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Evaluation of major trauma in elderly patients – a single trauma center analysis

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Summary
Background The objective of the study was to gather information about elderly major trauma patients admitted to one particular Slovenian trauma centre in Celje and examine this group of polytrauma patients, specifically with respect to mechanisms of injury, injury severity and distribution of injuries. Further on, to identify morbidity and mortality rates and compare these to the younger population and, finally, to determine the factors that have the most impact on treatment results.
Methods The study gathered and evaluated data of 532 patients included in the Trauma Register DGU® of the German Trauma Society (TR-DGU) during a 10-year period and two distinct groups of patients were established, separated on account of age as older or younger than 65 years. The differences between these two groups were analyzed with respect to demographics, comorbidities, preclinical management, injury patterns, relevant clinical and laboratory findings. Furthermore, differences between deceased and surviving elderly patients were also analyzed.
Results The majority of elderly patients suffered from a blunt mechanism of trauma (96.6%) and of these simple falls represented 47.9% within this injury mechanism. There were two body regions, which were most frequently represented, namely head and thorax injuries, accounting for 54.7% each. Complications were more frequent among the elderly, with sepsis being present in 29.9% and multiple organ failure (MOF) in 19.7% of cases. Cardiovascular failure was also high in both the elderly and young, accounting for 45.3% of the elderly and 31.3% of the younger population. The in-hospital mortality rate for the elderly group was 25.6% and was significantly higher compared to the younger counterparts (14.7%). Low fall mechanism of injury, coma and the new injury severity score (NISS) were statistically important factors for the mortality of seriously injured elderly patients during the acute phase of treatment.
Conclusions Despite advances in care, morbidity and mortality in elderly patients after major trauma remains considerably higher than in younger populations with head injuries accounting for the majority of fatalities. The elderly patient population in this study mostly suffered from blunt mechanisms of injury, with simple falls representing a high proportion of injury mechanisms. Generally, the injury severity scale (ISS) in the elderly is not statistically higher than with the younger population. Likewise, the distribution of injuries according to body regions is also similar; however, the elderly are more prone to complications (e. g. sepsis and MOF), which is likely due to a lower physiological reserves.

Keywords Geriatrics · Polytrauma · Registry · Outcome · Mortality

Introduction

In recent decades life expectancy in developed countries has significantly increased. The current life expectancy in Slovenia is 83.6 years for women and 77.2 years for men [1]. The population continues to grow older but as the elderly became fitter and more mobile, they are also confronted with more injuries. Hospitals are dealing with increasing numbers

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of injured elderly patients, in many cases sustaining multiple injuries, who may require diagnostic and therapeutic strategies that differ from those applied in younger trauma patients. Within recent years, trauma has become the third leading cause of death in Slovenia. Predictably, morbidity and mortality rates are higher among the elderly population compared to their younger counterparts, although studies have not established a conclusive linear relationship between age and trauma-related mortality [2]. There are different factors that contribute to this with age being the primary one; however, they also include a higher number of comorbidities and concomitant medications in the older population, which impairs age-dependent physiological reserves [3].

Despite the statistically bleak prognosis, several reports have suggested that early aggressive management of these patients can lead to a better outcome [4]. Among the recommendations regarding the approach to elderly trauma patients are: (1) the threshold for field triage for injured patients with advanced age and pre-existing medical conditions should be lowered for direct transfer to a designated trauma center, (2) the advanced age of a patient should not be used as the sole criterion for denying or limiting care and (3) an initial aggressive approach should be pursued in the management of elderly patients, unless an experienced trauma surgeon concludes that the injury burden is too severe and the patient appears moribund [5]. The mortality of elderly patients suffering trauma continues to fall but is still considerably higher compared to younger patients.

In Slovenia trauma patients are referred to regional hospitals, where they receive dedicated trauma care. In the General and Teaching Hospital Celje (GH Celje) approximately 50 severely injured trauma patients are admitted to the emergency unit annually, with these cases being included in The Trauma Register DGU® of the German Trauma Society (TR-DGU). Participation in the TR-DGU provides a sound database of hospital care and treatment data, which can be used for various scientific purposes. The scope of this article is threefold. Firstly, to examine the group of elderly polytrauma patients treated at the Slovenian trauma centre in Celje, specifically with respect to mechanisms of injury, injury severity and distribution of injuries. Secondly, to identify morbidity and mortality rates and compare these to the younger population, thereby also keeping in mind different time periods and finally to determine the factors that have the most considerable impact on the treatment results.

Patients and methods

The TR-DGU contains prospectively collected data on demographics, injury patterns, comorbidities, preclinical and clinical management, time course, relevant laboratory findings and outcome of trauma patients [6]. Approximately 100 data points per patient are collected, including the coding of each injury according to the abbreviated injury scale (AIS, version 2005/08). Data are submitted online to a central database. The GH Celje has been part of TR-DGU since 2006. Patients are selected for inclusion in the TR-DGU according to the following criteria: (1) polytrauma patients (i. e. patients with injuries to at least two body regions) with an injury severity score (ISS) ≥18, (2) patients with injuries to a single region and AIS 5, (3) patients with injuries to a single body region and AIS 4 and exhibiting abnormal vital signs and a triage revised trauma score code (T-RTS) <4 and (4) patients with multiple long bone, spinal or pelvic fractures and abnormal vital signs (T-RTS <4). All patients who were declared dead on arrival to hospital or presented to hospital >24 h after injury were excluded from the register, as were patients on anticoagulation drugs with head injuries that occurred with low energy mechanisms.

The prospectively collected clinical and laboratory data of 532 patients, who were included in the TR-DGU during a 10-year period from 2006 to 2015 and fulfilled the inclusion criteria, were evaluated in the study. Two groups of patients were subsequently formed: those older and those younger than 65 years, with differences between these two groups being analyzed, most notably differences pertaining to demographics (e.g. age, gender and mechanism of injury), comorbidities according to the American Society of Anesthesiologists (ASA) score prior to injury, preclinical management (time management and fluid administration), injury pattern (ISS regions), relevant clinical (systolic blood pressure, SBP) and laboratory findings, e.g. base excess (BE). Hospital mortality (all causes of death), early mortality (within 24 h), morbidity with multiple organ failure (MOF) and sepsis, overall duration of mechanical ventilation, intensive care unit (ICU) treatment and hospital stay were all used as outcome measures. The mortality rate was calculated separately and compared for two time periods, 2006–2010 and 2011–2015, as in the latter the treatment algorithms were modified with whole body computed tomography (WBCT), massive transfusion protocol with thromboelastometry (ROTEM analysis) and formal advanced trauma life support (ATLS) training. All patients were treated according to ATLS guidelines with only few modifications. Since 2010 hemodynamically stable patients undergo early WBCT scanning, whereas life-saving surgery is performed in unstable patients according to damage control principles. Following initial stabilization, patients are either transferred to the trauma ICU or undergo further diagnostic imaging, if necessary.

The charts of all elderly patients who died in hospital were retrospectively reviewed for time and cause of death. Two groups of elderly patients (including both deceased and surviving patients) were formed, based on a comparison of demographics, comorbidities, mechanism, severity and distribution of injuries,

Table 1 Basic characteristics of young and old patients with main differences between both groups

	Young (<65 years) 415 (78%)	Old (≥65 years) 117 (22%)	*P*-value
Age (mean ± SD)	41.3 ± 14.4	73 ± 5.8	<0.001
Male (No. %)	353 (85.1%)	86 (73.5%)	0.004
ISS (mean ± SD)	26.4 ± 9.8	28.1 ± 13.1	0.15
NISS (mean ± SD)	33.2 ± 11.6	35.1 ± 13.7	0.13
ASA score ≥3 (No. %)	15 (3.6%)	33 (28.2%)	<0.001
Mechanism of injury (No. %)			
Traffic – car	98 (23.6%)	14 (12.0%)	–
Traffic – motor bike	78 (18.8%)	7 (6.0%)	–
Traffic – bicycle	19 (4.6%)	9 (7.7%)	–
Traffic – pedestrian	22 (5.3%)	13 (11.1%)	–
High fall (>3 m, stairs)	82 (19.8%)	27 (23.1%)	–
Low fall	39 (9.4%)	29 (24.8%)	–
Blunt injury	392 (94.5%)	113 (96.6%)	–
Type of injury (No. %)			
Head injury (AIS ≥3)	214 (51.6%)	64 (54.7%)	0.55
Head injury (isolated) (AIS ≥3)	71 (17.1%)	26 (22.2%)	0.2
Thoracic injury (AIS ≥3)	182 (43.9%)	64 (54.7%)	0.04
Abdominal injury (AIS ≥3)	108 (26.0%)	22 (18.8%)	0.11
Extremities (AIS ≥3, including pelvis)	150 (36.1%)	31 (26.5%)	0.05
Pelvic injury (AIS ≥2)	79 (19.0%)	29 (24.8%)	0.17
Spinal injury (AIS ≥2)	88 (21.2%)	25 (21.4%)	0.97
Musculoskeletal (AIS ≥2)	191 (46%)	45 (38.5%)	0.15
Polytrauma (No. %)	146 (35.2%)	48 (41.0%)	0.25
BP <90 mmHg (No. %)	81 (19.5%)	29 (24.7%)	0.21
Unconsciousness (GCS 3–8) (No, %)	167 (40.2%)	46 (39.3%)	0.86
Coagulopathy (*N*,%)	74 (17.8%)	23 (19.7%)	0.65
BE ≤–6 (No, %)	67 (16.1%)	20 (17.1%)	0.43
CPR (No. %)	14 (3.4%)	8 (6.8%)	0.1
WBCT (since 2009)	96 (23.1%)	30 (25.6%)	0.59
ROTEM (since 2012)	32 (7.7%)	10 (8.5%)	–
Prehospital time ≥60 min (no. %)	191 (46.0%)	59 (50.4%)	0.25
Time from injury to OR/ICU ≥180 min (no. %)	29 (7.0%)	6 (5.1%)	0.18

ISS injury severity scale, *NISS* new injury severity scale, *ASA* American Society of Anesthesiologists, *AIS* abbreviated injury scale, *BP* blood pressure, *GCS* Glasgow coma scale, *BE* base excess, *SD* standard deviation, *CPR* cardiopulmonal resuscitation, *WBCT* whole body computed tomography, *ROTEM* tromboelastometry, *OR/ICU* operating the atre/intensive care unit

preclinical management (time management and fluid administration) and number of complications. All the data were analyzed using standard statistical software (SPSS, IBM, Armonk NY). The comparison of the clinical data between the groups was done using the chi square test in cases of categorical variables and Student's t-test in cases of continuous variables. A *p*-value <0.05 was considered significant. Survival analysis was performed using the Kaplan-Meier method. By means of univariate analyses (t-test, chi square test and Fisher's exact test) we scrutinized the predictors of survival and included them into the logistic regression model by the forward stepwise procedure. Data were collected in advance of a planned quality improvement in the clinical setting. Formal consent is not required for this type of study; however, the study was reviewed by an ethics committee. Details, which might have disclosed the identity of the included patients, were omitted.

Definitions

Single organ failure was defined as a value of 3 or 4 for one organ according to the sequential organ failure assessment (SOFA) score and MOF was defined as the simultaneous failure of at least two organs. Sepsis was defined according to the criteria of the American College of Chest Physicians/Society of Critical Care Medicine (ACCP-SCCM) consensus conference definition. Early MOF was defined as having signs of organ failure within 3 days after trauma, late MOF as diagnosed with signs of organ failure 3 days after trauma. Polytrauma was defined as sustaining significant injuries to ≥3 points of ≥2 different anatomical AIS regions in conjunction with 1 or more additional variables from the 5 physiological parameters: hypotension (systolic blood pressure ≤90 mmHg), level of consciousness with a Glasgow Coma Scale (GCS) score ≤8, acidosis (base excess ≤–6.0), coagulopathy (international normalized ratio ≥1.4, partial thromboplastin time ≥40 s; this was also taken as the definition of coagulopathy) and age (≥70 years) [7].

Results

Demographic characteristics, comorbidities and severity of injury

The study included 532 patients of which 117 (22%) were multiple trauma patients older than 65 years. The mean age of the elderly in this study cohort was 73 years (±5.8) with 73.5% (86 patients) male and 26.5% (31 patients) female patients. The mean ISS was 28.1 (±13.1) and mean new injury severity scale (NISS) was 35.1 (±13.7), both comparable to the younger population aged less than 65 years. The percentage of women increased with advancing age, rising from 14.9% among the subjects under 65 years to 26.5% in those older than 65 years. Similarly, the percentage of patients with comorbidities also increased with advancing age, with 3.6% of the younger population exhibiting an ASA score of 3 or more and 28.2% of the older population. Having regard to the inclusion criteria for the new Berlin polytrauma definition, only 48 patients (41.0%) from the age group over 65 years met these criteria. Hypotension

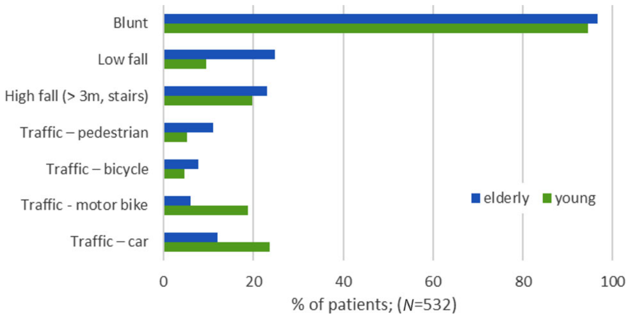

Fig. 1 Mechanisms of injury in the old and young populations

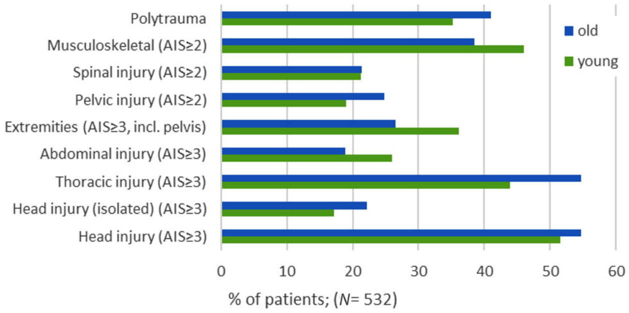

Fig. 2 Types of injuries in the study population according to AIS score (*AIS* abbreviated injury scale)

with a blood pressure (BP) < 90 mmHg was noted for 29 patients (24.7%) from the older group, also demonstrating a higher proportion compared to the group of younger patients (81 patients, 19.5%); however, when considering the GCS score, 46 elderly patients (39.3%) and 167 younger patients (40.2%) were documented as having a GCS score of 3–8. Likewise, the proportion of patients with coagulopathy was also similar in both age groups, with 23 elderly patients (19.7%) exhibiting this condition and 74 younger patients (17.8%) (Table 1).

Mechanism of injury

A blunt mechanism of injury prevailed over penetrating injuries in the elderly with 113 cases (96.6%) overall, the same being noted also among the younger patients (392 patients, 94.5%). On the other hand, traffic accidents (e.g. car, motorbike, bicycle and pedestrian accidents) accounted for 43 cases (36.8%) in the elderly, whereas there were to 217 cases documented in the younger population (52.3%). Compared to younger patients (22 patients, 5.3%) more older patients were injured as pedestrians (13 patients, 11.1%). Falls were the predominant cause of injury in the elderly population and were documented in 56 cases (47.9%), compared to 121 cases in the younger population (29.2%). A fall from a height of ≥3 m was a mechanism of injury in 27 patients (23.1%), while 29 (24.8%) fell from a lower height (Fig. 1).

Types of injuries

Head and thoracic trauma were the most common types of injury, each present in 64 patients (54.7%). Similar percentages were observed in the young population, with head injury being present in 214 patients (51.6%), while the second most common type of injury was musculoskeletal (191 patients, 46%). Head trauma was mostly combined with other injuries, as isolated head trauma was only documented in 26 elderly patients (22.2%), compared to 71 young patients (17.1%). Abdominal injuries were present in 18.8% of the elderly patients (108 patients) and 26.0% in the young patients and extremities were injured in 26.5% of the elderly patients (150 patients) and 36.1% in the young. Polytrauma was documented in 48 elderly patients (41%) and 146 young patients (35.2%) (Fig. 2).

Clinical management

Prehospital resuscitation with fluid replacement was more restrictive in the older population, with 17 patients (14.5%) receiving over 1000 ml of fluids, compared to younger patients, among which 102 (24.6%) received more than 1000 ml of fluids. In 2010 we started using WBCT and since then 25 older patients (45.5% of all elderly patients treated in that time period) were examined using this diagnostic tool. In 2012 we implemented the massive transfusion protocol with the use of ROTEM and since then, 9 elderly patients (26.5%) were treated according to the aforementioned protocol. Prehospital time was more than 60 min in 59 elderly patients (50.4%), compared to 191 younger patients (46.0%), while time from injury to the operating room (OR) or ICU was more than 180 min in 6 elderly patients (5.1%) and 29 younger patients (7.0%). The average time spent in the ICU was longer for the elderly, averaging 14.5 days (±14.9), compared to 10.5 days (±10.3) among the young. These patients also needed respiratory support for longer periods, being on a respirator for 10.3 days (±11.6) on average whereas younger patients needed respirator support for 6.9 days (±7.6) on average (Table 2).

Complications

Cardiovascular system failure was the most common complication in both the elderly and the young and was present in 53 (45.3%) elderly patients and 130 (31.3%) younger patients. Other complications in the elderly included sepsis (29.9%), respiratory failure (23.9%), nervous system failure (23.1%), coagulation failure (19.7%) and renal failure (10.3%). All of them, except nervous system failure, were significantly higher than in the younger group of patients. The latter was present in 27 (23.1%) elderly and 82 (19.8%) young (Table 2).

Table 2 Outcome differences between young and old patients

	Young (<65 years) 415 (78%)	Old (≥65 years) 117 (22%)	*P*-value
Mortality (30 days)	61 (14.7%)	30 (25.6%)	0.006
Early mortality (<24 h)	23 (5.5%)	12 (10.3%)	0.07
RISC (mean ± SD)	15.2 ± 22.4	31.5 ± 29.2	<0.001
Surgery	349 (84.1%)	93 (79.5%)	0.24
Massive transfusions (≥10 units)	13 (3.1%)	3 (2.6%)	0.9
Sepsis	68 (16.4%)	35 (29.9%)	0.001
Respiratory failure	43 (10.4%)	28 (23.9%)	<0.001
Coagulation failure	35 (8.4%)	23 (19.7%)	0.001
Hepatic failure	7 (1.7%)	2 (1.7%)	0.98
Cardiovascular failure	130 (31.3%)	53 (45.3%)	0.003
CNS failure	82 (19.8%)	27 (23.1%)	0.4
Renal failure	8 (1.9%)	12 (10.3%)	<0.001
MOF	28 (6.7%)	23 (19.7%)	<0.001
ICU days	10.5 ± 10.3	14.5 ± 14.9	0.001
Respirator days	6.9 ± 7.6	10.3 ± 11.6	<0.001
Hospital days	31 ± 30.5	36.3 ± 28	0.09

RISC revised injury severity classification, *SD* standard deviation, *CNS* central nervous system, *MOF* multiple organ failure, *ICU* intensive care unit

Mortality

The in-hospital mortality rate for the elderly group was 25.6% and was significantly higher compared to the younger counterparts (14.7%, $p = 0.002$) (Fig. 3). Predicted standardized mortality for this group of patients according to revised injury severity classification (RISC) was 31.5 (compared to 15.2 in the younger population) and 12 patients (10.3%) died within the first 24 h of admission to hospital.

The causes of death in the elderly were traumatic brain injury in 20 patients, early consequences of hemorrhagic shock in 6 patients, early MOF in 1 and late MOF in 3 patients (Fig. 4).

We compared mortality during two time periods (2006–2010 and 2011–2015). During the latter, some major changes in treatment were applied (WBCT and transfusion protocol). There were 67 patients in the first and 50 patients in the second group. Comparable RISC values (30.7 vs. 32.5) showed an almost equal distribution of variables that influence outcome. Mortality rate was 25.4% vs. 26% despite some major improvements in treatment in the later period.

Predictors of mortality

Univariate analysis was performed to analyze predictors of death in the elderly. Severity of injury measured by NISS, low fall mechanism of injury, severe head injury and coma on admission were all found to have a strong impact on survival. These factors were included in the logistic regression model, which was statistically typical ($p < 0.001$); however, only coma and NISS values were statistically important for the mortality of seriously injured elderly patients during the acute phase of treatment. The Hosmer-Lemeshow statistic (0.88) indicates that the model adequately fits the data. Nagelkerke's R^2 was 0.51. Based on the model, 81.2% of the cases were classified correctly. Variables and equation are presented in Table 3.

Discussion

There is no consensus in the available literature regarding the definition of a geriatric trauma patient and the characteristic age varies from 55 to 70 years old. We followed the study of Perdue et al. who found the mortality rate among trauma patients older than 65 years to be twice as high compared to younger patients [8]. In our study we selected patients aged 65 years and over at the time of accident. We confirmed a significantly higher mortality compared to patients younger than 65 years of age, although they had comparable injury severity.

Broos et al. analyzed 126 severely injured elderly patients (average ISS 33.2) and concluded there was no age difference between those who died and those who survived [9]. In our group of patients the situation was the same as in the article of Broos et al., meaning there was no significant age difference between the group of patients who died and those who survived. We are of the opinion that all the patients above the age of 65 years can be classified as one group, moreover, this single group is highly threatened after injuries.

It remains unclear whether age represents an independent risk factor for mortality. In elderly patients with an increased occurrence of pre-existing diseases (PED) and less physiological reserve, the literature addressing the connection between pre-injury illness and mortality after the injury is inconclusive. The most frequent problem for all research is that there is no standardized definition of PED. The ASA scale used in our study as a measure of PED was not connected with higher mortality after injuries. We believe that because of the already reduced physiological reserve, elderly patients with a severe injury are in a serious life-threatening situation, even if they do not suffer from any other chronic illness. This might be the reason why more elderly patients suffered sepsis, coagulation, cardiovascular and renal failure, finally leading to a higher incidence of MOF in the elderly.

Injury severity measured by NISS was a reliable predictor of survival in our research. Some other studies identified injury severity but not age as the variable that correlated most significantly with mortality [10]; however, the predictive value of injury severity was also not undisputed. In a multivariate analysis Bala et al. found that the ISS was not a predictor of in-hospital mortality [11]. We analyzed the elderly with injuries, which happened as a result of a simple fall. In

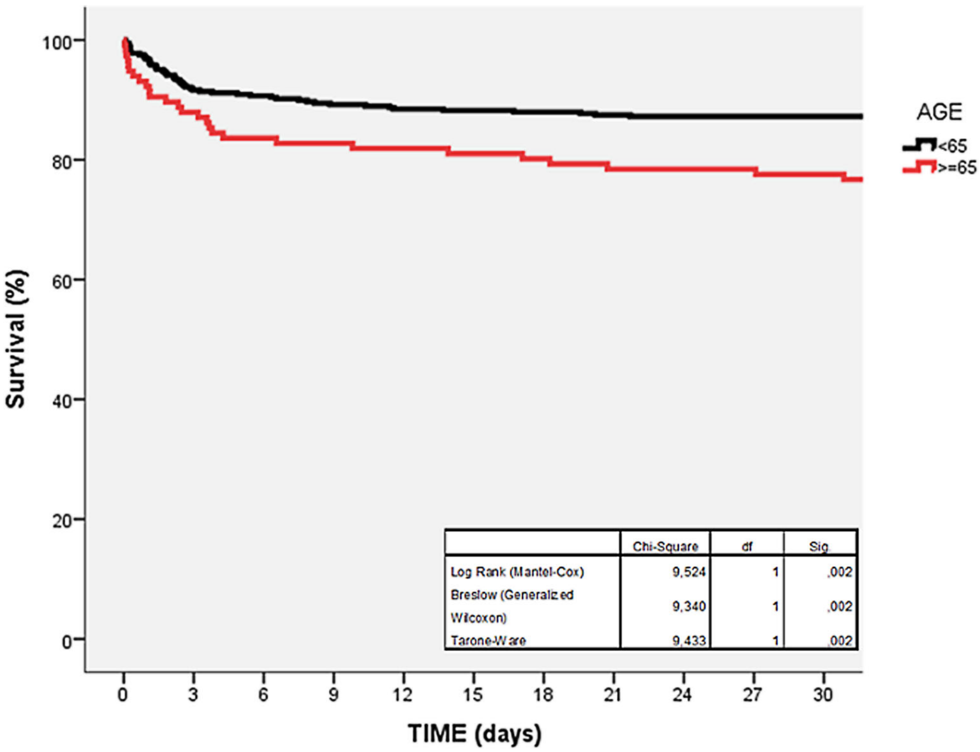

Fig. 3 Survival curve for the study population (Kaplan Meier)

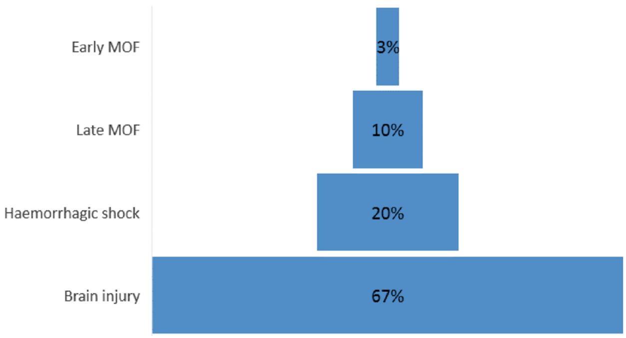

Fig. 4 Causes of death for the elderly group (*MOF* multiple organ failure)

elderly patients these falls happen due to vagaries of aging and illness. Although their injuries were less serious, 40% of elderly patients that subsequently died fell from a low height. Serious multiple injuries are in most cases the results of traffic accidents (where elderly suffer more from bicycle and pedestrian accidents) or falls from a height. In those patients NISS had good prognostic value.

Specific injuries have a significant impact on the mortality rate of elderly patients. In our study, traumatic brain injury was shown to be the most frequent cause of death in the geriatric trauma population. Like some other authors, we can conclude that patients older than 65 years with traumatic brain injury and a GCS lower than 8 were associated with a particularly adverse prognosis [12, 13]. Similar associations have been described for chest trauma, abdominal injuries and fractures but our study did not confirm these findings [14]. In our group chest injuries were the most frequent but the distribution between the groups of elderly that died and the group that survived was not significant; however, chest injuries co-relate with numerous complications during treatment. Broken ribs cause pain and hypoventilation, usually followed by atelectasis and pneumonia. Supplementary lung contusions and weakened respiratory muscles increase the possibility that an elderly patient might need early intubation and mechanical ventilation and the risk of gram-negative pneumonia becomes significant. Our results show a higher rate of pulmonary complications and sepsis related to chest injuries. Development of these complications significantly affects the ICU length of stay in the elderly survivors and non-survivors more than it does in younger patients. Unexpectedly, the survival rates were not affected in our study.

Apart from low GCS values, abnormal physiological values, such as blood pressure, coagulopathy and BE were not reliable predictors of survival in our group of patients. Many elderly patients have problems with response to stress due to endocrine system dysfunction. High blood pressure before the accident often leads to the systolic blood pressure, which is, despite major blood loss, often higher than 90 mmHg. Scalea et al. utilized early invasive monitoring in the management of the geriatric patients and found that when they were admitted to hospital, 8 out of 15 elderly patients who had normal vital signs had cardiac output less than 3.5 l/min. By providing better oxygen transport the survival rate was increased from 7% to 53%, and patients with less serious injuries benefited

Table 3 Variables of multivariate analysis

Variables in the equation		B	S.E.	Wald	df	Sig	Exp (B)
Step 1[a]	ST_NISS	–0.090	0.021	18.734	1	0.000	0.914
	Constant	4.471	0.848	27.803	1	0.000	87.439
Step 2[b]	ST_NISS	–0.083	0.021	15.330	1	0.000	0.920
	GCS_8(1)	1.816	0.533	11.603	1	0.001	6.150
	Constant	3.308	0.878	14.183	1	0.000	27.328
Step 3[c]	ST_NISS	–0.091	0.024	14.734	1	0.000	0.913
	GCS_8(1)	2.271	0.624	13.266	1	0.000	9.694
	Fall (1)	1.976	0.681	8.426	1	0.004	7.212
	Constant	1.978	0.988	4.009	1	0.045	7.230

[a]Variable(s) entered on step 1: ST_NISS
[b]Variable(s) entered on step 2: GCS_8
[c]Variable(s) entered on step 3: fall
ST_NISS New injury severity Score, *GCS* Glasgow coma scale, *B* Wald, *S.E.* standard error, *df* degrees of freedom, *Sig, Exp(B)*

most from this [15]. Patients suffering from hypertension and high BP values despite medication might be of particular concern. In these patients relative hypotension can have a detrimental effect on mortality and complications; therefore, it has been suggested that a borderline BP of 110 mmHg is set for elderly patients [16].

Altered or blunted physiological response may result in an underestimation of the injury severity and delay the response of the trauma team. In the relative absence of data to the contrary, our elderly patients should receive care at centers that have devoted specific resources to attaining excellence in the care of the injured [5].

The specific geriatric triage protocols might improve the identification of older patients who need immediate care. In our study prehospital time and time to definitive care was comparable in the group of elderly and younger patients. Subtle monitoring, adequate resuscitation and surgical management can improve outcomes and are adapted to the physiological reserves of the patient [10]. Our data shows that, despite improvements in trauma care and the introduction of new treatment and diagnostic tools, the mortality rate in different time periods did not change. We believe, therefore, that a better understanding of the pathophysiological mechanisms is needed to develop age-specific therapies in the future.

The shortcomings of our analysis are mainly related to the quality of data in the registry, which may not be comparable to a clinical trial, where data is collected specifically to address a given issue; however, all data entered in the TR-DGU and used for model building has been collected prospectively, and data input into the registry is routinely verified using several criteria of plausibility.

Conclusion

Despite advances in care, morbidity and mortality in elderly patients after major trauma remains considerably higher than in a younger population, with head injuries accounting for the majority of fatalities. Our elderly patient population mostly suffered from blunt mechanism of injury, with simple falls representing a high proportion of injury mechanisms. Generally, ISS in the elderly is not statistically higher than with the younger population. Likewise, the distribution of injuries according to body regions is also similar; however, the elderly are more prone to complications (i. e. sepsis and MOF), which is likely due to a lower physiological reserve.

Compliance with ethical guidelines

Conflict of interest S. Kocuvan, D. Brilej, D. Stropnik, R. Lefering and R. Komadina declare that they have no competing interests.

Ethical standards For this type of the study informed consent is not required. The study was reviewed by the appropriate ethics committee. Details that might disclose the identity of the patients included are omitted.

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