequently validated that it can differentiate between patients who benefit from HEMS and those who do not in Pennsylvania, and that it is a more cost-effective approach than current practice.[10,11] Future research will focus on incorporating logistical factors to help EMS providers make the best transport decision for their patients.

***Joshua Brown, MD, MSc**, is a surgical critical care fellow at UPMC. He completed his general surgery residency at UPMC and received his medical degree from the University of Rochester School of Medicine.*

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Mechanical Bowel Obstruction

by Louis H. Alarcon, MD, FACS, FCCM

Bowel obstruction is a common yet clinically challenging condition with more than 300,000 operations performed annually in the United States.[1] The most common causes of mechanical small bowel obstruction are postoperative adhesions, cancer, and hernia, while colonic obstruction is most often due to cancer, diverticulitis, or volvulus.

CT Scans of Bowel Obstructions

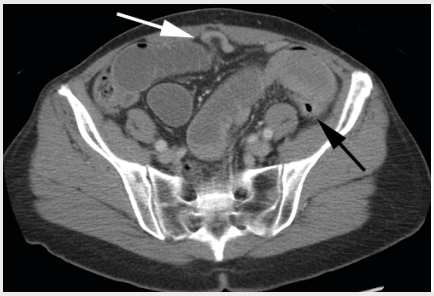

Figure 1a. CT scan demonstrating high-grade small bowel obstruction with a transition point or "bird's beak" (white arrow) between distended and decompressed loops of small intestine. The decompressed descending colon is also seen (black arrow).

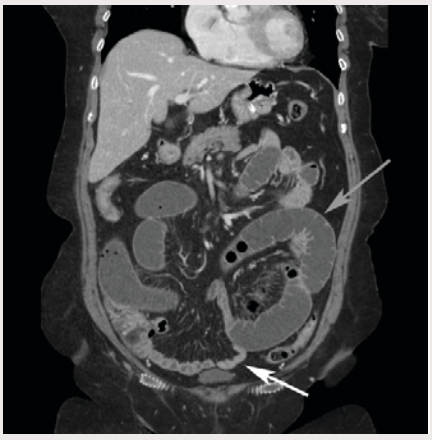

Figure 1b. Coronal CT scan demonstrating small bowel obstruction with dilated proximal small intestine (gray arrow) and decompressed distal small intestine (white arrow) beyond the level of the obstruction.

Figure 1c. CT scan of a patient with small bowel obstruction shows pneumatosis of the intestine (white arrow), concerning for intestinal ischemia.

Determining the need for and the timing of surgery is important when managing patients with intestinal obstruction. Delay to surgery is a significant cause of morbidity and mortality. Early surgical consultation is vital, even for cases where a trial of nonoperative management is proposed. Patients with mechanical bowel obstruction often present with abdominal pain and distention, nausea, vomiting, and obstipation. They typically require simultaneous evaluation and resuscitation, as they often present with physiologic abnormalities such as hypovolemia, electrolyte abnormalities, or prerenal azotemia. Establishment of intravenous access and fluid resuscitation are important parts of the initial management of these patients. Nasogastric decompression may be necessary to reduce the incidence of vomiting and aspiration.

Abdominal plain radiographs are routinely obtained in patients suspected of having a bowel obstruction, but their sensitivity and specificity are poor. Computed tomography (CT) scanning may allow determination of the etiology and location of intestinal obstruction. As such, CT has become the radiographic modality of choice for the diagnosis of intestinal obstruction.[1] CT findings that indicate a need for early surgery include the presence of free intra-abdominal fluid, high grade obstruction, intestinal ischemia, or closed loop obstruction (see Figure 1).[2] Oral contrast may not be tolerated by acutely ill and obstructed patients and is usually not essential for the CT identification of obstruction. If renal function permits, the administration of intravenous contrast during CT imaging is recommended so that the intestinal perfusion can be assessed.

Admission to Surgical Service

Patients with bowel obstruction should usually be admitted to a surgical service capable of timely intervention 24/7, as admission to nonsurgical service is associated with increased morbidity and mortality.[3] Patients with mechanical, complete bowel obstruction should undergo immediate surgery after expeditious correction of hypovolemia and fluid and electrolyte disorders. The dictum, "the sun shall not rise or set on a bowel obstruction" applies here. Immediate surgery is indicated for patients with bowel obstruction in the presence of peritonitis or signs of systemic toxicity, incarcerated or strangulated hernia, pneumatosis intestinalis, cecal volvulus, or sigmoid volvulus with systemic toxicity. On the other hand, patients with partial bowel obstruction may be admitted for a trial of bowel rest and serial exams, with a plan to operate if the obstruction fails to resolve within 48 to 72 hours.

Surgery for bowel obstruction usually entails laparotomy or laparoscopy. While classically open laparotomy was previously the procedure of choice, studies have shown that laparoscopy can be safe in select patients. Patients who undergo laparoscopy may require conversion to open laparotomy if the dissection is difficult due to adhesions or inflammation. In experienced hands, laparoscopy for bowel obstruction has a lower overall complication rate and hospital length of stay compared to laparotomy.[4] In addition, the rate of recurrent intestinal obstruction due to adhesions may be lower after laparoscopy.

Conclusion

Intestinal obstruction is a common diagnosis and reason for hospital admission and surgical consultation. There are many different etiologies of intestinal obstruction, which vary based on the location and prior history of the patient. CT scanning is the most accurate radiographic test to determine the location and nature of the obstruction and, along with clinical presentation, allows determination of the need and urgency of surgery to manage this problem. Patients who need urgent surgery include those with perforation, peritonitis, strangulation, or complete intestinal obstruction. Early surgical consultation is critical, even for patients who are admitted with a plan for nonoperative management.

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