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Predictors of postdischarge complications: role of in-hospital length of stay

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Abstract

BACKGROUND: Surgical length of stay (LOS) has been correlated with quality of care, with shorter stays implying better care. The relationship between LOS and postdischarge complications (PDCs) has not been evaluated effectively.

METHODS: The 2005 to 2007 National Surgical Quality Improvement Program data were queried for patients undergoing elective colectomies. The outcome of interest was the development of a PDC. Multivariate analysis was then performed adjusting for demographics, surgical approach, and comorbidities.

RESULTS: A total of 12,956 colectomies were analyzed with an overall PDC of 8.7%. LOS was not associated with increased odds of developing a PDC. The laparoscopic approach reduced the risk of PDCs by 30% (odds ratio = .70, 95% confidence interval, 0.61–0.81). Body mass index, female sex, the presence of diabetes mellitus, and prolonged operative time increased the odds of developing a PDC.

CONCLUSIONS: A shorter LOS did not correlate with a reduction in the likelihood of PDCs. Further investigation into the role of LOS as a measure of quality care is needed.
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With an expenditure of over $2.5 trillion and accounting for approximately 17% of the US gross domestic product in 2009, US health care spending is astronomic compared with other developing nations.[1,2] This translates to $1 of every $5 of US gross domestic product, which has thus far not translated to improved health care delivery. Unfortunately, there seems to be no respite because the health care expenditure has been on the rise for the last 10 consecutive years. As would seem to be the consequence, American society is currently evolving toward a state of effective yet conservative use of resources. The government spotlight has been on the health sector, with the aim of making health care delivery more efficient without sacrificing quality of care. Although many measures of quality care are being evaluated

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and validated, one measure that has been touted as a metric for both quality of care and the efficient use of health care dollars is the hospital length of stay (LOS). LOS came to the forefront as a quality of care tool over 2 decades ago when researchers espoused its validity as a tool for assessing different types of health care delivery.[3] Although initially shown among intensive care unit (ICU) patients, other subspecialties of medicine and surgery have since used LOS as a measure for health care outcomes during hospitalization. However, there has been concern about the true impact of LOS on surgical outcomes. As shown among ICU and coronary artery disease patients, a shorter LOS was either associated with increased morbidity postdischarge after hospitalization or none at all.[4,5] By contrast, as a quality of care tool, a shorter LOS has been shown to be associated with fewer in-hospital complications and morbidity.[6] The fact that a shorter LOS is associated with a reduced cost of hospitalization is not surprising; whether this translates to efficient care has remained controversial. One major concern with some researchers is that patients are being discharged home too early.[4] Although this is a possibility, it has been difficult to link data postdischarge with the index admission because most health care institutions hardly collate data postdiscahrge, especially in elective surgical cases. Another concern, and probably a more important one, is whether LOS is a good outcome metric for measuring quality of care because its impact is not consistent.[4,5] Given the current era of maximizing every health care dollar without necessarily sacrificing quality, it is important to assess the quality of health care provided to ensure patients are receiving adequate care. Therefore, LOS, as a potentially important outcome measure or indicator, needs to be investigated to evaluate its efficacy in correctly predicting patient outcome. This is most crucial in the subspecialty of surgery in which any postoperative complication could mean increased morbidity and cost to the institution and unplanned discomfort to the patient. The early discharge of patients from hospitals presents the added risk of having caregivers provide the skill-intensive perioperative management of surgical patients. This added degree of complexity separates surgical patients from other types of patients, making them the ideal population in which to study LOS as a reliable outcome measure. Therefore, the aim of this study was 2-fold: to (1) determine if LOS has an impact on postdischarge complications (PDCs) and (2) to ascertain if LOS is a consistent and reliable predictor of these outcomes. Another objective was to determine other potential predictors of postdischarge morbidity, with the ultimate goal of mitigating these morbidities on discharge.

Methods

Data source (setting)

The American College of Surgeons' National Surgical Quality Improvement Program (ACS NSQIP) public use files from 2005 to 2007 were analyzed for this study. Using a systematic sampling strategy, the ACS NSQIP collects data on 135 variables including patient demographics, preoperative risk factors, intraoperative variables, and 30-day postoperative mortality and morbidity outcomes for patients undergoing major surgical procedures in both the inpatient and outpatient setting. More details on the data collection methodology for the NSQIP can be obtained elsewhere.[7]

Patient selection

The current procedural terminology code of the principal operative procedure field was used to identify all elective total and partial colectomies performed either using the open or the laparoscopic approach. To enhance the homogeneity of the cohort, inclusion into the study population was limited to those patients with a total LOS of <30 days with an admission year corresponding to the operation year and with the day of surgical admission the same as the day of the operation. This eliminated patients who might have been admitted to the hospital for other indications before admission to the surgical service. The study population was also limited to those with an independent functional health status before surgery, no preoperative systemic sepsis, and no intraoperative occurrences (such as myocardial infarction, unplanned intubation, and cardiac arrest requiring cardiopulmonary resuscitation). Patients with a preoperative history of steroid use for chronic conditions, disseminated cancer, or an open wound/wound infection; patients undergoing chemotherapy within 30 days preoperatively; patients considered moribund as per the American Society of Anesthesiology (ASA) physical status classification (ASA 5); and patients who were on a ventilator for >48 hours postoperatively, developed a complication predischarge, or died during the surgical admission were excluded from the study. This eliminated potential confounders by patients who may be more prone to developing some of the PDCs that were being investigated.

Outcome (dependent) variable

The main outcome of interest was the occurrence of any PDC. This was defined as any complication occurring after hospital discharge. A complication was categorized as occurring postdischarge if the time to the occurrence of the complication was greater than the surgical LOS. Complications of interest included a superficial surgical site infection, a deep incisional surgical site infection, an organ space surgical site infection, pneumonia, pulmonary embolism, progressive renal insufficiency, acute renal failure, a urinary tract infection, a peripheral nerve injury, deep venous thrombosis, and sepsis or septic shock. Other complications such as a prolonged time of ventilation (>48 hours), coma, and reintubation were not included as PDCs because they were deemed not to be potentially viable PDCs and were very rare occurrences.

Independent variables

Other variables included in the analysis were the total surgical LOS, body mass index (categorized as 18.5–24.9, 25–29.9, 30–34.9, 35–39.9, and ≥40), smoking status (if the patient smoked cigarettes within 1 year of surgical admission), alcohol use (>2 drinks per day in 2 weeks before admission), the type of colectomy performed (partial or total), the technique of the colectomy performed (open or laparoscopic), age in years, sex, preexisting comorbidities (categorized as cardiac, pulmonary, renal comorbidities, and diabetes), ASA classification (1–4), operative time (every half-hour increase), and ethnicity (defined according to the ACS NSQIP definitions: white non-Hispanic, black non-Hispanic, Hispanic, American Indian, Asian, or unknown).

Statistical analysis

Descriptive statistics were analyzed using univariate analysis. Bivariate analysis comparing patients by the presence of PDCs was performed. Categorical variables were compared using the Pearson chi-square test, whereas continuous variables were compared using the Wilcoxon rank sum test. Multivariate regression analysis adjusting for the independent variables listed previously was performed. Subset analyses performed by using the operative approach (open vs laparoscopic) were completed. Graphic representations showing the odds of PDCs with an increasing LOS were derived from the calculated predicted probability of PDCs by LOS after the main multivariate analyses. All statistical analyses were performed using Stata Statistical Software (release 11; StataCorp, College Station, TX).

Results

A total of 12,956 index cases of colectomies met the inclusion criteria for this study, with partial colectomies accounting for 94%. The overall PDC was 8.7%, and the study population was predominately white (76.9%). The median LOS and age were 5 days and 61 years, respectively. In descending order, the most common PDCs were superficial surgical site infections, 5.50%; organ space surgical site infections, 1.20%; urinary tract infections, 1.11%; sepsis, 1.08%; deep surgical site infections, .63%; deep vein thrombosis, .41%; dehiscence, .30%; renal insufficiency, .19%; and pulmonary embolism, .18%. Additional demographic data are listed in Table 1. According to bivariate (unadjusted) analyses, total colectomies (11.5% vs 8.5% in partial), the open approach (10.1% vs 7.1% in laparoscopic), and an increasing body mass index (Table 2) were significantly associated with PDCs ($P < .05$). Sex, age, and ethnicity showed no association in the unadjusted analyses (Table 1).

After controlling for all the independent variables in the multivariate regression with PDCs as the outcome, the total surgical LOS was not independently associated with the odds of developing a PDC (Table 3). However, the laparoscopic approach was associated with a 30% reduction in the risk of developing a PDC (odds ratio [OR] = .70; CI, .61–.81; $P < .001$). In contrast, body mass index, female sex, the presence of diabetes mellitus, and a prolonged operative time were all associated with increased odds of developing PDCs (Table 3). When analyzed by operative approach, total colectomy, diabetes mellitus, and female sex were all associated with increased odds of developing PDCs among patients undergoing open colectomies, whereas a longer LOS reduced the odds by 4% with each additional day of in-hospital stay (OR = .96; CI, .92–.99; $P = .02$; Table 4). Among patients who underwent laparoscopic colectomies, increasing LOS and preexisting pulmonary comorbidities (pneumonia, chronic obstructive pulmonary disease) were associated with increased odds of developing PDCs (OR = 1.07; CI, 1.03–1.12 and OR = 1.94; CI, 1.09–3.43; both $P < .05$; Table 4). Figure 1 shows the graph of predicted probabilities of PDCs plotted against LOS using the operative technique.

Table 1 Baseline demographics of the patient population

	n	Percentage (%)
Colectomies	12,956	
Partial	12,173	94
Total	783	6
Complications postdischarge		
Observation		
0	11,826	91.3
1	1,130	8.7
Sex		
Male	6,177	47.7
Female	6,779	52.3
Age		
<20 y	48	.4
20–29 y	269	2.1
30–39 y	678	5.2
40–49 y	1,743	13.5
50–59 y	3,128	24.1
Age > = 60	7,001	54
Race		
White	9,968	76.9
Black	954	7.4
Hispanic	532	4.1
Asian or Pacific islander	259	2
American Indian or Alaska native	97	.8

Comments

This study did not show an association between LOS and the odds of developing a PDC in the entire study population. However, a minimally invasive surgery (MIS) significantly decreased the likelihood of PDCs, whereas body mass index, female sex, diabetes mellitus, and a prolonged opera-

Table 2 Bivariate analysis showing demographics of the patient population comparing the incidence and absence of PDCs

	No PDCs		PDCs		
	n	Percentage (%)	n	Percentage (%)	*P* value
Colectomies					.005
Total	693	91.5	1,040	8.5	
Partial	11,133	88.5	90	11.5	
Approach					<.001
Open	6,193	89.9	699	10.1	
Laparoscopic	5,633	92.9	431	7.1	
Sex					.073
Male	5,667	91.7	510	8.3	
Female	6,159	90.9	620	9.2	
Age					.281
<20 y	44	91.7	4	8.3	
20–29 y	240	89.2	29	10.8	
30–39 y	610	90.0	68	10.0	
40–49 y	1,575	90.4	168	9.6	
50–59 y	2,874	91.9	254	8.1	
≥60 y	6,399	91.4	602	8.6	
BMI					<.001
18.5–24.9	3,472	92.6	276	7.3	
25–29.9	4,305	91.9	379	8.1	
30–34.9	2,340	90.6	243	9.4	
35–39.9	872	88.2	117	11.8	
≥40	488	85.3	84	14.7	
	Mean	SD	Mean	SD	
Length of surgical stay (d)	5.43	2.71	5.58	2.28	

BMI = body mass index; SD = standard deviation.

tive time independently increased the odds of acquiring a PDC. Patients with major comorbidities were also found to have increased odds of developing a PDC.

LOS

The prominent finding on the multivariate analysis in this study was that LOS was not independently associated with the odds of developing a PDC. Although the association between in-hospital complications and a prolonged LOS has been well documented and validated in the literature,[8,9] few studies have actually looked at the impact of LOS on PDCs. A study performed by McAleese and Odling-Smee[10] noted that a shorter LOS may lead to readmission after discharge. However, this study did not show a similar finding across the entire study population. Although subset analysis performed by using the operative approach showed that a longer LOS was associated with lower odds of a PDC among patients undergoing open surgery, this impact was the reverse in the minimally invasive approach. When assessing the operative approach (ie, open and laparoscopic), the impact on PDC by LOS was not consistent.

Table 3 Predictors of PDCs among patients undergoing elective colectomies

	Odds ratio	*P*	95% CI
LOS	1.00	.90	.97–1.03
BMI (ref = 18–24.9)			
25–29.9	1.03	.72	.87–1.23
30–34.9	1.16	.14	.95–1.41
35–39.9	1.43	<.001	1.11–1.85
≥40	1.73	<.001	1.29–2.32
LC (ref: OC)	.70	<.001	.61–.81
Female	1.21	<.001	1.06–1.39
Diabetes	1.35	<.001	1.11–1.64
Operative time*	1.04	<.001	1.01–1.06

LC = laparoscopic colectomy; OC = open colectomy.
*Every additional half-hour.

Table 4 Predictors of PDCs by colectomy approach

	OR	*P*	95% CI
Open colectomy			
LOS	.96	.02	.92–.99
Total colectomy	1.49	.02	1.08–2.04
Female	1.23	.02	1.03–1.47
DM	1.38	.01	1.08–1.76
Laparoscopic colectomy			
LOS	1.07	.00	1.03–1.12
Pulmonary	1.94	.02	1.09–3.43
DM	1.35	.07	.97–1.86

DM = diabetes mellitus.

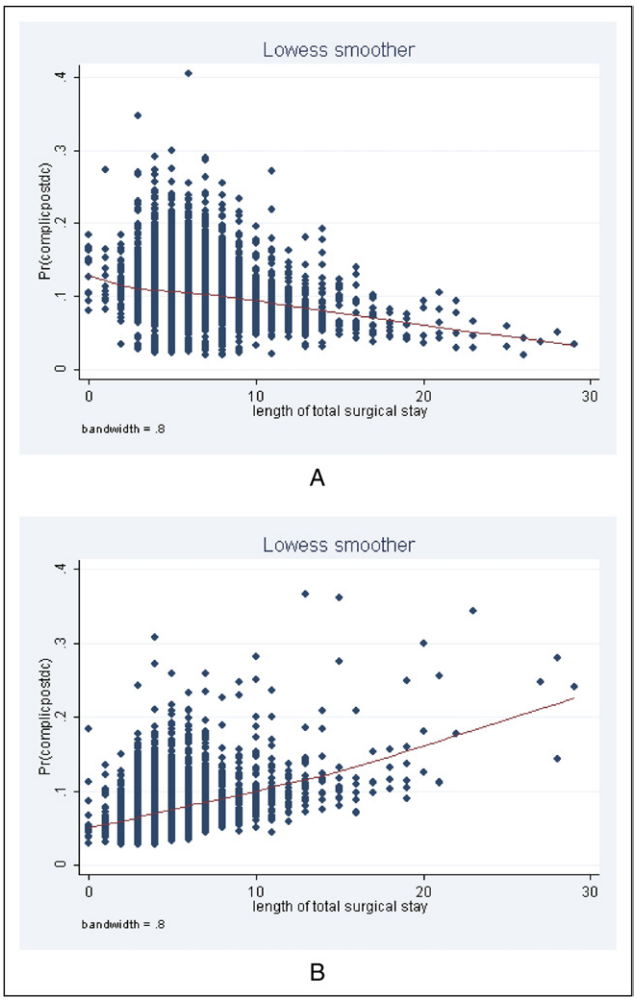

Figure 1 Graphs showing the plot of predicted probabilities of PDCs against LOS by operative approach. (A) Open colectomy. (B) Laparoscopic colectomy.

Although the laparoscopic approach overall reduced PDCs, the finding of increased PDCs in the MIS subset with an increased LOS seems counterintuitive. A thorough evaluation of the predicted probabilities (Fig. 1A and B) shows the potential influence of outliers on the overall result. The fact that MIS techniques reduce LOS is well accepted. Therefore, it is a possibility that subsets of MIS patients with a prolonged LOS probably had a more difficult perioperative course, which increased LOS and subsequently led to PDCs after discharge. With open procedures, the finding of a higher number of PDCs with a shorter LOS may be related to early discharge. Because open procedures have larger incisions and surgical wounds, they are highly prone to surgical site infections, a major component of PDCs, after hospital stay. This variation in the impact of LOS when the operative approach is used strongly suggests the role of LOS as a modifier of outcome, rather than a predictor, and requires more extensive investigation. This conflicting result suggests that LOS in itself may potentially be modified by various factors and, thus, still requires further investigation as a quality of care measurement tool.

Subset multivariate analyses in patients who underwent laparoscopic colectomies showed that an increased LOS and pulmonary comorbidities led to increased PDCs. This finding is corroborated in a study by Khan et al[11] in which postoperative pneumonia was similarly associated with an increase in postoperative complications and an increase in LOS. This finding identifies a potential area to be addressed in reducing PDCs and potential readmissions in this subset of patients. The role of targeted aggressively perioperative pulmonary care needs to be further emphasized in these patients.

Body mass index and sex

That body mass index significantly predicts the likelihood of complications is not surprising when one takes into account all the comorbidities often seen in more obese patients, which contribute to perioperative morbidity and mortality. A study performed by Hawn et al,[12] among other studies, validates this finding. Obese patients had longer operative times, which is associated with greater postoperative complications.

Comorbidities

Diabetes mellitus is a pervasive disease with multiple components and potential complications. Problems with wound healing in the postoperative period have long been attributed to problems with glycemic control, and with surgical site infections being the most common PDC, it is not surprising to find diabetes mellitus is a predictor of PDCs. An extensive multicountry study performed by Clarke et al[13] concluded that diabetes mellitus as a risk factor is associated with increased hospital use and cost across different disease subsets exclusive of surgery. A focus on tight perioperative glycemic control can better improve postoperative and postdischarge outcomes of surgical patients.

Operative approach

The laparoscopic approach showed a significant benefit compared with the open approach in reducing the rates of PDCs, with an associated 30% reduction in the risk of PDCs. This is in line with several studies showing the superiority of the minimally invasive approach with outcomes of fewer postoperative complications and better pain control.[14–16] Differences in LOS comparing the open approach with the laparoscopic approach were discussed previously.

Operative time

Similar to the finding in this study, a prolonged operative time has been shown to increase infectious complications in

the NSQIP data by 6% for every additional half hour (vs 4% in this study) although PDCs were not specifically studied.[17] Because the most common PDC in this study was surgical site infection, it is not surprising that operative time independently predicts PDCs. Factors that improve efficiency in the operating room, without sacrificing excellent technique, need to be investigated further and incorporated into the armamentarium of the surgeon.

The study limitations are inherent in the dataset itself. The NSQIP, although a very strong clinical database with rigorous and well-validated data collection methods, may not be entirely generalizable to all hospitals because the standard of the hospital cohort contributing data into the NSQIP may be different. Another limitation of this study relates to the exclusion of severely ill patients and those with preexisting confounding comorbidities from the analysis. Although this cohort of patients may likely have increased LOS and PDCs, it may be difficult to show this association in a very heterogenous study population using multivariate regression. Knowing the limitation of observational studies compared with randomized controlled trials, the principle adopted by the authors in all our studies is to make the study population as homogenous as possible (which is a strength of randomized controlled trials), leaving fewer variables for which to adjust. However, there is a need to further research the impact of preexisting comorbidities on PDCs, and this remains an area of interest to the authors. A final limitation is the unavailability of readmission data in this dataset, which severely limited the ability to investigate the severity of the PDCs. The hospital charges accrued from the treatment of PDCs may have been helpful in determining the true cost benefit of LOS on overall patient care and hospital savings. Notwithstanding, NSQIP remains an excellent clinical database that actually tracks patients beyond their hospital stay, thereby enabling the clinician/researcher to accurately survey likely complications occurring beyond the walls of the hospital. This is probably one of the few datasets that empowers the researcher to investigate such outcomes.

In conclusion, LOS was not shown to be a significant and consistent predictor of negative postdischarge outcome. There is a need to redefine the role of LOS as a measure indicator of quality care because it can easily be influenced by other variables, thus making it more suitable as a modifier of outcomes. Its role as a surveillance tool for quality care also needs to be further researched.

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