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Systolic blood pressure criteria in the National Trauma Triage Protocol for geriatric trauma: 110 is the new 90

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Abstract

BACKGROUND—Undertriage is a concern in geriatric patients. The National Trauma Triage Protocol (NTTP) recognized that systolic blood pressure (SBP) less than 110 mm Hg may represent shock in those older than 65 years. The objective was to evaluate the impact of substituting an SBP of less than 110 mm Hg for the current SBP of less than 90 mm Hg criterion within the NTTP on triage performance and mortality.

METHODS—Subjects undergoing scene transport in the National Trauma Data Bank (2010–2012) were included. The outcome of trauma center need was defined as Injury Severity Score (ISS) greater than 15, intensive care unit admission, urgent operation, or emergency department death. Geriatric (age > 65 years) and adult (age, 16–65 years) cohorts were compared. Triage characteristics and area under the curve (AUC) were compared between SBP of less than 110 mm Hg and SBP of less than 90 mm Hg. Hierarchical logistic regression was used to determine whether geriatric patients newly triaged positive under this change (SBP, 90–109 mm Hg) have a risk of mortality similar to those triaged positive with SBP of less than 90 mm Hg.

RESULTS—There were 1,555,944 subjects included. SBP of less than 110 mm Hg had higher sensitivity but lower specificity in geriatric (13% vs. 5%, 93% vs. 99%) and adult (23% vs. 10%, 90% vs. 98%) cohorts. AUC was higher for SBP of less than 110 mm Hg individually in both geriatric and adult ($p < 0.01$) cohorts. Within the NTTP, the AUC was similar for SBP of less than 110 mm Hg and SBP of less than 90 mm Hg in geriatric subjects but was higher for SBP of less than 90 mm Hg in adult subjects ($p < 0.01$). Substituting SBP of less than 110 mm Hg resulted in an undertriage reduction of 4.4% with overtriage increase of 4.3% in the geriatric cohort. Geriatric subjects with SBP of 90 mm Hg to 109 mm Hg had an odds of mortality similar to those of

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AUTHORSHIP

J.B.B. designed the study and performed the literature search, data collection, and data analysis. J.B.B., M.L.G., and J.L.S. participated in initial manuscript preparation. All authors contributed to the data interpretation and critical revision of the manuscript.

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geriatric patients with SBP of less than 90 mm Hg (adjusted odds ratio, 1.03; 95% confidence interval, 0.88–1.20; $p = 0.71$).

CONCLUSION—SBP of less than 110 mm Hg increases sensitivity. SBP of less than 110 mm Hg has discrimination as good as that of SBP of less than 90 mm Hg, with superior improvements in undertriage relative to overtriage in geriatric patients. Geriatric patients newly triaged to be positive under this change have a risk of mortality similar to those under the current SBP criterion. This change in SBP criteria may be merited in geriatric patients, warranting further study to consider elevation to a Step 1 criterion in the NTTP.

LEVEL OF EVIDENCE—Diagnostic study, level IV

Keywords

Prehospital; triage; systolic blood pressure; geriatric; trauma

As the population ages, the proportion of individuals older than 65 years is rapidly approaching one fifth of all Americans.¹ Concurrently, injury is a growing cause of mortality and morbidity in the geriatric population, with geriatric patients now accounting for one fourth of all trauma admissions.² This group is at increased risk for adverse outcomes as a result of impaired physiologic reserve, comorbidities, and polypharmacy leading to complications or death with an injury burden lower than would be expected.^{1,3}

Field triage is a key component of prehospital trauma care because the success of trauma systems requires accurate triage of patients that require the resources of a trauma center. The American College of Surgeons' Committee on Trauma (ACS COT) and the Centers for Disease Control jointly developed the National Trauma Triage Protocol (NTTP), which is based on the stepwise identification of four clinical features readily identifiable by prehospital providers at the scene of injury (Fig. 1).⁴ These include physiologic, anatomic, mechanism of injury, and special consideration criteria, which are evaluated in a sequential fashion to identify patients that should be transported to a trauma center.

It is increasingly recognized that significant undertriage exists in the geriatric population.^{5–8} Potential causes include significant injury from low-energy mechanisms and altered physiologic response to injury with aging.^{6,8–10} Some have suggested that geriatric patients require triage criteria different from those of their younger counterparts.^{11,12} There is evidence that current NTTP physiologic criteria have low predictive power to identify seriously injured older adults.^{6,9} The latest revision of the NTTP recognized that a systolic blood pressure (SBP) of less than 110 mm Hg may represent shock in those older than 65 years. Currently, this change is implemented as Step 4 special consideration under criteria for older adults that do not necessarily mandate transport to a trauma center. This clearly represents a physiologic criterion that would normally be applied in Step 1, requiring transport to the highest level of trauma care in the system. The NTTP expert panel had good reason to not immediately implement this as a Step 1 criterion because there was little evidence for using an SBP of less than 110 mm Hg for older adults in the context of triage. Thus far, this change has not been studied in the context of the NTTP, and the current triage trigger remains an SBP of less than 90 mm Hg for all adults.

The objective of this study was to evaluate the impact of substituting an SBP of less than 110 mm Hg criterion for the current SBP of less than 90 mm Hg criterion within the context of the NTTP on triage performance and mortality in geriatric and adult trauma patients. The primary study hypothesis was that an SBP of less than 110 mm Hg criterion would have equal or superior discrimination to identify patients requiring trauma center care, and would reduce undertriage when compared with the existing SBP of less than 90 mm Hg criterion in geriatric trauma patients. The secondary study hypothesis was that geriatric patients who would be newly triaged positive under this change in SBP criteria would be at similar or higher risk for mortality as geriatric patients triaged positive under the current SBP of less than 90 mm Hg criterion.

PATIENTS AND METHODS

Study Population

Subjects older than 15 years transported from the scene of injury in the National Trauma Data Bank (NTDB) from 2010 to 2012 were identified. Subjects undergoing interfacility transfer or those who died on arrival were excluded. Demographics, injury characteristics, prehospital and admission vital signs, DRG International Classification of Diseases—9th Rev. (ICD-9) diagnosis codes, intensive care unit (ICU) admission, emergency department (ED) disposition, and hospital disposition were collected for each subject. The geriatric cohort was defined as subjects older than 65 years. The adult cohort was defined as subjects age 16 years to 65 years.

Missing Data

For missing data, multiple imputation was performed for prehospital SBP, prehospital respiratory rate (RR), prehospital Glasgow Coma Scale (GCS) score, and Injury Severity Score (ISS). Multiple imputation using chained equations with a fully conditional specification model based on available demographics, vital signs, and injury characteristics was performed using five imputation steps to develop a complete data set. Data analysis was performed on the pooled data. Sensitivity analyses were performed to assess the multiple imputation procedure.

Triage Criteria and Outcomes

The presence of physiologic Step 1 NTTP criteria (GCS score ≤ 13 , SBP < 90 mm Hg, RR < 10 or RR > 29) was determined using prehospital vital signs. Prehospital SBP was also used to define a positive triage criterion for SBP of less than 110 mm Hg. The presence of anatomic Step 2 NTTP criteria (penetrating injury, flail chest, open skull fracture, ≥ 2 proximal long bone fractures, pelvic fracture, crush injury, amputation, paralysis) was determined using ICD-9 diagnosis codes. Subjects were classified as to the presence or absence of each of the 11 available Step 1 and Step 2 triage criteria from the NTTP. The presence of any one of the Step 1 physiologic criteria or Step 2 anatomic criteria was considered sufficient to triage a subject to a trauma center.

The primary outcome of trauma center need (TCN) was defined as a composite of ISS greater than 15, ICU admission of 24 hours or greater, need for urgent surgery (defined as

ED disposition to the operating room), or death in the ED to identify patients who would potentially benefit from trauma center care. The secondary outcome was in-hospital mortality.

Triage Performance

The SBP criteria were evaluated both individually and within the first two sequential steps of the NTTP to replicate the way in which prehospital personnel would apply the algorithm. Thus, each subject was triaged to a trauma center care by looking for the presence of any Step 1 physiologic criterion (including either the current SBP < 90 mm Hg criterion or using an SBP < 110 mm Hg criterion). If no Step 1 criterion was present, Step 2 anatomic criteria were evaluated and the subject was triaged to trauma center care if any was present. This method allows for the examination of diagnostic test characteristics in the context of the stepwise NTTP and the assessment of any change in performance using an SBP of less than 110 mm Hg

Standard diagnostic test characteristics including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for SBP of less than 90 mm Hg and SBP of less than 110 mm Hg to predict TCN. Two-by-two tables were constructed and diagnostic test characteristics were calculated based on subjects triaged to trauma center care (defined by the presence of any triage criteria under consideration) and the presence of TCN as the outcome. Undertriage and overtriage were also calculated. Undertriage was defined as a subject who did not have any Step 1 or Step 2 NTTP criteria present but met the definition of TCN. Overtriage was defined as a subject who did have at least one Step 1 or Step 2 NTTP criteria present but did not meet the definition of TCN.

Logistic regression models were used to generate receiver operating characteristic (ROC) curves for the SBP triage criteria to predict TCN individually and within the first two steps of the NTTP. The area under the ROC curve (AUC) for SBP of less than 90 mm Hg and SBP of less than 110 mm Hg were compared using a methodology described by Hanley and McNeil¹³ to compare discrimination for each criterion to classify TCN. Overall goodness-of-fit of these models was assessed using the Akaike information criterion (AIC), whereby models with lower AIC were considered to have better fit.

The optimal SBP cutoff was then determined, evaluating SBP as a continuous variable, by locating the SBP cutoff that maximizes sensitivity and specificity. Optimal SBP cutoffs were determined for TCN and in-hospital mortality in both cohorts.

Newly Triaged Positive Geriatric Patients

To determine whether geriatric patients who would be newly triaged positive under this change in SBP criteria (SBP, 90–109 mm Hg) have a similar or higher risk for in-hospital mortality compared with those who are triaged positive under the current SBP of less than 90 mm Hg criterion, a hierarchical logistic regression model was constructed in the geriatric cohort among subjects with an SBP of less than 110 mm Hg with in-hospital mortality as the outcome. This model was a two-level model, with the first level a fixed-effects model of patient-level data and the second level as a random effect for centers. This random effect for centers was included to account for clustering at the center level and was also allowed for

the possibility that the effect of SBP level on mortality may differ between centers. The association between in-hospital mortality and SBP level dichotomized as SBP of less than 90 mm Hg versus SBP of 90 mm Hg to 109 mm Hg was determined. Covariates in the models included sex, race, mechanism, prehospital time, transport mode, prehospital and admission vital signs, ISS, urgent surgery, ICU admission, and trauma center level. The c statistic was used to assess model discrimination, and Pearson goodness-of-fit test was used to assess model fit.

Statistical Analysis

Analyses were performed separately in the geriatric and adult cohorts to allow comparison between cohorts of performance using either an SBP of less than 90 mm Hg or SBP of less than 110 mm Hg triage criterion. Data analysis was conducted using STATA version 13 (College Station, TX). For univariate comparisons, χ^2 tests and Wilcoxon rank-sum tests were used for categorical and continuous variables, respectively. Two-tailed tests were used, and $p < 0.05$ was considered significant.

RESULTS

Study Population

From the NTDB, 1,555,944 subjects were included in the study. The geriatric cohort had fewer males, more cases of blunt injury, higher prehospital SBP, and higher ISS compared with the adult cohort overall (Table 1). Fewer geriatric subjects met either SBP criteria or the definition of TCN; however unadjusted mortality was higher.

Triage Performance

Table 2 shows triage characteristics for SBP of less than 110 mm Hg and SBP of less than 90 mm Hg, individually and applied within the first two steps of the NTTP for the geriatric and adult cohorts. Substituting SBP of less than 110 mm Hg for the current SBP of less than 90 mm Hg resulted in increased sensitivity and NPV with decreased specificity and PPV in both cohorts. As individual criteria, the AUC was higher for SBP of less than 110 mm Hg than for SBP of less than 90 mm Hg both in the geriatric cohort ($p < 0.01$) and in the adult cohort ($p < 0.01$). When applied within the first two steps of the NTTP, the AUC remained higher using an SBP of less than 110 mm Hg compared with SBP of less than 90 mm Hg in the geriatric cohort; however, this was not significantly different ($p > 0.05$). The AUC was higher using an SBP of less than 90 mm Hg compared with SBP of less than 110 mm Hg in the adult cohort ($p < 0.01$). In the geriatric cohort, substituting an SBP of less than 110 mm Hg within the first two steps of the NTTP resulted in an undertriage reduction of 4.4% and overtriage increase of 4.3%. In the adult cohort, the same substitution resulted in an undertriage reduction of 4.3% but an overtriage increase of 5.3%.

Model fit assessment of the SBP criteria demonstrated a lower AIC using the individual SBP of less than 110 mm Hg criterion and using an SBP of less than 110 mm Hg criterion within the first two steps of the NTTP in the geriatric cohort (Table 2). The AIC was lower using the current SBP of less than 90 mm Hg criterion in the adult cohort, both individually and within the first two steps of the NTTP. In the geriatric cohort, the optimal SBP cutoff for

TCN was less than 122 mm Hg, yielding a sensitivity of 22% and a specificity of 83%. The optimal SBP cutoff for mortality was less than 118 mm Hg, yielding a sensitivity of 29% and a specificity of 86%. In the adult cohort, the optimal SBP cutoff for TCN was less than 118 mm Hg, yielding a sensitivity of 32% and a specificity of 73%. The optimal SBP cutoff for mortality was less than 106 mm Hg, yielding a sensitivity of 49% and a specificity of 88%.

Newly Triage Positive Geriatric Patients

Among geriatric subjects, those newly triaged to be positive with an SBP of 90 mm Hg to 109 mm Hg had an odds of mortality similar to those with an SBP of less than 90 mm Hg (adjusted odds ratio [AOR], 1.03; 95% confidence interval [CI], 0.88–1.20; $p = 0.76$). The model c statistic was 0.910 (95% CI, 0.904–0.915), indicating excellent discrimination, and the Pearson goodness-of-fit test was nonsignificant ($p = 0.71$), indicating adequate model fit.

Sensitivity Analyses

Sensitivity analysis using complete cases ($n = 939,161$) demonstrated prehospital SBP, RR, and GCS score were missing in 34% and ISS in 0.3% of the subjects. Subjects missing prehospital SBP compared with subjects with prehospital SBP had similar admission SBP (138 mm Hg vs. 139 mm Hg) and age (48 vs. 48). Subjects missing prehospital SBP had lower ISS (5 vs. 9), TCN (32% vs. 40%), and mortality (3.3% vs. 4.7%). Original and imputed means were similar for prehospital SBP (134.7 vs. 135.4), prehospital RR (18.2 vs. 18.3), prehospital GCS score (13.8 vs. 13.9), and ISS (9.4 vs. 9.4).

When comparing complete cases with the imputation data set, sensitivity values on average were different by 4%, specificity by 3%, PPV by 5%, and NPV by 2%. AUC values were different by less than 1%. A similar trade-off of specificity for sensitivity was seen. The AUC was higher for SBP of less than 110 mm Hg individually and similar within the first two steps of the NTTP for the geriatric cohort but higher for SBP of less than 90 mm Hg within the first two steps of the NTTP for the adult cohort ($p < 0.01$). In the geriatric cohort, the optimal SBP cutoff was less than 118 mm Hg for TCN and less than 116 mm Hg for mortality. In the adult cohort, the optimal SBP cutoff was less than 115 mm Hg for TCN and less than 101 mm Hg for mortality. Geriatric subjects with an SBP of 90 mm Hg to 109 mm Hg again had odds of mortality similar to those with an SBP of less than 90 mm Hg (AOR, 1.02; 95% CI, 0.86–1.21; $p = 0.82$).

A best-case sensitivity analysis was performed, given that those missing prehospital SBP were likely less injured based on lower ISS and mortality. The median prehospital SBP of 135 mm Hg was imputed for all missing values, resulting in no subjects with missing SBP meeting either SBP triage criterion. This analysis again revealed 5% differences or less in triage characteristics in both cohorts with similar tradeoffs of specificity for sensitivity. The geriatric cohort had similar discrimination and better goodness-of-fit using SBP of less than 110 mm Hg and those with SBP of 90 mm Hg to 109 mm Hg had odds of mortality similar to those with SBP of less than 90 mm Hg (AOR, 1.02; 95% CI, 0.86–1.21; $p = 0.82$).

DISCUSSION

The current study demonstrates that using an SBP of less than 110 mm Hg as a criterion for triage to a trauma center improves sensitivity at the expense of specificity. As an individual criterion, SBP of less than 110 mm Hg has better discrimination for TCN than the current SBP of less than 90 mm Hg in both geriatric and adult patients. When incorporated within the first two steps of the NTTP as would be applied in the field, using an SBP of less than 110 mm Hg criterion had as good discrimination as the current SBP of less than 90 mm Hg criterion in geriatric patients, while the current SBP of less than 90 mm Hg has significantly higher discrimination in adult patients. Substituting an SBP of less than 110 mm Hg for the current SBP of less than 90 mm Hg in geriatric patients achieves a larger reduction in undertriage than increase in overtriage; however, the same substitution in adult patients results in a larger increase in overtriage than decrease in undertriage.

Goodness-of-fit using an SBP of less than 110 mm Hg was better in geriatric patients using both the criterion individually as well as within the first two steps of the NTTP. In addition, the optimal SBP cutoffs identified were higher in geriatric patients compared with adult patients for both TCN and mortality. Finally, geriatric patients who would be newly triaged to be positive under this change in SBP criteria have a risk for mortality similar to that of geriatric patients with an SBP of less than 90 mm Hg. Thus, the combination of these findings suggests that geriatric patients with an SBP of less than 110 mm Hg likely warrant treatment at a trauma center.

A disturbing trend has emerged, with several authors demonstrating significant undertriage among geriatric patients. A 10-year review of Maryland data demonstrated an undertriage rate of 50% in those older than 65 years compared with 18% in younger patients.⁵ Significant increases in undertriage were seen at ages 50 years and 70 years. Lehmann et al.¹⁴ reported that geriatric patients were less likely to undergo trauma team activation among patients requiring urgent procedures. Those undertriaged elderly had a fourfold higher mortality than undertriaged younger patients. Rogers et al.⁷ examined a state trauma registry, noting a 15% undertriage rate in geriatric patients with a dose-response increase in the risk of death associated with undertriage as age increased. A multicenter consortium group demonstrated undertriage rates of 20% in those older than 55 years compared with 10% in younger patients, with significant undertriage beginning at age 60 years and increasing to nearly 60% at age 90 years in population-based cohorts.^{15,16} Another population-based study demonstrated a 33% undertriage rate for patients older than 55 years with significantly increased costs.⁸

A potential driver of high undertriage in geriatric patients is poor sensitivity of current triage criteria.¹⁶ Geriatric patients are significantly less likely than younger adults to meet any of the current NTTP triage criteria.¹⁷ The altered physiologic response to injury coupled with underlying comorbidities and medications makes the current physiologic triage criteria poorly suited to identify severely injured older adults. A recent analysis demonstrated significant nonlinearity among all three NTTP physiologic criteria and severe injury.⁶ SBP for geriatric patients in particular has been shown to be an unreliable predictor of mortality or urgent interventions.¹⁴ Martin et al.¹⁰ revealed that 39% of geriatric patients with an SBP

greater than 90 mm Hg had occult hypoperfusion evidenced by abnormal base deficit or lactate. A 5-year review of presenting physiology demonstrated an inflection point between risk of death and SBP at 95 mm Hg in young patients but at 110 mm Hg in geriatric patients.¹⁸ These findings prompted the last revision of the NTTP to include an SBP of less than 110 mm Hg may represent shock in patients older than 65 years under the older adults criterion in the special considerations step.⁴

Modifications of triage criteria in the geriatric population have demonstrated promise in previous studies and are consistent with the data presented here. Werman et al.¹² systematically reviewed the literature to identify potential geriatric-specific triage criteria and subsequently used state trauma registry to develop the first statewide geriatric trauma triage algorithm in Ohio. These revised criteria resulted in gains of up to 10% in sensitivity with specificity comparable with younger adults under the original criteria and recommended an SBP cutoff of less than 100 mm Hg.^{9,12} Newgard et al.¹⁷ used classification and regression tree analysis to show that additional criteria in elderly patients can substantially increase triage sensitivity in this population. This group also showed that modification of physiologic criteria in geriatric patients to include an SBP of less than 110 mm Hg or greater than 200 mm Hg criterion increased sensitivity by 8%, with a 36% relative reduction in undertriage.⁶

These studies and the current results suggest that formally substituting an SBP of less than 110 mm Hg for the current SBP of less than 90 mm Hg is beneficial in geriatric patients and may be potentially valuable in all adult patients. Several authors have explored alternate SBP cutoffs to define hypotension. Several studies demonstrate that an SBP of less than 110 mm Hg is associated with increased mortality and base deficit in all adult patients, suggesting that this represents a more relevant SBP trigger.^{19–22} Seamon et al.²³ reported that a single episode of SBP of less than 105 mm Hg is associated with the need for therapeutic operation or endovascular procedure in adult patients.

As expected, this change in triage criteria represents a trade-off between sensitivity and specificity that, if implemented, would increase overtriage at trauma centers. Substantial increases in overtriage of geriatric patients can have serious consequences, impairing trauma system efficiency, increasing costs, and overwhelming trauma center resources, potentially degrading outcomes.^{6,17,24} The ACS COT has set a goal overtriage rate between 25% and 50%, which the current NTTP criteria seem to achieve.^{4,25} Thus, any further increases in overtriage must be justified by comparable reductions in undertriage and improved outcomes.

The current data suggest that this trade-off may be acceptable when using an SBP of less than 110 mm Hg criterion in geriatric patients, as an additional 4.4% of subjects would now be triaged to a trauma center who did require trauma center care, while only an additional 4.3% of subjects would be triaged to a trauma center who did not require trauma center care. Furthermore, many authors argue that because geriatric patients are more likely to die than their younger counterparts with less severe injury and mechanism, the traditional classification of overtriage may need to be modified in the context of this patient population.^{3,14,18} Ultimately, it is unclear if the favorable trade-off seen here would persist

in a prospective validation study that can assess mechanism criteria and population-based triage rates to nontrauma centers. Thus, the current study suggests a potential favorable reduction in undertriage with acceptable increase in overtriage that requires further investigation before widespread adoption of this change in criteria.

This study has several limitations. First are those inherent to a retrospective design. Second are those of the NTDB.²⁶ Despite a large national sample, there are limited variables for analysis. This limited our ability to evaluate mechanism of injury (Step 3) or special consideration (Step 4) criteria. Thus, we were unable to evaluate the SBP criteria in the context of the NTTP as a whole, and further prospective study using all steps of the NTTP is required to confirm any performance improvements using an SBP of less than 110 mm Hg criterion in geriatric patients suggested by these data. Furthermore, these data are restricted to centers that submit to the NTDB and are skewed toward trauma centers, introducing potential selection bias. Since few nontrauma centers submit data to the NTDB, we do not have any information regarding most patients who were not treated at a trauma center. Because this study focuses on a change in criteria that increases sensitivity, it is possible that a group of patients with no other NTTP criteria who would have been captured by the SBP of less than 110 mm Hg criterion were not taken to a trauma center under the current SBP of less than 90 mm Hg criterion and thus would not be represented in the NTDB. If this group is substantial and ultimately does not require trauma center care, a significantly greater increase in overtriage from that reported here is possible, with the attendant problems highlighted earlier. The current study cannot assess this scenario because of the limitations of the database, serving to again underscore the need for further prospective evaluation of the impact this change in SBP criteria in geriatric patients would have on trauma systems.

A substantial amount of prehospital physiologic data was missing; however, multiple imputation was used to mitigate this limitation. The amount of missing data is generally larger than would be suitable for multiple imputation to avoid bias; however, we felt it important to use prehospital vital signs rather than admission vital signs because prehospital and admission vital signs were often disparate and this study evaluates field triage. Furthermore, imputation did not skew the physiologic data and has been shown effective for physiologic data in the NTDB.²⁷ Multiple imputation does assume that missing data occur at random, which our analysis suggested may not be the case, prompting the best-case sensitivity analysis. Because of the limitations of multiple imputation using this data set, we believe that the results can only be interpreted in the context of the sensitivity analyses and imputed data. The use of imputation allowed us to retain all patients regardless of missing data to avoid selection bias of patients with missing data. The complete case analysis allows estimation of triage characteristics without the potential bias introduced from large amounts of missing data and nonrandom missingness. The best-case analysis allows evaluation under the assumption that those with missing data were less injured. Thus, without any one of these analyses, the results would be in question because of the limitations of each individual analysis. All analyses did demonstrate very similar results, which generate some confidence in the estimates obtained from the current data.

The overall AUC values were low, and this is likely due to several factors. First, as noted earlier, we could not evaluate Steps 3 and 4 of the NTTP. The first two NTTP steps are

highly specific but have lower sensitivity, and this is reflected in a lower AUC. Second, many NTTP criteria were adopted based on performance for identifying patients with ISS greater than 15. Repeating the current analysis defining TCN only as ISS greater than 15 produces higher AUC values ranging from 0.674 to 0.704. There is evidence, however, that incorporating resource-based definitions of TCN is superior to anatomic injury alone.^{28,29} This is particularly likely to be true in geriatric patients. Our outcome of TCN was a composite outcome published elsewhere;^{30–32} however, a consistent outcome measure identifying patients who benefit from trauma center care is lacking.³³ Finally, the lower AUC values in the geriatric group highlights the fact that current triage criteria do not perform as well for identifying older adults requiring trauma center care, especially given that poor outcomes are seen in geriatric patients with lower anatomic injury severity and low-energy mechanisms of injury.

CONCLUSION

This is the first study to evaluate the use of an SBP of less than 110 mm Hg criterion in patients older than 65 years compared with the existing SBP of less than 90 mm Hg criterion for all adults in the context of the most recent revision to the NTTP. Substituting an SBP of less than 110 mm Hg criterion in geriatric patients results in discrimination as good as the current SBP of less than 90 mm Hg criterion, with superior improvements in undertriage relative to overtriage. Geriatric patients who would be newly triaged positive under this change have a risk of mortality similar to those under the current SBP triage criterion, warranting transport to a trauma center. An SBP of less than 110 mm Hg criterion may be merited among geriatric patients, and these findings warrant further prospective study to explore elevating this change to a physiologic Step 1 criterion in the NTTP.

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DISCLOSURE

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Figure 1.

ACS COT and Centers for Disease Control NTTP, 2011. Reproduced with permission from Sasser et al.⁴

TABLE 1

Characteristics of the Geriatric and Adult Cohorts

	Geriatric Cohort n = 438,828	Adult Cohort n = 1,117,116	P
Age, median (IQR), y	80 (73–86)	37 (25–50)	<0.01
Sex, male, %	39	71	<0.01
Blunt injury, %	99	85	<0.01
Prehospital time, median (IQR)	48 (37–70)	44 (32–67)	<0.01
Prehospital SBP, median (IQR)	144 (128–164)	131 (118–146)	<0.01
Prehospital SBP < 90 mm Hg, %	2.7	5.3	<0.01
Prehospital SBP < 110 mm Hg, %	9.0	15.5	<0.01
ISS, median (IQR)	9 (4–10)	6 (4–13)	<0.01
TCN, %	32	40	<0.01
Mortality, %	4.4	3.8	<0.01

TABLE 2
Triage and Model Characteristics of SBP of Less Than 90 mm Hg and SBP of Less Than 110 mm Hg for TCN

	Sensitivity	Specificity	PPV	NPV	ROC AUC (95%CI)	AIC*
Geriatric (age > 65 y)						
SBP < 110 mm Hg	13%	93%	50%	68%	0.532 (0.530–0.534)	364865
SBP < 90 mm Hg	5%	99%	66%	67%	0.519(0.517–0.522)	365258
NTTP Step 1 + 2 using SBP < 110 mm Hg [†]	44%	71%	44%	71%	0.575 (0.572–0.577)	361316
NTTP Step 1 + 2 using SBP < 90 mm Hg [‡]	40%	75%	45%	71%	0.574 (0.571–0.576)	363319
Adult (age, 16–65 y)						
SBP < 110 mm Hg	23%	90%	63%	61%	0.564 (0.563–0.566)	980176
SBP < 90 mm Hg	10%	98%	79%	59%	0.539 (0.538–0.541)	979913
NTTP Step 1 + 2 using SBP < 110 mm Hg [†]	67%	62%	58%	70%	0.641 (0.640–0.642)	1022308
NTTP Step 1 + 2 using SBP < 90 mm Hg [‡]	62%	67%	59%	69%	0.646 (0.645–0.647)	1013075

* Models with lower AIC values are considered to have better overall goodness-of-fit.

[†]Triage characteristics when NTTP is applied to the study population in a stepwise fashion where Step 1 uses an SBP of less than 110 mm Hg criterion as the SBP physiologic criterion.

[‡]Triage characteristics when NTTP is applied to the study population in a stepwise fashion where Step 1 uses the current SBP of less than 90 mm Hg criterion as the SBP physiologic criterion.