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ORTHOPAEDIC SURGERY

Four questions to identify patients with ASA III or higher

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Abstract

Background Increased age, obesity, and American Society of Anesthesiologists (ASA) Physical Status class III and IV have been reported as predictors for mortality and perioperative complications. High-volume institutions rely on central referral services as first contact point for patients. The current study reports on a simple four-step questionnaire to identify patients with ASA-physical status class III and IV to improve referral processes and optimize perioperative work ups.

Materials and methods Seven hundred and seventy-five patients who called the physician referral service (PRS) at the author's institution and subsequently underwent surgery were enrolled in this study. The answers to the initial PRS questionnaire were analyzed. The study cohort consisted of 414 women (53.4%) and 361 men (46.6%) with an average age of 61.4 years (range 44–90 years) at the time of surgery.

Results Binary logistic regression revealed hypertension, diabetes mellitus (using medication), using blood thinner (other than Aspirin) and a number of 4–9 prescribed medication, respectively, as predictors for ASA III and IV. Receiver-operating characteristic (ROC) curve analysis identified a sensitivity of 82.4%, a specificity of 82.9%, and an accuracy of 82.8%, when two of these four questions are answered "yes". The area under the curve for this analysis was 0.876 [95% confidence interval (CI) 0.845–0.908]. Positive and negative likelihood ratios were 4.8 (95% CI 4.0–5.8) and 0.2 (95% CI 0.1–0.3), respectively.

Conclusions This study revealed a simple four-step questionnaire to identify patients with ASA III or IV before a medical appointment. This helps to balance referrals between multiple providers in high-volume medical groups.

Keywords Total hip arthroplasty (THA) · Total knee arthroplasty (TKA) · ASA-physical status classification · Questionnaire · Prediction of perioperative risk

Introduction

In most countries, the average life expectancy has increased substantially over the last decades [1]. At the same time, the number of total hip arthroplasties (THA) and total knee arthroplasties (TKA) has increased steadily. Several studies have shown that increased age is a significant risk factor for perioperative adverse events after total joint arthroplasties (TJA) [2–6]. Feng et al. [7] reported that patients older than 80 years have an increased risk of systemic complications within first 30 days after surgery.

Beside age, obesity is another predictor for perioperative complications. The current literature suggests a significantly higher risk for perioperative adverse events in patients with a BMI above 30 [2, 7, 8]. Obesity is also associated with increased readmission rates and surgical complications [9, 10].

In 1941, the American Society of Anesthesiologists (ASA) established a physical status classification system, which was modified in 1963 [11–13]. It is used to summarize a patient's preoperative medical status and predicts perioperative morbidity and mortality. In the previous studies, ASA III and IV were reported as significant risk factors for perioperative complications and increased mortality [3, 6, 14–18]. Schaeffer et al. [19] suggested a 2.9-times increased risk of readmission in patients with ASA III and IV. Due to the importance of the ASA-physical status classification, predicting a patient's ASA class before referral is important

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for large physician groups. In the US, high-volume institutions often rely on central referral services as the first contact point for patients. Patients are usually referred to its providers based on age, BMI, and insurance status. The current study reports on a simple four-step questionnaire to identify patients with ASA III and IV to balance referrals and optimize preoperative work ups based on a patient's medical status.

Materials and methods

After obtaining institutional review board approval, 3658 patients who called the physician referral service (PRS) at the author's institution between January 2016 and July 2017 were identified. During their initial contact, they were asked a standardized questionnaire that also included several questions about their current health status. Sixty-eight patients (0.02%) did not answer four or more questions and were excluded. Two thousand and seven hundred and eighty-four patients (76.1%) did not undergo surgery or did not schedule an appointment, and in 31 cases (0.008%), the ASA class was not recorded. These patients were excluded, as well. A total of 775 patients, who underwent surgery at the author's institution, were enrolled in this study (Fig. 1).

The study cohort consisted of 414 women (53.4%) and 361 men (46.6%). The average age at the time of surgery was 61.4 years (range 44–90 years). Sixty-five (8.4%) patients were classified as ASA I, 574 (74.1%) as ASA II, 127 (16.4%) as ASA III, and 9 (1.2%) as ASA IV, respectively. Table 1 shows the details of patient demographics and distributions of ASA-physical status classification and performed surgeries.

The initial PRS questionnaire asked whether the patient is taking a blood thinner (other than Aspirin), has diabetes mellitus (using medication), chronic liver diseases, dementia, history of myocardial infarction, history of pulmonary embolism, congestive heart failure, tumor with chemotherapy, history of stroke, and the number of prescribed medication. The latter were sorted in three subgroups. One to three, four to nine, and ten or more prescribed medications daily, respectively. Dietary or vitamin supplements were not considered prescription medication. Patients' medical records were reviewed to check answers to the initial questionnaire. If a mismatch occurred, the data were updated according to medical records. During the review of data, hypertension, hypercholesteremia, thyroid diseases, asthma, and chronic obstructive pulmonary disorder (COPD) were added to the questionnaire. These data points were collected retrospectively. All enrolled patients underwent surgery at the author's institution. An anesthesiologist obtained the ASA-physical status preoperatively. The recorded ASA class was collected retrospectively from the medical records.

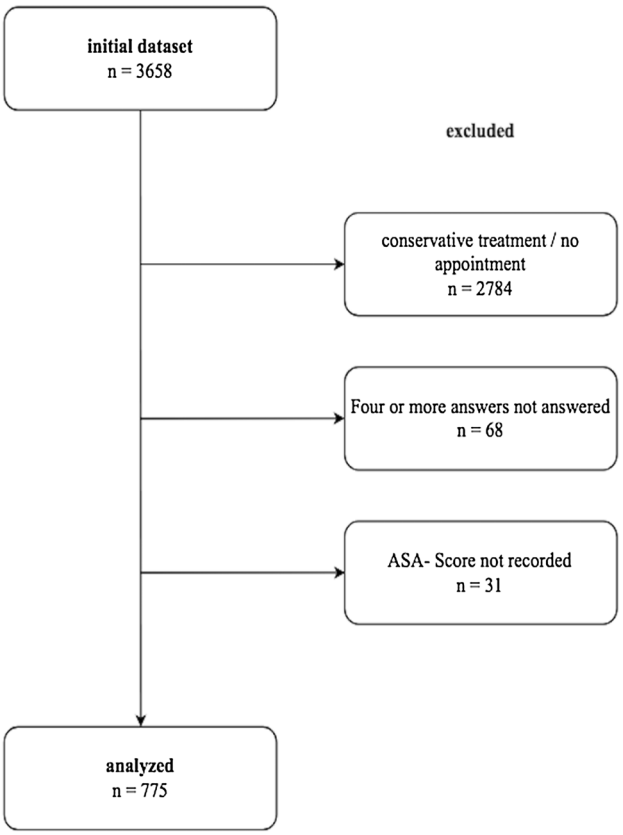

Fig. 1 Flowchart that illustrates the study cohort and patients that were excluded from the analysis

Statistical analysis

Frequencies, proportions, means, and ranges were used to describe the study cohort.

Binary logistic regression was performed to investigate the predictive value of the questions that were asked at the time patients initially contacted PRS. All 16 variables/questions of the questionnaire were included in the analysis. By the use of a backward elimination model, variables/questions were removed one by one until a point was reached where removing any further variable would have had a significant impact on the overall fit of the model. After 11 elimination steps, six statistically significant variables/questions were left. Four of these were highly statistically significant.

The highly statistically significant variables/questions were subsequently used to perform a receiver-operating characteristic (ROC) curve analysis to identify thresholds for the possible combinations in answering these questions (How many of the four questions should be answered "yes"). The area under the curve (AUC) ranges from 0.5 to 1.0. An AUC of 0.5 indicates that the test has no accuracy

Table 1 Patient demographics, ASA-physical status classification, and performed surgeries

Variable	*n* (%)
Number of patients	775 (100)
Sex	
Female	414 (53.4)
Male	361 (46.6)
Age at surgery[a] (years)	61.4 (44–90)
Body mass index[a] (kg/m^2)	29.5 (17.5–54.7)
ASA-physical status classification	
ASA I	65 (8.4)
ASA II	574 (74.1)
ASA III	127 (16.4)
ASA IV	9 (1.2)
Performed surgery	
TKA	254 (32.8)
UKA	38 (4.9)
Replacement patellofemoral joint	7 (0.9)
THA	293 (37.8)
Hip resurfacing	19 (2.5)
Revision THA/TKA	29 (3.7)
Arthroscopy	89 (11.5)
Other	46 (5.9)

ASA American Society of Anesthesiologists, *THA* total hip arthroplasty, *TKA* total knee arthroplasty, *UKA* unicompartmental knee arthroplasty

[a]Data presented as means with ranges

in identifying patients with ASA III and IV. An AUC of 1.0 indicates a perfectly accurate test. The current literature coincides that a cut-off in the ASA-physical status classification for a worse outcome and increased incidence of complications is at ASA II [3, 6, 14–17, 20]. This is why, we decided to aim for ASA III and IV. The threshold of the ROC curve reveals the number of the four questions that have to be positive to reach the highest sensitivity and specificity in predicting patients with ASA III and IV [21]. Positive (PPV) and negative predictive values (NPV) and positive (+LR) and negative likelihood ratios (−LR) were calculated using the Bayes theorem. Jaeschke et al. [22] classified likelihood ratios as follows: +LR between 1 and 2 and −LR between 0.5 and 1 suggest "rarely diagnostic evidence"; +LR between 2 and 5 and −LR between 0.2 and 0.5 suggest "slight diagnostic evidence"; +LR between 5 and 10 and −LR between 0.1 and 0.2 suggest "high diagnostic evidence"; +LR > 10 and −LR < 0.1 suggest "strong diagnostic evidence".

All statistical tests were two-sided. Results with p values < 0.05 were considered as statistically significant, p values of < 0.001 as highly statistically significant. All calculations were performed with SPSS version 23.0 for Mac OS X (SPSS Inc./IBM, Chicago, IL).

Results

Regression analysis

All questions of the PRS questionnaire, which are related to the current health status, were included in the analysis. To receive the accurate results, each subgroup of the variable "number of prescription medication" was evaluated separately.

Using blood thinner (other than Aspirin) [Odds ratio (OR) 8.699, 95% confidence interval (CI) for OR 4.404–17.184, $p < 0.001$], diabetes mellitus (using medication) (OR 4.744, 95% CI for OR 2.455–9.165, $p < 0.001$), hypertension (OR 4.672, 95% CI for OR 2.536–8.607, $p < 0.001$), and a number of 4–9 prescribed medication (OR 3.754, 95% CI for OR 2.249–6.265, $p < 0.001$) were identified as highly statistically significant predictors for ASA III or IV. Thyroid disease (OR 2.279, 95% CI for OR 1.149–4.520, $p = 0.018$) and hypercholesteremia (OR 1.712, 95% CI for OR 1.049–2.792, $p = 0.031$) were recognized as statistically significant predictors.

The four highly significant factors were used for further investigation by performing an ROC curve analysis to evaluate sensitivity and specificity in identifying patients that are classified as ASA III or IV. A detailed listing of the results is shown in Table 2.

Sensitivity and specificity

ROC curve analysis identified a cut-off at two of four questions. This suggests that at least two of the four questions have to be answered "yes" to achieve an 82.4% sensitivity (95% CI 74.7–88.2%) and 82.9% specificity (95% CI 79.7–85.7%) (AUC 0.876; 95% CI 0.845–0.908, $p < 0.001$) in predicting patients with ASA III or IV (Fig. 2). At this cut-off, PPV and NPV were 50.7% (95% CI 43.9–57.4%) and 95.7% (95% CI 93.5–97.1%), respectively. The +LR was 4.8 (95% CI 4.0–5.8) (slight-to-high diagnostic evidence) and −LR was 0.2 (95% CI 0.1–0.3) (slight-to-high diagnostic evidence). This suggested that the probability to be ASA III or IV was 4.8 times higher, if patients answered two or more questions positively. A −LR of 0.2 indicates that one of the five patients is ASA III or IV, although less than two questions were answered positively. Overall accuracy of the questionnaire was 82.8%. Table 3 summarizes the four questions.

Table 2 Backward elimination model of a binary logistic regression: six of the initial 16 variables/questions showed statistically significant results

Variable	Odds ratio (OR)	95% CI for OR	*p* value
Using blood thinner (other than aspirin)	8.699	4.404–17.184	<0.001[a]
Diabetes mellitus (using medication)	4.744	2.455–9.165	<0.001[a]
Hypertension	4.672	2.536–8.607	<0.001[a]
Number of prescribed medication: 4–9	3.754	2.249–6.265	<0.001[a]
Thyroid disease	2.279	1.149–4.520	0.018[b]
Hypercholesteremia	1.712	1.049–2.792	0.031[b]

Four of these were highly statistically significant and subsequently used to perform an ROC curve analysis

[a]Highly statistically significant

[b]Statistically significant

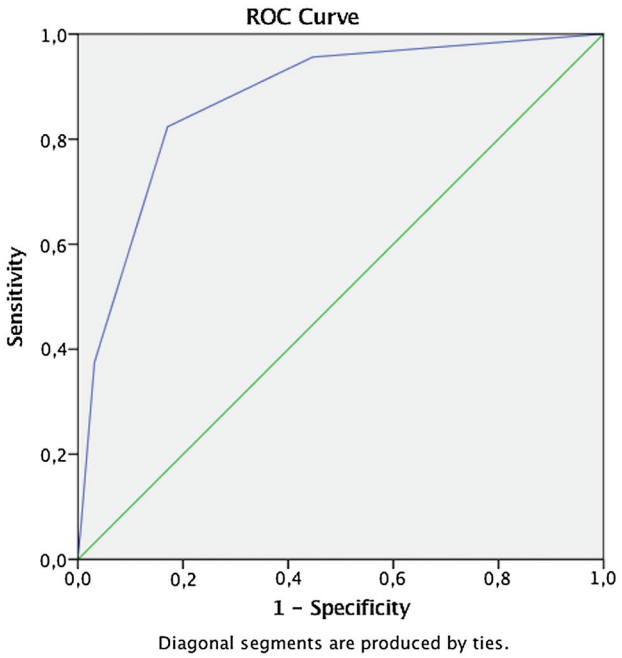

Fig. 2 Receiver-operating characteristic (ROC) curve for predicting a patient with ASA III or IV by asking four questions. The area under the curve is 0.876 (95% CI 0.845–0.908, $p < 0.001$). Maximal sensitivity (82.4%) and specificity (82.9%) is reached when answering at least two of the four questions with "yes"

Table 3 Summary of the four questions to predict ASA III and IV

Question
Are you taking a blood thinner (other than aspirin)?
Do you take 4–9 prescribed medications daily?
Do you suffer from diabetes mellitus and use medication?
Are you suffering from hypertension?

Discussion

Several studies have reported that ASA-physical status classification is a simple, reproducible, and reliable comorbidity tool that correlates with complications (minor and major), mortality, morbidity, length of hospital stay, and readmission rates following to TJA [19, 23–27]. Patients with ASA III or IV are at a higher risk for perioperative complications. Singh et al. [20] also reported that the risk for cardiac events within 90 days after TJA is significantly higher in patients with ASA III and IV. It is crucial to identify these patients as early as possible. The current literature does not report on a diagnostic tool that provides pre-appointment risk stratification. Many institutions in the US use central referral services as first contact for patients. Our study reported a simple four-step questionnaire that facilitates the identification of patients with ASA III or IV at the time of the initial contact. If at least two of the four questions are answered "yes", prediction can be made with an 82.4% sensitivity, 82.9% specificity, and 82.8% accuracy, respectively. Considering that patients with ASA III and IV are more likely to have reportable complications, distributing these patients among providers minimizes negative impact on reimbursement and online complication reporting.

Our findings are equally relevant for both internists and surgeons. Beside the variety of studies that reported on an increased mortality in case of ASA III or IV, many authors also suggested a correlation between an increased ASA score and complications that are directly related to the surgery. They indicated a higher risk of infections [16, 28] and dislocations [15]. Bieger et al. [29] reported that ASA III and IV, furthermore, have a significant negative influence on the Knee Society Score after TKA.

An increased ASA score was also associated with an increased inpatient complication rate. These patients are at most risk for complications during the early postoperative period [30, 31]. Knowing a patient's health status in advance allows preoperative work up to be streamlined. It will also allow us to plan the hospital stay more accurately

and assure that these patients are not planned for outpatient TJA.

The importance and influence of the ASA-physical status classification has not only been suggested for primary but also for revision TJA [32].

The current study has the following limitations: (1) Although ASA-physical status classification has been associated with postoperative mortality, morbidity, and a great number of complications (minor and major), its subjective interpretation and poor inter-observer reliability is frequently criticized [33, 34]. This potential error has only a small impact on the significance of our results. Only ASA III and IV are at increased risk and the distinction between ASA I and ASA III is straight forward [14]. Another disadvantage of the ASA classification is that age is not included [19]. However, several studies supported the utilization of ASA-physical status classification as a reliable tool to evaluate comorbidities [34, 35]. (2) The review of the medical records revealed that the definition of prescribed medication might vary between patients. In some cases, patients considered dietary and vitamin supplements as prescribed medication. This fact should be kept in mind. Adding the information that supplements should not be included in the count might solve this problem. (3) One might argue that identifying patients classified as ASA III or IV with an 82.4% sensitivity, 82.9% specificity, and 82.8% accuracy, before they are seen in the office, is not perfect. However, to our knowledge, this is the only simple test that can be applied by non-medical professionals. (4) Some statistical outcomes used in this study including PPV are prevalence-dependent. The PPV increases with a higher prevalence and decreases with a lower prevalence. Therefore, these data have to be evaluated carefully. All included patients underwent elective surgeries, and as a result, prevalence of ASA III and IV in the study cohort is low (17.6%). The reached PPV of 50.7% is a result of low prevalence. (5) This study does not aim to show that identifying patients at risk alters their perioperative outcome. To our knowledge, treatment of risk factors does not lead to a change in ASA classification.

In conclusion, ASA III and IV are reported as important risk factors for a great number of complications and increased mortality after TJA. Early identification of patients with an increased perioperative risk helps to balance referrals among multiple providers. The current study reports a simple four-question questionnaire to identify patients with ASA III and IV.

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Compliance with ethical standards

Conflict of interest Dr. Boettner has received royalties by Smith and Nephew and Orthodevelopment. Dr. Boettner has also received compensation by Smith and Nephew, Orthodevelopment, and DePuy. All other authors have no conflict of interest.

Research involving human participants and/or animals All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed consent For this type of study, formal consent is not required.

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