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Predictive factors of length of hospital stay after primary total knee arthroplasty

Lotte van den Belt · Peter van Essen · Petra J. C. Heesterbeek · Koen C. Defoort

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Abstract
Purpose To reduce post-operative length of hospital stay (PLOS) after primary total knee arthroplasty (TKA), the fast-track method was introduced which focusses on mobilising the patient within 2 h after surgery. The aim of this prospective study was to identify the factors that predict PLOS using the fast-track method.
Methods In a consecutive series from July 2012 to November 2012, all patients who were admitted for a primary TKA (Genesis II prosthesis, Smith and Nephew, Memphis, TN) were included in a prospective study. Demographic and relevant preoperative, perioperative and post-operative parameters for PLOS were collected. Multivariate linear regression analysis was performed to identify predictive factors.
Results In total, 240 patients were included (59.6 % female) with a median age of 64.1 years (range 38–90). Median PLOS was 5 days (range 3–19). The predictive model suggested that ASA score (American Society of Anesthesiologists' physical status classification) wound exudate and range of motion (ROM) at the day of surgery (day 0) were significant predictive factors for PLOS using the fast-track procedure after TKA (adjusted $R^2 = 0.43$).
Conclusions Predictive factors for PLOS after TKA were ASA score, wound exudate and ROM at day 0. Adjustments in patient counselling, nursing ward, mode of physiotherapist training and discharge criteria regarding wound exudate may result in a further reduction of post-operative length of hospital stay.
Level of evidence Prognostic studies: high-quality prospective cohort study, Level I.

Keywords Post-operative length of stay · Fast-track · Predictive factors · Total knee arthroplasty · ASA score · Range of motion

L. van den Belt (✉) · K. C. Defoort
Department of Orthopedics, Sint Maartenskliniek, Hengstdal 3, 6574 NA Nijmegen, The Netherlands
e-mail: l.vanderbelt@maartenskliniek.nl

P. van Essen · P. J. C. Heesterbeek
Department of Research, Sint Maartenskliniek, Hengstdal 3, 6574 NA Nijmegen, The Netherlands

Introduction

Previous studies showed that an optimised and quick surgical procedure together with fast patient mobilisation results in a reduction of perioperative complications and faster recovery of the patient [11, 16]. This fast-track method focusses on quick post-operative mobilisation using an adapted anaesthetic technique, faster physiotherapeutic treatment and adaptation of mindset [12, 14]. In orthopaedic surgery, this results in a more rapid functional recovery compared with conventional treatment [5, 20]. The patient recovers faster from the stress catabolism that can appear during surgery. In studies by Ho and Kehlet, the fast-track procedure resulted in a post-operative length of hospital stay (PLOS) of 3–4 days and less complications [10, 16].

The fast-track method also enables an increase in the number of surgeries that can be performed in hospitals [27]. Together with a shorter PLOS, this can lead to significant cost savings [9]. Bearing in mind that the elderly population is predicted to increase, the number of total knee arthroplasties (TKAs) will grow [27]. Therefore, the need for cost reduction is an important issue as well.

Previous studies showed that the following parameters affect the PLOS: age, sex, American Society of Anesthesiologists' physical status classification (ASA), body mass index (BMI), diagnosis, preoperative pain medication, co-morbidity, preoperative use of walking aids, pre- and post-operative haemoglobin levels, the need for blood transfusion, day of surgery, surgeon, functional scores and time between surgery and mobilisation [7, 12, 14, 15, 26, 27]. An additional factor that may also be expected to affect PLOS is smoking, due to its negative effect on wound healing [18]. The fast-track method in our hospital was also introduced with the aim to reduce PLOS to a mean of 4 days with equal or higher quality of care. To find starting points for further reduction of the PLOS in the future, we studied a consecutive series of 240 patients admitted for TKA to identify all predictive factors for PLOS in combination with the fast-track method for primary TKA.

Material and methods

Between July 2012 and November 2012, all patients admitted for primary unilateral TKA in our hospital were enrolled in this study consecutively. Most patients were female (59.6 %), and the median age was 64.1 years (range 38–90 years).

All TKAs were performed by seven experienced orthopaedic surgeons, and their residents using a midline incision with a median parapatellar quadriceps-splitting approach. These seven surgeons are all staff of the knee reconstruction unit. They worked following the same steps during surgery. Some data collection was performed by the surgeons and their residents, but mainly by an independent researcher. Approximately 30 min before surgery, 2,000 milligrams of Cefazolin was administered intravenously. Routinely, 24 h post-operatively antibiotics were given. In case of increased infection risk (diabetes, rheumatoid arthritis), antibiotics were continued for 72 h intravenously. A tourniquet was applied. The implant used was the Genesis II knee prosthesis (Smith and Nephew, Memphis, TN). All implants were cemented with Palacos (Heraeus Kulzer Gmbh, Hanau, Germany). Patella resurfacing was performed at the discretion of the surgeon based on perioperative judgement of the amount of osteoarthritis of the patellofemoral joint. No drain was used. Post-operatively, all patients received multimodal pain control medication (Gabapentin 300–600 mg, Paracetamol 1,000 mg 4 times a day, Meloxicam 15 mg once a day and Oxycodone 10 mg in case of breakthrough pain). A compression bandage was used for 24 h after surgery [2]. During rehabilitation, the knee was cooled frequently with a liquid ice brace (Aircast, DJO Global, Vista, CA). In all cases, low molecular weight Heparin was given as prophylaxis for deep vein thrombosis.

Fast-track rehabilitation

In the fast-track treatment, patients were offered preoperative voluntary group information and an online "knee portal" that informed them prior to the treatment [12, 14, 27]. To enable rapid mobilisation, an adapted anaesthetic technique—a single-leg spinal anaesthetic (bupivacaine 0.5 % and glucose total 2 ml) with intra-operative high-volume local infiltration analgesia [LIA, 200 ml ropivacaine 0.2 % (50 + 150 ml with 0.75 ml adrenaline)]—was mostly used [8, 14]. The physiotherapist started within 2–3 h after surgery with a mobilisation programme [14, 17, 22]. When the patient was nauseous or dizzy, mobilisation was postponed until complaints were resolved sufficiently. The goal was to discharge the patient to home at day 4 after the surgery or any time earlier. The physiotherapist treated the patient twice a day, and self-exercises were shown. Outpatient physiotherapy was prescribed for all patients at discharge. The patients had to meet all of the following criteria before discharge:

- Transfers (lie down/sit, stay/sit and sit/walking) done independently.
- Safe and independent walking with walking aid.
- Safe and independent walking the stairs (if necessary in home situation).
- Flexion of the knee ≥60° (unforced), passive extension ±0° and strength of quadriceps ≥3 according to the Medical Research Council scale.
- Normal wound healing: dry wound or minimal wound leakage (<0.5 cm in the band-aid).
- Adequate pain control (NRS, numeric rating scale ≤5).

Data collection

Based on the previous literature, data that were collected included gender, age, BMI, ASA classification, smoking, ward, preoperative use of pain medication, type of anaesthesia, surgeon, preoperative haemoglobin percentage, weekday of surgery, surgery duration, blood loss, tourniquet duration, blood transfusion, use of patella prosthesis and the number of times physiotherapy was conducted before discharge [7, 12, 26, 27]. Pain score (NRS) and range of motion (ROM) were scored daily until patient discharge. A pilot study was performed with four patients to prevent logistic errors. Four case report forms were used to collect all data: (1) surgeon-reported operative data; (2) pain scores, pain medication and any use of anaesthesia; (3) knee function scores; and (4) general patient data from the electronic files. All patients were admitted on the day of surgery, and PLOS was recorded until discharge. The day of surgery was counted as day 0.

Table 1 Spearman's correlation coefficient between PLOS and continuous variables

	Mean	SD	Spearman's correlation coefficient (R_s)
Age (year)	64.1	8.8	0.23
BMI (kg/m^2)	29.2	5.4	0.23
Preoperative NRS pain (0–10)	5.4	2.4	0.05
Preoperative ROM (degrees)	115.0	14.5	−0.17
Perioperative ROM (degrees)	120.0	9.0	−0.32
Post-operative day 0 ROM (degrees)	62.4	16.3	−0.26
Post-operative day 1 ROM (degrees)	64.4	15.8	0.06
Operating time (min)	73.6	14.1	0.13
Blood loss (ml)	62.6	84.0	0.10
Tourniquet use (min)	56.0	14.1	−0.12
Post-operative NRS pain day 0	2.4	2.0	0.01
Post-operative NRS pain day 1	3.8	1.9	−0.06
Post-operative NRS pain day 2	2.7	1.6	0.12
Post-operative NRS pain day 3	2	1.6	0.30
Post-operative NRS pain day 4	1.6	1.7	0.36
Preoperative haemoglobin level men (8.5–11.0 mmol/l)	9.0	0.7	−0.07
Preoperative haemoglobin level women (7.5–10.0 mmol/l)	8.3	0.7	−0.10
Post-operative number of physiotherapy sessions	4.9	2.0	0.37

Mean and SD are also shown for all variables

The study was approved by the research committee of the Sint Maartenskliniek and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. According to Dutch law, no further institutional review board approval was necessary. All persons gave their informed consent prior to their inclusion in the study.

Statistical analysis

Based on the number of predictive factors, the sample size was estimated at 240 patients.

Spearman's correlation coefficients were calculated between PLOS and continuous variables. The nonparametric Wilcoxon signed-rank test (comparison of two groups) or Kruskal–Wallis test (comparison of 3 or more groups) was used to analyse categorical variables. To identify potential variables that could predict PLOS, a univariate logistic regression analysis was performed. Relevant variables ($R_s > 0.20$ or $R_s < -0.20$ for continuous data and $p \leq 0.05$ for categorical data in the univariate regression analysis) were included in the subsequent multivariate logistic regression analysis. A forward, stepwise selection method was used for this analysis. This procedure started with the independent variable that correlated the strongest with the dependent variable, PLOS, based on the univariate logistic regression analysis. Subsequently, the next independent variable was selected and added to the final model. All identified significant predictive variables (x) were then included in the logistic function that predicts PLOS: $\text{PLOS} = a + b_1x_1 + b_2x_2 \ldots b_kx_k$.

The level of statistical significance was set at $p \leq 0.05$. Data analysis was performed using the statistical software STATA 10.1 (StataCorp, College Station, TX).

Results

Of the 240 patients, 89 patients (37 %) were discharged within 4 days after surgery and 160 patients (66.7 %) within 5 days. Median PLOS was 5 days (3–19). Eighty patients stayed 6 days or longer. Median PLOS of this subgroup was 7 days (6–19). In the correlation analysis, no continuous variable showed a strong correlation with PLOS (Table 1). However, of the discrete variables, gender, ASA score, wound exudate and ward showed statistically significant differences in PLOS (Table 2). In the univariate regression analysis of PLOS, the variables ASA score, age, BMI, preoperative ROM, perioperative ROM, post-operative ROM at day 0, surgery duration, NRS pain scores from day 3 to 6, number of physiotherapeutic sessions, wound exudate and ward were all significant contributing factors. In the final multivariate linear regression model, the ASA score, post-operative ROM at day 0 and wound exudate remained significant with an adjusted R^2 of 0.43 (Table 3). No interacting variables or multi-collinearity was

Table 2 Relation between PLOS and categorical variables

	Patients (*N*)	Median PLOS (days)	Min	Max	*p* value
Gender					
Male	98	5	3	19	0.011
Female	142	5	3	14	
ASA classification					
ASA1	71	4	3	9	0.001
ASA2	141	5	3	19	
ASA3	28	6	4	16	
Smoking					
Yes	22	5	3	11	n.s.
No	218	5	3	19	
Wound exudate					
Yes	65	6	5	19	0.001
No	175	4	3	19	
Patella prosthesis					
Yes	160	5	3	19	n.s.
No	80	5	3	19	
Nausea					
Yes	20	5.5	4	8	n.s.
No	220	5	3	19	
Ward					
A	100	5	3	19	0.007
B	71	5	3	8	
C	69	5	3	11	
Anaesthetic type					
Spinal	211	5	3	19	n.s.
Other	29	6	3	11	
Weekday					
Monday	52	5	3	16	n.s.
Tuesday	53	5	3	19	
Wednesday	56	5	3	14	
Thursday	41	5	3	12	
Friday	38	5	3	7	
Pain medication (preoperative)					
Group 0 (no medication)	95	5	3	19	n.s.
Group 1 (Paracetamol)	64	5	3	16	n.s.
Group 2 (non-steroidal anti-inflammatory drugs)	29	5	3	7	n.s.
Group 3 (1 + 2)	29	5	4	8	n.s.

Number of patients, median PLOS (and minimum and maximum) and *p* values (Wilcoxon signed-rank test or Kruskal–Wallis) are shown

Table 3 Parameter estimates with 95 % confidence intervals and *p* values (Wald statistic) from multivariate linear regression analysis for the PLOS. Adjusted $R^2 = 0.43$

	Patients (*N*)	Parameter estimate (95 % confidence interval)	*p* value
ASA score	240	0.52 (0.25–0.78)	<0.001
ROM at day 0	115	−0.017 (−0.027–0.0079)	<0.001
Wound exudate	240	1.28 (0.93–1.64)	<0.001
Constant		4.64 (3.84–5.43)	<0.001

found between any variables. The model indicated that for each point of the ASA score, the PLOS increased by almost half a day ($p < 0.001$), while the presence of wound exudate increased the PLOS by more than one day ($p < 0.001$). Lower ROM at day 0 also extended the PLOS ($p < 0.001$).

Patients with higher ASA scores had a significantly higher BMI ($p < 0.001$) and were more likely to have an exudating wound ($p < 0.001$). The likelihood of an exudating wound was also significantly higher in patients with higher BMI ($p < 0.001$). However, BMI did not improve

Table 4 Comparison of our method [Sint Maartenskliniek, Nijmegen, The Netherlands (SMK)] with Husted's method [11]

Comparison criteria	Husted	SMK	Note
Required preoperative patient information	+	−	At the SMK this is voluntary
Dedicated wards	+	−	
Combined spinal and epidural analgesia	+	−	At the SMK mostly a half sided spinal with LIA
Bladder catheter	+	−	
Discharge criteria			
Independent	+	+	
In and out of bed	+	+	
Walking with crutches	+	+	
Sitting and rising from a chair	+	+	
Walking stairs	−	+	
Sufficient pain treatment	+	+	
Acceptance of going home	+	+	

the predictive model for PLOS, although the ASA score and wound exudate did.

Discussion

The major findings of this study were that ASA score, wound exudate and ROM at day 0 were statistically significant contributors in predicting PLOS. The median PLOS in the present study was 5 days, which was longer than expected. This PLOS could hardly be considered "fast-track". In other studies, median PLOS is generally shorter and may be as short as 2 days [11]. The most important difference with the present study is that in our hospital, one of the criteria for discharge was that the wound had to be dry, whereas other studies allowed an exudating wound at discharge (Table 4). The reason for these strict discharge criteria is the fact that patients come to our hospital from an expansive region, which leads to stricter in-hospital wound control. Furthermore, the policy of our clinic is that the responsibility for wound healing must not rest completely with the patient..

As a dry wound is one of the criteria for discharge, it was expected that wound exudate would also be a predictive factor for PLOS. In other fast-track methods, a dry wound is not a requirement for discharge [12, 16, 24]. Our goal was to limit the risk of wound infection by monitoring the wound in the hospital [6, 14]. However, staying longer in the hospital can lead to a higher chance of having a bacterial wound infection. Most fast-track methods with a low mean of PLOS allow discharge with a leaking wound. Post-operative wound control should then be used to check for wound infections. The chance of a post-operative knee joint infection may be increased, because the patient has a large responsibility to monitor the exudating wound [25]. Post-operative knee joint infection or complications to the prosthesis may result in patient morbidity and significant cost [19, 22, 28]. When treating a post-operative joint infection, it is important to start as soon as possible with the treatment in order to reduce the number of revisions and complications. Infectious complications of the knee prosthesis occur in 1–3 % of patients. In Husted's study, the risk of having a deep infection was shown to be 1.8 % [13]. In the year 2012, the Sint Maartenskliniek had an infection risk of 1.6 % for primary TKA. Although the incidence of an infected prosthesis should theoretically be the same in all the procedures, the literature shows that this is not always the case [19].

Regarding our finding that presence of wound exudate is strongly predictive of PLOS, a difference in PLOS between studies was expected. However, this does not explain a difference in PLOS of 3 days. Other relevant differences may be the mandatory preoperative patient information, which was voluntary in the present study (Table 4) [14]. The mindset of the patient is likely to affect the patients' contribution to fast mobilisation, training sessions and motivation to go home [23]. The mindset of the personnel is just as important as well. Specifically trained and motivated ward staff are also likely to reduce PLOS significantly. In this study, no dedicated wards were used in which only primary TKA patients with a fast-track procedure were treated (Table 4).

The ASA score as a predictive factor for PLOS was also found in previous studies [12, 23]. Not surprisingly, the ASA score was correlated with both BMI and wound exudate as the ASA score is an indication of co-morbidities. Adding BMI did not improve the predictive model for PLOS [21], although it was significantly associated with PLOS in the univariate regression analysis. This is not in agreement with other studies [12, 27]. Increased body weight could be associated with more difficult surgery [1, 14, 21]. Furthermore, higher BMI may be correlated with problems in the post-operative mobilisation and complications [4].

Post-operative ROM at day 0 was the third predictive factor for PLOS in our model. This factor is obviously associated with the patient's knee function. Previous studies did not show ROM as a predictive factor for PLOS, but instead they identified the use of walking aids or stair walking scores [12, 27]. Since a proper knee function and well-performed movement exercises are also criteria for discharge, post-operative ROM was not a surprising predictor of PLOS.

There were some limitations of this study. One limitation of the study was that data were collected by different observers and medical staff which may have resulted in different interpretations of variables. Patient discharge was also carried out by many different physicians, who may have been relaxed or firm in regard to discharge criteria. Post-operative ROM at day 0 was not collected for all patients (125), because the physiotherapists did not document this from the beginning of the study. A second limitation was that co-morbidities were not scored separately because it was thought that ASA score would provide enough information. Furthermore, it was thought that scoring co-morbidities separately would create too many subgroups. However, it might have given more information on the reason of extended PLOS in a few cases [3]. Thirdly, the use of 72 h intravenous antibiotics in some cases could have negatively affected the PLOS, especially when the patient sufficiently meets the discharge criteria. Patients were offered preoperative voluntary group information. A fourth limitation of the study was that no list of which patients attended the group information session was created. Therefore, the relationship of this factor with PLOS remains unknown. Fifth, the mental state of a patient may influence the PLOS. In the present study, this was not taken into account. The literature suggests that high preoperative levels of depression and internalising/catastrophising were associated with less improvements in pain and physical functioning after TKA [24]. Finally, the focus of the present study was to identify predictive factors of initial PLOS. Factors that can predict readmission and complication rates were outside the scope of this paper. Future work will be carried out on this topic.

The clinical relevance of this study is that it shows that evaluating new hospital procedures in research results in the achievement of starting points for further improvements. Based on this study the policy of discharge with a dry wound can be debated. To achieve a future reduction of PLOS, patients may be discharged with an exudating wound, but need to be monitored closely by use of, for example, internet communication or short-term outpatient medical examination. Additionally, better, and perhaps mandatory, patient information may positively change the mindset of patients. Furthermore, dedicated wards for fast-track primary knee surgery with specifically trained ward staff may also help to achieve a further reduction of PLOS. The present study examines PLOS with discharge with a dry wound; other studies have not been previously published on this topic.

Conclusion

In conclusion, significant predictive factors of PLOS in patients receiving a primary TKA through the fast-track method were ASA score, ROM at day 0 and wound exudate. The median PLOS of 5 days was higher than desired and is mostly caused by the current policy of discharging with a dry wound.

Conflict of interest The authors declare that they have no conflict of interest.

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