Comorbidities, anticoagulants, and geriatric-specific physiology for the field triage of injured older adults

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BACKGROUND: Comorbid conditions and anticoagulants have been considered as field triage criteria to raise the sensitivity for identifying seriously injured older adults, but research is sparse. We evaluated the utility of comorbidities, anticoagulant use, and geriatric-specific physiologic measures to improve the sensitivity of the field triage guidelines for high-risk older adults in the out-of-hospital setting.

METHODS: This was a cohort study of injured adults 65 years or older transported by 44 emergency medical services agencies to 51 trauma and nontrauma hospitals in seven Oregon and Washington counties from January 1, 2011, to December 31, 2011. Out-of-hospital predictors included current field triage criteria, 13 comorbidities, preinjury anticoagulant use, and previously developed geriatric specific physiologic measures. The primary outcome (high-risk patients) was Injury Severity Score of 16 or greater or need for major nonorthopedic surgical intervention. We used binary recursive partitioning to develop a clinical decision rule with a target sensitivity of 95% or greater.

RESULTS: There were 5,021 older adults, of which 320 (6.4%) had Injury Severity Score of 16 or greater or required major nonorthopedic surgery. Of the 2,639 patients with preinjury medication history available, 400 (15.2%) were taking an anticoagulant. Current field triage practices were 36.6% sensitive (95% confidence interval [CI], 31.2%–42.0%) and 90.1% specific (95% CI, 89.2%–91.0%) for high-risk patients. Recursive partitioning identified (in order): any current field triage criteria, Glasgow Coma Scale score of 14 or less, geriatric-specific vital signs, and comorbidity count of 2 or more. Anticoagulant use was not identified as a predictor variable. The new criteria were 90.3% sensitive (95% CI, 86.8%–93.7%) and 17.0% specific (95% CI, 15.8%–18.1%).

CONCLUSIONS: The current field triage guidelines have poor sensitivity for high-risk older adults. Adding comorbidity information and geriatric-specific physiologic measures improved sensitivity, with a decrement in specificity. (*J Trauma Acute Care Surg.* 2019;86: 829–837. Copyright © 2019 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Prognostic/Epidemiologic, level II.

KEY WORDS: Emergency medical services; geriatric; trauma; triage.

Field triage processes have been used by emergency medical services (EMS) in US trauma systems for over 30 years[1] and are an integral mechanism for concentrating seriously injured patients in major trauma centers.[2] Field triage is guided by a national algorithm called the Field Triage Decision Scheme.[3] The function and efficiency of field triage are measured through accuracy metrics, with national targets for sensitivity of 95% or greater and specificity of 65% to 75% to minimize missing seriously injured patients and resource overuse in trauma systems.[2] Previous studies and traditional thinking held that triage sensitivity was high and specificity was low.[4] However, more recent research has shown the opposite to be true, particularly for older adults.[5,6] A prospective validation study of field triage processes showed that half of seriously injured older adults are missed by the guidelines and transported to nontrauma centers.[5] Because older adults are a particularly vulnerable population with high morbidity and mortality following injury,[7–11] developing better methods for the early identification of high-risk patients is a major priority for field triage.

The national Field Triage Decision Scheme[3] provides the backbone for field triage processes in the United States and is a logical starting point for improving the early identification of high-risk older adults. Several studies have explored triage criteria specific to older adults,[12–15] but the decision scheme remains largely geared toward seriously injured younger patients. Comorbid conditions, use of anticoagulants, and geriatric-specific physiologic measures are three potential criteria to target high-risk older adults. Comorbidities were included in the triage guidelines from 1987 to 2006,[1,16] but were removed in 2011 because of lack of supporting evidence.[3] Anticoagulant use is mentioned in the current decision scheme as "Anticoagulants and bleeding disorders—Patients with head injury are at high risk for rapid deterioration,"[3] although there has been a paucity of out-of-hospital literature directly supporting this criterion. A recent study by Nishijima et al.[17] suggested that using anticoagulant and antiplatelet medications as triage criteria could potentially identify older adults with serious brain injury otherwise missed by triage processes. A previous study also suggested that geriatric-specific physiologic parameters would raise the sensitivity of field triage.[12] To date, no studies have tested all three of these criteria (comorbidities,

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anticoagulant use, and revised physiologic measures) against the current field triage guidelines to determine their potential role in better identifying high-risk older adults in the out-of-hospital setting.

In this study, we evaluated the utility of adding comorbidities, anticoagulant use, and geriatric-specific physiologic measures[12,13] to the field triage guidelines to improve the sensitivity for identifying high-risk injured older adults (Injury Severity Score[18] [ISS] ≥16 or need for major nonorthopedic surgery) in the out-of-hospital setting. We also assessed how the new criteria could mesh with the current triage algorithm to facilitate implementation and use.

METHODS

Study Design

This was a retrospective cohort study that was reviewed and approved by the institutional review boards of all study sites, which waived the requirement for informed consent.

Study Setting

We conducted the study in seven counties in Oregon and Washington. The counties included urban, suburban, rural, and frontier settings served by 44 public and private EMS agencies transporting to 51 hospitals. The counties use multiple types of EMS systems, including dual advanced life support response, tiered response, and single-agency advanced life support response. The agencies work under close medical direction and use standardized field trauma triage protocols based on the national guidelines. Both states have established, inclusive trauma systems, with participating hospitals categorized as Levels I to V trauma centers. Levels I and II trauma hospitals are considered major trauma centers, consistent with the American College of Surgeons Committee on Trauma national guidelines for tertiary trauma care.[2] For patients who were transferred from the initial receiving hospital, we tracked information at all hospitals, which resulted in the inclusion of six additional hospitals. The 57 hospitals have varying capabilities and services and include three Level I trauma centers, seven Level II trauma centers, 10 Level III trauma hospitals, nine Level IV hospitals, one Level V hospital, and 27 nontrauma hospitals.

Selection of Participants

We included consecutive injured adults 65 years or older transported by 44 EMS agencies in seven counties from January 1, 2011, through December 31, 2011, with a matched Medicare record. Every patient was tracked for 12 months following the 911 call (follow-up through December 31, 2012). We restricted the sample to patients with continuous Medicare fee-for-service coverage during the 30 days prior to 911 contact and through the index ED/hospital visit to capture preinjury comorbidity and medication use. We included patients regardless of receiving hospital, injury severity, or admission status. The presence of injury was based on EMS provider primary or secondary impression. We excluded patients with a hospice claim or a Physician Orders for Life-Sustaining Treatment (POLST) form specifying “Limited Treatment” or “Comfort Measures Only” prior to the date of 911 contact, as these patients often have different goals of care and may be managed differently with regard to field triage.

Data Processing

We collected EMS data as part of a prospective cohort study validating the national field triage guidelines.[5] We used probabilistic linkage[19,20] (LinkSolv, v.9.0.0190; Strategic Matching, Inc., Morrisonville, NY) to match EMS records to state trauma registries, state discharge databases, state death registries, and the Oregon electronic POLST registry. We used validated electronic data methods[21] and probabilistic linkage routines.[22] An external data contractor for the Centers for Medicare & Medicaid Services deterministically matched Medicare claims data to the EMS cohort for 1 year before and 1 year after 911 contact. Using a random subset of 3,140 patients from the full cohort, we independently validated the accuracy of probabilistic linkage (n = 1,350) and key study variables (n = 3,140).[23] Our overall match rate of electronic records into the EMS cohort was 87.3%, with 59.4% matching to the index visit.

Variables

We captured field triage status (positive versus negative), as determined by EMS providers, independent of hospital destination, injury severity, and admission. To minimize misclassification bias for determining triage status, we triangulated ambulance records, fire department records, trauma registry data, and base hospital phone records.[24] We coded out-of-hospital variables based on standardized definitions from the National EMS Information System.[25] Out-of-hospital variables included age, sex, rural versus urban county of 911 response, initial physiologic measures (Glasgow Coma Scale [GCS] score, systolic blood pressure [SBP], respiratory rate, and heart rate), mechanism of injury, intravenous line placement, need for assisted ventilation (bag-mask ventilation or intubation), mode of transport, and receiving hospital. We also coded previously developed geriatric-specific physiologic triage criteria: GCS score ≤14, SBP ≤110 or ≥200 mm Hg, respiratory rate ≤10 or ≥24 breaths/min, and heart rate ≤60 or ≥110 beats/min.[12,13] The geriatric physiologic measures were analyzed with and without heart rate to account for previous research questioning use of heart rate as a criterion in this population.[13]

We coded comorbidities using the framework of the Charlson Comorbidity Index (CCI).[26] Comorbid conditions were based on preinjury Medicare records from the previous 12 months, the Medicare Chronic Conditions Warehouse, and comorbidities noted in state trauma registries. Rather than using the CCI term, which weighs comorbidities differently, we used the 13 individual comorbidities included in the CCI: myocardial infarction, ulcer, cancer, congestive heart failure, stroke, dementia, diabetes, hepatic failure, paralysis, pulmonary dysfunction, renal insufficiency, rheumatic arthritis, and vascular disease. We also created a nonweighted count-based measure to represent the total number of comorbid conditions.

To capture preinjury anticoagulant use, we used Medicare Part D claims made in the 90 days prior to 911 contact. The 90-day window represents the maximum time period for which medications are supplied by Medicare, allowing us to capture all outpatient prescriptions filled during this time period and therefore patients taking these medications at the time of 911 contact. Medication data were available for only a subset of patients because not all Medicare beneficiaries participate in Part D. We included the following medications: warfarin, enoxaparin, rivaroxaban, dabigatran, dalteparin, and fondaparinux (apixaban was not yet approved during the study period). We did not evaluate antiplatelet medications as a triage criterion because they were inconsistently recorded in Part D claims, possibly due to the over-the-counter availability of certain agents (e.g., aspirin). For purposes of the analysis, we assumed that if a patient filled a prescription within the 90-day window with adequate supply, they were taking it. As a sensitivity analysis, we also evaluated whether a patient filled a prescription within 7 days and separately within 2 days of the date of 911 contact.

Outcomes

The primary outcome was ISS of 16 or greater or need for major nonorthopedic surgical intervention (brain, neck, chest, abdominal-pelvic, or spine surgery). This measure integrates the primary metric recommended by American College of Surgeons Committee on Trauma for tracking field triage and trauma system performance (ISS ≥16)[2] and a resource-based measure of specialized interventional trauma care. Because injury severity is not included in claims data, we used a mapping function (ICDPIC module for Stata v11; StataCorp, College Station, TX) to convert *International Classification of Diseases, Ninth Revision, Clinical Modification* diagnosis codes into Abbreviated Injury Scale (AIS) scores and ISS,[17] which we have previously validated.[27] For procedures, we used the Agency for Healthcare Research and Quality Clinical Classification System[28] to categorize *International Classification of Diseases, Ninth Revision, Clinical Modification* procedure codes into the following major operative groups: brain, neck, chest, abdominal-pelvic, spine, and orthopedic. We also tracked blood transfusion and cardiac procedures (percutaneous coronary intervention, coronary artery bypass grafting, and valve repair). Secondary outcomes included serious injuries (AIS score ≥3) in the head, chest, or abdominal-pelvic regions; 30-day mortality; and 1-year mortality.

Analysis

We used binary recursive partitioning[29] to evaluate the utility of comorbid conditions, anticoagulant use, and geriatric-specific physiologic measures as predictors of ISS of 16 or greater or major nonorthopedic surgical intervention. We sought to test these criteria against the current triage criteria and used misclassification costs to favor a high-sensitivity decision tree (≥95%), consistent with the national sensitivity target.[2] To fully explore the predictive value of comorbid conditions, we included each of the 13 conditions as a dichotomous variable (yes/no), as well as a continuous variable for total comorbidity count. We included anticoagulant use and geriatric-specific physiologic measures (both with and without the heart rate criterion) as dichotomous variables. We had two analysts independently perform binary recursive partitioning with the same data and two different software programs (Classification and Regression Tree analysis v8.0 [Salford Systems, San Diego, CA] and “party” in RStudio 1.0.153 [Boston, MA]).[29] The use of different software programs and different analysts working independently with the same data increased the rigor of the tree-building process and consistency in the final results. Following the independent analyses, the analysts compared results and combined them into a final decision tree.

To handle missing values, we used multiple imputation.[30,31] We generated 10 multiply imputed data sets using flexible chains regression models[32] (IVEware; University of Michigan, Ann Arbor, MI), analyzing each multiply imputed data set separately using binary recursive partitioning. We compared the resulting decision trees from all multiply imputed data sets, then generated a final decision tree based on the most consistent results across all 10 data sets and the two analyses. We generated sensitivity, specificity, and corresponding 95% confidence intervals (CIs) using Rubin's[30] rules to combine estimates across the multiply imputed data sets and to appropriately account for overall variance. We used SAS (v. 9.4; SAS Institute, Cary, NC) for database management and to generate descriptive statistics for the sample.

RESULTS

Of the 15,649 injured older adults transported by EMS during the study period, 5,021 had a matched Medicare fee-for-service record and formed the primary sample. Comparison of included versus excluded patients demonstrated similar characteristics, but with a higher proportion of patients in the primary sample meeting field triage criteria, having a fall mechanism, and transported to Levels III–V trauma centers (data not shown). Of the 5,021 patients, 248 (4.9%) had ISS of 16 or greater, 101 (2.0%) required a major nonorthopedic operation, and 320 (6.4%) had ISS of 16 or greater *or* required major nonorthopedic surgery. The mortality rates at 30, 90, and 365 days were 4.7%, 9.1%, and 20.9%, respectively. There were 2,639 patients (52.6% of the primary sample) with Medicare Part D medication data available, of which 400 (15.2%) had filled an anticoagulant prescription within 90 days of 911 contact. Characteristics of the study sample are listed in Table 1. In Figure 1, we demonstrate the frequency of use for individual triage criteria by EMS among patients meeting current field triage guidelines. None of the 44 EMS agencies listed anticoagulant use as a criterion. Age, EMS judgment, and “medical condition” were the three most commonly used criteria (all categorized as part of the Step 4 “Special Considerations” criteria in the triage guidelines).

Current field triage practices identified 117 of the 320 patients with an ISS of 16 or greater or major nonorthopedic surgery (sensitivity, 36.6% [95% CI, 31.2–42.0%]; specificity, 90.1% [95% CI, 89.2%–91.0%]). Recursive partitioning yielded the following predictors (in order of priority): any of the current field triage criteria; GCS score of 14 or less; geriatric-specific vital signs, including heart rate; and comorbidity count of 2 or more (Fig. 2). Overall, this decision rule had 90.3% sensitivity (95% CI, 86.8%–93.7%) and 17.0% specificity (95% CI, 15.8%–18.1%) for identifying older adults with ISS of 16 or greater *or* requiring major nonorthopedic surgery. Accuracy estimates for field triage with the sequential addition of each new criterion, plus secondary outcomes, are demonstrated in Table 2. Current field triage guidelines were poor at identifying patients with short- and long-term mortality. However, the new decision rule had similar sensitivity and specificity for short- and long-term mortality outcomes to other definitions of high-risk patients.

Anticoagulant use was not identified as a primary predictor variable in recursive partitioning analyses using the 2,639

TABLE 1. Characteristics of Injured Older Adults Transported by EMS (n = 5,021)

Demographics		
Mean age	81.5 y	
65–74 y	1,256	(25.0%)
75–84 y	1,624	(32.3%)
85–94 y	1,871	(37.3%)
≥95 y	270	(5.4%)
Women	3,373	(67.2%)
Urban county	4,826	(96.1%)
Rural county	195	(3.9%)
Pre-911 comorbidities:		
Myocardial infarction	1,822	(36.3%)
Congestive heart failure	1,594	(31.8%)
Dementia	1,516	(30.2%)
Diabetes	1,464	(29.2%)
Chronic renal failure	1,445	(28.8%)
Chronic obstructive pulmonary disease	1,429	(28.5%)
Cerebrovascular disease	1,252	(24.9%)
Peripheral vascular disease	1,008	(20.1%)
Cancer	1,027	(20.5%)
Rheumatoid arthritis	283	(5.6%)
Ulcers	116	(2.3%)
Paralysis	114	(2.3%)
Liver disease	59	(1.2%)
Mean total count of comorbidities	2.6	(range 0–10)
Preinjury anticoagulation use (among 2,639 with known medication data):*		
Any	400	(15.2%)
Warfarin	385	(14.6%)
Nonwarfarin anticoagulants (enoxaparin, rivaroxaban, dabigatran, dalteparin, and fondaparinux)	33	(1.3%)
Out-of-hospital triage, physiology, and procedures:		
Met ≥1 current field triage criteria, per EMS	583	(11.6%)
SBP ≤110 mm Hg	503	(10.0%)
SBP ≥ 200 mm Hg	193	(3.8%)
GCS score ≤8	22	(0.4%)
GCS score 9–12	93	(1.8%)
GCS score 13–15	4,906	(97.7%)
Respiratory rate ≤10 or ≥24 breaths/min	288	(5.7%)
Heart rate ≤60 or ≥110 beats/min	631	(12.6%)
Assisted ventilation (bag-valve mask ventilation, intubation, supraglottic airway)	29	(0.6%)
Intravenous or intraosseus line	889	(17.7%)
Mechanism of injury:		
Fall	4,177	(83.2%)
Motor vehicle crash	284	(5.7%)
Motor vehicle vs. pedestrian	120	(2.4%)
Penetrating injury (gunshot wound or stabbing)	44	(0.9%)
Other	397	(7.9%)
Initial hospital:		
Level I	427	(8.5%)
Level II	376	(7.5%)
Level III	1,056	(21.0%)
Level IV	781	(15.6%)
Level V	59	(1.2%)
Nontrauma hospital	2,322	(46.3%)
Interhospital transfer	434	(8.7%)
Injury severity and injury patterns:		
Mean ISS	6.6	

Continued next page

TABLE 1. *(Continued)*

Demographics		
ISS 0–8	3,117	(62.1%)
ISS 9–15	1,656	(33.0%)
ISS 16–24	212	(4.2%)
ISS >24	36	(0.7%)
Head AIS score ≥3	243	(4.9%)
Chest AIS score ≥3	137	(2.7%)
Abdominal-pelvic AIS score ≥3	86	(1.7%)
Extremity AIS score ≥3	819	(16.3%)
Hospital interventions:		
Major surgery—nonorthopedic	101	(2.0%)
Orthopedic surgery	808	(16.1%)
Packed red blood cell transfusion (any)	358	(7.1%)
Cardiac procedures	31	(0.6%)
Outcomes:		
30-d mortality	234	(4.7%)
90-d mortality	458	(9.1%)
1-y mortality	1,047	(20.9%)

*There were 2,639 patients with Medicare Part D records for medication use within 90 days prior to 911 contact; 18 patients filled more than one anticoagulation medication during this time period.

patients with medication data. When analyses were repeated using a definition of anticoagulant fill within 7 days of 911 contact (353/400 patients [88.3%]) or within 2 days of 911 contact (335/400 [83.8%]), the results did not qualitatively change. However, we evaluated the decision rule with and without anticoagulant use to assess its potential contribution to field triage (Table 2). Adding anticoagulant use to the decision tree (in addition to current field triage criteria, GCS score ≤14, geriatric-specific vital signs, and comorbidity count ≥2) demonstrated 94.1% sensitivity (95% CI, 90.1%–98.1%) and 14.0% specificity (95% CI, 12.6%–15.4%). Replacing comorbidity count with anticoagulant use generated a decision tree with 78.9% sensitivity (95% 71.5%–86.2%) and 40.8% specificity (95% CI, 38.7%–42.9%).

We also evaluated ambulance transport patterns for older adults. Of the 5,021 injured patients transported by EMS, 803 (16.0%) were initially transported to Level I/II trauma centers. Among the 583 patients meeting current field triage criteria, 222 (38.1%) were transported to Level I/II trauma centers. Using hospital destination as a measure of triage, 114 of 320 patients with ISS of 16 or greater *or* major nonorthopedic surgery were initially transported to a Level I/II trauma center (sensitivity 35.6%; 95% CI, 30.1%–41.1%). Of the 4,701 patients without serious injuries or requiring specialized operative intervention, 689 were transported to major trauma centers (specificity, 85.3% [95% CI, 84.3%–86.3%]). Among the 206 high-risk patients initially transported to nonmajor trauma centers, 51 (24.8%) were subsequently transferred to Level I/II hospitals, resulting in the following accuracy metrics calculated by final destination Level I/II trauma center: sensitivity of 50.8% (95% CI, 45.0%–56.6%) and specificity of 84.5% (95% CI, 83.5%–85.6%).

DISCUSSION

In this study, we confirm the poor sensitivity of current field triage practices for identifying high-risk older adults. Whether calculated by overall serious injury, specific types of serious injuries, need for operative intervention, or short- and long-term mortality, the current guidelines missed the majority of high-risk older adults. Among patients who did meet current field triage criteria, the majority were not transported to major trauma centers. These findings highlight major gaps in trauma systems for older adults. Using preinjury comorbidity and medication data in combination with geriatric-specific physiologic measures, we developed a decicion algorithm to better identify high-risk older adults. The addition of any abnormal GCS, abnormal vital signs, and comorbidities substantially improved the sensitivity of field triage, at the expense of specificity. These findings demonstrate that high-sensitivity out-of-hospital identification of high-risk older adults is possible, with inherent trade-offs in specificity and overtriage. Previous triage research using an all-age sample suggested that there is a marked drop in specificity when pushing sensitivity from 90% to 95%[33]; our results illustrate a similar drop in specificity that occurs at a much lower sensitivity value for older adults. Whether trauma systems, hospitals, and patients are willing to accept such large increases in overtriage and major shifts in ambulance transport patterns to achieve a substantial reduction in undertriage is unclear. Our findings and these concepts are highly relevant to the next revision of the Field Triage Decision Scheme.

Comorbidity-based criteria were previously included in the field triage guidelines (1987, 1990, 1999, and 2006),[1,16] but were removed in 2011 because of lack of evidence.[3] Our results provide this evidence and quantify their contribution to triage processes for older adults. There was no single comorbidity that consistently identified high-risk older adults. Rather, the total comorbidity burden was a stronger predictor. Having two or more comorbid conditions from the CCI list was a useful predictor of high-risk patients, including those with overall serious injury, specific types of serious injuries, need for operative intervention, and short- and long-term mortality. Because the current triage guidelines have such poor sensitivity for high-risk older

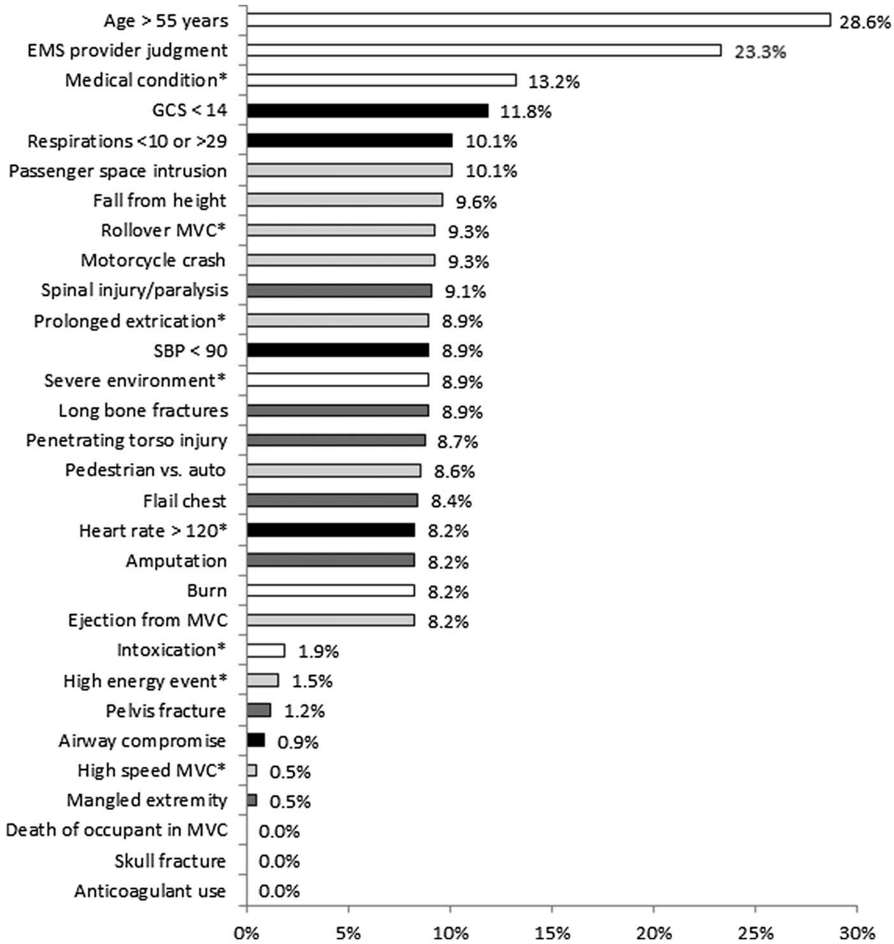

Figure 1. Current use of individual triage criteria by EMS among older adults meeting the field trauma triage guidelines (n = 583). *Triage criteria used by EMS agencies that are not included in the current (2011) national field triage guidelines. †Color scheme for histogram bars follows steps of national Field Triage Decision Scheme: Step 1 criteria (physiologic) = black; Step 2 criteria (anatomic) = dark gray; Step 3 criteria (mechanism) = light gray; Step 4 criteria (special considerations) = white. ‡Data for individual triage criteria were collected only when EMS marked a criterion as present. To account for varying proportions of missingness, percentages were calculated using a fixed denominator of 583 triage-positive patients. Multiple criteria could be applied to a single patient, so the percentages do not add to 100%.

adults, additional criteria will be required to identify this unique population.

Anticoagulant use was not a good identifier of high-risk patients in comparison to current triage criteria, geriatric-specific physiologic measures, and comorbidities. This was an unexpected finding. Use of anticoagulants is already mentioned in the field triage algorithm (Step 4 criterion "Anticoagulants and bleeding disorders"), although it was not cited as an individual triage criterion by any of the 44 EMS agencies. It is possible that this criterion has already largely been integrated to triage practices (even if not explicitly listed by EMS providers) and represented through other triage criteria (e.g., EMS judgment or medical condition). However, our findings contrast with recent research by Nishijima and colleagues,[17] which demonstrated the potential value of anticoagulant use in identifying older adults with serious brain injury. The differences in our findings may reflect how we considered anticoagulants in the analysis. To assess the predictive utility of anticoagulant use, we evaluated this criterion against all current and potential triage criteria. This analytic strategy allowed anticoagulant use to be compared with other triage criteria, as would be done in practice. Another possibility is that comorbidity information already largely encompasses conditions that lead to anticoagulation use and therefore serves as a more important predictor of high-risk patients.

Additional considerations are how to align the new triage criteria for older adults with triage guidelines that are intended for use in all ages, as well as the ideal type of hospital to care for high-risk older adults. Separate triage guidelines for different age groups are likely too complicated for the field, as the current triage algorithm is already complex. The additional criteria for older adults could be included in Step 4 ("special consideriations") to highlight subtle presentations of serious injury among a vulnerable population. Alternatively, the geriatric-specific physiologic criteria could be integrated to Step 1 (physiologic step), including notation that they apply only to patients 65 years or older, with integration of the comorbidity criterion to Step 4. In addition to identifying high-risk patients, the triage guidelines direct hospital selection. The guidelines are predicated on the

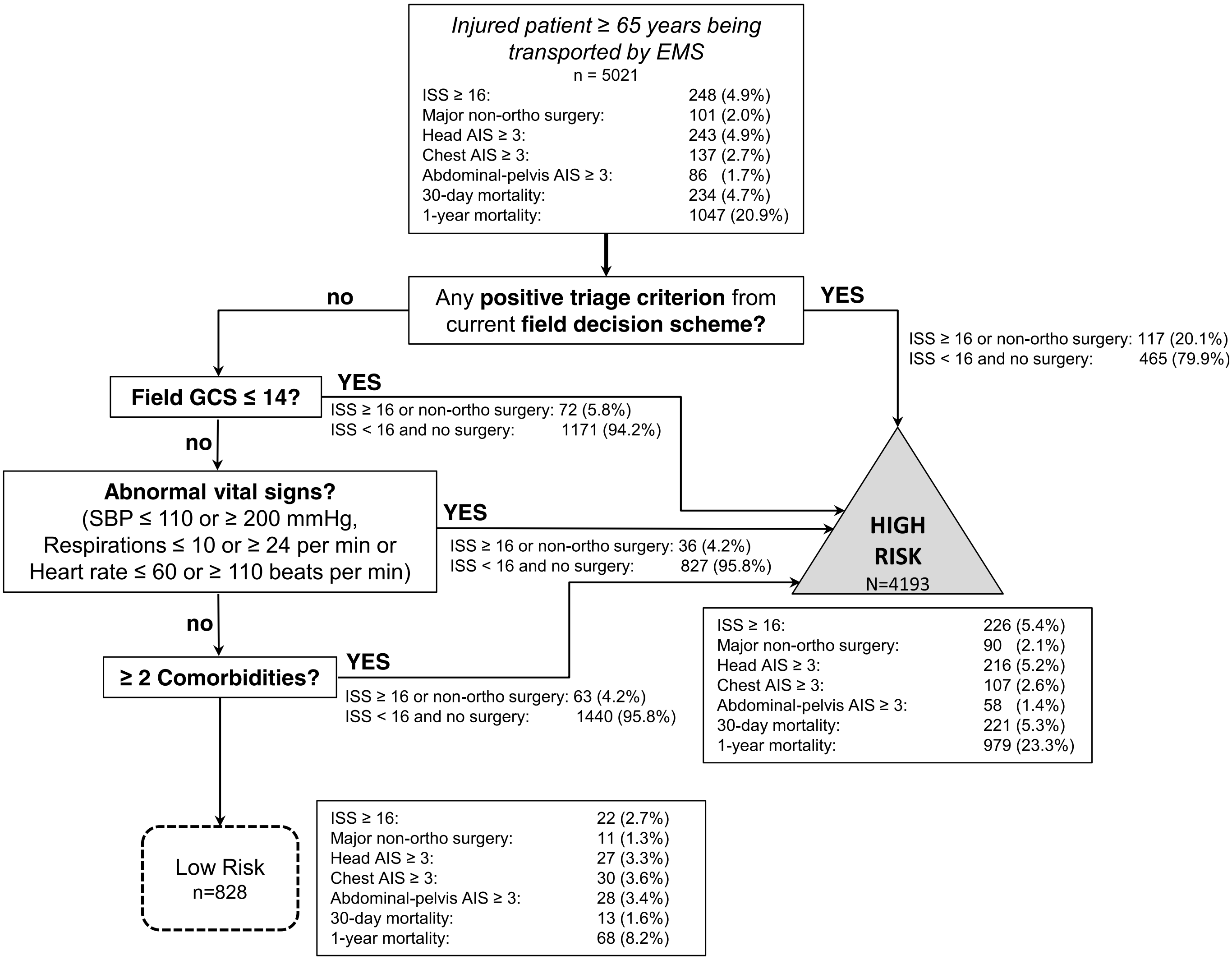

Figure 2. Derived clinical decision rule aligning the current triage guidelines with geriatric-specific physiology and comorbidity criteria to better identify high-risk injured older adults (n = 5,021).

idea that patients with serious injuries have better outcomes when cared for in major trauma centers. While this concept has been proven in younger patients,[34] the benefit of major trauma centers for older adults remains unclear.[34–36] Nonetheless, we believe that early identification of high-risk older adults is an important first step in the out-of-hospital decision-making process.

Because this analysis focused on evaluation of comorbidities and medications as potential field triage criteria, we restricted the sample to patients with preinjury information available, which could have introduced selection bias. While characteristics of patients included versus excluded from the analysis were generally similar, our sensitivity estimates for current field triage practices were lower than those of similar cohorts drawn from the same geographic regions.[5,12,37] This comparison suggests that if bias was present in the sample, the direction appears toward worsening triage sensitivity, reflecting greater difficulty in creating a high-sensitivity decision rule. Therefore, we believe our results provide conservative estimates for how the proposed decision rule may work in practice.

Another factor reflected in our results is the disconnect between identifying high-risk older adults in the field and selecting an appropriate receiving hospital. That is, the majority of patients meeting current triage guidelines were not transported to major trauma centers. So, even if more than 90% of high-risk older adults were identified using revised triage criteria, most of these patients would still not be transported to major trauma centers. If major trauma centers are assumed to be the ideal destination for high-risk older adults, this disconnect will need to be addressed. Our estimates also assume that EMS personnel can obtain timely and accurate information about comorbidities and be compliant with the additional triage criteria. Some research has suggested that EMS personnel have incomplete adherence to the triage algorithm.[38] If comorbidity information is to be integrated into the triage guidelines, the importance of obtaining accurate comorbidity information in the field will need to be highlighted, integrated to EMS training activities, and studied. With the goal of getting "the right patient to the right place at the right time,"[2] our findings demonstrate that

TABLE 2. Stepwise Accuracy Metrics for the Field Triage of Injured Older Adults Using Current Field Triage Guidelines and Additional Triage Criteria (n = 5,021)

	Sensitivity	95% CI	Specificity	95% CI	Sensitivity	95% CI	Specificity	95% CI
	Outcome: ISS ≥16 or Major Nonorthopedic Surgery				Outcome: ISS ≥16			
Current triage guidelines	36.6%	(31.2–42.0%)	90.1%	(89.2%–91.0%)	39.9%	(33.7%–46.0%)	89.9%	(89.0%–90.7%)
Add: GCS score ≤14	59.2%	(53.3%–65.0%)	65.2%	(63.6%–66.7%)	63.8%	(57.5%–70.1%)	65.1%	(63.5%–66.6%)
Add: geriatric-specific vital signs	70.5%	(65.2%–75.9%)	47.6%	(46.1%–49.2%)	74.4%	(68.5%–80.2%)	47.5%	(46.0%–49.0%)
Add: comorbidity count ≥2	90.3%	(86.8%–93.7%)	17.0%	(15.8%–18.1%)	91.3%	(87.7%–94.9%)	16.9%	(15.7%–18.1%)
Add: oral anticoagulant use*	94.1%	(90.1%–98.1%)	14.0%	(12.6%–15.4%)	95.6%	(91.7%–99.5%)	14.0%	(12.6%–15.4%)
	Outcome: Head AIS Score ≥3				Outcome: Head, Chest, or Abdominal-Pelvic AIS Score ≥3			
Current triage guidelines	33.9%	(24.8%–43.0%)	89.5%	(88.6%–90.4%)	28.0%	(21.9%–34.1%)	89.9%	(89.0%–90.7%)
Add: GCS score ≤14	61.5%	(51.6%–71.3%)	64.9%	(63.4%–66.4%)	51.4%	(44.5%–58.3%)	65.0%	(63.4%–66.5%)
Add: geriatric-specific vital signs	73.2%	(63.9%–82.5%)	47.4%	(45.9%–49.0%)	65.3%	(59.2%–71.4%)	47.5%	(45.9%–49.1%)
Add: comorbidity count ≥2	89.3%	(80.9%–97.6%)	16.8%	(15.5%–18.0%)	82.5%	(77.3%–87.7%)	16.4%	(15.2%–17.6%)
Add: oral anticoagulant use*	94.2%	(87.5%–100%)	13.9%	(12.5%–15.3%)	89.2%	(83.3%–95.1%)	13.7%	(12.3%–15.2%)
	Outcome: 30-d Mortality				Outcome: 1-y Mortality			
Current triage guidelines	15.7%	(11.0%–20.4%)	88.6%	(87.8%–89.5%)	11.3%	(9.3%–13.2%)	88.3%	(87.3%–89.3%)
Add: GCS score ≤14	54.1%	(47.2%–61.0%)	64.5%	(63.0%–66.1%)	45.0%	(41.7%–48.2%)	65.9%	(64.1%–67.6%)
Add: geriatric-specific vital signs	71.1%	(65.1%–77.2%)	47.3%	(45.7%–48.8%)	63.2%	(60.1%–66.2%)	49.0%	(47.2%–50.7%)
Add: comorbidity count ≥2	94.4%	(91.4%–97.4%)	17.0%	(15.9%–18.2%)	93.5%	(92%–95.1%)	19.1%	(17.8%–20.5%)
Add: oral anticoagulant use*	96.0%	(92.3%–99.7%)	13.9%	(12.5%–15.3%)	95.0%	(93.1%–96.9%)	15.7%	(14.1%–17.3%)

*When use of anticoagulant medication replaces comorbidity count in the decision rule, sensitivity and specificity are 78.9% and 40.8% for ISS of 16 or greater or major nonorthopedic surgery; 83.3% and 40.8% for ISS of 16 or greater; 82.1% and 40.7% for head AIS score of 3 or greater; 74.7% and 40.7% for head, chest, or abdominal-pelvic AIS score of 3 or greater; 80.1% and 40.5% for 30-day mortality; and 69.9% and 42.1% for 1-year mortality.

several additional aspects of triage and transport processes beyond just the criteria need attention.

Finally, we used a retrospective cohort study design, which has inherent limitations. Our findings will need to be replicated using a prospective study design, ideally performed in regions beyond those used to derive the decision rule, before considering integration to national guidelines.

In summary, the current field triage guidelines had poor sensitivity for identifying high-risk older adults. We propose additional triage criteria to better identify these patients. Adding key physiologic and comorbidity information notably improved the identification of high-risk older adults and represents an opportunity to improve triage processes for the older adult population.

AUTHORSHIP

C.D.N. was responsible for study conception and design, obtained funding for this study, and drafted the manuscript. D.Z. assisted with acquisition of data for the project (electronic EMS data from three counties, trauma registry data, and POLST records), interpretation of data and the study results, and critical revision of the submitted manuscript. C.D.N. and E.B. assisted with acquisition of data. A.L. and C.D.N. assisted with analysis of data. S.M. was responsible for database management and linkage. C.D.N., A.L., E.E., A.C., S.M., D.G., and E.B. assisted with interpretation of data. C.D.N., A.L., E.E., A.C., S.M., D.G., and E.B. were responsible for critical revision of the manuscript.

DISCLOSURE

The authors declare no conflicts of interest.

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