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ORIGINAL ARTICLE

Can the APACHE II score be used to assess the risk of mortality in the elderly with hip fractures?

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ABSTRACT

Aim Various predictive models have been developed to help identify patients with hip fractures with greater or lower probability of survival. The aim of this study was to establish the capacity of the APACHE II score to predict the survival of patients with hip fracture, in people aged over 65 years, and compare it with the existing score used to predict the survival of these patients.

Methods This was a prospective, cohort study conducted in a tertiary care teaching hospital including 410 consecutive patients with hip fracture aged ≥65 years. As part of the preoperative preparation, general health of the patients was classified according to the ASA score. The Charlson Comorbidity Index (CCI), the Nottingham Hip Fracture Score (NHFS), the POSSUM-P and the APACHE II scores were analysed.

Results The sensitivity and specificity of the P-POSSUM score were 78.3 and 73.0, respectively, which was better than the APACHE II whose sensitivity and specificity were 56.6 and 89.7. The area beneath the ROC curve for P-POSSUM was 0.809, and for APACHE II, 0.803. However, there was no statistically significant difference between the APACHE II and P-POSSUM scores. The P-POSSUM and APACHE II scores were statistically significantly better than ASA, the Nottingham score and CCI.

Conclusion This study showed that POSSUM-P and APACHE II can be used to predict mortality in elderly people with hip fractures.

Keywords: ASA score, CCI, morbidity, older people, P-POSSUM score

INTRODUCTION

The risk of hip fracture increases significantly with increasing age (1). Given the ageing of the global population, the incidence of hip fractures in the elderly in developed countries will increase (2). The main treatment of hip fractures is surgical, but the elderly will often have comorbidities before admission to hospital (3). Hip fractures are related to increased morbidity and mortality, especially in patients with one or more comorbidities (4,5).

The assessment of mortality and morbidity risk at the time of admission to hospital is a major challenge (6). As a result, various predictive models have been developed to help identify patients with a greater or lower probability of survival (7). They are useful and important because they alert both surgeons and anaesthesiologists to the possible development of postoperative complications and mortality, so that suitable treatment can be used for such patients.

The American Society of Anaesthesiologist's (ASA) classification system was developed in an attempt to assess the general health status of patients before surgical procedures and anaesthesia (8). A high ASA score at admission is linked to increased mortality. The Charlson Comorbidity Index (CCI) takes comorbidities into account, such as heart disease, diabetes, and kidney disease (9) and, like the ASA score, a high score is related to increased mortality. Both ASA and CCI are general scoring systems.

Scoring systems have been developed specifically for surgical patients. One of the first developed in the field of orthopaedics was the Physiological and Operative Severity Score for enumeration of mortality and morbidity (POSSUM), introduced in 1991 (10). The POSSUM score was able to assess the postoperative mortality rate (11) and, after simplification using exponential analysis technology in the POSSUM scoring system, the P-POSSUM scoring system was obtained, which is more appropriate for surgical patients (12). Another score, developed for orthopaedic patients, was the Nottingham HIP Fracture Score (NHFS), which showed adequate prediction of early mortality after a hip fracture (6).

Acute Physiology and Chronic Health Evaluation II scoring system (APACHE) II has demonstrated its usefulness in surgical Intensive Care Units (ICUs). Higher APACHE II score is related to higher morbidity and mortality in ICUs (13). However, the APACHE II score is not used in people with hip fractures who are >65 years old. Nevertheless, we presumed that in

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the elderly physiological parameters could prevail over surgical, and that APACHE II could be used in these patients to predict survival. In the literature we could not find any studies about the use of APACHE II in assessing the risk of mortality in the elderly with hip fractures.

The aim of this study was to establish the capacity of APACHE II to assess the prediction of survival of patients with hip fractures, and to compare them with specific scoring systems developed for orthopaedic patients, and with the general ASA score and the CCI index, in patients over 65 years of age.

PATIENTS AND METHODS

Patients and study design

This was a prospective study conducted in a tertiary care teaching hospital Tuzla University Clinical Centre (UCC) that covers the entire Tuzla canton, which has 445,028 inhabitants. This is the only health institution that provides health services in the field of orthopaedics/traumatology. The Orthopaedics and Trauma Clinic of the UCC has 54 beds. From 1 February 2022 to 1 June 2023 24,536 patients were attended to the Outpatient Clinic of Tuzla UCC, of which 2,504 were hospitalized, and of these 448 had a hip fracture.

The study included 410 consecutive patients over 65 years old with hip fractures, who met the inclusion criteria.

The inclusion criteria were: patients older than 65 years of age, of both genders, who were surgically treated for hip fractures, with surgical methods, including total endoprosthesis of the hip, and proximal femoral wedge.

The exclusion criteria were patients: younger than 65 years of age, with ASA score V, with hip fractures treated with a plate or dynamic hip screw, with a pathological fracture, who had a deformity before the injury, with multiloculated fractures, with ipsilateral lower leg amputation, polytraumatized patients, or those with penetrating wounds.

All patients included in this study signed an informed consent to participate in the research.

An approval was obtained from the Ethics Committee of Tuzla UCC.

Methods

All patients were treated in the identical manner. The following data were collected: name and surname, gender, age, mechanism of injury, side of injury, time that passed from the injury to admission to hospital, and from admission to the surgical procedure, accompanying injuries, type of fracture, duration of surgery, type of anaesthesia, treatment method, and length of hospital stay.

As part of the preoperative preparation, general health of the patients was classified according to the ASA score (8).

The Charlson Comorbidity Index (CCI) (9), the Nottingham Hip Fracture Score (NHFS) (6), and the POSSUM-P (12) and APACHE II (14) scores were analysed. All variables required for the scores were recorded in the first 24 hours, except for the P-POSSUM score, if the operation was delayed. In that case the operational parameters were taken in the subsequent 48 hours. Cut-off points were specified (2 for ASA, 5 for CCI, 29 for POSSUM-P, 4 for NHFS and 15 points for APACHE II), and all the values greater than the cut-off points were taken to predict mortality.

All complications were registered up to six months postoperatively, and the mortality rate was monitored for one year after the surgery.

Statistical analysis

For statistical analysis of data descriptive statistical methods were used and the z-test test to calculate the significance of the results obtained. The empirical (nonparametric) method by DeLong was used as a method for computing the Area under the ROC Curve (AUC) and Standard Error (SE). AUC measures the entire two-dimensional area underneath the entire receiver operating characteristic (ROC) curve from (0.0) to (1.1). We used the Youden's index that is the value that maximizes the sensitivity and specificity of any continuous variable, helping to choose an appropriate cut-off point for dichotomization. The binomial exact test and the corresponding 95% confidence interval (CI) were used to determine whether a proportion of the binary variable was equal to a hypothesized value. The relationship of the prognostic scores and the probability of death is shown by the curve for scores in terms of survival. We analysed APACHE II, CCI, ASA, Nottingham and P-POSSUM scores.

Differences were considered statistically significant at $p<0.05$. The cut-off points were specified for all scoring systems, and all values greater than the cut-off points were taken to predict death. Sensitivity and specificity were calculated for different values of the cut-off points.

RESULTS

Four hundred and ten patients were admitted to the Orthopaedic Trauma Clinic of Tuzla UCC, comprising 283 (69.03%) females and 127 (30.97%) males, with an average age of 77.36 (SD ±7.84) years.

The surface under the ROC curve was the best for the P-POSSUM score (Figure 1), as well as the relatively high sensitivity and specificity of the cut-off score. The APACHE II score was very close in terms of area, showing better specificity, but significantly lower sensitivity was found (Table 1).

The comparison of all scores with each other showed that the surface under the ROC curve was best for the P-POSSUM and the APACHE II scores, as was the Youden index, which was highest for the P-POSSUM and APACHE II scores (Table 2).

When we compared these scores with each other, both the P-POSSUM ($p<0.0001$; $p=0.0149$) and APACHE II scores ($p<0.0001$, $p=0.0121$) were statistically significantly better than the ASA and Nottingham scores. The CCI was significantly better than the ASA score ($p=0.0492$). There was no significant difference between the APACHE II and P-POSSUM scores ($p=0.7909$) (Table 3).

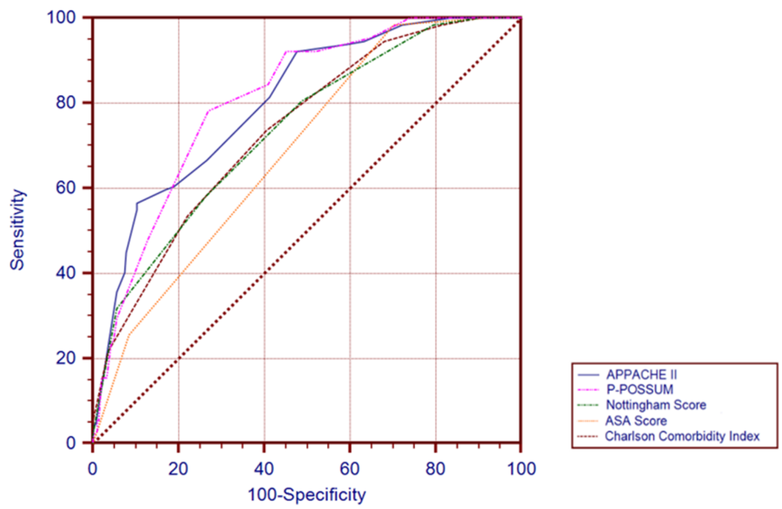

Figure 1.ROC curve comparing the sensitivity and specificity of Acute Physiology and Chronic Health Evaluation (APACHE II)
CCI, Charlson Comorbidity Index; ASA, American Society of Anaesthesiologists' classification system; P-POSSUM, Physiological and Operative Severity Score for enumeration of mortality and morbidity

DISCUSSION

More than 25 risk prediction models are currently used for hip fractures (15). This is the first study to examine the capacity of the APACHE II score in predicting mortality in people with hip fractures who are older than 65 years of age. The results of this study show that the P-POSSUM score showed better specificity and sensitivity than the other scores, but this advantage is not statistically significant in relation to the APACHE II score. APACHE, like P-POSSUM, is better than the Nottingham, ASA and CCI indexes. POSSUM shows consistency, although its prediction is better in younger patients and patients undergoing elective surgery (16). APACHE II is aligned to predict mortality in people in intensive care units (17). POSSUM is the best at predicting morbidity and mortality 30 days from surgery (3). It is emphasized that further optimization of POSSUM could improve clinicians' ability to identify risk in elderly patients requiring hip fracture surgery (18).

The Nottingham Hip Fracture Score is not routinely used outside the United Kingdom, but in general it is a good fit and shows fair discrimination ability, although it is inferior to POSSUM and APACHE II (19,20).

The ASA score gives a general assessment of perioperative anaesthetic risk and correlates with post-operative mortality. However, the score is subjective, limited to systemic illnesses, and requires significant clinical experience for use (21).

CCI is not specific for hip fractures, and in our study it was inferior to POSSUM and APACHE. There are on-line calculators available for CCI and with information about medical history they are easy to use. CCI has poor-to-fair discrimination, but calibration measures were not reported in most studies in which CCI was used (22,23). It was established that patients with the greatest risk of dying within six months of a hip fracture were male, >85 years, with a CCI score >7 (24).

Table 2. Characteristics of tested scores

Score	AUC	SE	95% CI	Youden index
APACHE II	0.803	0.0223	0.761-0.841	0.4627
CCI	0.737	0.0250	0.692-0.779	0.3307
ASA	0.690	0.0205	0.643-0.734	0.2834
Nottingham	0.738	0.0251	0.692-0.780	0.3187
P-POSSUM	0.809	0.0214	0.768-0.846	0.5125

AUC, Area under the ROC Curve; SE, Standard Erro; CI, Confidence interval

This cohort study has limitations, because it included all types of hip fracture. Reportedly, intracapsular hip fractures may have a significantly higher risk of mortality than extracapsular fractures (25), but the type of fracture is not included in the Nottingham score. We should also mention the small sample for this type of research. This is a report from a university teaching hospital in the country with a small population. We did not divide patients >65 years into groups (>75 or >85 years).

A full understanding of factors linked with a greater risk of

Table 1. Sensitivity, specificity, and positive and negative predictive value of tested scores

Score	Sensitivity	Specificity	Positive predictive value	Negative predictive value
APPACHE II	56.6	89.7	71.6	81.8
CCI	73.6	59.4	45.4	83.1
ASA Score	98.4	29.9	39.2	97.6
Nottingham Score	80.6	51.2	43.1	85.2
P-POSSUM	78.3	73.0	57.1	88.0

APACHE II, Acute Physiology and Chronic Health Evaluation II scoring system; CCI, Charlson Comorbidity Index; ASA, American Society of Anesthesiologists' classification system; P-POSSUM, Physiological and Operative Severity Score for the enumeration of mortality and morbidity

Table 3. Pairwise comparison of receiver operating characteristic (ROC) curves of tested scores

Pairs	Difference between areas	SE	95% CI	p
APPACHE II ~ CCI_Index	0.0658	0.0295	0.00792 to 0.124	p = 0.0259
APPACHE II ~ ASA Score	0.113	0.0245	0.0652 to 0.161	p < 0.0001
APPACHE II ~ Nottingham_Score	0.0654	0.0261	0.0143 to 0.117	p = 0.0121
APPACHE II ~ P-POSSUM	0.00639	0.0241	-0.0408 to 0.0536	p = 0.7909
CCI_Index ~ ASA Score	0.0474	0.0241	0.000174 to 0.0946	p = 0.0492
CCI_Index ~ Nottingham_Score	0.000331	0.0284	-0.0553 to 0.0559	p = 0.9907
CCI_Index ~ P-POSSUM	0.0721	0.0293	0.0148 to 0.130	p = 0.0137
ASA Score ~ Nottingham_Score	0.0477	0.0264	-0.00400 to 0.0995	p = 0.0705
ASA Score ~ P-POSSUM	0.12	0.0272	0.0662 to 0.173	p < 0.0001
Nottingham_Score ~ P-POSSUM	0.0718	0.0295	0.0140 to 0.130	p = 0.0149

APACHE II, Acute Physiology and Chronic Health Evaluation II scoring system; CCI, Charlson Comorbidity Index; ASA, American Society of Anesthesiologists' classification system; P-POSSUM, Physiological and Operative Severity Score for enumeration of mortality and morbidity; SE, Standard Error; CI, Confidence interval

mortality and morbidity is crucial, in order to optimize patient care, to determine appropriate guidelines, improve the accuracy of prognosis and risk assessment, and develop targeted interventions in order to improve post-operative outcomes (26).

In conclusion, POSSUM-P and APACHE II can be used to predict mortality in elderly people with hip fractures. This and similar studies explain the capacities of individual scores, or the variables they include, and will help to create machine learning models, which will probably be the basic tools for prediction in the near future.

AUTHOR CONTRIBUTIONS

Conceptualization, S.D.; methodology, S.D.; software, T.B.; validation, S.D., and T.B.; formal analysis, S.D. and T.B.; investigation, T.B.; resources, T.B..; data curation, S.D. and T.B.; writing—original draft preparation, S.D.; writing—review and editing, S.D.; visualization, T.B.; supervision, S.D.; project administration, T.B.; funding acquisition, T.B. All authors have read and agreed to the published version of the manuscript.

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TRANSPARENCY DECLARATION

Conflict of interests: None to declare.

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