



Published Comorbidity Indices Poorly Identify Patients at Risk for Failing to Achieve Same Day Discharge Following Unilateral Unicondylar Knee Arthroplasty

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Abstract

Background: Predicting which patients will successfully achieve same-day discharge (SDD) following unicondylar knee arthroplasty (UKA) continues to be challenging. This study evaluated the efficacy of three comorbidity indices in predicting successful SDD in unselected patients treated in a community hospital setting.

Methods: Data for 97 UKA patients were retrospectively examined. Patient demographics, the American Society of Anesthesiology (ASA) comorbidity classification, Charlson Comorbidity Index (CCI), and Outpatient Arthroplasty Risk Assessment (OARA) score were the independent variables determined for each patient. Day of discharge was the dependent variable of interest. Multivariable logistic regression models were constructed to assess the associations between independent and dependent variables.

Results: Overall, 77 (79.4%) patients achieved SDD, with SDD failure best predicted by gender (Odds Ratio (OR): 4.45, 95% Confidence Interval (CI): 1.307-15.147) and pre-operative need for an assistive walking device (OR: 3.633, CI: 1.218-10.832). The ASA, CCI, and OARA demonstrated similar positive predictive values, but were not significant indicators of SDD success. While racial group was not different between SDD and next day discharge groups, differences in race were present with White patients having a greater proportion with OARA scores >79 and >110, compared to Asian and Native Hawaiian/Pacific Islander patients ($p = 0.046$ and $p = 0.010$, respectively).

Conclusions: None of the comorbidity indices that were evaluated accurately predicted which patients would fail SDD following unilateral UKA. The OARA score was the only measure different between racial groups. Future research should reexamine and develop better clinical tools to identify patients at high risk for failing SDD. The current classification systems may not be equally applicable to racial groups other than White.

Keywords: Same Day Discharge; Charlson Comorbidity Index; American Society Anesthesiology; Outpatient Arthroplasty Risk Assessment; Unicondylar Knee Arthroplasty

Introduction

Same day discharge or outpatient protocols for joint arthroplasty have demonstrated high success rates and reduce the cost of patient treatment [1,2]. Most studies evaluating the success of SDD or outpatient discharge following unicondylar knee arthroplasty (UKA) procedures examined results from ambulatory surgical centers (ASC) and report high success with few complications. These studies, however, usually involve highly selected patient cohorts which exclude patients with higher ASA scores or comorbidity pro-

files [3,4]. These results are not applicable to community hospital settings where less healthy patients must be treated. The current study site, a high volume tertiary community hospital, implemented a rapid discharge arthroplasty pathway in 2018 which increased SDD rates following unilateral UKA from 11.2% to 82.4% in an unselected patient cohort [5,6]. Similar to previous literature, age and the need for an assistive walking device prior to surgery were identified as independent risk factors for failing to achieve SDD [5,6]. Achieving 95-100% SDD success rates as reported by studies exam-

ining highly selected patients [3,4] was still not achieved and predicting which patients are likely to require next day or subsequent day discharge remains unclear.

Recent research has examined the potential of risk stratification using existing patient comorbidity indices. A commonly used tool in research is the American Society of Anesthesiology (ASA) comorbidity classification [5,7]. This includes a small number of broad classification levels which may limit its usefulness in identifying patients unlikely to achieve SDD [5,6]. A second tool, the Charlson Comorbidity Index (CCI), assigns weighted values to specific comorbidities, [8] but similar to ASA, may not be optimized for predictive use among outpatient arthroplasty patients [7,8]. Amidst concerns regarding the limited usefulness of ASA and CCI in accurately predicting SDD success or post-operative complications, the Outpatient Arthroplasty Risk Assessment (OARA) score was designed specifically for joint arthroplasty [9]. While only a few studies have evaluated its effectiveness, the OARA scoring system has been shown to more precisely predict SDD in young, homogenous patient cohorts compared to ASA and CCI [8-12]. The purpose of the current study was to analyze and compare the SDD predictive ability of the ASA, CCI, and OARA indices and compare outcomes with previously identified barriers to SDD success in an effort to further assess the generalizability of the OARA score to other patient cohorts.

Materials and Methods

This retrospective, institutional-review-board-approved study evaluated data from a consecutive cohort of 100 UKA patients who underwent medial unilateral UKA between September 2018 and December 2019. Two patients were excluded due to having a lateral, fixed bearing unicondylar implant and one due to a surgical start time of 4:26pm which provided an unrealistic expectation of SDD. The final data analysis included 97 patients.

Surgical and patient protocols have previously been described [5,6]. Briefly, each patient received the Oxford® Partial Knee (Zimmer Biomet, Warsaw, IN) cemented mobile bearing implant with all procedures performed by a single, fellowship-trained orthopedic surgeon in a high-volume, community hospital. Patients were instructed to expect SDD and surgery was scheduled prior to noon when possible. A dedicated acute care nurse practitioner who managed only adult arthroplasty patients facilitated post-operative evaluation, medical co-management, and efficient, safe discharge planning. Following surgery, UKA patients were navigated back to the surgical admission center and evaluated for discharge potential. Same day discharge was feasible up to 8:00 pm upon meeting discharge criteria including the ability to walk 50 feet using an assistive device, controlled pain and nausea, hemodynamic stability, and the ability to navigate stairs if stairs were present in the patient's home environment.

Comorbidities were classified using three instruments. First, ASA was assigned by a core team of anesthesiologists as part of the Perioperative Surgical Home [13] and patients were grouped by an ASA score of ≤ 2 and ≥ 3 . Second, the manual chart review was conducted to identify specific comorbidities evaluated by the CCI. These data were reported as composite score and categorized as (1) patients with no comorbidities compared to patients with one or more and (2) patients with ≤ 1 comorbidity compared to those with two or more comorbidities. Finally, comorbidities evaluated by OARA score were collected through manual chart review and presented as a composite score, as well as by (1) ≤ 59 compared to those above 59 [9-12], (2) ≤ 79 compared to those above 79 [12], and (3) ≤ 110 compared to those above 110 [11].

Additional data collected included patient demographics and pre-operative patient assessments including pre-operative use of an assistive walking device. Peri-operative variables collected included surgical start (incision time) categorized as prior to and after 12:00 pm and the occurrence of post-operative nausea. For patients experiencing post-operative nausea and requiring an overnight hospital stay, the influence of nausea was assessed by the documented reason for unsuccessful SDD.

Data were first compared between patients achieving SDD and those requiring an overnight stay. Group differences were determined with independent t-tests and Chi-square tests. The frequencies of individual comorbidities as identified by the CCI, were compared by performing Chi-square tests. Univariate logistic regression analyses were performed to determine the independent influence of patient demographics, all comorbidity indices, and peri-operative variables. This analysis was also performed for individual comorbidity differences ($p < 0.100$). A multivariable logistic regression analysis was completed for all significant variables excluding post-operative nausea to determine the most influential factors for requiring an overnight hospital stay. Results from the logistic regression analyses were presented as odds ratios (OR) and 95% confidence intervals (CI). Similar to previous research [9-12], the positive predictive value (PPV) was defined as the probability a patient with a lower score would be discharged on the same day and the negative predictive value (NPV) was defined as the probability a patient with a higher score would not be discharged on the same day. All statistical analyses were completed using SPSS version 25 with a significant level of $p < 0.05$.

Results

Of the 97 patients evaluated in the current study, 77 (79%) achieved SDD while 20 (21%) required a one-night stay but were discharged within 24 hours following surgery. The comparison of SDD and next day discharge patient demographics and comorbidity indices are presented in table 1. Patients achieving SDD were

more frequently male (53.2% SDD vs. 25% next day, $p = 0.021$) and were significantly less likely to need an assistive walking device prior to surgery (23.7% SDD vs. 52.6% next day, $p = 0.016$). A significantly greater proportion of patients failing SDD experienced post-operative nausea (35.0%) compared to patients who achieved SDD (7.8%) ($p = 0.005$). There were no significant differences in any of the comorbidity indices measured between patients who achieved SDD and those who failed SDD.

	Same Day (n = 77)	Next Day (n = 20)	p-value
Age	68.9 (8.2)	72.5 (12.4)	0.125
BMI (kg/m ²)	29.1 (4.6)	27.9 (5.9)	0.357
Gender (Male)	41 (53.2%)	5 (25.0%)	0.021
Ethnicity			0.924
Asian	49 (63.6%)	14 (70.0%)	
White	18 (23.4%)	4 (20.0%)	
NH/PI	9 (11.7%)	2 (10.0%)	
Other	1 (1.3%)	0 (0.0%)	
KSS-Knee	45.3 (13.8)	41.4 (18.5)	0.309
KSS-Function	57.2 (18.7)	46.7 (24.9)	0.048
Need Assistive Device	18 (23.7%)	10 (52.6%)	0.016
ASA			
≥3	42 (54.5%)	13 (65.0%)	0.280
OARA	57.0 (51.9)	54.3 (54.3)	0.838
>59	37 (48.1%)	7 (35.0%)	0.215
>79	22 (28.6%)	7 (35.0%)	0.380
>110	12 (15.6%)	4 (20.0%)	0.428
CCI	2.6 (2.2)	2.3 (1.5)	0.570
≥1	67 (87.0%)	17 (85.0%)	0.531
≥2	49 (63.6%)	15 (75.0%)	0.248
Post-Op Nausea	6 (7.8%)	7 (35.0%)	0.005
Surgery Start > 12:00pm	5 (6.5%)	3 (15.0%)	0.210

Table 1: Comparison of Patient Characteristics, Preoperative Knee Scores and Comorbidity Indices Between Patients Achieving Same Day (SD) Discharge and Those Requiring an Overnight Stay. Mean (Standard Deviation) or Frequency (%).

Abbreviations: NH/PI: Native Hawaiian/Pacific Islander; KSS: Knee Society Score; ASA: American Society of Anesthesiologist; OARA: Outpatient Arthroplasty Risk Assessment; CCI: Charlson Comorbidity Index

Univariate logistic regression models (Table 2) showed associations between patients not achieving SDD and being female (OR = 3.42, 95% CI (1.13, 10.33)), the pre-operative need or use of an assistive walking device (OR = 3.58, 95% CI (1.26, 10.17)), and experiencing post-operative nausea (OR = 6.37, 95% CI (1.84, 22.03)). None of the three comorbidity indices were associated with SDD following surgery.

	OR	95% CI	p-value
Age	1.045	0.988-1.105	0.127
Gender			
Male	Reference		
Female	3.417	1.130-10.33	0.030
Assistive Walking Device	3.58	1.260-10.173	0.017
ASA			
≤2	Reference		
>2	1.548	0.557-4.303	0.403
OARA	0.999	0.989-1.009	0.836
≤59	Reference		
>59	0.582	0.210-1.617	0.299
≤79	Reference		
>79	1.346	0.474-3.822	0.577
≤110	Reference		
>110	1.354	0.385-4.759	0.636
CCI	0.926	0.714-1.203	0.566
0	Reference		
>0	0.846	0.209-3.415	0.814
≤1	Reference		
>1	1.714	0.563-5.220	0.343
Post-Operative Nausea	6.372	1.843-22.028	0.003
Start Time			
Prior 12:00pm	Reference		
After 12:00pm	2.541	0.553-11.687	0.231
Pulmonary Dx (CCI)	2.871	0.896-9.201	0.076
Controlled Asthma (OARA)	3.238	0.993-10.563	0.051

Table 2: Influence of Independent Patient Factors and Comorbidity Indices on Failure to Achieve Same Day Discharge Following Unila.

Abbreviations: OR: Odds Ratio; CI: Confidence Interval; CCI: Charlson Comorbidity Index; OARA: Outpatient Arthroplasty Risk Assessment; ASA: American Society of Anesthesiologist; Dx: Diagnosis

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The positive and negative predictive values false positive and negative rates and specificity and sensitivity for each of the three comorbidity indices are presented in table 3. The most accurate positive predictive value (PPV) was the CCI score when stratified by a score of ≥ 2 (84.8%), followed by ASA ≥ 3 (83.3%), and finally OARA score when stratified by a score of >79 (80.9%). The least accurate was the OARA score when stratified by a score of >59 (75.5%). The sensitivity and specificity of all three comorbidity indices at predicting the likelihood of success or failure to achieve

SDD was generally poor for all three comorbidity indices reviewed. Specificity was 85% only for CCI ≥ 1 with sensitivity exceeding 84% only for OARA > 110.

	PPV	NPV	FPR	FNR	Sensitivity	Specificity
ASA						
≥3	83.3%	23.6%	76.4%	16.7%	45.5%	65.0%
OARA						
>59	75.5%	15.9%	84.1%	24.5%	51.9%	35.0%
>79	80.9%	24.1%	75.9%	19.1%	71.4%	35.0%
>110	80.2%	25.0%	75.0%	19.8%	84.4%	20.0%
CCI						
≥1	76.9%	20.2%	79.8%	23.1%	13.0%	85.0%
≥2	84.8%	23.4%	76.6%	15.2%	36.4%	75.0%

Table 3: The Positive and Negative Predictive Values, False Positive and False Negative Rates and Sensitivity and Specificity of Three Comorbidity Indices Regarding Ability to Predict Successful Same Day Discharge Following Unilateral Unicondylar Knee Arthroplasty. **Abbreviations:** PPV: Positive Predictive Value; NPV: Negative Predictive Value FPR: False Positive Rate; FNR: False Negative Rate CCI: Charlson Comorbidity Index; OARA: Outpatient Arthroplasty Risk Assessment; ASA: American Society of Anesthesiologist

Comorbidity scores and proportion of patients successfully achieving SDD were also compared between racial groups (Table 4). The proportion of patients from each racial group that successfully achieved SDD was similar (p = 0.898), but a significantly greater proportion of White patients were classified with higher OARA scores (OARA > 79; p = 0.046 and OARA > 110; p = 0.010) compared to Asians and NH/PI patients.

Discussion

In the current study, SDD was achieved in 79.4% of study participants, with being female and pre-operative need or use of an assistive walking device identified as independent patient factors that increase the odds of failure. Of the comorbidity indices evaluated, CCI ≥ 2 had the highest PPV (84.8%) and OARA >59 had the lowest PPV (75.5%). However, if the goal of these comorbidity indices is to estimate the health status of patients, it is reasonable to question the validity of their use in predicting which patients are more likely to fail SDD following surgery. The OARA score was specifically created to address this need for arthroplasty patients [9]. The current study, however, indicates that all three comorbidity indices are poor at predicting which patients are likely to succeed or fail at achieving SDD following unicondylar knee arthroplasty including the OARA scoring system. Furthermore, all three comorbidity indices had poor negative predictive values (NPV) ranging from 15.9%

	Asian (n = 63)	White (n = 22)	NH/PI (n = 11)	p-value
SDD	49 (77.8%)	18 (81.8%)	9 (81.8%)	0.898
CCI				
≥1	85.7%	81.8%	100.0%	0.340
≥2	68.3%	59.1%	63.6%	0.730
OARA				
>59	38.1%	59.1%	54.5%	0.184
>79	23.8%	50.0%*	18.2%	0.046
>110	9.5%	36.4%*	9.1%	0.010
ASA				
≥3	49.2%	68.2%	72.7%	0.153

Table 4: Comparison of Proportion of Patients Successfully Achieving Same Day Discharge Following Unicondylar Knee Arthroplasty by Racial Group and Comparison of Comorbidity Index Score Assigned to Each Racial Group. Freq (%)/(%).

Abbreviations: NH/PI: Native Hawaiian/ Pacific Islander; CCI: Charlson Comorbidity Index; OARA: Outpatient Arthroplasty Risk Assessment; ASA: American Society of Anesthesiologist
* = significantly different proportion

to 25.0% and inadequate sensitivity and specificity. Based on these results, comorbidity index scores should not be used to indicate which patients are likely to succeed or fail at SDD following UKA. This appears consistent with previous publications questioning the use of these comorbidity scoring systems in arthroplasty patients [5-8]. Female gender and pre-operative use of an assistive walking device appear to be consistently associated with greater failure to achieve SDD [5,6,14-17].

To our knowledge, the current study was the first to evaluate the predictive ability of the OARA score for SDD following unilateral UKA. Previous research identified three potential OARA score cutoffs including >59 [9-12], >79 [12], and >110 [11]. Unfortunately, these studies vary in both procedure demographics, including lower extremity [9,10,12] and shoulder [11] arthroplasties, and primary outcome measure, including SDD only [10-12] and combined SD and next day discharge [9,11] (Table 5). Nevertheless, previous studies reported OARA > 59 to have a PPV of 81.6% to 91.5% following total hip and/or knee arthroplasty [9,10,12], compared to 75.5% observed in the current study. The OARA > 79 cutoff provided the best PPV in the current study at 80.9% but was well below the 98.8% PPV previously reported for combined total hip/knee arthroplasty patients achieving SDD [12]. While the reason for the differences in these studies compared to the current could not be determined, this might demonstrate a potential lack of generalizability across lower extremity arthroplasties or when such scores are applied to different racial groups.

Author	Arthroplasty	N	Discharge	Positive Predictive Value					
				OARA > 59	OARA > 79	OARA > 110	CCI ≥ 1	CCI ≥ 2	ASA
Meneghini	THA and TKA	980	POD 0 and 1	81.6%	--	--	70.3%	--	56.4%
Kim	THA	332	POD 0	86.1%	--	--	--	--	--
Davis	THA and TKA	1785	POD 0	91.5%	98.8%	--	--	--	--
Polisetty	Shoulder	422	POD 0 and 1	59.70%	--	90.8%	--	--	73.0%
Polisetty	Shoulder	422	POD 0	66.70%	--	98.0%	--	--	80.4%
Current Study	UKA	97	POD 0	75.50%	80.90%	80.20%	76.90%	84.80%	83.3%
				Negative Predictive Value					
Kim	THA	332	POD 0	23.1%	--	--	--	--	--
Davis	THA and TKA	1785	POD 0	28.1%	17.0%	--	--	--	--
Current Study	UKA	97	POD 0	15.9%	24.1%	25.0%	20.2%	23.4%	23.6%

Table 5: Summary of Previous Research Evaluating the Positive and Negative Predictive Values of the Three Comorbidity Indices Evaluated in the Current Study.

Abbreviations: N: Number of Patients; POD: Post Operative Day; THA: Total Hip Arthroplasty; TKA: Total Knee Arthroplasty; UKA: Unicondylar Knee Arthroplasty

Only one previous study compared the predictive ability of OARA > 59 to CCI and ASA in both total hip and knee arthroplasty patients [9]. In their study, Meneghini, *et al.* reported a PPV of 70.3% for CCI ≥ 1 and 56.4% for ASA ≥ 3 in the evaluation for combined SD and next day discharge [9]. Only 46% of their patients were managed with the expectation of SDD and discharge expectations shifted throughout the study period. Furthermore, Meneghini and colleagues applied the OARA score to THA and TKA patients, which makes direct comparison to the current study difficult [9]. In the current study, all patients were managed with a rapid discharge protocol with the specific expectation of achieving SDD for all unilateral UKA patients which likely influenced the success of SDD [6]. The PPV for patients with OARA scores >79 (80.9%) was only slightly better than the PPV offered by CCI ≥ 1 (76.9%) but was lower than CCI ≥ 2 (84.8%) and ASA ≥ 3 (83.3%). The highest PPV in the current study was provided by CCI ≥ 2 (84.8%). Unfortunately, the highest NPV in the current study was only 25.0% (OARA > 110). Therefore, the clinical usefulness of any of these comorbidity indices in predicting which patients are likely to succeed or fail to achieve SDD is questionable at best.

A significant confounding variable not accounted for in previous literature could be the racial diversity of this patient cohort. Between 70% and 88.7% of previously studied cohorts involved White patients [9,10]. The current study has a unique patient demographic due to location and involved 23% White, 65% Asian, and 11% Native Hawaiian/Pacific Islanders. While there was no difference in the proportion of patients achieving SDD between the racial groups studied, the proportion of Asian and NH/PI patients classified as OARA>79 and OARA>110 was significantly less than

the proportion of White patients. This was especially interesting as there were no significant differences between racial groups regarding ASA classification or CCI index score. Asian patients had a higher prevalence of pulmonary disease such as chronic asthma (Asian: 17.5%; White: 9.1%) and controlled or uncontrolled type II diabetes compared to White patients (Asian: 27.0%; White: 13.6%). However, Asian patients had a lower prevalence of chronic pain (Asian: 9.5%; White: 27.3%), asymptomatic chronic obstructive pulmonary disease (Asian: 1.6%; White: 13.6%), and obesity (30 ≤ BMI ≤ 39) (Asian: 31.7%; White: 54.5%) compared to White patients. While it is impossible to determine the association of these differences and how such varying combinations of comorbidities affect different racial groups, these descriptive results highlight the possible impact of racial differences and the meaningfulness of such standardized scores when applied to racial groups poorly studied. For these reasons, the OARA score, CCI and ASA may not be generalizable beyond White patients.

Multiple limitations exist in the current study design. Firstly, while a thorough chart review was completed for each patient, the retrospective design could have limited the full evaluation of comorbidities present at the time of surgery. Secondly, all procedures were performed in a high-volume setting with a well-established and successful rapid discharge protocol, and the success of SDD may not be generalizable to all surgical facilities. Thirdly, the sample size of this cohort was much smaller than previous studies and may be underpowered. Lastly, this study cohort had a significantly different racial composition compared to most previous research. While this may assist in providing a more heterogeneous sample, it was impossible to evaluate the influence of race on the OARA score

due to the proprietary system used to calculate the OARA score. Therefore, these results may not be generalizable and should be considered in context of the specific patient population. Future research should evaluate more closely and comprehensively the clinical applicability of these comorbidity indices to arthroplasty patients and how racial differences may influence results.

Conclusion

The ASA, CCI and OARA scoring systems were poor at being able to predict which patients are likely to achieve SDD following unilateral UKA in a high-volume, community hospital with well-established rapid discharge arthroplasty protocols. While all indices had an acceptable PPV, the NPV appears to be unable to accurately identify patients at high risk for failure to achieve SDD. Unlike the CCI and ASA, the OARA score was significantly different between racial groups reviewed, suggesting poor applicability to non-White patients. Although the OARA score evaluates a wide scope of comorbidities, further research is necessary to understand how racial differences may affect results.

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