Predictors of postoperative hospital length of stay after total knee arthroplasty

Davide Tornese[1], MD, Alessandro Robustelli[2], MD, Gabriele Ricci[1], MD, Paola Maria Vittoria Rancoita[3], PhD, Nicola Maffulli[4,5,6], MD, PhD, Giuseppe Michele Peretti[7,8], MD

[1]Center for Sports Rehabilitation, IRCCS Istituto Ortopedico Galeazzi, Milan, Italy, [2]Residency Program in Physical Medicine and Rehabilitation, University of Milan, Milan, Italy, [3]University Centre for Statistics in the Biomedical Sciences, Vita-Salute San Raffaele University, Milan, Italy, [4]Faculty of Medicine and Psychology, University of Rome La Sapienza, Rome, Italy, [5]School of Pharmacy and Bioengineering, Keele University School of Medicine, Stoke-on-Trent, England, [6]Queen Mary University of London, Barts and The London School of Medicine and Dentistry, Centre for Sports and Exercise Medicine, Mile End Hospital, London, England, [7]University Equipe of Regenerative and Reconstructive Orthopaedics (EUORR), IRCCS Istituto Ortopedico Galeazzi, Milan, Italy, [8]Department of Biomedical Sciences for Health, Università degli Studi di Milano, Milan, Italy

Abstract

Introduction: We aimed to collect and analyse clinical and functional variables of patients undergoing rehabilitation after total knee arthroplasty (TKA), to identify the variables that influence the postoperative hospital length of stay (LOS).

Methods: We conducted a retrospective analysis of prospectively collected data of 1,082 consecutive patients (746 females and 336 males) who underwent primary TKA and rehabilitation in our orthopaedic institute between January 2013 and July 2017. Clinical and anthropometric data were analysed using a multivariate linear regression model.

Results: The average LOS was 5.08 ± 2.52 days in the Department of Orthopaedic Surgery and 12.67 ± 5.54 days in the Sports Rehabilitation Unit. Factors such as age, female sex and the presence of comorbidities were predictive of a longer stay. The presence of caregiver assistance at home was associated with shorter LOS. There was no evidence of a statistically significant positive association between body mass index and LOS.

Conclusion: An in-depth and early knowledge of factors that influence LOS may enable the multidisciplinary team to plan a patient-tailored rehabilitation path and better allocate resources to maximise patients' functional recovery, while reducing LOS and the overall cost of the procedure.

Keywords: Fast-track surgery, length of stay, predictors, rehabilitation, total knee arthroplasty

INTRODUCTION

Osteoarthritis is the most common osteoarticular degenerative disease in the adult population, especially among the elderly.[1] The knee is the most commonly affected joint in the lower limb.[1,2] The prevalence and social and economic impact of gonarthrosis are constantly rising in industrialised countries.[2] This condition involves a progressive loss of articular function and a consequent impairment in the patient's quality of life, gradually compromising the working capacity and ability to perform activities of daily living (ADL).

Total knee arthroplasty (TKA) is usually performed as an elective procedure. It is a safe and effective treatment for advanced knee osteoarthritis that is refractory to conservative therapies.[3,4] According to the Italian Arthroplasty Registry (Registro Italiano ArtroProtesi) database,[5] TKA is the second most frequent elective procedure of total joint replacement in Italy. In 2017, 20,656 primary TKAs were performed, accounting for 80.9% of all knee arthroplasties performed in Italy.[5]

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Correspondence: Prof. Giuseppe Michele Peretti, Professor, University Equipe of Regenerative and Reconstructive Orthopaedics (EUORR), IRCCS Istituto Ortopedico Galeazzi, Via R. Galeazzi 4, 20161 Milan, Italy.
E-mail: giuseppe.peretti@unimi.it

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Due to a constant increase in total joint replacement procedures over the last few decades,[6] reduction of hospital length of stay (LOS) has increasingly become a priority, both to favour patients' recovery and to contain costs. Shorter LOS may lower the risk of nosocomial infections[7] and reduce the overall costs associated with the procedure; the resources used for inpatient rehabilitation account for more than half of the total cost of a TKA procedure.[8,9] In this sense, the implementation of early recovery after surgery or fast-track[10-14] protocols (which include reduced anaesthesia and operating times, careful fluid management and analgesia, and early patient mobilisation[12,15]) has recently led to a significant reduction in the average postoperative LOS. Some other factors, such as the patient's age, sex and preoperative clinical and functional status may well influence LOS and the long-term functional recovery,[9,13,16-22] while the role of other factors, such as body mass index (BMI), remains controversial.[2,23-27]

This study aimed to collect and analyse relevant clinical and functional variables of patients undergoing inpatient rehabilitation after TKA, and to identify the variables that could affect postoperative LOS. To achieve this aim, data were analysed using a multiple median regression model. An in-depth and early knowledge of these factors may enable orthopaedic surgeons, physiatrists and the multidisciplinary team to implement a more personalised rehabilitation path, leading to better allocation of resources, which will maximise the patient's functional recovery and reduce the overall LOS and total cost of the TKA procedure.

METHODS

We conducted a retrospective analysis of prospectively collected data of 1,082 patients (746 females and 336 males), who underwent TKA at IRCCS Orthopaedic Institute Galeazzi, Milan and were subsequently hospitalised in the Sports Rehabilitation Unit between January 2013 and July 2017. Data collection was performed in accordance with STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines, and the investigations were carried out following the rules of the Declaration of Helsinki of 1975, revised in 2013. Patients with a diagnosis of gonarthrosis, at least grade 2 according to the Ahlbäck classification,[28] who had undergone primary unilateral TKA were included in the study. We excluded patients who had undergone unicompartmental knee arthroplasty, simultaneous bilateral TKA, previous contralateral TKA performed in our institution, and revision procedures.

Data were collected primarily by analysing the medical record and the discharge letter of each patient. Our database was constructed by extrapolating: (a) sociodemographic variables such as age, sex, BMI and the presence of a caregiver at home; (b) comorbidities at hospital admission; and (c) surgical and rehabilitation factors, including time to inpatient rehabilitation admission, LOS in the rehabilitation unit, origin of surgical team and postoperative complications (i.e., the need for blood transfusions). Finally, we considered the scores achieved by the patients on entry and discharge from the rehabilitation unit, based on two functional evaluation scales: the functional independent measure (FIM)[29] and the modified Barthel index (MBI),[30] capturing the patient's care burden and ADL performance, respectively.

All patients underwent cemented posterior stabilised TKA, performed by four different surgical teams. The physiotherapy treatment, which was provided for 1 h per day for 6 days a week, started from the first postoperative day and included passive and active assisted range of motion (ROM) exercises, isometric and isoinertial exercises to strengthen the lower limb muscles (in particular, the knee flexors and extensors, gluteus muscles, and evertor and invertor ankle muscles), stretching and proprioceptive training, postural transition and walking aids training, stair climbing exercises and illustration of home rehabilitation education programmes. The rehabilitation programme also included the use of continuous passive motion[31] machines for 1 h per day.

Patients were discharged when they met the following conditions: (a) stability of haematological and blood chemistry parameters (haemoglobin and inflammatory markers); (b) knee ROM recovery (at least 90° of flexion and 0° of extension); (c) acceptable muscle strength recovery; (d) evidence of uncomplicated surgical wound healing; (f) autonomy in postural transitions/transfers and walking with aids; and (e) improvement of ADL performance, as quantified by the MBI and FIM scales (MBI >75 or 30% increase and FIM >90 or 10% increase, as compared to the score during hospitalisation).

Categorical variables are reported as absolute and relative frequencies. Numeric variables are presented as mean and standard deviation, as well as median, first (Q1) and third (Q3) quartiles, given the asymmetric distribution of some variables and the presence of outliers. For the same reason, comparisons between LOS were conducted using Kruskal–Wallis test (*post hoc* analysis conducted with Dunn test with Bonferroni correction for multiple comparisons) and multiple regression analysis for LOS prediction was conducted using a median regression model (included in the R quantreg package). Total LOS and LOS in the rehabilitation unit were included separately in our multiple regression analysis using the backward selection method (setting P value < 0.05 for the tests made on coefficients) for selection of variables. The variables included in the model were sex (male vs. female), age (>70 vs. ≤70 years), BMI (≥25 vs. <25 kg/m^2) and home caregiver (present vs. absent). Comorbidities were included in the model, considering either their type or the number of co-occurring conditions for each patient. All analyses were performed using R version 3.5.0.

RESULTS

There were 1,082 subjects (746 [69%] females and 336 [31%] males) in the study. The sociodemographic variables considered and the average scores on the MBI and FIM scales at entry and discharge are shown in Table 1. Table 2 presents the major comorbidities of patients at hospital admission.

The average LOS was 5.08 ± 2.52 (median [interquartile range] 4 [3–6]) and 12.67 ± 5.54 (12 [9–14]) days in the Department of Orthopaedic Surgery and Sports Rehabilitation Unit, respectively; the total postoperative LOS was 17.75 ± 5.78 (17 [15–20]) days. There was no statistically significant difference in the length of rehabilitation time or total LOS according to the surgical team that performed the TKA procedure.

During the stay at the rehabilitation unit, 42 (3.7%) patients underwent blood transfusion; of these, 18 (1.6%) patients required more than one unit, resulting in a total of 66 transfused bags. The most frequently reported complication was urinary tract infection in 94 (8.5%)patients. Other relevant complications were respiratory complications (acute bronchitis, pneumonia or chronic obstructive pulmonary disease exacerbations) in 21 (1.9%) patients, diarrhoea in 11 (1%) patients, acute urinary retention in four (0.4%) patients, two (0.2%) episodes of severe paroxysmal hypertension, two (0.2%) patients with acute deep vein thrombosis, three (0.3%) patients with damages to the external popliteal nerve and three (0.3%) patients who needed knee manipulation under anaesthesia for postoperative stiffness.[32]

Based on multivariate median regression analysis, we identified the variables associated with the patient's LOS, defined as 'LOS in rehabilitation unit' and 'Total postoperative LOS' [Table 3]. Patients were divided into three groups depending on the number of comorbidities presented at admission ('0', '1' or '>1') and classified based on the type of comorbidity encountered (i.e. heart diseases, metabolic disorders, hypertension, etc.). The 'Intercept' coefficient represents the median LOS calculated for all patients included in the study, while all other coefficients indicate the difference between the median LOS of each subgroup and the 'Intercept' value. The variables that did not show a statistically significant correlation with the overall LOS are not reported.

Regression analysis performed in consideration of the number of comorbidities [Table 3] showed that older age ($P < 0.001$), female sex ($P = 0.003$) and the presence of comorbidities ($P = 0.02$) were significantly associated with a longer LOS, whereas BMI ≥25 kg/m^2 ($P < 0.001$) and the presence of caregiver assistance at home ($P = 0.002$) were associated with shorter LOS. In addition, regression analysis performed in consideration of the type of comorbidities [Table 3] confirmed the association of older age ($P < 0.001$) and female sex ($P < 0.001$) with a longer LOS, and showed that patients with heart diseases ($P = 0.04$) had prolonged LOS, while patients with arterial hypertension ($P < 0.001$) and patients with caregiver assistance ($P < 0.001$) had shorter LOS.

Table 1. Sociodemographic variables and functional scores of patients who underwent primary TKA and inpatient rehabilitation.

Variable	Mean±SD	Median [IQR]
Age (yr)	69.93±8.73	70.9 [65.32–76]
BMI (kg/m^2)	29.05±4.83	28.6 [25.8–31.6]
Modified Barthel index		
Admission	71.72±13.34	74 [65–82.75]
Discharge	96.03±4.95	97 [95–99]
Improvement	24.27±12.23	22 [14–32]
FIM score[a]		
Admission	98.78±12.19	100 [91–109]
Discharge	118.02±5.82	119 [116–121]
Improvement	19.23±10.33	18 [10–26]
Gender[b]		
Male	336 (31)	
Female	746 (69)	
Caregiver[b]		
Yes	837 (77)	
No	245 (23)	

[a]Functional scores were collected at both admission and discharge from the inpatient rehabilitation unit. [b]Data presented as *n* (%). BMI: body mass index, FIM: functional independent measure, IQR: interquartile range, SD: standard deviation, TKA: total knee arthroplasty

Table 2. Major comorbidities at hospital admission of patients who underwent primary TKA and inpatient rehabilitation.

Comorbidity	*n* (%)
Arterial hypertension	645 (60)
Vasculopathies (arterial aneurysm, peripheral artery disease, chronic venous insufficiency, previous deep vein thrombosis, previous saphenectomy)	256 (24)
Metabolic disorders (type 2 diabetes mellitus, dyslipidaemia, hyperuricaemia)	194 (18)
Heart diseases (ischaemic heart disease, previous myocardial infarction, coronary angioplasty, heart failure NYHA class II or higher, hypertensive heart disease, moderate or severe valvular heart disease, heart conduction or rhythm disorders, implantable cardiac devices)	153 (14)
Other orthopaedic or rheumatic conditions (rheumatoid arthritis, psoriatic arthritis, osteoporosis)	82 (8)
Respiratory diseases (COPD, asthmatic bronchitis, restrictive lung disease, OSAS treated with CPAP, pulmonary lobectomy)	73 (7)
Neurological conditions (stroke, Parkinson's disease or parkinsonism, poliomyelitis sequelae, radiculopathies, peripheral sensory or motor neuropathies, common peroneal nerve dysfunction)	57 (5)

COPD: chronic obstructive pulmonary disease, CPAP: continuous positive airway pressure, NYHA: New York Heart Association; OSAS: obstructive sleep apnoea syndrome, TKA: total knee arthroplasty

Table 3. Multiple median regression analysis of LOS with number and type of comorbidities in patients who underwent primary TKA and inpatient rehabilitation.

Variable	LOS in rehab unit (day)	*P*	Total postop (day)	*P*
No. of comorbidities				
(Intercept)	13	<0.001	18	<0.001
Age >70 yr (vs. ≤70 yr)	+1	<0.001	–	–
Male (vs. female)	−1	0.003	−1	0.005
Presence of home caregiver	−1	0.002	−1	0.01
BMI ≥25 (vs. <25)	−1	<0.001	−1	0.01
1 comorbidity (vs. 0)	–	–	+1	0.02
>1 comorbidity (vs. 0)	–	–	+1	0.02
Type of comorbidities			–	
(Intercept)	13	<0.001	17	<0.001
Male (vs. female)	−1	0.005	−1	<0.001
Age>70 yr (vs. ≤70 yr)	+1	<0.001	+1	<0.001
Presence of caregiver	−1	0.005	−1	<0.001
Heart diseases	+1	0.005	+2	0.004
Arterial hypertension	−1	<0.001	–	–

Note: The 'Intercept' coefficient represents the median LOS calculated on all patients included in the study, while all other coefficients indicate the difference between the median LOS of each subgroup and the 'Intercept' value. The variables that did not show a statistically significant (P>0.05) correlation with the overall LOS are not reported. BMI: body mass index, LOS: length of stay, TKA: total knee arthroplasty

DISCUSSION

Several studies analysed the factors influencing patient's recovery time following TKA, in terms of postoperative LOS, the onset of complications, the extent and quality of functional recovery or the rehabilitation pathways.[9,16,20,22,23,33-39] Nonetheless, only a few investigations have included samples of size and homogeneity comparable to those included in the present study.[18,21,22,33]

We analysed data collected from 1,082 consecutive patients with a primary diagnosis of knee osteoarthritis who were treated in a single orthopaedic centre and underwent the same postoperative rehabilitation protocols. To ensure greater homogeneity, patients undergoing unicompartmental knee arthroplasty, simultaneous bilateral TKA or any revision surgery were excluded from the study, so that different surgical procedures and postoperative courses would not affect the clinical relevance of our analysis.

Moreover, this study included several major comorbidities that may influence the postoperative course. The available literature does not report a 'gold standard' for the evaluation of comorbidities,[40] and different scoring systems are used. The most commonly used are the Charlson Comorbidity Index (CCI) and the American Society of Anesthesiologists (ASA) score.[13,35,38] However, these scoring systems have some limitations. Although widely used, the ASA score does not include all morbid conditions and shows only moderate interoperator reliability.[41,42] Similarly, even though CCI is an excellent mortality predictor in life-threatening conditions, it does not have the same prognostic value in low-risk conditions such as in elective TKA patients.[43] For these reasons, as anticipated, our analysis included the comorbidities that can potentially affect the postoperative course. Our study shows that patients with heart conditions experienced longer LOS, while hypertensive patients experienced shorter LOS in the rehabilitation unit.

Older age, female sex and the presence of comorbidities directly influence the overall LOS, prolonging postoperative LOS, in accordance with previous studies.[18-21,23,34] On the other hand, no statistical significance was detected when comparing a patient's overall LOS and the origin of the surgical team, potentially revealing a technical and procedural uniformity between the various teams working at the Galeazzi Institute. As evidenced in previous studies,[17,44] we observed shorter LOS in patients with caregiver assistance at home, emphasising the important role played by family and social conditions in the definition of rehabilitation process. A stable home environment, guaranteed by the presence of a caregiver, could favour early discharge and avoid potential organisational delays.

Being overweight is a widely recognised risk factor associated with lower limb osteoarthritis[2,45,46] and could negatively affect LOS. In this regard, the evidence is controversial: some studies reported that obesity or being overweight is potentially related to longer recovery after surgery,[23,27,37] while others failed to show such a correlation.[2,24-26,35] In our analysis, patients with higher BMI had shorter LOS (association seen only in the model that considered the number of comorbidities).

In addition, when analysing our findings and comparing them to the existing literature, we should consider the universal coverage of the Italian healthcare system, as opposed to that of other countries such as the USA. In particular, it should be

stressed that in the USA, most of the registry studies arise from insurance registries, introducing a fundamental bias in patient selection. However, in Italy, there is a free national healthcare system, and hence the patients included in our database came from all possible socioeconomic backgrounds. Likewise, we should also take into account the different postoperative regimens adopted by facilities in the USA and Italy. In the USA, only a small percentage of patients (generally those with greater comorbidities and worse functional status) are transferred to a rehabilitation facility after TKA, while most are usually discharged home a few days after surgery and are generally prescribed an outpatient rehabilitation programme. This is different in Italy, where patients are usually transferred to an inpatient rehabilitation facility and discharged only when they have reached a greater functional status and are able to perform the majority of ADL without assistance. Indeed, this postoperative regimen was implemented in our setting, where patients who had undergone TKA were transferred to the hospital's rehabilitation unit after being discharged from the Department of Orthopaedic Surgery.

The present data have been used to support for a new postoperative regimen, which involved a drastic reduction in the average LOS after TKA. Since 2018, an accurate biopsychosocial assessment was performed at the prehospitalisation evaluation, identifying subjects suitable for early discharge without the need for inpatient rehabilitation. The data collected have contributed to the definition of the early recovery after surgery pathway currently adopted at the institute, with the ultimate aim of reducing LOS and the rate of complications, while optimising the allocation of professional and economic resources.

This study is not without limitations. The first limitation is the retrospective design of our study; however, we have mitigated this with a meticulous data recording and extraction process. Second, our data analysis had excluded some factors that may potentially affect LOS, such as preoperative use of walking aids, preoperative haemoglobin level, postoperative day of mobilisation, as well as operative procedures and perioperative complications.

In conclusion, the study has identified factors that may predict hospital LOS after TKA. The variables considered could be easily collected at prehospitalisation and may be useful to define a patient-tailored rehabilitation path and for better optimisation of costs and resources. Therefore, this study could provide reference for future research on the cost-effectiveness of total joint replacement procedures and may lead to the identification of other predicting factors and help refine preoperative patient assessment.

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Conflicts of interest

There are no conflicts of interest.

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