Practice Management Guidelines for the Appropriate Triage of the Victim of Trauma

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Statement of the Problem

The optimal triage of trauma patients has been the source of vigorous debate over the years. Clearly, as from the French, an efficient "sorting" of potentially injured patients translates into decreased transport times to definitive care, better outcomes as well as improved resource utilization. As a result, a trauma field triage decision scheme has been established by the American College of Surgeons Committee on Trauma (ACS-COT) and adapted by trauma systems across the nation (Figure 1). This scheme is based on a 5-10% under-triage rate and a 30-50% over-triage rate. It is this very issue which seems to be the most vexing: How do we ensure the minimum over-triage necessary without missing significant numbers of injuries? Furthermore, what is defined as a significant missed injury? Without accurate evidence based definitions and criteria it will be increasingly difficulty to optimize resource utilization and maximize patient safety.

General criteria for patients who require trauma center care is outlined in Chapter 6 of the *Textbook of Trauma*. It is these criteria that determine the under- and over-triage rates. The reason previous evidence-based efforts have failed and the literature found difficult to evaluate is because no one definition has been agreed upon. Initial reports, including many of those reviewed here, used a plethora of variables, including the Injury Severity Score (ISS) >15, death rate in Emergency Department (ED), death rate in the Operating Room (OR), either immediately or within 24 hours, and ICU admission rate.

Complicating matters further is that there have been profound changes in trauma care since the mid-1980s, such as employment of 23-hour or less observation, the advent of non-operative management and angiographic interventions as well as improved surgical techniques and resuscitative methods. How do these issues alter the definition of major trauma? Do billing and ED disposition concerns affect which patients are seen by the trauma team or the level of response? Does the burden of finding physicians to care for such patients force "minor trauma" patients to be transferred to trauma centers? The literature to date offers little insight. Much of the literature is based on those initial definitions. We decided to proceed with the guidelines and report the literature as it exists presently. We also intend to develop a definition of "major" trauma to be utilized in future studies.

Questions to Be Addressed by the Trauma Triage Guideline Subcommittee

The following issues all have some relation to trauma triage and, as such, we felt should be addressed by our group. However, this task will take more than 1 year.

1. What factors should determine who goes to the trauma center? (Year 1)
    a. Physiology
    b. Anatomy
    c. Mechanism
    d. Co-morbidities/modifying factors
    e. Field triage scores
2. How should they get there? (Year 2)

Year 1

Process

An initial computerized search was undertaken using OVID Medline with citations published between the years 1966 and 2005. Search words included "trauma triage criteria" as keywords as well as combinations of the headings "Trauma Center," "Emergency Medical Services," and "Triage." References were limited to human studies in the English language. These citations were supplemented by a list from another national workgroup, bibliographic references, and team recommendations. One hundred and thirty-two references were reviewed by a trauma surgeon, trauma nurse, or emergency medicine physician and classified according to the following standards. Data from each article was extracted using a data extraction form and arranged in a table format (Table 1). Conclusions of each article were critiqued and a determination made regarding consistency of the conclusion and data. Case reports and reviews of the literature were excluded save for examining the bibliography for further references. Six articles which addressed next year's questions were removed.

Criteria for achieving a specific classification and the number of articles for each class are shown below:

Class I: Prospective randomized controlled trials. **(0 studies)**

Class II: Clinical studies in which data was collected prospectively and retrospective analyses that were based on clearly reliable data. Types of studies so classified include observational studies, cohort studies, prevalence studies and case control studies **(36 studies)**.

Class III: Studies based on retrospectively collected data, i.e. clinical series, database or registry review, large series of case reviews, and expert opinion **(52 studies, 1 expert opinions/position statements)**.

Recommendations

Adult Prehospital Triage

Level 1 Standards

There are no Level 1 standards.

Level 2 Guidelines

–A combination of physiologic and anatomic parameters along with mechanism of injury (MOI), comorbidities, and demographics provides better triage than any smaller combination or any alone.

–If one considers single criteria, then physiologic parameters give the most accurate triage followed by anatomic parameters. Certain mechanisms are better indicators than others. Comorbidities and field personnel judgment have the lowest yields.

Level 3 Recommendations

–Field personnel judgment should still be a factor in prehospital trauma triage but is more effective when there is physician medical control.

–Extrication time over 20 minutes and death of occupant in same vehicle may be considered as stand alone triage criteria.

–All other mechanisms may not be useful in and of themselves as triage criteria.

–The Revised Trauma Score (rTS), Prehospital Index (PHI), Trauma Score (TS), CRAMS (Circulation, Respiration, Abdomen, Motor GCS, and Speech GCS), Baxt Trauma Triage Rule (TTR), and Triage Index are not to be used as standalone criteria to triage patients.

–There should be increased weight given to advanced age (≥65) during triage.

–GCS Motor Score is valid for blunt trauma triage.

Adult In-hospital Triage

Level 1 Standards

There are no Level 1 standards.

Level 2 Guidelines

–Secondary triage with a tiered response is safe, accurate, and useful in optimizing team and resource utilization.

  –Note: If not done appropriately, workup time and ED length of stay may increase.

–A combination of physiologic and anatomic parameters with mechanism provides better triage than any single factor.

–Mechanism alone may not be useful and should not be used as stand alone criteria for highest level trauma team response.

–GCS Motor Score is valid for blunt trauma triage.

Level 3 Recommendations

There are no Level 3 recommendations.

Pediatric Triage

Level 1 Standards

There are no Level 1 standards.

Level 2 Guidelines

There are no Level 2 guidelines.

Level 3 Recommendations

–A two-tiered triage system in the ED by physicians can effectively reduce unnecessary resource utilization.

–Mechanism of injury alone may not be useful in triaging pediatric patients.

–A combination of physiologic and anatomic parameters with mechanism provides better triage utilizing age-appropriate vital signs.

Scientific Foundation

Prehospital Triage

Seventy-seven articles were examined with reference to prehospital triage. Twenty-six were rejected for use due to lack of relevancy or inaccurate conclusions. Class II data (1-6) and Class III data (7,8) all support the assertion that a combination of anatomic,

physiologic, mechanistic, and/or demographic factors provide better triage than any one factor alone. In the study of the 1993 ACS criteria by Wuerz and co-workers (8), physiology by itself was only 50% reliable in identifying patients with major injuries. In a 1995 study by Esposito et al. (1), it was suggested that physiologic factors had higher yield than anatomic factors which had a higher yield than provider judgment. Knudson's (3) Class II data supported the claim that combination field triage criteria achieve the best sensitivity and specificity.

Trauma scores incorporating physiologic factors seemed to perform better than those that did not. Reviewing the individual scores, PHI had two Class II data articles in favor of its use alone (9,10), one Class II in favor of its uses in combination with MOI (11), and two articles, Class II (12) and Class III (13) data, respectively, citing poor triage performance. Three studies referred to the Trauma Index. Two were rejected for inaccurate conclusions. The third was a validation study.

Baxt TTR was the topic of two Class II articles (14,15) and two Class III articles (16,17). Both Class II articles support its use, Emerman et al. (14) as a stand alone and Fries and colleagues (15) as an adjunct to paramedic judgment. Some limitations of the data in the Emerman paper may limit the strength of the conclusions. These limitations include lack of follow-up on 414 patients not taken to trauma centers, no mention of overall mortality in the group and a definition of major trauma that only includes requiring operation within two hours of admission or death. The Class III articles were rejected based on unjustified conclusions.

There were seven articles that referred to CRAMS Scale. Two Class II articles propose CRAMS as a stand alone critieria (18,19). However, the definition of major trauma in the latter reference was based on need for surgery. In this era of non-operative management, that may not be appropriate. Another Class II data article by Knudson (3) recommended CRAMS' use alone or the Trauma Score in conjunction with mechanistic and anatomic critieria. CRAMS score <7 was only 33% sensitive and 96% specific in this reference. The threshold was therefore increased to <9 resulting in 93% sensitivity and 30%

specificity. Class II data from Kane (20) contradicted these findings, with CRAMS not performing well. Two Class III articles (21,22) did not support the use of CRAMS as a stand-alone critieria. A third Class III article (23) rejected the use of CRAMS completely.

The Trauma Score was used in 17 articles. Three were rejected for use due to inaccurate conclusions or lack of applicability. Of the 14 remaining, 6 were based on Class II data, and 8 were based on Class III data. All of these articles are discussed in the paragraph which follows. Prehospital TS <15 identified 92% of deaths, but did not adequately identify major thoracic injury (24). Knopp et al. (2) with Class II data showed that a combination of TS <13 along with MOI or anatomic injuries had the highest predictive values and best under- and over-triage rates. Class II data of Kreis et al. (25) supported use of a Trauma Score <12 as the most accurate single predictor of severe injury, but the definition of severe injury was death in the emergency department, requiring emergent surgery or immediate admission to the ICU. The Class II data of Kane and co-workers (20) contradicted this; compared to five other triage tools, TS did not perform well. The remaining Class II data showed the Trauma Score to be comparable or inferior to the Revised Trauma Score or other measures (26,27). In Class III data, TS predicted mortality as well as injury severity (6,16,28). However, Long (6) indicated superiority of combined criteria over TS alone. The conclusions in the paper by Deane et al. (28) were weakened by poor compliance with data collection. The use of the Trauma Score is supported by Sacco and others (29), but only as a part of the triage scheme. Trauma Score was deemed not helpful (23) or inferior to TRISS (30) in the remaining Class III articles.

The Revised Trauma Score (rTS) was used as the triage criteria in five papers, three Class II and two Class III. The Class II data was mixed on the use of the rTS. Champion et al. (26) cite improved reliability compared to TS. Guzzo et al. (27) list the RTS and TS as comparable. The data of Gilpin et al. (31) indicates that RTS is inaccurate for blunt trauma. As for the Class III data, Baxt and co-workers (21) show of the Trauma Score, CRAMS, PHI and RTS in mortality prediction. Additional Class III data (22) show that RTS is not sufficiently sensitive to be used alone.

ACS COT criteria (Figure 1) were the focus of four articles. Three were Class III data (see below). The only Class II article by Henry and colleagues (4) showed in a large state database study that anatomic and physiologic criteria performed well in predicting severe injury but some mechanisms only worsened specificity without increasing sensitivity. Scheetz (32) showed a significant increase in under-triage in the elderly (>64). Sensitivity was 83% in the younger age group and 91% in the older age group. Norcross et al. (33) indicated that the criteria were accurate. Wuerz and colleagues (8) referred to the 1993 version of the ACS COT criteria. Physiologic criteria were only 50% reliable. Mechanism of injury was more sensitive but less specific and accounted for much of the over-triage, which agreed with the Henry et al. (4) article.

Isolated physiologic parameters were examined in four Class III data references (see below). One paper examined cardiac electrical activity, asystole, and severe bradycardia (HR <40) (34). No patient with asystole or severe bradycardia in the field requiring CPR survived. Only 2 of 455 with an emergency department heart rate of < 40 survived. They suggest not transporting patients in asystole or severe bradycardia requiring CPR in the field. However, the paper is prone to type II error, as small numbers may miss a small survival rate. McManus et al. (35) looked at radial pulse character as a method of evaluation where instrumentation is not available. This seems quite subjective. The last two papers looked at loss of consciousness (LOC) (36,37). The results were contradictory. The first (36) showed that isolated transient LOC was a significant risk factor for critical neurosurgical injuries. The second from Horowitz and Earle quoted a 97% over-triage rate (37).

Many papers included anatomic considerations but only one considered anatomic factors as the sole triage criteria. None supported the use of anatomic criteria alone.

Four papers examined Glasgow Coma Score (GCS) or its components alone as triage criteria (36-39). Class II data from Norwood et al. (38) showed that GCS ≤14 was the only physiologic parameter after motor vehicle crash with an identifiable difference between those patients admitted to the hospital and those sent home. However, the reason

for the altered mental status was not delineated. Healey and colleagues (39) found a logarithmic format of the motor portion of the GCS (GCSM) was useful in predicting survival, but the data was Class III. Ross (40) also used Class III data to show that the GCSM <6 and the full GCS <14 were equally effective in field identification of serious brain injury. However, 32% of patients needing craniotomy were not predicted by field triage criteria. Meredith (41) showed the GCSM was as accurate as TS in field triage. However, this study suffered from its retrospective nature and incomplete data. Only 52% of patients had complete datasets and only 30% had the TS on their prehospital record. An additional paper by Holcomb et al. (42) added radial pulse character to GCSM and GCSV (verbal) and was able to predict the need for lifesaving interventions (LSIs) in 88% of cases. However, radial pulse character is subjective and major trauma does not only involve lifesaving interventions.

Provider judgment was examined in combination with other criteria. Esposito et al. (1) determined that the field provider's gut feeling resulted in a relatively low yield compared to other criteria. Only 15% of those triaged on provider "gut feeling" alone were considered major trauma victims. The yield was higher with rural providers. On the other hand, Fries et al. (15) showed paramedic judgment to have a sensitivity of 91% and a specificity of 60%. Physician involvement raised the average severity of patients taken to a trauma center according to Champion (30). One Class III showed that EMT judgment was as good as the TS, CRAMS, and PHI was disregarded due to poor study design (43).

Mechanism of injury criteria appear to be a major cause of overtriage, as reported by West et al. (44). However, few agree on which ones are most accurate. There were seven other Class II papers addressing this issue (1-3,11,25,45,46). Esposito et al. (1) showed that prolonged prehospital time, pedestrian struck by a motor vehicle, and death of occupant in the same compartment had high yields. Patient ejection and vehicle intrusion had intermediate yields. And fall >20 feet and motor vehicle rollover had low yields. Only 13% of those falling over 20 feet and 12% involved in a vehicle rollover were considered major trauma victims. Knopp and co-workers (2) determined the positive

predictive values for ISS >15 for certain mechanisms. Values are prolonged extrication 40%, ejection 22.4%, fatality same vehicle 21.4%, intrusion 19%, pedestrian struck 19.9%, and fall > 15feet 14.3%. Knudson et al. (3) reported 10% sensitivity and 90% specificity for mechanism of injury criteria alone. Kreis et al. (25) and Cooper et al. (45) concluded that mechanism of injury was not a good indicator of severe injury or eventual outcome. Henry and colleagues (46) concluded that some mechanism criteria such as speed of motor vehicle crash and vehicle deformity worsen specificity and do not increase sensitivity. There was no increase in length of stay, intensive care unit services, or major non-orthopedic operative intervention. Counter to these, Bond et al. (11) suggested that mechanism of injury criteria performed better than PHI alone, but a combination of the two is better. One Class III paper showed overtriage rates of 43% (47). Long et al. (6), using a definition of major trauma as ISS ≥16, cited only prolonged extrication and death of occupant in the same passenger compartment as stand alone triage criteria. Norcross (33) and Henry and co-workers (46) seemed to agree with these conclusions, but had severe data limitations. Barnoski et al. (48) showed falls did not accurately predict ISS >14 or mortality of 20% or greater. Santaniello et al. (49) contradicted this data, stating that patients who sustained a significant mechanism of injury were likely to have serious injury requiring surgical intervention and/or ICU observation.

Age and comorbidities as criteria were examined in several articles. As mentioned previously, Scheetz (32) cited a 15-18% undertriage rate in those >64 years old screened with the ACS-COT criteria. Demetriades' paper (50) discussing those over age 70 also supported this finding. However, this group was not compared to other age groups. Phillips et al. (51) found the undertriage rate with the Florida trauma triage criteria to be doubled in the elderly (Table 2). These studies suggest lower physiologic reserves in the elderly may result in minimal detectable physiologic changes allowing for a similar degree of injury. Co-morbidities were low yield according to Esposito et al. (1).

In-hospital Triage

In-hospital triage was specifically addressed in 10 of the papers. Six consisted of Class II data and four were Class III (52-60, 61). One was removed from consideration because it was not clinically applicable (52). Four of the papers looked at two-tier triage systems; all considered such systems safe and even reduced overtriage (53-56). One of these papers suggested that emergency department time increased (55). A three-tier system was studied by Kaplan et al. (57). This system increased early involvement of the trauma service while decreasing emergency department time and minimizing overtriage. Kohn and co-workers (58) identified four mechanisms of injury that did not need trauma team activation, including motorcycle crash with separation of rider, pedestrian struck by motor vehicle, motor vehicle crash with rollover, and motor vehicle crash with death of occupant. However, the last was based on only two patients. Simon et al. (59) and Terregino et al. (54) only used physiologic and anatomic criteria for secondary in-hospital triage. About one-quarter of the patients not undergoing trauma team activation required admission while 100% of those undergoing team activation required admission (54). Mechanisms of injury did not require highest level (major trauma) response in the Class II study by Ryan et al. (53). The only Class III paper looking at anatomic criteria supported the use of gunshot wound to the torso warranting trauma team activation regardless of physiologic parameters (60).

Pediatric Triage

Pediatric triage issues were examined in nine articles (62-70). Four of the papers could not support their conclusions due to poor study design or lack of generalizability (65-67,69). A tenth (71) looked at care of pediatric patients in an adult ICU and is not within the scope of this guideline. In the studies looking at prehospital triage, mechanism of injury did not perform well alone. Qazi and co-workers (70) showed that mechanism alone was a poor predictor of injury severity in stable blunt trauma patients. In patients who sustained falls, Wang et al. (64) found that clinical and physiologic signs were more reliable indicators of injury. Contact surface seemed more important than height. Engum et al. (68) supported the use of combination criteria again in the pediatric population. As

far as in-hospital triage, use of a modified pediatric trauma score reduced the trauma team usage by 58% with a negative predictive value of 99% and a positive predictive value of 32% (62). This score is similar to the Pediatric Trauma Score, but simpler to use. Mechanism of injury alone did not predict risk for significant injury by statistical analysis. Of the five patients not identified by the modified Pediatric Trauma Score, three would have been triaged differently if loss of consciousness in the field was considered. The fourth suffered only a skull fracture with no intracranial injury and the fifth had abdominal symptoms. Sola and co-workers (63) supported a two-tier system to reduce unnecessary resource utilization.

Summary

The literature is of poor quality and does not answer definitively such important questions regarding trauma triage and system utilization. In addition, the lack of a consistent definition of the trauma patient with "major" injuries requiring care at a trauma center prohibits comparisons of existing studies. The primary message from the existing literature is that a combination of physiologic, anatomic, and select mechanistic criteria provides the best performance for pre-hospital and in-hospital triage of the trauma patient. Physiologic criterion gives the highest yield followed by anatomic criteria. Certain mechanisms of injury perform better than others and comorbidities and field personnel judgment have the lowest yields. Extremes of age should be given more importance in the triage of the trauma patient. None of these should be used as the sole criteria for triage decisions. Triaging patients into a tiered trauma response in-hospital can be very effective and reduce unnecessary resource utilization while maintaining quality of care.

Future Investigations

Clearly, a more comprehensive definition of the trauma patient requiring trauma center care needs to be developed. A subcommittee is working to accomplish this. Major

trauma, complex care, resource availability and regionalization of care need to be considered. This definition must be developed prior to any further research in order for these studies to be meaningful. We need to be certain we are making valid comparisons of similar patients. The National Trauma Data Bank could then be examined for criteria effectiveness. Pediatric trauma centers and adult trauma centers with added pediatric qualifications should pool their data to address the paucity of literature on pediatric trauma triage.

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60. Sava J, Alo K, Velmahos GC, et al. All patients with truncal gunshot wounds deserve trauma team activation. *J Trauma.* 2002;52:276-279.
61. Al-Salamah MA, McDowell I, Stiell IG, et al. OPALS Study Group. Initial emergency department trauma scores from the OPALS study: the case for the motor score in blunt trauma. *Acad Emerg Med*. 2004;11: 834-842.
62. Simon B, Gabor R, Letourneau P. Secondary triage of the injured pediatric patient within the trauma center: support for a selective resource-sparing two-stage system. *Pediatric Emerg Care.* 2004;20:5-11.
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64. Wang MY, Kim KA, Griffith PM, et al. Injuries from falls in the pediatric population: an analysis of 729 cases. *J Pediatric Surg.* 2001;6:1528-1534.
65. Johnson WP. Evaluation of the Pediatric Trauma Triage Checklist as a prehospital pediatric trauma triage tool for the state of Florida. *Prehospital & Disaster Med.* 1996;1:20-25; discussion 25-26.
66. Newgard CD, Lewis RJ, Jolly BT. Use of out-of-hospital variables to predict severity of injury in pediatric patients involved in motor vehicle crashes. *Ann Emerg Med.* 2002;9:481-491.
67. Dowd MD, McAneney C, Lacher M, et al. Maximizing the sensitivity and specificity of pediatric trauma team activation criteria. *Acad Emerg Med.* 2000;7:1119-1125.
68. Engum SA, Mitchell MK, Scherer LR, et al. Prehospital triage in the injured pediatric patient. *J Pediatric Surg.* 2000;35:82-87.
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Figure legends

Figure 1. Trauma field triage decision scheme established by the American College of Surgeons Committee on Trauma (ACS-COT).

Table 1. Studies

First Author	Year	Reference Title	Data Class	Conclusions/Comments	Do conclusions seem justified? (Yes/No)
Gormican SP[19]	1982	CRAMS scale: field triage of trauma victims. *Ann Emerg Med.* 1982;11:132-135.	II	CRAMS potentially useful for triage.	Yes
Clemmer TP[18]	1985	Prospective evaluation of the CRAMS scale for triaging major trauma. *J Trauma.* 1985;25:188-191.	II	Evaluates the CRAMS Scale. The scale evaluates Circulation, Respiration, Abdomen, Motor component from the GCS, and Speech determining the need for treatment in a trauma center. The study scores the patients 3 separate times and is able to accurately reproduce the prehospital report and ED triage scores.	Yes
Kane G[20]	1985	Empirical development and evaluation of prehospital trauma triage instruments. *J Trauma.* 1985;25:482-489.	II	None of the tools had high sensitivity along with high positive accuracy. No instrument performed well. Reducing the absolute number of patients taken to trauma centers comes at the cost of: Sensitivity: 85% - 60% of all transports needed. Sensitivity: 80% - 26% of all transports needed.	Yes
Koehler JJ[10]	1986	Prehospital Index: a scoring system for field triage of trauma victims. *Ann Emerg Med.* 1986;15(2):178-82.	II	PHI was able to predict mortality and the need for emergency general or neurosurgical operative intervention.	Yes, however, the PHI was calculated in ED by physicians based on EMT data and not by the EMTs themselves.
Long WB[6]	1986	Accuracy and relationship of mechanisms of injury, trauma score, and injury severity score in identifying major trauma. *Am J Surg.* 1986;151:581-584.	II	1. Patients with ISS ≥16 are in danger of death related to trauma and may be defined as major trauma for whom trauma center is appropriate; 2. Mechanisms of injury which stand alone as triage criteria are delay in extrication over 20 minutes and death of occupant in same passenger compartment; 3. Combining the remaining	Yes

				mechanisms with a trauma score of 14 or less will more nearly approach the goal of appropriate triage; 4. TS score of ≤14, if used alone, is the most appropriate standard.	
Morris JA Jr[24]	1986	The Trauma Score as a triage tool in the prehospital setting. *JAMA.* 1986;256(10):1319-25.	II	A prehospital trauma score ≤14 identifies a group of patients where 92% of the deaths occurred. The false positives were 9.7% and the false negatives were 6%.29/66 pts in the false negative group had a major thoracic injury. Thus the trauma score does not adequately identify major thoracic injury.	Yes
West JG[44]	1986	A method for evaluating field triage criteria. *J Trauma.* 1986;26(7):655-9.	II	Developed anatomic and physiologic variables determining who should be triaged to a trauma center. Discussed over and under triage and implications. Implicated mechanism as the cause of most over triage.	Yes
Koehler JJ[9]	1987	A multicenter validation of the prehospital index. *Ann Emerg Med.*1987;16(4):380-5.	II	PHI was applied prospectively to trauma pts in the ED; accurate in predicting need for emergency life saving surgery within 4hrs and mortality within 72hrs	Yes
Knopp R[2]	1988	Mechanism of injury and anatomic injury as criteria for prehospital trauma triage. *Ann Emerg Med.* 1988;17(9):895-902.	II	TS, MOI, and anatomic criteria were applied in prehospital setting and then followed through the hospital stay; results of the positive predictive value for ISS >15.	Yes
Knudson P[3]	1988	Improving the field triage of major trauma victims. *J Trauma.* 1988;28(5):602-6.	II	CRAMS score < 7 = 33% sensitive/96% specific; MOI = 10% sensitive/90%specific; TS < 12 = 21% sensitive/100% specific for identification of significant injury (I.e., death; HLOS > 3 days; ED-TS < 15; ISS > 15). Recommend the following field triage criteria: 1) TS < 15 or CRAMS < 9; 2) MVC > 40 mph; 3) MCC > 20 mph; 4) Ped vs. auto > 5	Yes

				mph; 5) Major assault; 6) Penetrating wound to neck/torso - achieve 40% specificity (60% overtriage) and 93% sensitivity (7% undertriage). Combination field triage criteria achieve best sensitivity and specificity.	
Kreis DJ Jr[25]	1988	A prospective evaluation of field categorization of trauma patients. *J Trauma.* 1988;28(7):995-1000.	II	Trauma score of <12 was the most accurate predictor of severe injury. MOI was not a good predictor of severe injury.	Yes, severe trauma was identified as those patients dying in ED, requiring emergent surgery (although orthopedics was not removed from this group), or immediate admission to ICU.
Champion HR[26]	1989	A revision of the Trauma Score. *J Trauma.* 1989;29:623-629.	II	RTS demonstrated substantially improved reliability in outcome predictions compared to TS, even for serious head injuries	Yes
Gilpin DA[31]	1991	Revised trauma score: a triage tool in the accident and emergency department. *Injury.* 1991;22:35-37.	II	Revised Trauma Score (RTS) is used to determine the need for care by senior physicians. The study indicates a RTS of <11 is an indicator of serious injury requiring higher care. However, many of the patients who were sustained injury from blunt trauma did not present with an altered RTS.	I do not believe that RTS is a predictor or indicator of required interventions and care in trauma patient with blunt trauma.
Emerman CL[14]	1992	Comparative performance of the Baxt Trauma Triage Rule. *Am J Emerg Med.* 1992;10:294-297.	II	BAXT TTR is accurate in identifying specific major trauma patients from a prehospital perspective.	Yes
Sola JE[63]	1994	Criteria for safe cost-effective pediatric trauma triage: prehospital evaluation and distribution of injured children. *J Pediatr Surg.* 1994;9:738-741.	II	A two-tiered triage system in the ED by physicians evaluating pediatric trauma can effectively reduce unnecessary resource utilization	Yes, but this study looks at triage in the ED and not field triage, which is our goal.

Fries GR[15]	1994	A prospective comparison of paramedic judgment and the trauma triage rule in the prehospital setting. *Ann Emerg Med.* 1994;24(5):885-9.	II	Trauma triage rule applied in prehospital setting sensitivity of 88%, specificity 86%; paramedic judgment sensitivity 91%, specificity 60%, combined sensitivity 100%, specificity 75% - identifying pts needing trauma center/seriously injured pts	Yes
Cooper ME[45]	1995	Application of field triage guidelines by pre-hospital personnel: is mechanism of injury a valid guideline for patient triage? *Am Surg* 1995;61(4):363-7.	II	Small numbers, but said that mechanism is not a good indicator of eventual outcome.	Yes
Esposito TJ[1]	1995	Do prehospital trauma center triage criteria identify major trauma victims. *Arch Surg* 1995;130(2):171-6.	II	Physiologic criteria, prolonged prehospital time, pedestrian struck, death of occupant - high yield for major trauma victims; anatomic criteria/MOI, ejection, intrusion-intermediate; provider gut feeling, fall > 20', rollover, comorbid factors-low yield; provider gut feeling with MOI enhances yield esecially with ejection, rollover, associated fatality, and fall > 20'; higher yield for provider gut feeling in rural EMS.	Yes
Henry MC[4]	1996	Incremental benefit of individual American College of Surgeons trauma triage criteria. *Acad Emerg Med.* 1996;3(11):992-1000.	II	Author concludes that physiologic and anatomic triage criteria predict severe injury but that some mechanism criteria such as speed in a MVC and vehicle deformity worsen specificity and do not increase sensitivity.	Yes
Henry MC[46]	1996	Evaluation of American College of Surgeons trauma triage criteria in a suburban and rural setting. *Am J Emerg Med.* 1996;14:124-129.	II	MOI criteria alone do not predict ED deaths, need for non-orthopedic operative care, or intensive care.	No
Kaplan LJ[57]	1997	Improved emergency department efficiency	II	In hospital three-tier system results in an increase in	Yes

		with a three-tier trauma triage system. *Injury.* 1997;28:449-453.		early involvement of the trauma service while decreasing emergency department time and minimizing overtriage	
Terregino CA[54]	1997	Secondary emergency department triage (supertriage) and trauma team activation: effects on resource utilization and patient care. *J Trauma.* 1997;43:61-64.	II	Supertriage (quick in-hospital triage anatomic/clinical checklist for response level) identified a majority requiring team activation. However, resources must be available for the seriously injured not meeting field or hospital triage criteria.	Yes
Bond RJ[11]	1997	Field trauma triage: combining mechanism of injury with the prehospital index for an improved trauma triage tool. *J Trauma.* 1997;43:283-287.	II	PHI/MOI score was better at identifying those patients with ISS >16 than PHI or MOI alone.	They suggest that MOI criteria are more predictive than physiology for triage which does not correlate with many other studies. Undertriage rate is 59% for PHI and only 27% for MOI. Overtriage rates were incredibly low as well. PHI was only 2% and MOI was 9%. For combined score looking at under- and overtriage, rates were 22% and 11%, respectively.
Ryan JM[53]	1998	Implementation of a two-tier trauma response. *Injury.* 1998;29:677-683.	II	Triage tool was applied for two-tier system then evaluated for accuracy of identifying admissions, ISS; tool sensitivity 65%, specificity 87%, accuracy 82%, undertriage 8%, overtriage 10%.	Yes
Engum SA[68]	2000	Prehospital triage in the injured pediatric patient. *J Pediatric Surg.* 2000;35:82-87.	II	Physiologic variables, anatomic site and mechanism provide sensitive/safe triage system. GCS better in kids, mechanism and medic judgment worse.	Yes
Eastes LS[55]	2001	Outcomes of patients	II	No evidence that two-tier	Yes

		using a tiered trauma response protocol. *J Trauma.* 2001;50:908-913.		response had adverse effects on outcome. Implementation of two tiers safe. ED LOS increased. Knowledge of the modified team response led paramedics to take more lesser injured patients to the trauma center based on discretion and mechanism (also, based on less complaining by the receiving team if the patient was not badly injured).	
Norwood SH[38]	2002	A prehospital Glasgow Coma Scale (GCS) score ≤14 accurately predicts the need for full trauma team activation and patient hospitalization after motor vehicle collisions. *J Trauma*. 2002;53(3):503-7.	II	GCS ≤14 only prehospital physiologic parameter with an identifiable difference between pts admitted and d/c to home after MVC	Yes
Tamim H[12]	2002	Field triage of trauma patients: improving on the Prehospital Index. *Am J Emerg Med.* 2002;20:170-176.	II	PHI poor predictor of major trauma. Including other variables could lead to better triage.	Yes
Kohn MA[58]	2004	Trauma team activation criteria as predictors of patient disposition from the emergency department. *Acad Emerg Med.* 2004;11:1-9.	II	4 MOI Triage criteria identified that were least predictive of need for Trauma Team activation at Trauma Center.	Yes
Guzzo JL[27]	2005	Prediction of outcomes in trauma: Anatomic or physiologic parameters? *J Am Coll Surg.* 2005;201: 891-897.	II	The predictive ability of the Mortality Predictive Equation using GCS, BD, transfusions, ISS, and age is superior to anatomic models (ISS) but comparable to RTS, TS, and TRISS.	Yes, but needs data not available at intake. Not useful for triage.
Hannan EL[5]	2005	A comparison among the abilities of various injury severity measures to predict mortality with and without accompanying physiologic information. *J Trauma.* 2005;58:244-	II	For our purposes the addition of physiologic and demographic information improves the discrimination and calibration of each severity score.	No

		251.			
Champion HR[30]	1981	Trauma score. *Crit Care Med.* 1981;9:672-676.	III	Triage score better predictor of survival than trauma score. TRISS very good predictor. TS <12 good indicator of need for patient to go to trauma center.	Yes
Sacco WJ[29]	1984	The Trauma Score as applied to penetrating trauma. *Ann Emerg Med.* 1984;13:415-418.	III	The Trauma Score is a useful measurement of injury severity. Clearly it is only one component in gauging severity information.	Yes
Ornato J[23]	1985	Ineffectiveness of the trauma score and the CRAMS scale for accurately triaging patients to trauma centers. *Ann Emerg Med.* 1985;14:1061-1064.	III	Trauma Score and CRAMS scale not helpful for triage of patients to trauma center.	Yes
Deane SA[28]	1986	Trauma triage--a comparison of the trauma score and the vital signs score. *ANZ J Surg.* 1986;56(3):191-197.	III	TS does correlate with patient outcome as assessed by mortality VSS, also correlates with outcome but with less discrimination than TS.	Low number of patients and 41% compliance with data collection in retrospective review severely weakens any conclusions.
Lowe DK[47]	1986	Evaluation of injury mechanism as a criterion in trauma triage. *Am J Surg.* 1986;152:6-10.	III	Patients without respiratory failure, shock, significant CNS injury, TS = 14 defined as "overtriage".Use of triage criteria based on MOI results in overtriage rate of 43%. Accounting for patients who went to trauma center because it was the closest hospital reduced overtriage rate to 14%.	Yes, emphasizing physiologic and anatomic criteria to identify Category 1 trauma patients can successfully reduce overtriage without compromising patient outcomes.
Ferko JG 3rd [7]	1987	The utilization of trauma scores as a method of triage. *Emergency.* 1987;19:22-28.	III	Both mechanism and trauma score should be used for considering trauma center.	Yes, but not from data.
Baxt WG[21]	1989	The failure of prehospital trauma prediction rules to classify trauma patients accurately. *Ann Emerg Med.* 1989;18:1-8.	III	Comparison of TS, CRAMS, RTS, prehospital index; all were able to accurately predict mortality, but none were able to accurately identify surviving patients with major injuries; inherent	Yes

				limitation of the clinical data.	
Jubelirer RA[71]	1990	Pediatric trauma triage: review of 1,307 cases. *J Trauma.* 1990;30:1544-1547.	III	The article was a retrospective review of pediatric trauma patients care for in an designated adult trauma center. The article states that pediatric patients with a PTS >8 and/or have an altered LOC scan be safely cared for the in adult ICU and not be transferred.	Yes, the patients in study were shown to have been safely treated in adult ICU.
Baxt WG[16]	1990	The trauma triage rule: a new, resource-based approach to the prehospital identification of major trauma victims. *Ann Emerg Med.* 1990;19:1401-1406.	III	A retrospective review that states that if a simple trauma triage rule of systolic BP <85, motor GCS <5 and penetrating injury to head neck and trunk is used, 92% of seriously injured pts were identified and 92% of pts who did not need major procedures were identified as well. The 17 misclassified patients represent not just 3% of the major trauma cohort but nearly 9%. 10/17 patients were explained away by the authors as not having complications by the delay in treatments during a very brief follow-up. The validation population was the same as the algorithm development population, so applicability to other populations is suspect.	No
Emerman CL[43]	1991	A comparison of EMT judgment and prehospital trauma triage instruments. *J Trauma.* 1991;31:1369-1375.	III	EMT judgment as accurate as TS, CRAMS, and PHI.	No, poor design.
Simon BJ[59]	1994	Vehicular trauma triage by mechanism: avoidance of the unproductive evaluation. *J Trauma.* 1994;37:645-649.	III	An identifiable subset of trauma patients referred by mechanism alone could be safely evaluated on arrival in the ED as a form of secondary triage rather than referral to trauma team.	Yes
Meredith W[41]	1995	Field triage of trauma patients based upon the ability to follow commands: a study in	III	Both scores were significantly associated with mortality of injured patients.TS sensitivity was	Simple question answered. Good information as far as it goes.

		29,573 injured patients. *J Trauma.* 1995;38:129-135.		46%, specificity was 99%, accuracy was 95%. GCS-M sensitivity was 59%, specificity was 98%, accuracy was 95%. Both scores had similar predictive power, which is worse than ideally hoped for. However, GCS-M is simpler to use.	Only 52% of patients in database had complete data.
Norcross ED[33]	1995	Application of American College of Surgeons' field triage guidelines by pre-hospital personnel. *J Am Coll Surg.* 1995;181:539-544.	III	ACSCOT field triage guidelines accurate. Mechanism of injury (MOI) alone may result in unnecessary bypass of local hospital. Addition of MCP may help with MOI decision.	Yes for ACSCOT field criteria. No for MOI recommendations (based on 4 patients only).
Plant JR[13]	1995	Limitations of the prehospital index in identifying patients in need of a major trauma center. *Ann Emerg Med.* 1995;26:133-137.	III	PHI had limitations as a triage tool with high number of patients needing emergency surgery classified as minor trauma.	Yes
Zechnich AD[17]	1995	Applying the trauma triage rule to blunt trauma patients. *Acad Emerg Med.* 1995;2:1043-1052.	III	A chart review to look at the sensitivity of trauma triage criteria in a blunt trauma population. Baxt's triage criteria are looked at and sensitivity and specificity of applying these criteria is found decreased from 92% to 74% (sensitivity) and 92% to 84% (specificity). For Emmerman criteria, these numbers were 94% to 76% (sensitivity) and 89% to 80% (specificity). The trauma triage criteria are, thus, not sensitive enough to use because they are not very sensitive and miss critical injuries.	No, since the populations are not necessarily comparable. Also 16% of patients were excluded due to incomplete records.
Johnson WP[65]	1996	Evaluation of the Pediatric Trauma Triage Checklist as a prehospital pediatric trauma triage tool for the state of Florida. *Prehospital Disaster Med.* 1996;1:20-25; discussion 25-26.	III	Small numbers. Developed a useful pediatric prehospital triage tool, needs prospective validation.	Yes
Phillips S[51]	1996	The failure of triage criteria to identify	III	A registry review that shows that the Florida	Yes

		geriatric patients with trauma: results from the Florida Trauma Triage Study. *J Trauma.* 1996;40:278-283.		trauma triage criteria undertriage geriatric pts by71% and younger pts by 36% and thus are inadequate.	
Phillips S[69]	1996	The need for pediatric-specific triage criteria: results from the Florida Trauma Triage Study. *Pediatr Emerg Care*. 1996;12:394-399.	III	State-adopted triage scorecard with unacceptable undertriage rate in pediatric population.	Yes
Wuerz R[8]	1996	Accuracy of trauma triage in patients transported by helicopter. *Air Med J.* 1996;15:168-170.	III	ACS Trauma Triage Scheme is very sensitive for patients with ISS greater than 15 among patients transported by air ambulance. Overtriage is a problem. Physiologic criteria is only 50% reliable in identifying patients with major injuries. Situational criteria is more sensitive but less specific leading to overtriage. Age and co-morbidity are low predictors.	Yes
Gray A[22]	1997	Trauma triage: a comparison of CRAMS and TRTS in a UK population. *Injury.* 1997;28:97-101.	III	CRAMS score <9 demonstrates 69% sensitivity / 75% specificity for major injury: i.e., 1) ISS >14; 2) admission to ICU; 3) death after arrival. RTS <12 demonstrates 60% sensitivity/90% specificity. CRAMS <9 performs similarly to RTS, but neither is sufficiently sensitive alone to identify patients with major injury without becoming too low.	Yes
Qazi K[70]	1998	Stable pediatric blunt trauma patients: is trauma team activation always necessary? *J Trauma.* 1998;45:562-564.	III	Mechanism alone poor predictors of injury severity in stable, blunt trauma patients.	Yes
Barnoski A[48]	1998	Trauma triage: do AAMS transport guidelines do it effectively? *Air Med J.* 1998;17:19-23.	III	AAMS transport guidelines accurately predict potential for serious or life-threatening injury ISS >14-except amputations and falls; each guideline had associated mortality ≥20%	Yes

				except MVC, falls, amputations, degloving.	
Owings JT[36]	1998	Isolated transient loss of consciousness is an indicator of significant injury. *Arch Surg.* 1998;133:941-946.	III	Isolated transient LOC at significant risk of critical surgical / neurosurgical injuries. Should be triaged to trauma center.	Yes
Ross SE[40]	1998	Efficacy of the motor component of the Glasgow Coma Scale in trauma triage. Efficacy of the motor component of the Glasgow Coma Scale in trauma triage. *J Trauma.* 1998;45:42-44.	III	GCSM <6 and full GCS <14 were equally effective in field identification of serious head injury.	Unclear.
Battistella FD[34]	1999	Field triage of the pulseless trauma patient. *Arch Surg.*1999;134:742-5; discussion 745-746.	III	Trauma patients be triaged by electric activity in the field with a heart rate <40 BPM pronounced dead. Asystole decreased transports 75% of pulseless patients, HR <40 BPM decrease transports 57% of pulseless patients.	Type II error likely because small numbers may miss a small survival rate. Retrospective review with suspect data quality by EMS personnel.
Dowd MD[67]	2000	Maximizing the sensitivity and specificity of pediatric trauma team activation criteria. *Acad Emerg Med.* 2000;7:1119-1125.	III	Mechanism of injury not useful in triaging pediatric patients.	No, patients under mechanism criteria required resuscitation and 5 of 107 had ISS>15
Cook CH[56]	2001	Reducing overtriage without compromising outcomes in trauma patients. *Arch Surg.* 2001;136:752-756.	III	In an existing two-tiered triage system, using physiologic and anatomic criteria as sole criteria for Category 1 patients effectively reduces overtriage - demonstrated by increased ISS from 18.7 to 27.5, decrease GCS from 11.1 to 9.9 and increased mortality from 16.4% to 23.9% in Category 1 patients. Overtriage reduced with more appropriate response to level of patient injury - no significant change in ISS or GCS for Category 2 patients.	Yes, emphasizing physiologic and anatomic criteria to identify Category 1 trauma patients can successfully reduce overtriage without compromising patient outcomes.
Demetriades D[50]	2001	Old age as a criterion for trauma team	III	Elderly trauma patients have a high mortality, even	No, only included those

		activation. *J Trauma.* 2001;51:754-756; discussion 756-757.		with fairly minor or moderately severe injuries. It is suggested that age ≥70 years alone should be a Trauma team activation criteria.	>70 years of age in retrospective review.
Wang MY[64]	2001	Injuries from falls in the pediatric population: an analysis of 729 cases. *J Pediatr Surg.* 2001;6:1528-1534.	III	Contact surface is likely a major factor in predicting SOI. GCS scores unreliable predictor of intracranial bleeding. Fall height not correlated with intracranial bleeding; ISS was reliably predictive by fall height. Viscera organ injury not as likely to occur regardless of high vs.low falls. Clinical/physiologic signs may be a more reliable indicator of injury after a fall.	Yes, but low height category compromised because of high proportion of referral population increasing the SOI.
Horowitz BZ[37]	2001	Should transient loss of consciousness in blunt head trauma be a pre-hospital trauma triage criterion? *J Emerg Med.* 2001;21:381-386.	III	Transient loss of consciousness, in the absence of any other ACS criteria triaged 97% of patients to a trauma center who did not require trauma center services based on our criteria.	Yes
Newgard CD[66]	2002	Use of out-of-hospital variables to predict severity of injury in pediatric patients involved in motor vehicle crashes. *Ann Emerg Med.* 2002;9:481-491.	III	Out of hospital variables could be used to effectively triage pediatric MVC patients.	This study predicts who *doesn't* need a trauma a center, not who does. They suggest measuring inches of vehicle intrusion at scene which is variable. GCS was calculated in ED, not at scene. Median ISS for group with ISS <16 was 0 which suggests they are uninjured. Study is based on National Automotive Sampling System Database and ultimate numbers are too small to draw any conclusions.

					Only 47 patients with ISS >16.
Sava J[60]	2002	All patients with truncal gunshot wounds deserve trauma team activation. *J Trauma.* 2002;52:276-279.	III	GSW to trunk should use Trauma Team Activation regardless of Physiologic criteria.	Yes
Talbert S[52]	2003	Developing a methodology to improve the allocation of specialized health resources for acutely injured persons. *AMIA Annu Symp Proc*. 2003;1025.	III	Use of computer based decision tree induction demonstrated good accuracy in predicting need for specialized health resources following injury.	Yes, but not yet clinically applied.
Healey C[39]	2003	Improving the Glasgow Coma Scale score: motor score alone is a better predictor. *J Trauma.* 2003;54:671-678; discussion 678-680.	III	Motor GCS in log format is helpful and more useful in predicting survival.	Yes, but does not distinguish penetrating vs. blunt or account for quadriplegia.
Santaniello JM[49]	2003	Mechanism of injury does not predict acuity or level of service need: field triage criteria revisited. *Surgery.* 2003;134:698-703; discussion 703-704.	III	This study evaluated the field triage of trauma patients using mandatory physiologic, anatomic, and mechanistic criteria. The study found that patients who sustained a significant mechanism of injury without mandatory trauma center criteria were likely to have a serious injury requiring surgical intervention and or ICU observation.	Yes
Scheetz LJ[32]	2003	Effectiveness of prehospital trauma triage guidelines for the identification of major trauma in elderly motor vehicle crash victims. *J Emerg Nurs.* 2003;29:109-115,	III	ACS-COT triage guidelines demonstrate 83% sensitivity (age 25-64) and 91% (age >64). Specificity low for both age groups - therefore, guidelines less effective for detecting absence of major trauma (overtriage). Undertriage rates 8-12% (age 25-64) vs.15-18% (age >64). Significantly increase undertriage rates in elderly patients suggests lower physiologic reserves in elderly patients may result in minimal physiologic changes following similar degree of injury (i.e.,	Yes

				blunted physiologic response to trauma). Recommend inclusion of age in trauma triage guidelines defined by ACS-COT.	
Al-Salamah MA[61]	2004	OPALS Study Group. Initial emergency department trauma scores from the OPALS study: the case for the motor score in blunt trauma. *Acad Emerg Med*. 2004;11: 834-842.	III	The motor score on the GCS "in the ED" is valid for blunt trauma triage when compared to GCS or RTS.	Yes, but this did not look at field triage.
Simon B[62]	2004	Secondary triage of the injured pediatric patient within the trauma center: support for a selective resource-sparing two-stage system. *Pediatr Emerg Care.* 2004;20:5-11.	III	Modified pediatric trauma score incorporating airway status, open wounds, neurostatus, hemodynamics, and skeletal integrity predictive of need for full trauma team activation.	Retrospective review of patients where trauma team fully activated which means modified pediatric trauma score remains unproven.
Holcomb JB[42]	2005	Manual vital signs reliably predict need for life-saving interventions in trauma patients. *J Trauma.* 2005;59;821-828, discussion 828-829.	III	GCS motor and verbal components and radial pulse character predicted need for LSI without automated monitors at 88% if all three abnormal.	Yes
McManus J[35]	2005	Radial pulse character relationships to systolic blood pressure and trauma outcomes. *Prehosp Emerg Care.* 2005;9:423-428.	III	A weak radial pulse may be an acceptable method for initial rapid evaluation of trauma patients. Consider where limited instrumentation.	Yes--that is may be.

Table 2. **Florida Trauma Scorecard Criteria**

Physiologic criteria
Blood pressure <90
Respiration rate <10 or >29
GCS <12
Anatomy and mechanism of injury criteria
Second- and third-degree burns >15% body surface area
Paralysis
Ejection from vehicle
Amputation proximate to wrist or ankle
Penetrating injury to head, neck, chest, abdomen, or groin
From Phillips et al.[51]