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Assessment of the Risk Factors Related to the Length of Hospital Stay and Postoperative Complications in Patients Undergoing Primary Total Knee Arthroplasty

Avaliação dos fatores de risco relacionados ao tempo de internação e às complicações pós-operatórias em pacientes submetidos a artroplastia total primária do joelho

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Abstract

Objective To assess the risk factors involving longer hospital stays and early postoperative complications (first 30 days after surgery) in patients undergoing total knee arthroplasty (TKA).

Materials and Methods A cross-sectional study was conducted with collection of data of patients who underwent TKA in a private hospital between 2015 and 2019. The following data were collected: age, gender, body mass index, and clinical comorbidities. We also collected intraoperative data such as the grade on the classification of the American Society of Anesthesiologists (ASA), the duration of the surgery, the length of stay, the postoperative complications, and readmission within 30 days. Statistical models were used to investigate the possible risk factors associated with longer hospital stays and postoperative complications.

Results There was evidence of an increase in the length of hospital stay in older patients, with higher grades on the ASA classification or who suffered postoperative complications. For each increase in 1 year of age, we expect the length of stay to be multiplied by 1.008 (95% confidence interval [95%CI]: 1.004 to 1.012; $p < 0{,}001$). In patients who were ASA grade III, the time is expected to be multiplied by 1.297 (95%CI:

Keywords
- arthroplasty, replacement, knee
- outcome assessment
- postoperative complications
- length of stay

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1.083 to 1.554; $p = 0{,}005$) when compared with grade-I patients. In patients who suffered postoperative complications, the time is expected to be multiplied by 1.505 (95%CI: 1.332 to 1.700; $p < 0.001$) compared with patients without complications.

Conclusion The present study demonstrated that, in patients who underwent primary TKA, preoperative characteristics such as older age and ASA grade $\geq$ III, as well as the development of postoperative complications, independently predict the increase in the length of hospital stay.

Resumo

Objetivo Avaliar os fatores de risco relacionados a um tempo de internação mais longo e às complicações pós-operatórias precoces (primeiros 30 dias após a cirurgia) em pacientes submetidos a artroplastia total do joelho (ATJ).

Materiais e Métodos Este é um estudo transversal com coleta de dados de pacientes submetidos a ATJ em um hospital privado entre 2015 e 2019. Os seguintes dados foram coletados: idade, gênero, índice de massa corporal, e comorbidades clínicas. Também coletamos dados intraoperatórios, como o grau na classificação da American Society of Anesthesiologists (ASA) e a duração da cirurgia, além do tempo de internação, as complicações pós-operatórias, e a readmissão em 30 dias. Os possíveis fatores de risco associados a um tempo de internação mais longo e às taxas de complicações pós-operatórias foram investigados por meio de modelos estatísticos.

Resultados Os pacientes mais velhos, com graus mais elevados na classificação da ASA ou que sofreram complicações pós-operatórias, ficaram internados por mais tempo. Para cada aumento em um ano de idade, esperamos que o tempo de internação seja multiplicado por 1,008 (intervalo de confiança de 95% [IC95%]: 1,004 a 1,012; $p < 0{,}001$). Em pacientes de grau III na classificação da ASA, espera-se que o tempo seja multiplicado por 1,297 (IC95%: 1,083 a 1,554; $p = 0{,}005$) em comparação com pacientes de grau I. Em pacientes com complicações pós-operatórias, espera-se que o tempo seja multiplicado por 1,505 (IC95%: 1,332 a 1,700; $p < 0{,}001$) em comparação com pacientes sem complicações.

Conclusão Este estudo demonstrou que, em pacientes submetidos a ATJ primária, características pré-operatórias, como idade avançada e grau $\geq$ III na classificação da ASA, e o desenvolvimento de complicações pós-operatórias predizem o aumento do tempo de internação hospitalar de forma independente.

Palavras-chave
- artroplastia do joelho
- avaliação dos resultados
- complicações pós-operatórias
- tempo de internação

Introduction

Total knee arthroplasty (TKA) is an orthopedic procedure that can successfully reduce pain, restore function, and improve the quality of life of patients with osteoarthritis of the knee. The mean age of patients undergoing TKA is 71 years old, and in advanced degrees of osteoarthritis, the procedure is considered the gold-standard treatment.[1–4] The demand for TKA has grown rapidly all over the world. The data available suggest that 650,674 primary TKAs were performed in 2017 in the United States, and this number is expected to grow by 673% to 3.48 million procedures by 2030.[4,5]

The main complications of the procedure are deep vein thrombosis, surgical wound infection, joint stiffness, aseptic loosening of the prosthesis, and periprosthetic fractures, among others.[6,7] All of these can dramatically affect the outcomes of the procedure and increase the healthcare costs, leading to greater patient disability and even death.[8]

There is not much epidemiological information on the risk factors associated with early complications after primary TKA, readmission within the first 30 days, and hospital length of stay (LOS). Some studies even propose risk predictive models; however, few of these use intraoperative variables.[9–11] Though not a substitute for clinician expertise, these models are a valuable adjunct as they can help orthopedists assess a patient's expected risk based on similar patients.

The present study aims to assess the risk factors for longer hospital LOS and early postoperative complications (first 30 days after surgery) in patients undergoing primary TKA.

Materials and Methods

Data Collection

The present study was sent to and approved by the institutional Ethics in Research Committee (CAAE- 39446720.6.0000.0071).

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All data were analyzed anonymously so that there was no personal identification of the patients included.

We conducted a cross-sectional study with retrospective data of patients undergoing primary TKA between 2015 and 2019 at a single institution. The following data were collected: age, gender, body mass index (BMI), comorbidities, grade on the classification of the American Society of Anesthesiologists (ASA), duration of surgery, postoperative complications, and 30-day readmission.

Early operative complications were any events within 30 days after the procedure that altered the normal postoperative course, requiring any type of intervention or acceptance of functional loss by the patient. All patients underwent standardized rehabilitation programs.

The inclusion criteria were patients undergoing primary TKA between 2015 and 2019 who were included in the institutional database. The exclusion criteria were revision TKAs, bilateral TKAs, and unicompartmental TKAs.

Statistical Analysis

The data were expressed as absolute and relative frequencies for the categorical variables, and as means, standard deviations (SDs), medians, interquartile ranges, and minimum and maximum values for the numerical variables.

For the analysis of the association of the LOS with variables of interest, we used generalized mixed models, contemplating the dependence regarding surgeries performed on the same patient, with Gamma distribution due to the asymmetric distribution observed. The model results were also expressed as mean values and estimated odds ratios and their respective 95% confidence intervals (95%CIs).

The associations of the occurrence of postoperative complications within 30 days with the variables of interest were investigated using mixed models with binomial distribution, considering the dependence regarding surgeries performed on the same patient. The model results were also expressed as mean values and estimated odds ratios, and their respective 95%CIs.

The statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS Statistics for Windows, SPSS Inc., Chicago, IL, United States), software, version 17.0. Values of $p > 0.05$ were considered statistically significant.

Results

A total of 527 primary TKAs in 485 patients were included in the study sample. Two surgeries were performed in patients diagnosed with osteonecrosis, and three, in patients diagnosed with osteoarthritis secondary to rheumatoid arthritis or fracture sequelae. The others were diagnosed with primary osteoarthritis. We observed that 42 patients underwent bilateral TKAs at different times during the study period.

The sample was composed of 348 (66.0%) women and 179 (34.0%) men, with ages ranging from 36 to 93 years and a mean of 70.3 ± 8.9 years. The patients weighed between 43 kg and 160 kg, with a mean of 79.8 ± 15.4 kg, and the BMI ranged from 16.8 kg/m^2 to 46.7 kg/m^2, with a mean of 29.1 ± 4.7kg/m^2.

The LOS ranged from 1 to 28 days. Immediately after surgery, 128 (24.3%) patients went to the semi-intensive care unit and 93 (17.6%), to the intensive care unit. In the postoperative period, 3 patients (0.6%) required readmission within 30 days due to the surgical site infection (2 patients) and deep vein thrombosis (1 patient) (►**Table 1**).

Considering the occurrence of any early postoperative complications, 39 (7.4%) patients had some type of complication (surgical site or systemic infection, dislocation, and venous or pulmonary thromboembolism), 472 (89.6%) did not have any complication, and 16 (3.0%) patients were not classified due to insufficient information.

Table 1 Demographic, intraoperative, and postoperative data

	Mean ± standard deviation	n (%)
Gender		
Female		348 (66.0%)
Male		179 (34.0%)
Age (years)	70.3 ± 8.9	
Body mass index (kg/m^2)	29.1 ± 4.7	
Comorbidities		
Arterial hypertension		234 (44.4%)
Diabetes mellitus		85 (16.1%)
Behavioral disorders		70 (13.3%)
Smoking		18 (3.4%)
Previous cancer diagnosis		34 (6.5%)
Heart disease		59 (11.2%)
Grade on the ASA classification		
I		41 (7.8%)
II		438 (83.1%)
III		35 (6.6%)
IV		1 (0.2%)
No Information		12 (2.3%)
Operative time (hours)	2.5 ± 0.7	
Length of stay (days)	4.4 ± 2.4	
Postoperative complications		
No		472 (89.6%)
Yes		39 (7.4%)
No information		16 (3.0%)
Readmission within 30 days		
No		524 (99.4%)
Yes		3 (0.6%)

Abbreviation: ASA, American Society Anesthesiologists.

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Association of the Length of Stay with the Variables of Interest

There was evidence of a significant association between the patient's age and the LOS (►**Table 2**), and for each increase in 1 year in age, we expect the LOS to be multiplied by 1.008 (95%CI: 1.004 to 1.012; $p < 0.001$). In an attempt to better understand this relationship, patients were classified according to age group in decades, and the age groups with little representation were placed in the same category. There was evidence of an increase in the LOS in the age group of patients 80 years or older compared with those aged up to 59 years, in which the time is expected to be multiplied by 1.257 (95%CI: 1.082 to 1.460; $p = 0.003$) in the older age group. There was no evidence of differences regarding patients aged up to 59 years compared with groups aged 60 to 69 years ($p = 0.382$) and 70 to 79 years ($p = 0.359$).

There was also evidence of an association between the LOS and the grade on the ASA classification, and, for ASA grade-III patients, the time is expected to be multiplied by 1.297 (95%CI: 1.083 to 1.554; $p = 0.005$) when compared with ASA grade-I patients, but there is no evidence of differences between ASA grade-II and grade-I patients ($p = 0.849$). Finally, we also found evidence of increased LOS in patients who developed postoperative complications compared with those who did not, and, in this case, the time is expected to be multiplied by 1.505 (95%CI:1.332 to 1.700; $p < 0.001$) in the group with complications.

Associations of the Occurrence of Postoperative Complications with the Variables of Interest

No evidence was found of an association of the occurrence of postoperative complications with any of the variables analyzed. The analysis of this association is shown in ►**Table 3**.

Discussion

The most interesting finding of the present study was that some preoperative characteristics of patients undergoing TKA, including age over 80 years and grade $\geq$ III on the ASA classification, as well as the development of postoperative complications, can be considered predictors of increased hospital LOS. This analysis can be used to stratify the risk of candidates for primary TKA preoperatively. Adequate stratification of patients assists in preoperative planning and in establishing expectations for patients and their families. Understanding which risk factors can influence complications and increase the LOS for patients undergoing major surgeries such as TKA is of fundamental importance to reduce the risks involved in the procedure, as well as to reduce the operating cost and optimize health resources. In 2017, Molloy et al.[12] found an increase in the cost of hospitalization of patients undergoing TKA and total hip arthroplasty in an American national database from 2002 to 2013, despite a reduction in the LOS from 4.06 days to 2.97 days. This cost could have increased more had there not been such a reduction in the average LOS.

Several studies[12–16] have been performed on the incidence of postoperative complications and mortality after primary TKA. However, the authors of these studies tend to combine complications from primary prostheses with revision prostheses, or to associate knee and hip procedures in the same study to assess risk factors. Thus, the benefits of applying these findings to patients undergoing primary TKA may be limited.

The identification of factors that interfere with the LOS of patients undergoing arthroplasties has been the focus of recent studies. In a 2019 study, Roger et al.,[17] analyzing TKA and total hip arthroplasty, found female gender, age, and the presence of diabetes as independent variables for increased LOS. Sarpong et al.,[18] in a retrospective study of the American National Surgical Quality Improvement Program database from 2006 to 2016, found a reduction in the LOS throughout the decades, and an association with shorter LOS in patients who were younger, male, and had low BMI and fewer comorbidities. Foni et al.[19] demonstrated that the focus on early rehabilitation of patients undergoing TKA can also contribute to shorter LOS without compromising the patients' health. Characteristics like female gender, higher grade on the ASA classification, high BMI, laboratory alterations related to malnutrition and systemic inflammation, and comorbidities such as smoking, diabetes, and lung diseases, have been reported and corroborated by other studies as predictors of increased hospital LOS.[20,21]

The Cleveland Clinic Orthopaedic Arthroplasty Group[22] performed a prospective cohort study in 2019 with 4,509 patients undergoing primary TKA with a follow-up of 1.5 years and found that, despite patient-related factors such as age, gender, and comorbidities being predictive of increased hospital LOS after TKA, the main predictors of LOS 24 hours after TKA were either procedure- or structure-related factors, including the hospital and the surgeon. In a systematic review conducted in 2019, March et al.[23] showed that the patient's worse psychological state in the preoperative period can also influence the LOS. In the present study, older patients ($>$ 80 years) or those with higher grades ($\geq$ III) on the ASA classification were found to be more likely to have increased LOS compared with younger patients or those with lower grades on the ASA classification.

Although many studies analyze variables that may interfere with the LOS, few studies seek to identify risk factors for early complications related to TKA. Some studies[24–26] have found an association with complications in patients with increased BMI, heart disease, neurological disease, preoperative low back pain, blood transfusion, male gender, smoking, and arthritis in a joint other than the knee. However, most of these studies analyzed arthroplasties in general, without differentiating TKA from total hip arthroplasty, or even looked for an association with a specific complication, disregarding other general complications. In the present study, no associations regarding increased incidence of postoperative complications were found in relation to any variable analyzed. However, an interesting finding was that postoperative complications can increase the hospital LOS. Patients who develop complications after TKA require more hospital resources, and there is also an increase in the costs due to the longer hospital stay; therefore, these patients should be monitored to prevent such occurrences. As the present study was performed in a reference

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Table 2 Association regarding the length of stay and the variables of interest

	Lenght of stay[#] (95%CI)	Odds ratio (95%CI)	*p*-value
Gender			
Female	4.17 (3.98–4.36)	1.053 (0.975–1.138)	0.191
Male	3.96 (3.72–4.22)	1.00	—
Age	—	1.008 (1.004–1.012)	< **0.001**
Age by subgroup			
≤ 59 years	3.96 (3.53–4.45)	1.00	—
60 to 69 years	3.73 (3.51–3.98)	0.943 (0.826–1.076)	0.382
70 to 79 years	4.20 (3.98–4.44)	1.062 (0.934–1.206)	0.359
≥ 80 years	4.98 (4.53–5.47)	1.257 (1.082–1.460)	**0.003**
BMI (kg/m^2)	—	0.996 (0.988–1.004)	0.352
BMI by subgroup			
Low weight/Normal weight	4.14 (3.81–4.51)	1.00	—
Overweight	4.19 (3.95–4.44)	1.011 (0.912–1.120)	0.835
Grade-1 obesity	3.92 (3.67–4.19)	0.946 (0.850–1.053)	0.307
Grade-2 obesity	3.89 (3.41–4.45)	0.939 (0.802–1.100)	0.435
Arterial hypertension			
No	4.04 (3.85–4.24)	1.00	—
Yes	4.16 (3.94–4.39)	1.029 (0.957–1.106)	0.434
Diabetes mellitus			
No	4.05 (3.90–4.22)	1.00	—
Yes	4.29 (3.93–4.69)	1.059 (0.961–1.167)	0.246
Behavioral disorders			
No	4.08 (3.92–4.24)	1.00	—
Yes	4.19 (3.80–4.63)	1.029 (0.926–1.144)	0.597
Smoking			
No	4.10 (3.95–4.26)	1.00	—
Yes	4.11 (3.38–5.00)	1.002 (0.822–1.222)	0.982
Previous cancer diagnosis			
No	4.09 (3.94–4.25)	1.00	—
Yes	4.13 (3.60–4.75)	1.011 (0.875–1.167)	0.883
Heart disease			
No	4.06 (3.91–4.22)	1.00	—
Yes	4.38 (3.94–4.88)	1.080 (0.964–1.209)	0.185
Grade on the ASA classification			
I	3.96 (3.50–4.48)	1.00	—
II	4.01 (3.85–4.17)	1.013 (0.890–1.152)	0.849
III	5.14 (4.49–5.88)	1.297 (1.083–1.554)	**0.005**
Operative time (hours)	—	1.045 (0.992–1.102)	0.098
Postoperative complications			
No	3.90 (3.76–4.04)	1.00	—
Yes	5.86 (5.21–6.60)	1.505 (1.332–1.700)	< **0.001**

Abbreviations: 95%CI, 95% confidence interval; ASA, American Society of Anesthesiologists; BMI, Body mass index.
Note: [#]Average time estimated by the model.

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Table 3 Association regarding the occurrence of postoperative complications and the variables of interest

	Proportion of patients with postoperative complications[#] (95%CI)	Odds ratio (95%CI)	*p*-value
Gender			
Female	7.2% (4.9%–10.5%)	0.688 (0.360–1.313)	0.256
Male	10.1% (6.4%–15.6%)	1.00	—
Age	—	1.000 (0.965–1.036)	0.998
Age by subgroup			
$\leq$ 59 years	11.4% (5.2%–23.2%)	1.00	—
60 to 69 years	5.9% (3.2%–10.7%)	0.486 (0.167–1.413)	0.185
70 to 79 years	8.1% (5.2%–12.5%)	0.684 (0.258–1.813)	0.444
$\geq$ 80 years	11.7% (6.0%–21.7%)	1.026 (0.334–3.153)	0.965
BMI (kg/m^2)	—	0.992 (0.925–1.064)	0.830
BMI by subgroup			
Low weight/Normal weight	9.0% (4.6%–16.9%)	1.00	—
Overweight	8.8% (5.6%–13.6%)	0.975 (0.410–2.316)	0.954
Grade-1 obesity	5.7% (3.0%–10.7%)	0.609 (0.226–1.638)	0.325
Grade-2 obesity	11.0% (4.2%–25.7%)	1.239 (0.352–4.354)	0.738
Arterial hypertension			
No	7.7% (5.1%–11.4%)	1.00	—
Yes	8.7% (5.7%–13.1%)	1.146 (0.606–2.167)	0.674
Diabetes mellitus			
No	7.6% (5.5%–10.6%)	1.00	—
Yes	10.7% (5.7%–19.3%)	1.459 (0.672–3.170)	0.339
Behavioral disorders			
No	7.9% (5.8%–10.9%)	1.00	—
Yes	9.3% (4.3%–18.9%)	1.183 (0.482–2.899)	0.714
Smoking			
No	8.2% (6.1%–11.0%)	1.00	—
Yes	6.7% (1.1%–32.6%)	0.803 (0.116–5.557)	0.824
Previous cancer diagnosis			
No	8.2% (6.1%–11.1%)	1.00	—
Yes	6.7% (1.8%–21.6%)	0.800 (0.200–3.205)	0.752
Heart Disease			
No	8.0% (5.8%–10.9%)	1.00	—
yes	9.2% (4.0%–20.1%)	1.174 (0.446–3.091)	0.745
Grade on the ASA classification			
I	8.2% (2.7%–21.9%)	1.00	—
II	7.3% (5.1%–10.1%)	0.879 (0.263–2.936)	0.834
III	20.6% (10.1%–37.4%)	2.920 (0.707–12.068)	0.138
Operative time	—	1.517 (0.987–2.331)	0.057

Abbreviations: 95%CI, 95% confidence interval; ASA, American Society of Anesthesiologists; BMI, Body mass index.
Note: [#]Average time estimated by the model.

center in Latin America, we had few events of complications during the study period; in addition, the profile of the cases in the present study consists mostly of patients without comorbidities or with well-controlled comorbidities, with a low number of smokers, for example, something that may have influenced this finding.

The present study is not without limitations. First, it is a retrospective analysis of a database. Thus, some clinical information, such as operative details, blood transfusion, and rehabilitation protocol, was not completely available. Furthermore, the present study was performed in a private hospital, and this may have implications for the generalization of our findings. Finally, the data reflect the work of a small number of surgeons, and the observed pattern of care may only represent orthopedic practices in a given healthcare system. On the other hand, the present study has important clinical relevance as it provides information to the orthopedic community that can refine the understanding of the risk factors related to increased hospital LOS in patients undergoing primary TKA.

Conclusions

The present study demonstrated that preoperative characteristics such as age $>$ 80 years, grade $\geq$ III on the ASA classification, and the development of postoperative complications are considered predictors of increased hospital LOS. Among these factors, the presence of postoperative complications demonstrated the greatest risk for prolonged LOS.

Conflict of Interests
The authors have no conflict of interests to declare.

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