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Laparoscopy is safe among patients with congestive heart failure undergoing general surgery procedures

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Abstract

Background—Over the past 2 decades, laparoscopy has been established as a superior technique in many general surgery procedures. Few studies, however, have examined the impact of the use of a laparoscopic approach in patients with symptomatic congestive heart failure (CHF). Because pneumoperitoneum has known effects on cardiopulmonary physiology, patients with CHF may be at increased risk. This study examines current trends in approaches to patients with CHF and effects on perioperative outcomes.

Methods—The 2005–2011 National Surgical Quality Improvement Program Participant User File was used to identify patients who underwent the following general surgery procedures: Appendectomy, segmental colectomy, small bowel resection, ventral hernia repair, and splenectomy. Included for analysis were those with newly diagnosed CHF or chronic CHF with new signs or symptoms. Trends of use of laparoscopy were assessed across procedure types. The primary endpoint was 30-day mortality. The independent effect of laparoscopy in CHF was estimated with a multiple logistic regression model.

Results—A total of 265,198 patients were included for analysis, of whom 2,219 were identified as having new or recently worsened CHF. Of these patients, there were 1,300 (58.6%) colectomies, 486 (21.9%) small bowel resections, 216 (9.7%) ventral hernia repairs, 141 (6.4%) appendectomies, and 76 (3.4%) splenectomies. Laparoscopy was used less frequently in patients with CHF compared with their non-CHF counterparts, particularly for nonelective procedures. Baseline characteristics were similar for laparoscopy versus open procedures with the notable exception of urgent/emergent case status (36.4% vs 71.3%; $P < .001$). After multivariable adjustment, laparoscopy seemed to have a protective effect against mortality (adjusted odds ratio, 0.45; $P = .04$), but no differences in other secondary endpoints.

Conclusion—For patients with CHF, an open operative approach seems to be utilized more frequently in general surgery procedures, particularly in urgent/emergent cases. Despite these patterns and apparent preferences, laparoscopy seems to offer a safe alternative in appropriately selected patients. Because morbidity and mortality were considerable regardless of approach, further understanding of appropriate management in this population is necessary.

Over the past 2 decades, laparoscopy has been established as a safe and superior technique in many general surgery procedures. Because the pneumoperitoneum required for laparoscopic visualization has known effects on cardiopulmonary physiology, patients with CHF may be at increased risk during minimally invasive procedures. Despite these theoretic risks, there is a paucity of data examining the impact of the laparoscopic approach on patients with symptomatic congestive heart failure (CHF).

The use of laparoscopy is known to affect numerous hemodynamic factors, including decreased cardiac index and stroke work index, as well as increased systemic and pulmonary vascular resistance.^{1,2} Some have even suggested that the physiologic changes induced by the establishment of pneumoperitoneum mimics closely those of CHF itself, with 1 case reporting possible laparoscopy-induced CHF in a patient with no history of cardiac disease.³ As the prevalence of heart disease and CHF continues to increase owing to an aging population, and as laparoscopy continues to evolve into the standard operative approach across many general surgery procedures, a better understanding of the interaction between CHF and laparoscopy on these patients is necessary.

The objective of this study was to utilize a national clinical database to examine current trends in operative approach for patients with CHF and the subsequent effects on perioperative outcomes.

METHODS

The 2005 through 2011 National Surgical Quality Improvement Program (NSQIP) Participant User Files were used for this analysis. The NSQIP provides one of the largest collections of validated and independently audited clinical data available in the United States, capturing numerous clinically relevant perioperative variables from both community and academic medical centers. Variables collected include preoperative risk factors, intraoperative variables, and 30-day postoperative mortality and morbidity. The information is collected prospectively by an on-site surgical clinical reviewer at each participating institution and undergoes validation and auditing to ensure data integrity.

Patients were included for analysis based on Current Procedural Terminology coding, and included those who underwent one of the following general surgery primary procedures: Appendectomy (44950, 44960, 44970), segmental colectomy (44140–44144, 44204–44206), small bowel resection (44120, 44125, 44202), ventral hernia repair (49560, 49561, 49570, 49572, 49652, 49653), or splenectomy (38100, 38120). Included for analysis were those with CHF, defined by NSQIP as (a) newly diagnosed CHF within the previous 30 days or (b) a diagnosis of chronic CHF with new signs or symptoms in the 30 days before operation.

Trends of laparoscopy use in these patients were assessed across procedure types. The primary outcome measure for our analysis was 30-day mortality. Secondary outcome measures included early return to the operating room, overall major complication rates, wound-specific complications, renal failure, sepsis, and respiratory complications. Preoperative patient characteristics and postoperative outcomes, stratified by procedure type,

were compared for patients with versus without CHF using Pearson's Chi-square test for categorical variables and 1-way analysis of variance for continuous variables.

To estimate the independent effect of laparoscopy in patients with CHF, a nonparsimonious, multiple logistic regression model was constructed to adjust for patient- and procedure-related confounding factors. In addition to operative approach (open versus laparoscopic) the following predictor variables were considered for inclusion in this model: Procedure type, urgency (elective versus urgent/emergent), patient age, sex, body mass index, American Society of Anesthesiologists physical status classification, functional status, diabetes mellitus, tobacco use within past year, >2 alcoholic drinks per day, dyspnea at rest or on exertion, chronic obstructive pulmonary disease, hypertension, coronary artery disease (angina, history of myocardial infarction, percutaneous coronary intervention, or coronary artery bypass surgery), preoperative dialysis dependence, use of steroids within 30 days of operation for chronic medical condition, systemic chemotherapy within 30 days of operation, radiotherapy treatment for cancer in the 90 days before operation, >10% loss body weight in the 6 months before operation, bleeding disorder, case classification of contaminated or dirty, intraoperative surgical trainee participation, need for packed red blood cell transfusion, and year of operation. Preoperative laboratory values included in the model were serum albumin and creatinine and hematocrit. Because of potential changes in perioperative management and surgeon experience with laparoscopy over the study timeframe, year of operation was included in the model. To test for a differential benefit of laparoscopy related to case urgency, an interaction term of procedure type: urgency was also introduced into the model. Consistent with previous studies modeling NSQIP data, laboratory values were categorized as normal or abnormal using standard cutoffs, and missing laboratory data were assigned a third categorical indicator variable.⁴⁻⁶ Missing data for other variables were handled with case-wise deletion, given the substantial completeness of NSQIP data for variables other than laboratory values. The effect of CHF on duration of stay was modeled using standard linear regression techniques on the logtransformed duration of stay, adjusting for the same variables as previously described.

This study was approved by our Institutional Review Board. Model diagnostics were assessed, and no major model assumptions were violated. We made an affirmative decision to control for type I error at the level of the comparison. Statistical analyses were performed using R version 3.0.1 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Among all patients undergoing the procedures of interest captured in NSQIP ($n = 265,198$), rates of urgent/emergent case were greater in patients with CHF (65.5% vs 45.6%; $P < .001$; Fig 1). Furthermore, the percent of cases performed laparoscopically across all 5 procedure types was significantly less in the patients with CHF compared with their non-CHF peers (Fig 2). Although laparoscopic utilization remained low, there seems to be a clear upward trend over time in the use of laparoscopy in the setting of CHF (Fig 3).

A total of 2,219 patients were identified as having undergone one of our defined general surgery procedures in the setting of new or worsened CHF. Of these patients, there were

1,300 (58.6%) colectomies, 486 (21.9%) small bowel resections, 216 (9.7%) ventral hernia repairs, 141 (6.4%) appendectomies, and 76 (3.4%) splenectomies. Baseline characteristics comparing patients undergoing laparoscopic versus open approach for all patients with CHF are shown in Table I. In patients with CHF regardless of procedure type, those treated with a laparoscopic approach were less likely to undergo an urgent/emergent procedure (36.4% vs 71.3%; $P < .001$), have preoperative sepsis/septic shock, and had lesser overall American Society of Anesthesiologists class ($P < .001$), or have chronic obstructive pulmonary disease (21.4% vs 30.9%; $P < .001$). They were more likely to have an independent functional status (70.6% vs 46.8%; $P < .001$). Baseline characteristics comparing laparoscopic to open approach, stratified by procedure type, are shown in Table II.

Unadjusted outcomes by operative approach demonstrated greater rates of mortality and complications among open cases; however, these differences did not attain significance. Prolonged ventilation also showed a trend toward greater rates in open surgery. A complete list of unadjusted outcomes, stratified by procedure type, is shown in Table III. Regardless of operative approach, morbidity and mortality were considerable across all procedure types.

After adjusting for patient comorbidities and other potential confounders using our logistic regression model (Table IV), the laparoscopic approach was associated with a 2-fold decrease in odds of 30-day mortality (adjusted odds ratio, 0.45; 95% CI, 0.21–0.95; $P = .04$). This model, however, failed to identify differences in reoperation rates, major complications, as well as renal, respiratory and sepsis-related complications after adjusting for confounders. Based on a linear regression model, a laparoscopic approach was associated with a 17.5% decrease (95% CI, 6.3–27.2%; $P = .003$) in overall duration of stay among patients undergoing an operation in the presence of CHF. In both the multivariable logistic and linear regression models, there was no interaction found between operative approach and case urgency (P -values ranging from .08 to .99 for the endpoints of interest).

DISCUSSION

Among patients with recent diagnoses or exacerbations of CHF, a traditional open operative approach seems to be utilized more frequently in patients undergoing general surgery procedures, particularly in urgent and emergent cases. Despite these patterns and apparent preferences, our results suggest that laparoscopy is a safe alternative in appropriately selected patients with CHF, even after adjusting for comorbidities and case urgency.

In recent years, there have been several approaches to minimize perioperative morbidity and mortality among patients with decreased cardiopulmonary reserve. One of the more popular procedures, particularly in Asia, is the abdominal lift, which has been proposed as an alternative to traditional pneumoperitoneum. A number of small prospective trials have demonstrated that although such an approach causes fewer cardiopulmonary disturbances than pneumoperitoneum, operative times and postoperative pain are increased, with no appreciable differences in morbidity or mortality.^{7–10} Although abdominal lift procedures may have a role in very specific patient populations, our results suggest that traditional pneumoperitoneum can be tolerated safely in most patients with CHF.

To our knowledge, this analysis represents the most comprehensive evaluation of operative approach and CHF to date. Our results seem consistent with existing reports in the literature, which have demonstrated that in patients with CHF and gallbladder disease, laparoscopy seems to be a safe approach.^{11,12} Although these studies failed to detect a significant increase in morbidity or mortality among patients with CHF, they were limited by small sample sizes and a focus only on laparoscopic cholecystectomy.

Based on the results of this study, CHF alone is not a contraindication to proceeding laparoscopically. Because morbidity and mortality were substantial across procedure types regardless of operative approach, careful consideration should be given to patients with recently diagnosed or worsened CHF who are undergoing major general surgery operations. It is essential that realistic expectations be set for patients and their families to facilitate shared decision-making discussions in these situations.

The use of American College of Surgeons NSQIP has clear advantages over traditional database studies, because it provides a robust and clinically relevant set of standardized perioperative variables and does not rely on administrative data. Nonetheless, our study has several important limitations intrinsic to all retrospective analyses. Most important, we were only able to evaluate and adjust for variables documented in the NSQIP database. Notably, no data are available regarding previous abdominal operations, which might influence the decision to attempt a laparoscopic approach. Similarly, although we were able to control for American Society of Anesthesiologists class, case urgency, and other critical preoperative attributes, we recognize that selection bias and patient characteristics that are difficult to quantify may play an important role in preoperative planning and decisions regarding operative approach. Similarly, the NSQIP does not provide institution-or surgeon-specific data, and our results may be biased by the possibility that greater volume surgeons and institutions are performing a disproportionate number of the laparoscopic cases. Last, although much of the power of this study is derived from a comprehensive investigation across a wide range of general surgery procedures, the fairly broad case mix poses additional limitations. Despite our attempts to control for procedure type in our models, combining multiple procedures with substantial variability in complexity and baseline risks may oversimplify a very complex perioperative decision.

The results of our analysis suggest that, for patients with recently diagnosed or worsening CHF who require major general surgery procedures, laparoscopy is as safe as the traditional open approach, despite apparent national preferences to the contrary. In light of the considerable perioperative morbidity and mortality seen regardless of approach, further understanding of appropriate perioperative management and patient selection in this population is needed.

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Fig 1.
Case urgency for select general surgery procedures, stratified by congestive heart failure (CHF) versus no CHF. *SBR*, Small bowel resection.

Fig 2.
Percent of cases performed laparoscopically, stratified by procedure type and congestive heart failure (CHF) status. *SBR*, Small bowel resection.

Fig 3.
Trends in the use of laparoscopy for patients with congestive heart failure (CHF) over time.

Table I

Preoperative and intraoperative characteristics of patients with congestive heart failure (CHF), stratified by operative approach

Characteristic	Total (n = 2,219)	All patients with recent CHF		P value
		Open (n = 1,854)	Laparoscopic (n = 365)	
Age (y)	75	75 (65, 83)	76 (64, 83)	.785
Female	1,129	972 (52.6%)	157 (43%)	.001
Tobacco smoker	409	350 (18.9%)	59 (16.2%)	.251
Preoperative dyspnea	1,207	1,005 (54.2%)	202 (55.3%)	.733
Do-not-resuscitate order	144	124 (7.4%)	20 (6.3%)	.585
Case urgency				<.001
Elective	765	533 (28.7%)	232 (63.6%)	
Urgent/emergent	1,454	1,321 (71.3%)	133 (36.4%)	
Procedure type				<.001
Appendectomy	141	71 (3.8%)	70 (19.2%)	
Colectomy	1,300	1,078 (58.1%)	222 (60.8%)	
SBR	486	465 (25.1%)	21 (5.8%)	
Splenectomy	76	46 (2.5%)	30 (8.2%)	
VHR	216	194 (10.5%)	22 (6%)	
ASA class				<.001
1-No disturbance	2	1 (0.1%)	1 (0.3%)	
2-Mild disturbance	63	44 (2.4%)	19 (5.2%)	
3-Severe disturbance	776	602 (32.5%)	174 (47.7%)	
4-Life threatening	1,223	1,056 (57%)	167 (45.8%)	
5-Moribund	153	149 (8%)	4 (1.1%)	
Preoperative sepsis				<.001
None	1,099	817 (44.2%)	282 (77.3%)	
SIRS	385	337 (18.2%)	48 (13.2%)	
Sepsis	317	299 (16.2%)	18 (4.9%)	
Septic shock	414	397 (21.5%)	17 (4.7%)	
Diabetes mellitus	736	597 (32.2%)	139 (38.1%)	.034
Chronic steroid use	264	227 (12.2%)	37 (10.1%)	.295
Non-independent functional status	1,089	982 (53.2%)	107 (29.4%)	<.001
Alcohol >2 drinks/d	70	63 (3.8%)	7 (2.2%)	.231
COPD	651	573 (30.9%)	78 (21.4%)	<.001
Coronary artery disease	896	750 (44.8%)	146 (46.3%)	.663
Disseminated cancer	87	74 (4%)	13 (3.6%)	.811
Bleeding disorder	664	572 (30.9%)	92 (25.2%)	.037
Preoperative transfusion requirement	202	175 (9.4%)	27 (7.4%)	.254
Resident participation in OR	1,257	1,073 (57.9%)	184 (50.4%)	.010

Univariate comparisons for continuous variables made with Student's *t*-test; comparisons for categorical variables made using Pearson's Chi-square test or Fisher's exact test, as appropriate.

ASA, American Society of Anesthesiologists; *COPD*, chronic obstructive pulmonary disease; *OR*, operating room; *SBR*, small bowel resection; *SIRS*, systemic inflammatory response syndrome; *VHR*, ventricular heart rate.

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Table II

Preoperative and intraoperative characteristics, stratified by procedure type

Characteristic	Colectomy		Small bowel resection		Ventral hernia repair		Appendectomy		Splenectomy	
	Open (n = 1,078)	Lap (n = 222)	Open (n = 465)	Lap (n = 21)	Open (n = 194)	Lap (n = 22)	Open (n = 71)	Lap (n = 70)	Open (n = 46)	Lap (n = 30)
Age (y)	76 (66, 83)	79 (72, 85)*	75 (66, 83)	71 (65, 82)	69 (60, 78)	69 (56.8, 80.8)	67 (57, 77)	68 (54.2, 78.8)	70 (59.5, 79)	56 (46.2, 74.8)*
Female	538 (50%)	99 (44.6%)	259 (55.7%)	13 (61.9%)	117 (61.3%)	10 (45.5%)	35 (49.3%)	24 (34.3%)	23 (50%)	11 (36.7%)
Tobacco smoker	205 (19%)	26 (11.7%)*	80 (17.2%)	1 (4.8%)	40 (20.6%)	6 (27.3%)	14 (19.7%)	19 (27.1%)	11 (23.9%)	7 (23.3%)
Preoperative dyspnea	610 (56.6%)	127 (57.2%)	239 (51.4%)	12 (57.1%)	103 (53.1%)	12 (54.5%)	28 (39.4%)	33 (47.1%)	25 (54.3%)	18 (60%)
Do-not-resuscitate order	78 (8%)	11 (5.9%)*	37 (8.6%)	0 (0%)	7 (4.1%)	1 (5.3%)	0 (0%)	4 (6.6%)	2 (4.9%)	4 (13.8%)
Case urgency		*		*						*
Elective	320 (29.7%)	172 (77.5%)	75 (16.1%)	10 (47.6%)	111 (57.2%)	17 (77.3%)	12 (16.9%)	13 (18.6%)	15 (32.6%)	20 (66.7%)
Urgent/emergent	758 (70.3%)	50 (22.5%)*	390 (83.9%)	11 (52.4%)	83 (42.8%)	5 (22.7%)	59 (83.1%)	57 (81.4%)	31 (67.4%)	10 (33.3%)
ASA class		*								
1-No disturbance	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (4.5%)	1 (1.4%)	0 (0%)	0 (0%)	0 (0%)
2-Mild disturbance	21 (2%)	8 (3.6%)	10 (2.2%)	1 (4.8%)	8 (4.1%)	1 (4.5%)	4 (5.6%)	8 (11.4%)	1 (2.2%)	1 (3.3%)
3-Severe disturbance	336 (31.2%)	119 (53.6%)	122 (26.2%)	10 (47.6%)	102 (52.6%)	9 (40.9%)	26 (36.6%)	26 (37.1%)	16 (34.8%)	10 (33.3%)
4-Life threatening	619 (57.5%)	92 (41.4%)	292 (62.8%)	9 (42.9%)	83 (42.8%)	11 (50%)	39 (54.9%)	36 (51.4%)	23 (50%)	19 (63.3%)
5-Moribund	100 (9.3%)	3 (1.4%)	41 (8.8%)	1 (4.8%)	1 (0.5%)	0 (0%)	1 (1.4%)	0 (0%)	6 (13%)	0 (0%)
Diabetes mellitus	347 (32.2%)	86 (38.7%)	135 (29%)	6 (28.6%)	77 (39.7%)	13 (59.1%)	24 (33.8%)	20 (28.6%)	14 (30.4%)	14 (46.7%)
Chronic steroid use	147 (13.6%)	16 (7.2%)*	57 (12.3%)	2 (9.5%)	14 (7.2%)	1 (4.5%)	5 (7%)	5 (7.1%)	4 (8.7%)	13 (43.3%)*
Non-independent functional status	593 (55.3%)	68 (30.6%)*	283 (61%)	8 (38.1%)	63 (32.5%)	4 (18.2%)	23 (32.4%)	16 (23.2%)	20 (43.5%)	11 (36.7%)
Alcohol >2 drinks/d	38 (3.9%)	5 (2.7%)	12 (2.8%)	0 (0%)	6 (3.5%)	0 (0%)	5 (7.8%)	2 (3.3%)	2 (4.9%)	0 (0%)
COPD	345 (32%)	49 (22.1%)*	134 (28.8%)	5 (23.8%)	68 (35.1%)	4 (18.2%)	15 (21.1%)	15 (21.4%)	11 (23.9%)	5 (16.7%)
Coronary artery disease	425 (43.9%)	78 (41.7%)	212 (49.5%)	11 (57.9%)	69 (40.1%)	9 (47.4%)	26 (40.6%)	30 (49.2%)	18 (43.9%)	18 (62.1%)
Disseminated cancer	47 (4.4%)	9 (4.1%)	21 (4.5%)	1 (4.8%)	4 (2.1%)	0 (0%)	0 (0%)	3 (4.3%)	2 (4.3%)	0 (0%)
Bleeding disorder	340 (31.5%)	39 (17.6%)*	148 (31.8%)	4 (19%)	40 (20.6%)	4 (18.2%)	30 (42.3%)	31 (44.3%)	14 (30.4%)	14 (46.7%)
Preoperative transfusion requirement	113 (10.5%)	16 (7.2%)	47 (10.1%)	2 (9.5%)	3 (1.5%)	1 (4.5%)	2 (2.8%)	5 (7.1%)	10 (21.7%)	3 (10%)
Resident participation in OR	616 (57.1%)	98 (44.1%)*	289 (62.2%)	13 (61.9%)	101 (52.1%)	12 (54.5%)	43 (60.6%)	38 (54.3%)	24 (52.2%)	23 (76.7%)

* $P < .05$.

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Univariate comparisons for continuous variables made with Student's *t*-test; comparisons for categorical variables made using Pearson's Chi-square test or Fisher's exact test, as appropriate.
ASA, American Society of Anesthesiologists; COPD, chronic obstructive pulmonary disease; LAP, laparoscopic; OR, operating room; SBR, small bowel resection; SIRS, systemic inflammatory response syndrome; VHR, ventricular heart rate.

Table III

Unadjusted postoperative outcomes, stratified by procedure type

Specific outcome/complication	Colectomy			Small bowel resection			Ventral hernia repair			Appendectomy			Splenectomy		
	Open (<i>n</i> = 1,078)	Lap (<i>n</i> = 222)	<i>P</i> value	Open (<i>n</i> = 465)	Lap (<i>n</i> = 21)	<i>P</i> value	Open (<i>n</i> = 194)	Lap (<i>n</i> = 22)	<i>P</i> value	Open (<i>n</i> = 71)	Lap (<i>n</i> = 70)	<i>P</i> value	Open (<i>n</i> = 46)	Lap (<i>n</i> = 30)	<i>P</i> value
Mortality (30-day)	324 (30.1%)	22 (9.9%)	*	150 (32.3%)	4 (19%)		19 (9.8%)	1 (4.5%)		8 (11.3%)	3 (4.3%)		11 (23.9%)	2 (6.7%)	
Operative mortality	18 (1.7%)	0 (0%)		10 (2.2%)	0 (0%)		1 (0.5%)	0 (0%)		0 (0%)	0 (0%)		2 (4.3%)	0 (0%)	
Overall complication rate	758 (70.3%)	100 (45%)	*	321 (69%)	12 (57.1%)		65 (33.5%)	5 (22.7%)		30 (42.3%)	21 (30%)		31 (67.4%)	15 (50%)	
Early return to the OR	198 (18.4%)	23 (10.4%)	*	94 (20.2%)	4 (19%)		14 (7.2%)	1 (4.5%)		7 (9.9%)	5 (7.1%)		9 (19.6%)	4 (13.3%)	
Duration of stay	18 (11, 28)	13 (7, 19)	*	20 (11, 32)	17 (7, 27)		7 (3, 15)	5 (2, 14.8)		11 (6, 17)	5 (2, 11)		20 (11.5, 29.8)	12 (5, 30)	
Sepsis	100 (9.3%)	10 (4.5%)	*	52 (11.2%)	3 (14.3%)		9 (4.6%)	0 (0%)		0 (0%)	2 (2.9%)		6 (13%)	2 (6.7%)	
Septic shock	150 (13.9%)	15 (6.8%)	*	84 (18.1%)	3 (14.3%)		17 (8.8%)	0 (0%)		5 (7%)	2 (2.9%)		8 (17.4%)	3 (10%)	
Superficial SSI	64 (5.9%)	18 (8.1%)		27 (5.8%)	0 (0%)		5 (2.6%)	0 (0%)		4 (5.6%)	2 (2.9%)		1 (2.2%)	1 (3.3%)	
Deep SSI	28 (2.6%)	1 (0.5%)	*	9 (1.9%)	0 (0%)		2 (1%)	0 (0%)		1 (1.4%)	1 (1.4%)		0 (0%)	0 (0%)	
Organ space SSI	54 (5%)	7 (3.2%)		26 (5.6%)	2 (9.5%)		2 (1%)	0 (0%)		3 (4.2%)	0 (0%)		1 (2.2%)	2 (6.7%)	
Fascial dehiscence	42 (3.9%)	4 (1.8%)		15 (3.2%)	0 (0%)		0 (0%)	0 (0%)		2 (2.8%)	1 (1.4%)		4 (8.7%)	0 (0%)	
Pneumonia	149 (13.8%)	18 (8.1%)	*	79 (17%)	5 (23.8%)		11 (5.7%)	0 (0%)		4 (5.6%)	5 (7.1%)		8 (17.4%)	3 (10%)	
Reintubation	163 (15.1%)	21 (9.5%)	*	72 (15.5%)	1 (4.8%)		17 (8.8%)	2 (9.1%)		11 (15.5%)	5 (7.1%)		2 (4.3%)	2 (6.7%)	
Prolonged ventilatory dependence	392 (36.4%)	22 (9.9%)	*	176 (37.8%)	1 (4.8%)	*	31 (16%)	2 (9.1%)		14 (19.7%)	8 (11.4%)		13 (28.3%)	5 (16.7%)	
Pulmonary embolism	10 (0.9%)	1 (0.5%)		4 (0.9%)	1 (4.8%)		0 (0%)	0 (0%)		0 (0%)	0 (0%)		0 (0%)	1 (3.3%)	
Renal insufficiency	28 (2.6%)	3 (1.4%)		12 (2.6%)	0 (0%)		5 (2.6%)	0 (0%)		0 (0%)	0 (0%)		0 (0%)	1 (3.3%)	
Renal failure	77 (7.1%)	5 (2.3%)	*	42 (9%)	0 (0%)		10 (5.2%)	1 (4.5%)		4 (5.6%)	1 (1.4%)		1 (2.2%)	1 (3.3%)	
Urinary tract infection	68 (6.3%)	12 (5.4%)		25 (5.4%)	5 (23.8%)	*	11 (5.7%)	1 (4.5%)		5 (7%)	0 (0%)		2 (4.3%)	2 (6.7%)	
Stroke	14 (1.3%)	4 (1.8%)		8 (1.7%)	0 (0%)		1 (0.5%)	0 (0%)		1 (1.4%)	0 (0%)		0 (0%)	0 (0%)	
Coma	13 (1.2%)	0 (0%)		9 (1.9%)	0 (0%)		1 (0.5%)	0 (0%)		1 (1.4%)	0 (0%)		0 (0%)	0 (0%)	
Cardiac arrest	74 (6.9%)	4 (1.8%)	*	29 (6.2%)	0 (0%)		8 (4.1%)	0 (0%)		1 (1.4%)	1 (1.4%)		2 (4.3%)	1 (3.3%)	
Myocardial infarction	22 (2%)	3 (1.4%)		10 (2.2%)	0 (0%)		3 (1.5%)	2 (9.1%)		1 (1.4%)	1 (1.4%)		1 (2.2%)	0 (0%)	
Postoperative bleeding	197 (18.3%)	27 (12.2%)	*	75 (16.1%)	2 (9.5%)		9 (4.6%)	1 (4.5%)		1 (1.4%)	1 (1.4%)		14 (30.4%)	6 (20%)	
Deep venous thrombosis	59 (5.5%)	5 (2.3%)	*	14 (3%)	0 (0%)		3 (1.5%)	1 (4.5%)		3 (4.2%)	0 (0%)		3 (6.5%)	0 (0%)	

* *P* < .05.

Univariate comparisons for continuous variables made with Student's *t*-test; comparisons for categorical variables made using Pearson's Chi-square test or Fisher's exact test, as appropriate.

OR, Operating room; LAP, laparoscopic approach; SSF, surgical site infection.

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Table IV

Postoperative outcomes in patients with congestive heart failure: Laparoscopic versus open approach after multivariable adjustment

Complication	Odds ratio (95% CI)	<i>P</i> value	Differential benefit in urgent/emergent (<i>P</i> value) [*]
Mortality (30-day)	0.45 (0.21, 0.95)	.038	.32
Early return to the OR	0.99 (0.53, 1.84)	.97	.99
Major complication	0.84 (0.56, 1.25)	.39	.10
Wound complication	1.48 (0.79, 2.75)	.22	.47
Renal failure	0.61 (0.17, 2.24)	.46	.46
Sepsis or septic shock	0.91 (0.43, 1.93)	.81	.16
Respiratory complications [†]	0.7 (0.42, 1.17)	.18	.83
Duration of stay	−17.5% (−6.3%, −27.2%)	.003	.08

^{*} Differences in effect of operative approach based on procedure acuity/urgency tested with interaction term of urgency:surgical approach.

[†] Respiratory complication defined as pneumonia, reintubation, or failure to wean from ventilator within 48 hours.

Multivariable logistic regression model adjusting for National Surgical Quality Improvement Program preoperative variables.