A Simplified Set of Trauma Triage Criteria to Safely Reduce Overtriage

A Prospective Study

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Background: Many trauma systems have adopted complex triage algorithms that are difficult to use and contain poorly validated variables.

Objective: To prospectively evaluate the performance of our institution’s current triage system compared with a simplified system using only 4 highly predictive variables.

Design, Setting, and Patients: A prospective observational study of trauma patients in a 9-month period at an academic level II trauma center was undertaken. All trauma admissions were analyzed for the need for immediate emergency interventions or operative procedures. The accuracy and safety of the current triage system was compared with a simplified triage protocol using only 4 variables (hypotension, mental status, altered respirations, and penetrating truncal wound). Overtriage and undertriage rates were compared, and detailed analysis of all undertriaged patients was performed.

Main Outcome Measures: Rates of overtriage, undertriage, morbidity, and mortality.

Results: There were 244 trauma team activations, with 21% requiring urgent intervention. Existing criteria produced an overtriage rate of 79%, an undertriage rate of 1%, and mistriage in 14%. Using the simplified criteria, the overtriage rate was reduced to 12% and the undertriage rate was increased to 4% (both P < .05). Undertriaged patients were all hemodynamically stable, with 4 requiring tube thoracostomy only and 4 undergoing nonemergent laparotomy (2 nontherapeutic laparotomies, 1 bladder repair, and 1 bowel mesenteric injury). There were no deaths among undertriaged patients with either system.

Conclusions: Using a simplified triage system can safely reduce the rate of overtriage. This could conserve resources, reduce mistriage from misunderstood guidelines, and improve specificity by including only those variables with high predictive value.

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Numerous studies in the last few decades have demonstrated lower mortality and improved resource use with appropriate triage of injured patients within developed trauma systems. The simplified goal of triage within a trauma system is the safe delivery of injured patients to the first medical center capable of providing appropriate treatment in a stratified trauma center system as dictated by the triage criteria. This system is designed for the safe, efficient, and timely care of the entire spectrum of acute injury and optimal resource use. To achieve the goal of optimal safety in delivery of care within a trauma system, criteria should minimize undertriage. Conversely, resource use may be optimized by keeping overtriage low.

Multiple triage systems that incorporate a variety of variables into a triage scheme have been developed. These variables are typically based on physiological, mechanistic, and demographic factors in an attempt to predict injury severity and need for interventions. However, including multiple poorly predictive variables and complex triage schemes in an attempt to minimize undertriage can have the unintended effect of resulting in massive overtriage, which diminishes the efficiency of the system. On the system level, overtriage results in an unnecessary increase in the patient load at higher-level trauma centers. At the hospital level, this results in overburdening the trauma service with uninjured patients. In addition, these variables increase the complexity of the criteria, which results in confusion and
mistriage. The current triage scheme used by our institution relies on the Pierce County Prehospital Trauma Triage Guidelines (Figure). These procedures involve a set of criteria that guide hospital destination based on 3 levels, or steps, of criteria. Trauma patients meeting any of the 3 levels of criteria are taken to a trauma center. At our institution, once an individual patient is designated as meeting any of the criteria, the trauma team is activated and the trauma service evaluates the patient.

We previously performed a retrospective database study of all trauma patients presenting to our institution in a 4-year period to identify high-yield variables that predict the need for urgent intervention. Based on the variables we found, we devised a simplified triage scheme. The purpose of this study was to prospectively investigate this simplified triage system and compare it with the existing system in terms of overtriage, undertriage, and mistriage.

**METHODS**

Madigan Army Medical Center is a level II state-designated trauma center located in Pierce County, Washington. This hospital serves as 1 of 2 principal trauma centers for the county. The Pierce County trauma system has devised a set of Prehospital Trauma Triage Guidelines that are used to determine hospital destination for trauma patients seen by the emergency medical services in the field. These are in turn used by the Madigan Army Medical Center emergency department (ED) as a guide for in-hospital trauma team activation. The triage criteria used by Madigan Army Medical Center and Pierce County include physiological, anatomical, and mechanistic variables (Figure). At least 1 criterion is identified as the reason for trauma team activation by ED personnel for each trauma presentation. The level of trauma team activation is determined by the criterion that results in the highest level of activation. Activation of the trauma team follows a 3-tiered response system. Both steps 1 and 2 result in a full trauma team activation, which includes the presence of the on-call surgery attending and chief resident as well as the on-call surgery junior resident, emergency medicine attending, senior and junior resident, ED nurse, anesthesia provider, nursing supervisor, radiology resident, radiology technician, blood bank technician, pathology resident on call, chaplain, and trauma nurse coordinator. Step 3 activation requires the presence of the surgery junior resident, emergency medicine attending and senior and junior residents, ED nurse, and radiology technician.

From the previously published retrospective database review, 4 independent prehospital predictors of the need for urgent intervention (hypotension <100 mm Hg in either the field or the ED, altered sensations, penetrating truncal injury, and Glasgow Coma Scale [GCS] score <14) were used again to compare overtriage and undertriage rates with those rates using the current set of criteria.

After review and approval by the institutional review board, we conducted our study during a 9-month period (August 1, 2007, to April 30, 2008). Data were prospectively collected and analyzed using SPSS version 14.0 statistical software (SPSS Inc, Chicago, Illinois). All patients older than 15 years were included in the study. The level of trauma team activation and the reason for trauma team activation were included in the database. Other significant prehospital and ED variables were entered into the database. These included age, presence of hypotension, prehospital loss of consciousness, prehospital and arrival GCS score, elevated serum alcohol level, prehospital intubation, and mechanism of injury. Outcome variables included in the database were type of ED intervention (intubation, tube thoracostomy, thoracotomy, blood transfusion, cricothyroidotomy), ED disposition, hospital disposition, intensive care unit admission, reason for intensive care unit admission, intensive care unit length of stay, and hospital length of stay. Each prehospital variable was evaluated for association with the need for urgent intervention in the ED or emergent transfer from the ED to the operating room (OR) for a lifesaving procedure (craniotomy, thoracotomy, laparotomy, major vascular procedure) using a χ² test. Those variables found to be significantly associated with the need for urgent intervention on univariate analysis were then subjected to multivariate logistic regression analysis to determine their independent predictive value.

Of particular importance was the analysis of the subgroup of patients who were undertriaged by either the existing or the simplified triage scheme. Detailed descriptive analysis of this subset was performed to determine the reason for undertriage and the effect of the real or potential undertriage on mortality and morbidity. In addition, the overall incidence and effect of mistriage were examined for both triage systems. Mistriage was defined as an inappropriate level of trauma team activation based on misinterpretation of or disregard for the patient variables or stated triage criteria. This subset of patients was then evaluated for the need for urgent intervention as well as outcomes in terms of morbidity, mortality, and hospital disposition using a χ² test.

**RESULTS**

From August 1, 2007, to April 30, 2008, 244 trauma patients were included in the study. The mean age was 40 years, with 14% older than 65 years. Most patients (95%) were injured by blunt mechanism. Of the trauma team
activations, 44% were step 1 activations, 7% were step 2 activations, and 49% were step 3 activations. Overall, 52 patients (21%) required an urgent procedure in the ED and/or emergent transfer to the OR for a lifesaving procedure. Specific procedures are listed in Table 1.

Urgent intervention was required in 36% of step 1 activations, compared with 31% of step 2 activations and 7% of step 3 activations (P < .05, step 1 or 2 vs step 3). In the group of patients who met at least 1 of the 4 new criteria (simplified triage), urgent intervention was required in 58% (P < .05). Specific procedures required for the current and new criteria are listed in Table 2.

Using the need for an urgent procedure in the ED or emergent transfer to the OR for a lifesaving procedure as the determining factor for overtriage or undertriage, the new criteria were much more specific. Using the existing criteria, 79% of patients who underwent full trauma team response did not require any urgent intervention (P = .38). The simplified criteria reduced this rate of overtriage to 12% (P < .05). When undertriage was evaluated, the existing criteria resulted in a rate of 0.4% (P < .05). The new simplified criteria did result in a significantly higher rate of undertriage of 4% (P < .05). The mortality for undertriaged patients was 0 for both sets of criteria.

The specificity and sensitivity of the new and existing criteria are determined by the rates of urgent interventions. Using the existing criteria, only 21% of patients required urgent intervention (specificity), but only 0.4% of the patients who did not meet criteria still required an urgent intervention, resulting in a sensitivity of 99.6%. With the new criteria, those who met the criteria required urgent intervention 58% of the time (specificity), whereas those who did not meet the new criteria did not need an urgent intervention 96% of the time (sensitivity).

Using the new criteria, undertriaged patients included 5 hemodynamically stable patients requiring a chest tube in the ED and 4 hemodynamically stable patients requiring nonemergent transfer from the ED to the OR. These operative procedures included 2 nontherapeutic laparotomies (1 mesenteric hematoma and 1 hemostatic liver laceration), 1 bladder repair, and 1 bowel resection for a mesenteric injury.

When we subjected individual criteria to univariate analysis, we found that all existing step 1 criteria and all new criteria had P < .05 when evaluated for their association with the need for urgent intervention. No step 2 or 3 criteria, with the exception of penetrating truncal injury, were significantly associated with the need for urgent intervention.

Those patients who did not meet any of the current criteria but still underwent a trauma team activation (mistriaged) composed 14% of all trauma team activations. Of these, 6% were step 2 responses and 94% were step 3 responses. The most common reasons for inappropriate triage were ED physician discretion (29%) and misunderstanding triage criteria (66%). Two of these patients required urgent intervention: one underwent tube thoracostomy in the ED for an occult pneumothorax and the other underwent a nontherapeutic laparotomy for a positive result on ultrasonography as well as abdominal ten-

derness. Both patients presented with normal vital signs and a GCS score of 15 in both the field and the ED. No mistriaged patients required transfer from the ED to the intensive care unit.

In the previous study, step 3 trauma activations contributed the most to overtriage. This was found again in the present study. Only 8 step 3 activations required urgent intervention. Two of these patients did not meet any existing step criteria (1 chest tube, 1 nontherapeutic laparotomy). Of the other 6 patients who met step 3 criteria and required urgent intervention, 3 met new criteria (1 was intubated, 1 required emergent craniotomy for precipitous decline in the GCS score, and 1 required lapa-
orotomy for hypotension in the ED). These 3 would represent inappropriate triage—they met criteria for full trauma team activation by the existing criteria but were designated step 3 owing to a misunderstanding of the criteria or ED physician discretion.

Trauma triage remains the first and most critical link between the injured patient and the local system of trauma care. Prehospital triage strategies attempt to use a variety of variables to identify which patients warrant immediate transfer to an appropriate trauma center and what level of urgency and resources they will require on arrival. The most important and emphasized goal of these systems is to minimize undertriage, which can lead to preventable mortality and morbidity. To minimize the chance of an undertriage event, many systems have adopted extensive lists of variables related to the mechanism of injury and patient demographics that often have little to no scientific validation.

All trauma triage systems that aim to minimize undertriage will uniformly result in some degree of overtriage of uninjured or minimally injured patients. This is a well-understood and accepted consequence of maximizing patient safety. However, an unintended result of inclusion of many of these variables is an extremely high rate of overtriage with no significant effect on undertriage. In this situation, the addition of these variables only serves to magnify all of the adverse effects of overtriage, with no effect on improving patient safety or outcomes. The overtriage of uninjured or minimally injured patients results in significant wasted costs and resources.

### Table 1. Specific Emergency Department and Operating Room Procedures

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Patients, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In emergency department</td>
<td></td>
</tr>
<tr>
<td>Intubation</td>
<td>24 (9.8)</td>
</tr>
<tr>
<td>Tube thoracostomy</td>
<td>11 (4.5)</td>
</tr>
<tr>
<td>Blood transfusion</td>
<td>6 (2.5)</td>
</tr>
<tr>
<td>Resuscitative thoracostomy</td>
<td>1 (0.4)</td>
</tr>
<tr>
<td>In operating room</td>
<td></td>
</tr>
<tr>
<td>Laparotomy</td>
<td>13 (5.3)</td>
</tr>
<tr>
<td>Craniotomy</td>
<td>2 (0.8)</td>
</tr>
<tr>
<td>Vascular procedure</td>
<td>1 (0.4)</td>
</tr>
<tr>
<td>Angioembolization</td>
<td>2 (0.8)</td>
</tr>
</tbody>
</table>

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inappropriate and unnecessary patient interventions and imaging, and unnecessary disruption of ED and OR workflow. It can contribute to significant health care provider-level dissatisfaction with the trauma system and providing trauma coverage. In the current era of crisis regarding health care costs, shortages of personnel willing to provide trauma coverage, and declining resident interest in careers in trauma, the problem of overtriage warrants close inspection.

Optimal triage within a trauma system inherently includes keeping overtriage low without compromising the goal of minimizing undertriage.\textsuperscript{2, 4, 8, 9} We have previously shown in a retrospective database review that a simplified set of trauma triage criteria that include only highly predictive variables can potentially minimize overtriage while safely keeping undertriage at an acceptable level.\textsuperscript{6} In that study and other studies, the variables found to contribute the most to overtriage were those related to mechanistic and scene variables such as severity of damage to the vehicle or death of another vehicle occupant.\textsuperscript{5, 8, 10}

Penetrating injury has been found in other prior work to have high predictive value for severe injury and the need for operative intervention.\textsuperscript{11} Variables with the highest predictive value over several studies have reflected altered physiology after traumatic injury such as hypotension, altered mental status, and altered respiratory effort.\textsuperscript{6, 10, 12-14} Highly predictive variables such as these are therefore considered to contribute to a decrease in undertriage.

The American College of Surgeons Committee on Trauma has set forth several recommendations for trauma triage systems. These recommendations include keeping the rate of undertriage below 5% and the rate of overtriage below 50%. In a previous study from our institution, we found an undertriage rate of 1% and an overtriage rate of 51%.\textsuperscript{8} These overtriage and undertriage rates were based on the requirement for an urgent ED procedure or operative intervention requiring surgical support. In an effort to improve the specificity of the criteria and thus reduce overtriage, we used logistic regression to determine which variables in the criteria were independent predictors of the need for intervention requiring surgical support either in the ED or in the OR.

Of the numerous criteria shown in the Figure, the previous study found 4 field variables that were predictive of the need for urgent ED intervention or emergent transfer to the OR for craniotomy, laparotomy, thoracotomy, or a peripheral vascular procedure. We then compared this set of new criteria with our current standard triage system in terms of overtriage and undertriage. The new criteria would have had an undertriage rate of 3% and an overtriage rate of 29%.

In the current study, we included mistriage as an additional means of evaluation of our criteria. We defined this as the rate of trauma team activation for patients who did not meet any triage criteria. Presumably, this results when the criteria are complicated and poorly understood or are too numerous to be user-friendly. If the criteria are only complicated but have sufficient sensitivity, mistriage would result in only an increase in overtriage. If the criteria lack sensitivity as well, mistriage would result in an increase in both overtriage and undertriage. We hypothesized that the study of prospectively collected data would show similar rates of overtriage and undertriage when compared with the previous study and that mistriage would contribute to overtriage. Also, the simplified criteria would have superior specificity (low rate of overtriage) while maintaining an acceptable safety level (an undertriage rate <5%).

The prospective nature of the database used in the current study allowed for a more detailed evaluation of mistriage. The high level of overtriage seen with the existing criteria was augmented by a 14% rate of mistriage. Only 2 of these patients (0.8% of the total) required urgent intervention. The overwhelming majority of mistriage resulted in step 3 trauma activations and was due to poor understanding of the criteria. Presumably, truncating the criteria simply by eliminating mechanistic variables could help minimize mistriage and in turn minimize overtriage. Subset analysis of step 3 activations that required urgent intervention showed that the new criteria would have even improved undertriage in those patents because 3 of the 8 patients who required urgent intervention would have met the new criteria.

When we subjected the existing criteria to analysis, we found that most of the time altered mental status was given as the reason for trauma team activation; the GCS score was 14 or 15. Of these patients, 2 required intubation, 1 required tube thoracostomy, and 4 required emergent transfer to the OR or angiography suite. The criterion of altered mental status therefore requires re-evaluation or retraining.

The strengths of this study include its prospective nature and the resulting ability to evaluate specific interventions undertaken as well as specific patient factors and

<table>
<thead>
<tr>
<th>Procedure</th>
<th>New Criteria</th>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Trauma Consult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intubation</td>
<td>24</td>
<td>23</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Chest tube</td>
<td>6</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Transfusion</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Thoracotomy</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Operating room procedure</td>
<td>13</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>
physician decisions that result in trauma team activation. Limitations of this study are data points that were not evaluated, including costs, delays in treatment, and complications other than mortality.

While we did not perform a cost analysis in this study, the potential cost savings is substantial. On an individual level, a trauma patient who has been deemed likely to be severely injured and thus requires trauma team activation should be evaluated with the goal of ruling out severe injury. This leads to multiple tests, including a myriad of serum tests as well as unnecessary axial imaging. Therefore, a more inclusive system for trauma center destination guidelines and trauma team activation can lead to an increase in cost for the trauma system as a whole and the individual trauma center.

Numerous previous studies have shown mechanistic variables, with the obvious exception of penetrating mechanism, to contribute significantly to overtriage without a significant benefit in decreasing undertriage.6,9 We found this to be true in our previous study as well as the present study. However, trauma systems continue to use mechanistic variables based on anecdotal evidence and fear of increasing undertriage and mortality. We have shown that relying on only physiological and anatomical variables with high predictive value can help keep overtriage low while keeping undertriage and mortality at a minimum. In addition, simplifying criteria can potentially aid in adherence to the criteria and minimize mistriage. For our institution, the current study has shown that abandoning mechanistic variables and adhering to agreed-on criteria can optimize resource use while maintaining safety.

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REFERENCES


DISCUSSION

Martin Schreiber, MD, Portland, Oregon: Avoiding undertriage while maximizing the use of resources is a critical element of any trauma system. The authors have previously performed a retrospective analysis that revealed 4 simple criteria were predictive of the need for an emergent intervention. These criteria included hypotension, changes in mental status, altered respiration, and penetrating mechanism. In the current study, the authors test these simplified criteria in a prospective cohort of patients delivered to their trauma center. The study shows that use of the simplified criteria results in less overtriage and slightly more undertriage than the much more complex Pierce County 3-step criteria. I have the following comments and questions:

1. The authors have only evaluated patients who were brought to Madigan and not to the other Pierce County hospital. Is there potential for bias in this analysis? Are certain types of patients brought to Madigan and other types taken elsewhere? The penetrating trauma rate was 5%; is what is it at the other hospital?
2. How much does penetrating mechanism add to the model? We have noticed that penetrating patients who have normal vital signs in the prehospital and early-hospital setting rarely need emergent procedures. Would you consider deleting step 2 altogether since only 7% of your patients fit those criteria and the response and need for emergent procedures is the same as step 1 anyway? You could simplify your system further by just having full and modified responses.
3. How do you define altered respirations?
4. You have based your analysis on the need for an emergent procedure, but not all critical patients require emergent procedures. A patient with intraparenchymal hemorrhages, a nonoperative splenic injury, and a closed femur fracture requires emergent admission to the ICU [intensive care unit] and comprehensive multidisciplinary trauma care but not necessarily an emergent procedure. This patient probably needs a full response more than a patient with a stab wound to the chest who simply requires a chest tube that the junior resident and emergency physician could place. How should complex multi-trauma patients who do not require emergent procedures be analyzed in your model? How many of your patients really required a full response, and how does this affect overtriage and undertriage?

Dr Martin: There is a big difference in the impact of overtriage depending on the type of center. At a fully staffed level I center with an in-house team solely dedicated to trauma, overtriage may be a minor nuisance. At my level II center, overtriage has a much more significant impact that can end up driving personnel and institutions out of trauma coverage, which we know is becoming a national issue. Overtriage and methods to reduce it are important issues for our trauma system.

We only looked at patients who came to Madigan. The triage is based on location in our area, so as far as I know there is no specific type of patient that is brought to Madigan vs the downtown center. To my knowledge, our breakdown of blunt and penetrating is approximately the same.

Regarding our low incidence of penetrating trauma and whether we should be using penetrating injury as a criterion, our previous study and several others have found that penetrating truncal injury still remains one of the strongest predictors. Especially in a center that has a low volume of penetrating injury, these patients often require a little more expertise and experience. In the Pierce County guidelines, a penetrating gunshot wound to the abdomen only rates a step 2 activation, while someone who is intoxicated with a GCS score of 14 is a step 1. This is a major weakness in the current triage system, and we have already upgraded penetrating truncal injury to step 1 at our center.

I agree wholeheartedly that we should delete the step 2. One of the purposes of this study was to simplify ours to a 2-level trauma activation system as in many other centers.

Altered respirations are a part of the prehospital index score that the medics use, and their definitions are a respiratory rate of more than 25 or less than 10 [breaths/min] or a patient who is not breathing or requires a field airway.

Regarding the need for an emergent procedure as an end point, we were asking whether the surgeon, anesthesiologist, and other personnel need to be pulled away from other activities and report to the ED immediately. We were pretty liberal in our definitions, including need for a blood transfusion or a central line, so many patients who did meet our end point probably did not need the full team to be there right away. In our retrospective study we also evaluated patients who needed ICU admission, and that captures the patient population you were discussing—lung and spleen injuries, others who do not need to go to the OR. I believe that most of those are going to have some alteration in their physiology and would be captured with our simplified system. But that would need to be validated, and that is why we have taken this stepwise approach of retrospectively analyzing our data, prospectively observing it, and then we plan to change our triage criteria and collect data to assure that we are doing it safely. In the rare instance of a seriously injured patient who has not been properly triaged by either system, we have criteria for immediate activation of the full trauma team.

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