Out-of-Hospital Triage of Older Adults With Head Injury: A Retrospective Study of the Effect of Adding "Anticoagulation or Antiplatelet Medication Use" as a Criterion

Daniel K. Nishijima, MD, MAS*; Samuel D. Gaona, BS; Trent Waechter, RN; Ric Maloney, RN; Troy Bair, EMT-P, BA; Adam Blitz, EMT-P, BA; Andrew R. Elms, MD; Roel D. Farrales, MD; Calvin Howard, MBE; James Montoya, MD; Jeneita M. Bell, MD; Mark Faul, PhD, MA; David R. Vinson, MD; Hernando Garzon, MD; James F. Holmes, MD, MPH; Dustin W. Ballard, MD; for the Sacramento County Prehospital Research Consortium

*Corresponding Author. E-mail: dnishijima@ucdavis.edu, Twitter: @dknishijima.

Study objective: Field triage guidelines recommend that emergency medical services (EMS) providers consider transport of head-injured older adults with anticoagulation use to trauma centers. However, the triage patterns and the incidence of intracranial hemorrhage or neurosurgery in these patients are unknown. Our objective is to describe the characteristics and outcomes of older adults with head trauma who are transported by EMS, particularly for patients who do not meet physiologic, anatomic, or mechanism-of-injury (steps 1 to 3) field triage criteria but are receiving anticoagulant or antiplatelet medications.

Methods: This was a retrospective study at 5 EMS agencies and 11 hospitals (4 trauma centers, 7 nontrauma centers). Patients aged 55 years or older with head trauma who were transported by EMS were included. The primary outcome was the presence of intracranial hemorrhage. The secondary outcome was a composite measure of inhospital death or neurosurgery.

Results: Of the 2,110 patients included, 131 (6%) had intracranial hemorrhage and 41 (2%) had inhospital death or neurosurgery. There were 162 patients (8%) with steps 1 to 3 criteria. Of the remaining 1,948 patients without steps 1 to 3 criteria, 566 (29%) had anticoagulant or antiplatelet use. Of these patients, 52 (9%) had traumatic intracranial hemorrhage and 15 (3%) died or had neurosurgery. The sensitivity (adjusted for clustering by EMS agency) of steps 1 to 3 criteria was 19.8% (26/131; 95% confidence interval [CI] 5.5% to 51.2%) for identifying traumatic intracranial hemorrhage and 34.1% (14/41; 95% CI 9.9% to 70.1%) for death or neurosurgery. The additional criterion of anticoagulant or antiplatelet use improved the sensitivity for intracranial hemorrhage (78/131; 59.5%; 95% CI 42.9% to 74.2%) and death or neurosurgery (29/41; 70.7%; 95% CI 61.0% to 78.9%).

Conclusion: Relatively few patients met steps 1 to 3 triage criteria. For individuals who did not have steps 1 to 3 criteria, nearly 30% had anticoagulant or antiplatelet use. A relatively high proportion of these patients had intracranial hemorrhage, but a much smaller proportion died or had neurosurgery during hospitalization. Use of steps 1 to 3 triage criteria alone is not sufficient in identifying intracranial hemorrhage and death or neurosurgery in this patient population. The additional criterion of anticoagulant or antiplatelet use improves the sensitivity of the instrument, with only a modest decrease in specificity. [Ann Emerg Med. 2017;70:127-138.]

Please see page 128 for the Editor's Capsule Summary of this article.

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INTRODUCTION

Background

Traumatic brain injury accounts for an annual toll in the United States of 2.2 million emergency department (ED) visits, 280,000 hospitalizations, and more than 50,000 deaths, at an estimated cost of $60 billion annually.[1,2] With an aging population, older adults represent an increasing proportion of patients with traumatic brain injury treated at hospitals and trauma centers.[3] Older adults have higher morbidity and mortality after traumatic brain injury than younger patients because of brain anatomic differences, higher comorbidity burden, and more frequent use of anticoagulant and antiplatelet medications.[1,3-5] Preinjury use of these medications is especially problematic with head trauma, increasing the risk for traumatic intracranial hemorrhage and posttraumatic disability and death.[6-9] Traumatic intracranial hemorrhage in patients receiving anticoagulants has been described as an epidemic in patients aged 55 years or older.[10]

Editor's Capsule Summary

What is already known on this topic

Older adults with injuries requiring trauma center care are frequently taken to nontrauma centers.

What question this study addressed

This retrospective study of patients aged 55 years and older with head trauma (n=2,110) examined the accuracy of standard out-of-hospital triage criteria with or without information on use of anticoagulant or antiplatelet medication (ascertained from hospital records) to identify patients with traumatic intracranial hemorrhage.

What this study adds to our knowledge

The addition of anticoagulant or antiplatelet medication use increased the sensitivity of the triage instrument for identifying intracranial hemorrhage from 20% to 60%; specificity decreased from 93% to 67%.

How this is relevant to clinical practice

Adding this criterion may improve the out-of-hospital identification of older adults requiring trauma center care, but prospective studies of risk versus benefit are needed.

Rapid diagnosis of traumatic intracranial hemorrhage with cranial computed tomography (CT) is critical to determine whether reversal agents or blood products should be administered. In patients receiving warfarin and requiring immediate neurosurgical intervention, rapid and efficacious reversal to an appropriate international normalized ratio level is essential because levels greater than 1.25 increase postoperative mortality.[11-13] Patients receiving antiplatelet medications or direct oral anticoagulants who have significant bleeding after trauma or require emergency surgery may need careful evaluation and specific reversal agents.[14-17]

Importance

As such, the goal of field trauma triage guidelines for patients transported by emergency medical services (EMS) is to transport high-risk patients with suspected traumatic brain injury to trauma centers with the capability of rapidly and comprehensively treating them.[18] The most recent recommendations (Figure 1) for the transport of injured patients to trauma centers include physiologic criteria (step 1), anatomic criteria (step 2), mechanism-of-injury criteria (step 3), and special considerations, which include anticoagulant use (step 4).[18] It is recommended that patients who meet these criteria be transported to the nearest trauma center. Many older adults with head injury, however, do not meet these criteria yet have a higher incidence of traumatic brain injury–related hospitalization and worse traumatic brain injury–related outcomes compared with younger adults.[19-22] In addition, older adults are more frequently undertriaged to nontrauma centers than younger adults with similar injuries.[23,24] In response to these issues involving older adults with head injury, particularly those who receive anticoagulation, the most recent field triage guidelines revised the special considerations criteria (step 4) to include additional language for patients receiving anticoagulants (including both anticoagulant and antiplatelet medications), stating that "[p]atients with head injury are at high risk for rapid deterioration."[18] The characteristics of EMS transport decisions and clinical outcomes in head-injured patients meeting only step 4 triage criteria, however, have not been previously described to our knowledge.

Goals of This Investigation

In this study, our primary objective was to describe the characteristics and health outcomes of older adults (55 years and older) with blunt head trauma who were transported by EMS, with a particular focus on patients who did not meet physiologic, anatomic, or mechanism-of-injury field triage criteria but were receiving anticoagulant or antiplatelet medications. We compared the sensitivity and specificity of steps 1 to 3 of the field triage guidelines on identifying clinical outcomes with the sensitivity and specificity of steps 1 to 3 with the additional criterion of anticoagulant or antiplatelet use.

MATERIALS AND METHODS

Study Design and Setting

This was a countywide, retrospective study at 5 EMS agencies and 11 hospitals in Northern California. Institutional review board approval was obtained at all study sites with a waiver of informed consent. Study procedures followed previous recommendations to reduce bias in emergency medicine chart review studies.[25]

This investigation was part of a larger study previously described in detail.[26] The study was conducted primarily in Sacramento County, which encompasses 994 square miles and has a resident population of 1,445,327 (2010 census). Sacramento County is served by 5 EMS agencies that respond to medical emergency 911 calls. More than 2,700 emergency personnel are certified or accredited by the Sacramento County EMS Agency, including approximately 250 mobile intensive care nurses, 1,050 paramedics, and 1,400 emergency medical technicians. These 5 EMS agencies transport patients to 11 general acute care hospitals that have a cumulative capacity of approximately 240 ED beds and 3,400 inpatient beds. Nine hospitals are located within Sacramento County and 2 are located in adjacent Placer County. We included these 2 out-of-county acute care hospitals because Sacramento County EMS agencies routinely transport patients to them and do so under the guidance of the Sacramento County Trauma Triage Tool (Figure E1, available online at http://www.annemergmed.com) that was adapted from the most recent field triage guidelines (2011).[18] Of these 11 hospitals, one is a Level I adult trauma center, 3 are designated as Level II adult trauma centers, and 7 are nontrauma centers. In 2011, there were 3,345 patients with major trauma (adults and children) admitted to the 4 designated trauma centers from incidents within Sacramento County.

Selection of Participants

We included patients aged 55 years and older with head trauma who were transported to a hospital by the participating EMS agencies from January 1, 2012, to December 31, 2012. The patient cohort was identified with EMS agency billing data and *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* diagnosis codes 959.01 (head injury unspecified) or 959.09 (injury of face and neck). We excluded patients transferred by EMS from another receiving facility (interfacility transport), patients with penetrating head trauma, prisoners, and patients with unmatched hospital data.

Methods of Measurement

All EMS agencies used similar out-of-hospital patient care report forms that included transport information; patient demographics; medical history, including current medications; history of present illness; vital signs; physical examination findings; treatments; and assessments.

A trained research coordinator abstracted the following data from EMS charts: patient identifiers (name and date of birth), transport characteristics (date of transport, EMS agency, level of transport, level of EMS provider, and receiving hospital), and mechanism of injury and clinical characteristics (initial field Glasgow Coma Scale [GCS] score, reported dementia, and reported intoxication). Steps 1 to 3 field triage criteria were coded according to the presence or absence of explicit criteria documented on EMS charts.

Eligible EMS patient transports were linked to ED and hospital records with patient identifiers (name, date of birth, and date of transport). For the linked hospital visit, we reviewed ED and hospital electronic charts including patient demographics, emergency physician notes, hospital admission and discharge physician notes, and medication reconciliation lists and abstracted the following data: demographics (age, sex, ethnicity, and race), antiplatelet and anticoagulant use, ED neuroimaging type and result, ED disposition, hospital length of stay, Abbreviated Injury Score and Injury Severity Score for hospitalized patients, and neurosurgical interventions and death caused by head injury. Anticoagulants and antiplatelets included warfarin or direct oral anticoagulants (dabigatran, rivaroxaban, or apixaban), aspirin, clopidogrel, ticlopidine, prasugrel, dipyridamole, cilostazol, and ticagrelor. Use of anticoagulant or antiplatelet medications was based on receiving hospital documentation of patient use during the week before the ED visit. We reported isolated head injury to better characterize injury patterns. Isolated head injury was defined as an Abbreviated Injury Score less than 3 in all nonhead body regions.[27]

A formal coding manual that defined all variables was developed. Study data were collected and managed with REDCap (Research Electronic Data Capture) tools hosted at UC Davis.[28] REDCap is a secure, Web-based application designed to support data capture for research studies. Electronic data collection forms were pilot tested before data abstraction.

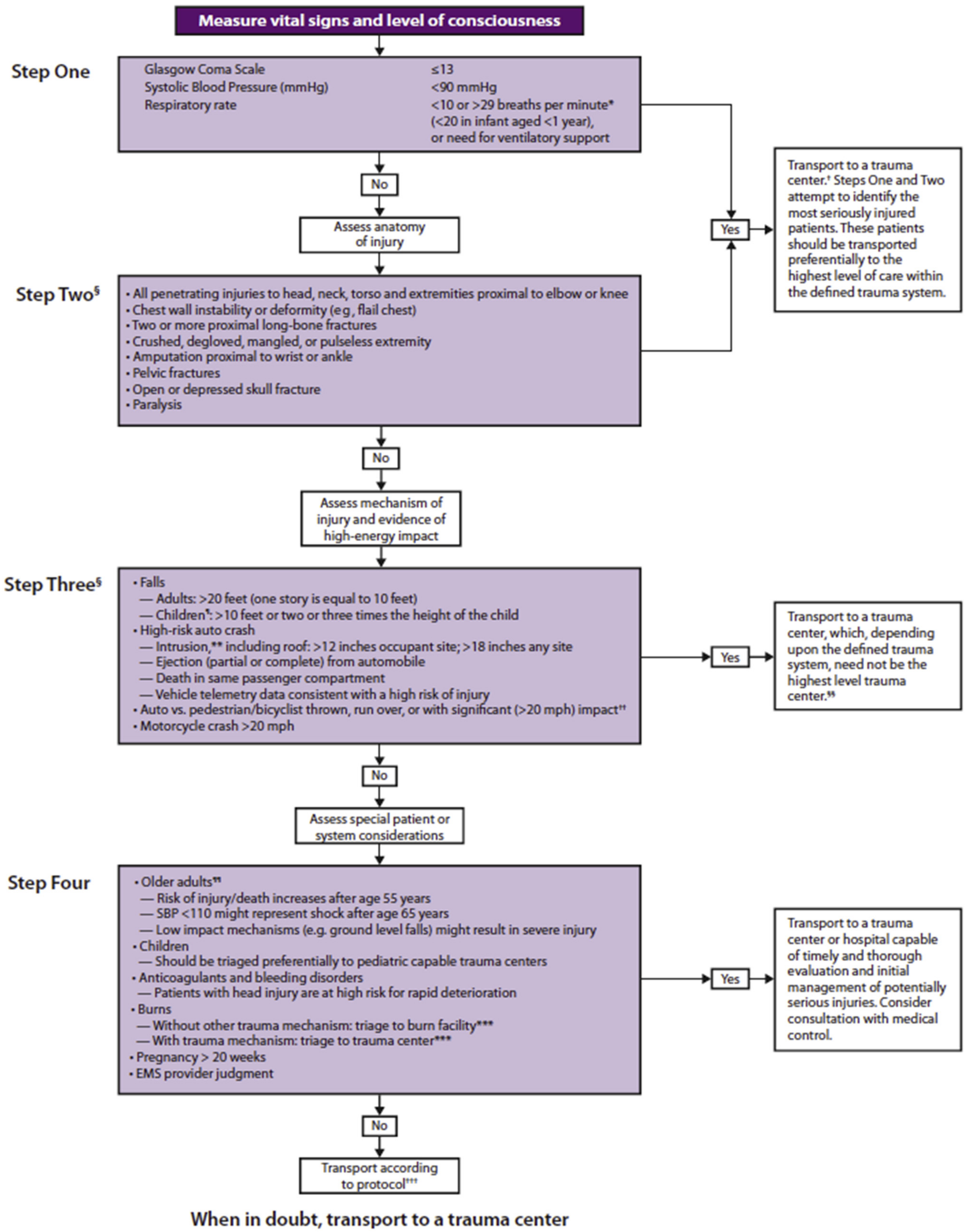
A second data abstractor (D.N.), blinded to the responses from the first abstractor (S.G.), performed an independent data abstraction of out-of-hospital and ED or hospital variables, including the study outcomes. This second data abstraction was a 5% random sample of the study cohort.

Outcome Measures

Our primary outcome measure was the presence of traumatic intracranial hemorrhage on initial cranial CT imaging in the ED according to radiologist interpretation. Our secondary outcome measure was a composite one of death or neurosurgical intervention during hospitalization. This secondary outcome measure was adapted according to previous consensus-based recommendations for trauma center need.[29] We chose not to focus on Injury Severity Score as a primary outcome because of previous work suggesting that a discrete cutoff may be a poor predictor of actual trauma center need, especially for a specific population such as head-injured patients.[30]

Primary Data Analysis

We formatted the data and recoded the variables with Stata (version 13.1; StataCorp, College Station, TX).


Measure vital signs and level of consciousness
Step One
Glasgow Coma Scale ≤13
Systolic Blood Pressure (mmHg) <90 mmHg
Respiratory rate <10 or >29 breaths per minute* (<20 in infant aged <1 year), or need for ventilatory support
No
Assess anatomy of injury
Step Two§
• All penetrating injuries to head, neck, torso and extremities proximal to elbow or knee
• Chest wall instability or deformity (e.g, flail chest)
• Two or more proximal long-bone fractures
• Crushed, degloved, mangled, or pulseless extremity
• Amputation proximal to wrist or ankle
• Pelvic fractures
• Open or depressed skull fracture
• Paralysis
Yes
Transport to a trauma center.† Steps One and Two attempt to identify the most seriously injured patients. These patients should be transported preferentially to the highest level of care within the defined trauma system.
No
Assess mechanism of injury and evidence of high-energy impact
Step Three§
• Falls
— Adults: >20 feet (one story is equal to 10 feet)
— Children¶: >10 feet or two or three times the height of the child
• High-risk auto crash
— Intrusion,** including roof: >12 inches occupant site; >18 inches any site
— Ejection (partial or complete) from automobile
— Death in same passenger compartment
— Vehicle telemetry data consistent with a high risk of injury
• Auto vs. pedestrian/bicyclist thrown, run over, or with significant (>20 mph) impact††
• Motorcycle crash >20 mph
Yes
Transport to a trauma center, which, depending upon the defined trauma system, need not be the highest level trauma center.§§
No
Assess special patient or system considerations
Step Four
• Older adults¶¶
— Risk of injury/death increases after age 55 years
— SBP <110 might represent shock after age 65 years
— Low impact mechanisms (e.g. ground level falls) might result in severe injury
• Children
— Should be triaged preferentially to pediatric capable trauma centers
• Anticoagulants and bleeding disorders
— Patients with head injury are at high risk for rapid deterioration
• Burns
— Without other trauma mechanism: triage to burn facility***
— With trauma mechanism: triage to trauma center***
• Pregnancy > 20 weeks
• EMS provider judgment
Yes
Transport to a trauma center or hospital capable of timely and thorough evaluation and initial management of potentially serious injuries. Consider consultation with medical control.
No
Transport according to protocol†††
When in doubt, transport to a trauma center

Descriptive statistics were used to characterize the study population overall. Non-normal interval data were reported with medians and interquartile ranges.

We evaluated the test characteristics of 4 separate criteria to identify traumatic intracranial hemorrhage or inhospital death or neurosurgery. The 4 criteria were as follows: if only steps 1 to 3 criteria were used, if steps 1 to 3 and anticoagulant or antiplatelet criteria were used, actual transport, and actual transport plus if anticoagulant or antiplatelet criteria were used. Sensitivity and specificity were calculated with 95% confidence intervals (CIs) and based on 2×2 tables and adjusted for clustering by EMS agency.[31] For this primary analysis, we included patients who did not receive a cranial CT scan during hospitalization and those with missing data. To evaluate the effect of excluding these patients, we conducted 2 sensitivity analyses. First, we calculated test characteristics of the 4 criteria as described above, but including only patients who received a cranial CT scan. Second, we calculated test characteristics of the 4 criteria including only patients with complete data.

To assess interrater agreement, we calculated percentage agreement and the κ statistic (with 95% CIs), using normal approximation methods for binary or categorical variables and the weighted κ statistic for ordinal variables.[32,33] In accordance with previous data that evaluated a similar patient population, we estimated that collecting 12 months' worth of data would generate a sufficiently large sample of patients with anticoagulant or antiplatelet use to ensure adequate precision of analyses.[34]

RESULTS

Characteristics of Study Subjects

A total of 2,110 patients were included in the study after exclusion of 174 (7.6%; 173 for unmatched hospital data and one with penetrating head trauma). The median age was 73 years (interquartile range 62 to 85 years) and 1,259 (60%) were male patients. The most common mechanism of injury was fall from standing height or lower (1,445/2,110; 68%). The majority of patients had an initial GCS score by EMS of 15 (1,638/2,047; 80%). Five hundred ninety-five patients (595/2,110; 28%) had preinjury anticoagulant or antiplatelet use. Complete patient characteristics are reported in Table 1.

The 5 EMS agencies transported from 104 to 952 patients, and the majority of patients were transported by advanced life support (1,199/2,110; 57%) and treated by a paramedic (1,567/2,110; 74%). Median transport time (time from scene to arrival at hospital) was 14 minutes (interquartile range 10 to 18 minutes). There was substantial agreement for all measured variables (Table E1, available online at http://www.annemergmed.com).[35]

Main Results

Of the 2,110 transports, 131 (6.2%; 95% CI 5.2% to 7.3%) patients received a diagnosis of traumatic intracranial hemorrhage on cranial CT imaging and 41 (1.9%; 95% CI 1.4% to 2.6%) had the composite outcome measure of death or neurosurgery. The cranial CT characteristics of patients with traumatic intracranial hemorrhage are reported in Table 2. Nine of the 131 patients (7%) with traumatic intracranial hemorrhage underwent a neurosurgical intervention (Table 3). Of patients with a neurosurgical intervention, 4 died (4/9; 44%).

Overall, 1,100 patients (1,100/2,110; 52%) were transported initially to a trauma center. Of the remaining 1,010 patients (1,010/2,110; 48%) transported initially to a nontrauma center, 48 (48/1,010; 4.8%) had a traumatic

Figure 1. Guidelines for field triage of injured patients—United States, 2011. *The upper limit of respiratory rate in infants is greater than 29 breaths/min to maintain a higher level of overtriage for infants. †Trauma centers are designated Levels I to IV. A Level I center has the greatest amount of resources and personnel for care of the injured patient and provides regional leadership in education, research, and prevention programs. A Level II facility offers resources similar to those of a Level I facility, possibly differing only in continuous availability of certain subspecialties or sufficient prevention, education, and research activities for Level I designation; Level II facilities are not required to be resident or fellow education centers. A Level III center is capable of assessment, resuscitation, and emergency surgery, with severely injured patients being transferred to a Level I or II facility. A Level IV trauma center is capable of providing 24-hour physician coverage, resuscitation, and stabilization to injured patients before transfer to a facility that provides a higher level of trauma care. §Any injury noted in step 2 or mechanism identified in step 3 triggers a "yes" response. ¶Younger than 15 years. ***Intrusion* refers to interior compartment intrusion, as opposed to deformation, which refers to exterior damage. ††Includes pedestrians or bicyclists thrown or run over by a motor vehicle or those with estimated impact greater than 20 miles/hour with a motor vehicle. §§Local or regional protocols should be used to determine the most appropriate level of trauma center within the defined trauma system; need not be the highest-level trauma center. ¶¶Older than 55 years. ***Patients with both burns and concomitant trauma for whom the burn injury poses the greatest risk for morbidity and mortality should be transferred to a burn center. If the nonburn trauma presents a greater immediate risk, the patient may be stabilized in a trauma center and then transferred to a burn center. †††Patients who do not meet any of the triage criteria in steps 1 through 4 should be transported to the most appropriate medical facility as outlined in local EMS protocols.

Table 1. Patient characteristics, n=2,110.

Characteristic	No. (%)
Age, median (IQR), y	73 (62–85)
Male sex	1,259 (60)
Race*	
White	1,403 (66)
Black	172 (8.2)
Asian	182 (8.6)
American Indian/Alaskan Native	11 (0.52)
Pacific Islander/Native Hawaiian	27 (1.3)
Other	169 (8.0)
Not reported	205 (9.7)
Ethnicity	
Hispanic	141 (6.7)
Advanced life support transport	1,199 (57)
EMS provider a paramedic	1,567 (74)
Initial out-of-hospital GCS score 15[†]	1,638 (80)
Mechanism of injury	
Direct blow to head	107 (5.1)
Fall from greater than standing height	81 (3.8)
Fall from standing height or less	1,445 (68)
Motor vehicle crash >35 miles/h	117 (5.5)
Motor vehicle crash ≤35 miles/h	186 (8.8)
Auto vs pedestrian/bicyclist	58 (2.7)
Other mechanism of injury	57 (2.7)
Unknown mechanism	59 (2.8)
Reported dementia	254 (12)
Reported intoxication	213 (10)
Anticoagulant/antiplatelet therapy	
Warfarin	137 (6.5)
Aspirin	303 (14)
Direct oral anticoagulant[‡]	12 (0.57)
Other antiplatelet medication[§]	71 (3.4)
More than 1 anticoagulant or antiplatelet medication	72 (3.4)
None	1,515 (72)
Initial INR if warfarin use, median (IQR)	2.2 (1.7–2.6)
Received initial cranial CT scan in the ED	1,616 (77)
ED disposition	
Discharged home	1,410 (67)
Admitted to the floor	372 (18)
Admitted to the ICU	152 (7.2)
Admitted for observation	92 (4.4)
Death in the ED	2 (0.1)
Operating room	22 (1.0)
Transferred to another hospital	26 (1.2)
Other	16 (0.8)
Left against medical advice	18 (0.9)
Hospital length of stay, median (interquartile range)[‖]	3 (2–5)
Injury Severity Score, median (interquartile range)[‖]	5 (2–10)
Isolated head injury[¶]	1,920 (91)

IQR, Interquartile range; *INR*, international normalized ratio.
*May have more than one race listed.
[†]Missing GCS scores in 63 patients.
[‡]Dabigatran, rivaroxaban, and apixaban.
[§]Clopidogrel, ticlopidine, prasugrel, dipyridamole, cilostazol, and ticagrelor.
[‖]Calculated only for admitted patients.
[¶]If Abbreviated Injury Scale score for all nonhead body regions is less than 3.

intracranial hemorrhage on cranial CT imaging. Of these 48 patients, 6 (6/48; 13%) were transferred for a higher level of care to a trauma center, with only one patient receiving a neurosurgical intervention at the trauma center, and 7 (7/48; 15%) were not transferred to a trauma center but died in the hospital from their head injuries.

Table 2. Findings in the 131 patients with traumatic intracranial hemorrhage on CT imaging.

Finding*	No. (%)
Skull fracture	18 (14)
Subdural hematoma	78 (60)
Epidural hematoma	9 (6.9)
Intraparenchymal hematoma/contusion	40 (31)
Intraventricular hemorrhage	12 (9.2)
Subarachnoid hemorrhage	59 (45)
Evidence of midline shift	9 (6.9)
Evidence of herniation	7 (5.3)

*Patients may have more than one finding on CT imaging.

Patients that Met Step 1-3 Field Triage Criteria

One hundred sixty-two patients (162/2,110; 7.7%) met steps 1 to 3 field triage criteria (Figure 2). The majority of these patients were initially transported to a trauma center (113/162; 70%). Twenty-six patients (26/162; 16%) had traumatic intracranial hemorrhage on cranial CT imaging, and 14 (14/162; 8.6%) had a composite outcome of death or neurosurgical intervention. Three patients (3/26; 12%) with traumatic intracranial hemorrhage and 5 (5/14; 36%) with a composite outcome were not initially transported to a trauma center. Patients who met steps 1 to 3 criteria and had a traumatic intracranial hemorrhage or the composite outcome measure but were not initially transported to a trauma center are further described in Table E2, available online at http://www.annemergmed.com.

Of the 162 patients who met steps 1 to 3 criteria, 125 had step 1 criteria (most common specific criteria, GCS score less than 14 [68%]), 5 had step 2 criteria, and 42 had step 3 criteria (most common specific criteria, auto versus pedestrian/bicyclist thrown [43%]), and 10 patients had more than one criterion. Twenty-nine patients (29/162; 18%) were receiving an anticoagulant or antiplatelet medication.

Table 3. Interventions in the 9 patients undergoing neurosurgical intervention.

Neurosurgical Intervention*	No. (%)
Craniotomy	7 (78)
Intracranial pressure monitor placement	2 (22)
Intracranial oxygen probe placement	0
Burr hole	4 (44)
Subdural drain	3 (33)
Ventricular shunt	1 (11)

*Patients may have more than one intervention.

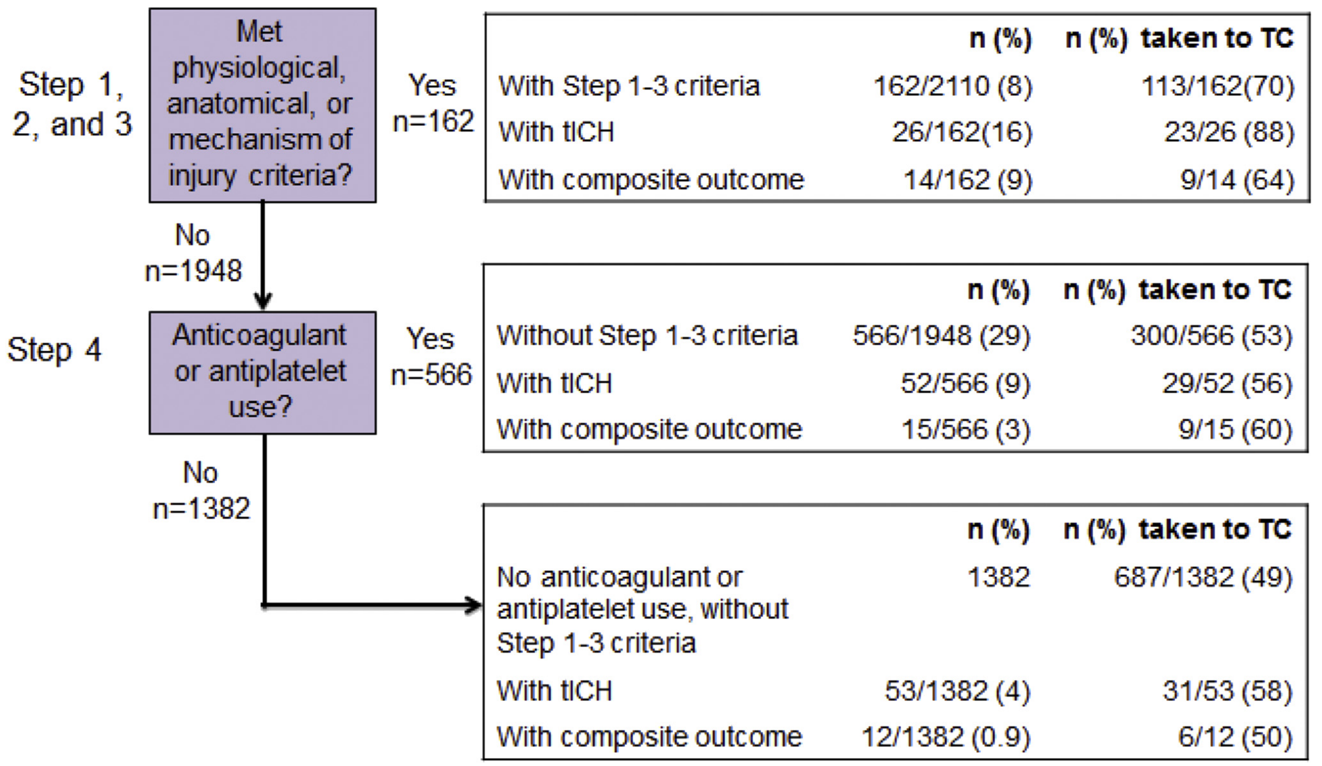


Figure 2. Incidence of outcomes by field triage criteria, n=2,110. Composite outcome includes in-hospital death or neurosurgery. *TC*, Level I or II trauma center; *tICH*, acute traumatic intracranial hemorrhage.

Patients that Did Not Meet Step 1-3 Field Triage Criteria but Had Anticoagulant or Antiplatelet Use

Of the remaining 1,948 patients who did not meet steps 1 to 3 criteria, 566 (566/1,948; 29%) had preinjury anticoagulant or antiplatelet use. Among these 566 patients, 52 (52/566; 9.2%) had traumatic intracranial hemorrhage on cranial CT imaging, and 15 (15; 2.7%) had the composite outcome measure. Three hundred (53%) of the 566 patients were initially transported by EMS to a trauma center (trauma center triage by anticoagulant is described in Table E3, available online at http://www.annemergmed.com). Twenty-three patients (23/52; 44%) with traumatic intracranial hemorrhage and 6 (6/15; 40%) with the composite outcome measure were not initially transported to a trauma center (see Table E4, available online at http://www.annemergmed.com, for further description of these patients). Of the 23 patients with traumatic intracranial hemorrhage who were not taken to a trauma center, 5 (22%) died from their head injury at the initial hospital. One patient (1/23; 4.3%) was transferred to a trauma center and underwent neurosurgery but died during hospitalization. Only 2 patients underwent neurosurgical procedures.

Of the 52 patients with traumatic intracranial hemorrhage on cranial CT imaging, 36 (69%) were receiving aspirin, 13 (25%) were receiving warfarin, 10 (19%) were receiving other antiplatelet medications (all clopidogrel), and 7 (13%) were receiving more than one anticoagulant or antiplatelet medication. No patients with traumatic intracranial hemorrhage on CT were receiving direct oral anticoagulants. Four patients (4/52; 7.7%) underwent neurosurgery and 7 (7/52; 13%) died during hospitalization.

Patients that Did Not Meet Step 1-3 Field Triage Criteria and Had No Anticoagulant or Antiplatelet Use

There were 1,382 patients (1,382/2,110; 71%) who did not meet steps 1 to 3 field triage criteria and were not receiving anticoagulant or antiplatelet medications. Among these patients, 687 (687/1,382; 49%) were initially transported to a trauma center. Fifty-three patients (53/1,382; 3.8%) had traumatic intracranial hemorrhage on CT imaging and 12 (12/1,382; 0.87%) had the composite outcome measure. Of the 53 patients with traumatic intracranial hemorrhage on CT imaging, 3 (5.7%) had neurosurgery and 6 (11%) died during hospitalization. Twenty-two patients (22/53; 42%) with traumatic intracranial hemorrhage and 6 (6/12; 50%) with the composite outcome measure were not initially transported to a trauma center (see Table E5, available online at http://www.annemergmed.com, for further description of these patients).

Of the 22 patients with traumatic intracranial hemorrhage who were not taken to a trauma center, 2 (9.1%) died from their head injury at the initial hospital. Five patients (5/22; 23%) were transported to a trauma center for a higher level of care, and one (1/5; 20%) died during hospitalization. None of these 22 patients underwent a neurosurgical procedure.

The use of only steps 1 to 3 criteria demonstrated poor sensitivity in identifying traumatic intracranial hemorrhage (26/131; 19.8%; 95% CI 5.5% to 51.2%) and inhospital death or neurosurgery (14/41; 34.1%; 95% CI 9.9% to 71.1%). The addition of anticoagulant or antiplatelet use to steps 1 to 3 criteria improved the sensitivity of identification of traumatic intracranial hemorrhage (78/131; 59.5%; 95% CI 42.9% to 74.2%) and death or neurosurgery (29/41; 70.7%; 95% CI 61.0% to 78.9%), with only a moderate decrease in specificity. Actual transport had a sensitivity of 63.4% (83/131; 95% CI 53.7% to 72.1%) in identification of traumatic intracranial hemorrhage and a sensitivity of 58.5% (24/41; 95% CI 40.1-74.9%) in identification of death or neurosurgery. Actual transport plus the use of anticoagulant or antiplatelet criteria had a sensitivity of 81.7% (107/131; 95% CI 72.4% to 87.4%) in identification of traumatic intracranial hemorrhage and a sensitivity of 78.0% (32/41; 95% CI 63.3% to 88.0%) in identification of death or neurosurgery. See Table 4 for complete test characteristics of field triage criteria and actual transport. Test characteristics of steps 1 to 3 criteria, steps 1 to 3 criteria and anticoagulant or antiplatelet use, actual transport, and actual transport plus the use of anticoagulant or antiplatelet criteria including only patients who received a cranial CT scan (n=1,616) and patients with complete data (n=2,047) were overall similar to those of the primary analysis (n=2,110) (Tables E6 and E7, available online at http://www.annemergmed.com).

LIMITATIONS

Our results should be interpreted in the context of some limitations. This was a retrospective study and subject to the inherent limitations of using retrospective data.[25] We followed recommended guidelines for retrospective reviews to minimize any bias.[25] The study was conducted in a single county EMS system; thus, the results might not be generalizable to other EMS systems with different patient populations and access to trauma centers. Our study did, however, include EMS and hospital data from all EMS agencies and hospitals in Sacramento County. This included small- and large-volume EMS agencies, both academic and community hospitals, and trauma and nontrauma centers. EMS transport of patients to specific hospitals may be influenced by other nonclinical factors, such as patient preference, proximity, and health insurance coverage. We were unable to capture these factors and thus could not determine their influence on EMS transport decisions.

To identify patients with head trauma, we used *ICD-9* codes that may not accurately identify all patients with blunt head injury in this population. However, given that the cranial CT imaging rate was 77%, a rate similar to that of a previous prospective ED-based study of a similar study population,[34] we believe our procedures were reasonably accurate in identifying our intended study cohort. Anticoagulant and antiplatelet use was determined according to ED and hospital documentation. It is possible that a variety of factors such as limited access to medication lists, language barriers, altered mental status, or dementia limited the ability of EMS providers to accurately ascertain medication use and influence hospital transport decisions.[26,36] We did not report information about trauma activations or the timing of interventions at trauma and nontrauma centers. Finally, during the study, direct oral

Table 4. Test characteristics of steps 1 to 3 criteria, steps 1 to 3 criteria and anticoagulant or antiplatelet use, actual transport, and actual transport plus if anticoagulant or antiplatelet criteria were used to identify traumatic intracranial hemorrhage (n=131) or the composite outcome of death or neurosurgery during hospitalization (n=41).

	Sensitivity		Specificity	
Test Characteristics	**n**	**% (95% CI)***	**n**	**% (95% CI)***
Identification of traumatic intracranial hemorrhage				
If only steps 1–3 criteria were used	26/131	19.8 (5.5–51.2)	1,843/1,979	93.1 (91.2–94.7)
If steps 1–3+anticoagulant or antiplatelet criteria were used	78/131	59.5 (42.9–74.2)	1,329/1,979	67.2 (61.1–72.7)
Actual transport	83/131	63.4 (53.7–72.1)	962/1,979	48.6 (41.5–55.8)
Actual transport + anticoagulant or antiplatelet criteria were used	107/131	81.7 (74.2–87.4)	710/1,979	35.9 (29.6–42.6)
Identification of death or neurosurgery				
If only steps 1–3 criteria were used	14/41	34.1 (9.9–71.1)	1,921/2,069	92.8 (90.0–94.9)
If steps 1–3+anticoagulant or antiplatelet criteria were used	29/41	70.7 (61.0–78.9)	1,370/2,069	66.2 (61.0–71.1)
Actual transport	24/41	58.5 (40.1–74.9)	993/2,069	48.0 (41.1–55.0)
Actual transport + anticoagulant or antiplatelet criteria were used	32/41	78.0 (63.3–88.0)	725/2,069	35.0 (29.0–41.6)

*Adjusted for clustering by EMS agency.

anticoagulants had only recently been approved by the Federal Drug Administration, and therefore we had few patients with preinjury direct oral anticoagulant use. With increasing use of direct oral anticoagulants, future studies should evaluate head injury outcomes in this population.[37]

DISCUSSION

To our knowledge, this is the first study to examine the rate of traumatic intracranial hemorrhage in older adults with head trauma who are transported by EMS. With an aging population and the proliferation of anticoagulation and antiplatelet therapy in the elderly, this is a critically important patient population commonly treated by EMS providers and in community EDs across the United States. We were particularly interested in the subgroup of patients who did not meet steps 1 to 3 criteria but were receiving anticoagulant or antiplatelet medications. This subgroup is of particular interest to the National Expert Panel on Field Triage, whose most recent field triage guidelines highlighted the risk for traumatic intracranial hemorrhage and neurologic deterioration within this group.[18] The findings in this study can inform future guideline revisions.

The results of our study demonstrated several interesting findings. First, only 8% of older adults with head trauma met steps 1 to 3 field triage criteria. The most common reason for meeting these steps was a GCS score less than 14. The low prevalence of older adults with head trauma who met these criteria is likely because this group primarily has low-mechanism injuries such as falls from standing height or less (68%), isolated head injuries (91%), and initial out-of-hospital GCS scores of 15 (80%). Consequently, this group infrequently meets physiologic (step 1), anatomic (step 2), or mechanism-of-injury (step 3) field triage criteria. These characteristics are consistent with those in other studies evaluating older adults with head trauma.[19,34]

Second, of the patients who did not meet steps 1 to 3 field triage criteria, nearly 30% had preinjury anticoagulant or antiplatelet use, with aspirin and warfarin the 2 most common medications. This relatively high prevalence of anticoagulant or antiplatelet use is both surprising and concerning. Given the higher rate of morbidity and mortality associated with preinjury anticoagulant or antiplatelet use, EMS and hospital providers need to be vigilant about the assessment of these medications. In our study, of patients not meeting steps 1 to 3 criteria, those with anticoagulant or antiplatelet use had a higher rate of traumatic intracranial hemorrhage (9.2%; 95% CI 6.9% to 11.9%) compared with those without anticoagulant or antiplatelet use (3.8%; 95% CI 2.9% to 5.0%).

Third, of patients who did not meet steps 1 to 3 criteria but were receiving anticoagulant or antiplatelet medications, EMS providers transported roughly half of them to trauma centers. This group of patients had a relatively high proportion of traumatic intracranial hemorrhage (9%), with only approximately half of these patients initially transported to a trauma center. Because rates of trauma center triage were similar for patients with traumatic intracranial hemorrhage (56%) and without it (55%), this group of patients likely appeared well, and it may have been difficult for EMS providers to discern which patients were at risk for traumatic intracranial hemorrhage. Trauma center triage was also similar in this group of patients with anticoagulant or antiplatelet use (53%) and without it (50%). This suggests that the decision to transport to a trauma center may be less influenced by the use of anticoagulants or antiplatelets and more due to other factors such as patient preference or hospital proximity. Moreover, trauma center transport did not seem to differ by type of anticoagulant or antiplatelet medication (Table E3, available online at http://www.annemergmed.com).

Potential advantages exist in regard to the initial management of older adults with traumatic intracranial hemorrhage at a trauma center compared with a nontrauma center. Trauma centers (Level I or II) have 24-hour, 7-day-a-week coverage of neurosurgical capabilities, whereas nontrauma centers often must transfer these patients to a trauma center, thus potentially leading to a delay in surgical intervention and a greater likelihood of secondary injury.[38-40] Our study, however, demonstrated that less than 1% of patients underwent a neurosurgical intervention. Also, of the 48 patients who were triaged to a nontrauma center but then received a diagnosis of a traumatic intracranial hemorrhage, only 6 were transferred to a trauma center for a higher level of care, and only one of these patients received a neurosurgical intervention. This suggests that the majority of patients with traumatic intracranial hemorrhage who were initially managed at nontrauma centers were managed with observation and ultimately discharged from the hospital without neurosurgical intervention or transfer to a trauma center. Although neurosurgical intervention and death were rare in older adults with head trauma, it is possible that initial management of these patients at trauma centers will lead to improved outcomes such as long-term cognitive functioning. For example, trauma centers may have more availability of traumatic brain injury–related resources such as neurorehabilitation specialists.[41,42]

The best method to triage this population of patients from the field remains unclear. Previous work has established the mortality benefit of trauma center care for severely injured patients and the lack of sensitivity of relying on only anatomic, physiologic, and mechanism-of-injury field criteria (steps 1 to 3) to identify such patients.[18,43] However, with few patients meeting steps 1 to 3 criteria in our cohort of older adults with head injury, it is clear that use of only steps 1 to 3 criteria would miss the majority of patients with traumatic intracranial hemorrhage and death or neurosurgery. Similarly, in a sample of 90,000 injured patients transported by EMS, Newgard et al[44] found that steps 1 to 3 criteria were only 71% sensitive in detecting patients with an Injury Severity Score greater than 15. The addition of anticoagulant or antiplatelet use to steps 1 to 3 criteria would increase the sensitivity of field triage criteria but would still miss a number of patients with traumatic intracranial hemorrhage (40%) and death or neurosurgery (30%). The addition of anticoagulant or antiplatelet use as a criterion for trauma center transport also increased the sensitivity to identify patients with traumatic intracranial hemorrhage (increased by 18%) and death or neurosurgery (increased by 20%) compared to actual transport alone. This criteria of actual transport plus the additional criterion of anticoagulant or antiplatelet use was the most sensitive triage criteria evaluated. This suggests that perhaps the most accurate model is a pragmatic one, where EMS provider judgment plus anticoagulant or antiplatelet use criterion performs better than physiological, anatomical, and mechanism of injury criteria for older adults with head trauma. Prior work has demonstrated that EMS provider judgment is the most commonly used field trauma triage criterion and is useful in identifying high-risk patients missed by other criteria.[45] In addition, increasing the proportion of older adults identified by triage criteria does not necessarily lead to increased transport of these patients to trauma centers. One previous study demonstrated that statewide adoption of a specific trauma triage for older adults increased the proportion of patients meeting criteria but did not increase trauma center transports.[46,47]

In particular, the existing literature is mixed in regard to the benefit of trauma center care for traumatic brain injury patients. In the United Kingdom, a systematic review by Fuller et al[48] demonstrated no benefit accrued with transfer of nonsurgical traumatic brain injury patients, calling into question the benefit of direct transport of such patients from the field. Another systematic review of 36 observational studies did not find an association between trauma admission type (transfer versus direct) and mortality, although the review was limited by heterogeneity of data.[49]

The results of our study do not necessarily support more stringent step 4 language or implementation. Our study demonstrated that patients not meeting explicit steps 1 to 3 field triage criteria but who had preinjury anticoagulant or antiplatelet use had a higher risk for traumatic intracranial hemorrhage (compared with those without steps 1 to 3 criteria and no anticoagulant or antiplatelet use) but very low risk for requiring a neurosurgical intervention or death resulting from traumatic intracranial hemorrhage. In the majority of cases, these patients with traumatic intracranial hemorrhage were managed without neurosurgical intervention or were transferred to a trauma center. All receiving hospitals in our system had the capability of providing an initial evaluation and stabilization of these patients. With the advent and spread of rapid retriage protocols that simplify transfer of trauma patients, the timeliness of transfer in the setting of rapid neurologic deterioration is also becoming maximized to the benefit of patients needing definitive trauma care.[50] In our study, it would require transport of 37 patients who did not explicitly meet steps 1 to 3 field triage criteria but had preinjury anticoagulant or antiplatelet use to trauma centers to identify one patient with death or neurosurgical intervention.

In conclusion, in our study of older adults with head trauma in a single EMS system in California, relatively few patients met steps 1 to 3 triage criteria. For patients who did not have steps 1 to 3 criteria, nearly 30% had anticoagulant or antiplatelet use, with only approximately half of them being triaged to a trauma center. A relatively high proportion of these patients had traumatic intracranial hemorrhage, but a much smaller proportion had a composite outcome of death or neurosurgical intervention. Use of steps 1 to 3 triage criteria alone is not sufficient in identifying traumatic intracranial hemorrhage and death or neurosurgery in this patient population. Including the criterion of anticoagulant or antiplatelet use in the field triage guidelines improves the sensitivity of the field triage criteria.

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Author affiliations: From the Department of Emergency Medicine, UC Davis School of Medicine, Sacramento, CA (Nishijima, Gaona, Holmes); the City of Sacramento Fire Department, Sacramento, CA (Waechter); the Sacramento Metropolitan Fire Department, Sacramento, CA (Maloney); the Cosumnes Community Services District Fire Department, Elk Grove, CA (Bair); American Medical Response, Sacramento, CA (Blitz); the Kaiser Permanente South Sacramento Medical Center, Sacramento, CA (Elms); Mercy General Hospital, Sacramento, CA (Farrales); the City of Folsom Fire Department, Folsom, CA (Howard); Sutter General Hospital, Sacramento, CA (Montoya); the Centers for Disease Control and Prevention, Atlanta, GA (Bell, Faul); the Kaiser Permanente Sacramento Medical Center, Sacramento, CA (Vinson, Garzon); and the Kaiser Permanente San Rafael Medical Center, San Rafael, CA (Ballard).

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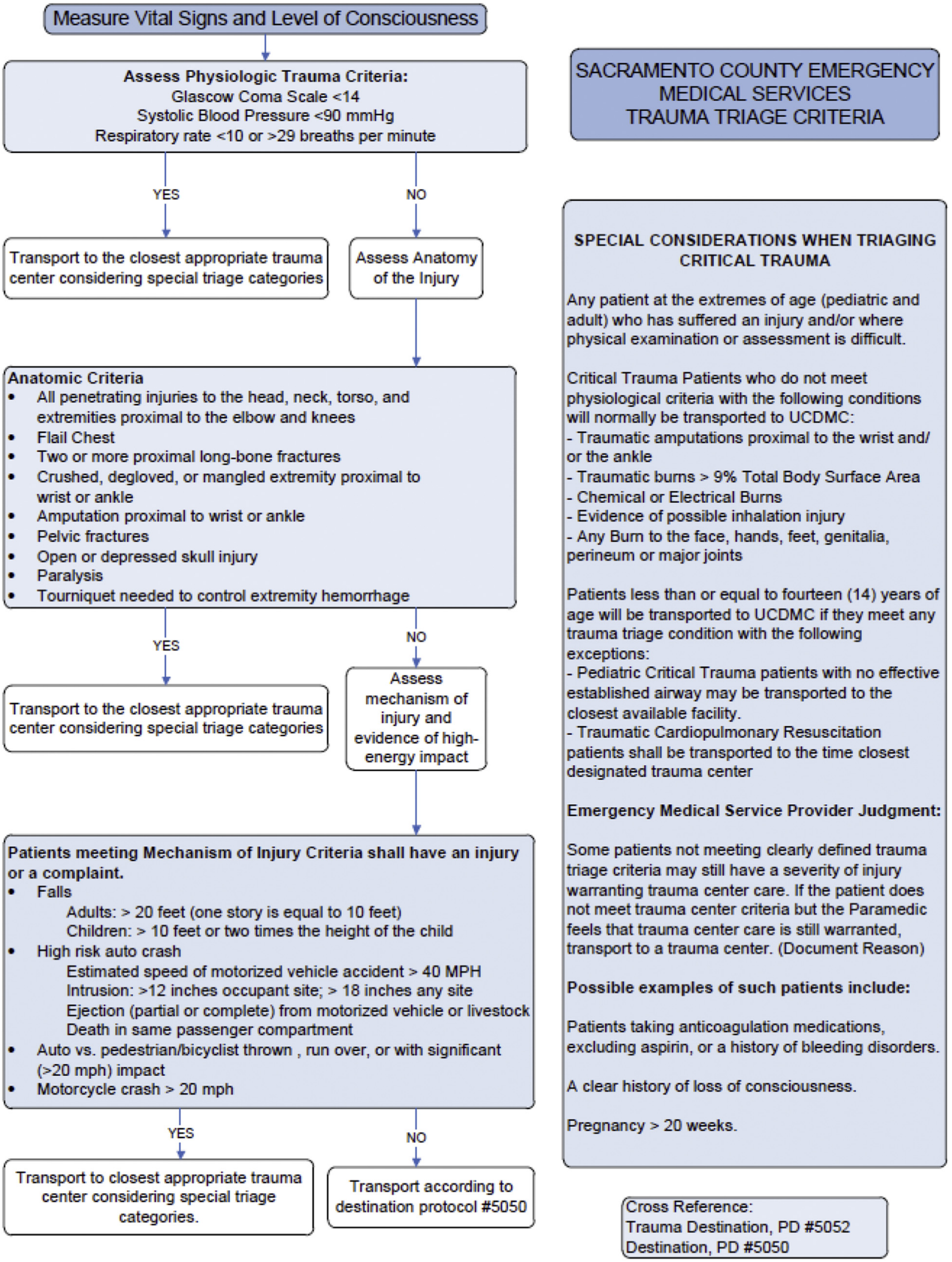

Figure E1. Sacramento County Trauma Triage Tool.

Table E1. Interrater agreement for out-of-hospital and ED or hospital variables, n=93.

Characteristic	Percentage Agreement, No. (%)	κ (95% CI)
Mechanism of injury	87/93 (94)	0.87 (0.78–0.94)
Out-of-hospital documented warfarin use	92/93 (99)	0.96 (0.90–1.00)
Out-of-hospital documented aspirin use	91/93 (98)	0.94 (0.93–1.00)
Out-of-hospital initial GCS score	92/93 (99)	0.97 (0.92–1.0)
ED or hospital documented warfarin use	92/93 (99)	0.94 (0.83–1.0)
ED or hospital documented aspirin use	91/93 (98)	0.93 (0.83–1.0)
ED initial GCS score	88/93 (95)	0.78 (0.70–0.80)
Traumatic intracranial hemorrhage on cranial CT	93/93 (100)	1.0 (1.0–1.0)
Inhospital death or neurosurgery	93/93 (100)	1.0 (1.0–1.0)

Table E2. Description of 6 patients who met steps 1 to 3 criteria and had a traumatic intracranial hemorrhage or the composite outcome measure but were not transported to a trauma center.*

Age, Years Sex	Mechanism of Injury	Anticoagulant/ Antiplatelet Agents	Initial EMS GCS Score	Steps 1–3 Criteria Met	EMS Transport Time	Cranial CT Findings	ISS	Hospital Disposition	Composite Outcome†	Death Caused by Head Trauma	Transfer to Trauma Center	Neurosurgery
89 M	Fall from standing	None	15	Physiologic (SBP 80)	17	SDH	17	Discharged home, HD 3	None	—‡	No	No
84 F	Fall from standing	None	13	Physiologic (GCS score 13)	7	IPH, SAH, herniation	25	Died, HD 3	Death	Yes	No	No
82 F	Fall from standing	Warfarin, aspirin	13	Physiologic (GCS score 13)	7	SDH, IPH, SAH	17	Died, HD 3	Death	Yes	No	No
66 F	Fall from standing	None	12	Physiologic (GCS score 12)	8	Normal	0	Died, HD 9	Death	No	No	No
88 M	Fall from standing	None	13	Physiologic (GCS score 13)	11	Normal	1	Died, HD 1	Death	No	No	No
80 M	Fall from standing	Clopidogrel	10	Physiologic (GCS score 10)	23	Normal	2	Died, HD 3	Death	No	No	No

ISS, Injury Severity Score; *SBP*, systolic blood pressure; *SDH*, subdural hematoma; *HD*, hospital day; *IPH*, intraparenchymal hemorrhage/contusion; *SAH*, subarachnoid hemorrhage.
*Two patients had both traumatic intracranial hemorrhage and composite outcome measure.
†Inhospital death or neurosurgery.
‡Dashes indicate data not applicable.

Table E3. Trauma center triage for patients who did not meet steps 1 to 3 criteria and had anticoagulant or antiplatelet use, n=566.

Medication	Triaged to Trauma Center, No. (%)*
Warfarin	97/161 (60)
Direct oral anticoagulants†	8/15 (53)
Aspirin	186/350 (53)
Other antiplatelet agents‡	51/110 (46)

*Includes concomitant medications.
†Dabigatran, rivaroxaban, and apixaban.
‡Clopidogrel, ticlopidine, prasugrel, dipyridamole, cilostazol, and ticagrelor.

Table E4. Description of 24 patients who did not meet steps 1–3 criteria, had anticoagulant or antiplatelet use, had a traumatic intracranial hemorrhage or the composite outcome measure, and were not transported to a trauma center.*

Age, Years Sex	Mechanism of Injury	Anticoagulant/ Antiplatelet Agents	Initial EMS GCS Score	EMS Transport Time	Cranial CT Findings	ISS	Hospital Disposition	LOS, Days	Composite Outcome†	Death Caused by Head Trauma	Transfer to Trauma Center	Neurosurgery
80 F	Fall from standing	Aspirin	14	10	SAH	17	Discharged SNF	5	None	—‡	No	No
84 F	Fall from standing	Warfarin	14	17	SAH	21	Discharged SNF	9	None	No	No	No
84 M	Fall from standing	Aspirin	14	27	IPH	17	Died	3	Death	Yes	No	No
69 M	Fall from standing	Aspirin	Missing	17	SDH, IPH	17	Discharged home	1	None	—	No	No
82 M	Fall from standing	Clopidogrel	15	18	SDH	17	Discharged home	3	None	—	No	No
86 F	Unknown	Warfarin	Missing	15	SDH, SAH	17	Discharged intermediate care facility	3	None	—	No	No
77 F	Fall from standing	Aspirin	15	16	IPH	10	Discharged home	1	None	—	No	No
91 F	Fall from standing	Aspirin	14	19	SAH	10	Discharged rehabilitation facility	9	None	—	No	No
75 F	Fall from standing	Aspirin	15	1	SDH, IPH	17	Died	1	Death, neurosurgery	Yes	No	ICP monitor
84 M	Fall from standing	Clopidogrel, aspirin	14	2	SDH, IPH, SAH	21	Discharged home	24	None	—	No	No
84 M	Fall from standing	Aspirin	15	15	SDH	17	Discharged home	1	None	—	No	No
64 F	Fall from standing	Aspirin	15	17	SDH	26	Discharged home	2	None	—	No	No
72 M	Fall from standing	Clopidogrel	15	13	IPH	16	Died	5	Death	Yes	Yes	No
69 M	Fall from standing	Warfarin	15	9	SDH	9	Died	11	Death, neurosurgery	Yes	Yes	Subdural drain
94 F	Fall from standing	Clopidogrel, aspirin	15	19	SDH, SAH	16	Died	6	Death	Yes	No	No
81 M	Fall from standing	Aspirin	15	13	SDH	17	Discharged home	2	None	—	No	No
95 F	Fall from standing	Warfarin	15	19	SAH	10	Discharged SNF	3	None	—	No	No
86 F	Fall from standing	Aspirin	15	3	SDH	17	Discharged home	1	None	—	No	No
92 M	Fall from standing	Aspirin	15	18	Normal	9	Died	2	Death	No	No	No
82 M	Fall from standing	Clopidogrel, aspirin	15	11	SAH	9	Discharged home	0	None	—	No	No
56 M	Unknown	Warfarin	15	5	SDH	21	Discharged home	3	None	—	No	No
81 F	Fall from standing	Warfarin	15	23	IPH	9	Discharged home	0	None	—	No	No
71 F	Fall from standing	Aspirin	15	20	SDH, SAH	17	Discharged home	3	None	—	No	No
82 F	Fall from standing	Warfarin	15	11	SDH	17	Discharged SNF	6	None	—	No	No

LOS, Length of stay; *SNF*, skilled nursing facility; *ICP*, intracranial pressure.
*Five patients had both tICH and composite outcome measure.
†Inhospital death or neurosurgery.
‡Dashes indicate data not applicable.

Table E5. Description of 25 patients who did not meet steps 1 to 3 criteria, had no anticoagulant or antiplatelet use, had a traumatic intracranial hemorrhage or composite outcome measure, and were not transported to a trauma center.*

Age, Years Sex	Mechanism of Injury	Initial EMS GCS score	EMS Transport Time	Cranial CT Findings	ISS	Hospital Disposition	LOS, Days	Composite Outcome†	Death Caused by Head Trauma	Transfer to Trauma Center	Neurosurgery
55 M	Fall from standing	15	12	IPH	10	Discharged home	3	None	—‡	No	No
88 M	Fall from standing	15	26	EDH	17	Died	3	Death	Yes	No	No
95 M	Fall from height	15	26	Normal	1	Died	0	Death	No	No	No
89 F	Fall from standing	15	3	SDH	21	Discharged SNF	3	None	—	No	No
89 F	Fall from standing	15	22	IPH	17	Discharged SNF	4	None	—	No	No
94 M	Fall from standing	15	12	SDH	17	Discharged home	1	None	—	No	No
70 M	Unknown	15	21	SDH	10	Discharged home	0	None	—	No	No
55 F	Fall from standing	15	14	SAH	20	Discharged home	6	None	—	No	No
88 F	Fall from standing	15	17	SDH, IPH, SAH	17	Discharged SNF	6	None	—	No	No
78 F	Fall from standing	15	18	IPH	9	Discharged SNF	2	None	—	No	No
87 F	Fall from standing	14	12	IPH, SAH	17	Died	3	Death	Yes	No	No
87 F	Fall from standing	15	6	SDH, IPH, SAH	26	Died	4	Death	Yes	Yes	No
76 F	Fall from standing	15	16	SDH, IPH	17	Discharged home	5	None	—	Yes	No
85 M	Fall from standing	14	16	IPH, SAH	10	Discharged SNF	5	None	—	No	No
75 F	Fall from standing	15	18	SAH	10	Discharged SNF	3	None	—	No	No
104 F	Fall from standing	15	23	Normal	0	Died	2	Death	No	No	No
92 M	MVC >35 mph	15	14	IPH, SAH	21	Discharged home	1	None	—	Yes	No
89 F	Fall from standing	15	19	SAH	10	Discharged home	1	None	—	No	No
88 F	Fall from standing	15	14	SAH	17	Discharged home	2	None	—	Yes	No
84 F	Fall from standing	15	11	Normal	5	Died	2	Death	No	No	No
63 F	Fall from standing	15	13	IVH	17	Discharged SNF	3	None	—	Yes	No
92 F	Fall from standing	15	16	SDH	17	Discharged SNF	3	None	—	No	No
91 M	Unknown	15	11	SDH, SAH	18	Discharged SNF	30	None	—	No	No
93 M	Unknown	15	13	SDH	17	Discharged home	1	None	—	No	No
77 M	Fall from standing	14	14	IVH	17	Discharged home	1	None	—	No	No

MVC, Motor vehicle crash.
*Three patients had both traumatic intracranial hemorrhage and composite outcome measure.
†Inhospital death or neurosurgery.
‡Dashes indicate data not applicable.

Table E6. Sensitivity analysis including only patients who received a cranial CT scan (n=1,616).*

	Sensitivity		Specificity	
Test Characteristics	**n**	**% (95% CI)**	**n**	**% (95% CI)**
Identification of traumatic intracranial hemorrhage				
If only steps 1–3 criteria were used	26/131	19.8 (13.9–27.5)	1,349/1,485	90.8 (89.3–92.2)
If steps 1–3+anticoagulant or antiplatelet criteria were used	75/131	57.3 (48.7–65.4)	922/1,485	62.1 (59.6–64.5)
Actual transport	83/131	63.4 (54.8–71.1)	676/1,485	45.5 (44.4–48.1)
Actual transport + anticoagulant or antiplatelet criteria were used	107/131	81.7 (74.2–87.4)	476/1,485	32.1 (29.7–34.5)
Identification of death or neurosurgery				
If only steps 1–3 criteria were used	13/40	32.5 (20.1–48.0)	148/1,576	90.6 (89.1–92.0)
If steps 1–3+anticoagulant or antiplatelet criteria were used	28/40	70.0 (54.6–81.9)	966/1,576	61.3 (58.9–63.7)
Actual transport	23/40	57.5 (42.2–71.5)	707/1,576	44.9 (42.4–47.3)
Actual transport + anticoagulant or antiplatelet criteria were used	31/40	77.5 (62.5–87.7)	491/1,576	31.2 (28.9–33.5)

*Test characteristics of steps 1 to 3 criteria, steps 1 to 3 criteria and anticoagulant or antiplatelet use, actual transport, and actual transport and anticoagulant or antiplatelet use to identify traumatic intracranial hemorrhage (n=131) or the composite outcome of death or neurosurgery during hospitalization (n=40).

Table E7. Sensitivity analysis including only patients with complete data (n=2,047).*

	Sensitivity		Specificity	
Test Characteristics	**n**	**% (95% CI)**	**n**	**% (95% CI)**
Identification of traumatic intracranial hemorrhage				
If only steps 1–3 criteria were used	26/125	20.8 (14.6–28.7)	1,786/1,922	92.9 (91.7–94.0)
If steps 1–3+anticoagulant or antiplatelet criteria were used	75/125	60.0 (51.2–68.2)	1,284/1,922	66.8 (64.7–68.9)
Actual transport	79/125	63.4 (54.5–71.1)	939/1,922	48.9 (46.6–51.1)
Actual transport + anticoagulant or antiplatelet criteria were used	101/125	80.8 (73.0–86.7)	693/1922	36.1 (33.9–38.2)
Identification of death or neurosurgery				
If only steps 1–3 criteria were used	14/40	35.0 (22.1–50.5)	1,859/2,007	92.6 (91.4–93.7)
If steps 1–3+anticoagulant or antiplatelet criteria were used	29/40	70.7 (55.5–82.4)	1,323/2,007	65.9 (63.8–67.9)
Actual transport	24/40	58.5 (43.4–72.2)	969/2,007	48.2 (46.1–50.4)
Actual transport + anticoagulant or antiplatelet criteria were used	31/40	77.5 (62.5–87.7)	708/2007	35.3 (33.2–37.4)

*Test characteristics of steps 1 to 3 criteria, steps 1 to 3 criteria and anticoagulant or antiplatelet use, actual transport, and actual transport and anticoagulant or antiplatelet use to identify traumatic intracranial hemorrhage (n=125) or the composite outcome of death or neurosurgery during hospitalization (n=40).