Factors Associated with Longer Length of Hospital Stay After Primary Elective Ankle Surgery for End-Stage Ankle Arthritis

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Background: Longer length of stay in the hospital after elective surgery results in increased use of health-care resources and higher costs. Improved perioperative care permits many foot and ankle surgical procedures to be performed as day surgery. This study determined perioperative factors associated with a longer length of stay after elective total ankle replacement or ankle arthrodesis.

Methods: Data were prospectively collected on patients who underwent open or arthroscopic ankle fusion or total ankle replacement for end-stage ankle arthritis at our institution from 2003 to 2010. Univariate and multivariable generalized linear regression models with gamma distribution and log link function were conducted with use of the length of the hospital stay as the dependent variable and preselected risk factors of age, sex, physical and mental functional scores, comorbid factors, American Society of Anesthesiologists grade, body mass index, type of surgery, duration of surgery, and surgery day of the week as the independent variables.

Results: This study included 343 patients with a median length of stay of seventy-five hours (interquartile range, fifty-two to ninety-seven hours). With use of regression analyses, the variables of age, female sex, higher American Society of Anesthesiologists grade, multiple medical comorbidities, rheumatoid arthritis, lower Short Form-36 Physical Component Summary and General Health domain scores, and open surgery were significantly associated with increased length of stay. Conversely, the variables of obesity, Short Form-36 Mental Component Summary score, surgery day of the week, and surgical duration were not associated with length of stay. Two predictive models of the length of stay were developed: one included only patient-related factors, and the other included patient and surgery-related factors.

Conclusions: The patients who are identified with a higher risk of a longer length of stay may warrant better education and more focused perioperative care when designing care pathways and allocating health-care resources.

Level of Evidence: Prognostic Level IV. See Instructions for Authors for a complete description of levels of evidence.

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A longer hospital stay following elective surgery results in increased use of health-care resources and higher costs. The cost of a one-day admission is greater in an acute care hospital following surgery than for inpatient rehabilitation facilities. Thus, cost savings may be realized with a constant patient length of stay if the patient is transferred from acute care to inpatient rehabilitation for part of that stay, provided that there are no clinical contraindications. With escalating costs overall, the identification of factors that influence the total combined length of stay at any facility is a universal consideration and has enabled improved allocation and use of health-care resources plus a substantial reduction in the cost of

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health-care delivery[1]. Regardless of the category of admission, pay rate policy, or payment and reimbursement system, all payers benefit from a decreased length of stay when patients are safely discharged home and do not require readmission. Consequently, many different care pathways have been developed for operative procedures to reduce the length of stay without simultaneously compromising outcome[2-4].

Foot and ankle surgery is an expanding branch of orthopaedics. Reductions in the length of stay after foot and ankle surgery have been facilitated by a patient population that is mostly walking on a single leg in the immediate postoperative phase. The length of stay can also be shortened by improvements in perioperative care and the use of regional anesthesia. If this patient population is discharged directly home, with low readmission rates, then there will be cost savings.

This study evaluated the potential factors that influence the length of stay after major elective foot and ankle surgery. It is envisioned that this knowledge can assist surgeons to better select their day-case candidates and to ultimately improve patient outcome.

Materials and Methods

Patient Selection

Patients were selected from our institution's end-stage ankle arthritis database. Patients are entered into this database once a diagnosis of end-stage ankle arthritis is made and surgical intervention is proposed. Information including patient demographics, medical history, and patient-reported outcome measures is collected in a continuous fashion. The hospital ethics review board approved the collection of patient data for the database; patients provided informed consent for data collection and completed questionnaires.

At our institution, once they are offered surgery, patients are given a booklet on foot and ankle surgery that includes patient-relevant perioperative information. The prospective surgical candidate attends a preadmission consultation two weeks prior to surgery to ascertain his or her fitness for surgery.

On the day of surgery, the anesthesiologist and the surgeon discuss options for intraoperative anesthesia and postoperative pain relief with the patient. Most major foot and ankle surgery is performed under regional blockade together with mild sedation[5]. A patient-controlled analgesia device may be instituted if a short hospital stay is anticipated.

Sample and Study Design

A review of our database identified 408 patients undergoing total ankle replacement or open or arthroscopic ankle fusion. These procedures were studied because they are performed in a standard fashion and require a period of postoperative hospitalization.

Thirty-seven patients who underwent revision ankle fusion or revision total ankle replacement were excluded because these procedures require more surgical time, have multiple confounding variables, and have more complications. Twenty-seven patients who underwent total ankle replacement or arthroscopic or open ankle fusion at another institution were excluded, as their inpatient records were not available. One patient was excluded because of a respiratory complication. No patients underwent more than one procedure within thirty days before or after the index ankle fusion or replacement. Thus, 343 patients who underwent total ankle replacement or arthroscopic or open ankle fusion at our institution from 2003 to 2010 were included.

Data Sources and Measurement

Data routinely entered into the end-stage ankle arthritis database include self-reported demographic information, medical history, weight, height, health status, and the Short Form-36 Version 2.0 (SF-36) of the Foot and Ankle Follow-Up Questionnaire from the American Academy of Orthopaedic Surgeons. The SF-36 is a thirty-six-question generic health outcomes measure comprised of eight scales: Physical Function, Role Physical, Bodily Pain, and General Health (GH), summarized in a Physical Component Summary (PCS) score; and Mental Health, Role Emotional, Social Function, and Vitality, summarized in a Mental Component Summary (MCS) score. A higher score represents better general health and well-being. The SF-36 is the most frequently used health status measure in the United States[6] and is validated in a range of patients[7].

The operating room record was examined to identify the American Society of Anesthesiologists (ASA) grades and type of surgery (open ankle fusion, arthroscopic ankle fusion, or total ankle replacement). The surgery duration in minutes in the operating room and the surgery day of the week (to determine if hospitalization over a weekend affected the length of stay) were also recorded. At our institution, prior to discharge, patient pain must be well controlled with oral medication, the physiotherapist must be satisfied with patient mobility and a safe home environment, and the patient must have no observed complications. Accurate recordings of the length of stay in hours, to facilitate precise analyses of differences between variables affecting the length of stay, were obtained from our institution's electronic patient records system.

Statistical Methods and Analysis

Twelve preselected risk factors were included in the analysis: three surgery-related factors (surgery duration, type of surgery, and surgery day of the week), and nine patient-related factors (sex, age, ASA grade, SF-36 GH, PCS, and MCS scores, rheumatoid arthritis, body mass index [BMI], and number of comorbidities). SF-36 scores were used to determine if the patient's physical health and mental health were potential factors in postoperative recovery and were associated with a shorter length of stay. Patient BMI was classified into five categories: underweight (BMI $\leq$ 18.5 kg/m^2), normal (BMI between 18.6 and $\leq$25 kg/m^2), overweight (BMI between 25.1 and $\leq$29.9 kg/m^2), obese (BMI between 30.0 and $\leq$34.9 kg/m^2), and morbidly obese (BMI $\geq$ 35 kg/m^2). Because there were no underweight patients and only six morbidly obese patients in the study cohort, BMI categories were combined into three levels: underweight or normal (BMI $\leq$ 25 kg/m^2), overweight (BMI between 25.1 and $\leq$29.9 kg/m^2), and obese (BMI $\geq$ 30 kg/m^2).

Regression models were developed using the length of stay as the dependent variable and the preselected risk factors as the independent variables. Given the right-skewed distribution of the dependent variable (length of stay in hours) in the data, generalized linear regression models of gamma distribution with log link function were performed. The gamma distribution is a family of continuous probability distributions with scale and shape parameters[8]. A gamma regression model with a log link is suitable for analysis of the length of stay and cost data with right-skewed continuous measurements[9,10].

Two models assessed the effect of each risk factor on the length of stay: (1) univariate analysis, whereby each risk factor was modeled as the explanatory variable against the length of stay; and (2) multivariable analysis including each risk factor as the primary interest variable, with adjustment for potential confounding variables. Specifically, age and sex were confounding variables for each patient-related risk factor. Analysis for surgery type was adjusted for all patient-related risk factors. Analysis for surgery duration was adjusted for all patient-related risk factors and surgery type. We also investigated clinically meaningful interactions among risk factors.

To explore if we could predict patients' length of stay at the time of admission, we built a prediction model with risk factors recorded during admission. Risk factors with a p value of $\leq$0.20 in the univariate analysis were considered in the initial model. We built a separate prediction model to predict the length of stay after surgery using both patient-related and surgery-related risk factors. A model selection procedure based on the Akaike information criterion (AIC) was used to select risk factors in the final model. A measure of goodness of fit, AIC takes into account how well the model fits the data and includes a penalty for model complexity[11,12].

Goodness of fit of the model was examined with use of a modified Hosmer-Lemeshow test. To assess the performance of the prediction models, agreement between the observed and predicted length of stay was measured by the Lin concordance correlation coefficient[13]. To assess the ability of the prediction model to distinguish a patient with a length of stay shorter than the median from a patient with a length of stay longer than the median, an area under the receiver operating characteristic curve (AUC) was calculated. An

TABLE I Baseline Summary Statistics for Risk Factors*

Risk Factor	No. of Patients	Summary Statistics
Patient-related factors		
Age†	343	60.65 ± 12.41 years
Sex		
Male	192	56.0%
Female	151	44.0%
ASA grade‡		
1	41	14.0%
2	164	56.0%
3	88	30.0%
SF-36 scores†		
General Health	335	47.57 ± 9.65 points
Physical Component Summary	319	30.72 ± 8.19 points
Mental Component Summary	319	50.11 ± 12.17 points
Rheumatoid arthritis		
No	283	82.5%
Yes	60	17.5%
No. of comorbidities		
None	75	21.9%
One to two	229	66.8%
More than two	39	11.4%
BMI†	343	28.02 ± 4.88 kg/m2
BMI classification		
Underweight or normal (≤25 kg/m^2)	89	25.9%
Overweight (25.1 to ≤29.9 kg/m^2)	159	46.4%
Obese (≥30 kg/m^2)	95	27.7%
Surgery-related factors		
Type of surgery		
Open ankle fusion	77	22.4%
Arthroscopic ankle fusion	62	18.1%
Ankle replacement	204	59.5%
Surgery on Friday		
No	291	84.8%
Yes	52	15.2%
Surgery duration†	278	132.20 ± 35.67 minutes

*These patients had a median length of stay of seventy-five hours (IQR, fifty-two to ninety-seven hours). †The values in the summary statistics are given as the mean and the standard deviation. ‡The ASA grade was available in 293 of 343 patients; the percentages in the summary statistics are based on 293 patients.

AUC between 0.7 and 0.8 was considered the threshold for acceptable discriminatory performance and an AUC of >0.8 was considered to be the threshold for excellent discriminatory performance[14].

All reported p values were two-sided with no adjustments for multiple testing. P values of <0.05 were considered significant.

Source of Funding

There was no external funding for this study.

Results

Patient Characteristics

The analysis included 343 patients, of whom 204 (59.5%) underwent a total ankle replacement, sixty-two (18.1%) underwent an arthroscopic ankle fusion, and seventy-seven (22.4%) underwent open ankle fusion. There were 192 male patients (56%) and 151 (44%) female patients. The mean patient age (and standard deviation) at the time of surgery was 60.65 ± 12.41 years. The indication for surgery in all cases was end-stage ankle arthritis. Baseline demographic, clinical, and surgical-related characteristics are summarized in Table I. The median length of stay in the hospital for all patients was seventy-five hours (interquartile range [IQR], fifty-two to ninety-seven hours). The median length of stay was seventy-seven hours (IQR, sixty-one to 100 hours) for patients who underwent total ankle replacement, seventy-five hours (IQR, fifty-two to ninety-seven hours) for

TABLE II Estimated Effect of Risk Factors Associated with Length of Stay

	Unadjusted		Adjusted	
Risk Factor	Average Length of Stay*	P Value	Average Length of Stay*	P Value
Patient-related factors†				
Age (ten-year increase)	1.10 (1.05 to 1.14)	<0.05	1.10 (1.06 to 1.15)	<0.05
Sex (female versus male)	1.20 (1.08 to 1.35)	<0.05	1.23 (1.10 to 1.37)	<0.05
ASA grade				
2 versus 1	1.29 (1.08 to 1.53)	<0.05	1.22 (1.03 to 1.44)	<0.05
3 versus 1	1.43 (1.19 to 1.72)	<0.05	1.33 (1.11 to 1.59)	<0.05
3 versus 2	1.11 (0.98 to 1.27)	0.10	1.09 (0.96 to 1.24)	0.17
SF-36 score (ten-unit increase)				
General Health	0.91 (0.86 to 0.96)	<0.05	0.89 (0.84 to 0.94)	<0.05
Physical Component Summary	0.86 (0.80 to 0.93)	<0.05	0.88 (0.82 to 0.95)	<0.05
Mental Component Summary	0.97 (0.92 to 1.02)	0.21	0.96 (0.91 to 1.01)	0.10
Rheumatoid arthritis (yes versus no)	1.33 (1.15 to 1.54)	<0.05	1.30 (1.12 to 1.51)	<0.05
Number of comorbidities				
One to two versus none	1.28 (1.11 to 1.47)	<0.05	1.27 (1.11 to 1.45)	<0.05
More than two versus none	1.40 (1.14 to 1.71)	<0.05	1.38 (1.13 to 1.68)	<0.05
BMI (ten-unit increase)	1.02 (0.92 to 1.14)	0.72	1.01 (0.91 to 1.12)	0.92
BMI classification				
Overweight versus normal	0.88 (0.77 to 1.01)	0.07	0.89 (0.78 to 1.02)	0.09
Obese versus normal	1.04 (0.89 to 1.21)	0.65	1.01 (0.88 to 1.17)	0.85
Obese versus overweight	1.18 (1.03 to 1.34)	<0.05	1.14 (1.00 to 1.30)	0.05
Surgery-related factors				
Type of surgery‡				
Open ankle fusion versus arthroscopic ankle fusion	1.58 (1.34 to 1.87)	<0.05	1.36 (1.13 to 11.84)	<0.05
Ankle replacement versus arthroscopic ankle fusion	1.61 (1.39 to 1.86)	<0.05	1.31 (1.11 to 8.88)	<0.05
Surgery on Friday§ (yes versus no)	1.05 (0.90 to 1.23)	0.51	—	—
Surgery duration# (five-minute increase)	1.02 (1.01 to 1.03)	<0.05	1.01 (1.00 to 1.02)	0.07

*The values are given as the ratio, with the 95% confidence interval in parentheses. †The values were adjusted for age and sex. ‡The values were adjusted for patient-related factors. §This category was not adjusted. #The values were adjusted for patient-related factors and type of surgery.

patients who underwent open ankle fusion, and fifty-one hours (IQR, twenty-eight to fifty-seven hours) for patients who underwent arthroscopic ankle fusion.

Age and Sex

Results of the generalized linear regression model in Table II suggest that both age and sex had a significant effect on hospital length of stay after surgery. With every annual increase in age, the length of stay increased by 1% ($p < 0.05$). The average length of stay was significantly higher in female patients, who stayed 1.20 times longer than male patients ($p < 0.05$).

Clinical and Surgical Risk Factors

The results of the univariate regression model and the multivariable regression model for each risk factor are summarized in Table II. Several factors were significantly associated with the length of stay after surgery.

Both SF-36 GH and PCS scores were significantly associated with the length of stay. Higher SF-36 GH or PCS scores resulted in a shorter length of stay ($p < 0.05$). The SF-36 MCS score was not associated with the length of stay ($p = 0.10$).

On the basis of patient BMI, of the 343 patients in the study, 26% (eighty-nine patients) were classified as underweight or normal, 46% (159 patients) were classified as overweight, and 28% (ninety-five patients) were classified as obese. Compared with normal weight patients, there was no significant difference in the length of stay for overweight or obese patients. However, the average length of stay was significantly longer for obese patients when compared with overweight patients ($p < 0.05$).

The ASA grade was available in 293 (85%) of 343 patients. There was a shorter length of stay in patients classified as ASA grade 1, followed by patients classified as ASA grade 2, as compared with patients classified as ASA grade 3. Multivariable analysis indicated that length of stay in patients classified as ASA grade 3 was 1.3 times the length of stay in patients classified as ASA grade 1 ($p < 0.05$). The length of stay of patients classified as ASA grade 2 was 1.2 times the length of stay of patients classified as ASA grade 1 ($p < 0.05$).

TABLE III Multivariable Prediction Model Based on Patient-Related Risk Factors*

Risk Factor	Average Length of Stay†	P Value
Age (ten-year increase)	1.12 (1.08 to 1.17)	<0.05
Sex (female versus male)	1.13 (1.01 to 1.26)	<0.05
SF-36 General Health score (ten-unit increase)	0.91 (0.86 to 0.97)	<0.05
Rheumatoid arthritis (yes versus no)	1.22 (1.05 to 1.43)	<0.05

*The modified Hosmer-Lemeshow test determined that p = 0.64; the concordance correlation coefficient is 0.22; and the area under the receiver operating characteristic (ROC) curve is 0.67. †The values are given as the ratio, with the 95% confidence interval in parentheses.

Sixty patients (17.5%) had rheumatoid arthritis. The hospital length of stay was significantly longer in patients with rheumatoid arthritis than in patients without rheumatoid arthritis in both univariate and multivariable analyses. After adjusting for age and sex as confounding variables, the length of stay for patients with rheumatoid arthritis was 1.30 times the length of stay for those without rheumatoid arthritis ($p < 0.05$).

No medical comorbidities were recorded in 22% of patients. The median length of stay in this group was fifty-four hours (IQR, forty-nine to seventy-six hours). One or two medical comorbidities were present in 67% of patients. The median length of stay in this group was seventy-six hours (IQR, fifty-five to ninety-seven hours). Three or more medical comorbidities were present in 11% of patients; the median length of stay in this group was seventy-eight hours (IQR, fifty-one to 101 hours). The analysis suggested that the length of stay for patients with one or two comorbidities was 1.27 times the length of stay for patients with no comorbidity, and the length of stay for patients with three or more comorbidities was 1.38 times the length of stay for patients with no comorbidity.

Three surgery-related factors were examined. The type of surgery had a significant effect on the length of stay. Arthroscopic ankle fusion had the shortest length of stay. Patients who had undergone open ankle fusions stayed 1.36 times longer than those who had undergone arthroscopic ankle fusions ($p < 0.05$). Similarly, patients who had undergone total ankle replacement had a length of stay 1.31 times greater than those who had undergone arthroscopic ankle fusion ($p < 0.05$). Surgery duration and surgery on Friday were not linked to the length of stay.

To examine the effect of modification of risk factors, we included interaction terms in the analyses. No significant interactions between risk factors were found (see Appendix).

Predictive Model and Model Performance

To preoperatively predict the length of hospital stay following ankle surgery, a predictive model was created using patient-related factors recorded at admission as potential predictors (model 1). Age, sex, SF-36 GH score, and rheumatoid arthritis status were included in the final model (Table III).

A further predictive model based on both patient and surgery-related risk factors was created (model 2) and included age, sex, SF-36 score, type of surgery, and surgery duration (Table IV).

The modified Hosmer-Lemeshow test was not significant for the two models ($p = 0.64$ for model 1 and $p = 0.37$ for model 2), indicating a good fit of the models. The concordance correlation coefficient between the observed length of stay and the predicted length of stay was 0.22 for model 1 and 0.32 for model 2, indicating that the two models cannot effectively predict the length of stay in hours. The AUC was 0.67 for model 1 and 0.72 for model 2. Thus, model 1 was unable to discriminate patients with a length of stay shorter than the median from patients with a length of stay longer than the median, while the discrimination ability of model 2 reached the acceptable level, but was moderate (i.e., AUC < 0.8).

TABLE IV Multivariable Prediction Model Based on Both Patient and Surgery-Related Risk Factors*

Risk Factor	Average Length of Stay†	P Value
Age (ten-year increase)	1.10 (1.05 to 1.16)	<0.05
Sex (female versus male)	1.14 (1.02 to 1.28)	<0.05
SF-36 score (ten-unit increase)		
General Health	0.90 (0.85 to 0.96)	<0.05
Physical Component Summary	0.93 (0.86 to 1.00)	0.06
Type of surgery		
Open ankle fusion versus arthroscopic ankle fusion	1.33 (1.11 to 1.60)	<0.05
Total ankle replacement versus arthroscopic ankle fusion	1.27 (1.07 to 1.51)	<0.05
Surgery duration (five-minute increase)	1.01 (1.00 to 1.02)	<0.05

*The modified Hosmer-Lemeshow test determined that p = 0.37; the concordance correlation coefficient is 0.32; and the area under the receiver operating characteristic curve is 0.72. †The values are given as the ratio, with the 95% confidence interval in parentheses.

Discussion

Health care provided by surgical subspecialists can encompass up to 40% of hospital costs[15]. Hence, substantial effort is being directed at reducing such costs while maintaining the quality of health care delivered. Postoperative length of stay is a large component of surgical care costs, and reductions in length of stay are desirable. In Denmark, Husted et al.[16] reported that a nationwide reduction of the length of stay to five days from the previous 4.4 to twelve days after total hip or knee arthroplasty would make up to 28,000 hospital beds available and would generate savings of approximately 13 million euros. If these data were extrapolated to a larger population such as in North America, the potential savings could amount to billions of U.S. dollars.

Although inconsistent, several studies have shown an association between length of stay and patient-related factors. Preoperative patient characteristics that have been implicated include age[17-20], sex[17,21,22], and high ASA grades[19,23]. Our study reflected similar findings, but with subtle variations. Although the average patient age in our study population was sixty years, the range was diverse, from eighteen to eighty-nine years. The length of stay increased by 10% for every decade of aging. Similar to studies of patients undergoing primary total hip arthroplasty[16,24], female sex was a risk factor for a longer length of stay. Our data also demonstrated that ASA grades were associated with a longer length of stay[25,26], where patients classified as ASA grade 1 had a significantly shorter length of stay compared with those classified as ASA grades 2 and 3.

Comorbidities linked to an increased length of stay include a history of chronic obstructive pulmonary disease[17,19,27], cardiovascular disease[20], and diabetes mellitus[19,28,29]. Paterson et al.[30] showed in a cohort of patients undergoing hip or knee arthroplasty that patient comorbidity was a significant factor in the length of stay. We stratified our patients into three distinct comorbidity groups and showed a similar trend.

Curtis et al.[31] reported that the SF-36 PCS score was significantly negatively associated with in-hospital mortality and a longer length of stay after coronary artery bypass graft surgery. Our results support a significant negative correlation between the length of stay and SF-36 PCS and GH scores.

The literature supporting the role of BMI as a risk factor for an increased length of stay has been somewhat conflicting[32-34]. Our findings suggest that BMI on its own does not influence the length of stay after foot and ankle surgery. However, because <2% of our patients were morbidly obese (BMI of ≥35 kg/m^2), we cannot comment on the role of morbid obesity as an influential factor.

Previous reports suggested that patients with rheumatoid arthritis have a delayed discharge following surgical intervention[35]. Similarly, with a 17% prevalence of rheumatoid arthritis in our study, the average length of stay in patients with rheumatoid arthritis was 1.30 times longer than in those without rheumatoid arthritis.

Intraoperative processes have been factors reported in a longer length of stay following urologic, orthopaedic, vascular, and general surgery[19]. We evaluated three intraoperative processes: type of surgery, surgery duration, and surgery day of the week. Arthroscopic procedures have typically been associated with a reduced length of stay. The median length of stay for the patients in our study was significantly shorter ($p < 0.05$) for those who underwent arthroscopic ankle fusion (2.1 days) compared with those who underwent open ankle fusion (3.1 days) and those who underwent total ankle replacement (3.2 days). We found no reports of the length of stay following total ankle replacement for comparison, but our reported length of stay following ankle arthrodesis is comparable with reported mean hospital stays of 1.5[36] and 1.6[37] days following arthroscopic ankle arthrodesis and 4.0[36] and 3.4[37] days following open ankle arthrodesis. In contrast, Nielsen et al.[38] reported mean lengths of stay of 6.6 days following arthroscopic ankle arthrodesis and 8.9 days following open ankle arthrodesis. Regarding surgery duration, we showed a significant positive correlation between longer operating times and a longer length of stay. Both variables may be dependent on the severity of the ankle arthritis, the complexity of the surgery, and the operating surgeon's technique and case volume. However, variation in the number of patients and the types of procedure contributed by each surgeon, together with the lack of a universally accepted preoperative radiographic classification of ankle arthritis, precluded the establishment of a correlation between the length of stay and the surgeon case volume or between the length of stay and the severity of arthritis.

In this study, the length of stay was calculated in hours, rather than days. Inaccuracies are inherent in both measures. In some systems, bed utilization is charged in days. In the system in which our study was conducted, bed utilization is maximized to maximize care, resulting in high levels of inpatient bed occupancy. A modest two to eight-hour change in the length of stay can have a clinical impact, allowing another patient to have surgery and be admitted to the same bed on the same day. Although the measurement of the length of stay in hours reflects optimal utilization within our system, it may be less clinically relevant in other systems.

This study had limitations. The average age of our patients was sixty-one years, older than the national average age of patients undergoing ankle arthrodesis[39]. We did not evaluate the length of stay following revision or emergency surgery; thus, the results may not be generalizable to this group. Study data were obtained from our end-stage ankle arthritis database, and our findings may not extrapolate to the population at large or to patients undergoing foot and ankle surgery who have diagnoses other than end-stage ankle arthritis. The stage of arthritis and other disease-specific variables may be critical to the length of stay and the overall surgical outcome. One may speculate that patients with more advanced arthritis are likely to report different SF-36 scores, require extended operating time, and have longer postoperative rehabilitation, potentially extending the length of stay. The subtype of patient undergoing arthroscopic or open ankle fusion may be inherently different. In this study, the two populations were similar for age, sex, BMI, ASA grade, number of comorbidities, and SF-36 PCS, MCS, and GH scores; however, there was a higher rate of rheumatoid arthritis in the open ankle fusion group (13%) compared with the arthroscopic ankle fusion group (3%). Other factors that we were unable to analyze, such as the type of anesthesia, the patient level of education, the patient wealth, or the patient distance from the hospital, may affect the length of stay. Finally, we did not analyze surgeon experience and volume, which could influence both intraoperative and postoperative patient factors.

Using the type of surgery as a predictive factor for the length of stay in this study may be questioned. It can be argued that the inclusion of arthroscopic procedures with open ankle fusion is too heterogeneous, despite the observed similarities of the two populations in this study. An evaluation of the degree of deformity instead might have resulted in a different predictive model. However, deformity correction can be achieved arthroscopically[39], and many previously open fusions, including cases with deformity, are now performed arthroscopically. As evaluated in the current study, type of surgery encompassed other surgical factors in the open ankle fusion group, including magnitude of soft-tissue dissection, presence of a surgical drain to evacuate hematoma, and prophylactic antibiotic treatment, all of which may have contributed to the 33% predicted longer length of stay following open ankle fusion compared with that following arthroscopic fusion.

We analyzed risk factors routinely collected in a real-life clinical setting. The limited capacity to capture comprehensive patient factors may partly explain the inability of our models to effectively predict the length of stay in hours and to discriminate between a shorter or longer length of stay.

This study did not evaluate readmission rates or visits to emergency departments for pain relief or complications that may have been prevented by keeping the patient in the hospital longer and that would increase the overall cost to the health system associated with the procedure. However, strict discharge criteria for patients at our institution include adequate pain control, no observed complications, satisfactory patient mobility, and a safe home environment to ensure minimal need for readmission.

Our institution provides individualized perioperative patient education, presenting an opportunity to address potential barriers to discharge prior to surgery. In the future, better perioperative education and increased resources could be focused on patients at a higher risk for a longer length of stay. Prior knowledge of such higher-risk patients may facilitate better patient selection and improved patient care for day procedures in foot and ankle surgery. In some systems, increased reimbursement may be required to monitor patients who are likely to have an increased length of stay.

In conclusion, preoperative patient characteristics and intraoperative processes correlated with a longer length of stay after major elective foot and ankle surgery. Our results suggested that increased age, female sex, multiple medical comorbidities, higher ASA grade, lower SF-36 PCS score, lower SF-36 GH score, and open surgery were associated with an increased length of stay.

The predictive models were limited in their ability to effectively predict the length of stay in hours. The prediction model with both patient and surgery-related factors showed acceptable but moderate capacity in discriminating a shorter or longer length of stay.

Appendix

eA A table showing tests for interaction is available with the online version of this article as a data supplement at jbjs.org. ■

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