Type of underlying fracture after the surgical treatment of geriatric trauma patients has no effect on mortality during intensive care treatment

Tom Knauf,1 Kai Oliver Jensen,2 Juliana Hack,1 Juliane Barthel,1 Hannah Althaus,1 Benjamin Buecking,3 Rene Aigner,1 Matthias Knobe,4 Steffen Ruchholtz1 and Daphne Eschbach1

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1Center for Orthopedics and Trauma Surgery, University Hospital Giessen and Marburg, Marburg, Germany
2Center of Trauma Surgery, University Hospital Zuerich, Zürich, Switzerland
3Center for Orthopedics and Trauma Surgery, DRK-Kliniken Nordhessen, Kassel, Germany
4Department of Orthopedic Trauma, Cantonal Hospital Lucerne, Lucerne, Switzerland

Correspondence
Dr Tom Knauf MD, Center for Orthopaedics and Trauma Surgery, University Hospital Giessen and Marburg GmbH, Baldingerstrasse 1, 35043 Marburg, Germany.
Email: knauf@med.uni-marburg.de

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Introduction

As a result of demographic change, the treatment of geriatric patients is gaining more attention. In 2013, it was estimated that 3 million older adults presented in the USA to emergency departments for fall-related injuries, with approximately 800 000 hospitalizations.1 Hip fractures are often considered the typical fracture of geriatric patients, so this fracture entity is frequently the topic of current research. There have been numerous investigations regarding the short- and long-term mortality, and the functional outcome of patients after prolonged intensive care unit (ICU) treatment after hip fracture.2-4 These kind of fractures should not be underestimated, because they can cause a high burden for life and reduced functional outcome for each individual.5 Nevertheless, less is known about the whole cohort of geriatric trauma patients – apart from hip related trauma patients – in the ICU so far. Menaker and Scalea already stated in 2010 the need for understanding the changes in postoperative management due to age-related physiological changes. Those are associated with a decrease in the physiological reserves, and lead to increased rates of postoperative complications and death.6 Patients aged >80 years might even be the most rapidly expanding subgroup of all ICU patients.7 Nevertheless, until now, this has been no standardized treatment consensus, especially regarding the needs of geriatric trauma patients. Only single aspects, such as ethics in decision-making and surgical treatment, and special needs of geriatric poly-trauma, have been available in the literature over the past few years.8-10 In fact, until now, we do not even have data about the fracture patterns distribution in the ICU cohort. In particular, data on the distribution of the various fractures and the possible influence of the fracture distribution on mortality or the length of stay...
in the ICU are missing. However, there are some studies that deal with mortality in the ICU. De Rooij et al. analyzed the short- and long-term mortality in the ICU. They reported a higher mortality in the ICU for unplanned surgical patients (34.0%) and medical patients (37.6%) compared with planned surgery patients (10.6%). Factors associated with ICU mortality were related to the patients’ severity of illness at admission.14 In a transnational prospective cohort study, Flaatten et al. analyzed the impact of frailty on ICU and 30-day mortality in patients aged ≥80 years. They stated an overall ICU mortality of 22.1%.15 All of these studies focused on the whole cohort of geriatric patients, and not on the group of patients with geriatric trauma. Thus, one aim of the present study was to characterize the cohort of geriatric trauma patients who were treated in a surgical ICU.

A further goal was to estimate whether the traumatic injury was the most important factor or whether the clinical course of the patients was determined by their general condition, in particular represented by their previous illnesses. For this, we subsequently focused on the mortality and length of stay, and their predicting factors.

Methods

We carried out a retrospectively analysis of patients attending surgical ICU at University Hospital Giessen and Marburg, Marburg, Germany, from 2013 until 2017. The inclusion criteria were all patients aged ≥65 years suffering from fractures and having the need for ICU treatment. Patients attending the ICU after elective surgeries, with pathological fractures or without having a fracture were excluded in this analysis. Ethical approval was obtained from local authorities. The patients were identified on the basis of the ward books and checked in detail on the basis of our hospital information system. The data on the course of the disease were taken from the digital file and the intensive care documentation. The need for ICU treatment was determined by consensus of treating physicians and surgeons.

Baseline data and influencing factors

The following data were collected retrospectively: age, sex, Charlson Comorbidity Index (CCI), mortality, length of stay in ICU and type of fracture. Additionally, the time point of death was assessed during the observation period (Fig. 1).

We also subdivided the various types of injury into individual fracture regions and distinguished between the presence of multiple fracture types, as shown in Tables 1 and 2. We investigated the influence of age, sex, different types of injuries and CCI on mortality and length of stay in the ICU. Length of stay was divided into subgroups to improve clarity, as listed hereinafter: 1–2 days, 3–7 days and >7 days. To detect differences between the best aged, old and very old population, age groups were divided in 65–74 years, 75–84 years and >84 years.

Statistical analysis

Data were collected in Microsoft Excel version 16.28 (Redmond, WA, USA). For statistical analysis IBM SPSS statistics 24 (Statistical Package for the Social Science; IBM Corporation, Armonk, NY, USA) was used. Data are presented as the mean, 95% confidence

Figure 1 The mortality rate in the intensive care unit.

Table 1 Single fractures

| Type of fracture                      | Number of patients n (%) | Age (years) Mean (95% KI) | Sex (women) n (%) | CCI Mean (95% KI) | Length of stay at intensive care unit – days (95%KI) |
|--------------------------------------|--------------------------|---------------------------|------------------|-------------------|---------------------------------------------------|
| Total                                | 823                      | 82 (81.9-82.9)            | 533 (64.8%)      | 5.8 (5.7-6.0)     | 3.9 (3.4-4.3)                                     |
| Skull                               | 9 (1.1%)                 | 81 (76-86)                | 3 (33.3%)        | 5.9 (4.6-7.7)     | 6.1 (2.0-14.0)                                   |
| Spine                               | 61 (7.6%)                | 83 (82-85)                | 33 (54.1%)       | 5.7 (5.2-6.1)     | 4.2 (2.8-6.2)                                    |
| Humerus                             | 71 (8.8%)                | 81.1 (79-83)              | 51 (71.8%)       | 5.4 (5.1-5.6)     | 4.2 (2.6-4.3)                                    |
| Proximal femur (pertrochanteric)     | 159 (19.8%)              | 84 (83-85)                | 108 (67.9%)      | 6.1 (5.8-6.4)     | 3.0 (2.6-3.4)                                    |
| Proximal femur (subtrochanteric)     | 47 (5.8%)                | 84 (83-87)                | 33 (70.2%)       | 6.5 (5.6-7.0)     | 4.1 (2.9-5.7)                                    |
| Femoral neck                        | 177 (22.0%)              | 83 (82-84)                | 112 (63.3%)      | 5.9 (5.6-6.2)     | 3.5 (2.8-4.3)                                    |
| Femoral shaft                       | 97 (1.1%)                | 81 (76-86)                | 7 (77.8%)        | 5.1 (4.0-6.2)     | 3.0 (2.0-4.7)                                    |
| Distal Femur                        | 9 (1.1%)                 | 81 (76-86)                | 8 (88.9%)        | 5.7 (4.7-6.5)     | 3.4 (2.0-7.5)                                    |
| Ribs/Clavicle                       | 17 (2.1%)                | 79 (76-81)                | 6 (35.5%)        | 5.0 (4.3-5.8)     | 5.4 (2.8-9.2)                                    |
| Pelvis                              | 38 (4.7%)                | 81 (79-84)                | 22 (57.9%)       | 5.7 (5.0-6.5)     | 3.8 (2.5-5.3)                                    |
| periprosthetic humeral fracture     | 8 (1.0%)                 | 79 (73-84)                | 5 (62.5%)        | 6.1 (4.0-8.0)     | 4.1 (1.8-7.0)                                    |
| periprosthetic femoral fracture     | 49 (6.1%)                | 82 (80-84)                | 31 (63.3%)       | 5.5 (4.9-6.0)     | 3.1 (2.4-4.0)                                    |
| Forearm                             | 10 (1.2%)                | 84 (79-88)                | 7 (70%)          | 5.2 (4.4-6.3)     | 4.4 (1.9-8.0)                                    |
| Foot                                | 1 (0.1%)                 | 73 (73-73)                | 1 (100%)         | 5.0 (3.0-3.0)     | 3 (3.0-3.0)                                      |
| Lower leg                           | 18 (2.2%)                | 81 (78-83)                | 13 (72.2%)       | 6.2 (5.2-7.3)     | 7.2 (4.3-10.3)                                   |
| Others                              | 10 (1.2%)                | 82 (78-88)                | 8 (80%)          | 5.2 (4.1-6.6)     | 3.2 (2.3-4.3)                                    |

The baseline characteristics and outcome parameter divided into the different fractures. CCI = Charlson Comorbidity Index.
interval and frequency. Bivariate analysis was carried out to identify connections between mortality, length of stays and their predicting factors. The normal distribution test was carried out using the Shapiro–Wilk test. If no normal distribution was detected, either the Mann–Whitney U-test or the Kruskal–Wallis test were carried out. Nominal scaled variables were analyzed using Pearson’s χ²-test.

A multiple regression analysis was carried out with all variables that were able to predict the mortality and length of stay. Inclusion criterion to enter was \( P < 0.1 \), and \( P > 0.05 \) to exit.

### Results

#### Baseline characteristics

During the observation period, 1331 patients attended our ICU. A total of 993 (75%) patients were geriatric patients, and 805 (60.5%) of these patients met the inclusion criteria. This patient cohort was subjected to a retrospective evaluation. The data evaluation covered a period of 5 years from 2013 to 2017. In
each year, between 141 and 184 geriatric patients meeting the inclusion criteria were treated in our ICU. The mean age was 82.5 years (95% confidence interval [CI] 82.0–83.0). A total of 65.3% of the patients were women. The mean CCI was 5.8 points (95% CI 5.6–6.9). Patients stayed on average 3.9 days (95% CI 3.6–4.3) in the ICU. Further information regarding injury patterns is listed in Tables 1 and 2. Patients suffering from hip fractures (femoral neck, pertrochanteric and subtrochanteric fractures) were the most common types of injuries treated in our ICU (47.6%). They were followed by patients suffering from fractures of the humerus (8.8%) and spinal injuries (7.6%), and other various injuries listed in Tables 1 and 2, as aforementioned.

Mortality

During the observation period, a total of 59 patients (7.3%) died in the ICU. The annual mortality varied between 7.3% (2013), 8.2% (2014), 4.8% (2015), 10.5% (2016) and 5.7% (2017).

Predictive factors of mortality

CCI ($P < 0.001$) had a significant influence on mortality in the ICU. The survivors had a CCI of 5.6 (95% CI 5.4–5.7). The deceased patients showed a CCI of 8.0 (95% CI 7.4–8.7). Patients who died in the ICU had a significantly longer stay there compared with the survivors (6.0 days, 95% CI 4.4–7.6 vs 3.8 days, 95% CI 3.4–4.1). A longer stay in the ICU is associated with increased mortality ($P < 0.001$). Patients leaving the ICU on day 1–2 had a mortality of 2.6%. Patients dismissed from ICU between day 3–7 showed a mortality of 8.9% and patients with a stay of ≥7 days in ICU had a mortality of 15.7% (Fig. 1). Age ($P = 0.753$), sex ($P = 0.322$) and the type of fracture ($P = 0.862$) had no significant influence on mortality in the ICU. (Table 3).

Predictive factors of length of stay in the ICU

Significant differences in length of stay between different fracture entities were observed ($P = 0.002$). Patients categorized in group “D” – more than two fractures of larger bones and/or spine + polytrauma – were the patients that spent the most days in the ICU (8.2 days, 95% CI 5.6–11.1). These were followed by fractures of the lower leg (7.2 days, 95% CI 4.3–10.3) and fractures of the scull (6.1 days, 95% CI 2.0–14.0). The length of stay for each fracture is listed in Table 1. Age ($P = 0.136$), sex (0.155) and CCI (0.258) showed no significant influence on the length of stay (Table 4).
Multivariate analysis

The multivariate analysis showed that CCI (P < 0.001; B -0.434; OR 0.648, 95% CI 0.578–0.727) was a significant predictor of mortality. Length of stay is also associated with higher mortality (P < 0.001; B -0.733; OR 0.481, 95% CI 0.335–0.689). According to the multivariate analysis, the type of fracture (P < 0.001; B 0.110; OR 0.147, 95% CI 0.059–0.162) and sex (P < 0.007; B 1.043; OR 0.097, 95% CI 0.291–1.796) were significant predictors for lengths of stay.

Discussion

The “very old intensive care patients” are a noticeably growing subgroup of intensive care patients who will continue to gain importance in the future. Patients aged ≥80 years might even be the fastest expanding subgroup of all ICU patients.10

There are not many large epidemiological studies on this topic. Many of them show an increasing proportion of older patients in the intensive care population.10 Most of these studies deal with patients from non-surgical specialties.16,17 The aim of the present study was to characterize the cohort of geriatric trauma patients who were treated in a surgical ICU.

A further goal was to estimate whether traumatic injury was the most important factor influencing the outcome or whether the clinical course of the patients was determined by other factors of influence, such as their general condition, in particular represented by their previous illnesses. For this, we subsequently focused on the mortality and length of stay, and their predictive factors.

Until now, there is no literature showing the distribution of fractures of geriatric trauma patients in ICU. In the present study, the most common fractures were hip fractures (46.5%). This is consistent with the data of the Federal Statistical Office, “Statistisches Bundesamt”, of Germany analyzing the frequencies of fractures. Femoral fractures are the most common fractures in the German population. Taking a close look at the observation period of the present study, the national database reported n = 119 767 patients (aged 65–90 years) suffering from femoral fractures in 2013, rising each year until n = 129 381 in 2017.18 It must be noted that there is no differentiation between proximal fractures, distal fractures and fractures of the femoral shaft. According to the Federal Statistical Office, the second and third most frequent fractures at that age are fractures of the spine and pelvis, followed by fractures of the humerus. Although we only focused on patients treated in the ICU, this is consistent with the present data. A total of 12.0% of the present patients suffered a spine or pelvic fracture, and 8.6% had a fracture of the humerus. The similarity of these distributions seems to indicate that on one hand, the data of our cohort had a certain representativeness in relation to the general population, but on the other hand, that the fracture itself does not necessarily serve as an indicator for treatment in an ICU.

We observed an annual mortality between 4.8% and 10.5%, with an overall mortality of 7.3%. Unfortunately, it was not possible for us to identify factors that were responsible for the much lower mortality in 2015 and 2017 compared with the other years.

Flaatten et al. stated a mortality rate in ICU among patients aged ≥80 years of 22.1%. In the present study group, the mortality rate was 9.9% in the group aged 75–84 years, and 6.6% in the group aged ≥85 years.15 However, they focused on geriatric patients in general and not exclusively geriatric trauma patients. The study cohorts are different and therefore not comparable. De Rooij et al. differentiated between unplanned surgical, medical and planned surgical patients. They were able to show a mortality in ICU of 34.0% for unplanned surgical patients aged ≥80 years.14 However, it must be noted that those patients described were not only trauma patients, but also patients with surgeries other than fractures; nevertheless, the overall mortality seems to be quite low in the present study cohort. On the one hand, this might be due to different indications for ICU treatment. On the other hand, this might also be an expression of the fact that most trauma patients are not treated in the ICU due to the worsening of a chronic disease, but that the initial intensive care event is a trauma and thus a reversible cause.

The type of fracture suffered before the ICU stay had no significant influence on mortality in the ICU (P = 0.862). In contrast to this, a higher CCI (P < 0.001) led to a higher mortality.

This indicates that the patient’s characteristics as comorbidities predict mortality in the ICU. So far, no author has focused on the different types of fractures, but nevertheless, there are some studies dealing with mortality of older patients in the ICU. There are studies showing sex,19 age,20,21 lower Glasgow Coma Scale score,14 frailty,19,22 cardiac arrest before admission,19 a high Simplified Acute Physiology Score,14,19 and brain injury before admission19 as predictors for mortality in the ICU. Because of the inhomogeneous study cohorts, only limited comparability is provided between the different studies cited. With regard to age as a predictor of mortality, different results can be seen in the literature. Oshima et al. analyzed trauma patients admitted to the ICU through the emergency room and divided them into two age-related groups (≥80 years and >80 years). As expected, patients aged ≥80 years stayed significantly longer in the ICU (10 days vs 4 days; P = 0.001), but the hospital mortality was not significantly higher in the elderly group (11.5% vs 6.2%; P = 0.179).23 These data support the finding that age alone is not a good predictor of mortality.

Length of stay was also associated with increased mortality. Similar results have already been shown by Eschbach et al., analyzing the mortality of hip fracture patients after prolonged ICU treatment.4 Taking a closer look at the present data regarding the development of mortality according to the length of stay, we could show that the longer the patients remain in the ICU, the greater the probability of death. This fact alone does not really seem unusual. On the one hand, the length of the ICU stay is determined by the severity of the illness, and accordingly, the patients are all the more ill the longer they stay. On the other hand, due to an often reduced general health condition, most geriatric patients die relatively quickly when complications occur, and as a result, the cohort that survives several days of intensive care treatment also represents a healthier cohort among critically ill geriatric patients. Therefore, surprisingly, many of these geriatric trauma patients manage to survive even longer intensive care stays, so the difference in daily mortality was not shown to be to be significant in the present study.

Furthermore, we found out that patients’ CCI is more likely to predict ICU mortality than the fracture pattern itself. Frequency distribution of fractures in the age-related group in the national demographic register is equal to the frequency of fracture distribution of fractures in the ICU. Therefore, patients do not require intensive care treatment because of the type of fracture they suffer, but because of their comorbidities and estimated frailty.

Polytraumatized patients, as well as patients suffering from more than two fractures of larger bones and/or the spine, spent the most days in our ICU. These patients were followed by patients suffering from fractures of the lower leg and skull fractures. As already mentioned, to our knowledge, until now there was no study showing and analyzing the distribution of the different types of fractures in our study cohort. Toptas et al. showed that length of stay of in the ICU is significantly longer for non-
surgical patients than for surgical patients ($P < 0.01$). Therefore, it is difficult to compare the length of stay of the present study cohort with other studies dealing with geriatric ICU patients. Most of them include predominantly medical patients, mainly without restrictions regarding the reason for admission. Nevertheless, in a systematic review and meta-analyses, Muscedere et al. showed no significant influence of frailty on ICU length of stay. However, we were able to prove that the injury of several long bones and/or the suffering of a polytrauma were injury patterns that did not directly influence mortality, but nevertheless, significantly prolonged the inpatient stay in the ICU. An explanation of why these injury patterns significantly prolong the stay, which in turn is a significant influencing factor for mortality, but at the same time mortality is not influenced by the injury pattern, could be the following.

To comply with the “damage control” principle and to minimize secondary losses, polytraumatized geriatric patients were first stabilized on the admission day, and were treated some days afterwards. This means that some operations are carried out in the course of time. In the meantime, the patients usually stay in the ICU. In contrast to mortality, the length of stay seems to depend more on the fracture itself.

In addition to the type of fracture, the multivariate analysis showed that men had a significantly longer length of stay in the ICU than women. This cannot be explained by the differences in gender comorbidities, as CCS differs only slightly.

A limitation of the present study was the retrospective design. Nevertheless, the strengths of the study were the large number of patients and its focus on the patient cohort of geriatric trauma patients in the ICU, which has not been evaluated so far.

It has to be mentioned that during the period of analysis, there were no consistent criteria for ICU admission. The need for ICU treatment was determined by the consent of treating physicians and surgeons. There might therefore have been some over-triage in favor of an intensive care stay treatment.

Patients with proximal femoral fractures account for approximately half of geriatric trauma patients in the ICU. If geriatric trauma patients need to be monitored in the ICU postoperatively, patients suffering from apparently simple fractures face the same risk as patients suffering from hip fractures. There is no significant correlation between the type of fracture and mortality. The prognosis is essentially influenced by the patient’s comorbidities. Regardless, almost two-thirds of patients in intensive care in a maximum care hospital are nowadays geriatric patients. Thus, the focus of further studies shifts comprehensively from trauma care, in line with demographic change, to the therapy of concomitant diseases. Nevertheless, this cohort, adequately treated, shows a comparatively low mortality rate.

Disclosure statement

The authors declare no conflict of interest.

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