

## Severe trauma in the geriatric population

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### Abstract

Geriatric trauma constitutes an increasingly recognized problem. Aging results in a progressive decline in cellular function which leads to a loose of their capacity to respond to injury. Some medications commonly used in this population can mask or blunt the response to injury. Falls constitute the most common cause of trauma and the leading cause of trauma-related deaths in this population. Falls are complicated by the widespread use of antiplatelets and anticoagulants, especially in patients with brain injury. Under-triage is common in this population. Evaluation of frailty could be helpful to solve this issue. Appropriate triaging and early aggressive management with correction of coagulopathy can improve outcome. Limitation of care and palliative measures must be considered in cases with a clear likelihood of poor prognosis.

**Key words:** Geriatric trauma; Elderly patients; Severe trauma; Triage; Outcome

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**Core tip:** Geriatric trauma constitutes an increasing problem. These patients have a limited response to injury. Falls constitute the most relevant mechanism of injury. Specific problems in this population include frailty, under-triage and the combination of traumatic brain injury and use of anticoagulants. Early aggressive treatment and palliative care in cases with a clear likelihood of poor prognosis must be considered.

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## INTRODUCTION

In spite that different cutoff levels have been suggested, 65 years represents the most commonly accepted age to consider a patient as an elderly or geriatric patient<sup>[1,2]</sup>. In the following years, it is expected that people over 65 years will represent up to one-fifth of the world population<sup>[1,3]</sup> and almost 39% of trauma admissions by 2050<sup>[4]</sup>. This will constitute a major problem worldwide, but especially in developed countries with higher life expectancy.

Geriatric trauma constitutes an increasingly recognized problem<sup>[1-4]</sup>. Although the number of articles dealing with this topic showed a 6-fold increase in the last 25 years<sup>[3]</sup>, the optimal management of these patients remains to be determined. A specific ad-hoc Geriatric Trauma Committee was constituted by the American Association for the Surgery of Trauma<sup>[2]</sup>. In summary, participants concluded: Geriatric trauma was an increasing problem with increased secondary hospital admissions; elderly trauma patients were usually under-triaged; outcome was better when patients were admitted in higher level trauma centers<sup>[2]</sup>.

Trauma patients aged > 65 years present different comorbidities that imply a higher risk of death and severe disability<sup>[5]</sup>, in spite of having similar severity scores that younger patients<sup>[6,7]</sup>. Hospital costs are also increased, even in low-energy traumas<sup>[1]</sup>. In our environment, patients aged > 65 years represent up to 20% of trauma patients admitted to intensive care units<sup>[8]</sup>. Therefore, specific skills and an evidence-based approach in the management of this population are required.

In this review we will focus on the characteristics of elderly patients, the mechanisms of injury, the areas of controversy and specific strategies to improve outcome.

## PHYSIOLOGICAL CONSIDERATIONS AND EFFECT OF MEDICATIONS

Aging results in a progressive decline in cellular function which leads to a loose of their capacity to respond to injury<sup>[4]</sup>. Impaired adaptive and homeostatic mechanisms are associated to a diminished physiological reserve<sup>[4]</sup> and, therefore, an impaired response to a physical insult<sup>[4,9]</sup>. In addition, comorbidities are commonly associated with an increased use of medical treatments that can also affect the response to injury<sup>[1,3,4]</sup>.

Specifically, the following conditions are present<sup>[1,4,10]</sup>.

### Brain

Elderly patients are more likely to present baseline neurologic deficits, such as dementia, stroke, hearing and visual loss and less pain reporting<sup>[1,4]</sup>. All of this

results in gait instability and therefore, in patients prone to low-energy or ground-level falls. Additionally, the use of some medications such as antipsychotic or antidopaminergics can mask symptoms and precipitate falls<sup>[1]</sup>.

### Cardiovascular

Most elderly patients can present hypertension, cardiovascular disease and impaired sensitivity to catecholamines. In addition, they are receiving chronic medications that can affect heart rate and blood pressure<sup>[1,3,4]</sup>, blunting the response to injury in hemodynamically compromised patients<sup>[1]</sup>.

### Respiratory

Respiratory function is compromised in elderly patients through different mechanisms, such as decreased functional residual capacity, impaired mucociliary clearance of bacteria and reduced cough and reduction in compliance<sup>[1,4]</sup>. These factors result in increased work of breathing and a higher risk of respiratory failure and need of mechanical ventilation, ventilator associated pneumonia and intensive care unit stay<sup>[4,11]</sup>. Steroids, usually administered in patients with chronic obstructive pulmonary disease can affect wound healing, induce adrenal impairment and have deleterious effects in patients with traumatic brain injury<sup>[1,12]</sup>.

### Kidney

There is a fall in glomerular filtration rate and renal tubular function in elderly patients, limiting the ability to tolerate large-volume resuscitation<sup>[4]</sup>. Additionally, patients with low glomerular filtration rate are prone to develop contrast induced nephropathy<sup>[10]</sup>.

### Skeletal

These patients usually present osteoporosis<sup>[1]</sup>. Osteoporosis and tendency to fall increase the incidence of hip fractures, which is the most common cause of traumatic injury in elderly patients, mainly in women<sup>[4]</sup>. Aging bones are more easily fractured with minor trauma<sup>[10]</sup>.

**Coagulation:** Elderly patients are usually taking antiplatelets or anticoagulants which clearly can affect outcome, especially in patients with traumatic brain injury<sup>[1,3,4,7]</sup>. The widespread use of novel anticoagulants might complicate the management and outcome in this setting<sup>[13,14]</sup>.

## MECHANISMS OF INJURY

A recent study showed a linear association between different patterns and intensity of injury and aging<sup>[7]</sup>. As age increased, low-energy traumas complicated with the use of antiplatelets and anticoagulants were more prevalent, as well as being run-over. High-energy traumas, such as motor vehicle collision under the abuse of toxic substances were less frequent as age increased<sup>[7]</sup>.

### Falls

Constitute the most common cause of trauma and

the leading cause of trauma-related deaths, even in low-energy cases<sup>[2,3]</sup>. The morbidity and mortality seems correlated with frailty<sup>[15]</sup> and age constitutes the strongest, but not unique, predictor of mortality<sup>[16]</sup>. A recent systematic review identified six risk factors appearing in more than one study that could be used to predict falls in the geriatric population: Previous fall, living alone, walking aid, depression, cognitive deficit and use of > 6 medications<sup>[16]</sup>.

### **Motor vehicle collision**

This mechanism accounts for up to one-quarter of patients with geriatric trauma<sup>[1]</sup>, with 26.8% in the 66-75 years group and 14.4% in patients older than 75 years<sup>[7]</sup>. Elderly patients are more likely to present severe injuries caused by low speed vehicles and have a doubled mortality rate than younger counterparts<sup>[1,10]</sup>.

### **Blunt vs penetrating trauma**

Elderly patients usually undergone blunt rather than penetrating trauma, which accounts for less than 5% of the cases<sup>[7,17]</sup>. Most of the cases of penetrating trauma rely on self-inflicted injuries mediated by chronic illness and depression.

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## **CLINICAL FEATURES**

In brain injured patients, aging is strongly associated to significant epidural or subdural hematomas even when presenting with mild symptoms<sup>[18]</sup>. In this setting, the Glasgow Coma Scale is an unreliable clinical tool, and the repeated use of computed tomography of the head becomes essential to rule out increased intracranial pressure<sup>[19]</sup>. When anticoagulants are used there should be a low threshold to repeat brain imaging, even in cases without any clinical neurologic change<sup>[1,19]</sup>. If the elderly patient with traumatic brain injury is taking warfarin, there is a significantly increased risk of fatal intracranial hemorrhage. Therefore, such patients benefit from rapid correction<sup>[19]</sup>.

Elderly patients are at a significantly increased risk of high cervical spinal cord injuries (C1-C2) as a result of degenerative changes and stiffening of the lower cervical spine<sup>[20]</sup>. In this scenario, early spinal evaluation and appropriate spine immobilization are of paramount importance to avoid secondary devastating injuries.

Chest trauma is most likely to be blunt and secondary to motor vehicle accidents. It carries a significant risk of morbidity, even in patients with isolated rib fractures<sup>[21]</sup>. The risk of mortality after a rib fracture is proportional to the number of fractured ribs and may serve as a predictor of trauma severity and risk of complications<sup>[22]</sup>. The most common complications include pneumonia and pulmonary contusions<sup>[21]</sup>. Pneumonia following a rib fracture can be a devastating complication in these patients with limited respiratory function. It is essential to aggressively manage rib fractures, including, when indicated, optimized analgesia and epidural anesthesia and/or rib fixation for pain control<sup>[23]</sup>.

Abdominal trauma has similar characteristics in elderly patients than in younger counterparts, but its management is controversial in elderly patients. A conservative approach can be used, but elderly patients seem to fall to a non-operative management more frequently than younger patients<sup>[24]</sup>. However, risk must be well-balanced since mortality after laparotomy increases with age and higher lactate levels<sup>[25]</sup>. In this scenario, a recently developed geriatric emergency surgery score using 5 clinical variables could be helpful in predicting 1-year mortality and assist in preoperative counseling<sup>[26]</sup>. However, this score has to be specifically validated in elderly trauma patients yet.

Pelvic fractures in the elderly have a higher incidence of complications and mortality than in the younger population. Specifically, the pattern of injury is different with a higher incidence of lateral compression fractures, which are associated to secondary bleeding requiring angiography for bleeding control<sup>[27]</sup>. Therefore, these patients should be promptly treated, since associated mortality is high<sup>[27]</sup>. In patients with initially stable pelvic fractures, advanced age along with injury severity, mental status, prolonged mechanical ventilation, and/or in-hospital blood product administration were predictors of mortality<sup>[28]</sup>.

Osteoporosis is the main contributor factor to skeletal injuries in elderly trauma patients, especially in women. Fractures in the geriatric population are associated to a high morbidity and mortality and diminished quality of life<sup>[29]</sup>. Forearm and hip fractures are the most common<sup>[10]</sup>. Elderly patients have a high mortality following a hip fracture. It is mandatory that these patients receive coordinated care including early surgical repair balanced with medical optimization and appropriate rehabilitation. Evidence suggests that a dedicated orthogeriatric team approach to these patients may improve functional outcomes, but its effects on mortality are not clear<sup>[30,31]</sup>.

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## **SPECIFIC AREAS OF INTEREST AND POTENTIAL STRATEGIES TO IMPROVE OUTCOME**

### **Under-triage**

Consensus exists that elderly trauma patients are usually under-triaged to trauma centers<sup>[1,2,10]</sup>. Different underlying causes have been described, such as low-energy mechanisms of injury, unconscious age bias, unreliability of vital signs, the use of medications that can blunt the physiologic response to injury and, until recently, the lack of specific triaging scores<sup>[1,10,32]</sup>. This is especially surprising if we take into consideration that age itself is a strong determinant of higher mortality in trauma patients<sup>[7]</sup> and that when aggressive treatment is initiated, the outcome difference between younger and older patients decreases<sup>[33]</sup>. Elderly patients have a decreased mortality if they are transferred to trauma centers with a high volume of elderly trauma patients<sup>[34]</sup>. To solve under-triage, different authors

suggested advanced age to be the sole criteria for referral to level I trauma centers and activation of the trauma team in the presence of traumatic injuries, since this led to reduced odds of mortality when controlling for severity in before-and-after studies<sup>[35,36]</sup>. Taking into consideration the evidence available, under-triaging of elderly trauma patients can be considered as a form of ageism.

Another potential strategy is the use of alternative parameters for triage purposes, since conventional scores, the Revised Trauma Score and the Injury Severity Score did not perform well in this population. To this purpose, different alternatives such as a different cutoff for systolic blood pressure in 110 mmHg (due to the high percentage of patients with hypertension in this population)<sup>[37]</sup>, as well as the values of the shock index, modified shock index and age shock index<sup>[38,39]</sup> were analyzed with improved but not optimal results. Specific geriatric criteria could increase the sensitivity in identifying the need of a trauma center<sup>[40]</sup>, but with limited impact of the number of elderly patients transferred to trauma centers and mortality<sup>[41,42]</sup>. The recently developed Geriatric Trauma Outcome Score<sup>[43]</sup>, which uses the values of Age, Injury Severity Score and the need of transfusion in the initial 24 h in a dichotomized form can be of outstanding interest for establishing the odds of mortality, but of limited interest for triaging purposes.

### **Frailty**

Age itself could not be an accurate indicator of the ability of the elderly patient to respond to injury. In addition, as previously explained, traditional vital signs and severity scores do not perform well in this specific population. Here the concept of frailty arose. Frailty syndrome is considered as decreased physiologic reserve in multiple organ systems which leads to an impaired ability to withstand physiological stress<sup>[3]</sup>. Therefore, frail patients are at a higher risk for a variety poor outcomes following injury<sup>[44]</sup>.

Among the different tools developed, the most interesting is the Trauma-specific Frailty Index. This modified 15-component scale was validated in 200 patients and was useful in planning discharge disposition of elderly trauma patients<sup>[45]</sup>. In a follow-up study with 250 patients with median Injury Severity Score 15 and mean age 77.9 years, forty-four percent of the patients had frailty. These patients were more likely to have in-hospital complications and adverse discharge disposition. All patients who died had frailty<sup>[44]</sup>. This index was also superior to traditional signs or scores<sup>[46]</sup>. It is therefore reasonable that the use of this index may help in planning the process of care of geriatric trauma patients.

### **Traumatic brain injury and anticoagulation**

In patients with traumatic brain injury, there is a clear relationship between age and mortality and poor outcomes. One meta-analysis of 5600 severe head-injured patients confirmed the strength of this association, expressed as an odds ratio per 10 years of age of 1.39

(95%CI: 1.3-1.5) for death and 1.46 (95%CI: 1.36-1.56) for unfavorable outcomes in multivariable analyses, reaching 6-mo mortality 72% in patients aged > 65 years<sup>[47]</sup>. In a more recent report, elderly patients with moderate to severe brain injury had an overall in-hospital mortality rate approaching 30%. Most interestingly, no patient with an admission Glasgow Coma Scale score less than 9 had good outcomes; the mortality for that subgroup was 80%<sup>[48]</sup>. Therefore, concerns about futility arise in this setting.

This picture is complicated by the common use of anticoagulants in elderly patients<sup>[7]</sup>. Anticoagulants are commonly used in elderly patients to reduce the risk of potential stroke, but this potential benefit must be weighed against the risk of falls with potentially fatal bleeds<sup>[13,49]</sup>. Anticoagulant use was associated with progression of known intracranial hemorrhage as well as the development of new foci of hemorrhage on repeated head computed tomography<sup>[50]</sup>. In this scenario, the use of the CHADS scores could be helpful to distinguish which patients at risk of falls clearly benefit from antiplatelets or anticoagulants<sup>[51]</sup>. In recent years, new anticoagulants have been developed, which are replacing vitamin K antagonists<sup>[13]</sup>. More elderly patients face severe trauma under these new anticoagulants<sup>[14]</sup>. Until recently, specific antidotes were not developed, and urgent treatment was limited to general measures and different doses of prothrombin complex concentrate, activated prothrombin complex concentrate or even recombinant factor VIIa<sup>[14,52]</sup>. All these measures had variable and limited support of clinical evidence<sup>[52]</sup>. Currently, a specific antidote for direct thrombin inhibitors (dabigatran) is available, idarucizumab, which is a Fab fragment of a monoclonal antibody. In the case of FXa inhibitors (apixaban, edoxaban, rivaroxaban) it has been recently developed the andexanet alfa, a recombinant, modified human factor Xa decoy protein that binds factor Xa inhibitors but does not have intrinsic catalytic activity<sup>[52,53]</sup>. However, these agents have not been extensively evaluated in trauma patients. Fortunately, and contrary to initially expected, large recently published series showed that trauma patients under new anticoagulants had a better outcome than those anticoagulated with vitamin K antagonists<sup>[54,55]</sup>. This controversy highlights the need of specific screening protocols for coagulopathy in this setting.

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## **CAN WE PREDICT OUTCOME?**

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The Eastern Association for the Surgery of Trauma published in 2012 their guidelines for the management of elderly trauma patients, concluding that evidence-based care of this population requires aggressive triage, correction of coagulopathy and limitation of care when clinical evidence suggests a clear likelihood of poor prognosis<sup>[56]</sup>. This implies treating aggressively patients with limited physiological reserve and uncertain outcome. In this context, several tools to predict morbidity and outcome have been developed and can help to make the

right decision.

Min *et al*<sup>[57]</sup> recently developed a simple clinical risk normogram to predict mortality-associated geriatric complications in elderly patients using a secondary analysis of the National Trauma Data Bank. They found that elderly patients had complicated and unfavorable clinical courses compared with younger patients if they developed pneumonia, abscess, wound infection, empyema, urinary tract infection, bacteremia, aspiration pneumonia, failure of reduction/fixation, pressure ulcer, deep venous thrombosis, pneumothorax, pulmonary embolism or compartment syndrome<sup>[57]</sup>. A recent systematic review identified increasing age (those aged > 74 years), increasing severity of injury and low systolic blood pressure as independent predictors of mortality<sup>[58]</sup>. As detailed above, the Geriatric trauma Outcome Score can be helpful to predict in-hospital mortality with good results<sup>[43]</sup>. Its performance is even better when patients with care restrictions are excluded. However, it has a poor ability to predict 1-year mortality<sup>[59]</sup>.

Given these limitations, the frailty index<sup>[15,44-46]</sup> can be of interest to predict which patients are at highest risk of having poor outcomes and then require focused interventions. Joseph *et al*<sup>[60]</sup> recently showed that frail patients were more likely to develop in-hospital complications (non-frail: 12%, pre-frail: 17.4%, and frail: 33.4%,  $P = 0.02$ ) and an adverse discharge disposition. The Edmonton frail scale, which has a great interest in the general population, has not been extensively evaluated in elderly trauma patients except in postoperative state after hip fracture<sup>[61]</sup>. More interest raised other markers of frailty, such as sarcopenia and osteopenia, that were found to be associated with 1-year mortality in elderly trauma patients<sup>[62]</sup>. A dichotomy approach of responding vs non-responding at 72 h after intensive treatment could identify patients with higher in-hospital mortality and was associated with differences in end-of-life decision making<sup>[63]</sup>.

## POSTACUTE CARE AND PALLIATIVE CARE

Despite aggressive treatment, more than 60% of elderly trauma patients who survive are ultimately discharged to different types of facilities, including skilled nursing facilities, assisted living or long-term rehabilitation care<sup>[64-66]</sup>. To determine which type of facility may be of benefit for these patients is challenging and remains to be elucidated<sup>[65]</sup>. An appropriate management of these facilities is essential for optimal transfers and prevention of readmissions<sup>[66]</sup>.

In cases with a clear likelihood of poor prognosis despite aggressive initial treatment, especially in those patients aged > 74 years old and with non-responding traumatic brain injury, palliative care must be considered<sup>[67]</sup>. Limitation of care plays an important role in the high in-hospital mortality of elderly trauma ICU patients in our environment<sup>[7]</sup>, so a comprehensive

approach fulfilling patient needs and comfort is warranted<sup>[65-67]</sup>. Future investigations may deepen in this approach and in the quality of life rather than in-hospital mortality for evaluating outcome in elderly trauma patients<sup>[67,68]</sup>. Returning to their baseline quality of life is difficult in these patients, even in relatively minor trauma<sup>[69]</sup>. This expectative must be discussed with the patient (if possible) and relatives when we consider the treatment alternatives of elderly trauma patients. Interventions to reduce frailty in the community are required and are potentially effective to improve the ability to prevent and recover from injuries<sup>[70]</sup>. Effective interventions included exercise, nutrition, cognitive training, geriatric assessment and management and prehabilitation<sup>[70]</sup>.

## CONCLUSION

In summary, elderly trauma patients present specific characteristics that imply increased morbidity and mortality. Appropriate triage, evaluation of frailty and aggressive early management including correction of coagulopathy can improve outcome. In non-responding cases with a clear likelihood of poor prognosis, limitation of care and palliative measures must be considered.

## REFERENCES

- 1 **Bonne S**, Schuerer DJ. Trauma in the older adult: epidemiology and evolving geriatric trauma principles. *Clin Geriatr Med* 2013; **29**: 137-150 [PMID: 23177604 DOI: 10.1016/j.cger.2012.10.008]
- 2 **Kozar RA**, Arbabi S, Stein DM, Shackford SR, Barraco RD, Biffl WL, Brasel KJ, Cooper Z, Fakhry SM, Livingston D, Moore F, Luchette F. Injury in the aged: Geriatric trauma care at the crossroads. *J Trauma Acute Care Surg* 2015; **78**: 1197-1209 [PMID: 26151523 DOI: 10.1097/TA.0000000000000656]
- 3 **Adams SD**, Holcomb JB. Geriatric trauma. *Curr Opin Crit Care* 2015; **21**: 520-526 [PMID: 26539925 DOI: 10.1097/MCC.0000000000000246]
- 4 **Banks SE**, Lewis MC. Trauma in the elderly: considerations for anesthetic management. *Anesthesiol Clin* 2013; **31**: 127-139 [PMID: 23351539 DOI: 10.1016/j.anclin.2012.11.004]
- 5 **Keller JM**, Sciadini MF, Sinclair E, O'Toole RV. Geriatric trauma: demographics, injuries, and mortality. *J Orthop Trauma* 2012; **26**: e161-e165 [PMID: 22377505 DOI: 10.1097/BOT.0b013e3182324460]
- 6 **Taylor MD**, Tracy JK, Meyer W, Pasquale M, Napolitano LM. Trauma in the elderly: intensive care unit resource use and outcome. *J Trauma* 2002; **53**: 407-414 [PMID: 12352472 DOI: 10.1097/01.TA.0000020257.29911.70]
- 7 **Llompарт-Pou JA**, Chico-Fernández M, Sánchez-Casado M, Alberdi-Odriozola F, Guerrero-López F, Mayor-García MD, González-Robledo J, Ballesteros-Sanz MÁ, Herrán-Monge R, León-López R, López-Amor L, Bueno-González A; Trauma Neurointensive Care Working Group of the Spanish Society of Intensive Care Medicine (SEMICYUC). Age-related injury patterns in Spanish trauma ICU patients. Results from the RETRAUCI. *Injury* 2016; **47** Suppl 3: S61-S65 [PMID: 27692109 DOI: 10.1016/S0020-1383(16)30608-8]
- 8 **Chico-Fernández M**, Llompарт-Pou JA, Guerrero-López F, Sánchez-Casado M, García-Sáez I, Mayor-García MD, Egea-Guerrero J, Fernández-Ortega JF, Bueno-González A, González-Robledo J, Servià-Goixart L, Roldán-Ramírez J, Ballesteros-Sanz MÁ, Tejerina-Alvarez E, García-Fuentes C, Alberdi-Odriozola F; en representación del Grupo de Trabajo de Trauma y Neurointensivismo SEMICYUC. Epidemiology of severe trauma in Spain. Registry of trauma in the

- ICU (RETRAUCI). Pilot phase. *Med Intensiva* 2016; **40**: 327-347 [PMID: 26440993 DOI: 10.1016/j.medin.2015.07.011]
- 9 **Frankenfield D**, Cooney RN, Smith JS, Rowe WA. Age-related differences in the metabolic response to injury. *J Trauma* 2000; **48**: 49-56; discussion 56-57 [PMID: 10647565]
  - 10 **Reske-Nielsen C**, Medzon R. Geriatric Trauma. *Emerg Med Clin North Am* 2016; **34**: 483-500 [PMID: 27475011 DOI: 10.1016/j.emc.2016.04.004]
  - 11 **Chalfin DB**. Outcome assessment in elderly patients with critical illness and respiratory failure. *Clin Chest Med* 1993; **14**: 583-589 [PMID: 8222571]
  - 12 **Edwards P**, Arango M, Balica L, Cottingham R, El-Sayed H, Farrell B, Fernandes J, Gogichavili T, Golden N, Hartzenberg B, Husain M, Ulloa MI, Jerbi Z, Khamis H, Komolafe E, Laloë V, Lomas G, Ludwig S, Mazairac G, Muñoz Sánchez Mde L, Nasi L, Oлдashi F, Plunkett P, Roberts I, Sandercock P, Shakur H, Soler C, Stocker R, Svoboda P, Trenkler S, Venkataramana NK, Wasserberg J, Yates D, Yutthakasemsunt S. Final results of MRC CRASH, a randomised placebo-controlled trial of intravenous corticosteroid in adults with head injury-outcomes at 6 months. *Lancet* 2005; **365**: 1957-1959 [PMID: 15936423 DOI: 10.1016/S0140-6736(05)66552-X]
  - 13 **Ho P**, Brooy BL, Hayes L, Lim WK. Direct oral anticoagulants in frail older adults: a geriatric perspective. *Semin Thromb Hemost* 2015; **41**: 389-394 [PMID: 25973587 DOI: 10.1055/s-0035-1550158]
  - 14 **Egea-Guerrero JJ**, Quintana Diaz M. New oral anticoagulants in severe trauma patients: enemy at the gates? *Med Intensiva* 2015; **39**: 167-171 [PMID: 25510394 DOI: 10.1016/j.medin.2014.09.008]
  - 15 **Joseph B**, Phelan H, Hassan A, Orouji J, O'Keefe T, Azim A, Gries L, Kulvatunyou N, Latifi R, Rhee P. The impact of frailty on failure-to-rescue in geriatric trauma patients: A prospective study. *J Trauma Acute Care Surg* 2016; **81**: 1150-1155 [PMID: 27602908 DOI: 10.1097/TA.0000000000001250]
  - 16 **Carpenter CR**, Avidan MS, Wildes T, Stark S, Fowler SA, Lo AX. Predicting geriatric falls following an episode of emergency department care: a systematic review. *Acad Emerg Med* 2014; **21**: 1069-1082 [PMID: 25293956 DOI: 10.1111/acem.12488]
  - 17 **Labib N**, Noh T, Winocour S, Deckelbaum D, Banici L, Fata P, Razek T, Khwaja K. Severely injured geriatric population: morbidity, mortality, and risk factors. *J Trauma* 2011; **71**: 1908-1914 [PMID: 21537212 DOI: 10.1097/TA.0b013e31820989ed]
  - 18 **Rathlev NK**, Medzon R, Lowery D, Pollack C, Bracken M, Barest G, Wolfson AB, Hoffman JR, Mower WR. Intracranial pathology in elders with blunt head trauma. *Acad Emerg Med* 2006; **13**: 302-307 [PMID: 16514123 DOI: 10.1197/j.aem.2005.10.015]
  - 19 **Ivascu FA**, Howells GA, Junn FS, Bair HA, Bendick PJ, Janczyk RJ. Rapid warfarin reversal in anticoagulated patients with traumatic intracranial hemorrhage reduces hemorrhage progression and mortality. *J Trauma* 2005; **59**: 1131-1137 [PMID: 16385291]
  - 20 **Touger M**, Gennis P, Nathanson N, Lowery DW, Pollack CV, Hoffman JR, Mower WR. Validity of a decision rule to reduce cervical spine radiography in elderly patients with blunt trauma. *Ann Emerg Med* 2002; **40**: 287-293 [PMID: 12192352]
  - 21 **Elmistekawy EM**, Hammad AA. Isolated rib fractures in geriatric patients. *Ann Thorac Med* 2007; **2**: 166-168 [PMID: 19727369 DOI: 10.4103/1817-1737.36552]
  - 22 **Stawicki SP**, Grossman MD, Hoey BA, Miller DL, Reed JF. Rib fractures in the elderly: a marker of injury severity. *J Am Geriatr Soc* 2004; **52**: 805-808 [PMID: 15086666 DOI: 10.1111/j.1532-5415.2004.52223.x]
  - 23 **Senekjian L**, Nirula R. Rib Fracture Fixation: Indications and Outcomes. *Crit Care Clin* 2017; **33**: 153-165 [PMID: 27894495 DOI: 10.1016/j.ccc.2016.08.009]
  - 24 **Harbrecht BG**, Peitzman AB, Rivera L, Heil B, Croce M, Morris JA, Enderson BL, Kurek S, Pasquale M, Frykberg ER, Minei JP, Meredith JW, Young J, Kealey GP, Ross S, Luchette FA, McCarthy M, Davis F, Shatz D, Tinkoff G, Block EF, Cone JB, Jones LM, Chalifoux T, Federle MB, Clancy KD, Ochoa JB, Fakhry SM, Townsend R, Bell RM, Weireter L, Shapiro MB, Rogers F, Dunham CM, McAuley CE. Contribution of age and gender to outcome of blunt splenic injury in adults: multicenter study of the eastern association for the surgery of trauma. *J Trauma* 2001; **51**: 887-895 [PMID: 11706335]
  - 25 **Joseph B**, Zangbar B, Pandit V, Kulvatunyou N, Haider A, O'Keefe T, Khalil M, Tang A, Vercruysse G, Gries L, Friese RS, Rhee P. Mortality after trauma laparotomy in geriatric patients. *J Surg Res* 2014; **190**: 662-666 [PMID: 24582068 DOI: 10.1016/j.jss.2014.01.029]
  - 26 **Olufajo OA**, Reznor G, Lipsitz SR, Cooper ZR, Haider AH, Salim A, Rangel EL. Preoperative assessment of surgical risk: creation of a scoring tool to estimate 1-year mortality after emergency abdominal surgery in the elderly patient. *Am J Surg* 2017; **213**: 771-777 [PMID: 27743591 DOI: 10.1016/j.amjsurg.2016.08.007]
  - 27 **Henry SM**, Pollak AN, Jones AL, Boswell S, Scalea TM. Pelvic fracture in geriatric patients: a distinct clinical entity. *J Trauma* 2002; **53**: 15-20 [PMID: 12131383]
  - 28 **Wang H**, Phillips JL, Robinson RD, Duane TM, Buca S, Campbell-Furtick MB, Jennings A, Miller T, Zenarosa NR, Delaney KA. Predictors of mortality among initially stable adult pelvic trauma patients in the US: Data analysis from the National Trauma Data Bank. *Injury* 2015; **46**: 2113-2117 [PMID: 26377773 DOI: 10.1016/j.injury.2015.08.039]
  - 29 **Roth T**, Kammerlander C, Gosch M, Luger TJ, Blauth M. Outcome in geriatric fracture patients and how it can be improved. *Osteoporos Int* 2010; **21**: S615-S619 [PMID: 21058001 DOI: 10.1007/s00198-010-1401-4]
  - 30 **Wang H**, Li C, Zhang Y, Jia Y, Zhu Y, Sun R, Li W, Liu Y. The influence of inpatient comprehensive geriatric care on elderly patients with hip fractures: a meta-analysis of randomized controlled trials. *Int J Clin Exp Med* 2015; **8**: 19815-19830 [PMID: 26884892]
  - 31 **Stenqvist C**, Madsen CM, Riis T, Jørgensen HL, Duus BR, Lauritzen JB, van der Mark S. Orthogeriatric Service Reduces Mortality in Patients With Hip Fracture. *Geriatr Orthop Surg Rehabil* 2016; **7**: 67-73 [PMID: 27239379 DOI: 10.1177/2151458515625296]
  - 32 **Chang DC**, Bass RR, Cornwell EE, Mackenzie EJ. Undertriage of elderly trauma patients to state-designated trauma centers. *Arch Surg* 2008; **143**: 776-781; discussion 782 [PMID: 18711038 DOI: 10.1001/archsurg.143.8.776]
  - 33 **DeMaria EJ**, Kenney PR, Merriam MA, Casanova LA, Gann DS. Aggressive trauma care benefits the elderly. *J Trauma* 1987; **27**: 1200-1206 [PMID: 3682032]
  - 34 **Zafar SN**, Obirieze A, Schneider EB, Hashmi ZG, Scott VK, Greene WR, Efron DT, MacKenzie EJ, Cornwell EE, Haider AH. Outcomes of trauma care at centers treating a higher proportion of older patients: the case for geriatric trauma centers. *J Trauma Acute Care Surg* 2015; **78**: 852-859 [PMID: 25742246 DOI: 10.1097/TA.0000000000000557]
  - 35 **Hammer PM**, Storey AC, Bell T, Bayt D, Hockaday MS, Zarzaur BL, Feliciano DV, Rozycki GS. Improving geriatric trauma outcomes: A small step toward a big problem. *J Trauma Acute Care Surg* 2016; **81**: 162-167 [PMID: 27032005 DOI: 10.1097/TA.0000000000001063]
  - 36 **Demetriades D**, Karaiskakis M, Velmahos G, Alo K, Newton E, Murray J, Asensio J, Belzberg H, Berne T, Shoemaker W. Effect on outcome of early intensive management of geriatric trauma patients. *Br J Surg* 2002; **89**: 1319-1322 [PMID: 12296905 DOI: 10.1046/j.1365-2168.2002.02210.x]
  - 37 **Brown JB**, Gestring ML, Forsythe RM, Stassen NA, Billiar TR, Peitzman AB, Sperry JL. Systolic blood pressure criteria in the National Trauma Triage Protocol for geriatric trauma: 110 is the new 90. *J Trauma Acute Care Surg* 2015; **78**: 352-359 [PMID: 25757122 DOI: 10.1097/TA.0000000000000523]
  - 38 **Pandit V**, Rhee P, Hashmi A, Kulvatunyou N, Tang A, Khalil M, O'Keefe T, Green D, Friese RS, Joseph B. Shock index predicts mortality in geriatric trauma patients: an analysis of the National Trauma Data Bank. *J Trauma Acute Care Surg* 2014; **76**: 1111-1115 [PMID: 24662879 DOI: 10.1097/TA.0000000000000160]
  - 39 **Kim SY**, Hong KJ, Shin SD, Ro YS, Ahn KO, Kim YJ, Lee EJ. Validation of the Shock Index, Modified Shock Index, and Age Shock Index for Predicting Mortality of Geriatric Trauma Patients in Emergency Departments. *J Korean Med Sci* 2016; **31**: 2026-2032 [PMID: 27822945 DOI: 10.3346/jkms.2016.31.12.2026]
  - 40 **Ichwan B**, Darbha S, Shah MN, Thompson L, Evans DC, Boulger CT, Caterino JM. Geriatric-specific triage criteria are more sensitive

- than standard adult criteria in identifying need for trauma center care in injured older adults. *Ann Emerg Med* 2015; **65**: 92-100.e3
- 41 **Caterino JM**, Brown NV, Hamilton MW, Ichwan B, Khaliqina S, Evans DC, Darbha S, Panchal AR, Shah MN. Effect of Geriatric-Specific Trauma Triage Criteria on Outcomes in Injured Older Adults: A Statewide Retrospective Cohort Study. *J Am Geriatr Soc* 2016; **64**: 1944-1951 [PMID: 27696350 DOI: 10.1111/jgs.14376]
- 42 **Saillant NN**, Earl-Royal E, Pascual JL, Allen SR, Kim PK, Delgado MK, Carr BG, Wiebe D, Holena DN. The relationship between processes and outcomes for injured older adults: a study of a statewide trauma system. *Eur J Trauma Emerg Surg* 2017; **43**: 121-127 [PMID: 26510941 DOI: 10.1007/s00068-015-0586-9]
- 43 **Zhao FZ**, Wolf SE, Nakonezny PA, Minhajuddin A, Rhodes RL, Paulk ME, Phelan HA. Estimating Geriatric Mortality after Injury Using Age, Injury Severity, and Performance of a Transfusion: The Geriatric Trauma Outcome Score. *J Palliat Med* 2015; **18**: 677-681 [PMID: 25974408 DOI: 10.1089/jpm.2015.0027]
- 44 **Joseph B**, Pandit V, Zangbar B, Kulvatunyoun N, Hashmi A, Green DJ, O'Keefe T, Tang A, Vercruyse G, Fain MJ, Friese RS, Rhee P. Superiority of frailty over age in predicting outcomes among geriatric trauma patients: a prospective analysis. *JAMA Surg* 2014; **149**: 766-772 [PMID: 24920308 DOI: 10.1001/jamasurg.2014.296]
- 45 **Joseph B**, Pandit V, Zangbar B, Kulvatunyoun N, Tang A, O'Keefe T, Green DJ, Vercruyse G, Fain MJ, Friese RS, Rhee P. Validating trauma-specific frailty index for geriatric trauma patients: a prospective analysis. *J Am Coll Surg* 2014; **219**: 10-17.e1 [PMID: 24952434 DOI: 10.1016/j.jamcollsurg.2014.03.020]
- 46 **Joseph B**, Pandit V, Rhee P, Aziz H, Sadoun M, Wynne J, Tang A, Kulvatunyoun N, O'Keefe T, Fain MJ, Friese RS. Predicting hospital discharge disposition in geriatric trauma patients: is frailty the answer? *J Trauma Acute Care Surg* 2014; **76**: 196-200 [PMID: 24368379 DOI: 10.1097/TA.0b013e3182a833ac]
- 47 **Hukkelhoven CW**, Steyerberg EW, Rampen AJ, Farace E, Habbema JD, Marshall LF, Murray GD, Maas AI. Patient age and outcome following severe traumatic brain injury: an analysis of 5600 patients. *J Neurosurg* 2003; **99**: 666-673 [PMID: 14567601 DOI: 10.3171/jns.2003.99.4.0666]
- 48 **Utomo WK**, Gabbe BJ, Simpson PM, Cameron PA. Predictors of in-hospital mortality and 6-month functional outcomes in older adults after moderate to severe traumatic brain injury. *Injury* 2009; **40**: 973-977 [PMID: 19540490 DOI: 10.1016/j.injury.2009.05.034]
- 49 **Boltz MM**, Podany AB, Hollenbeak CS, Armen SB. Injuries and outcomes associated with traumatic falls in the elderly population on oral anticoagulant therapy. *Injury* 2015; **46**: 1765-1771 [PMID: 26117415 DOI: 10.1016/j.injury.2015.06.013]
- 50 **Peck KA**, Calvo RY, Schechter MS, Sise CB, Kahl JE, Shackford MC, Shackford SR, Sise MJ, Blaskiewicz DJ. The impact of preinjury anticoagulants and prescription antiplatelet agents on outcomes in older patients with traumatic brain injury. *J Trauma Acute Care Surg* 2014; **76**: 431-436 [PMID: 24458049 DOI: 10.1097/TA.000000000000107]
- 51 **Inui TS**, Parina R, Chang DC, Inui TS, Coimbra R. Mortality after ground-level fall in the elderly patient taking oral anticoagulation for atrial fibrillation/flutter: a long-term analysis of risk versus benefit. *J Trauma Acute Care Surg* 2014; **76**: 642-649 [PMID: 24553530 DOI: 10.1097/TA.000000000000138]
- 52 **Levi M**. Management of bleeding in patients treated with direct oral anticoagulants. *Crit Care* 2016; **20**: 249 [PMID: 27543264 DOI: 10.1186/s13054-016-1413-3]
- 53 **Connolly SJ**, Milling TJ, Eikelboom JW, Gibson CM, Curnutte JT, Gold A, Bronson MD, Lu G, Conley PB, Verhamme P, Schmidt J, Middeldorp S, Cohen AT, Beyer-Westendorf J, Albaladejo P, Lopez-Sendon J, Goodman S, Leeds J, Wiens BL, Siegal DM, Zotova E, Meeks B, Nakamya J, Lim WT, Crowther M; ANNEXA-4 Investigators. Andexanet Alfa for Acute Major Bleeding Associated with Factor Xa Inhibitors. *N Engl J Med* 2016; **375**: 1131-1141 [PMID: 27573206 DOI: 10.1056/NEJMoa1607887]
- 54 **Feeney JM**, Santone E, DiFiori M, Kis L, Jayaraman V, Montgomery SC. Compared to warfarin, direct oral anticoagulants are associated with lower mortality in patients with blunt traumatic intracranial hemorrhage: A TQIP study. *J Trauma Acute Care Surg* 2016; **81**: 843-848 [PMID: 27602897 DOI: 10.1097/TA.0000000000001245]
- 55 **Maung AA**, Bhattacharya B, Schuster KM, Davis KA. Trauma patients on new oral anticoagulation agents have lower mortality than those on warfarin. *J Trauma Acute Care Surg* 2016; **81**: 652-657 [PMID: 27438683 DOI: 10.1097/TA.0000000000001189]
- 56 **Calland JF**, Ingraham AM, Martin N, Marshall GT, Schulman CI, Stapleton T, Barraco RD; Eastern Association for the Surgery of Trauma. Evaluation and management of geriatric trauma: an Eastern Association for the Surgery of Trauma practice management guideline. *J Trauma Acute Care Surg* 2012; **73**: S345-S350 [PMID: 23114492 DOI: 10.1097/TA.0b013e318270191f]
- 57 **Min L**, Burruss S, Morley E, Mody L, Hiatt JR, Cryer H, Ha JK, Tillou A. A simple clinical risk nomogram to predict mortality-associated geriatric complications in severely injured geriatric patients. *J Trauma Acute Care Surg* 2013; **74**: 1125-1132 [PMID: 23511155 DOI: 10.1097/TA.0b013e31828273a0]
- 58 **Hashmi A**, Ibrahim-Zada I, Rhee P, Aziz H, Fain MJ, Friese RS, Joseph B. Predictors of mortality in geriatric trauma patients: a systematic review and meta-analysis. *J Trauma Acute Care Surg* 2014; **76**: 894-901 [PMID: 24553567 DOI: 10.1097/TA.0b013e3182ab0763]
- 59 **Ahl R**, Phelan HA, Dogan S, Cao Y, Cook AC, Mohseni S. Predicting In-Hospital and 1-Year Mortality in Geriatric Trauma Patients Using Geriatric Trauma Outcome Score. *J Am Coll Surg* 2017; **224**: 264-269 [PMID: 28017806 DOI: 10.1016/j.jamcollsurg.2016.12.011]
- 60 **Joseph B**, Orouji J, Kar T, Hassan A, Azim A, Mohler MJ, Kulvatunyoun N, Siddiqi S, Phelan H, Fain M, Rhee P. Redefining the association between old age and poor outcomes after trauma: The impact of frailty syndrome. *J Trauma Acute Care Surg* 2017; **82**: 575-581 [PMID: 28225741 DOI: 10.1097/TA.0000000000001329]
- 61 **Kua J**, Ramason R, Rajamoney G, Chong MS. Which frailty measure is a good predictor of early post-operative complications in elderly hip fracture patients? *Arch Orthop Trauma Surg* 2016; **136**: 639-647 [PMID: 26980097 DOI: 10.1007/s00402-016-2435-7]
- 62 **Kaplan SJ**, Pham TN, Arbabi S, Gross JA, Damodarasamy M, Bentov I, Taitsman LA, Mitchell SH, Reed MJ. Association of Radiologic Indicators of Frailty With 1-Year Mortality in Older Trauma Patients: Opportunistic Screening for Sarcopenia and Osteopenia. *JAMA Surg* 2017; **152**: e164604 [PMID: 28030710 DOI: 10.1001/jamasurg.2016.4604]
- 63 **Lilley EJ**, Williams KJ, Schneider EB, Hammouda K, Salim A, Haider AH, Cooper Z. Intensity of treatment, end-of-life care, and mortality for older patients with severe traumatic brain injury. *J Trauma Acute Care Surg* 2016; **80**: 998-1004 [PMID: 26953761 DOI: 10.1097/TA.0000000000001028]
- 64 **Devore S**, Parli SE, Oyler DR, Bernard A. Comprehensive Geriatric Assessment for Trauma: Operationalizing the Trauma Quality Improvement Program Directive. *J Trauma Nurs* 2016; **23**: 337-342 [PMID: 27828887 DOI: 10.1097/JTN.0000000000000244]
- 65 **Ayoung-Chee PR**, Rivara FP, Weiser T, Maier RV, Arbabi S. Beyond the hospital doors: Improving long-term outcomes for elderly trauma patients. *J Trauma Acute Care Surg* 2015; **78**: 837-843 [PMID: 25742250 DOI: 10.1097/TA.0000000000000567]
- 66 **Cooper Z**, Maxwell CA, Fakhry SM, Joseph B, Lundebjerg N, Burke P, Baracco R. A position paper: The convergence of aging and injury and the need for a Geriatric Trauma Coalition (GeriTraC). *J Trauma Acute Care Surg* 2017; **82**: 419-422 [PMID: 27893640 DOI: 10.1097/TA.0000000000001317]
- 67 **O'Connell K**, Maier R. Palliative care in the trauma ICU. *Curr Opin Crit Care* 2016; **22**: 584-590 [PMID: 27661439 DOI: 10.1097/MCC.0000000000000357]
- 68 **Rangel EL**. Future Directions of Geriatric Trauma Care: Function and Quality of Life Beyond Survival. *JAMA Surg* 2017; **152**: e164642 [PMID: 28030715 DOI: 10.1001/jamasurg.2016.4642]
- 69 **Moerman S**, Vochteloo AJ, Tuinebreijer WE, Maier AB, Mathijssen NM, Nelissen RG. Factors associated with the course of health-related quality of life after a hip fracture. *Arch Orthop Trauma Surg* 2016; **136**: 935-943 [PMID: 27236585 DOI: 10.1007/s00402-016-2474-0]
- 70 **Puts MT**, Toubasi S, Andrew MK, Ashe MC, Ploeg J, Atkinson E, Ayala AP, Roy A, Rodriguez Monforte M, Bergman H, McGilton K.

Interventions to prevent or reduce the level of frailty in community-dwelling older adults: a scoping review of the literature and

international policies. *Age Ageing* 2017; Epub ahead of print [PMID: 28064173 DOI: 10.1093/ageing/afw247]

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