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Practice Management Guidelines for Geriatric Trauma: The EAST Practice Management Guidelines Work Group

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Advanced age is a well-recognized risk factor for adverse outcomes after trauma. A substantial body of literature, much of it cited within this article, demonstrates increased morbidity and mortality in geriatric trauma patients compared with their younger counterparts. Whether this outcome difference is because of the decreased physiologic reserve that accompanies aging, a higher incidence of preexisting medical conditions in the geriatric patient, or other factors yet to be identified remains unclear. It is clear, however, that good outcomes can be achieved in this patient population when appropriately aggressive trauma care is directed toward geriatric patients with survivable injuries. Implicit in the above statement is the need to identify, as soon as possible after injury, those patients who will benefit from aggressive resuscitation, timely injury management, and posttrauma rehabilitation. It is equally important, however, to limit these intensive and expensive treatment modalities to patients whose injuries are not only survivable but also compatible with an acceptable quality of life.

Our purpose in developing this guideline was to provide the trauma practitioner with some *evidence-based* recommendations that could be used to guide decision-making in the care of the geriatric trauma patient. We began this process by first developing a series of questions, the answers to which we hoped could be supported by the existing scientific literature. The initial set of questions were as follows:

1. Is age itself a marker of increased morbidity/mortality? If so, what age should be used?
2. Is age instead a surrogate for increased preexisting conditions (PECs)? If so, which premorbid conditions are particularly predictive of poor outcomes?
3. Should age itself be a criterion for triage from the field directly to a trauma center, regardless of Glasgow Coma Scale (GCS) score, Trauma Score (TS), and so forth? If so, what age should be used?
4. Do trauma centers have better outcomes with geriatric trauma than nontrauma centers?
5. Are there specific injuries, scores (e.g., Injury Severity Score [ISS], TS, GCS score), or PEC/age combinations in geriatric trauma patients that are so unlikely to be survivable that a nonaggressive approach from the outset could be justified?
6. What resuscitation end-points should be used for the geriatric trauma patient?
7. Should *all* geriatric trauma patients receive invasive hemodynamic monitoring? If so, what specific types of monitoring should be used? If not, which geriatric patients benefit from invasive monitoring?

Unfortunately, after examining the available literature, it is clear that *evidence-based* responses to all of the questions raised above are not possible. As the evidentiary tables demonstrate, there are few, if any, prospective, randomized, controlled trials that definitively address any of the above issues. Second, there is a lack of uniformity as to a specific age criterion for geriatric trauma. As shown in the evidentiary tables, geriatric trauma is variously defined in the literature as age greater than or equal to 55, 60, 65, 70, 75, and even 80 years of age. There is even literature support for increased mortality from trauma beginning at age 45! Furthermore, because age is a continuous variable, and not a dichotomous one, adverse outcomes associated with geriatric trauma are likely to increase in a continuous fashion with age as opposed to a stepwise leap as a given patient reaches a specific age. Third, there is no concise definition of a geriatric trauma patient. In some studies, all patients over a given age are included, whereas in others, patients with penetrating injuries, burns, and minor injuries, such as slip-and-falls, are excluded. Some studies include all patients regardless of hemodynamic instability or injury severity, whereas others impose strict entrance criteria or exclude patients who do not survive for a predetermined period of time after admission. Such lack of uniformity regarding inclusion criteria makes it

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difficult to compare outcomes across different patient populations. Finally, much of the literature concerning geriatric trauma is relatively "old," that is, published more than 10 years ago. Given the significant improvements in patient care that have occurred over the past 10 to 20 years, recommendations made on the basis of outcomes achieved more than 10 years ago may not be applicable to today's geriatric trauma patient.

Despite the above-mentioned shortcomings, our committee still felt that it was important to summarize the available literature and make evidence-based recommendations where satisfactory evidence did exist. In light of the seven questions raised above, two broad areas of focus emerged within this guideline: issues of geriatric trauma triage, and issues of geriatric trauma resuscitation. Although there was considerable overlap between these two areas, each issue has been addressed separately within this guideline and, accordingly, two separate "subguidelines," each with its own recommendations, evidentiary table, and areas for future research, constitute this practice management guideline for geriatric trauma. It is hoped that the information provided within this guideline will provide evidence-based support for the difficult decisions that are required to achieve optimal outcomes in this difficult but ever-increasing patient group.

TRIAGE ISSUES IN GERIATRIC TRAUMA

I. Statement of the Problem

The process of triage, as it relates to the geriatric trauma patient, is an attempt to provide the patient with the appropriate intensity of medical resources, taking into account the severity of illness, the cost and availability of medical resources, the prognosis for functional survival and, if known, the expressed desires of the patient. For the geriatric trauma patient, this process begins in the prehospital phase of care, where decisions must be made regarding the appropriate patient destination, trauma center versus nontrauma center. In the resuscitative phase of trauma care, triage decisions regarding patient destination must again be made, specifically, whether patient circumstances dictate provision of intensive care resources or whether standard trauma inpatient care will suffice. Throughout the hospital phase of care, the patients must be "triaged" toward or away from operative procedures, invasive and expensive critical care therapies, and powerful yet potentially dangerous pharmacologic treatment options, decisions which, again, must be made on the basis of the likelihood of achieving a good, long-term outcome for the patient. An increasingly common circumstance, particularly in the geriatric trauma patient, involves the decision to withdraw, or perhaps not even institute, an aggressive course of treatment, when the clinical circumstances are incompatible with a quality of life that all parties concerned would deem acceptable. Fundamental to all of these triage decisions is the ability to predict with reasonable accuracy what a particular patient's outcome might be depending on which triage decision is made. To be of any value to the trauma practitioner, and ultimately to the patient and his or her family, the clinical variables on which these predictions are to be based must be easy to obtain, reliable, and available to the trauma practitioner within a relatively short period of time after injury. The task, therefore, of this particular subcommittee was to determine whether there existed adequate support in the scientific literature to develop recommendations regarding (1) appropriate criteria for triage of the geriatric trauma patient to trauma centers, (2) the clinical variables that would be useful in predicting the need for intensive care resources for the geriatric trauma patient, and (3) those clinical circumstances where a nonaggressive approach from the outset could be justified.

II. Process

An initial computerized search was undertaken using MEDLINE with citations published between the years 1966 and 1999. Using the search words "geriatric," "trauma," "elderly," and "injury," and by limiting the search to citations dealing with human subjects and published in the English language, well over 2,300 citations were identified. From this number were then excluded letters to the editor, case reports, reviews, and a large number of articles dealing with minor injury mechanisms, particularly hip fractures from slip-and-falls. An additional cause for exclusion of references was publication before 1975, as it was felt that the trauma care provided at this time was so different compared with current trauma care that recommendations made on the basis of data from this earlier time period would not be valid. The abstracts of the remaining citations were each reviewed, and those articles that did not address prognostic variables or other issues pertinent to the *triage* of the geriatric trauma patient were further excluded. This yielded a total of 32 articles that constituted the initial evidentiary table (Table 1). The bibliographies of these 32 articles were then further reviewed and an additional 13 articles meeting the above-mentioned criteria were added, for a total of 45 references within the evidentiary table. Each reference was then reviewed by three trauma surgeons, and consensus was reached regarding appropriate classification of each reference according to the Canadian and United States Preventive Task Force. Criteria for achieving a specific classification and the number of articles for each class (the total number of classified references exceeds the total number of references by one because one two-part study was classified as both a Class II and Class III reference) are shown below:

Class I: Prospective randomized controlled trials—the "gold standard" of clinical trials. Some may be poorly designed, have inadequate numbers, or suffer from other methodologic inadequacies (0 references).

Class II: Clinical studies in which data were collected prospectively, and retrospective analyses that were based on clearly reliable data. Types of studies so classified include observational studies, cohort stud-

Table 1 Evidentiary Table: Triage Issues in Geriatric Trauma

First Author	Year	Reference	Data Class	No. of Patients	Age (yr)	Pt. Population	Mortality (%)	Conclusion
Gubler KD	1997	Long-term survival of elderly trauma patients. *Arch Surg.* 132: 1010–1014.	II	9,424	≥ 67	All (HCFA database)	4.1 (in-hospital)	Determined 5-yr survival of injured cohort compared to 4:1 uninjured cohort matched for age and gender. *Injured cohort had more* PECs. Five-year risk of death in injured cohort was 1.7 times that of uninjured cohort and was related to age, gender, ISS, and PECs. Adverse effect of trauma on survival remains long after traumatic episode.
Oreskovich MR	1984	Geriatric trauma: injury patterns and outcome. *J Trauma.* 24:565–572	III	100	≥ 70	"Severe" injury; (mean ISS = 19)	14 at 1 mo; 15% at 1 yr	Factors affecting survival included "serious" CNS injury, shock (BP < 80), and burn mechanism. Survival was NOT affected by age, ISS, gender, or presence of PECs. Profile of the nonsurvivor: required prehospital intubation, was in shock at some time, was intubated > 5 days, and developed pulmonary sepsis. Less than 8% of patients were independent at 1-year follow-up. Vague definitions of PECs and entry criteria into study.
Horst HM	1986	Factors influencing survival of elderly trauma patients. *Crit Care Med.* 14:681–684.	III	39	> 60	ICU admits w/PAC and arterial catheter	31	Survival related to sepsis and the number of failed organ systems, but NOT age, ISS, TS, APS (Acute Physiology Score), injury mechanism, PEC, presence of shock at admission, or initial cardiopulmonary variables. Small number of patients in this study raises questions regarding the validity of its conclusions.
Amacher AL	1987	Toleration of head injury by the elderly. *Neurosurgery.* 20:954–958.	III	56	≥ 80	All head-injury admissions	25	Overall mortality 25%, but CNS-related mortality was 16%. Seven of eight patients with admission of GCS score of 3–6 died (87.5% mortality), but the single survivor had an excellent/good outcome. Conversely, 5 of 42 (12%) patients with GCS score of 13 or more died.
DeMaria EJ	1987	Survival after trauma in geriatric patients.	III	82	> 65	Excluded burns, penetrating, and isolated orthopedic injury (ISS = 17.9)	21	Nonsurvivors were older, had higher ISSs and AIS scores for the head and neck, and had more complications. Developed formula to predict outcome based on age, ISS, and the presence/absence of cardiac and septic complications. Prospectively tested formula on 61 pts. with 92% accuracy. Authors counsel against use of formula (Geriatric Trauma Survival Score) to predict mortality or to limit resuscitative efforts.
		Ann Surg. 206: 738–743.	II	61			16.4	

Table 1 *Continued*

First Author	Year	Reference	Data Class	No. of Patients	Age (yr)	Pt. Population	Mortality (%)	Conclusion
DeMaria EJ	1987	Aggressive trauma care benefits the elderly. *J Trauma.* 27: 1200–1206.	III	63	> 65	Excluded burns, penetrating, and isolated orthopedic injury	Study of survivors only	Examines factors related to home vs. NH disposition in elderly trauma survivors. NH pts. were older, had higher ISS, more complications, longer LOS, more severe head and neck trauma, and required surgery more frequently after trauma. These factors are probably not useful for triage purposes, as the majority of NH pts. ultimately returned home. Overall, 89% of pts. returned home and 57% returned to independent living.
Broos PL	1988	Polytrauma in patients of 65 and over: injury patterns and outcome. *Int Surg.* 73: 119–122.	III	49	≥ 65	Excluded DOAs and pts. who died prior to any intervention	18 [6 mo] (mean ISS = 33.2)	Factors predicting mortality included coma (not defined) and "early and continued intubation" (intubated prehospital or at admission and continued for 5 days or more). Age, ISS, and PECs were not significantly predictive of mortality. Small number of patients on which to make any recommendations. Vague definition of "polytrauma"; 76% of survivors returned home.
Osler T	1988	Trauma in the elderly. *Am J Surg.* 156:537–543.	III	100	≥ 65	Excluded if Pt. died before OR or ICU	17	Factors distinguishing elderly survivors from nonsurvivors included TS, GCS, ISS, shock, pulmonary sepsis, and prolonged ventilation (>5 days), but not age. Using logistic regression analysis, shock and GCS score were found to be the best predictors of geriatric trauma death. No elderly pt. survived a TS < 9.
Finelli FC	1989	A case control study for major trauma in geriatric patients.	III	3,669	≥65	All (MTOS)	18.3	MTOS data reveals increased trauma mortality beginning at age 45. In the Washington Hospital Center data set, overall mortality in pts. ≥ 65 was twice that of younger pts. ISS-adjusted mortality was greater in the elderly at all ISS levels. ISS was much higher in elderly nonsurvivors than survivors. Older pts. also had higher complication rates. Although no predictive factors for elderly mortality were given, authors recommend triaging elderly trauma victims to trauma centers at a much lower threshold.
		J Trauma. 29: 541–548.	III	180	≥ 65	All (Washington Hospital Center)	26.7	

Table 1 *Continued*

First Author	Year	Reference	Data Class	No. of Patients	Age (yr)	Pt. Population	Mortality (%)	Conclusion
Howard MA	1989	Acute subdural hematomas: an age-dependent clinical entity. *J Neurosurg.* 71:858–863.	III	67	>65	All patients with acute subdural hematoma >0.5 cm	74	Mortality rate of 74% compared to 18% in patients aged 18–40 yr. Older patients died significantly later than younger patients (11.2 days vs. 2.0 days). Admission GCS score was similar for the two groups, but elderly patients had larger SDH volume and more midline shift than younger patients. Advanced age, large SDH volume, and midline shift were each predictive of poor outcome, although not independently. The effect, if any, of PECs on outcome was not studied.
McCoy GF	1989	Injury to the elderly in road traffic accidents. *J Trauma.* 29: 494–497.	III	312	>65	All traffic incidents	9.3	Overall higher mortality in elderly group, even after correcting for ISS. AIS much better predictor of mortality if 1 point is added to the MAIS for patients > 65 yr. All pts. > 65 yr with MAIS ≥ 5 died. Small number of patients.
Reuter F	1989	Traumatic intracranial hemorrhages in elderly people. *Neurosurg.* 17: 43–48.	III	64	≥60	Included only patients requiring surgery	76	Mortality was 87% in patients with admission GCS score < 8. Mortality also affected by complications with 90% mortality in patients with complications. Description of head injury management not provided.
Morris JA	1990	Mortality in trauma patients: the interaction between host factors and severity. *J Trauma.* 30: 1476–1482.	III	199,737	≥ 15	All trauma discharges excluding transfers	1.9	Mortality from minor injury (ISS < 9) increases at age > 65, whereas for moderate injuries (ISS of 9–24), mortality begins to increase at 45 yr. ISS is best predictor of mortality in trauma patients, but age, gender, and PECs are also important *independent* predictive factors of mortality.
Morris JA	1990	The effect of preexisting conditions on mortality in trauma patients. *JAMA.* 263:1942–1946.	III	3,074	≥ 15	All hospitalized trauma deaths in California in 1983	N/A	Case-control study with 4:1 match (survivors:deaths). Trauma mortality increases with increasing numbers of PECs. PECs contributing significantly to mortality included liver disease, congenital coagulopathy, COPD, ischemic heart disease, and diabetes. The effect of PEC on mortality was greater in patients with/ISS < 13, and in pts. ≤ 65 yr.

Table 1 *Continued*

First Author	Year	Reference	Data Class	No. of Patients	Age (yr)	Pt. Population	Mortality (%)	Conclusion
Smith DP	1990	Trauma in the elderly: determinants of outcome. *South Med J.* 83:171–177.	III	456	≥ 65	All patients with traumatic injuries	8.6 (mean ISS = 10.8)	Factors associated with outcome included mechanism of injury (burns > MVC > pedestrian struck > assault > falls), and number of complications. The presence of PECs was not associated with adverse outcomes, but definition of "PEC" was vague. Low mortality series. PECs may not influence outcome when ISS and mortality rates are low.
Smith JS	1990	Do trauma centers improve outcome over non-trauma centers: the evaluation of regional trauma care using discharge abstract data and patient management categories. *J Trauma.* 30: 1533–1538.	III	1,332	N/A	All patients with femoral shaft fractures	1.0 at trauma centers vs. 2.2 at nontrauma centers	Compares outcomes in trauma centers vs. nontrauma centers for patients with femoral shaft fractures. Trauma center patients had significantly fewer overall complications (21% vs. 33%), and lower mortality. In the subset of patients > 55 yr of age, complication rates were 35% at trauma centers and 47% at nontrauma centers. Elderly trauma patients (age > 55) with significant injuries in addition to their femur fractures were much less likely to be triaged to trauma centers than their younger counterparts (38% vs. 70%).
van Aalst JA	1991	Severely injured geriatric patients return to independent living: a study of factors influencing function and independence. *J Trauma.* 31: 1096–1101.	III	98	≥ 65	Blunt trauma (ISS ≥ 16)	44 in hospital	1- to 6-yr follow-up (mean, 2.82 yr) of 54 elderly blunt trauma patients with ISS ≥ 16, who survived initial hospitalization; 11% of these died during the follow-up period, and only 17% regained their preinjury function. However, 67% returned to independent living. Factors associated with a poor outcome (death or dependent living status) included GCS score ≤ 7, age ≥ 75, shock at admission, presence of head injury (AIS Head ≥ 3), and sepsis.

ies, prevalence studies, and case control studies (two references).

Class III: Studies based on retrospectively collected data. Evidence used in this class indicates clinical series, database or registry review, large series of case reviews, and expert opinion (44 references).

III. Recommendations

A. Level I: There are insufficient Class I and Class II data to support any standards regarding triage of geriatric trauma patients.

B. Level II:

1. Advanced patient age should lower the threshold for field triage directly to a trauma center.

C. Level III:

1. All other factors being equal, advanced patient age, in and of itself, is not predictive of poor outcomes after trauma, and therefore should NOT be used as the sole criterion for denying or limiting care in this patient population.

2. The presence of PECs in elderly trauma patients adversely affects outcome. However, this effect becomes progressively less pronounced with advancing age.

Table 1 *Continued*

First Author	Year	Reference	Data Class	No. of Patients	Age (yr)	Pt. Population	Mortality (%)	Conclusion
Vollmer DG	1991	Age and outcome following traumatic coma: why do older patients are worse? *J Neurosurg.* 75:S37–S49.	III	661 71	≥15 ≥56	Traumatic Coma Data Bank (TCDB) patients; (age ≥15, GCS score ≤ 8, gunshot wounds to head, and patients meeting brain death criteria on arrival were excluded)	38 80	Reports outcomes at 6 mo postinjury for patients with severe brain injuries (GCS score < 8). Overall mortality was 38%, but was 80% for patients > 55 yr of age. No "elderly" patient made a "good" recovery, and there were fewer "elderly" patients with moderate disability, severe disability, and vegetative survival compared with younger patients. Early (<48 h) mortality was similar among all age groups, but late (>48 h) mortality was significantly higher in older patients. Although preexisting medical conditions and complications were more frequent in elderly patients and, thus, were associated with poor outcome, multivariate analysis revealed age to be an *independent* and significant predictor of death and vegetative outcome, beginning at age 45. Whether preexisting medical conditions and complications remain as *independent* predictors of poor outcome is not stated. The authors conclude that the poor outcome after head injury in "elderly" patients is primarily because of the limited capacity of the aging brain to recover after injury.
Cagetti B	1992	The outcome from acute subdural and epidural intracranial haematomas in very elderly patients. *Br J Neurosurg.* 6:227–232.	III	28	≥ 80	Excluded patients with intracerebral hematomas and contusions without significant extra-axial clots	88 (compared to 57 in pts. < 80 yr)	All patients with GCS score ≤ 11 died. Preexisting diseases and multiple system organ failure accounted for the majority of deaths. All surviving patients successfully returned to their preinjury state of health. No significant difference between the volume of clot or the frequency of associated cerebral contusions between those patients ≥ or < 80 yr. The authors conclude the level of consciousness at the time of operation correlates with outcome better than do other parameters. No description of management was provided, making it difficult to determine whether care provided to the two populations was equivalent.
Jamjoom A	1992	Outcome following surgical evacuation of traumatic intracranial haematomas in the elderly. *Br J Neurosurg.* 6:27–32.	III	66	≥65	All patients undergoing craniotomy for evacuation of posttraumatic hematoma	61	Increased mortality (86%) in the subset of patients ≥ 80 yr of age. Outcome also worse if craniotomy performed within 24 h of injury. Authors feel craniotomy not justified in patients with a preoperative GCS score of 4 or less or in those with unilateral or bilateral pupillary dilatation because all patients in these two categories had poor outcomes (Glasgow Outcome Score of 1–3).

Table 1 *Continued*

First Author	Year	Reference	Data Class	No. of Patients	Age (yr)	Pt. Population	Mortality (%)	Conclusion
Kotwica Z	1992	Acute head injuries in the elderly: an analysis of 136 consecutive patients. *Acta Neurochir (Wien)* 118:98–102.	III	136	> 70	Head injury only	52	For pts. with GCS score < 9, mortality was 90% when craniotomy was required and 76% when craniotomy was not required. Based on these results, authors recommend limiting therapy in pts. with GCS score < 9 with space-occupying lesions. In patients without space-occupying lesions and GCS score < 9, authors recommend aggressive treatment for 24 h, and limiting further treatment to those with significant improvement by this time. No statistical analysis performed. Small number of patients on which to base such critical recommendations.
Milzman DP	1992	Pre-existing disease in trauma patients: a predictor of fate independent of age and injury severity score. *J Trauma.* 32: 236–243.	III	7,798	≥ 15	All admissions with ISS > 1; Excluded if survival < 24 h or cardiac arrest on arrival	9.2 (PEC+) 3.2 (PEC–)	4-yr retrospective study at a single Level I trauma center. Trauma mortality increases with increasing numbers of PECs. The effect of PEC on mortality is independent of age and ISS, but becomes less important at age > 55 yr or at ISS > 20.
Pellicane JV	1992	Preventable complications and death from multiple organ failure among geriatric trauma victims. *J Trauma.* 33: 440–444.	III	374	≥ 65	Burns excluded	8	Elderly nonsurvivors were significantly older, had higher ISS and lower TS than elderly survivors. TS < 15 was associated with a 45% mortality, but 52% of deaths occurred in pts. with a TS ≥ 15. Potentially preventable complications contributed to mortality in 62% of organ failure deaths, and one third of sudden deaths; 70% of organ failure deaths in the TS 15–16 group were contributed to by potentially preventable complications.
Ross AM	1992	Prognosticators of outcome after major head injury in the elderly. *J Neurosci Nurs.* 24:88–93.	III	195	≥ 65	GCS score ≤ 8 or intracranial hematoma requiring evacuation	20 at 72 h 75 at 6 mo	In patients with admission GCS score ≤ 8, 83% were still in coma after 72 h. All of these patients died within 6 mo. Patients with ICP ≥ 20 had higher 72-h and 6-mo. mortality, and greater 72-h neurologic disability compared with patients with ICP < 20. However, incidence of shock and apnea were greater in elevated ICP group, which could have adversely affected neurologic outcome and mortality. Study describes patients treated between 1978 and 1988. Conclusions might therefore have limited applicability to current patient care.

Table 1 *Continued*

First Author	Year	Reference	Data Class	No. of Patients	Age (yr)	Pt. Population	Mortality (%)	Conclusion
Broos PL	1993	Multiple trauma in elderly patients: factors influencing outcome—importance of aggressive care. *Injury.* 24:365–368.	III	126	≥ 65	Excluded DOAs and pts. who died prior to any intervention	17 (6 mo) (mean ISS = 33.2)	Factors predicting mortality included GCS score ≤ 8 and "early and continued intubation" (intubated prehospital or at admission and continued for 5 days or more). Age, ISS, and PECs were not significantly predictive of mortality. Vague definition of "multiple trauma." Within 6 mo of discharge, 78% of patients had returned to their preinjury surroundings.
Carrillo EH	1993	Long term outcome of blunt trauma care in the elderly.	III	94	≥ 65	Excluded burns, penetrating, isolated orthopedic injury, and pts. with minimal injuries	13%	Mortality correlated well with APACHE II, but combination of APACHE II and ISS performed better than APACHE II alone. All patients with APACHE II ≥ 15 *and* ISS ≥ 30 died, but this accounted for only one third of all deaths in the series. At 1 to 3-yr follow-up, 84% of patients surviving hospital discharge were independent at home.
Pennings JL	1993	Survival after severe brain injury in the aged. *Arch Surg.* 128: 787–93.	III	42	≥ 60	Excluded if GCS score > 5, penetrating injury, pts. with normal CT scan, pts. dying within 6 h	79	Of nine survivors, six were in a persistently vegetative state, and two were severely disabled. The final survivor was moderately disabled and was discharged home. After discharge, older pts. tended to deteriorate neurologically, whereas younger pts. tended to improve or remain stable. Factors predictive of mortality were a decreased 6-h GCS score, age ≥ 60, lack of need for craniotomy, cerebral edema, and nonreactive pupils. Authors conclude that pts. > 60 y with GCS score < 5 have an extremely poor prognosis, and that if they do not regain substantial neurologic function within 24 h, they are unlikely to do so.
Day RJ	1994	Major trauma outcomes in the elderly. *Med J Aust.* 160:675–678.	III	118	> 60	ISS > 15	30.5 (early); 31 (late)	Mean ISS = 25. Minimum 2-yr (average, 3 yr) follow-up obtained. Late mortality much higher in patients > 70 yr old (50%) than in patients 61–70 yr old (8%). Of survivors, 81% were living independently and 76% scored maximally on ADL testing. Authors claim "that age is a significant factor in long term survival after major trauma." but no supporting statistical analysis provided.
Johnson CL	1994	Trauma in the elderly: an analysis of outcomes based on age. *Am Surg.* 60: 899–902.	III	289	≥ 65	SICU admits only	16.3	Despite similar mean ISS, elderly had higher SICU and overall mortality. For a given ISS, elderly pts. had higher admission SAPS compared with younger pts. SICU mortality increased with increasing ISS and SAPS, though ISS-adjusted mortality not statistically different between elderly and younger pts. Authors conclude that injury *physiology* (SAPS) better predictor of early death, whereas age still important predictor of death after ICU discharge.

Table 1 *Continued*

First Author	Year	Reference	Data Class	No. of Patients	Age (yr)	Pt. Population	Mortality (%)	Conclusion
Knudson MM	1994	Mortality factors in geriatric blunt trauma patients. *Arch Surg.* 129: 448–453.	III	852	≥ 65	Blunt trauma only	18.4	Factors predictive of *in-hospital* mortality were male gender; injury mechanism; ISS; injuries to brain, chest, or abdomen; TS; and RTS. Admission physiologic factors associated with death included BP < 90, RR < 10, TS < 7, and GCS score = 3. A TS < 7 was associated with 100% mortality, as was a RR < 10. ISS was best predictor of mortality, although ISS not "available" as a prognostic variable at admission.
Shapiro MB	1994	Geriatric trauma: aggressive intensive care unit management is justified. *Am Surg.* 60: 695–698.	III	170	≥ 60	All trauma admissions	21.8	All deaths were in ICU patients. ICU mortality correlated with the number of organ systems failing and with severe head injury (not defined). Survival not related to the presence of PECs.
Zietlow SP	1994	Multisystem geriatric trauma. *J Trauma.* 37: 985–988.	III	94	≥ 65	ISS ≥ 10 (mean ISS = 18)	23, in-hospital	Factors predictive of death (univariate): severe brain injury (GCS score ≤ 8), inotropic/ventilatory support, previous MI, shock, chronic renal insufficiency, and bradycardia. Factors predictive of death (multivariate): severe brain injury (GCS score ≤ 8) and previous MI. At mean follow-up of 12 mo, 75% of pts. were at home and independent and 49% were back to their normal level of activity.
Rakier A	1995	Head injuries in the elderly. *Brain Inj.* 9:187–193.	III	263	≥ 65	Consecutive series of head injuries, including concussions	17.5	High mortality rates noted in patients with cerebral contusions (~28% mortality) and acute subdural hematomas (33% mortality). All patients with acute epidural hematomas had poor outcomes. Overall conclusions weakened by lack of data on admission GCS score authors' grouping of patients according to predominant finding on head CT scan (only one finding allowed per patient), and lack of long-term follow-up.
Rozzelle CJ	1995	Predictors of hospital mortality in older patients with subdural hematoma. *J Am Geriatr Soc.* 43:240–244.	III	157	≥ 65	Pts. with traumatic subdural hematomas	30.6	Factors predictive of hospital mortality included GCS score ≤ 7, age ≥ 80, *acute* duration of hematoma, and need for craniotomy. Presence of comorbidities, use of antithrombotics, and midline shift on CT scan did not influence outcome.

Table 1 *Continued*

First Author	Year	Reference	Data Class	No. of Patients	Age (yr)	Pt. Population	Mortality (%)	Conclusion
Shabot MM	1995	Outcome from critical care in the "oldest old" trauma patients.	III	45	≥ 75	All trauma admissions to the SICU	28.9	"Oldest" patients had significantly higher ISS values. Although TS was similar between all age groups, SAPS (both on the first SICU day and also maximum SICU SAPS) increased significantly with age. In general, increases in ISS in the "oldest" group translated into larger increases in SAPS, indicating that these patients have a progressively greater physiologic response to a given level of injury. Factors predictive of overall SICU mortality (all ages) included ISS, TS, SAPS, and day of maximum SAPS. Age itself not predictive of overall SICU mortality, and when stratified by SAPS, mortality in "oldest" patients is similar to younger patients.
		J Trauma. 39: 254–259.		54	65–74		13.0	
Zimmer-Gembeck MJ	1995	Triage in an established trauma system.	III	26,025	N/A	ISS ≥ 1	N/A	Examines success of prehospital trauma triage. Assumes all pts. with ISS between 1 and 9 should have been triaged to a nontrauma hospital, whereas all pts. with ISS ≥ 16 should have been triaged to a trauma center. Undertriage rate for entire study population was 21%, but was 56% for patients > 65 yr of age. Overtriage of elderly trauma patients was only 10% (28% for entire study population). In addition to the problem of undertriage in the elderly trauma patient, this study also found that most trauma deaths in nontrauma hospitals were in elderly patients with ISS between 1 and 9.
		J Trauma. 39: 922–928.						
Kilaru S	1996	Long-term functional status and mortality of elderly patients with severe closed head injuries.	III	40	> 65	GCS score ≤ 8; DOAs and inaccurate GCS scores were excluded	68	Overall mortality at average 38-mo follow-up was 73%. Factors predictive of mortality were GCS score. GCS-motor response, and fixed pupils. ISS was not found to be predictive of mortality, but age and TS showed a trend toward significance. With multiple regression analysis, only GCS score and heart rate correlated with death. All pts. with admitting GCS score = 3 died in hospital, and all with GCS score ≤ 7 either died, were vegetative, or had severe disabilities. On long-term follow-up, neurologic function improved very little after hospital discharge. Overall weak conclusions because of small number of patients and limited use of ICP monitoring.
		J Trauma. 41: 957–963.						

Table 1 *Continued*

First Author	Year	Reference	Data Class	No. of Patients	Age (yr)	Pt. Population	Mortality (%)	Conclusion
Phillips S	1996	The failure of triage criteria to identify geriatric patients with trauma: results from the Florida Trauma Triage Study. *J Trauma.* 40: 278–283.	III	3,980	≥ 55	Excluded if burns, isolated hip fx, interhospital transfers, and incomplete data	2.4	Study uses AIS data and several assumptions to determine pt.'s "ideal" triage destination (trauma center vs. nontrauma center), and then compares actual pt. triage destination with "ideal" destination. Overtriage in the elderly population was 7.4% (compared with 11.3% in younger patients, and target overtriage rate of 20%). Undertriage in the elderly group was 71% (compared with 36% in younger group, and target undertriage rate of 5%). Triage criteria failed to identify nearly all elderly major trauma cases from falls.
van der Sluis CK	1996	Major trauma in young and old: what is the difference? *J Trauma.* 40: 78–82.	III	121	≥ 60	ISS ≥ 16	38.8	Compares outcome of elderly with that of younger patients, all with ISS ≥ 16. Mortality in both groups increased with increasing ISS, and ISS was similar for the two groups. ISS in elderly nonsurvivors was higher (34.3) compared with elderly survivors (23.9), but unable to determine from article whether this is a statistically significant difference. An ISS ≥ 50 was fatal for all elderly patients. Young nonsurvivors died much earlier than old nonsurvivors (2.6 days vs. 14.4 days). The percentage of elderly patients discharged home was similar to that of younger patients, and the functional outcome at 2 yr postdischarge was also similar. Therefore, elderly should be treated aggressively.
van der Sluis CK	1997	Outcome in elderly injured patients: injury severity versus host factors. *Injury.* 28:588–592.	III	42	> 60	ISS ≥ 16	31	Compares outcomes between elderly trauma pts. and elderly hip fracture pts. In-hospital mortality was much higher for the trauma elderly (31%) than for the hip fracture elderly (3%), but long-term survival (7–8 yr posttrauma) was similar (29%). Higher late mortality in hip fracture group ascribed to higher incidence of poor "preinjury medical status" (very loosely defined) in this pt. population (53% vs. 12%). Predictors of *late* mortality included age, poor preinjury medical status, and male gender, whereas *early* mortality is more a function of ISS.

3. In patients 65 years of age and older, a GCS score ≤ 8 is associated with a dismal prognosis. If substantial improvement in GCS score is not realized within 72 hours of injury, consideration should be given to limiting further aggressive therapeutic interventions. Because this recommendation is based on Class III data, it should be applied cautiously in individual patients.

4. Postinjury complications in the elderly trauma patient negatively impact survival and contribute to longer lengths of stay in survivors and nonsurvivors compared with younger

Table 1 *Continued*

First Author	Year	Reference	Data Class	No. of Patients	Age (yr)	Pt. Population	Mortality (%)	Conclusion
Battistella FD	1998	Trauma patients 75 years and older: long-term follow-up results justify aggressive management. *J Trauma.* 44: 618–623.	III	279	≥ 75	All trauma service admissions (mean ISS = 9.4)	23, including DOAs	4-yr follow-up obtained on 81% of the 279 patients who survived to hospital discharge. Poor outcome (survival < 6 mo after discharge) predicted by preexisting dementia, hypertension, and COPD, but not by age or ISS. Of long-term survivors, 83% living independently.
Davis JW	1998	Base deficit in the elderly: a marker of severe injury and death. *J Trauma.* 45: 873–877.	III	274	≥ 55	Excluded pts. with initial ABG obtained > 1 h after injury	varied with base deficit	Correlated aBD with mortality, ISS, and ICU LOS. Higher mortality in elderly despite similar ISS and aBD. In pts. ≥ 55 yr, an aBD ≤ –6 was associated with a 67% mortality and a 78% PPV for an ISS ≥ 16. However, less severe aBDs (> –6) were still associated with significant mortality (24%). Even a normal aBD (–2 to 2) in this age group was associated with an 18% mortality.
Perdue PW	1998	Differences in mortality between elderly and younger adult trauma patients: geriatric status increases risk of delayed death. *J Trauma.* 45: 805–810.	III	448	≥ 65	Excluded if isolated single-system injury admitted to nontrauma service	14	Elderly mortality twice that of younger patients and was more delayed, with the majority occurring more than 24 h after admission. Factors predictive of early (< 24 h) mortality included ISS, RTS, and age. Factors predictive of late (>24 h) mortality were ISS, RTS, age, preexisting cardiovascular or liver disease, and the development of cardiac, infectious, or renal complications.
Ma MH	1999	Compliance with prehospital triage protocols for major trauma patients. *J Trauma.* 46: 168–175.	III	32,950	≥ 55	All trauma transports	N/A	Documents compliance of prehospital providers with prehospital trauma triage criteria. Compliance with *anatomic* criteria was 86%, and did not vary with patient age. Compliance with *physiologic* and *mechanism* criteria was poor (34% and 46%, respectively), and was statistically worse for pts. ≥ 55 yr of age, compared to younger pts.
Tornetta P	1999	Morbidity and mortality in elderly trauma patients. *J Trauma.* 46: 702–766.	III	326	≥ 60	Blunt trauma only; slip-and-fall injuries were excluded	18.1	Factors predictive of mortality included transfusion, ISS (particularly AIS-Head and Neck and AIS-Thorax), GCS scores and fluid requirement. In addition, sepsis, ARDS, and MI were significant risk factors for mortality. Geriatric Trauma Survival Score was not predictive of survival.

DOA, dead on arrival; PAC, pulmonary arterial catheter; HCFA, Health Care Financing Administration; CNS, central nervous system; BP, blood pressure; NH, nursing home; LOS, length of stay; pts., patients; OR, operating room; MTOS, Major Trauma Outcome Study; SDH, subdural hematoma; COPD, chronic obstructive pulmonary disease; MVC, motor vehicle crash; CT, computed tomographic; ICP, intracranial pressure; ADL, activities of daily living; SAPS, Simplified Acute Physiology Score; MI, myocardial infarction; fx, fracture; ABG, arterial blood gas; aBD, admission base deficit; PPV, positive predictive value.

trauma patients. Specific therapies designed to prevent and/or reduce the occurrence of complications (particularly iatrogenic complications) should lead to optimal outcomes in this patient population.

5. With the exception of patients who are moribund on arrival, an initial aggressive approach should be pursued with the elderly trauma patient, as the majority will return home, and up to 85% will return to independent function.

6. In patients 55 years of age and older, an admission base deficit ≤ -6 is associated with a 66% mortality. Patients in this category may benefit from inpatient triage to a high-acuity nursing unit.

7. In patients 65 years of age and older, a Trauma Score < 7 is associated with a 100% mortality. Consideration should be given to limiting aggressive therapeutic interventions. Because this recommendation is based on Class III data, it should be applied cautiously in individual patients.

8. In patients 65 years of age and older, an admission respiratory rate < 10 is associated with a 100% mortality. Consideration should be given to limiting aggressive therapeutic interventions. Because this recommendation is based on Class III data, it should be applied cautiously in individual patients.

9. Compared with younger trauma patients, patients 55 years of age and older are at considerably increased risk for undertriage to trauma centers, even when these older patients satisfy appropriate triage criteria. The factors responsible for this phenomenon must be identified and strategies developed to counteract it.

IV. Scientific Foundation

Triage is the process whereby the patient's medical needs are matched with the available medical resources. For the geriatric trauma patient, the process begins in the prehospital arena, where prehospital providers must decide on the basis of relatively scant clinical information whether a patient should bypass the local hospital in favor of a trauma center. The American College of Surgeons Committee on Trauma (ACS-COT), among other medical organizations, in its manual *Resources for Optimal Care of the Injured Patient*, has published a set of triage criteria to aid prehospital providers in identifying appropriate patients for direct transport to trauma centers.[1] Within this document, it is suggested that patients older than age 55 should be "considered" for direct transport to a trauma center, apparently without regard to the severity of injury. This recommendation is based on a substantial medical literature that demonstrates significantly worse outcomes for geriatric trauma patients compared with their nongeriatric counterparts. One of the earliest studies to look at the influence of age on outcome from major trauma was the Major Trauma Outcome Study, sponsored by the ACS-COT. Data from 3,833 patients aged 65 years and older were compared with those of 42,944 patients less than 65 years of age. Mortality rose sharply between age 45 and 55 and doubled at age 75 years. This age-dependent survival decrement occurred at all ISS values, for all mechanisms of injury, and for all body regions.[2] Numerous other studies have supported the findings that the effect of trauma on the elderly is more serious than that on younger patients.[3–9]

Given these findings, some authors have suggested triaging elderly trauma victims to trauma centers at a much lower threshold than similarly injured younger patients, to minimize mortality and morbidity.[10] Support for this recommendation can be found in a study by Smith et al., documenting fewer complications for elderly femur fracture patients treated at trauma centers versus nontrauma centers.[11] Despite these poorer outcomes, trauma patients 55 years of age and older are frequently triaged to nontrauma hospitals even when they satisfy well-defined anatomic or physiologic criteria. Compliance with physiologic criteria appears to be especially troublesome.[12] In two unrelated studies, undertriage in patients over the age of 55 was *twice* that of younger patients,[12,13] and a similar study demonstrated even worse results for patients over the age of 65.[14]

The factors responsible for the increased morbidity and mortality seen in geriatric trauma are not entirely clear. It has been suggested that it is not patient age per se but the high incidence of preexisting medical conditions in the geriatric patient that accounts for the difference. Others have suggested that the elderly, simply by virtue of being more frail, sustain a greater degree of injury in response to a given impact, compared with their younger counterparts. The existing medical literature was therefore reviewed in an attempt to identify clinical factors that might be used to triage geriatric trauma patients to either aggressive versus nonaggressive treatment strategies.

Age and Outcome

It is difficult to find consensus in the existing literature regarding the relationship between patient age and outcome. Many of the reasons for this failure have been mentioned above, and include differences in the age definition of geriatric trauma and differences in inclusion criteria for the various studies. In addition to these two factors, there is a lack of uniformity regarding the length of follow-up required to define a poor outcome. This has been variably defined as death within 24 or 48 hours of injury, death before intensive care unit (ICU) or hospital discharge, and even death/vegetative outcome at 3 or 4 years postinjury. Furthermore, there are wide variances in the statistical methods used to explore the relationship between age and outcome. Many authors have documented a statistically significant difference between the mean age of geriatric survivors compared with the mean age of geriatric *non*survivors, and thus have concluded that age is significantly *associated* with poor outcome. Other authors have applied logistic regression analysis to their data set to determine which particular factors are *predictive* of adverse outcomes. Given the wide variation in inclusion criteria, outcome variables, and statistical methods present within the existing literature, the conflicting results regarding age and outcome are not surprising.

Certainly, the largest data set examined to date is that published by Morris et al. in 1990. These authors examined 199,737 trauma admissions, aged 15 and older, to acute care hospitals in the state of California during 1986. Using logistic regression techniques, the ISS was found to be the best predictor of mortality in trauma patients, but age, gender, and PECs were also found to be *independent* predictive factors of mortality. Mortality was defined as in-hospital death. The authors also found that although the mortality from minor injury (ISS < 9) begins to increase beyond the age of 65, the mortality for moderate injuries (ISS of 9–24) begins to increase at 45 years of age.[4] This increase in trauma mortality beginning at age 45 had been confirmed by other investigators as well.[2,10,15] Several authors have examined the relationship between *in-hospital* mortality and age, with differing conclusions. Pellicane et al. demonstrated a statistically significant difference in age between elderly nonsurvivors and elderly survivors in a series of 374 geriatric trauma patients, defined as age greater than or equal to 65 years. Five of the deaths in this series occurred in the emergency department, a subset of patients that has been excluded from the analyses in other series. Burn patients, however, were excluded from this series.[16] In a similar study performed by Osler et al., of 100 geriatric trauma patients 65 years or older, no significant difference in age was found between elderly survivors and nonsurvivors.[9] Despite the fact that patients who died before transfer to the operating room or to the ICU were excluded in the series by Osler et al., mortality in this series was more than twice that in the series by Pellicane et al. Perhaps this is explained by the lower mean TS in the series by Osler et al. relative to that of Pellicane et al. (13 vs. 15.4). The series by Pellicane et al. contains nearly four times as many patients, which raises the possibility of a type II statistical error regarding the inability of Osler et al. to demonstrate a statistical difference between the ages of geriatric trauma survivors and nonsurvivors. A large and more recent study of 448 patients, 65 years and older, used a logistic regression analysis and demonstrated age to be significantly predictive of both early ($<$ 24 hours) and late ($>$ 24 hours) mortality.[17] In this analysis, survival was used as the outcome variable, with "geriatric status" (age $\geq$ 65 years) entered into the logistic regression equation. In so doing, geriatric status was associated with a 2.46-fold increased likelihood of early mortality and a 4.64-fold increased risk of late mortality. However, an even larger study yet, consisting of 852 patients, reported by Knudson et al., using stepwise discriminant analysis, did not find age to be predictive of in-hospital death. The authors reported a 1.33-fold increased risk of death associated with age status greater than 75 years, just barely missing statistical significance with a *p* value of 0.06. Interestingly enough, however, the age of 75 years was entered into the discriminant analysis, not the age of 65 or greater, which was the authors' original age definition for entrance into the study. Perhaps statistical significance would have been demonstrated had age 65 or greater been used in the discriminant analysis.[18]

Two studies specifically examined the relationship between age and in-hospital mortality for geriatric trauma patients admitted to the ICU. Neither found any association between age and outcome. In a small series of 39 patients requiring intensive care unit admission and placement of pulmonary and radial artery catheters, Horst et al. reported no significant difference in age between elderly survivors and nonsurvivors. As would be expected, overall mortality (31%) was high in this intensive care population of patients older than 60 years of age. Logistic regression analysis was not performed in this study, probably because of the overall low number of patients.[19] A more recent study by Shabot and Johnson examined two subsets of geriatric trauma patients, those between the ages of 65 and 74 and those 75 years and older. Outcomes in these 99 geriatric trauma patients were then compared with 940 "younger" patients between the ages of 13 and 64, all of whom were admitted to a surgical intensive care unit (SICU). SICU mortality was then examined by comparing survivors with nonsurvivors, regardless of age. As would be expected, there was no significant difference in age between nonsurvivors and survivors (39.0 years vs. 34.8 years), likely because of the 10-fold larger number of patients seen in the younger patient group.[20]

Finally, several studies have examined the relationship of age to more long-term outcomes, although no clear consensus is evident. DeMaria et al. studied a group of 82 trauma patients over the age of 65 years. Patients with penetrating injury and isolated orthopedic injury were excluded, as were patients sustaining thermal injury. Survival was defined as 6 months postinjury. Not only were nonsurvivors older, but they also demonstrated higher ISSs and more complications. On the basis of these findings, the authors developed the Geriatric Trauma Survival Score (GTSS) and then prospectively tested it on 61 patients, with 92% accuracy. Unfortunately, the GTSS, although perhaps accurate, has little triage value at the time of patient admission, as it requires information not available to the practitioner at that time.[6] Van der Sluis et al. compared early and late mortality between elderly trauma patients and elderly hip fracture patients. Early mortality was higher for the trauma patients, but survival 7 to 8 years after injury was similar between the two groups. Logistic regression analysis was used to identify predictors of late mortality, and demonstrated age to be a significant predictor.[21] Van Aalst et al., in a study of blunt geriatric injury with a mean follow-up of almost 3 years, used logistic regression analysis to demonstrate an association between poor outcome and age $>$ 75.[5] Oreskovich et al., however, failed to demonstrate any relationship between age and outcome at 1 year after injury in a group of 100 patients age 70 and older.[22] Broos et al., in two separate publications examining 6-month outcome in trauma patients aged 65 and older, did not find age to be predictive of mortality.[23,24] Inclusion criteria for each of these three latter studies were vaguely defined, and the 18% mortality in the study by Broos et al. is inexplicably low compared with other series of similarly injured patients.[9,17,25,26] A larger study, with a more plausible mortality, was published by Battistella et al. in 1998. This study involved 279 geriatric trauma patients, which the authors defined as age greater than 75. Mean ISS in this patient group was 9.4 and associated mortality was 23%. Using logistic regression analysis, the authors found that poor outcome, defined in this study as survival less than 6 months after *hospital discharge*, was not predicted by patient age.[27] The issue of long-term survival and quality of life in the geriatric trauma patient is discussed more fully below.

Can the age of a geriatric patient, then, be used to predict outcome after trauma? Although age appears to have some value in mortality projections for a *population* of geriatric trauma patients, there is certainly no literature support for a specific age above which geriatric trauma *in-hospital mortality* can be predicted with any degree of confidence. It has been suggested, however, that *early* mortality may not be the best outcome measure in geriatric trauma, because of a high percentage of poor long-term *functional* survival in elderly trauma patients surviving hospital discharge.[22] The preponderance of available literature, however, suggests more favorable long-term outcomes, with up to 85% of survivors functioning independently at home at follow-up intervals as long as 6 years postinjury.[5,27–31] Thus, given reasonable long-term functional outcomes for geriatric trauma patients surviving hospitalization, and the inability of patient age, by itself, to predict in-hospital mortality, advanced patient age should not be used as the sole criterion for denying or limiting care in the geriatric trauma population.

Preexisting Conditions and Outcome

If *chronologic* age, then, is not useful in predicting geriatric trauma survival, perhaps it is the patient's *physiologic* age, or the nature and extent of PECs, that determines outcome. Because the frequency of PECs does increase with age, it may be difficult to separate these two factors and their relationships to adverse outcomes in geriatric trauma. Unfortunately, once again because of a wide variety of age definitions for geriatric trauma, statistical methodologies, and outcome measures, the literature addressing the prognostic value of PECs in geriatric trauma outcome is inconclusive. The largest studies, and those with the best statistical methodology, do seem to demonstrate a significant predictive capacity of PECs for adverse outcomes in geriatric trauma. Morris et al., in two separate publications in 1990, examined hospital discharge data for trauma patients in California for the year 1986. Using logistic regression analysis in both studies, Morris et al. were able to demonstrate that PECs were important predictive factors of mortality, independent of age. The effect of PECs on mortality, however, became less important in patients over the age of 65, perhaps because at this age chronologic age becomes the predominant predictor of mortality, and the added presence of PECs does little to increase trauma mortality further.[4,32] Similarly, Milzman et al., in a study of nearly 8,000 trauma patients, noted a threefold increase in trauma mortality in patients with PECs compared with those without. Once again, the effect of PECs on mortality was noted to be independent of age although, like Morris et al., these authors noted a decreasing influence of PECs on trauma mortality with advanced age.[33] A more recent study published in 1997 by Gubler et al. examined risk factors for mortality among a group of 9,424 trauma patients, aged 67 and greater, who were discharged from acute care hospitals within the state of Washington in 1987. For each trauma patient in the series, four uninjured patients, matched for age and gender, were identified from the same Health Care Financing Administration (HCFA) database. Comorbid diagnoses (PECs) were identified for each patient, and a Comorbid Diagnosis Index Score was calculated. This score is a weighted index that takes into account not only the number but also the severity of PECs.[34] Using Cox proportional hazards regression, Gubler et al. found that patients with PECs were between 2.0 and 8.4 times as likely to die within 5 years of injury compared with those without PECs, depending on the number and severity of PECs.[8] Several smaller studies, each reporting the experience of a single trauma center and using logistic regression analysis, confirmed the value of PECs as predictive factors of poor outcome in geriatric trauma, although inclusion criteria and age and outcome definitions were not uniform among these studies.[17,27,35] Other studies have refuted these findings but suffer from methodologic and statistical shortcomings that weaken their conclusions.[19,22–24,36,37]

Severity-of-Injury Scoring and Outcome

A number of physiologic and anatomic "scores" have been shown to correlate with geriatric outcome. These include TS, Revised Trauma Score (RTS), GCS score, Acute Physiology and Chronic Health Evaluation Score (APACHE), Acute Physiology Score (APS), Simplified Acute Physiology Score (SAPS), ISS, Maximal Abbreviated Injury Score (MAIS), and the GTSS. In addition, although not "scores" in the typical sense, geriatric trauma outcome has also been correlated with initial blood pressure, respiratory rate, and base deficit. Although most, if not all, of these scores do correlate with geriatric outcome, from the perspective of field or emergency department triage, many of these scores have little value in that they are not derivable at the moment that these particular triage decisions need to be made. This would apply particularly to APACHE, APS, SAPS, MAIS, ISS, and GTSS. These scores, however, perhaps in combination with patient age, may have some value in the prediction of lethal outcomes in geriatric trauma and, therefore, may be valuable triage tools in the intensive care unit. These scores will therefore be discussed solely within that context below.

In contrast, measures of *physiologic* derangement, whether obtained by means of physical examination or chemical analysis, may help to identify patients who will perhaps benefit from aggressive resuscitation strategies (and should therefore be triaged to an intensive care unit), and those where further resuscitative efforts are futile (thus facilitating earlier termination of resuscitation). TS (or RTS) and its components (blood pressure, respiratory rate, and GCS score) are the most readily obtainable, objective physiologic data available either to the prehospital provider or to the trauma resuscitation team in the emergency department. The prognostic value of each of these variables as they relate to geriatric trauma outcome will be discussed further below. (The prognostic value of the GCS score is discussed later within the section Outcome from Geriatric Head Injury.) Of those chemical analyses available in the emergency department, only base deficit has been subjected to sufficient scientific study and is sufficiently relevant to geriatric trauma resuscitation that it can be included within the discussion below of potentially useful triage scores.

The TS assesses five physiologic functions (blood pressure, respiratory rate, respiratory effort, GCS score, and capillary refill), yielding a minimal score of 0 and a maximal score of 16. The RTS is a simplified version of the TS, which deletes the assessment of respiratory effort and capillary refill, resulting in a range of scores between 0 and 8. Several studies have demonstrated the predictive value of TS (and RTS) on geriatric trauma mortality, although a specific numeric score signifying a fatal injury has not been identified by these authors.[17,20] Horst et al. were unable to find any relationship between TS and geriatric trauma patient mortality, although the small number of patients and the rather narrow entrance criteria of the study limit the applicability of this finding.[19] Two other studies, however, suggest that TS may be a useful triage tool in the early stages after geriatric trauma. In a case-matched review of 100 patients age 65 and above that suffered injuries severe enough to necessitate hospitalization, no elderly patient was able to survive a TS $<$ 9. More dramatically, no geriatric patient with a TS $<$ 7 survived long enough to reach the hospital and be included in the study. The authors felt this to be of importance in allowing more realistic counseling of patients and their families.[9] These findings were reinforced by a review from three trauma centers of 852 patients, age 65 and older, in which a TS $<$ 7 was associated with a 100% mortality.[18] These data suggest that aggressive care under these circumstances is likely to be futile, and that consideration should be given to limiting intensive therapy when a geriatric patient presents with a TS $<$ 7. In addition to the prognostic value of TS, the data of Knudson et al. also revealed a 100% mortality in patients 65 years and older who presented with a respiratory rate $<$ 10. Here, too, consideration should be given to limiting aggressive therapeutic interventions. In addition to its role in the prediction of fatal outcomes in geriatric trauma patients, the TS may also have implications for intensive care unit triage. In a study of 374 patients aged 65 and older, mortality was noted to be only 5% in those with a TS of 15 or 16, but was 25% in patients with a TS of 12 to 14 and 65% in patients with a TS $<$ 12.[16] Thus, patients with a TS between 7 and 14 may benefit from aggressive resuscitation strategies and triage to a critical care unit.

Measurement of arterial base deficit may provide useful information regarding the extent of shock and the adequacy of resuscitation in trauma patients, and may therefore be useful in early decision-making and resource allocation. In a series of 274 elderly trauma patients, defined for the purposes of this study as age greater than or equal to 55, arterial blood gases obtained within 1 hour of patient admission were correlated with ICU length of stay and mortality. Base deficits were characterized as mild (-3 to -5), moderate (-6 to -9), and severe (≤ -10). As expected, elderly patients with severe base deficits had a high mortality, 80% in this series. However, geriatric trauma mortality was still markedly elevated at 60% in patients with only moderate base deficits. Even a "normal" base deficit carried a mortality of 24%.[7] Thus, early determination of admission base deficit in geriatric trauma patients may facilitate early identification of "occult shock" and identify a subgroup of patients who may benefit from more intensive monitoring and resuscitation.

ISS is probably the most widely studied anatomic or physiologic severity-of-illness score yet to be correlated with geriatric trauma outcome. Most authors have found it to be a strong predictor of outcome in geriatric trauma,[9,16,17,20,21,25] and two large studies claimed that it is the best predictor of mortality in geriatric trauma.[4,18] Others, however, have failed to demonstrate any such relationship.[19,22–24,27] Whether or not such a relationship does indeed exist, ISS is severely limited in its prognostic capability because of significant delays in obtaining sufficient data to calculate the score. It therefore probably has very little prognostic value in geriatric trauma and, even then, only in patients in whom the question of futility has been raised. Despite the abundance of literature examining the relationship between ISS and geriatric trauma patient outcome, only two publications contain any ISS data that might be considered useful prognostically. Van der Sluis et al. reported on a series of 121 trauma patients age 60 and greater, all with ISS $\geq$ 16. No patient with an ISS $\geq$ 50 survived in this series. The authors, however, do emphasize the importance of not using the ISS to predict outcomes in individual patients.[35] A study by Carrillo et al. published in 1994 reported on 94 blunt trauma victims aged 65 or greater. Mortality correlated well with APACHE II score, but the combination of APACHE II and ISS performed better than APACHE II alone. All patients with APACHE II score $\geq$ 15 and ISS $\geq$ 30 died, but this accounted for only one third of all deaths in this series.[28] Thus, it would appear that there is little, if any, support in the literature to justify withdrawal of care on the basis of any combination of age and ISS. Likewise, for SAPS, APS, and MAIS there is no literature support for the use of any of these scores to predict individual patient outcome after geriatric trauma.[3,19,20,26] Finally, mention should be made of the GTSS. This score was derived by DeMaria et al. on the basis of their experience with 82 blunt trauma patients over the age of 65 years. The formula to calculate GTSS uses patient age, ISS, and the presence or absence of cardiac and septic complications to predict patient outcome.[6] Given the inadvisability mentioned above of using ISS to predict individual patient outcome, and the fact that information regarding the presence or absence of complications will not be obtainable before hospital discharge, the GTSS clearly has no role in guiding decision-making, a point that the authors themselves emphasize. Interestingly, a larger and more recent study of blunt trauma patients aged 60 and older failed to demonstrate any relationship between the GTSS and survival.[25]

Complications and Outcome

It is generally acknowledged that when the geriatric trauma patient sustains complications during the initial hospitalization, overall outcome is adversely affected. Both DeMaria et al. and Osler et al., in comparing elderly survivors with nonsurvivors, have noted a statistically higher incidence of cardiac and septic complications[6] and respiratory complications[9] in nonsurvivors. Other authors, using logistic regression statistical methodology, have identified cardiac, infectious, and pulmonary complications as independent predictors of poor outcome after geriatric trauma.[5,17,25] In addition to the specific types of complications sustained by the geriatric trauma patient, the *number* of complications sustained by a given geriatric trauma patient has been identified as a risk factor for poor outcomes. Smith et al., in a study of 456 trauma patients aged 65 and over, reported a 5.4% mortality for those patients with no complications, 8.6% for those with one complication, and 30% for those with more than one complication.[37] Similar results have been noted for geriatric patients sustaining traumatic brain injuries.[15]

Despite the well-documented relationship between complications and outcome in geriatric trauma, triage decisions are rarely, if ever, affected by this information. Early triage decisions, whether in the field or in the emergency department, clearly cannot be made on the basis of the presence or absence of complications yet to occur. Furthermore, there are no data to suggest that any particular number, or type, of complications will allow identification of the *individual* geriatric trauma patient destined for an outcome so dismal that a nonaggressive course of treatment could be justified. In light of these findings, efforts should be focused on the development and implementation of strategies aimed at the *prevention* of complications in the geriatric trauma patient. The importance of complication prevention is highlighted in a study by Pellicane et al., which revealed that preventable complications contributed to mortality in 32% of all deaths in this series and 62% of deaths related to multiple organ system failure.[16]

Outcome from Geriatric Head Injury

The topic of geriatric head injury has received more attention in the literature than any other aspect of geriatric trauma. Unfortunately, all of it is retrospective in nature and, therefore, suffers from many of the same methodologic shortcomings discussed above for the remainder of the geriatric trauma literature. These include lack of a specific age definition for geriatric head injury, lack of standardized definitions for specific subpopulations of geriatric head-injured patients, and lack of standardized outcome measures. In addition, much of the geriatric head injury literature provides either insufficient details regarding head injury management or results based on head injury management that would be considered outdated by today's standards. Therefore, it is difficult, and perhaps even dangerous, to make meaningful recommendations regarding the triage of current day geriatric neurotrauma patients on the basis of the existing literature. Despite these shortcomings, there is little question that outcomes after traumatic brain injury are much worse in geriatric patients than in their younger counterparts. Vollmer, in a study from the Traumatic Coma Databank, reported on 661 patients aged 15 and older with severe brain injuries, defined as GCS score < 8. Mortality for the entire series was 38%, but it was 80% for patients older than 55 years of age. Multivariate analysis revealed age to be an independent and significant predictor of death and vegetative outcome, beginning at age 45.[15] Another study examined the effect of age on outcome in patients with acute subdural hematomas. Mortality was 18% in patients between the ages of 18 and 40, but was 74% in patients older than age 65. Once again, advanced age was noted to be predictive of poor outcomes.[38] In addition to age, a number of other factors have been examined as potential predictors of poor outcome after head injury in geriatric patients. Not surprisingly, the most extensively studied factor is that of admission GCS score. Many other factors predictive of poor outcome have been examined, including anatomy of the brain injury (epidural vs. subdural),[39] need for craniotomy,[15,40–43] subdural hematoma volume,[38] midline shift,[38,43] pupillary status,[40,42,44] and intracranial pressure.[15,45] None of these factors has been examined in sufficient detail to allow us to make any recommendations regarding their potential role as triage tools in geriatric head injury. Therefore, they will not be considered further within this article.

"Low" admission GCS score is clearly associated with poor outcomes in elderly head-injured patients. Reuter documented a mortality rate of 87% in elderly patients (age $\geq$ 60) with traumatic intracranial hemorrhage and an admission GCS score < 8, although no details regarding head injury management were provided.[46] The available scientific literature, however, does not support the use of a specific GCS score that will reliably identify patients destined for poor outcomes. Zietlow et al., in a study of patients aged 65 and older with multisystem injury, identified a GCS score ≤ 8 as being predictive, and van Aalst et al., in a similar study, found a GCS score ≤ 7 to be associated with death or dependent living status.[5,29] Published studies limited to geriatric patients with head injuries likewise yield no consensus. Rozzelle et al. identified a GCS score ≤ 7 to be predictive of hospital mortality in patients with subdural hematomas, and Kilaru et al. noted that this same GCS score was associated with a universally poor long-term outcome.[43,44] Cagetti et al. found that a GCS score ≤ 11 was associated with a 100% mortality, although this study involved patients 80 years of age and older.[47] Amacher and Bybee, however, in a similar study of head-injured patients 80 years of age and older, did achieve an "excellent/good" outcome in a single patient with an admission GCS score in the 3 to 6 range.[48] Thus, although "low" GCS scores are indeed associated with poor outcomes, it does not seem possible, or advisable, on the basis of the existing literature, to make triage decisions in head-injured geriatric patients solely on the basis of the *admission* GCS score. It does seem reasonable to conclude that head-injured patients 65 years and older, as a group, have very poor outcomes when the admission GCS score is ≤ 7 or 8.

Other authors have examined the prognostic value of the "delayed" GCS score, that is, the GCS score determined 24 hours or more after injury. Both Pennings et al. and Kotwica and Jakubowski have advocated a limited course of aggressive therapy in geriatric trauma patients with severe head injuries, although their GCS score definitions of futility differ greatly. Kotwica and Jakubowski, in a study of head-injured patients 70 years of age and older, noted a 90% mortality in patients with a GCS score < 9 when craniotomy was required and 76% when craniotomy was not required. On the basis of this finding in 136 patients, they recommend aggressive treatment for 24 hours only for those patients *without* space-occupying lesions. Aggressive treatment, then, is continued only in those patients who show "significant" improvement within this time frame.[41] Pennings et al., in their study of 42 patients aged 60 and older with a GCS score ≤ 5, concluded that these patients have an extremely poor prognosis, and that if they have not regained "substantial" neurologic function within 24 hours, they are unlikely to do so.[42] Similarly, Ross et al. reported a 100% 6-month mortality among patients 65 years of age and older who had a persistent GCS score ≤ 8 at 72 hours after admission.[45] Even though the overall prognosis from geriatric head injury may have improved since these publications because of improvements in head injury management, it is reasonable to expect that these new therapies will exert their maximum effect in the early stages after injury. Thus, in geriatric head injury, it seems reasonable to adopt an initial course of aggressive treatment (with the possible exception of the patient who is moribund on arrival), followed by a reevaluation of the patient's neurologic status at 72 hours after admission. The intensity of the subsequent care provided can then be based on the initial response to therapy.

V. Summary

Although multiple clinical and demographic factors have demonstrated an association with outcome after trauma in geriatric patients, the ability of any specific factor alone or in combination with other factors to predict an unacceptable outcome for any individual geriatric trauma patient is quite limited. An initial course of aggressive therapy (see following section, Parameters for Resuscitation of the Geriatric Trauma Patient) seems warranted in all geriatric trauma patients, regardless of age or injury severity, with the possible exception of those patients who arrive in a moribund condition. Geriatric trauma patients who do not respond to aggressive resuscitative efforts within a timely fashion are likely to have poor outcomes even with continued aggressive treatment. Modification of the intensity of treatment provided to these "nonresponders" should be considered. For those geriatric trauma patients who do respond favorably to aggressive resuscitative efforts, the prognosis, not only for survival but also for return to their preinjury level of function, is quite good and certainly justifies the effort.

VI. Future Investigations

There are no Class I data that address triage issues in geriatric trauma. Prospective, randomized, controlled trials are desperately needed that address the prognostic values of age, injury severity, and injury physiology on ultimate outcome after geriatric trauma. Before conducting these studies, there must be agreement concerning the specific age definitions to be used for geriatric trauma, the outcomes to be measured, and the specific clinical criteria that will be used to define preexisting medical conditions. Furthermore, data generated in such a fashion should be subjected to rigorous and appropriate statistical analysis. Only when a substantial body of literature exists that meets these criteria will trauma practitioners succeed in providing an appropriate level of care to the geriatric trauma patient on the basis of that patient's predicted outcome.

PARAMETERS FOR RESUSCITATION OF THE GERIATRIC TRAUMA PATIENT

I. Statement of the Problem

There is no doubt that the elder trauma patient presents trauma surgeons with a complex challenge. The effects of aging on individual organ systems and the presence of comorbid conditions combine to create a milieu that does not allow for errors in resuscitation or delays in diagnosis. It is widely known that geriatric patients have less physiologic reserve than younger patients and that mortality rates are higher than in a younger cohort. There is a growing sentiment that the conduct of resuscitation for the injured elder must be undertaken with an aggressive and thoughtful approach. Outcome data suggest that the elderly benefit from an aggressive approach to resuscitation. It is believed by some that the pulmonary artery catheter should be a routine part of the resuscitation process for the severely injured geriatric patient. In addition, there are certain laboratory assays that have been recommended for use in this clinical scenario. There is confusion, however, regarding end-points for resuscitation and which patients benefit from invasive hemodynamic monitoring.

II. Process

Literature used for these guidelines was obtained by means of a search of the MEDLINE database from the National Library of Medicine. Citations in the English language during the period of 1966 through 1999 using the words "elderly," "geriatric," "trauma," "shock," and "resuscitation" were identified. Citations concerned primarily with multisystem trauma or single-organ injury in a multisystem context were used. Additional nontrauma references were used to relate epidemiologic or physiologic factors concerning the geriatric patient to the context of potential injury. This search identified 4,783 references. For use in the evidentiary table (Table 2), these were then sorted to identify articles associated with geriatric trauma patients exclusively. The bibliographies of each article were searched for additional references not identified by the original MEDLINE query. Letters to the editor, case reports, review articles, and series examining nontrauma patients were excluded for use in the evidentiary table (Table 2). The references were classified by methods used by the Canadian and United States Preventative Task Force. Classification of references was graded on the basis of the strength of the scientific evidence. For purposes of practice management guidelines for trauma, data were classified as follows:

Class I: Prospective randomized controlled trials (PRCTs)—the gold standard of clinical trials. Some may be poorly designed, have inadequate numbers, or suffer from other methodologic inadequacies, and thus may not be clinically significant (one reference).

Class II: Clinical studies in which the data were collected prospectively, and retrospective analyses that were based on clearly reliable data. These types of studies include observational studies, cohort studies, prevalence studies, and case control studies (one reference).

Class III: Most studies based on retrospectively collected data. Evidence used in this class includes clinical series, databases or registries, case reviews, case reports, and expert opinion (seven references).

III. Recommendations

A. Level I: There are insufficient data to support a Level I recommendation for the method and end-points of resuscitation in the elderly patient as a standard of care.

B. Level II:

1. Any geriatric patient with physiologic compromise, significant injury (Abbreviated Injury Scale [AIS] score > 3), and high-risk mechanism of injury, uncertain cardiovascular status, or chronic cardiovascular or renal disease should undergo invasive hemodynamic monitoring using a pulmonary artery catheter.

2. There are insufficient data to support a Level II recommendation for the method and end-points of resuscitation in the elderly patient as a standard of care.

C. Level III:

1. Attempts should be made to optimize to a cardiac index ≥ 4 L/min/m^2 and/or an oxygen consumption index of 170 mL/min/m^2.

2. Base deficit measurements may provide useful information in determining status of resuscitation and risk of mortality.

IV. Scientific Foundation

It is widely known that the citizenry of the United States is continuing to age.[49–51] The elderly population (65 years and older) increased 11-fold from 1900 to 1994, whereas the segment under the age of 65 increased only 3-fold during the same period.[50] Data from the U.S. government shows that the life expectancy of the U.S. population reached 76.5 years, the highest at any time in U.S. history.[49] There will be a dramatic increase in the elderly population because of the aging of the "baby-boom" generation (75 million babies born between 1946 and 1964).[50] Although projection assumptions vary, using the Census Bureau's "Middle Series" projections (moderate fertility, mortality, and immigration assumptions), the elderly will make up 12.8% of the population by 2000 and 20.4% by 2050.[50]

Trauma ranks as the fifth leading cause of death when considering all races, both sexes, and all ages.[49] For patients 65 years and over, trauma ranks seventh as a cause of death, although the rate per 100,000 is 92.1 compared with 35.7 for all age groups. Unlike younger age groups, there is relatively little variation in death rates between black and white races. These data indicate that in the future there will be an unprecedented number of elderly persons at risk for injury.

Advancing age is associated with a gradual decline in organ function. Problems attributable solely to senescence and diseases not associated with age may be difficult to distinguish from one another, but it is important to account for all disorders concomitant with the injury. The walls of the heart become less compliant and cardiac index decreases 1% per year with age and systemic vascular resistance increases 1% per year.[52] Maximum heart rate is also reduced with age. In addition, the heart is less able to respond to the stress of injury, as there is an age-related decrease in the effectiveness of adrenergic stimulation.[53] The prevalence of hypertension also increases as a function of age. In the United States, 59.2% of white men aged 65 to 74 are hypertensive, and this increases dramatically to 82.9% in elderly black women.[54] The end result of these age-related changes is a decreased ability to respond to the stress of injury or critical illness.

There are numerous changes in respiratory function with increasing age. The chest wall becomes less compliant and the elasticity of the lung decreases.[52] The loss of compliance results in a greater dependence on diaphragmatic breathing.

Renal mass is rapidly lost after the age of 50, and a corresponding fall in glomerular filtration rate occurs beyond the age of 60 because of the loss of nephrons.[52] Measurement of creatinine clearance becomes more important in the geriatric patient, because serum creatinine may be lowered as a result of decreased muscle mass, giving a false sense of security with respect to renal function. Age-related vascular changes result in a decreased percentage of blood flow to the older kidney.[52]

Deteriorating endocrine function is also seen with advancing age. The production and turnover of thyroid hormone species is significantly reduced.[55] Tissue responsiveness to thyroid hormone is lessened, resulting in striking similarities between clinical hypothyroidism and the changes commonly seen in the elderly as a result of senescence.[55] Normal adrenal function is critical to respond to the stress of injury and critical illness. Basal, circadian, and stimulated cortisol secretion remains intact with aging.[56] There is an age-related decrease in the catabolism of cortisol, although this is compensated for by a decrease in the rate of catabolism.

The question of whether or not preexisting disease contributes to poor outcome has not yet been conclusively answered, and is more fully discussed in the preceding section. The prevalence of comorbid conditions in trauma patients is between 8.8% and 19.3%.[57] In injured patients older than 65 years, however, the incidence climbs to 30%.[58] Milzman et al. found that by 75 years, 69% of patients had one or more preexisting conditions.[33] Smith et al. found at least one comorbidity in 61.6% of patients in their series.[37] In a study of 102 patients from Switzerland admitted with femur fractures, 16% presented with a single comorbid condition, 45% presented with two comorbid conditions, 28% presented with three conditions, and 11% presented with four.[59] Battistella et al. found an average of two preexisting medical problems in injured patients aged 75 years and older.[27] After controlling for age, Sacco et al. found that hepatic, cardiovascular, respiratory, and renal disease and diabetes adversely affected survival.[60] Milzman et al. and MacKenzie et al. noted higher mortalities and longer lengths of stay in patients with increased numbers of preexisting conditions.[33,61]

Criteria for hemodynamic monitoring are not clear in this population. The gravity of this situation is underscored because it has been found that the elderly patient is more likely to present in shock than younger patients with similar trauma and Injury Severity Scores.[62] In geriatric patients undergoing elective surgery, occult physiologic compromise has been shown to contribute to poor outcome. DelGuerico and Cohn found significant physiologic compromise in geriatric patients who had been "cleared" for elective surgery.[63] Among those who could not be optimized before surgery, all died postoperatively. Similar work has also been performed in trauma patients.

Scalea et al. found significant measurable hemodynamic compromise in elderly patients who were clinically stable after initial evaluation after blunt multiple trauma.[64] On the basis of institutional experience, criteria were developed to select patients for invasive hemodynamic monitoring. These criteria included pedestrian–motor vehicle mechanism, initial blood pressure < 150 mm Hg, acidosis, multiple fractures, and head injury. Patients were moved to the intensive care unit as quickly as possible. Pulmonary artery catheters and arterial lines were inserted in all patients. Volume infusion and inotropes were used to augment hemodynamic parameters. Attempts were made to optimize patients to a cardiac index ≥ 4 L/min/m^2 or an oxygen consumption index of 170 mL/min/m^2. Thirteen of 30 patients were found to be in cardiogenic shock and 54% of these died. There were statistically significant differences between optimized cardiac output and systemic vascular resistance in survivors compared with nonsurvivors. The vital message from this important work is that a geriatric patient with multiple injuries may appear "stable" yet have a profound perfusion deficit from a dangerously low cardiac output. The early use of invasive hemodynamic monitoring will identify this deficit and afford the opportunity to help improve survival.

The only randomized data concerning resuscitation in geriatric patients was conducted by Schultz et al.[65] These authors studied the role of physiologic monitoring in patients with fractures of the hip. Seventy patients were randomly divided into a monitored group and a control group. A central venous line was placed into the control group and a pulmonary artery catheter into the monitored group. The mean age for the nonmonitored group was 67 years (range, 40–89 years) and that for the monitored group was 78 years (range, 40–95 years). On the basis of the data obtained, physiologic abnormalities were "appropriately corrected." Postoperative morbidity was similar between the two groups. The postoperative mortality in the monitored group was 2.9% and the mortality in the nonmonitored group was 29%. The primary weakness in this study is that no clear parameters are provided to guide resuscitation. This study evaluated patients with hip fractures and not the multisystem elderly trauma patient.

Tornetta et al. retrospectively reviewed 326 patients 60 years of age or greater at four hospitals.[25] Using univariate analysis, patients who died displayed significantly greater transfusion requirement (10.9 vs. 2.9 U) and fluid infusion (12.4 vs. 4.9 L). Both transfusion and fluid requirements were found to be predictive of mortality. The authors concluded that the risks of invasive monitoring are justified in patients with an ISS > 18, but for patients with an ISS < 18, indications need to be clarified.

The importance of shock and fluid replacement in the elder trauma patient was addressed by Oreskovich et al.[22] One hundred consecutive elderly patients (mean age, 74 years) were followed for a minimum of 1 year. A profile of the nonsurvivor was constructed: (1) prehospital intubation

Table 2 **Evidentiary Table: Resuscitation Goals in Geriatric Trauma**

First Author	Year	Reference	Data Class	No. of Patients	Age (yr)	Pt. Population	Mortality (%)	Synopsis and Conclusions
Schultz RJ	1985	The role of physiologic monitoring in patients with fractures of the hip. *J Trauma.* 25: 309–316.	I	35	Mean = 67 in controls	All patients with hip fractures	29 in controls 2.9 in study group	All patients randomly assigned (not blinded) to monitored group or unmonitored group. Hemodynamic monitoring was accomplished using a pulmonary artery catheter. Preoperative risk factors, length of procedure, and postoperative morbidity were similar. The condition of each patient was optimized before surgery using diuretics or inotropes (no formal protocol given). Mortality in monitored group was one-tenth of unmonitored group.
Scalea TM	1990	Geriatric blunt multiple trauma: improved survival with early invasive monitoring. *J Trauma.* 30: 129–136	II	1986, 15 1987, 30	$>$ 65	Blunt multiple trauma	1986, 93 1987, 47	1986 Group I 3.5 L/min CO 100% (all cardiogenic shock) Group II 3.5–5 86% 1987 Group A 3.5 54% (3, cardiogenic shock; 4, organ failure) Group B 3.5–5 50% (3, head injury; 1, sudden death) Group C $>$5 33% Attempts were made to optimize to a cardiac index $\geq$ 4 L/min/m^2 and/or an oxygen consumption index of 170 mL/min/m^2. Fluid and inotropes used as needed. Although stable by usual clinical criteria, there may be a dangerous low-flow state. The ability to correct this low-flow state correlates with survival.
Oreskovich MR	1984	Geriatric trauma: injury patterns and outcome. *J Trauma.* 24: 565–572.	III	100	$>$ 70	"Severe" blunt trauma; burns included	15	All nonsurvivors were in shock (systolic blood pressure $<$ 80 mm Hg) for at least 15 min between injury and admission. Only 6% of survivors were found to be in shock. During this study, the protocol for prehospital care in the hypotensive patient called for 2,200 mL lactated Ringer's solution prior to arrival at hospital.
Horst HM	1986	Factors influencing survival of elderly trauma patients. *Crit Care Med.* 14:681–684.	III	39	$\geq$ 60	Admitted to SICU; monitored with PA and arterial catheters	31	Fifteen (38%) of 39 patients presented in shock. Survival related to sepsis and the number of failed organ systems, but NOT presence of shock at admission. Incidence of shock not statistically different between survivors and nonsurvivors. Although survivors had higher mean arterial pressure, cardiac index, left ventricular stroke work, oxygen delivery, and hemoglobin, this was not statistically significant.

Table 2 *Continued*

First Author	Year	Reference	Data Class	No. of Patients	Age (yr)	Pt. Population	Mortality (%)	Synopsis and Conclusions
Pellicane JV	1992	Preventable complications and death from multiple organ failure among geriatric trauma victims. *J Trauma.* 33: 440–444.	III	374	> 65	Consecutive trauma patients; burns excluded	8	Trauma score was significantly ($p < 0.001$) higher in patients who survived. Mortality was significantly ($p < 0.05$) increased in patients with TS < 12 (65%) and TS = 12–14 (25%) when compared with patients with TS = 15–16 (5%). Geriatric patients with a TS < 15 are at high risk and should be admitted to the ICU and treated aggressively.
Knudson MM	1994	Mortality factors in geriatric blunt trauma patients. *Arch Surg.* 129: 448–453.	III	852	≥ 65	Blunt trauma	18.4	Admitting physiologic status predictive of mortality. Systolic blood pressure < 90 mm Hg associated with 82% mortality rate. Multiple logistic regression used to construct formula to help predict which patients may benefit from aggressive care.
Davis JW	1998	Base deficit in the elderly: a marker of severe injury and death. *J Trauma.* 45: 873–877.	III	274	≥ 55	"Major trauma patients"; study group compared to cohort of younger patients	Varied with base deficit	Correlated base deficit with mortality. Arterial blood gases obtained within 1 h after admission. Higher mortality in elderly with increasing base deficit, despite similar ISS. In patients ≥ 55 yr, a BD 2 to –2 was associated with an 18% mortality; a BD –3 to –5 resulted in 23% mortality; a BD –6 to –9 resulted in 60% mortality; a BD < –10 resulted in 80% mortality. In all categories, mortality was increased for elderly compared to younger cohort. Positive predictive value not different between elderly and young. Negative predictive value of normal BD in young (60%) was greater than elderly (40%). BD < –6 is particularly ominous in elderly.
Perdue PW	1998	Differences in mortality between elderly and younger adult trauma patients: geriatric status increases risk of delayed death. *J Trauma.* 45: 805–810.	III	448	≥ 65	One-system injuries and admits to nontrauma service excluded	14	Elderly mortality significantly ($p < 0.001$) greater than that of younger patients. ISS and RTS independently predictive of mortality. Authors practice is to admit elderly patients to ICU if they have significant injury (AIS score > 3), shock, or significant chronic cardiovascular or renal disease. Pulmonary artery catheters not placed unless volume or cardiac status uncertain.
Tornetta P	1999	Morbidity and mortality in elderly trauma patients. *J Trauma.* 46: 702–706.	III	326 (multicenter)	≥ 60	Significant blunt trauma only; slip-and-fall injuries were excluded	18.1	Patients who died displayed greater transfusion requirement (10.9 vs. 2.9 U) and more fluid infused (12.4 vs. 4.9 L). Transfusion requirement and fluid requirement found to be predictive of mortality. Risks of invasive monitoring easily justified in patients with ISS > 18. In patients with ISS < 18, indications need to be evaluated further.

PA, pulmonary artery; BD, base deficit.

(93% mortality), (2) shock (100%), (3) intubated greater than 5 days (100%), and (4) gram-negative pulmonary sepsis (80%). All nonsurvivors were in shock (systolic blood pressure < 80 mm Hg) for at least 15 minutes between injury and admission. Only 6% of survivors were found to be in shock. During this study, the protocol for prehospital care in the hypotensive patient called for 2,200 mL of lactated Ringer's solution before arrival at hospital.

Perdue et al. retrospectively studied 4,691 patients aged 16 to 64 years and compared these with 448 patients aged 65 years or greater.[17] Elderly mortality was 14% compared with 6% in the younger cohort, and the difference was statistically significant ($p < 0.001$). After controlling for Injury Severity Score, Revised Trauma Score, preexisting disease, and complications, the elderly were 4.6 times as likely to die compared with the young. The author's practice is to admit elderly patients to the ICU if they have significant injury (AIS score > 3), shock, or significant chronic cardiovascular or renal disease. Pulmonary artery catheters were not placed unless volume or cardiac status was uncertain.

Knudson et al. retrospectively analyzed physiologic status in 852 blunt trauma patients aged 65 years or older.[18] Mortality increased with a decreasing TS and was 100% with a TS < 7. Each individual component of the TS was found to be predictive of mortality when analyzed independently. A systolic blood pressure < 90 mm Hg was associated with an 82% mortality rate. Multiple logistic regression analysis was used to construct a formula to help predict which patients would benefit from aggressive resuscitation.

Physiologic status was also addressed by Pellicane et al.[16] The authors reviewed 374 consecutive trauma patients over the age of 65 years. Trauma score was significantly ($p < 0.001$) higher in patients who survived. Mortality was significantly ($p < 0.05$) increased in patients with a TS < 12 (65%) and a TS of 12 to 14 (25%) when compared with patients with a TS of 15 to 16 (5%). The authors concluded that geriatric patients with a TS < 15 are at high risk for complications and should be admitted to the ICU and treated aggressively.

Horst et al. retrospectively studied 39 trauma patients over the age of 60 years.[19] Patients were admitted to the intensive care unit and monitored with arterial and pulmonary artery catheters. Fifteen (38%) patients presented with shock (systolic blood pressure < 80 mm Hg). Although survivors tended to have higher mean arterial blood pressure, cardiac index, left ventricular stroke work, and oxygen delivery, the differences compared with nonsurvivors were not statistically significant.

The importance of shock was further underscored by van Aalst et al.[5] The authors retrospectively analyzed 98 geriatric (≥ 65 years) blunt trauma patients with ISS ≥ 16. Of 48 surviving patients, only 1 presented in shock. Of the 50 nonsurvivors, 15 presented in shock. The presence of shock (systolic blood pressure < 90 mm Hg) at admission was the most significant factor associated with a poor outcome. Sepsis was also identified as a factor contributing to poor outcome.

The state of resuscitation as evaluated by base deficit was evaluated by Davis and Kaups.[7] The authors studied the utility of base deficit in 274 patients aged 55 years and older. Arterial blood gases were obtained within 1 hour of admission. There was a statistically significant increase in mortality with increasing base deficit. Compared with a younger cohort, mortality in the elderly was significantly increased for a given base deficit despite similar Injury Severity Scores. The positive predictive value of base deficit for significant injury was similar between young and old, but the negative predictive value was significantly better in younger patients. The authors concluded that a base deficit < -6 is particularly ominous in elderly trauma patients.

The above data emphasize the importance of close hemodynamic monitoring and careful trending of vital signs rather than relying on a single set of "normal" vital signs.[66] Because the elderly patient is often not able to generate an augmented cardiac output in response to hemorrhage, early invasive hemodynamic monitoring and judicious use of vasoactive drugs (after appropriate fluid resuscitation) as recommended by Scalea et al. should be recommended for any geriatric patient with significant injuries.

V. Summary

The elderly (65 years and older) are the fastest growing segment of the U.S. population. Although trauma is only the seventh leading cause of death in the elderly, the death rate (per 100,000) is significantly higher when compared with a younger cohort. U.S. Bureau of Census data indicate that in the future there will be an unprecedented number of elderly persons at risk for injury.

It is widely known that the elderly display a high incidence of premorbid conditions. However, the question of whether or not preexisting disease contributes to poor outcome after injury has yet to be conclusively answered. Several studies have indicated that shock, respiratory failure, decreasing TS, increasing ISS, increasing base deficit, and infectious complications portend a poor outcome in the elderly.

Data indicate that the geriatric patient with multiple injuries may appear "stable" yet have a profound perfusion deficit secondary to low cardiac output. The early use of invasive hemodynamic monitoring may afford the opportunity to help improve survival.

Although the injured elder is more likely to die than the younger patient, an aggressive treatment program will allow many geriatric patients to regain their preinjury independence. Attention to detail, although important for all trauma patients, must be heightened in the injured elder, as the opportunity for good outcomes may be fleeting.

VI. Future Investigations

The paucity of literature evaluating the conduct and end-points of resuscitation of the geriatric trauma patient requires that further clinical work be conducted. Randomized trials in severely injured geriatric patients must be performed to determine which patients would benefit from invasive monitoring and the end-points that should be used for completing the resuscitation. Trials such as this, however, have ethical, medicolegal, and methodologic implications that may prevent their inception.

There are many parameters that have been shown to correlate with poor outcome in this population. We have no control over some of these, such as patient age. Some can be controlled with prevention techniques, as in the case of the pedestrian–motor vehicle crash, which has been shown to be associated with mortality. As clinical practitioners, we should focus our efforts on those areas where we would be able to exert an impact. The shock state, acidosis, and sepsis have been shown to directly correlate with mortality. Aggressive identification, correction, and monitoring of these pathophysiologic states may be able to improve outcome. Laboratory assays, such as base deficit, may have promise for measuring the adequacy and completeness of resuscitation. Certain drugs, such as beta-blockers, have been shown to improve outcome in elderly general surgery patients, but have not yet been studied in trauma patients.

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