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Prehospital Triage of Older Adults with Head Injury: A Retrospective Study of the Impact of Adding "Anticoagulation or Antiplatelet Medication Use" as a Criterion

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Abstract

Study Objective—Field triage guidelines recommend 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 was to describe the characteristics and outcomes of older adults with head trauma

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DN and JH conceived the study, designed the trial, and obtained research funding. DN, SG, JB, MF, JH supervised the conduct of the trial and data collection. DN and SG undertook recruitment of participating centers and patients and managed the data, including quality control. DN, MF, JH provided statistical advice on study design and analyzed the data. DB drafted the manuscript, and all authors contributed substantially to its revision. DN takes responsibility for the paper as a whole.

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transported by EMS, particularly in patients that do not meet physiological, anatomical, or mechanism of injury (Step 1-3) field triage criteria but are taking anticoagulant or antiplatelet medications.

Methods—This was a retrospective study at 5 EMS agencies and 11 hospitals (4 trauma centers, 7 non-trauma centers). Patients ≥55 years 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 in-hospital death or neurosurgery.

Results—2110 patients were included; 131 (6%) had intracranial hemorrhage and 41 (2%) had in-hospital death or neurosurgery. There were 162 patients (8%) with Step 1-3 criteria. Of the remaining 1948 patients without Step 1-3 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 of Step 1-3 criteria was 19.8% (26/131; 95% CI 5.5-51.2%) for identifying traumatic intracranial hemorrhage and 34.1% (14/41; 95% CI 28.9-90.1%) for death or neurosurgery. The additional criterion of anticoagulant or antiplatelet use improved the sensitivity for intracranial hemorrhage (78/131; 59.5%, 95% 42.9-74.2%) and death or neurosurgery (29/41; 70.7%, 95% CI 61.0-78.9%).

Conclusions—Relatively few patients met Step 1-3 triage criteria. In those who did not have Step 1-3 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 Step 1-3 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.

INTRODUCTION

Background

Traumatic brain injury (TBI) 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 TBI patients treated at hospitals and trauma centers.[3] Older adults have higher morbidity and mortality after TBI than younger patients due to brain anatomical differences, higher co-morbidity 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 post-traumatic disability and death.[6-9] Traumatic intracranial hemorrhage in patients on anticoagulants has been described as an epidemic in patients 55 years of age or older.[10]

Rapid diagnosis of traumatic intracranial hemorrhage with cranial computed tomography (CT) is critical to determine if reversal agents and/or blood products should be administered. In patients on warfarin requiring immediate neurosurgical intervention, rapid and efficacious reversal to an appropriate international normalized ratio (INR) level is essential as INR levels >1.25 increase postoperative mortality.[11-13] Patients taking antiplatelet medications or direct oral anticoagulants with significant bleeding after trauma or requiring emergent surgery may require 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 TBI to trauma centers with the capability of rapidly and comprehensively treating these patients.[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 includes 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 TBI-related hospitalization and worse TBI-related outcomes compared to younger adults.[19-22] In addition, older adults are more frequently undertriaged to non-trauma centers than younger adults with similar injuries.[23,24] In response to these issues involving older adults with head injury, particularly those who are anticoagulated, the most recent field triage guidelines revised the special considerations criteria (Step 4) to include additional language for patients taking anticoagulants (including both anticoagulant and antiplatelet medications), stating “Patients 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.

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 transported by EMS, with a particular focus on patients that do not meet physiological, anatomical, or mechanism of injury field triage criteria but are taking anticoagulant or antiplatelet medications. We compared the sensitivity and specificity of Step 1-3 of the field triage guidelines on identifying clinical outcomes to the sensitivity and specificity of Step 1-3 with the additional criterion of anticoagulant or antiplatelet use.

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 prior 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 9-1-1 medical emergencies. Over 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 in-patient beds. Nine hospitals are located within Sacramento County and two are located in the adjacent Placer County. We included these two out-of-county acute care hospitals since Sacramento County EMS agencies routinely transport patients to these two hospitals and do so under the guidance of the Sacramento County Trauma Triage Tool (eFigure) that was adapted from the most recent field triage guidelines (2011).[18] Of these 11 hospitals, one is a Level I adult trauma center, three are designated as Level II adult trauma centers, and seven are non-trauma centers. In 2011, there were 3,345 major trauma patients (adults and children) admitted to the 4 designated trauma centers from incidents within Sacramento County.

Study Participants

We included patients 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 using EMS agency billing data and International Classification of Diseases, 9th> 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 and Measurements

All EMS agencies used similar prehospital 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, date of birth), transport characteristics (date of transport, EMS agency, level of transport, level of EMS provider, receiving hospital), mechanism of injury and clinical characteristics (initial field GCS score, reported dementia, reported intoxication). Step 1-3 field triage criteria were coded based on the presence or absence of explicit criteria documented on EMS charts.

Eligible EMS patient transports were linked to ED and hospital records using 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, ED physician notes, hospital admission and discharge physician notes, and medication reconciliation lists and abstracted the following data: demographics (age, sex, ethnicity, 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 due to head injury. Anticoagulants/antiplatelets included warfarin or direct oral anticoagulants (dabigatran, rivaroxaban, or apixaban), aspirin, clopidogrel, ticlodipine, prasugrel, dipyridamole, cilostazol, and ticagrelor. Use of anticoagulant or antiplatelet medications was based on receiving hospital documentation of the patient use during the week prior to 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 non-head body regions.[27]

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

A second data abstractor, blinded to the responses from the first abstractor, performed an independent data abstraction of prehospital and ED/hospital variables including the study outcomes. This second data abstraction was a 5% random sample of the study cohort.

Outcomes

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

Analysis

We formatted the data and recoded the variables using STATA 13.1 statistical software (STATA Corp, College Station, TX). 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 three separate criteria to identify a) traumatic intracranial hemorrhage or b) in-hospital death or neurosurgery. The three criteria were: a) If only Step 1-3 criteria were used, b) if Step 1-3 and anticoagulant or antiplatelet criterion were used, and c) actual transport. Sensitivity and specificity were calculated with 95% confidence intervals and based on two by two tables and adjusted for clustering by EMS agency.[31] For this primary analysis, we included patients that did not receive a cranial CT scan during hospitalization and patients with missing data. To evaluate the impact of excluding these patients, we conducted two sensitivity analyses. First, we calculated test characteristics of the three criteria as described above, however including only patients that received a cranial CT scan. Second, we calculated test characteristics of the three criteria including only patients with complete data.

To assess interrater agreement, we calculated percent agreement and the kappa statistic (with 95% confidence intervals) using normal approximation methods for binary or categorical variables and the weighted kappa statistic for ordinal variables.[32,33] Based on prior data that evaluated a similar patient population, we estimated that collecting 12 months 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 the Study Subjects

A total of 2110 patients were included in the study after excluding 174 patients (7.6%; 173 for unmatched hospital data, and 1 with penetrating head trauma). The median age was 73 years (IQR 62-85 years) and 1259 (60%) were male. The most common mechanism of injury was fall from standing height or less (1445/2110; 68%). The majority of patients had an initial GCS score by EMS of 15 (1638/2047; 80%). Five hundred and ninety-five patients (595/2110; 28%) had preinjury anticoagulant or antiplatelet use. Complete patient characteristics are reported in Table 1.

The five EMS agencies transported from 104 to 952 patients, and the majority of patients were transported by Advanced Life Support (1199/2110; 57%) and treated by a paramedic (1567/2110; 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 (eTable 1).[35]

Main Results

Of the 2110 transports, 131 (6.2%, 95% CI 5.2-7.3%) were diagnosed with traumatic intracranial hemorrhage on cranial CT imaging and 41 (1.9%, 95% CI 1.4-2.6%) 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 those with a neurosurgical intervention, 4 died (4/9; 44%).

Overall, 1100 patients (1100/2110; 52%) were transported initially to a trauma center. Of the remaining 1010 patients (1010/2110; 48%) transported initially to a non-trauma center, 48 patients (48/1010; 4.8%) had a traumatic 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.

Patients that met Step 1-3 field triage criteria—One hundred sixty-two patients (162/2110; 7.7%) met Step 1-3 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 patients (14/162; 8.6%) had a composite outcome of death or neurosurgical intervention. Three patients (3/26; 12%) with traumatic intracranial hemorrhage and 5 patients (5/14; 36%) with a composite outcome were not initially transported to a trauma center. Patients who met Step 1-3 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 eTable 2.

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

Patients that did not meet Step 1-3 field triage criteria but had anticoagulant or antiplatelet use—Of the remaining 1948 patients that did not meet Step 1-3 criteria, 566 patients (566/1948; 29%) had preinjury anticoagulant or antiplatelet use. Among these 566 patients, 52 patients (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 eTable 3). Twenty-three patients (23/52; 44%) with traumatic intracranial hemorrhage and 6 patients (6/15; 40%) with the composite outcome measure were not initially transported to a trauma center (see eTable 4 for further description of these patients). Of the 23 patients with traumatic intracranial hemorrhage not taken to a trauma center, five (22%) died from their head injury at the initial hospital. One (1/23; 4.3%) was transferred to a trauma center, underwent neurosurgery, but ultimately died during hospitalization. Only two patients underwent neurosurgical procedures.

Of the 52 patients with traumatic intracranial hemorrhage on cranial CT imaging, 36 (69%) were taking aspirin, 13 (25%) were taking warfarin, 10 (19%) were taking other antiplatelet medications (all clopidogrel), and seven (13%) were taking more than one anticoagulant or antiplatelet medication. No patients with traumatic intracranial hemorrhage on CT were taking direct oral anticoagulants. Four (4/52; 7.7%) patients underwent neurosurgery and seven patients (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 1382 patients (1382/2110; 71%) that did not meet Step 1-3 field triage criteria and were not taking anticoagulant or antiplatelet medications. Among these patients, 687 (687/1382; 49%) were initially transported to a trauma center. Fifty-three patients (53/1382; 3.8%) had traumatic intracranial hemorrhage on CT imaging and 12 (12/1382; 0.87%) had the composite outcome measure. Of the 53 patients with traumatic intracranial hemorrhage on CT imaging, three (5.7%) had neurosurgery and six patients (11%) died during hospitalization. Twenty-two patients (22/53; 42%) with traumatic intracranial hemorrhage and six patients (6/12; 50%) with the composite outcome measure were not initially transported to a trauma center (see eTable 5 for further description of these patients).

Of the 22 patients with traumatic intracranial hemorrhage not taken to a trauma center, two (9.1%) died from their head injury at the initial hospital. Five (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.

Sensitivity and specificity of field triage criteria and actual transport—The use of only Step 1-3 criteria demonstrated poor sensitivity in identifying traumatic intracranial hemorrhage (26/131; 19.8%, 95% CI 5.5-51.2%) and in-hospital death or neurosurgery (14/41; 34.1%, 95% CI 21.6-49.5%). The addition of including anticoagulant or antiplatelet use to Step 1-3 criteria improved the sensitivity of identification of traumatic intracranial hemorrhage (78/131; 59.5%, 51.0-67.6%) and death or neurosurgery (29/41; 70.7%, 55.5-82.4%) with only a moderate decrease in specificity. Actual transport had a sensitivity of 63.4% (83/131; 95% CI 54.8-71.1%) to identify traumatic intracranial hemorrhage and a sensitivity of 58.5% (24/41; 95% CI 40.1-74.9%) to identify death or neurosurgery. See Table 4 for complete test characteristics of field triage criteria and actual transport. Test characteristics of Step 1-3 criteria, Step 1-3 criteria and anticoagulant or antiplatelet use, and actual transport including only patients that received a cranial CT scan (n=1616) and patients with complete data (n=2047) were overall similar to the primary analysis (n=2110) (eTables 6 and 7).

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 non-trauma centers. EMS transport of patients to specific hospitals may be influenced by other non-clinical factors, such as patient preference, proximity, and health insurance coverage. We were unable to capture these factors and thus could not determine the influence of these factors on EMS transport decisions.

We used ICD-9 codes to identify patients with head trauma 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 a prior prospective ED based study on a similar study population,[34] we believe our procedures were reasonably accurate in identifying our intended study cohort. Anticoagulant and antiplatelet use was determined based on 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 may limit the ability of EMS providers to accurately ascertain medication use and influence hospital transport decisions.[26,36] We did not report information regarding trauma activations or the timing of interventions at trauma and non-trauma centers. Finally, at the time of the study, direct oral anticoagulants were recently approved by the Federal Drug Administration and therefore we have very 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 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 seen commonly by EMS providers and in community EDs across the United States. We were particularly interested in the subgroup of patients who did not meet Step 1-3 criteria but were taking anticoagulant or antiplatelet medications. This subgroup of patients are 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 neurological 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 Step 1-3 field triage criteria. The most common reason for meeting Step 1-3 triage criteria was a GCS score < 14. The low prevalence of older adults with head trauma meeting Step 1-3 field triage criteria is likely because this group of patients primarily have low mechanism injuries such falls from standing height or less (68%), isolated head injuries (91%), and initial prehospital GCS scores of 15 (80%). Consequently, this group infrequently meets physiological (Step 1), anatomical (Step 2), or mechanism of injury (Step 3) field triage criteria. These characteristics are consistent with other studies evaluating older adults with head trauma.[19,34]

Second, of the patients that did not meet Step 1-3 field triage criteria, nearly 30% had preinjury anticoagulant or antiplatelet use, with aspirin and warfarin the two 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 Step 1-3 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 to those without anticoagulant or antiplatelet use (3.8%; 95% CI 2.9 to 5.0).

Third, of patients that did not meet Step 1-3 criteria but were taking anticoagulant or antiplatelet medications, EMS providers transported roughly half of these patients to trauma centers. This group of patients had a relatively high proportion of patients (9%) with traumatic intracranial hemorrhage, with only about half of these patients initially transported to a trauma center. Since rates of trauma center triage were similar in patients with (56%) and without traumatic intracranial hemorrhage (55%), this suggests that this group of patients likely appeared well and it may have been difficult for EMS providers to discern which patients are at risk for traumatic intracranial hemorrhage. Trauma center triage was also similar in this group of patients with (53%) and without anticoagulant or antiplatelet use (50%). This suggests that the decision to transport to a trauma center may be less influenced by the use 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 (eTable 3).

Potential advantages with the initial management of older adults with traumatic intracranial hemorrhage at a trauma center compared to a non-trauma center exist. Trauma centers (Level I or II) have 24 hour, 7 days a week, coverage of neurosurgical capabilities while non-trauma 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 that were triaged to a non-trauma center but then diagnosed with a traumatic intracranial hemorrhage, only six 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 that were initially managed at non-trauma 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 was rare in older adults with head trauma, it is possible that initial management of these patients at trauma centers may lead to improved outcomes such as long-term cognitive functioning. For example, trauma centers may have more availability of TBI related resources such as neurorehabilitation specialists.[41,42]

The best method to triage this population of patients from the field remains unclear. Prior work has established the mortality benefit of trauma center care for severely injured patients and the lack of sensitivity of relying on only anatomical, physiological, and mechanism of injury field criteria (Step 1-3) to identify such patients.[18,43] However, with very few patients meeting Step 1-3 criteria in our cohort of older adults with head injury, it is clear that use of only Step 1-3 criteria would miss the majority of patients with traumatic intracranial hemorrhage and death or neurosurgery. The addition of anticoagulant or antiplatelet use to Step 1-3 criteria would increase the sensitivity of field triage criteria however would still miss a number of patients with traumatic intracranial hemorrhage (40%) and death or neurosurgery (30%). Similarly, in a sample of 90,000 injured patients transported by EMS, Newgard et al found Step 1-3 criteria were only 71% sensitive in detecting patients with an ISS greater than 15.[44] 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 prior 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.[45,46]

In particular, the existing literature is mixed regarding the benefit of trauma center care for TBI patients. In the United Kingdom, a systematic review by Fuller et al demonstrated no benefit accrued with transfer of non-surgical TBI patients, calling into question the benefit of direct transport of such patients from the field.[47] 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.[48]

The results of our study do not necessarily support more stringent Step 4 language or implementation. Our study demonstrated that patients not meeting explicit Step 1-3 field triage criteria but had preinjury anticoagulant or antiplatelet use had a higher risk for traumatic intracranial hemorrhage (compared to those without Step 1-3 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 large 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 re-triage protocols that simplify transfer of trauma patients, the timeliness of transfer in the setting of rapid neurological deterioration is also becoming maximized to the benefit of patients needing definitive trauma care.[49] In our study, it would require transport of 37 patients that did not explicitly meet Step 1-3 field triage criteria but had preinjury anticoagulant or antiplatelet use to trauma centers to identify one patient with death or neurosurgical intervention.

CONCLUSIONS

In conclusion, in our study of older adults with head trauma in a single EMS system in California, relatively few patients met Step 1-3 triage criteria. In those who did not have Step 1-3 criteria, nearly 30% had anticoagulant or antiplatelet use with only about half of these patients 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 Step 1-3 triage criteria alone is not sufficient in identifying traumatic intracranial hemorrhage and death or neurosurgery in this patient population. The additional criterion of anticoagulant or antiplatelet use included in the field triage guidelines improves the sensitivity of the field triage criteria with only a modest decrease in specificity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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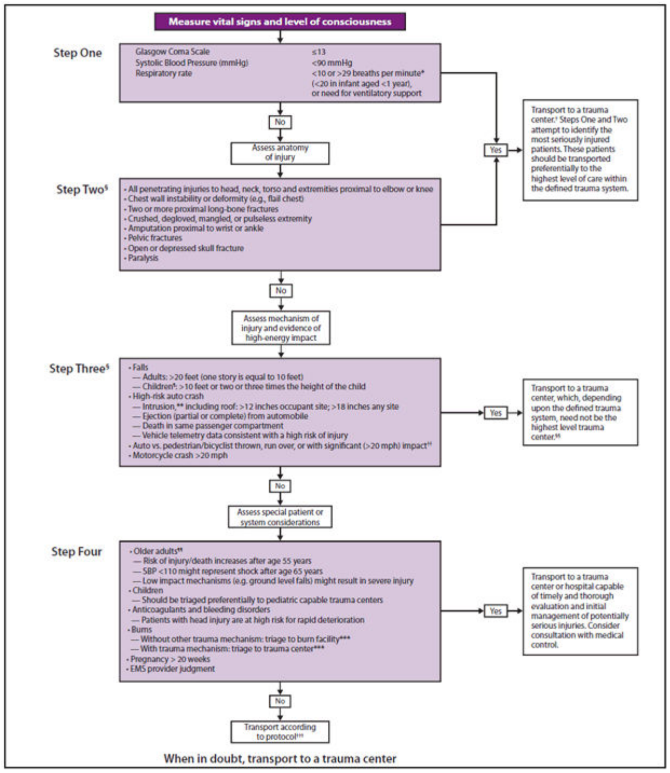

Figure 1. Guidelines for field triage of injured patients - United States, 2011

* The upper limit of respiratory rate in infants is >29 breaths per minute to maintain a higher level of overtriage for infants.

† Trauma centers are designated Level I-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 similar resources to 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 Two or mechanism identified in Step Three triggers a "yes" response.

¶ Age <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 >20 mph 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.

¶¶ Age >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 One through Four should be transported to the most appropriate medical facility as outlined in local EMS protocols.

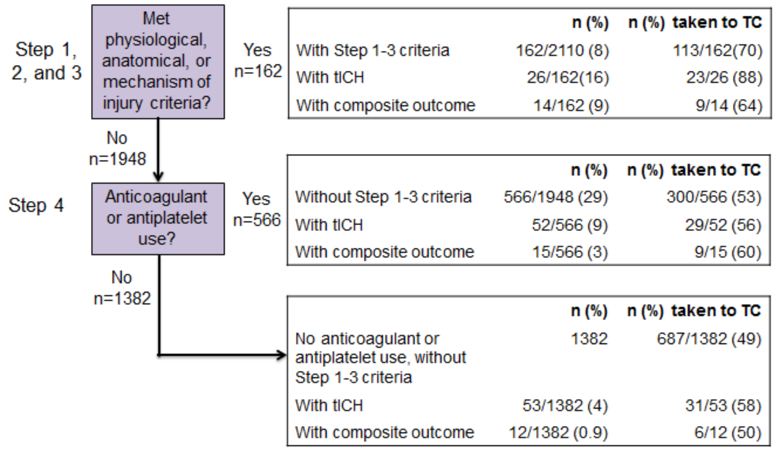

Figure 2. Incidence of outcomes by field triage criteria, n=2110

Abbreviations: TC; Level 1 or 2 trauma center: tICH, acute traumatic intracranial hemorrhage Composite outcome includes in-hospital death or neurosurgery

Table 1

Patient Characteristics, n=2110

Characteristic	n (%)
Age, median (IQR)	73 (62-85)
Male sex	1259 (60)
Race [a]	
• White	1403 (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	1199 (57)
EMS provider was a paramedic	1567 (74)
Initial prehospital Glasgow Coma Scale score of 15 [b]	1638 (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	1445 (68)
• Motor vehicle collision >35 miles per hour	117 (5.5)
• Motor vehicle collision ≤35 miles per hour	186 (8.8)
• Auto versus 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 [c]	12 (0.57)
• Other antiplatelet medication [d]	71 (3.4)
• More than one anticoagulant or antiplatelet medication	72 (3.4)
• None	1515 (72)
Initial INR if warfarin use, median (IQR)	2.2 (1.7-2.6)
Received initial cranial CT scan in the ED	1616 (77)

Characteristic	**n (%)**
ED disposition	
• Discharged home	1410 (67)
• Admitted to the floor	372 (18)
• Admitted to the intensive care unit	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) [e]	3 (2-5)
Injury severity score, median (interquartile range) [e]	5 (2-10)
Isolated head injury [f]	1920 (91)

Abbreviations: IQR, interquartile range; CT, computed tomography; ED, emergency department; EMS, emergency medical services; INR, international normalized ratio

[a] - May have more than one race listed

[b] - Missing GCS scores in 63 patients

[c] - Dabigatran, rivaroxaban, and apixaban

[d] - Clopidogrel, ticlodipine, prasugrel, dipyridamole, cilostazol, and ticagrelor

[e] - Calculated only in admitted patients

[f] - If Abbreviated Injury Scale score for all non-head body regions is less than 3

Table 2

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

Finding [a]	**n (%)**
• Skull fracture	18 (14)
• Subdural hematoma	78 (60)
• Epidural hematoma	9 (6.9)
• Intraparenchemal 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)

[a]- Patients may have more than one finding on CT imaging

Table 3

Interventions in the 9 patients undergoing neurosurgical intervention

Neurosurgical intervention [a]	**n(%)**
Craniotomy	7 (78)
Intracranial pressure monitor placement	2 (22)
Intracranial oxygen probe placement	0 (0)
Burr hole	4 (44)
Subdural drain	3 (33)
Ventricular shunt	1 (11)

[a]- Patients may have more than one intervention

Table 4

Test characteristics of a) Step 1-3 criteria, b) Step 1-3 criteria *and* anticoagulant or antiplatelet use, and c) actual transport to identify traumatic intracranial hemorrhage (n=131) or the composite outcome of death or neurosurgery during hospitalization (n=41)

	Sensitivity		**Specificity**	
	n	**% (95% CI)** [a]	**n**	**% (95% CI)** [a]
Identification of traumatic intracranial hemorrhage				
If only Step 1-3 criteria were used	26/131	19.8% (5.5-51.2%)	1843/1979	93.1% (91.2-94.7%)
If Step 1-3 + anticoagulant or antiplatelet criteria were used	78/131	59.5% (42.9-74.2%)	1329/1979	67.2% (61.1-72.7%)
Actual transport	83/131	63.4% (53.7-72.1%)	962/1979	48.6% (41.5-55.8%)
Identification of death or neurosurgery				
If only Step 1-3 criteria were used	14/41	34.1% (28.9-90.1%)	1921/2069	92.8% (90.0-94.9%)
If Step 1-3 + anticoagulant or antiplatelet criteria were used	29/41	70.7% (61.0-78.9%)	1370/2069	66.2% (61.0-71.1%)
Actual transport	24/41	58.5% (40.1-74.9%)	993/2069	48.0% (41.1-55.0%)

[a] – adjusted for clustering by emergency medical services agency