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Importance of Perioperative Processes of Care for Length of Hospital Stay after Laparoscopic Surgery

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ABSTRACT

***Background and Purpose*: The technologic imperative has prompted the adoption of complex laparoscopic techniques by physicians with various degrees of skill. We sought to measure the impact of both case mix and physician practice (perioperative process/risk factors) on length of stay (LOS)—a common benchmark—after laparoscopic surgery.**

***Patients and Methods*: We identified 911 patients undergoing laparoscopic retroperitoneal surgery between 1996 and 2004, who comprise our study population. Patients remaining in the hospital >5 days—the 90th percentile for the sample—were classified as having a prolonged LOS. Adjusted models were developed to determine the independent association of case mix and process measures with a prolonged LOS. The likelihood ratio test was used to discern the improvement of fit of the process model compared with the case-mix model.**

***Results*: Among factors related to case mix and structure of care, increasing age (odds ratio [OR] 1.1; 95% CI 1.0, 1.2), less surgeon experience (OR 6.1; 95% CI 2.1, 17.2), male gender (OR 2.1; 95% CI 1.2, 4.0), and American Society of Anesthesiologists score of 3 or 4 (OR 7.2; 95% CI 2.2, 23.3) were independently associated with a prolonged LOS. The need for a transfusion (OR 9.4; 95% CI 33.9, 23.2), the development of a postoperative complication (OR 4.6; 95% CI 2.2, 9.5), and longer operative time (OR 1.5; 95% CI 1.3, 1.8) explained additional variation in prolonged LOS outcomes when considering perioperative process/risk factors in the model. Perioperative factors significantly improved the fit of the model (χ^2 statistic 101.8; $p <$ 0.0001).**

***Conclusions*: Significant variation in outcomes is explained by factors describing aspects of surgical expertise. Variability in the surgical skill set is likely greatest during the laparoscopic learning curve, which raises a quality-of-care concern during the initial implementation of the technique. Policies attempting to smooth the laparoscopic learning curve, such as mentoring and skill measurement prior to credentialing, could improve the quality of care.**

INTRODUCTION

Approximately 25% of the 15 million operations performed annually in this country will utilize a minimally invasive technique such as laparoscopy or robotics.[1] The perceived benefits of minimally invasive techniques over a conventional approach include shorter length of stay (LOS), diminished postoperative pain, earlier return to productive activity, and smaller incisions.[2–5] These benefits are appealing to both patients and payers, as they theoretically have the capacity to minimize resource use by limiting hospitalization and the impact of infirmity on the individual and society (e.g., by facilitating return to work).

Variation in physician practice patterns has been implicated as a principal source for quality-of-care concerns, particularly when physicians fail to provide basic proven health services.[6] In the setting of laparoscopic surgery, short-term outcomes such as LOS often are used as benchmarks with which to compare various surgical techniques. Indeed, the variability in LOS outcomes has been demonstrated to be multifactorial and likely includes difficult-to-measure elements of care such as surgical expertise and operative technique.[7] Thus, practice pattern vari-

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Table 1. Description of Sample

	Nephrectomy	*Partial nephrectomy*	*Nephroureterectomy*	*Cyst decortication*	*Adrenalectomy*	*Pyeloplasty*	*RPLND*	*Other*	P *value*
Sample size	533	123	65	74	37	54	5	20	—
Mean age ± SD	48.7 ± 16.2	57.2 ± 14.9	70.1 ± 10.1	45.5 ± 13.3	54.4 ± 12.1	37.6 ± 15.6	29.4 ± 8.6	50.1 ± 12.9	<0.0001
Mean body mass Index ± SD	28.1 ± 7.0	28.4 ± 5.0	28.3 ± 5.4	27.2 ± 6.4	30.3 ± 6.7	26.2 ± 7.0	27.0 ± 5.4	26.9 ± 8.8	0.2087
Percent male	49.3	62.6	64.6	37.8	56.8	46.3	100.0	15	<0.0001
ASA score (%)									
1	38.9	20.6	8.0	26.7	6.2	58.3	33.3	18.8	<0.0001
2	41.3	57.1	56.5	61.7	59.4	39.6	66.7	56.2	
3	19.5	21.4	35.5	10.0	34.4	2.1	—	25.0	
4	0.3	0.9	—	1.6	—	—	—	—	
History of abdominal surgery (%)	38.2	36.6	62.5	46.5	44.4	33.3	—	45.0	0.0040
Right-sided procedure (%)	30.8	48.8	53.9	41.9	37.8	53.7	40.0	50.0	<0.0001
Bilateral procedure (%)	3.6	3.3	—	1.4	—	—	—	—	0.3930
Surgical approach (%)[1]									
Extraperitoneal	12.8	17.1	—	4.1	24.3	—	—	25.0	<0.0001
Standard	20.3	30.1	3.1	90.5	70.3	94.4	60.0	65.0	
Hand-assisted	65.7	52.0	95.4	5.4	—	3.7	—	10.0	
Open	1.2	0.8	1.5	—	5.4	1.9	40.0	—	
Mean estimated blood loss ± SD (mL)	284 ± 408	374 ± 538	333 ± 585	113 ± 199	352 ± 621	78 ± 64	125 ± 71	113 ± 124	0.0001
Operative complication (%)	10.9	5.7	21.5	12.2	24.3	1.9	—	10.0	0.0027
Mean operative time ± SD (min)	222.7 ± 55.6	191.8 ± 54.1	254.6 ± 76.0	144.2 ± 51.6	170.2 ± 47.7	228.8 ± 77.2	205.5 ± 33.2	178.8 ± 87.1	<0.0001
Postoperative complication (%)	25.1	30.1	26.2	17.6	35.4	33.3	20.0	20.0	0.3707
Transfusion (%)	4.9	9.8	12.3	1.4	5.4	—	—	—	0.0126
Mean LOS (days) ± SD	2.5 ± 3.2	2.9 ± 3.7	4.3 ± 3.2	2.5 ± 2.3	2.7 ± 3.6	2.5 ± 1.2	2.8 ± 2.5	1.9 ± 0.9	0.0030

Abbreviations: ASA = American Society of Anesthesiologists; RPLND = retroperitoneal lymph-node dissection.
[1]Approach = how procedure was completed.

ation has the potential to adversely impact these short-term outcomes, and identifying processes of care or risk factors that are either predictive or along the causal pathway may provide valuable insight into aspects of health-services delivery that are modifiable. To this end, we sought to determine elements of case-mix and perioperative processes of care/risk factors related to a prolonged LOS after laparoscopic surgery.

PATIENTS AND METHODS

The 911 patients undergoing retroperitoneal laparoscopic surgery between August 1996 and November 2004 at the University of Michigan were included in the study. Clinical, demographic, and follow-up data regarding each patient's postoperative course were collected prospectively as part of an Institutional Review Board-approved data repository (Table 1). The outcome of interest was LOS after surgery. Because of the skewed nature of LOS even after transformation, we elected to dichotomize the outcome into prolonged and not prolonged. We selected the 90th percentile for all procedures as the threshold; hence, all patients remaining in the hospital >5 days were classified as having a prolonged LOS.

The procedures were grouped into common categories to facilitate statistical inference related to procedure type and outcome. For example, patients undergoing radical nephrectomy for renal-cell cancer and donor nephrectomy were analyzed together as the nephrectomy group. The unadjusted relation between clinical (e.g., case mix) and perioperative factors and procedure type was undertaken first to provide insight into differences between patients undergoing different laparoscopic procedures. Next, the association between these factors and a prolonged LOS was assessed. Categorical data was analyzed using the chi-square test (Fisher's exact method where appropriate), and continuous measures were analyzed using the *t*-test (analysis of variance where appropriate).

Clinical and perioperative factors potentially related to a prolonged LOS (p value <0.1 on bivariate analysis) were incorporated into multivariate models. Using a backward model-building process, logistic regression was performed to determine the independent association of the factors with a prolonged LOS. Two distinct model-building processes were conducted. The first included only factors based on preoperative risk factors (e.g., ASA score), and the second included factors based on preoperative risk factors and perioperative process measures/risk factors (e.g., operative time). For the purposes of analysis, surgical approach was incorporated into the full (perioperative) model as the approach (extraperitoneal *v* standard laparoscopy *v* hand-assisted *v* open) actually experienced by the patient rather than the planned approach. Where appropriate, the likelihood ratio test was used to assess the difference in the ability of the models using preoperative factors only (reduced model) and the model using both preoperative and perioperative elements (full model) to explain the variance in prolonged LOS outcomes. The C and Hosmer-Lemeshow statistics were calculated for each of the adjusted models to illustrate model discrimination and calibration qualities, respectively. The C statistic, a value that ranges from 0 to 1, indicates the accuracy of the prediction model, with a higher number representing more accurate predictions. Multicollinearity diagnostics were performed on the final models to ensure absence of strong linear tendencies among the explanatory variables. All statistical analyses were performed using the SAS System (V. 9.1.2; SAS Institute, Cary, NC), and all $p < 0.05$ were considered significant.

RESULTS

Of note, partial nephrectomy, nephroureterectomy, and adrenalectomy were associated with the greatest blood loss (>300 mL), and the latter two procedures were more commonly

Table 2. Parameters Associated with Prolonged LOS (>90th Percentile for Sample) after Laparoscopic Surgery

	% with prolonged LOS	P *value*
Procedure		
Nephrectomy	5.6	0.0024
Partial nephrectomy	9.8	
Nephroureterectomy	20.0	
Cyst decortication	6.6	
Adrenalectomy	5.4	
Pyeloplasty	5.6	
RPLND	20.0	
Other	—	
Sex		
Male	9.5	0.0079
Female	4.9	
ASA score		
1	1.7	<0.0001
2	7.1	
3	19.2	
4	—	
Prior abdominal surgery		
Yes	9.1	0.0924
No	6.1	
Surgeon experience		
Cases 1–20	12.5	<0.0001
Cases 21–40	32.0	
Cases 41	6.3	
Side of surgery		
Right	9.9	0.0177
Left	5.7	
Laterality of surgery		
Bilateral	29.2	<0.0001
Unilateral	6.7	
Surgical approach		
Extraperitoneal	6.6	<0.0001
Standard	6.5	
Hand-assisted	6.8	
Open	42.9	
Transfusion		
Yes	44.9	<0.0001
No	5.1	
Operative complication		
Yes	22.0	<0.0001
No	5.4	
Postoperative complication		
Yes	19.4	<0.0001
No	3.0	

Abbreviations: RPLND = retroperitoneal lymph-node dissection; ASA = American Society of Anesthesiologists.

associated with intraoperative complications. Postoperative complications (minor and major) occurred in ≥20% of patients undergoing each of the procedures with the exception of cyst decortication. The mean LOS was <3 days for all procedures except nephroureterectomy.

The relation between clinical factors and a prolonged LOS after laparoscopic surgery are detailed in Table 2. Among continuous covariates, older age (59.9 *v* 49.9 years; $p < 0.0001$), greater intraoperative blood loss (589 *v* 209 mL; $P = 0.0078$), and longer operative time (269.3 *v* 208.6 minutes; $p < 0.0001$) were all related to prolonged LOS. Larger patient size (greater body mass index) was not related to prolonged LOS ($p = 0.8601$). Not surprisingly, all perioperative adverse events (e.g., open conversion, transfusion, operative/postoperative morbidity) were associated with a prolonged LOS (each $p < 0.0001$).

Both the reduced (case-mix only) and the full (case-mix and perioperative process/risk factors) models are depicted in Table 3. The discrimination and fit of each of the models are demonstrated by the C and Hosmer-Lemeshow statistics below the table. The likelihood ratio test χ^2 statistic for the difference between the full and reduced model was 101.8 (degrees of freedom = 3; $p < 0.001$), highlighting the superior fit characteristics of the model including perioperative process/risk factors.

DISCUSSION

Laparoscopic techniques and the technologic imperative[8] have revolutionized surgical care delivery in the U.S. Relative to the conventional open approach, patients undergoing laparoscopic surgery are generally afforded a reduction in postoperative pain[9] and narcotic requirements[5] and a shorter convalescence[10,11] for a wide variety of procedures. Perhaps the most dramatic and consistently reported advantage of laparoscopic surgery has been the shorter LOS required after major extirpative and reconstructive surgery.[5,9–13] These advantages are not always without potential tradeoffs—a large body of evidence supports the existence of a significant learning curve related to many laparoscopic procedures,[7,14–17] which may limit the extent of some, if not all, of these benefits. This reduction is most certainly a manifestation of processes of care (e.g., patient selection, operative time, surgical technique) that are refined during skill acquisition.

Given this caveat and the compelling advantage of laparoscopic techniques on minimizing LOS after surgery, the current study identifies several preoperative risk factors and a measure of structure of care that were independently related to a prolonged LOS—age, male sex, greater comorbidity, and surgeon experience. Although none of the patient factors is modifiable, this information can be used to counsel patients preoperatively regarding postoperative expectations. Furthermore, physicians can identify patients whose risk profile consists of multiple fixed risk factors and hence are at high postoperative risk regardless of preoperative process of care and selectively refer them to regional centers specializing in laparoscopic surgery.

As demonstrated in variety of other work,[7,18] surgical expertise plays a crucial role in determining the outcomes of laparoscopic surgery. The effects of surgeon experience on outcome are likely multifactorial, and the relation remains largely uncharacterized, although there is a plethora of potential mediating factors such as patient selection, surgical skill, selection of the operative approach (e.g., extraperitoneal *v* intraperitoneal *v* hand-assist), avoidance of "trouble," and early recognition of complications. Herein, we demonstrate that a patient's risk of remaining in the hospital longer than 90% of all patients undergoing laparoscopic surgery is increased more than three fold when the procedure is performed by a less-experienced surgeon

TABLE 3. ADJUSTED MODELS DEMONSTRATING RELATION OF CASE MIX AND PERIOPERATIVE FACTORS WITH PROLONGED LOS AFTER LAPAROSCOPIC SURGERY

		Prolonged LOS	
Clinical factor	*Reference level*	*Odds ratio*	*95% confidence interval*
	Case-mix model only[1]		
Age	Per 5-year increase	1.1	1.0–1.2
Surgeon experience			
Cases 1–20	Cases 41 and above	3.6	0.9–13.8
Cases 21–40		6.1	2.1–17.2
Male sex	Female	2.1	1.2–4.0
ASA score			
3 or 4	1	7.2	2.2–23.3
2		2.6	0.8–8.1
	Perioperative process and risk factors model[2]		
Transfusion	No transfusion	9.4	3.8–23.2
Postoperative complication	No complication	4.6	2.2–9.5
Operative time	Per 30-minute increase	1.5	1.3–1.8

Abbreviations: ASA = American Society of Anesthesiologists.
[1]C-statistic 0.79; Hosmer-Lemeshow χ^2 statistic 11.8, $p = 0.16$.
[2]Full model (includes case-mix covariates as well). C-statistic 0.92; Hosmer-Lemeshow χ^2 statistic 2.2, $p = 0.97$.

(earlier in the learning curve) rather than a more-experienced surgeon (at the tail of the learning curve). Although not necessarily surprising, this finding highlights the degree to which skill acquisition can affect patient outcomes and raises a potential quality-of-care dilemma. As novel complex techniques are assimilated into the surgeon's repertoire, measuring surgical skill for the purposes of credentialing may become necessary.[19,20]

The importance of surgical expertise to LOS outcomes is underscored by the findings of our perioperative process/risk factors model. The need for transfusion, the development of a postoperative complication, and longer operative time—all potential surrogate measures of surgical skill—independently increased the likelihood of a prolonged LOS after laparoscopic surgery, and all are *potentially* modifiable. Attention to detail intraoperatively and perioperatively may minimize blood loss and avoid complications postoperatively (e.g., preventing a collection of blood within the abdomen may reduce the likelihood of ileus). Similarly, operative times are certain to decrease with experience.[18] Collectively, the data suggest that the greatest risk for adverse outcomes (e.g., prolonged LOS) is when the likelihood of the risk factors (e.g., need for transfusion, longer operative time, and development of a postoperative complication) is greatest, which likely occurs during the initial phases of the learning curve for the technique. Standardized measurement of surgical skills and vigilant mentoring by a more experienced surgeon during the learning curve afford potential solutions to this quality-of-care concern.

A limitation of this work stems from the nature of the study population (single institution), which may limit the generalizability of the findings. However, we incorporated a wide array of laparoscopic procedures to attempt to capture the diversity of patient characteristics that may be manifest in external populations. Similarly, our relatively small sample prohibits precise estimates of the magnitude of the effect measures, as illustrated by the breadth of the 95% confidence intervals. Despite prospective data collection, the scope of explicit intraoperative and postoperative processes of care was somewhat narrow, which restricted our ability to identify modifiable predictors of prolonged LOS. Nonetheless, the striking impact (increase of the C statistic from 0.79 to 0.92) of the addition of perioperative processes/risk factors—need for transfusion, operative time, and a postoperative complication—to the model demonstrated the significant influence of factors related to surgical technique on outcome. Hence, future work pertaining to this topic should focus on explicit process identification as it relates to intraoperative technique/perioperative decision-making to minimize blood loss and operative time and prevent complications.

CONCLUSIONS

Elements of case mix, structure of care, and process of care contribute to the likelihood of a prolonged LOS after laparoscopic surgery. The highest-leverage factors were those that related to surgical skill and perioperative processes of care. Because the principal benefits of laparoscopic techniques seem to be mediated by physician practice-pattern variations that are potentially most suspect during the laparoscopic learning curve, efforts should be directed at minimizing such variation to improve the quality of the care delivered. Avenues that may address this concern include mentoring and rigorous skill assessment prior to credentialing. Explicit process measurement should be undertaken to identify additional modifiable elements of care to further improve the quality of care in this patient population.

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ABBREVIATION USED

LOS = length of stay.