
EVALUATION OF TRAUMA TRIAGE CRITERIA FOR MEDICAL TRANSPORT OF ADULTS AND CHILDREN

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Program

Werman
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Final
Report

INTRODUCTION

Currently, the state of Ohio has promulgated legislative mandated trauma triage criteria.

These criteria are to be used by emergency care providers to determine which patients are to be transported to state designated Trauma Centers. While the criteria are based on nationally recognized guidelines, they do not suggest the appropriate mode of transport. The current study hoped to address which of these criteria were useful in predicting the benefit of air transport of adult patients to a Level I trauma center and to extend this analysis to include pediatric patients as well.

Table of Contents

Introduction	Page 2
Acknowledgements	Page 3
Literature Review	Page 4
Study Design and Setting	Page 6
Results	Page 10
Discussion	Page 12
Conclusions	Page 15
References	Page 17
Tables and Figures	Page 20
Appendix A	Page 25

Executive Summary

The study was conducted to determine which of the statewide trauma criteria was predictive of the following outcomes: operative procedure in first 24 hours, administration of blood products, intensive care admission and in-hospital death in Level 1 trauma facilities among patients transported by helicopter. We had previously validated that the following criteria predicted high utilization: age \geq 45, Glasgow Coma Score \leq 13, systolic BP $<$ 90 and the presence of a flail chest. Applying these criteria prospectively, we found that these variables

had a sensitivity of 97% (80.2%-100%), specificity of 53.2% (50.6%-51.6%), a NPV of 100% (98.0%-100%) and a PPV of 11.9% (9.9%-12.3%). No deaths were seen among patients who met none of these criteria. On the other hand, the statewide pediatric trauma criteria performed poorly with over 35% of patients being discharged from the emergency department after evaluation.

Acknowledgements

This project was funded through an Ohio Department of Emergency Medical Services's Trauma Research Grants Program. This work has currently led to one published manuscript, two published abstracts, as well as national and regional presentations (see Appendix A)/

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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.

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A review of the literature related to the project topic

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 we understand and provide the most effective transport methods for this

population. This is particularly true since air medical transport has grown substantially in the last decade with over 400,000 patient transports utilizing over 900 helicopter resources has occurred in the United States.³

Some research has demonstrated the benefit of air medical transport for trauma victims, in terms of cost effectiveness and survival when compared to ground transport.⁴⁻⁶ 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.^{5,7} 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.^{8,9} It is estimated that the cost of an average air transport is 5 to 15 times the cost of a typical ground transport.³

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.^{9,10} Even less is known about the use of air transport in pediatric trauma victims.¹¹ 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. Our previous work¹² demonstrated that four variables available on scene could which patients would require the resources of a trauma center based on the need for early operative intervention, admission to an ICU, blood product administration and in-hospital mortality.

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

improved clinical outcomes. Additionally, we began a preliminary investigation as to the performance of pediatric trauma triage criteria as a tool for selective air medical transport.

Historical perspectives on the topic of this report

While there have been previous investigations on the outcomes of trauma patients transported by air when compared to ground transport, this is the first known investigation examining the specific topic of the performance of state or national trauma triage criteria in predicting the need for air medical transport. Previous investigations have cited high over-triage rates (i.e. transporting trauma patients with minor injuries) of over 60% in adults and over 85% in children.

A brief review of the current status of the topic in Ohio, the surrounding states, and nationally

Currently, there are over 35 helicopters transporting patients throughout Ohio. Nationally, the number is increasing at a rapid rate (currently there are over 900 air transport assets in the US) without clear and convincing evidence as to which patients truly benefit from air medical transport. The State of Ohio has promulgated pediatric, adult and even geriatric field trauma triage guidelines (see Table 1) but these do not specifically address the use of air medical assets.

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 three Level One trauma centers in Central Ohio (Grant Medical Center, Nationwide Children's Hospital, OSU Medical Center). The project was approved by the Institutional Review Boards (IRB) at all participating trauma centers.

Data were prospectively collected from August 1, 2010 through September 30, 2011. 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 ‘variables collected’ below). The questionnaire included 40 questions based on trauma triage guidelines for the State of Ohio including pediatric-specific triage criteria. The data were maintained by personnel at MedFlight and became part of the on-line 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. The three Level I trauma centers are located in a single large, metropolitan city and are the only two Level I trauma centers in the region (two adult and one pediatric). 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.¹² 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. We then compared the ability of our four variable clinical decision rule (CDR) to predict both mortality and the use of Level I resources as judged by the presence of early operative intervention, administration of blood products, ICU admission and in-hospital mortality. These variables included: age \geq 45 years, GCS \leq 13, systolic BP $<$ 90 mmHg and the presence of a flail chest.

We then calculated the sensitivity, specificity, and positive (PPV) and negative predictive values (NPV) 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

A total of 455 patients enrolled from August 2010 through September 2011. Demographics are listed in Table 2. The majority of patients were male (60%), white (79%), with injuries occurring in a rural locations (60%) and having sustained blunt force trauma (95%). The patients had a median ISS of 9 and an overall mortality of 6%.

The most common triage criteria used to summon air transport were motor vehicle collision (MVC) with high risk mechanism (18%), Glasgow Coma Score (GCS) \leq 13 (16%), a loss of consciousness for more than 5 minutes (16%) and an MVC of $>$ 20 MPH (13%). High risk mechanisms of injury included: death of another occupant in the vehicle compartment, ejection of the patient and vehicle telemetry data show high risk of injury. Of all the factors listed, however, only a GCS \leq 13 was associated with mortality ($p < 0.05$).

We evaluated whether criteria defined in our prior study¹¹ was predictive of trauma center resources among air transported patients. When applying the previously identified criteria to this population the model had a sensitivity of 97% (80.2%-100%), a specificity of 53.2% (50.6%-51.6%), a NPV of 100% (98.0%-100%) and a PPV of 11.9% (9.9%-12.3%). No deaths were missed if the CDR rule was negative (i.e. no deaths in patients without one of the four criteria). The area under the curve for the model was 0.88, suggesting a reasonably accurate model (see Figure 1).

Data collected on pediatric patients transported to Nationwide Children's Hospital by air medical transport are summarized in Table 3. It should be noted that a significant proportion of the patients (35.1%) were treated and discharged from the emergency department.

DISCUSSION

In this prospective portion of the project, we found that the predictive model developed in our previous work¹² performed well in terms of the negative predictive value and sensitivity of the model. Moreover, it suggests that the state-wide trauma triage criteria utilized to define the trauma patient may not perform well in determining which patients benefit from air medical transport. Our results suggest that further study is needed to determine if more patients can be transported by ground to their local facility where further assessment would determine the need for secondary transport to a trauma center. Only patients with a low systolic blood pressure < 90 mmHg, a GCS less than 14, evidence of a flail chest or trauma victims with other triage criteria who are older than 45 years have demonstrated a need for immediate resources available in the trauma center.

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.⁷ We found an even greater number of patients with minor injuries in our study population with 70% 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 triage criteria involving mechanism of injury alone is not a good indicator of risk of mortality or serious injury.¹⁴⁻¹⁶ 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 our study, mechanism of injury by itself may not be a suitable factor alone to warrant air medical transport to a Level I trauma center.

Some guidelines continue to advocate that mechanism, by itself, may be enough to warrant air medical transport to a trauma center.^{9, 10} While such patients may still require the resources and care available at a trauma center, they may not need a helicopter transport. 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.^{17, 18}

While there is a considerable body of evidence to suggest that appropriate use of air medical transport can improve patient outcomes,¹⁹ 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,²⁰ 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.²¹ In recent years, there has been an increase in the number of helicopter crashes with resultant injury and even deaths of the occupants.²² There is a clear 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.²³ 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 to both the patient and the trauma center. 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

There are several limitations to this project. The first is that we have described limited geographical system that may be very different from other trauma systems. There is also a 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.²⁴ 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.²⁵ It should also be noted that 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 during the study period, reducing such bias.

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. Mechanism of injury was clearly found to be a poor 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-triage of patients.

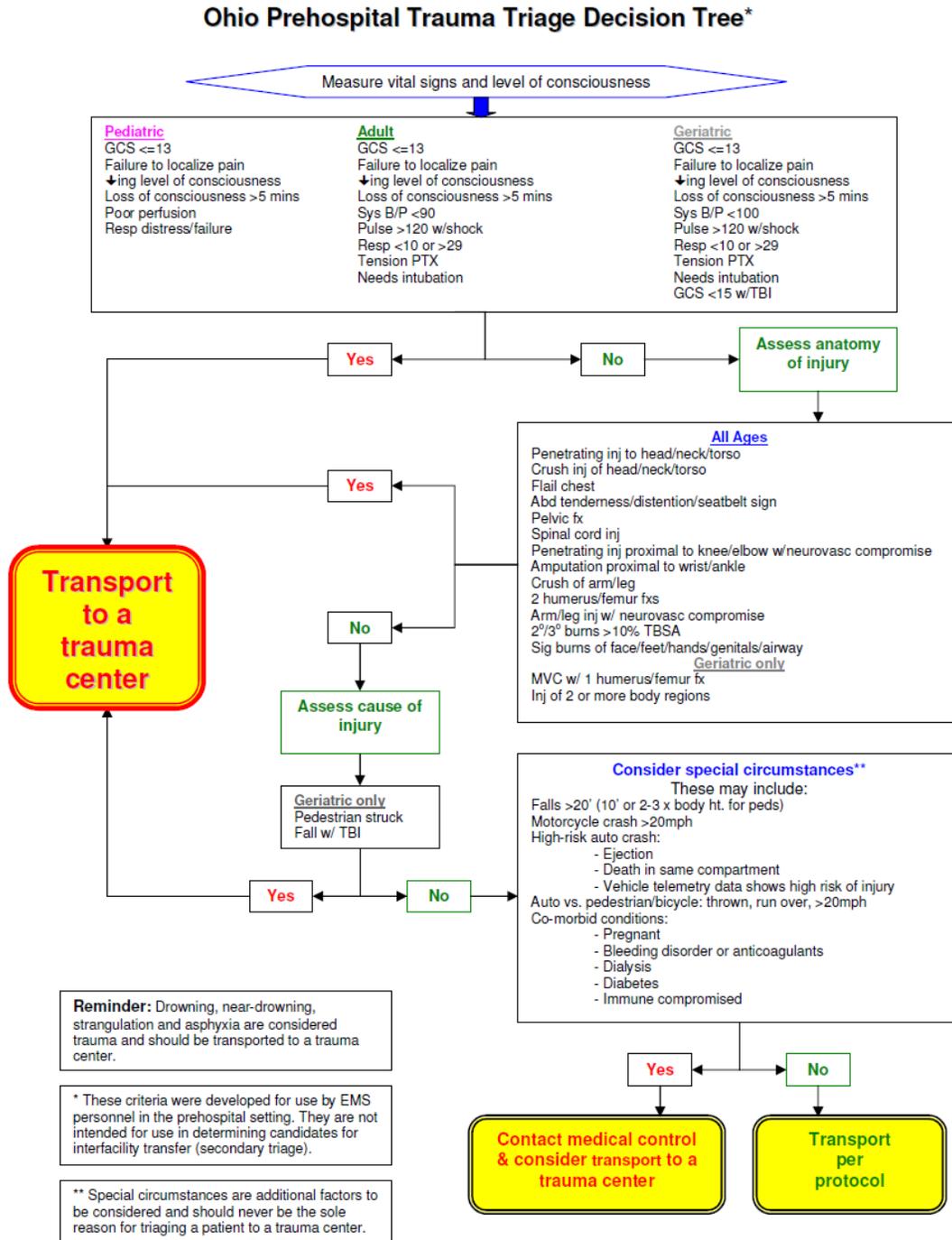
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Table 1. State-mandated trauma triage criteria



fx = fracture
GCS = Glasgow Coma Score
MVC = motor vehicle collision

PTX = pneumothorax
Sys B/P = systolic blood pressure
TBI = traumatic brain injury
TBSA = total body surface area

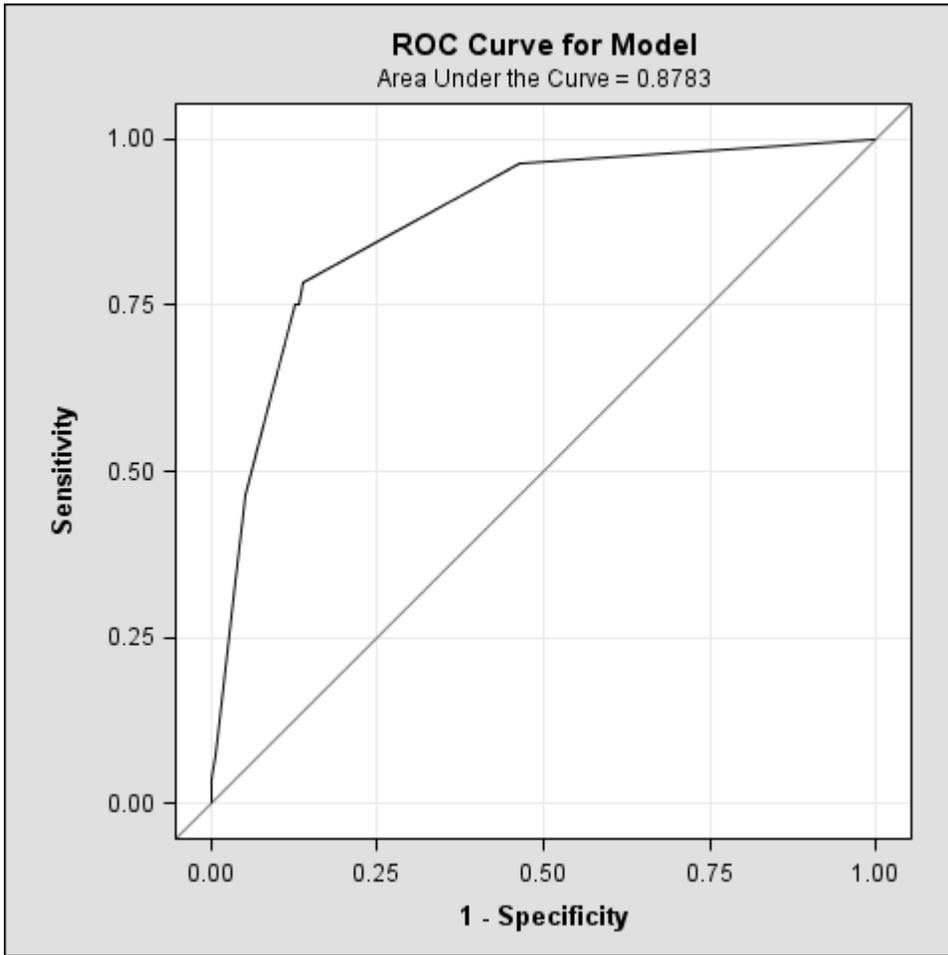
Table 2. Patient Demographics

Age, median [IQR]	39 [25-55]
Male (%)	272 (60%)
White (%)	361 (79%)
Rural Location (%)	270 (60%)
Distance, Miles [IQR]	38 [28-52]
Insurance	
Private (%)	322 (70%)
Self Pay (%)	50 (11%)
Medicare/Medicaid	77 (17%)
Workers	6 (1%)
Penetrating Injury (%)	23 (5%)
ED GCS <9 (%)	76 (17%)
ISS, median [IQR]	9 [5-17]
ISS >15 (%)	135 (30%)
EMS ETI (%)	111 (24%)
ICU Admit (%)	150 (33%)
ICU Stay >24 hours (%)	148 (33%)
Blood w/in 24 hours (%)	48 (11%)
Surgery w/in 24 h (%)	130 (29%)
ICU LOS, median [IQR]	0 [0-2]
Hospital LOS, median [IQR]	3 [1-8]
Mortality (%)	27 (6%)
Early Death, <24 hours (%)	8 (2%)

Table 3. Summary of pediatric trauma patients

	Admit (N = 70)	Discharge (N = 38)	Total (N = 108)
Age	10.15 ± 3.73	9.62 ± 5.48	9.96 ± 4.40
Sex (male %)	52/70 (74.3%)	21/38 (55.3%)	73/108 (67.6%)
Race (white %)	61/70 (87.1%)	25/35 (71.4%)	86/108 (79.6%)
Type (blunt %)	63/70 (90%)	38/38(100%)	101/108 (93.5)
Outcomes (Admit only)			
Deaths	3/70 (4.3%)		
Surgery w/in 24 hrs	20/70 (28.6%)		
Prehospital intubation	11/70 (15.7%)		
Total intubation	13/70 (18.6%)		

Figure 1. Receiver-Operator Curve for CDR



Appendix A. Outcomes of Ohio Division of EMS's Trauma Research Grants Program

Cudnik MT, Werman HA, White LJ, Opalek JM: Prehospital factors associated with mortality in injured air medical patients. *Prehosp Emerg Care* 2012; 16:121-127.

Cudnik MT, Werman HA, White LJ, Opalek JM: Prospective validation of clinical decision rule for helicopter transport of injured patients (abstract). *Acad Emerg Med* 2012; 19(4):S285

Cudnik MT, Werman HA, White LJ, Opalek JM: Prehospital intubation by air medical providers is not associated with increased mortality (abstract). *Acad Emerg Med* 2012; 19(4):S334

2nd Annual Central Ohio Trauma Symposium:

Werman HA: Prehospital intubation by air medical providers is not associated with increased mortality. Columbus, OH. May, 2012

Werman HA: Prospective validation of clinical decision rule for helicopter transport of injured patients. Columbus, OH. May, 2012

Society of Academic Emergency Medicine – 2012 Annual Meeting

Cudnik MT: Prospective validation of clinical decision rule for helicopter transport of injured patients. Chicago, IL. May, 2012

Cudnik MT: Prehospital intubation by air medical providers is not associated with increased mortality. Chicago, IL. May, 2012