

ABSTRACT

Introduction: To collect and analyse clinical and functional variables of patients undergoing rehabilitation after total knee arthroplasty (TKA), in order to identify which amongst them could influence the post-operative length of hospital 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 Orthopedic 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 Orthopedic Surgery, and 12.67 ± 5.54 days in the Rehabilitation Unit. 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 BMI and LOS.

Conclusion: An in-depth and early knowledge of these factors may enable the whole multidisciplinary team to plan a patient-tailored rehabilitation path and a better allocation of resources to maximize 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 amongst 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, refractory to conservative therapies.^(3,4) According to the Italian Arthroplasty Registry (Registro Italiano ArtroProtesi - RIAP) database,⁽⁵⁾ TKA is the second most frequent elective procedure of total joint replacement in Italy. In 2017, 20,656 primary TKA were performed, accounting for 80.9% of all knee arthroplasties performed in Italy.⁽⁵⁾

As a result of the constant increase of total joint replacements procedure over the last few decades,⁽⁶⁾ the reduction of hospital length of stay (LOS) is increasingly becoming a priority, both to favour patients' recovery and to contain costs. Shorter hospital stays may lower the risk of nosocomial infections,⁽⁷⁾ and may also reduce the overall costs associated to 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 (ERAS) or fast track⁽¹⁰⁻¹⁴⁾ protocols (which include, for instance, 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 post-operative length of stay. Some other factors, such as the patient's age, sex and pre-operative clinical and functional status, may well influence the length of stay and the long-term functional recovery,^(9,13,16-22) whilst the role of other factors (i.e. BMI) remains controversial.^(2,23-27)

The present study collected and analysed relevant clinical and functional variables of patients undergoing inpatient rehabilitation after TKA, to identify which could affect the post-operative LOS. To 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 whole multidisciplinary team to implement a more personalized rehabilitation path and a consequent better allocation of resources, maximising the patient's functional recovery and reducing the overall hospital stay and the total cost of a TKA procedure.

METHODS

We conducted a retrospective analysis of prospectively collected data on a sample of 1,082 patients (746 females and 336 males) undergoing total knee arthroplasty at the IRCCS Orthopedic Institute Galeazzi in Milan, and subsequently hospitalized in the Sports Rehabilitation Unit, in the period between January 2013 and July 2017. Data collection was performed in accordance with the 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. The inclusion criteria were: patients with diagnosis of gonarthrosis at least grade 2 according to the Ahlbäck classification⁽²⁸⁾ who had undergone primary unilateral TKA. 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 (1) socio-demographic variables such as age, sex, BMI, and the presence of a caregiver at home, (2) comorbidities at hospital admission, (3) surgical and rehabilitation factors, including time to inpatient rehabilitation admission, length of stay in the rehabilitation unit and overall, surgical team of origin, post-

operative 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, respectively, the patient's care burden and ADL performance.

All patients underwent cemented posterior stabilised total knee arthroplasty, performed by four different surgical teams. The physiotherapy treatment, consisting in one hour a day for 6 days a week, was undertaken starting from the first post-operative 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, the gluteus muscles and the evertor and invertor ankle muscles), stretching and proprioceptive training, postural transition and walking aids training, stair walking exercises, and illustration of home rehabilitation education programs. The rehabilitation program also included the use of continuous passive motion (CPM)⁽³¹⁾ machines for one hour a day.

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

Categorical variables are reported with absolute and relative frequencies. Numeric variables are presented with mean and standard deviation, as well as median, first (Q1) and third (Q3) quartile, given the asymmetric distribution of some variables and the presence of outliers. For the same reason, comparisons between LOS have been 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 has been conducted using a median regression model (included in the R `quantreg` package). Total LOS and LOS in Rehabilitation Unit have been included separately in our multiple regression analysis, using the backward selection method (setting p value <0.05 for the tests made on coefficients) for variables selection. The variables included in the model were: sex (male vs female), age (>70 years vs ≤ 70 years), BMI (≥ 25 vs <25) 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 3.5.0 software.

RESULTS

Our population included 1,082 subjects: 746 females (69%) and 336 males (31%). The socio-demographic variables considered, and the average scores on the MBI and FIM scale at entry and discharge are shown in Table I. Table II presents the major comorbidities registered at hospitalisation.

The average length of hospital stay was 5.08 ± 2.52 days (median [Q1-Q3]: 4 [3-6]) in the Department of Orthopedic Surgery, 12.67 ± 5.54 days (median [Q1-Q3]: 12 [9-14]) in the Rehabilitation Unit, and of 17.75 ± 5.78 days (median [Q1-Q3]: 17 [15-20]) for the total post-operative hospital stay. There was no statistically significant difference in length of rehabilitation time or total LOS according to the surgical team which performed the TKA procedure.

During their stay at the Rehabilitation Unit, 42 patients (3.7% of total patients) underwent blood transfusion, with 18 of them (1.6%) requiring more than one unit, for a total of 66 transfused bags. The most frequently reported complication was a urinary tract infection (UTI) in 94 patients (8.5%). Other relevant complications were: respiratory complications

(acute bronchitis, pneumonia or COPD exacerbations) in 21 patients (1.9%), diarrhoea in 11 patients (1%), acute urinary retention in 4 patients (0.4%), 2 episodes of severe paroxysmal hypertension (0.2%), 2 patients with acute deep vein thrombosis (0.2%), 3 damages to the external popliteal nerve (0.3%), 3 patients who needed knee manipulation under anaesthesia for post-operative stiffness (0.3%).⁽³²⁾

By computing a multivariate median regression analysis, we identified which variables were associated to the patient's LOS, defined as "LOS in Rehabilitation Unit" and "Total post-operative LOS" (Tables IIIa and IIIb). In Table IIIa, patients have been divided into three groups, depending on the number of comorbidities presented at admission ("0", "1" or "> 1"), whilst in Table IIIb, patients have been classified based on the type of comorbidity encountered (i.e. heart diseases, metabolic disorders, hypertension, etc.). 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 correlation with the overall LOS were not reported.

Regression analysis made considering the number of comorbidities (Table IIIa) found 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 a $BMI \geq 25$ ($p < 0.001$), and the presence of caregiver assistance at home ($p = 0.002$) were associated with shorter LOS. In addition, regression analysis made considering the type of comorbidities (Table IIIb) 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 hospital stays, while patients with arterial hypertension ($p < 0.001$) and patients with caregiver assistance ($p < 0.001$) reported shorter LOS.

DISCUSSION

Several studies analysed the factors influencing the patient's recovery time following a TKA, either in terms of the post-operative LOS, the onset of complications, the extent and quality of functional recovery and the rehabilitation pathways.^(9,16,20,22,23,33-39) Nonetheless, only few investigations include samples of size and homogeneity comparable that the one reported in the present study.^(18,21,22,33)

We analysed data collected on 1,082 consecutive patients with a primary diagnosis of knee osteoarthritis, treated in a single orthopaedic centre and undergoing the same post-operative 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 post-operative courses would not affect the clinical relevance of our analysis.

Moreover, the present study includes several major comorbidities that may influence the post-operative 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) which however have some limitations. The latter, although widely used, does not include all morbid conditions, and only shows moderate inter-operator reliability;^(41,42) the former, even though an excellent mortality predictor in life-threatening conditions, does not have the same prognostic value in low-risk conditions such as elective TKA patients.⁽⁴³⁾ For these reasons, as anticipated, our analysis included the comorbidities that can potentially affect the post-operative course. Our study shows that patients with heart conditions experienced longer hospital stays, while hypertensive patients experienced shorter stays in Rehabilitation Unit.

Older age, female sex and the presence of comorbidities directly influence the overall LOS, prolonging post-operative hospital stay, 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 surgical team of origin, 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 hospital stays in patients with caregiver assistance at home, emphasizing the important role played by family and social conditions in the definition of the rehabilitation process. A stable home environment, guaranteed by the presence of a caregiver, could favour early discharge and avoid potential organisational delays.

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

In addition, when analysing our findings, and especially when comparing them to the existing literature, we should consider the universal coverage of the Italian healthcare system, as opposed, for example, to the one in the US. In particular, it should be stressed that in the US most of the registry studies arise from insurance registries, introducing a fundamental bias in patient selection. In Italy, on the contrary, there is a free national healthcare system, hence the patients included in our database come from all possible socio-economic backgrounds. Likewise, we should also take into account the different post-operative regimens adopted in US facilities compared to the ones implemented in Italy. In fact, in the US, only a small percentage of patients (generally those with greater comorbidities and worse functional status)

is 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 does not occur in Italy, where patients are usually transferred to an inpatient rehabilitation facility and discharged only once they have reached a greater functional status and they are able to perform the majority of ADL without assistance. This is indeed implemented in our setting, where patients undergoing a TKA are usually transferred to the hospital's Acute Rehabilitation Unit after being discharged from the Orthopedic Surgery Department.

The present data have been used as support for a new post-operative regimen, which involved a drastic reduction in the average LOS after TKA. Since 2018, in fact, an accurate biopsychosocial assessment was performed at the pre-hospitalisation evaluation, identifying subjects suitable for early discharge without need for inpatient rehabilitation. The data collected have contributed to define the ERAS path currently adopted at the Institute, with the ultimate aim of reducing hospitalisation times and the rate of complications, while optimising the allocation of all professional and economic resources.

This work is not without limitations. The first is the retrospective design of the study. However, our data keeping was meticulous, as was the data extraction process. Second, some factors potentially affecting LOS, such as preoperative use of walking aids, preoperative haemoglobin level, postoperative day of mobilisation, as well as operative procedures and perioperative complications, were not included in the analysis.

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

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Table I. Socio-demographic variables and functional scores^a of patients who underwent primary TKA and inpatient rehabilitation at the IRCCS Orthopedic Institute Galeazzi, Milan between January 2013, and July 2017

	Mean (SD)	Median [Q1 - Q3]	
Age (years)	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			
Admission	98.78 (12.19)	100 [91-109]	
Discharge	118.02 (5.82)	119 [116-121]	
Improvement	19.23 (10.33)	18 [10-26]	
	N. of patients		
Males	336 (31%)		
Females	746 (69%)		
Caregiver			
Yes	837 (77%)		
No	245 (23%)		

^aFunctional scores were collected at both admission and discharge from the inpatient rehabilitation unit. BMI: body mass index; FIM: Functional Independent Measure; MBI: Modified Barthel Index; Q1-Q3: interquartile range

Table II. Major comorbidities at hospital admission of patients who underwent primary TKA and inpatient rehabilitation at the IRCCS Orthopedic Institute Galeazzi, Milan between January 2013, and July 2017

	N. of patients (% of total)
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, dyslipidemia, hyperuricemia)	194 (18%)
Heart diseases (ischemic 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 Orthopedic 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 apnea syndrome.

Table IIIa. Multiple median regression analysis of LOS of patients who underwent primary TKA and inpatient rehabilitation at the IRCCS Orthopedic Institute Galeazzi, Milan between January 2013, and July 2017. Analysis made considering the number of comorbidities^a

LOS in Rehabilitation Unit			Total post-operative LOS		
	Days	P value		Days	P value
(Intercept)	13	<.001	(Intercept)	18	<.001
Age >70 years (vs ≤70 years)	+1	<.001	Male (vs female)	-1	.005
Male (vs female)	-1	.003	Presence of home caregiver	-1	.01
Presence of home caregiver	-1	.002	1 comorbidity (vs 0)	+1	.02
BMI ≥ 25 (vs <25)	-1	<.001	>1 comorbidity (vs 0)	+1	.02
			BMI ≥ 25 (vs <25)	-1	.01

^aThe "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 ($P > .05$) correlation with the overall LOS were not reported.

BMI: body mass index; LOS: length of stay; TKA: total knee arthroplasty

Table IIIb. Multiple median regression analysis of LOS of patients who underwent primary TKA and inpatient rehabilitation at the IRCCS Orthopedic Institute Galeazzi, Milan between January 2013, and July 2017. Analysis made considering the type of comorbidities^a

LOS in Rehabilitation Unit			Total post-operative LOS		
	Days	P value		Days	P value
(Intercept)	13	<.001	(Intercept)	17	<.001
Male (vs female)	-1	.005	Male (vs female)	-1	<.001
Age >70 years (vs ≤70 years)	+1	<.001	Age >70 years (vs ≤70 years)	+1	<.001
Presence of caregiver	-1	.005	Presence of caregiver	-1	<.001
Heart diseases	+1	.005	Heart diseases	+2	.004
Arterial hypertension	-1	<.001			

^aThe "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 ($P > .05$) correlation with the overall LOS were not reported.

BMI: body mass index; LOS: length of stay; TKA: total knee arthroplasty