EVALUATION OF TRAUMA TRIAGE CRITERIA FOR AIR MEDICAL TRANSPORT

INVESTIGATORS: HOWARD WERMAN, MD; MICHAEL CUDNIK, MD, MPH;

LYNN WHITE, MS; JUDY OPALEK, PHD

ACKNOWLEDGEMENTS

This project was funded through an Ohio Department of Public Safety Trauma Grants

Program Award (#DPS01-0000017362)

INTRODUCTION

Trauma is the leading cause of death for patients between the ages of one and 44 and represents a substantial proportion of health care costs in the United States.[1,2] Transport of the most critically injured patients is understood to be of critical importance, and therefore, it is important that the we understand and provide the most effective transport methods for this population.

Some research has demonstrated the benefit of air medical transport for trauma victims, in terms of cost effectiveness and survival.[3, 4,5] However, overuse of air medical resources is a significant concern, with some studies demonstrating over-triage rates of 60% in the adult population and 85% in pediatric trauma.[4, 6] The cost of transport is high, and safety risk to both the patient and staff is real, making it essential that only patients who will clearly benefit should be transported by air.[7,8]

Although broad based trauma triage guidelines currently exist, there is little evidence-based information available to guide EMS in their decisions to call for air transport from the scene of injured patients.[8,9] Several states use destination protocols defining when a patient should be transported to a trauma center without clearly defining the most appropriate mode of transport.

The purpose of this study was to evaluate whether clinical variables available at the scene of injury were associated with appropriate trauma hospital resource utilization and improved clinical outcomes.

CONTENTS

INVESTIGATORS: Howard Werman, MD; Michael Cudnik, MD, MPH; Lynn White, MS; Judy Opalek, PhD . 1

Acknowledgements 1

INTRODUCTION 2

Qualifications of the Investigators 4

Review of the Literature 5

METHODS 6

Study Design and Setting 6

Variables Collected 7

Data Analysis 8

RESULTS 9

DISCUSSION 9

LIMITATIONS 11

CONCLUSIONS 12

Reference List 14

Table 1 Prehospital Criteria for Helicopter Transport to Trauma Center 17

Table 2 Patient Demographics 19

Table 3 Prehospital Reasons for Helicopter Transport to Trauma Center# **Error! Bookmark not defined.**

Table 4 Factors Independently Predictive of Mortality on Univariate Analysis**Error! Bookmark not defined.**

Figure 1* ..... **Error! Bookmark not defined.**

Figure 2* ..... **Error! Bookmark not defined.**

QUALIFICATIONS OF THE INVESTIGATORS

The PI for this project is Howard Werman, MD, Professor of Emergency Medicine at The Ohio State University College of Medicine, Columbus, OH. Dr. Werman is an attending physician at The Ohio State University Medical Center and has been the Medical Director for MedFlight of Ohio since 1998. Dr. Werman has an active publication record in the area of air medical transport and is the recipient of multiple awards for service, research and education.

Michael Cudnik, MD, MPH, is Assistant Professor of Emergency Medicine at The Ohio State University College of Medicine. Dr. Cudnik received his MPH in Biostatistics and Epidemiology from Oregon Health and Science University in 2007 where he completed a Clinical Research fellowship working with the Resuscitation Outcomes Consortium (ROC) research network. Dr. Cudnik has published extensively in the area of trauma and has considerable experience and expertise with large database analysis.

Lynn White, MS. At the time of this study, Ms. White was the Clinical Manager of the Research program at The Ohio State University Medical Center Department of Emergency Medicine. Ms. White holds an adjunct assistant professorship at The Ohio State University and has had considerable research

experience and publications in the areas of resuscitation, trauma and air medical transport. Ms. White is currently the National Director of Resuscitation and Accountable Care at AMR Medicine.

Judy Opalek, PhD, is the Trauma Research Manager at Grant Medical Center in Columbus, OH. She received her PhD from The Ohio State University and has published widely in the trauma literature.

REVIEW OF THE LITERATURE

Trauma is the leading cause of death for patients between the ages of one and 44 and represents a substantial proportion of health care costs in the United States.[1,2] Transport of the most critically injured patients is understood to be of critical importance, and therefore, it is important that the we understand and provide the most effective transport methods for this population.

Some research has demonstrated the benefit of air medical transport for trauma victims, with cost effectiveness studies and studies evaluating survival.[3, 4,5] However, overuse of air medical resources is a significant concern, with some studies demonstrating over-triage rates of 60% in the adult population and 85% in pediatric trauma.[4, 6] The cost of transport is high, and safety risk to both the patient and staff are real, making it essential that only patients who will clearly benefit should be transported by air.[7,8]

Although broad based trauma triage guidelines currently exist, there is little evidence-based information available to guide EMS in their decisions to call for air transport from the scene of injured patients.[8,9] Several states use destination protocols defining when a patient should be transported to a trauma center without clearly defining the most appropriate mode of transport.

The purpose of this study was to evaluate whether clinical variables available at the scene of injury were associated with appropriate trauma hospital resource utilization and improved clinical outcomes.

METHODS

STUDY DESIGN AND SETTING

This was a prospective, analysis of consecutive injured, adult patients (16 years of age or older) who were transported by a single air transport agency (MedFlight) to one of the two Level One trauma centers in Central Ohio. The project was approved by the Institutional Review Boards (IRB) at both participating trauma centers.

Data were prospectively collected from October 2009 through September 2010. The data collected for each patient transport were derived from three different sources. The first was a direct survey of prehospital personnel by air medical dispatch personnel. These indicators included elements of the State of Ohio Trauma Triage Criteria (Table 1) including mechanism of injury as well as anatomical and physiologic characteristics of the patient at the scene (see variable description below). The questionnaire included 40 questions based on trauma triage guidelines for the State of Ohio. The data were maintained by personnel at MedFlight and became part of the transport debriefing system. Additionally, patient demographic and geographical scene information data were included as these data are routinely collected as part of the program's computer aided dispatch system.

Hospital data were obtained from each receiving hospital's trauma registry. The registries are prospectively collected with specific data elements based on the State of Ohio's trauma data registry criteria which is further derived from the National Trauma Database (NTDB). All patients transported directly from the scene of the injury by air medical transport to each of the Level I trauma centers were included in the analysis. Both Level I trauma centers are located in a single large, metropolitan city and are the only two adult Level I trauma centers in the region. In order to be entered into the trauma registry,

a patient must have sustained a traumatic injury, within the ICD-9 injury diagnosis of 800 to 959.9, excluding those with an isolated hip fracture (ICD-9 series 820). In addition, the patient must be admitted to the trauma team, be classified as trauma team activation, or evaluated by a member of the hospital's trauma team while in the Emergency Department. Quality assurance measures, such as re-abstraction and data checks, are completed on a minimum of 10% of the registry patient entries. Edit fails are also in place to check blank or incorrectly entered data and the coding summary comparison from Medical Information Management is reviewed for inconsistencies in the diagnosis and the coding to ensure consistent and accurate data collection and documentation.

Variables Collected

Prehospital variables collected from the scene at the time of injury are listed in Table 1. These variables were obtained via direct query of the transport team by the dispatcher at MedFlight headquarters. In addition, the zip codes from the area in which the injury occurred, the number of loaded statute miles for each transport, and whether or not the injury occurred in a rural location (as defined by the U.S. Census Bureau), were also collected from the transport agency.

Variables obtained from each trauma center included: age (in years), gender, race (White, Black, Asian, Hispanic, Other), insurance status (private, Medicare/Medicaid, workers compensation, self pay), injury severity score (ISS), intensive care unit (ICU) length of stay (LOS) in days, hospital LOS in days, trauma type (blunt vs. penetrating), and the ICD-9 discharge diagnoses. ISS, LOS, and ICU LOS were continuous variables; all others were categorical.

The primary outcome of interest was in-hospital mortality, defined as death from any cause while in the hospital. Additional outcomes collected included: early death, defined as death within 24 hours of admission; early blood use, defined as a blood transfusion within 24 hours of admission; ICU admission for greater than 24 hours; and emergent surgery, defined as any operation that occurred within 24 hours of

arrival. These additional outcomes were chosen as they potentially represent extensive trauma center resource utilization and could represent the necessity of expeditious transport to a Level 1 trauma center via air transport. In particular, the outcome of early blood transfusion was chosen based on clinical experience as well as prior work that such patients are often much more seriously injured and will require additional resources in addition to the blood products themselves.[10] Such criteria have also been suggested by others as indicative of hospital resource use in trauma patients.[11] In addition, a combined outcome of all variables (death, ICU admit >24 hours, early emergent surgery within 24 hours, or blood transfusion within 24 hours) was also assessed.

Data Analysis

Descriptive statistics were used to describe the study population and the prehospital questions and were reported as means with 95% confidence intervals (CI) or medians with inter-quartile ranges (IQR), where appropriate. Continuous and categorical variables were compared using Chi-Square Analysis and Kruskal-Wallis test, where appropriate. Univariate associations between prehospital patient and clinical variables with mortality were assessed via logistic regression. We used multivariable logistic regression with forward stepwise selection with a *P* value greater than 0.05 for removal of variables, but we forced variables that we considered to have significant clinical relevance back into the model. Model fit was assessed using the Hosmer-Lemeshow Goodness of Fit test. We then calculated the sensitivity, specificity, and positive and negative predictive values with 95% CIs of the rule when applied to patients in the initial dataset. In addition, Receiver Operatic Characteristic (ROC) curves were calculated for each of the models with their respective outcomes.

RESULTS

Because this study manuscript has been accepted for publication, and the abstract has been accepted for presentation, but neither have been published at the time this report is due, we will defer from presenting the major results in this format until after the paper is published so we do not violate any copyright rules. However, once the manuscript is published, we will send a copy to the Ohio Department of Public Safety.

We have included Table 2 which lists the prehospital and hospital characteristics of our population as well as Table 3, which lists the reasons identified in the prehospital setting for the selection of helicopter transport to a trauma center.

DISCUSSION

In this prospective project, we discuss the prehospital criteria for high risk mechanisms of injury identified from the scene of injury in terms of their association or lack of with mortality in trauma patients.

We discuss the degree of over-triage and over-utilization of air medical transport in this system.

The findings of this project are similar to work that has done by others. Bledsoe et al, in a recent meta-analysis, reported that more than 60% of injured patients who were transported by air medical transport had only minor injuries and that 26% of patients were discharged less than 24 hours after arriving at the trauma center.[6] We found an even greater number of patients with minor injuries in our study population with 72% of patients ultimately having an ISS $\leq$ 15, suggesting that the issue of over-utilization may be greater in our system than others. This suggests that the criteria currently in use may

be overly conservative based on the current factors that are being incorporated from the scene of injury. Indeed, work by others has suggested that mechanism of injury alone is not a good indicator of risk of mortality or serious injury.[12-14] As such, the CDC has revamped their triage guidelines and has suggested that this criteria alone warrants transport to the closest trauma center, rather than the highest level trauma center.[1] Based on the results of this project, mechanism of injury by itself may not be a suitable factor alone to warrant air medical transport to a Level I trauma center.

While mechanism of injury alone has been shown to have a limited impact on outcomes of trauma patients, multiple organizations and guidelines have suggested that it is, by itself, enough to warrant air medical transport to a trauma center.[8, 9] In our published manuscript, we will discuss how our findings that show that these criteria alone may not be enough to initiate the use of a helicopter to transport a patient to a trauma center. A patient who suffers such a trauma may still require the resources and care of a trauma center, however, whether or not they need a helicopter to get there has yet to be determined. Such a finding has been observed by others and refining such a criterion could potentially decrease the over-utilization of air medical transport for injured patients.[15, 16]

While there is a considerable body of evidence to suggest that appropriate use of air medical transport can improve patient outcomes,[17] the overuse of air medical transport is in of itself not a benign process. The cost of air medical transport is often significantly greater than the cost of ground transport. As the cost of medical care continues to increase, such expenses will continue to be held under close scrutiny. In addition, flights deemed to be medically inappropriate may not be reimbursed for their services,[18] which will pass the burden of cost onto patients, many of whom may not be able to pay for such charges. In addition, there is also the issue of patient and staff safety.[19] In recent years, there has been an increase in the number of helicopter crashes with resultant injury and even deaths of the

occupants.[20] The reasons for this are currently unknown. However, what is clear is that the safety risk of transport of an injured patient who does not have life or limb-threatening injuries, as well as the safety risk for pilots and staff caring for the patient should not be considered acceptable. Ensuring that only appropriate patients are transported in the most effective and safest method possible should be the top priority for all agencies.

Field triage by prehospital providers is challenging not only because such decisions are made in the early stages of injury, but also because of the natural progression of symptoms that occur with injured patients.[21] One has to balance the amount of under-triage (i.e. sensitivity) with over-triage (i.e. specificity), as flying an uninjured patient has its own negative consequences. The clinical decision rule developed in this project due to its high sensitivity, would lend itself to a negligible under-triage rate with an acceptable over-triage rate. Moreover, the very clear and easily identifiable variables we have included in this model make it an attractive first step in identifying injured patients who require helicopter transport in our state. While the primary model developed is encouraging, the opposite is true for the model developed evaluating the combined clinical outcomes. This model will be included in the published manuscript. Its fair discriminatory ability, while it may be acceptable for some clinical decisions, would be unacceptable for field triage as the over-triage rate would be unacceptably high whenever any acceptable sensitivity would be reached.

LIMITATIONS

The biggest limitation in this project is the lack of a comparison group of ground transported patients. Prior work has shown that air transport is beneficial compared to ground transport in seriously injured patients.[22] The investigators are currently capturing data on the outcomes of ground and air medical transported patients in order to better understand this patient cohort. The lower median ISS in our

project also may limit the external validity of our findings as the median ISS in our project was much less than a recently published retrospective project from the NTDB, a study which found a beneficial impact of helicopter transport.[23] However, the authors were not expecting the findings of this project to be applicable to all states in the U.S. due to the vast diversity of not only geographic factors but also patient demographics throughout the nation.

There are additional air medical providers in the region that was covered in this project who were not included in this analysis. However, MedFlight is the highest volume air medical transport agency in this region and responds to approximately 95% of the scene calls for injured patients, reducing such bias. Furthermore, we only had data from the two Level I trauma centers in the region, omitting other potential, lower-level trauma centers. Because MedFlight transports scene runs of injured patients only to one of these two centers, only ground transported patients would be received at Level II trauma centers would have been omitted.

CONCLUSIONS

In this injured cohort of air medical transported patients, a minority of patients had serious injuries that required the resources immediately available at a Level I trauma center. In addition, mechanism of injury was not found to be a good indicator of trauma mortality or trauma center resource utilization. Future studies are needed to develop evidence-based prehospital trauma triage criteria specifically directed towards air medical transport in order to decrease over-utilization of this widely available technology.

REFERENCE LIST

(1) Centers for Disease Control and Prevention. Morbidity and Mortality Weekly Report. 2009 Jan 23.

(2) Peitzman AB, Rhodes M, Schwab CW, Yealy D, Fabian TC. *The Trauma Manual: Trauma and Acute Care Surgery*. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2008.

(3) Baxt WG, Moody P. The impact of a rotorcraft aeromedical emergency care service on trauma mortality. *JAMA* 1983 June 10;249(22):3047-51.

(4) Moront ML, Gotschall CS, Eichelberger MR. Helicopter transport of injured children: system effectiveness and triage criteria. *J Pediatr Surg* 1996 August;31(8):1183-6.

(5) Gearhart PA, Wuerz R, Localio AR. Cost-effectiveness analysis of helicopter EMS for trauma patients. *Ann Emerg Med* 1997 October;30(4):500-6.

(6) Bledsoe BE, Wesley AK, Eckstein M, Dunn TM, O'Keefe MF. Helicopter scene transport of trauma patients with nonlife-threatening injuries: a meta-analysis. *J Trauma* 2006 June;60(6):1257-65.

(7) Taylor CB, Stevenson M, Jan S, Middleton PM, Fitzharris M, Myburgh JA. A systematic review of the costs and benefits of helicopter emergency medical services. *Injury* 2010 January;41(1):10-20.

(8) Thomson DP, Thomas SH. Guidelines for air medical dispatch. *Prehosp Emerg Care* 2003 April;7(2):265-71.

(9) Association of Air Medical Services. Position Paper on the Appropriate Use of Emergency Air Medical Services. 1990.

(10) Newgard CD, Hedges JR, Adams A, Mullins RJ. Secondary triage: early identification of high-risk trauma patients presenting to non-tertiary hospitals. *Prehosp Emerg Care* 2007 April;11(2):154-63.

(11) Newgard CD, Hedges JR, Diggs B, Mullins RJ. Establishing the need for trauma center care: anatomic injury or resource use? *Prehosp Emerg Care* 2008 October;12(4):451-8.

(12) Kohn MA, Hammel JM, Bretz SW, Stangby A. Trauma team activation criteria as predictors of patient disposition from the emergency department. *Acad Emerg Med* 2004 January;11(1):1-9.

(13) Knopp R, Yanagi A, Kallsen G, Geide A, Doehring L. Mechanism of injury and anatomic injury as criteria for prehospital trauma triage. *Ann Emerg Med* 1988 September;17(9):895-902.

(14) Boyle MJ, Smith EC, Archer F. Is mechanism of injury alone a useful predictor of major trauma? *Injury* 2008 September;39(9):986-92.

(15) Stewart KE, Cowan LD, Thompson DM, Sacra JC. Factors at the Scene of Injury Associated with Air versus Ground Transport to Definitive Care in a State with a Large Rural Population. *Prehosp Emerg Care* 2011 January 5.

(16) Shatney CH, Homan SJ, Sherck JP, Ho CC. The utility of helicopter transport of trauma patients from the injury scene in an urban trauma system. *J Trauma* 2002 November;53(5):817-22.

(17) Sullivent EE, Faul M, Wald MM. Reduced mortality in injured adults transported by helicopter emergency medical services. *Prehosp Emerg Care* 2011 July;15(3):295-302.

(18) Department of Health and Human Services. Pub 100-02 Medicare Benefit Policy. 10-22-2010. Ref Type: Statute

(19) Foo CP, Ahghari M, MacDonald RD. Use of geographic information systems to determine new helipad locations and improve timely response while mitigating risk of helicopter emergency medical services operations. *Prehosp Emerg Care* 2010 October;14(4):461-8.

(20) Bledsoe BE. Air medical helicopter accidents in the United States: a five-year review. *Prehosp Emerg Care* 2003 January;7(1):94-8.

(21) Rehn M, Eken T, Kruger AJ, Steen PA, Skaga NO, Lossius HM. Precision of field triage in patients brought to a trauma centre after introducing trauma team activation guidelines. *Scand J Trauma Resusc Emerg Med* 2009;17:1.

(22) McVey J, Petrie DA, Tallon JM. Air versus ground transport of the major trauma patient: a natural experiment. *Prehosp Emerg Care* 2010 January;14(1):45-50.

(23) Brown JB, Stassen NA, Bankey PE, Sangosanya AT, Cheng JD, Gestring ML. Helicopters and the civilian trauma system: national utilization patterns demonstrate improved outcomes after traumatic injury. *J Trauma* 2010 November;69(5):1030-4.

TABLE 1 PREHOSPITAL CRITERIA FOR HELICOPTER TRANSPORT TO TRAUMA CENTER

Does the patient have 2 or more fractures of the humerus and/or femur?
Does the patient have 2nd or 3rd degree burns > 10% total body surface area?
Does the patient have abdominal tenderness or distention or a seatbelt sign?
Does the patient have an amputation proximal to the wrist and/or ankle?
Does the patient have an arm and/or leg injury with neurovascular compromise?
Is this auto vs a pedestrian and/or a bicycle that was either: thrown, run over, or speed > 20mph?
Does the patient have one of the following co-morbid conditions: • Bleeding disorder or on anticoagulants • Diabetes • End-stage Renal Disease on Hemodialysis • Immune Compromised • Pregnancy
Does the patient have a crush injury of the head and/or neck and/or torso?
Does the patient have a crush injury of the arm and/or leg?
Is the patient failing to localize to pain?
Does the patient have a falling level of consciousness?
Did the patient have a fall > 20'?
Does the patient have a flail chest
Does the patient have a GCS <= 13?
Was the patient in a High-risk auto crash, defined as: • Death in compartment • Ejection • Vehicle telemetry data shows high risk of injury
Did the patient have a loss of consciousness > 5 min?

Did this involve a motorcycle crash > 20mph?
Does the patient needs endotracheal intubation?
Does the patient have evidence of a pelvic fracture?
Does the patient have a penetrating injury that is proximal to the knee and/or elbow with neurovascular compromise?
Does the patient have a penetrating injury to the head and/or neck and/or torso?
Does the patient have a pulse > 120 with signs of shock?
Does the patient have respirations < 10 or > 29?
Does the patient have significant burns of the face and/or feet and/or hands and/or genitals and/or airway?
Does the patient have evidence of a spinal cord injury?
Does the patient have a systolic blood pressure < 90?
Does the patient have a Tension Pneumothorax?
Geriatric Criteria (70 years of age and older) • Was the patient in an MVC with 1 or more fractures of the humerus • and/or femur? • Is there injuries of 2 or more body regions? • Was the pedestrian struck by a vehicle or fall with traumatic brain injury? • Does the patient have a systolic blood pressure <100?

TABLE 2 PATIENT DEMOGRAPHICS

	Population N=557
Age, median [IQR]	39 [24-52]
Male (%)	374 (67%)
White (%)	529 (95%)
Rural Location (%)	321 (58%)
Distance, Miles [IQR]	39 [28-52]
Insurance	
Private (%)	339 (60%)
Self Pay (%)	92 (17%)
Medicare/Medicaid	109 (20%)
Workers	17 (3%)
Penetrating Injury (%)	19 (3%)
ED GCS <9 (%)	89 (16%)
ISS, median [IQR]	9 [5-17]
ISS >15 (%)	157 (28%)

EMS ETI (%)	109 (20%)
ICU Admit (%)	182 (33%)
ICU Stay >24 hours (%)	179 (32%)
Blood within 24 hours* (%)	59 (11%)
Emergent surgery within 24 h (%)	162 (29%)
ICU LOS, median [IQR]	0 [0-2]
Hospital LOS, median [IQR]	3 [1-7]
Mortality (%)	20 (4%)
Early Death, <24 hours (%)	10 (2%)
DC Alive <24 hours (%)	6 (1%)
Hospital LOS 1 day† (%)	93 (17%)

IQR: Interquartile Range
ED: Emergency Department
GCS: Glasgow Coma Score
ISS: Injury Severity Score
EMS: Emergency Medical Services
ETI: Endotracheal intubation
ICU: Intensive Care Unit
LOS: Length of stay
*2 patients (<1%) had this outcome alone
†Patients had none of the combined outcomes (death, ICU>24 hours, Surgery within 24 hours, Blood within 24 hours)

TABLE 3. PREHOSPITAL REASONS FOR HELICOPTER TRANSPORT TO A TRAUMA CENTER	
Prehospital Criteria	Population N=557
MVC with high risk mechanism*	103 (18%)
MVC >20 mph	102 (18%)
LOC >5 minutes	85 (15%)
GCS 13 or less	82 (15%)
Abnormal Vitals (HR >120, SBP<90, Abnormal RR)	60 (11%)
Falling LOC	58 (10%)
Ab tenderness/distention/seat belt sign	52 (9%)
Crush Head Injury	37 (7%)
MVC with ejection	39 (7%)
Evidence of Spinal Cord Injury	36 (6%)
Patient fails to localize	36 (6%)
Fall >20 feet	31 (6%)

Penetrating Head Injury	36 (6%)
Evidence of pelvic injury	30 (5%)
Arm and/or leg injury with neurovascular	23 (4%)
Crush injury of the arm and/or leg	24 (4%)
2 or > fractures of Humerus and/or Femur	22 (4%)
Auto vs. Pedestrian	15 (3%)
MVC with death of occupant	17 (3%)
Flail Chest	6 (1%)
2nd or 3rd Degree Burns >10% BSA	4 (<1%)
Proximal Amputation	3 (<1%)
Penetrating Injury proximal to knee and/or elbow	2 (<1%)
Burns to Face	5 (<1%)
Tension Pneumothorax	1 (<1%)

#: Patients may have had more than one reason for transport by helicopter
MVC: Motor vehicle crash
* Death in compartment, ejection, or vehicle telemetry data shows high risk of injury
LOC: Loss of consciousness
GCS: Glasgow Coma Score
HR: Heart Rate
SBP: Systolic blood pressure
RR: Respiratory rate
BSA: Body surface area