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An Evidence-based Guideline for the Air Medical Transportation of Prehospital Trauma Patients

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Abstract

Background. Decisions about the transportation of trauma patients by helicopter are often not well informed by research assessing the risks, benefits, and costs of such transport. **Objective**. The objective of this evidence-based guideline (EBG) is to recommend a strategy for the selection of prehospital trauma patients who would benefit most from aeromedical transportation. **Methods.** A multidisciplinary panel was recruited consisting of experts in trauma, EBG development, and emergency medical services (EMS) outcomes research. Representatives of the Federal Interagency Committee on Emergency Medical Services (FICEMS), the National Highway Traffic Safety Administration (NHTSA) (funding agency), and the Children's National Medical Center (investigative team) also contributed to the process. The panel used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodology to guide question formulation, evidence retrieval, appraisal/synthesis, and formulate recommendations. The process followed the National Evidence-Based Guideline Model Process, which has been approved by the Federal Interagency Committee on

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Author contributions: ST, ZO, DS, BL, and RS appraised the literature and reported their findings to the review panel. KB, TW, JW, and EL designed the methodologies for the EBG and gave input into the final recommendations. EL and YFY provided guidance regarding GRADE processes. All authors contributed to the manuscript.

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EMS and the National EMS Advisory Council. **Results.** Two strong and three weak recommendations emerged from the process, all supported only by low or very low quality evidence. The panel strongly recommended that the 2011 CDC Guideline for the Field Triage of Injured Patients be used as the initial step in the triage process, and that ground emergency medical services (GEMS) be used for patients not meeting CDC anatomic, physiologic, and situational high-acuity criteria. The panel issued a weak recommendation to use helicopter emergency medical services (HEMS) for higher-acuity patients if there is a time-savings versus GEMS, or if an appropriate hospital is not accessible by GEMS due to systemic/logistical factors. The panel strongly recommended that online medical direction should not be required for activating HEMS. Special consideration was given to the potential need for local adaptation. **Conclusions.** Systematic and transparent methodology was used to develop an evidence-based guideline for the transportation of prehospital trauma patients. The recommendations provide specific guidance regarding the activation of GEMS and HEMS for patients of varying acuity. Future research is required to strengthen the data and recommendations, define optimal approaches for guideline implementation, and determine the impact of implementation on safety and outcomes including cost. **Key words:** Air ambulances; ambulances; emergency medical services; evidence-based emergency medicine; practice guidelines; trauma; triage

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Background

The considerable health burden of trauma and the controversies surrounding the use of helicopter emergency medical services (HEMS) for trauma transport lend imperative to the development of an evidence-based guideline (EBG) for the transportation of prehospital trauma patients. Trauma is the leading cause of death for young adults in the United States and accounts for more than a third of all emergency department visits, while the aeromedicine industry now supplies approximately 3% of all ambulance transports.[1–3] In general, evidence-based guidelines focused on prehospital care are lacking, and the concrete advantages of HEMS as borne out in the literature remain the subject of debate. While the existing evidence supports a morbidity and mortality benefit, its interpretation is complicated by the heterogeneity of HEMS patients and incidents.[4] The true utility of HEMS most likely hinges upon the appropriate selection of injured patients for aeromedical transport, since undertriage has implications for patient outcomes, while overtriage significantly affects system resources and patient and provider safety.

Objectives

The objective of this guideline is to recommend an evidence-based strategy for the triage and transportation of all prehospital trauma patients who use 9-1-1 services. The following overarching questions regarding this patient population were used to structure the research and discussion:

i) Which field triage criteria should be used to risk-stratify injury severity and guide decisions as to destination and ground versus air transport modality?
ii) When should online medical direction be obtained for assignment to ground versus air transport to improve patient outcomes?
iii) What are the criteria that would necessitate assignment to air transport to improve patient outcomes?

Please refer to Appendix A (available online) for further detail on the PICO (Patient, Intervention, Comparison, Outcome) formatted research questions.[5]

Scope

This guideline applies to trauma patients in the prehospital setting who require transportation to a hospital for the evaluation and treatment of their injuries. The evidence analyzed included patients of all ages, but excluded secondary transfers, drowning, and burn patients. The guideline is most applicable to EMS systems where paramedics and other nonphysician EMS providers make care decisions that are partially or completely independent of online physician control. It is to be used by EMS systems administrators, medical directors, and policy makers.

Interpretation

This guideline was developed using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) methodology and contains both strong and weak recommendations. According to the GRADE paradigm, the implication of a strong recommendation is that it should be adopted as policy in most settings covered by the scope of the guideline. Weak recommendations are more conditional and should only be adopted after extensive dialogue regarding stakeholder values and preferences.[6]

Methods

Additional information regarding the methodology of this EBG may be found in a separate publication.[7] Overall, the panel followed the National Evidence-based Guideline Model Process, which was approved by the Federal Interagency Committee on EMS and the National EMS Advisory Council.[5]

A core guideline development working group consisting of the lead investigators and a GRADE methodologist recruited a panel with expertise in prehospital

medicine, EMS systems administration, and evidence-based medicine. Leaders from the Maryland Institute for Emergency Medical Services System (MIEMSS) were included from the outset because of the intent to eventually pilot test the protocol within their system.

The core working group undertook a preliminary survey of the literature to assess the quality of evidence surrounding the prehospital transportation of trauma patients. Although this overview did not identify any relevant high quality systematic reviews or randomized controlled trials, it was nevertheless agreed that a guideline based on the available evidence would have significant impact on prehospital care.

Next, panelists generated a series of questions of clinical importance (PICO questions) and each panelist then completed a more intensive evidence review based on one or more of the clinical questions. The search strategies used are cataloged in Appendix A (available online). Eligible outcomes were analyzed according to GRADE methodology (Appendixes B and C, available online). In July 2010, panelists convened to present the evidence pertinent to their PICO question, to discuss its quality, and to generate graded recommendations.

Emphasis was placed on the perspective of patients and their families, although health-care system and EMS provider viewpoints were considered as well. The final set of recommendations was transformed into an algorithm for prehospital trauma triage to be used in the field by EMS providers.

In February 2012, panelists repeated their literature searches to identify new research that might impact the recommendations. These recent publications were appraised and incorporated into the existing evidentiary tables where applicable. The core working group was prepared to reconsider the strength of recommendations based on this new evidence, although changes were deemed unnecessary given the concordance in quality and content between the old and new data.

RECOMMENDATIONS

Recommendation #1:
We recommend that field triage criteria for all trauma patients should include anatomic, physiologic, and situational components* in order to risk-stratify injury severity and guide decisions as to destination and transport modality.

(Strong recommendation, low quality evidence)

*As outlined by the CDC 2011 Guidelines for the Field Triage of Injured Patients (Figure 1).[1]

Remarks: In formulating this recommendation, the panel placed more importance on avoiding undertriage and less importance on possible overtriage. The panel also considered that most patients would highly value the potential morbidity and mortality benefit of incorporating all possible triage variables.

Recommendation #2a:
We recommend that EMS providers should not be required to consult with online medical direction (OLMD) before activating HEMS for trauma patients meeting appropriate physiologic and anatomic criteria for serious injury.*

(Strong recommendation, low quality evidence)

Recommendation #2b:
We suggest that for all other trauma patients, online medical direction may be used to determine transportation method as long as it does not result in a significant delay.

(Weak recommendation, very low quality evidence)

*Patients meeting appropriate physiologic and anatomic criteria have clinical features consistent with steps 1 and 2 of the CDC 2011 Guidelines for Field Triage of Injured Patients (Figure 1).[1]

Remarks: In formulating these recommendations, the panel acknowledges that the relative lack of evidence is at odds with the fact that strong GRADE recommendations are generally meant to be adopted as policy. However, the panel considered that most patients with severe injuries would highly value the most expedient mode of transport possible and felt strongly that OLMD should therefore not be *mandatory* in order to activate HEMS for the sickest patients. Thus, the panel suggests that, despite their strength of recommendation, it would be reasonable for individual EMS systems to reconsider the evidence and contextualize both recommendations for their own milieu.

Recommendation #3a:
We suggest that HEMS be used to transport patients meeting appropriate physiologic and anatomic criteria for serious injury to an appropriate trauma center if there will be a significant time-savings over GEMS.*

(Weak recommendation, very low quality evidence)

Recommendation #3b:
We suggest that GEMS be used to transport all other patients to an appropriate hospital, so long as system factors do not preclude safe and timely transportation.

(Weak recommendation, very low quality evidence)

*Patients meeting appropriate physiologic and anatomic criteria have clinical features consistent with steps 1 and 2 of the CDC 2011 Guidelines for the Field Triage of Injured Patients (Figure 1).[1]

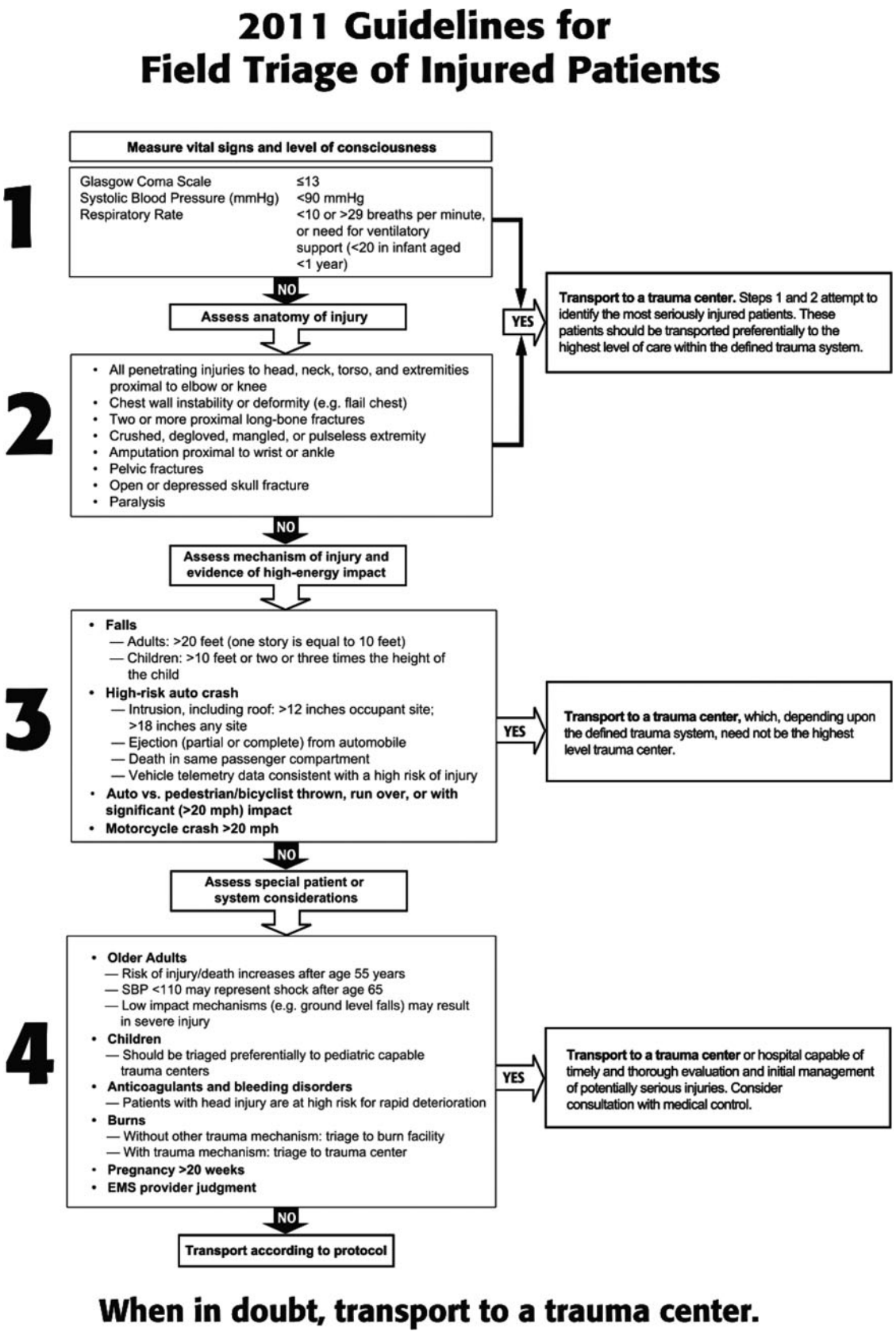


FIGURE 1. Guidelines for Field Triage of Injured Patients.

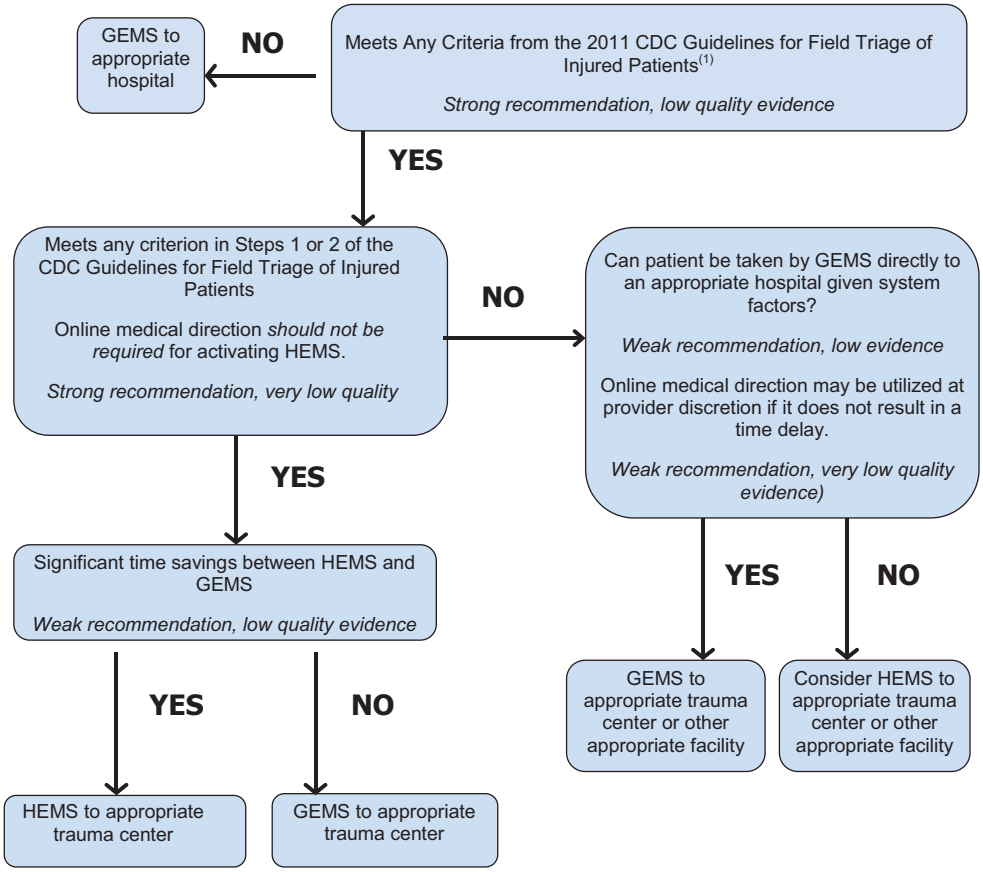


Figure 2. HEMS Evidence-based Guideline (with Trauma Center Designated).

Remarks: In formulating these recommendations, the panel placed high importance on potential morbidity and mortality benefit, and lower importance on cost and resource utilization.

A suggested protocol was drafted based on these recommendations (Figure 2).

Discussion

How Will This EBG Improve HEMS Triage?

The development of evidence-based guidelines for the transportation of trauma patients is intricately linked to the overall quality of the literature surrounding the benefits of HEMS. Given the inherent difficulties with assessing patient outcomes as a function of prehospital care, as well as with making ground versus air ambulance comparisons, the authors formulated the recommendations based on their assessment of the best available evidence.

In the United States, helicopters are used frequently for the transportation of trauma patients; a 2007 overview estimated that 753 helicopters (and 150 dedicated fixed-wing aircraft) are in EMS service.[3] The ideal HEMS triage tool ensures patients receive the right care from the right institution without wasting health-care resources. Accepting that patients needing specialized services might not have severe or readily identifiable injuries at the scene, the watershed territory of trauma triage is the identification of patients who might benefit from specialized services while not having readily apparent physiologic or anatomic derangements.

Being too selective in activating HEMS might lead to unacceptably high rates of undertriage and increased morbidity and mortality in trauma.[8] The possibility of undertriage, however, must be balanced against the opposite outcome of overtriaging and sending too many patients to specialized centers. The American College of Surgeons has stated that "an undertriage rate of 5–10% is considered unavoidable and is associated with an overtriage rate of 30–50%."[9] Despite this triaging challenge, studies focusing on this subject cite overtriage rates from 50–90%.[10,11] One recent analysis determined that the costs associated with trauma care and overtriage would decrease substantially if the CDC Guidelines for the Field Triage of Injured Patients were consistently applied.[12]

Patient and Care Provider Safety

Safety of both patients and care providers is a key consideration when assessing whether to transport by ground or air, and is a controversial topic both in the

EMS community and in the popular media. It is widely thought that the benefit to patient outcomes greatly exceeds any potential risks inherent in helicopter transport, although recent adverse incidents have instigated renewed dialogue about the best way to maximize this benefit:risk ratio.[4,13] A recent NTSB report indicates that the "aviation risk" of HEMS has not been well studied or evaluated.[14] The debate is confounded by heterogeneity in HEMS equipment, crew training, and safety protocols, as well as difficulties in directly comparing safety risks between ground and air transportation. Overall, the data indicate that the risk of aeromedical transport is very low, but the risks of ground transport are not negligible either.[15–17] Given the inconclusiveness of the data on this subject, this guideline recommends preferential use of HEMS only when there is a likely outcome benefit to the patient.

Use of the CDC 2011 Guidelines for the Field Triage of Injured Patients

This guideline recommends that the 2011 Centers for Disease Control (CDC) Guidelines for the Field Triage of Injured Patients (Figure 1) be used to stratify patients into groups most likely to benefit from HEMS. The CDC guidelines utilize the best available evidence to derive the safest possible triage guidelines. Factors that inform this triage process may be categorized as anatomic (e.g., specific injuries noted), physiologic (e.g., vital signs abnormalities), or situational (e.g., logistics, injury mechanism).[1,18] Each of these three major categories includes at least some variables that are associated with risk of major injury and worse outcomes.[11,19–27] This EBG builds off the CDC criteria as a starting point in the triage process, then elaborates on the circumstances in which ground and air medical transport might best be used. The decision-making surrounding transport modality is inextricably linked to the data informing trauma triage, since patients at higher risk of injury are more time-sensitive cases for which advanced intervention and transport to high-level trauma care is often achievable only via HEMS.[28]

Many laudable attempts to streamline prehospital trauma triage have attempted to identify anatomic, physiologic, or situational components that identify patients appropriate for advanced trauma care without resulting in substantial overtriage.[29–31] Reliance on physiologic criteria/vital signs alone, for instance, will likely result in unacceptable levels of undertriage, as patients with significant injuries may have normal vital signs at the scene.[32,33] The same concerns apply to triage decisions based solely on anatomic or situational factors.[31,34,35]

The strength of evidence addressing patient morbidity and mortality associated with field triage decisions was judged to be low, largely due to the lack of prospective, large-scale trials. The prospective data that do exist are derivation studies or pilot-testing of new triage parameters, such as heart-rate variability.[36,37] Thus, the evidence base is insufficient to meet the GRADE criteria for anything other than low evidentiary quality. Issuing a strong recommendation in the face of low evidence quality is potentially problematic, but is justified in the opinion of the review panel. This justification rests on the harm/benefit balance of promulgating the 2011 CDC Guidelines. The CDC criteria are potentially overinclusive, in that they incorporate all triage information categories that are currently known to be associated with time-sensitive and severe injuries. However, the harm of undertriage due to inappropriate reduction of triage criteria is significant.[38] The alternate harm, of overtriaging patients to high-level trauma care (and in many cases, helicopter transport), is primarily one of unnecessary resource utilization.[39] In addition, some data indicate that despite their broad inclusiveness, previous iterations of the CDC trauma triage criteria might actually reduce overtriage rates.[40] The panel considered patients' likely preferences regarding risk of death or major disability versus risk of potential resource overutilization. The weighting of significant risk of morbidity/mortality versus potential resource overutilization was considered by the panel to justify a strong recommendation.

The panel understands and intends that the strong recommendation set a standard by which EMS systems should be measured. In fact, this standard is also consistent with the standard developed by other national-level bodies such as the Centers for Disease Control and Prevention's National Center for Injury Prevention and Control.

Online Medical Control

The panel reviewed the literature to determine whether online medical direction should be required for activating helicopter transportation for trauma patients. Mortality, morbidity, and undertriage of critically ill patients were designated critical outcomes. Overtriage (with its associated higher costs and assumed risks) and system-related outcomes, such as scene times, error rates, and unnecessary treatments, were determined to be of secondary importance.

Despite an extensive literature search (see Appendix A, available online), the panel did not identify any high quality studies directly pertinent to the question at hand. Two prospective observational studies demonstrated that paramedics can apply standing orders for a variety of medical and trauma-related complaints with acceptably low error rates and few adverse outcomes.[41,42] Mulholland et al. demonstrated that paramedics could independently and reliably identify patients with life-threatening injuries, lessening the concern for undertriage for the critically ill.[35] A

retrospective review of triage appropriateness by Lubin et al. concluded that paramedics and community emergency physicians have similar proficiency at identifying cases appropriate for transfer to a level I trauma center.[43] However, a prospective observational study by Champion et al. suggested paramedics might have a tendency to overtriage, and that online medical direction (OLMD) might reduce the overtriage rates by up to 50% in low-severity cases.[44]

The panel also investigated whether OLMD affects scene times for trauma patients. Recent literature was not available. The panel reviewed four studies, all conducted more than 20 years ago; their applicability was limited given the many changes in EMS since their publication. Erder et al. determined that OLMD was associated with slightly longer scene times and infrequent physician-directed deviation from written care protocols, but the patient sample included medical and trauma patients.[45] In a prospective before-and-after study of nontrauma patients, Rottman et al. determined that the use of protocols by paramedics (rather than online medical direction by nurses) did not affect scene times or the appropriateness of clinical decisions.[46] A 1991 retrospective study by Gratton et al. determined that standing orders for procedural interventions in unstable trauma patients resulted in similar scene times as when OLMD was used.[47] No studies directly addressed morbidity, mortality, or cost as a function of requiring online medical direction for activating HEMS for trauma patients.

However, the available evidence does indicate that paramedics are able to exercise good judgment in identifying critically ill trauma patients, with perhaps a tendency toward overtriage. While online medical direction might lessen this overtriage, it has not been proven to reduce morbidity, mortality, or scene times. Improving triage specificity could have an indirect effect on patient and crew safety by lessening the number of flights and hence the inherent risks associated with aeromedical transportation, but this assumption has not been proven with objective data. The panel also considered that patients at greatest risk of life-threatening injury, and their families, would value the most expeditious transfer possible to the trauma center providing the highest level of care much more than the potential costs and risks associated with overtriage.

Considering the above factors, the panel strongly recommends HEMS can be activated without OLMD for patients falling into the CDC Guidelines steps 1 and 2. For all other trauma patients, the panel felt that a more balanced valuation of outcomes was warranted. The importance of air transport costs and risks might weigh in more heavily for patients whose injuries are less severe, and therefore improved triage specificity through OLMD is reasonable for this population. As such, the panel suggests for patients who meet the criteria for steps 3 or 4 of the CDC Guidelines that EMS providers utilize OLMD at their own discretion, provided it will not result in significant transport delays.

Helicopter Transportation for Patients Meeting Physiologic and Anatomic Criteria

There is some evidence to suggest that severely injured trauma patients benefit from being transported directly from the scene to an appropriate trauma center.[48–50] Since the initial review panel meeting for this guideline, two major pertinent peer-reviewed studies have been published. One study by the Resuscitation Outcomes Consortium (ROC) identified a positive, but not statistically significant, point estimate for the association between HEMS transport and scene trauma mortality. Another far more methodologically rigorous study focused only on those patients with severe injuries as defined by Injury Severity Score (ISS); a statistically significant association between air transport and mortality was identified.[51,52]

Attempts to isolate a workable subset of HEMS activation criteria have been stymied by both the variability in EMS systems and the challenges of prehospital research. For instance, a systematic review by Ringburg et al. examined a wide variety of physiologic, anatomic, and mechanistic dispatch criteria. No single component demonstrated sufficient accuracy in narrowing the number of considered dispatch variables and the authors concluded that a more rigorous analysis was needed.[31] A retrospective registry review by Braithwaite et al. found that patients with an ISS of 16–60 might have improved outcomes with HEMS.[53] A review panel led by Black selected decreased level of consciousness (LOC), airway obstruction, respiratory distress, shock, and significant head injury as the clinical features that should prompt HEMS activation.[29] In a database review, Giannakopoulos et al. isolated anatomic, physiologic, and mechanistic criteria that warranted the most timely transportation possible to a trauma center.[38] Moront et al. determined that in pediatric trauma, the combination of GCS < 12 and HR > 160 yielded a 99% sensitivity and 90% specificity for major trauma, although there were limitations in the study.[39] Stewart et al. determined that the mortality benefit of HEMS was minimal in patients with normal vital signs or in whom the Revised Trauma Score was less than 3.[49]

The issue of HEMS activation is perhaps even more complex in pediatric trauma, where the potential for saving life-years might prompt overtriage. Eckstein et al. retrospectively examined pediatric trauma transportation and concluded that many pediatric patients who were transported by helicopter had minor injuries. A third of the children in their study were discharged directly from the emergency department.[54] After deriving a pediatric overtriage rate of 85% in

their retrospective study, Moront et al. also expressed concerns regarding pediatric overtriage.[39]

Further confounding the analysis of this subject is the disputable time-savings of HEMS. Some studies found no difference in transport times for HEMS vs. GEMS, even when controlling for distance traveled.[55] From a methodological perspective, it is exceedingly difficult to retrospectively determine which transport modality is superior unless variables such as local weather, traffic congestion, and EMS crew capabilities are specifically noted as part of the patient record.

Overall, the quality of research examining this issue is low or very low, with most studies being retrospective and heavily reliant on large data registries. None of the HEMS activation variables derived in these studies have been prospectively validated in multicenter trials. And while the time and cost effectiveness of HEMS remains disputable, the authors posit that most seriously injured patients would choose HEMS over GEMS unless its perceived mortality and time benefits were conclusively disproven with high quality evidence. Reinforcing this patient perception of HEMS is some debatable evidence of mortality benefit for the sickest patients.

Given the poor quality of the evidence supporting mortality benefit and their estimation of patient preference, the authors have issued a weak recommendation to transport patients meeting anatomic and physiologic criteria as per the CDC Guidelines by HEMS to a trauma center, provided it will be more expedient. The authors suggest transporting all other patients by GEMS unless system variables such as patient condition, local weather, road conditions, and EMS crew training and availability make HEMS the preferable transport modality.

By assigning a weak strength to these recommendations, the authors intend that EMS policy makers and administrators will contextualize guidelines based on the dynamics of their particular system. They also suggest that further research on the benefits of HEMS is urgently required. Consultation with key stakeholders, including patients and EMS providers, should be a pivotal part of this process, particularly given the lack of published data regarding patient preferences for HEMS.

Guideline Strengths and Limitations

This guideline represents the first synthesis of the available evidence on prehospital trauma triage using the GRADE methodology. The GRADE process increases the transparency of guideline formulation while lending flexibility to the implementation of the end product by assigning strengths to the developed recommendations. Nevertheless, it was the authors' experience that the dearth of information about patient preferences, relative harms and benefits, and resource usage on the subject of HEMS made the assignment of recommendation strengths problematic and more susceptible to subjective decision-making by the expert panel. While there is some literature that addresses public perception vis-à-vis HEMS, the data are quite sparse. The available evidence suggests that, at least in some countries, the public preferences with respect to HEMS use are generally in line with policy-maker expectations with regard to use of financial resources to fund HEMS.[56]

Despite the lack of published literature, the volume of annual HEMS flights, combined with the nonlikelihood of significant short-term improvement in the evidence, renders it reasonable to promulgate guidelines based on the best available information. The guideline panel made every effort possible to be objective in areas where some consensus-based decision-making was necessary owing to lack of definitive evidence.

CONCLUSIONS

This guideline uses systematic methods to adjudicate the available evidence on the triage of prehospital trauma patients. It offers two strong and three weak recommendations regarding the use of online medical direction and the activation of HEMS vs. GEMS. Additional research, particularly in areas where the evidence base is currently weak, would further clarify how to best optimize undertriage and overtriage rates while maximizing safety for patients and EMS personnel.

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Supplementary Material Available Online

Appendix A: Literature Search Strategies

Appendix B: Evidence Tables

Appendix C: Recommendations and GRADE Tables

Supplementary contents can be viewed and downloaded at http://informahealthcare.com/pec.