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RESEARCH

A RETROSPECTIVE ANALYSIS OF HEALTHCARE COSTS FOR GERIATRIC PATIENTS IN INTENSIVE CARE UNIT FOLLOWING HIP FRACTURE SURGERY

Abstract

Introduction: The goal of this study was to identify potential predictors of intensive care unit (ICU) expenses in geriatric patients after hip fracture surgery. The research focused to investigate patient-related characteristics and fracture status markers that contribute to increased ICU and overall costs in geriatric hip fracture surgical patients.

Materials and Method: A retrospective review of patients who had hip fracture surgery and required intensive care was performed between January 1, 2020 and December 31, 2021. Patient variables were collected via hospital information management system including demographics, co-morbidities, length of stay in ICU and hospital, AO/OTA fracture classification and APACHE score. Hospital Invoice Service provided total and daily intensive care treatment charges and costs. The Spearman correlation coefficient was used to show the relationship between some variables and multiple linear regression analysis was used to evaluate the variables that impact the cost.

Results: Intensive care unit expenses constituted 18.92% of the entire cost (1252.46±282.838 TL). APACHE score, Age-adjusted Charlson Comorbidity Index (ACCI), ICU length of stay and hospital length of stay was found statistically significant correlation with ICU expenses ($p<0.05$). Regression analysis revealed statistically significance with length of hospital stay, fracture score, ASA, APACHE and ACCI ($p=0.000$) ($r^2=0.236$). When evaluated in a linear regression model, APACHE score ($p=0.000$), ACCI ($p=0.027$), and hospital length of stay ($p=0.001$) were the only statistically significant predictors.

Conclusion: The present study found out that length of hospital stay, APACHE and ACCI can be used as cost drivers that help to predict cost of intensive care for geriatric hip fractures.

Keywords: Hip Fractures; Geriatrics; Intensive Care Units; Health Care Costs.

INTRODUCTION

Hip fractures are a significant and costly public health problem; they are the most prevalent reason for emergency orthopedic surgeries in the geriatric population (1-4). Hip fractures are becoming more common as the population ages, and so are related healthcare expenses (5). Cost estimates based on data gathered prospectively from patients with hip fracture and age-matched controls revealed that it costs nearly three times more to treat the former group (3). Hip fractures account for only 14 percent of all fractures in the United States, yet they account for 72 percent of the costs associated with musculoskeletal fracture care (4). The average cost of treating hip fractures is estimated to be between $10 billion and $15 billion annually, and the cost is expected to rise to 240 billion by 2040 (6). Hence, thorough cost-benefit analyses of expenses and health implications are required.

Hip fractures are frequently associated with the presence of several comorbidities in the elderly (7). Elderly patients with hip fracture may have a worse prognosis because of these comorbidities and poor physiological reserves, and most may need to be treated in the intensive care unit (ICU). Because of the limited number of available ICUs, it is even more critical to make optimal and cost-effective use of them.

Previous research has examined variables that impact the cost of care following a hip fracture (8). Further, several studies have investigated the impact of comorbidities and fracture status on the cost of care among patients with hip fracture to develop critical strategies to lower the expenses (7-10). However, to the best of our knowledge, no studies on the cost associated with ICU admission following hip fracture surgery in the elderly have been published.

Bundled payment models for surgeries have been proposed as a way to enhance the quality of care while lowering costs (6, 11, 12). Patients in particular diagnosis-related groups are included in these payment models, which establish a target reimbursement based on past cost data for such a course of treatment. Reimbursement for this bundle models usually includes all costs associated with preoperative tests, procedures, and postacute care. Previous research has indicated that different patient demographics, comorbidities, and surgical methods result in a variety of femur fracture treatment costs (10, 13, 14). Studies have shown that bundled payments for hip fractures should be risk adjusted (6, 13, 14). This study aimed to evaluate the variables that can be used for risk assessment of bundled payment programs in the ICU. We hypothesized that if these variables are used, the treatment of elderly patients in the ICU following hip fracture surgery will be cost effective. As a result, we examined the factors and measurable variables that could be linked to an increase in ICU costs, particularly in patients who underwent hip fracture surgery and required intensive care.

MATERIALS AND METHOD

Ethics

The current observational, retrospective investigation was conducted in compliance with the Declaration of Helsinki. The study was approved by the institutional ethics committee (Diskapi Yildirim Beyazit Training and Research Hospital), which also gave consent for the use of electronic data (decision date: 13.12.2021, number: 126/25). Throughout the study, the authors followed good clinical practice guidelines.

Data Collection

The records of patients, who had a hip fracture and were followed up in the ICU between January 1, 2020 and December 31, 2021, were evaluated retrospectively in this study. The Origo Hospital Information Management System of Diskapi Yildirim Beyazit Training and Research Hospital, the Statistics Unit's records, and the invoice data from the Invoice Service records were used to collect information about the patients. Patients above 65 years who had hip fracture code 611000, 611132, or 612320 in their records were screened. AO/OTA 31-A1, 31-A2, and 31-A3 and AO/OTA 31-B1, 31-B2, and 31-B3 fracture degrees were assigned.

Age, gender, American Society of Anesthesiology (ASA) physical status, age-adjusted Charlson comorbidity index (ACCI), comorbid diseases, fracture type, fracture score, anesthesia method (general/regional), reason for ICU admission, hemoglobin value at the time of ICU admission, Acute Physiology and Chronic Health Evaluation (APACHE) score, and time spent in the ICU and hospital were all obtained from the hospital records. The Hospital Invoice Service provided the total and daily intensive care treatment charges for the patients.

Inclusion Criteria

Patients above 65 years who were admitted to the ICU following hip fracture surgery were included in this study.

Exclusion Criteria

Patients below 65 years, patients who did not require ICU follow-up, and patients with missing data were excluded from this study.

Statistical Analyses

Statistical analyses were carried out using IBM SPSS for Windows (version 23.0). The mean, standard deviation, and median (25th–75th percentile) values were used to summarize numerical variables, while categorical variables were presented as numbers and percentages. Before the groups were compared in terms of numerical variables, parametric test assumptions (normality and homogeneity of variances) were tested. The Kolmogorov-Smirnov test was used to determine whether the numerical variables had a normal distribution, and the Levene test was used to determine whether the variances were homogeneous. The Mann-Whitney U test and the Kruskal-Wallis test were used to examine differences in the numerical variables between two independent groups. The Spearman correlation coefficient was used to show the relationship between the numerical variables.

Multiple linear regression analysis was used to determine the variables that impact the cost of intensive care. A p-value less than 0.05 was considered statistically significance.

RESULTS

A total of 435 patients were identified and reviewed in this study. Following review, 173 patients were excluded because they did not require ICU follow-up. Two hundred and thirty geriatric intertrochanteric hip fractures were identified for analysis (Figure 1). The overall mean age was 81.25 ± 7.801 years, and 71.7% were females. The median APACHE score was 12.0 (minimum 7.0, maximum 34.0). The majority of the patients were ASA III–IV (n = 161, 70%). The patients' study population characteristics and demographic data are summarized in Table 1.

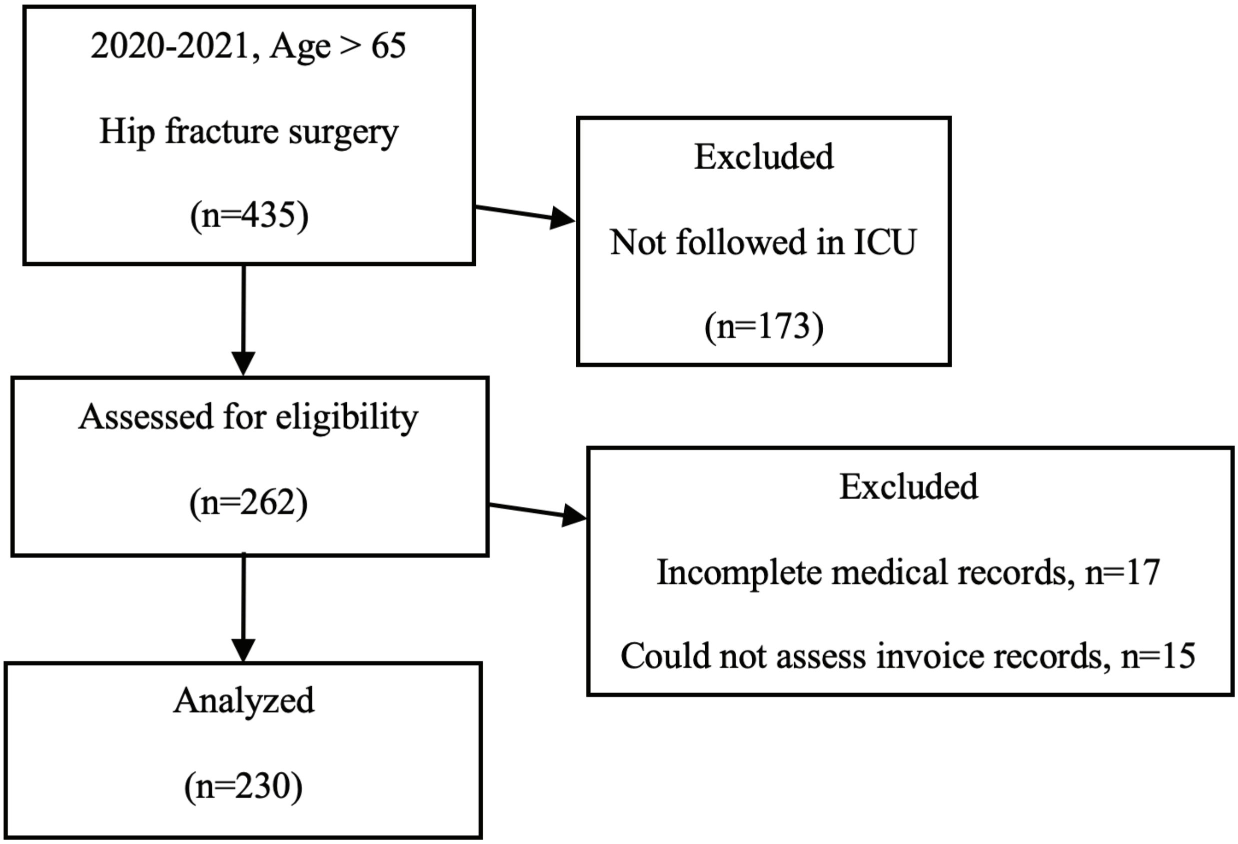
The most common fracture pattern was 31-A2 (26.1%), followed by 31-A1 (24.8%), 31-B1 (22.2%), and 31-B2 (20%), whereas the least common patterns were 31-B3 (4.3%) and 31-A3 (2.6%). The median ACCI score for the present research was 5 (minimum 2, maximum 11), while the median fracture score was 2 (minimum 1, maximum 6).

The top three comorbidities were myocardial infarction (47.9%), diabetes mellitus (32.3%), and heart failure (27.2%). The most common reasons for admission to the ICU were myocardial infarction (63.4%), chronic obstructive pulmonary disease (18.8%), and heart failure (9.4%). Length of stay in the ICU was 1–13 days (median 1) (Table 1).

The mean total cost of the entire cohort of patients was 6,973.27 ± 2,531.938 Turkish Lira (TL), ranging from 3,800 TL to 31,099 TL. The average ICU expenses, which was an 18.92% component of the entire cost, was 1,252.46 ± 282.838 TL (Table 2).

Multiple linear regression analysis revealed that the association between the cost of treatment of

Figure 1. Strobe flow-diagram of the study patient population



patients with hip fracture admitted to the ICU and the length of hospital stay, fracture score, ASA, APACHE, and ACCI was statistically significant ($p = 0.000$). The R square of the ratio of these five variables that impact the cost of treatment of patients with hip fracture admitted to the ICU was calculated as 0.236. When evaluated in a linear regression model, APACHE score ($p = 0.000$), ACCI ($p = 0.027$), and hospital length of stay ($p = 0.001$) were the only statistically significant parameters (Table 3). No other parameter was included in the regression. As shown in Table 4, some variables (APACHE, ACCI, ICU length of stay, and hospital length of stay) have a statistically significant correlation with ICU expenses. The length of stay in the ICU was found to be related to the length of stay in the hospital, however the distribution of the ICU length of stay was not regular. The association between the cost and the length of stay in the hospital was evaluated since the length of stay in the hospital had a regular distribution (Table 1).

DISCUSSION

The goal of this study was to identify potential predictors of ICU expenses in geriatric patients following hip fracture surgery. We suspected that some patients and fracture state measures would be related to the cost of treatment for geriatric patients with hip fracture who were admitted to the ICU fol-

Table 1. Study population characteristics

Age (years)	
mean ± SD (min-max)	81.25 ± 7.801 (65-102)
Gender	
Female, n (%)	165 (71.7)
Male, n (%)	65 (28.3)
APACHE	
mean ± SD (min-max)	12.79 ± 4.147 (7-34)
median (25th-75th percentile)	12.00 (11.00-13.00)
ASA	
I, n (%)	2 (0.9)
II, n (%)	67 (29.1)
III, n (%)	159 (69.1)
IV, n (%)	2 (0.9)
Comorbid diseases, n (%)	
Myocardial infarction	104 (47.9)
Heart failure	59 (27.2)
Peripheral vascular disease	24 (11.1)
Cerebrovascular disease, TIA	29 (13.4)
Dementia	40 (18.4)
COPD	52 (24.0)
Peptic ulcer	1 (0.5)
Liver disease	3 (1.4)
Diabetes Mellitus	70 (32.3)
Renal failure	20 (9.2)
Solid tumor	13 (6.0)
Leukemia	0 (0.0)
Lymphoma	0 (0.0)
AIDS	1 (0.5)
Connective tissue disease	8 (3.7)
Surgery	
Elective, n (%)	88 (38.3)
Emergent, n (%)	142 (61.7)
Anesthesia method	
General, n (%)	65 (28.1)
Regional, n (%)	164 (71.3)
Pre-operative Hb	
mean ± SD (min-max)	11.797 ± 2.018 (5.9-17.3)
The reason for admission to the ICU, n (%)	
Myocardial infarction	135 (63.4)
Heart failure	20 (9.4)
Peripheral vascular disease	7 (3.3)
Cerebrovascular disease, TIA	17 (8)
Dementia	8 (3.8)
COPD	40 (18.8)
Peptic ulcer	0 (0.0)
Liver disease	1 (0.5)
Diabetes Mellitus	5 (2.3)
Renal failure	1 (0.5)

AO/OTA Fracture Classification, n (%)	
31-A1	57 (24.8)
31-A2	60 (26.1)
31-A3	6 (2.6)
31-B1	51 (22.2)
31-B2	46 (20)
31-B3	10 (4.3)
Fracture score	
mean ± SD (min-max)	3.0 ± 1.636 (1.0-6.0)
median (25^{th}-75^{th} percentile)	2.0 (1.75-4.0)
ACCI	
mean ± SD (min-max)	5.21 ± 1.336 (2-11)
median (25^{th}-75^{th} percentile)	5.0 (4.0-6.0)
ICU length of stay (days)	
median (25^{th}-75^{th} percentile)	1 (1-13)
Hospital length of stay (days)	
median (25^{th}-75^{th} percentile)	5 (2-44)

APACHE: Acute Physiology and Chronic Health Evaluation
ASA: American Society of Anesthesiology physical status
TIA: Transient ischemic attack
ICU: Intensive care unit
COPD: Chronic obstructive pulmonary disease
AO/OTA: AO Foundation/Orthopaedic Trauma Association

ACCI: Age-adjusted Charlson Comorbidity Index

Table 2. Cost data

Total cost (TL)	
mean ± SD (min-max)	6973.27 ± 2531.938 (3800-31099)
median (25^{th}-75^{th} percentile)	6358.50 (5766.50- 7371.50)
ICU cost (TL)	
mean ± SD (min-max)	1252.46 ± 282.838 (974-4018)
median (25^{th}-75^{th} percentile)	1179.00 (1122.00-1278.50)
Ratio of ICU cost to total cost (%)	
mean ± SD (min-max)	18.9191 ± 4.82350 (5.93-54.88)
median (25^{th}-75^{th} percentile)	18.4332 (16.5799-21.3008)

Table 3. Multiple linear regression analysis for length of hospital stay, fracture score, ASA, APACHE and Age-adjusted Charlson Comorbidity Index (ACCI)

Variables	95% Confidence Interval	p
ASA	-144.298 – 11.554	0.095
APACHE	14.214 – 31.035	0.000
Fracture score	-25.599 – 14.488	0.585
ACCI	3.547 – 59.349	0.027

ASA: American Society of Anesthesiology physical status
APACHE: Acute Physiology and Chronic Health Evaluation
ACCI: Age-adjusted Charlson Comorbidity Index

Table 4. The Spearman correlation coefficient between APACHE, Age-adjusted Charlson Comorbidity Index (ACCI), intensive care unit (ICU) length of stay, hospital length of stay and ICU costs

Variable	Correlation Coefficient	p
APACHE	0.190**	0.004
ACCI	0.281**	0.000
ICU length of stay	0.484**	0.000
Hospital length of stay	0.267**	0.000

**. Correlation is significant at the 0.01 level (2-tailed)
APACHE: Acute Physiology and Chronic Health Evaluation
ACCI: Age-adjusted Charlson Comorbidity Index
ICU: Intensive care unit

lowing surgery. Thus, we reviewed surgical cases of geriatric hip fractures from 2020 to 2021. The present study found a correlation between cost of treatment and APACHE score, ACCI, and length of stay in the ICU and hospital. However, this study could not demonstrate a correlation between ASA or fracture classification and the overall cost of intensive care.

Wise et al. (4) investigated overall inpatient expenses by breaking them down into component costs to identify where the cost burden was highest in patients with hip fracture and found that critical care expenses accounted for the majority of (16.9%) the cost. Intensive care costs accounted for 20% of total costs in our analysis, which is similar to Wise's conclusion.

Bundled payment models have been introduced in some areas of medicine, most notably for surgical patients, and they offer significant cost savings (15, 16). In other fields of orthopedics, such as joint replacement, bundled payment methods have been developed and have shown promising cost-reduction outcomes (15, 17). However, some bundled payment schemes cannot differentiate patients undergoing elective arthroplasty from those undergoing arthroplasty for hip fractures, as both cases share the same diagnostic codes. Because of the disparity in these populations, there are concerns about using the same bundled payment approach for both elective arthroplasty and fracture care. The lack of risk stratification for these nonelective patients with multiple medical comorbidities is a major cause of concern (10, 13, 14). To decrease the costs and manage the risks associated with these payment schemes, determining the bundling inclusion and risk stratification of patients with hip fracture is essential (16). Different patient comorbidities have resulted in a wide range of femur fracture treatment costs (13). According to Cairns et al. (14), payments vary significantly based on age, comorbidities, demographic features, geographic factors, and surgical technique. Bundled payments for hip fractures, according to these experts, should be risk adjusted (13, 14).

Hospitalization expenses have been reported to be higher for patients with hip fracture and comorbidities (9). Comorbidities have been shown to have a significant impact on the length of stay in the hospital and hospitalization costs following hip fracture surgery in older patients compared to younger patients (7, 9). In line with these findings, we assumed that ACCI, which is routinely used to measure patient health status, would predict the cost of treatment of geriatric hip fractures. The present study found a correlation between ACCI, length of stay in the ICU and hospital, and cost of treatment. Similarly, Johnson et al. (10) observed a correlation between both the CCI and length of stay and the overall cost of treatment in patients with hip fracture. Generally, length of stay is a significant risk factor for high expenses. However, it is difficult to predict how long a patient would stay in the ICU or hospital before hospitalization. Therefore, it is not a useful prediction variable for risk adjustment of the overall cost.

Charlson comorbidity index and ACCI scores have been found to be associated with higher length of stay and hospital costs after hip fracture treatment (9, 10). The ACCI score could be a valuable instrument for risk assessment in bundled payment arrangements (10). On the contrary, Wise et al. (4) found no correlation between ACCI or ASA and the overall cost of care and indicated that only length of stay correlated with the overall cost of care.

The ASA score is another metric used to assess a patient's health status, and it has been shown in prior research to predict inpatient cost of care. For patients receiving surgery for hip fractures, the ASA classification has proved effective in estimating the length of stay and cost of care. In a study by Kay et al. (18), the ASA score was found to be the best predictor of postoperative length of stay and a significant predictor of inpatient expenses for orthopedic surgeries. Garcia et al. (8) also demonstrated the utility of ASA classification in estimating the cost of care of an elderly patient prior to surgery, as well as the potential benefit of adding patient characteristics into the development of risk stratified reimbursement models. This strategy, the utility of the ASA score as a variable, can be used practically by any hospital because the ASA categorization and cost of care are generally recorded. However, we could not demonstrate a correlation between ASA classification and the overall cost of intensive care. Instead, there was a significant correlation between APACHE score and ICU expenses. Previous research focused more on the surgical process, but the ASA score is the most significant variable. It is considered reasonable that the APACHE score was one of the most prominent variables in our analysis, considering the factors determining the cost of ICU hospitalization.

This research has certain limitations. The data are unique to this institution and the practices of the surgeons who participated in the research. Therefore, the patients investigated might not be representative of the orthopedic population as a whole; hence, the findings might not apply to all. Furthermore, this analysis solely considers expenses associated with the original index procedure's acute hospital period, not costs associated with post-discharge care, surgically related hospital readmissions, or reoperations. Patients with multiple admissions were not considered in this study. Finally, because this was a retrospective study analysis prone to selection bias and missing or incomplete data, it could only uncover possible associations and not infer causal relationships. Only patients admitted to the hospital where the study was conducted were identified through the review.

As a conclusion, in a world where healthcare costs are rising, having access to accurate data on the cost of various treatments and determining the factors that contribute to the rising costs is crucial to achieving cost effectiveness. Because ICU expenses account for a major portion of the cost, developing an alternative payment model for hip fracture surgeries necessitates identifying individuals with high ICU expenses. It is important to identify measurable variables that are proportional to incurred expenses to develop long-term bundled models. In geriatric patients who had hip fracture surgery and were admitted to the ICU, we observed a correlation between APACHE score, ACCI, length of stay, and cost of treatment. Our findings indicate the need to develop an alternate payment model for the cost of care of patients with hip fracture. Bundled payment models should take into account patients with significant variability in inpatient care costs, which could potentially interfere with the identification of a relationship between patient factors and the derived inpatient cost of care.

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