Geriatric traumatic brain injury—What we know and what we don't

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According to the Census Bureau, it is expected that the elderly population in the United States will more than double to 80 million by 2050.[1] Currently, older adults have fewer disabilities than those of previous generations. They also have more active lifestyles, which increase their risk of injury. In 2015, Kozar et al.[2] published "Injury in the aged: Geriatric trauma care at the crossroads" highlighting the issue of geriatric trauma as a significant and growing concern among trauma surgeons. The number traumatic brain injury (TBI)-related hospitalizations and fatalities in elderly patients will increase over the next decade as the world's population ages.

Although guidelines for the treatment of TBI have been established,[3,4] they simply do not address the challenges of managing TBI in older patients. Despite TBI being a well-recognized major public health problem, especially in geriatric patients, research in this area is surprisingly sparse. Furlan and Fehlings[5] reviewed abstracts presented at the National Neurotrauma Symposia from 1984 to 2007 and found that only 1% addressed the effects of age on TBI. Furthermore, only 7 of over 4,000 were clinical studies addressing the effects of aging on TBI. Most of the data available on management of geriatric patients with TBI come from subgroup analyses of larger cohorts and many studies explicitly exclude geriatric patients. Geriatric-specific research is sorely needed in nearly all aspects of TBI care, especially in monitoring and therapeutic interventions. The purpose of this review is to outline the unique considerations of the geriatric patient with TBI and highlight what is currently unknown about the best way to care for elderly patients with TBI.

Epidemiology of Geriatric TBI

The elderly is the fastest-growing age group of the world's population. A 2015 report commissioned by the National Institute of Aging projects that the percentage of elderly citizens worldwide will increase from 8.5% in 2015 to almost 17% by 2050, equating to over 1.6 billion elderly people.[6] Concurrently, it is anticipated there will be a by rapid rise in the number of injuries and injury-related deaths among the elderly. The Centers for Disease Control and Prevention lists unintentional injuries as the fourth leading cause of death for all age groups and seventh in individuals older than 65 years.[7] At least one study from 1990 estimated that 40% of all trauma patients will be 65 years or older by 2050.[8] With some major trauma centers already exceeding that figure, that number is likely to be higher.[9] Traumatic injury in the elderly accounts for US $12 billion in annual medical expenditures and US $25 billion in total annual healthcare expenditures.[10]

It was estimated in 2010 that TBIs accounted for 2.5 million emergency department (ED) visits. About 11% of TBIs were hospitalized and discharged and over 52,000 died. These figures are a gross underestimation; they do not include persons who did not receive medical care, had outpatient or office-based visits, or received care at a federal facility.[11] Furthermore, there is an increasing appreciation of TBI as a chronic disease resulting in significant long-term morbidity and mortality, which is highlighted by the CDC's Report to Congress in 2015.[12] For the elderly, TBI is particularly dangerous. Those 75 years and older have the highest rates of hospitalizations and deaths related to TBI across all ages. From 2006 to 2010, fall is the predominant mechanism for TBI-related deaths in those 65 years or older. Falls account for more than one third of all TBIs within the general population and more than 50% of all TBIs among people older than 65 years (Fig. 1).[11,13] Interestingly, self-inflicted injuries account for nearly 20% of deaths in persons older than 65 years.

Classically a disease of younger patients, TBI is being seen with increasing frequency in the elderly patient population. Although individuals 65 years or older represent only 10% of all patients with TBI, they account for 50% of TBI-related deaths.[14] Patients who are older than 75 years have the highest TBI-related hospitalization rate, which is twice the rate for any other age group.[15] The mortality rate of patients older than 65 years is more than twice that for younger patients aged 20 years to 44 years with TBI.[15] Among the elderly in the United States, there are 155,000 annual cases of TBI leading to 12,000 deaths[8] and more than 80,000 ED visits each year, approximately three quarters of which result in hospitalization.[9] In 2003, the aggregate charges for treating a principal diagnosis of TBI in the elderly exceeded US $2.2 billion.[10]

For most age-related studies, elderly or geriatric is generally defined as aged 65 years and older, and these terms are used interchangeably in this review. This is generally true for TBI studies, though there is evidence to suggest that differences in outcomes begin to appear as early as aged 40 years or 45 years.[14,16] Irrespective of what age cutoff is applied, age is a strong factor influencing both mortality and morbidity following TBI and has been shown to be linearly associated with poor outcome.[14,17]

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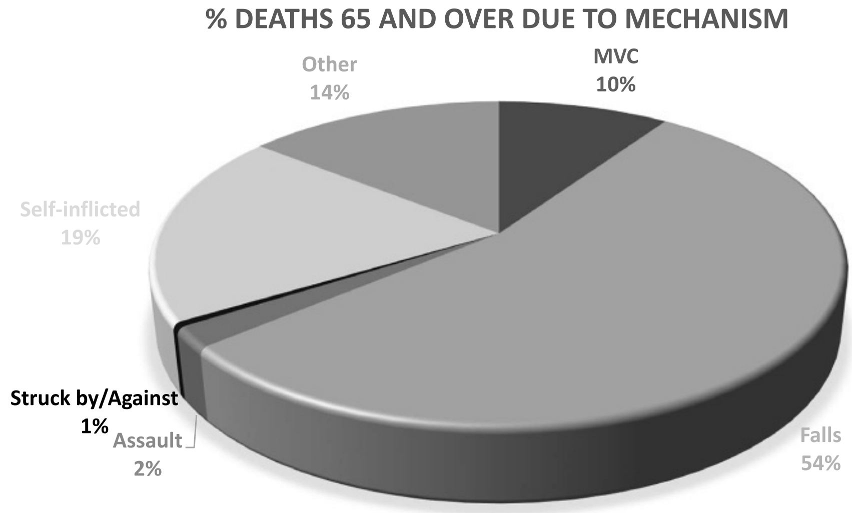

Figure 1. Causes of TBI related deaths in age ≥65 years.

Special Considerations for Geriatric Patients

Clinical Examination

The Glasgow Coma Scale (GCS) is the cornerstone of the rapid assessment during the primary survey of an injured patient. However, this objective score may be impacted by comorbidities that directly affect cognitive function, such as delirium, dementia, and other common diseases in elderly patients. These symptoms can often be unmasked in the unfamiliar environment of the hospital. The Mini-Mental Status Examination is useful in gaining information regarding the patient's global function, but a more detailed interview by a trained specialist may be necessary to differentiate baseline dysfunction from acute cognitive deficit. Likewise, it is important to ascertain preexisting sensory deficits, such as decreased vision and hearing, which may mislead the examiner who might conclude that the patient is cognitively impaired. When assessing visual acuity and hearing, the examiner should ensure that the patient is using corrective lenses and hearing aids whenever possible.

Pupillary response is another important aspect of the evaluation of a patient with suspected TBI. Abnormal pupillary response is associated with worse outcomes following TBI.[16,17] Pupillary responsiveness is also frequently used to guide the need for intervention or determine futility of intervention.[4] Preexisting chronic ophthalmic diseases, such as glaucoma or cataract disease, may alter the pupillary response. Thus, the medical history is a critical information to allow the correct interpretation of physical examination findings, such as an abnormal pupillary light reflex, anisocoria, or oculomotor palsy.

Anticoagulation Reversal

As the American population ages, there is a greater percentage who are prescribed anticoagulant and antiplatelet agents. Patients with TBI who are on anticoagulants have a two to six times greater mortality.[18] Furthermore, the mortality rate for elderly patients who are using anticoagulants prior to an injury is significantly higher when compared with their younger counterparts.[19]

For reversal of warfarin, prothrombin complex concentrate (PCC) is now recommended over fresh frozen plasma (FFP). The use of PCC leads to a shorter time for normalization of the INR, reduction of clinical progression of intracerebral hemorrhage, and reduced mortality rates as compared with treatment with FFP.[20] If PCC is not available, FFP and vitamin K can also be used.

Reversal of newer oral anticoagulant (NOACs) agents, which include Factor Xa inhibitors and direct thrombin inhibitors, is not well established as there are limited data. For dabigatran, dialysis can be considered due to its predominantly renal excretion. Prothrombin complex concentrate may be effective in reversal of the Factor Xa inhibitors, although there are insufficient data to conclude that reversing the NOAC effect based on laboratory test results correlates with improved clinical outcomes.[21] There are a few NOAC-specific reversal agents in clinical development, and the FDA gave idarucizumab accelerated approval in 2015 for emergent reversal of dabigatran. As with all anticoagulants, these agents are also associated with increased risk of intracranial hemorrhage (see Table 1).

Management of patients on preinjury antiplatelet agents remains controversial. One randomized trial of platelet transfusion in patients with intracranial hemorrhage demonstrated improved outcomes,[22] while other studies have failed to show an impact of platelet transfusion on clinically relevant outcome measures.[23] The PATCH randomized trial demonstrated worse outcomes in patients taking antiplatelet therapy who received platelet transfusion for acute nontraumatic intracranial hemorrhage (ICH).[24] Current recommendations are to transfuse platelets in patients taking antiplatelet medications with intracranial hemorrhage only if they are to receive a neurosurgical procedure,[25] but further data are needed.

Imaging

Any geriatric patient with suspicion of possible head trauma should undergo evaluation with a head computed tomography (CT) scan. In patients with minimal head injury, defined by a history of LOC or a GCS score of 14 to 15, the incidence

TABLE 1. Agents and Reversal Management

Anticoagulant Agent	Reversal in Patients With Intracranial Hemorrhage
Vitamin K antagonist	If INR ≥ 1.4 Vitamin K 10 mg IV + 3 or 4-factor PCC IV If PCC not available use FFP 10–15 ml/kg IV
Direct Factor Xa inhibitors	Activated charcoal (50 g) within 2 hours of ingestion Activated PCC (FEIBA) 50 units/kg IV or 4 factor PCC 50 units/kg IV Dialysis is not recommended as the drug is highly protein bound
Direct thrombin inhibitors	For dabigtran reversal: Activated charcoal (50 g) within 2 h of ingestion and Idarucizumab 5 g IV Consider hemodialysis or idacruzamab redosing for refractory bleeding after initial administration For other agents: Activated PCC (FEIBA) 50 units/kg IV or 4-factor PCC 50 units/kg IV
Unfractionated heparin	Protamine 1 mg for every 100 units of heparin administered in the previous 2–3 h (up to 50 mg in a single dose)
Low-molecular weight heparins	Enoxaparin: Dosed within 8 h: protamine 1 mg IV per 1 mg enoxaparin (up to 50 mg in a single dose) Dosed within 8–12 h: Protamine 0.5 mg IV per 1 mg enoxaparin (up to 50 mg in a single dose) Minimal utility in reversal >12 h from dosing dalteparin, nadroparin, and tinzaparin: Dosed within 3–5 half-lives of LMWH: Protamine 1 mg IV per 100 anti-Xa units of LMWH (up to 50 mg in a single dose) OR rFVIIa 90 μg/kg IV if protamine is contraindicated
Danaparoid	rFVIIa 90 μg/kg IV
Pentasaccharides	Activated PCC (FEIBA) 20 units/kg IV or rFVIIa 90 μg/kg IV

PCC, prothrombin complex concentrates; LWMH, low-molecular weight heparin; rFVIIa, recombinant factor VIIa.
From: Frontera JA, Lewin III JJ, Rabinstein AA, Aisiku IP, Alexandrov AW, Cook AM, Del Zoppo GJ, Kumar MA, Peerschke EI, Stiefel MF. Guideline for reversal of antithrombotics in intracranial hemorrhage. *Neurocritic Care*. 2016 Feb;24(1):6–46.

of an intracranial injury on CT is 10% to 15%.[26] These data do not appear to be influenced by age, but many studies excluded those patients with preexisting intracranial abnormalities or those on anticoagulants. In the original Canadian CT Head Injury Rule, an age older than 65 years was an independent risk factor of having an ICH.[27] A recent study by Wolf et al.[28] suggests that older patients may have an increased risk of ICH over younger patients. The American College of Emergency Physicians recommends a noncontrast CT scan of the head for all patients age 65 years or older who present with a mild head injury.[29]

The use of anticoagulation in many geriatric trauma patients complicates the recommended indications for imaging. In this group, the incidence of ICH is higher,[30] therefore, a more liberal use of early CT scanning is warranted. Additionally, patients on preinjury anticoagulants should have repeat CT scanning even in the absence of ICH on initial imaging if they are going to be discharged from the ED, although the timeframe for observation and repeat imaging is controversial. Given that the geriatric patient often has underlying cerebral atrophy, bleeds may progress without a significant change in their neurologic exam. In patients who are anticoagulated with warfarin and who initially have a normal CT scan, there is a small (<2%), but real incidence of the subsequent scan demonstrating hemorrhage.[31] Although the need for neurosurgical intervention is rare, further observation with additional CT imaging is recommended. For patients using platelet inhibitors, the data are even weaker. Many studies and algorithms have considered aspirin to be low risk for the development of ICH. However, recent studies question this assertion[32] and recommend that if a patient is to be discharged from the ED, a second CT scan may be prudent.

Early autopsy studies of noninjured people reveal age-related decreases in brain weight and brain volume (Fig. 2).[33] Cerebral atrophy is a normal part of aging although it is seen in a number of other disease states as well. Much of the morbidity of ICH is related to compression of vital structures. However, with the cerebral atrophy that occurs with aging, space-occupying lesions may be less likely to compress structures and cause symptoms as the patient has "room for expansion." Thus, the volume of an extra-axial hemorrhage in an asymptomatic geriatric patient would likely be symptomatic in a younger person. Chronic subdural hematomas are one type of TBI that are relatively specific to geriatric patients (Fig. 3). They are thought to be due to remote stretching of bridging veins often from minor insults. Often, the patient is initially asymptomatic and then develops clinical manifestations of mass effect or increased intracranial pressure (ICP). Symptoms may include headache, altered mental status, ataxia, or new motor deficits. Although acute subdural hematoma and intraparenchymal contusions are not uncommon in geriatric patients, epidural hematomas rarely occur.[34]

Mild TBI

Much of the literature in the field of TBI has focused on moderate to severe brain injury. However, of the estimated 2.8 million people in the United States who sustain a TBI each year, most have mild TBI.[11,35] Studies suggests that mild TBI, most typically defined as GCS score 13 to 15, comprises over 80% of all TBI; far outnumbering severe injuries.[36] Mild TBI

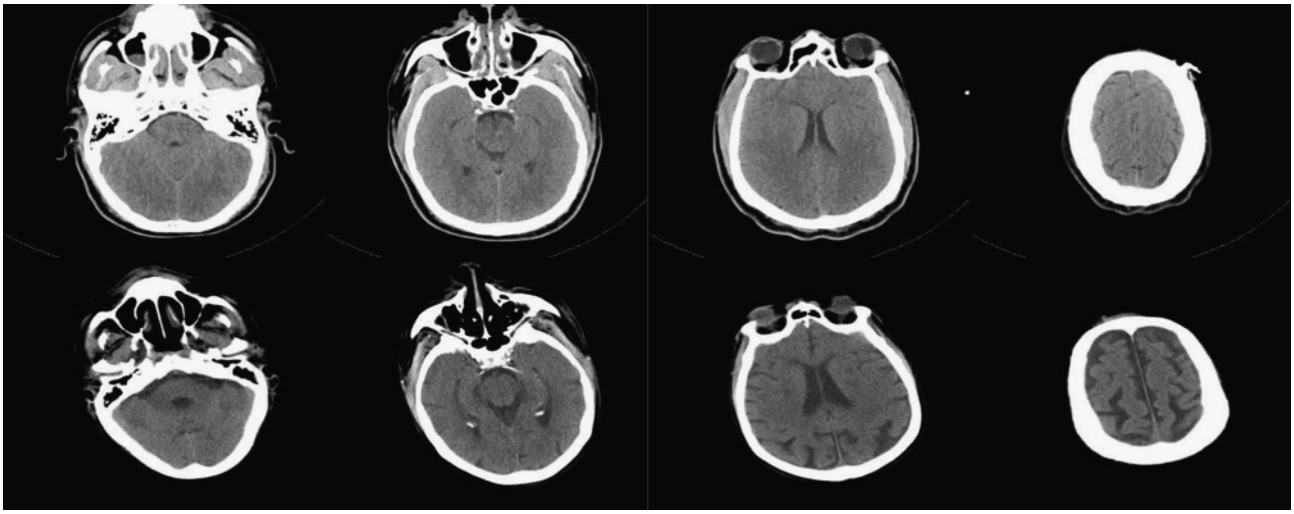

Figure 2. Normal head CT of 28 year old (top row) and an 88 year old (bottom row) demonstrating age-related changes and atrophy.

is frequently encountered in the elderly, particularly because of the vulnerability to fall. Assessing the severity of a TBI can be challenging in the elderly because of age-related decline in cognitive function, memory, burden of comorbidities, frailty status, and altered sensorium due to polypharmacy.

"Mild TBI" is a misnomer and refers only to the severity of the initial insult and should not be interpreted as suggesting the outcome will be mild.[37] Mild TBI can exacerbate age-related decline in function leading to long-lasting impairment of physical, cognitive, behavioral and psychosocial functions.[27,38] Clinical depression is common in patients of all ages after a mild TBI.[39] One study concluded that 53% of patients sustaining a TBI met criteria for major depression at least once during the follow-up period. A high index of suspicion is required due to overlap of symptoms between depression, TBI and other medical illnesses. Mild TBI has also been linked to the development of early onset of psychiatric and neurodegenerative diseases.[40,41] Early diagnosis and identification of patients at risk and tailored management of the elderly following a mild TBI may help to improve outcomes and improve quality of life.

Blood Pressure Targets

Hypotension is associated with poorer outcomes following TBI.[42,43] The original threshold for a systolic blood pressure (SBP) less than 90 mm Hg has recently been brought into question. More recent studies have defined hypotension as a SBP less than 120 mm Hg. These studies demonstrated that a single episode of SBP less than 120 mm Hg in the first 48 hours after TBI is associated with increased mortality and disability at 1 year.[44] However, these data are based on studies of patients of all ages and are not specific to the geriatric patient.

It would be appropriate to assume that older patients normally have a higher preinjury blood pressure and be more susceptible to even modest decreases in systemic blood pressure. As higher blood pressure cutoffs for geriatric trauma activation have been promoted, it is likely that conventional BP targets for TBI patients may be inappropriate. Further discrimination based on age has resulted in a threshold of SBP 110 mm Hg for ages 15 years to 49 years or older than 70 years and 100 mm Hg for ages 50 years to 69 years to been advocated in the Brain Trauma Foundation (BTF) guidelines.[3] Further studies are needed to fill this knowledge gap and delineate blood pressure targets according to age, comorbidities, and associated injuries.

ICP Monitoring

Intracranial pressure monitoring has been considered the standard of care following TBI, though evidence proving benefit is lacking. Available studies using a variety of databases and methodologies have found divergent results. Some studies have found an improved survival with ICP monitoring,[45] some an increased mortality rate,[46,47] and one meta-analysis found no difference.[48] These studies are all limited by their observational

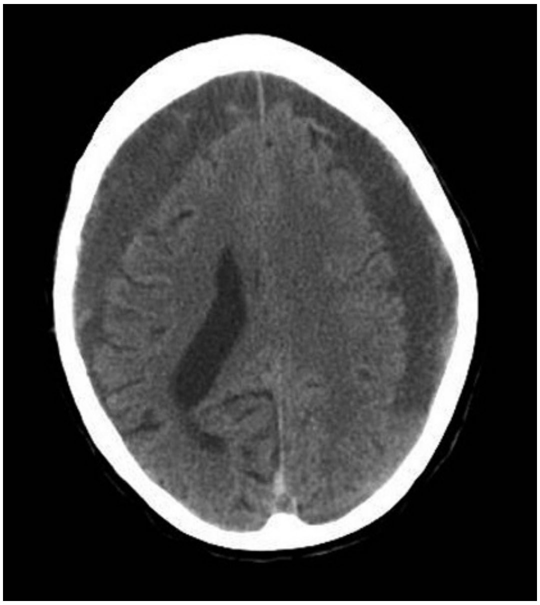

Figure 3. Example of a chronic subdural hematoma. Patient is an 84-year-old female who complained of only headache and denied a history of trauma.

design. The randomized-controlled BEST:TRIP trial demonstrated no mortality benefit in patients managed with an ICP monitor when compared with a group of patients managed with serial imaging and clinical examination.[49] Despite this report, the BTF guidelines still recommended ICP monitoring as a level IIB recommendation to "reduce in-hospital and 2-week postinjury mortality."[3]

The above recommendations are not specific to geriatric patients. One could postulate that due to cerebral atrophy, older patients would be at lower risk of intracranial hypertension. Thus, ICP monitoring may not indicated for most elderly patients. However, this is not reflected in current guidelines and the weakly evidenced criteria promulgated by the BTF guidelines for ICP monitoring in the presence of a negative head CT for patients older than 40 years[3] has promoted a culture of aggressive ICP monitoring regardless of age.

Few studies have investigated the use of ICP monitoring in geriatric patients with TBI. Intracranial pressure monitoring rates in older patients range from 5% to 44%, depending on the population studied.[46,50] Some studies on severe TBI report that the mean or median ages of ICP-monitored patients are invariably younger.[50] Alali et al.[51] found an adjusted odds ratio for mortality of 0.60 (0.44-0.83) in patients older 65 years with ICP monitoring. Conversely, Shimoda et al.[52] concluded that ICP monitoring was a significant factor associated with an unfavorable outcome in older patients. Similarly, Utomo et al.[53] found that use of an ICP monitor in older patients more than doubled the risk of mortality. Two studies, which specifically investigated the use of ICP monitoring in geriatric patients with TBI, reached contradictory conclusions. The first study used the National Trauma Data Bank and observed that monitoring ICP was associated with an increased odds of death,[54] while a single-center observational trial found a protective effect.[55] Clearly, further investigations are needed to define the role of ICP monitoring in the elderly.

Cerebral Perfusion Targets

Following placement of an ICP monitor, maintenance of cerebral perfusion pressure (CPP) has become a cornerstone of therapy in patients with TBI. Cerebral perfusion pressure is defined as the pressure gradient across the cerebral vascular bed (mean arterial pressure minus ICP). Existing literature suggests that mild ICP elevations can be tolerated if acceptable CPP is maintained.

There is insufficient evidence to support Level I recommendations for CPP monitoring in BTF guidelines.[3] However, use of CPP monitoring was associated with decreased mortality (Level 2B recommendation). Based on Level IIB evidence, the BTF recommends a target CPP of 60 mm Hg to 70 mm Hg for improved survival and favorable outcomes. Whether 60 years or 70 years is the ideal threshold may depend on the patient's innate autoregulatory status, and over aggressive attempts to maintain the CPP greater than 70 mm Hg have been associated with increased cardio-pulmonary complications.[56]

The applicability of these CPP guidelines to elderly patients is unknown, as none of the studies directly address age-specific outcomes or recommendations. Aging results in a decrease in cerebral blood flow (CBF) and vascular reactivity is altered.[57] It is not clear whether older individuals have decreased ability to autoregulate CBF[58] with brain injury. As noted above, any cause of decreased CBF can lead to worsening tissue hypoxia and secondary insult in the injured brain.[57,59] Despite typically lower ICPs, with concomitant higher CPP, it is well known that older patients with TBI have poorer outcomes than younger patients with similar injuries.[57,60] The reasons for this finding are poorly understood and this represents one of many gaps in understanding the goals of CPP management of geriatric TBI.

Operative Interventions

The most recent evidence-based guidelines from the BTF make specific recommendations about the surgical management of epidural and subdural hematomas and intraparenchymal contusions based on size and type of lesion and clinical examination.[4] The use of decompressive craniectomy (DC) for elevated ICP refractory to medical management is a frequent practice in most high-volume trauma centers as good functional outcomes have been reported.[61] The randomized controlled DECRA trial reported higher mortality for patients undergoing DC[62] whereas the randomized controlled RESCUEicp trial demonstrated lower mortality, but higher rates of poor neurologic outcome in patients treated with DC.[63] The indications for DC in geriatric patients have not yet been defined.

These guidelines and the studies referenced above fail to address age or any frailty markers as factors in selecting patients for operative intervention. Based on the anatomy of the geriatric brain, pure size criteria alone may not be a valid indication for operative intervention in patients with significant cerebral atrophy. Elderly patients can often harbor large mass lesions with relatively little mass effect because of the extra space provided by atrophy. The findings of coma, neurologic decline, or pupillary abnormalities may also be more difficult to appreciate in older patients with dementia, hearing loss, or chronic ophthalmological disease. Additionally, none of the data from the randomized controlled trials above are applicable as older patients were explicitly excluded. At least one study has demonstrated worse outcomes in geriatric patients treated with primary DC.[64]

One study has attempted to specifically address the issue of indications for operative intervention in geriatric patients with Subdural hematoma based on admission GCS, pupillary response, degree of midline shift versus thickness of SDH, and ICP.[65] As importantly, they also make recommendations about which patients would not benefit from intervention due to futility. Chronic subdural hematoma is one disease that is relatively unique in older patients. Evacuation is indicated when a patient is symptomatic and there is significant mass effect.[34] The most common operative procedure utilized is creation of a burr-hole. Other procedures include subdural drains, open craniotomy, or twist drill craniostomy.

Outcomes

Outcome following TBI, most often measured as mortality, has historically been considered to be worse in the geriatric population. Age, admission GCS, and Charlson Comorbidity Index,[66] head Abbreviated Injury Scale score and Injury Severity Score[67] have all been found to be reliable for predicting mortality. Within the geriatric population, younger age is protective as patients age 65 years to 74 years are less likely to die than are older elderly (74–84 years) or the "old old."[68] Hypotension on arrival, intraventricular hemorrhage, subarachnoid hemorrhage, and use of antiplatelet agents further increase the risk of death.[66] Resource utilization is higher in geriatric TBI because these patients require longer hospitalization, more home health visits, and other care in the first year after injury.[69] Geriatric patients with TBI also have more respiratory complications and are more likely to be discharged to a nursing home.[67]

Evidence suggests that elderly patients with TBI are treated less aggressively than their younger counterparts, perhaps partly because of perceived unfavorable outcomes, but predicting outcome is more complex than simply collecting admission data and applying a scoring system. Outcome measures for TBI should include functional outcome in addition to mortality and should be evaluated at time frames beyond admission and discharge. Outcome predictions may vary through the treatment course. Though GCS score on admission is predictive of survival, GCS score at 14 days is not.[70] Functional outcome and independence, cognitive function, mental health, and quality of life are important outcome measures in TBI.[71] The optimal outcome measure or predictor and the ideal point in time to measure them are unknown.

Extended Glasgow Outcome Scale (GOSE) has been reported to gradually improve for at least 1 year in most age groups after TBI, but the geriatric subpopulation fails to show improvement in GOSE.[70] All age groups improve in the physical category of Health-related Quality of Life (HRQoL) Short Form 12 (SF12). The fact that physical HRQoL improves but GOSE does not suggests that TBI patients may experience less subjective physical disability over time, even if GOSE is not sensitive enough to detect it. These data further illustrate that outcome depends on the measurement tool being used, the population measured, and the time of the measurement.

Rehabilitation is an important component of recovery from TBI in geriatric patients, and it can dramatically influence outcome. Elderly patients spend a longer time in acute rehabilitation, which is associated with higher costs. Inpatient rehabilitation improves 6-month physical functional outcome even in elderly patients with severe TBI.[72] Relative improvement is similar to a younger cohort, but in older patients, the final level of disability is higher.[73] Despite the potential benefit of rehabilitation, fewer geriatric patients with TBI receive inpatient rehabilitation services 3 months after injury compared to younger patients. Since inpatient rehabilitation is important for maximizing recovery, provider bias against rehabilitation must be minimized.[70]

Aggressive intensive care unit (ICU) care can improve survival in geriatric TBI but is associated with an increased prevalence of patients discharged with severe disability. Cognitive outcome may be more accurately predicted by CT scan findings[74] and by admission GCS score[75] than by age. Prediction models for patients with severe TBI may overestimate mortality in geriatric patients.[76] A recent study showed that in a geriatric population with varying severity of TBI, the final functional outcome fell into high- and low-performing strata, with a paucity of patients in the mid-range of function. These dichotomous outcomes suggest that other factors, such as comorbidity and frailty, may also play a role.[70] The myriad of factors associated with recovery make further investigation essential.

Prognostication

Formulating prognosis is important for establishing treatment goals, setting expectations, and for care planning. Seriously ill older patients are more likely to value function, independence, and freedom from symptoms over longevity.[77,78] Thus, although most studies estimate risk based on in-hospital or 30-day mortality, there is an increasing demand for clinicians to better understand the impact of injury on long-term function, quality of life, setting (home versus chronic care), and survival.

Older patients do worse after even a mild TBI when compared to younger patients, and prognostic tools validated in younger patients are less reliable in the elderly. For example, admission GCS score is a less reliable indicator of mortality or functional recovery in patients over 55 years, who may present with a higher GCS score, yet worse Abbreviated Injury Scale scores.[79–81] A multicenter observational study by Mosenthal et al[82] compared functional outcomes between older and younger patients with mild TBI (GCS score, 13–15) at hospital discharge and 6 months. Older patients had worse Functional Independence Measure scores at discharge and at six months, but with rehabilitation, the difference became clinically negligible, suggesting that older patients with mild TBI benefit from time for recovery and aggressive rehabilitation. In cases of severe head injury (GCS score, ≤8), mortality is high, but not certain. Despite guidelines suggesting that early failure of neurologic improvement should prompt reconsideration of aggressive treatment in older patients with severe TBI, clinical improvement at 72 hours is an unreliable predictor for death.[83] A single center study of patients over 70 years admitted to Level I trauma center with GCS score less than 8 requiring mechanical ventilation and ICU admission, found that of patients who survived 72 hours, 1-year survival was 29%. Patients who were improved at 72 hours and those who were not had similarly poor survival, and all had functional impairment.[84]

In addition to age, other important risk factors for adverse outcomes include underlying health status and physical function, which can be quantified by numerous frailty scores. Most TBI in the elderly are the result of falls from standing, which are themselves associated with accelerated mortality and life-limiting geriatric syndromes, including frailty, dementia, and motor disorders. As compared with other causes of hospitalization, falls are associated with 40% greater risk of disability at 6 months, and more than three times greater risk of discharge to a long-term nursing facility.[85] It is estimated that between 44% and 78% of geriatric trauma patients are frail at the time of injury,[86,87] and frailty is associated with a 15% to 50% greater mortality risk depending on the frailty definition used.[88] Risk of mortality increases with the number of deficits or frailty characteristics that are present

TABLE 2. Recommendations for Early Palliative Care Interventions

Within 24 h	
	Identifying a health care proxy
	Obtain or complete advance directives
Within 72 h	
	Family meeting/goals-of-care discussion

TABLE 3. Research Priorities

Fall prevention
Anticoagulation reversal
Indications for and timing of repeat imaging
Blood pressure and CPP targets
Indications for intracranial pressure monitoring
Indications for operative intervention
Outcome measurement instruments
Prognostication tools
Efficacy of palliative care interventions

preinjury.[88] Poor preinjury physical function is associated with 30% higher mortality and 50% worse physical function 1 year after injury.[89] The Palliative Performance Scale (0–100), which assesses functional performance and palliative care needs in seriously ill patients, shows promise as a prognostic tool in older trauma patients. In a single-center study of geriatric trauma patients admitted to an ICU, those with Palliative Performance Scale score less than 80 had almost three times higher in-hospital mortality and eight times higher risk of discharge to dependent care.[90]

Palliative Care

Palliative care refers to the prevention and relief of suffering for patients with an advanced illness.[91] Palliative care is provided based on patient and family needs, not prognosis, and is focused on communication, pain and symptom management, identifying goals of care, bereavement, and spiritual support.[92] In 2005, the ACS affirmed palliative care as integral to the care of all surgical patients[93] and recently published a palliative care best practices guidelines for trauma.[94] Patients with TBI have special palliative care needs, given the acute onset of injury and the devastating toll that the brain injury has on the patient and family.[95] Helping patients and families navigate the prognostic uncertainty and either recovery or end-of-life care involves challenges that make palliative care an essential component of the treatment plan.

The majority of older patients make medical decisions based on benefits or burdens of treatment, and quality of life rather than quantity. Many will forego life-sustaining interventions if the outcome will not result in improved functional or cognitive outcome.[96] Older adults with severe TBI experience high in-hospital mortality, but also high functional impairment at 12 months; thus, early goals-of-care discussions are essential to high quality palliative care.[84] Providers may struggle with communicating an unclear prognosis, particularly in a brain-injured patient whose clinical status may be rapidly changing.[97] Furthermore, in severely injured patients who cannot communicate, both family members and providers must determine what they understand to be the patient's goals, values, and preferences to develop appropriate care plans.

The use of prognostic tools that predict function as well as survival is evolving and may serve as a trigger for goals-of-care discussions and time-limited trials of therapy. Early structured palliative care interventions—identifying a healthcare proxy and advance directives within 24 hours and family meeting/goals-of-care discussion within 72 hours (Table 2)—has resulted in earlier goals of care consensus and lower use of nonbeneficial life support.[98] It is critical to understand that many older patients value quality of life more than quantity and to incorporate each patient's preferences into treatments.

CONCLUSION

Care of the geriatric patient with a TBI is a significant issue facing trauma care providers. The number of geriatric patients with TBIs continues to rise annually. There is, however, a shortage of literature on TBI in the elderly, representing a large void in our knowledge. High-quality research (Table 3) is needed to guide the development of geriatric-specific management guidelines for TBI and ultimately improve outcomes and decrease mortality in this vulnerable population.

AUTHORSHIP

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DISCLOSURE

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