

Trends in Splenectomy: Where Does Laparoscopy Stand?

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ABSTRACT

Background and Objectives: Laparoscopic splenectomy (LS) has been shown to offer superior outcomes when compared to open splenectomy (OS). Despite the potential advantages associated with the minimally invasive technique, laparoscopy appears to be underused. We sought to evaluate the nationwide trends in LS.

Methods: The Nationwide Inpatient Sample (NIS) database was queried for both OS and LS procedures performed from 2005 through 2010. Partial splenectomies and those performed for traumatic injury, vascular anomaly, or as part of a pancreatectomy were excluded. The included cases were examined for age of the patient and comorbid conditions. We then evaluated the postoperative complications, overall morbidity, mortality, and length of hospital stay.

Results: A total of 37,006 splenectomies were identified. Of those, OS accounted for 30,108 (81.4%) cases, LS for 4,938 (13.3%), and conversion to open surgery (CS) for 1,960 (5.3%). The overall rate of morbidity was significantly less in the LS group than in the OS group (7.4% vs 10.4%; $P < .0001$). The LS group had less mortality (1.3% vs 2.5%, $P < .05$) and a shorter length of stay (5.6 ± 8 days vs 7.5 ± 9 days).

Conclusions: Despite the benefits conferred by LS, it appears to be underused in the United States. There has been an improvement in the rate of splenectomies completed laparoscopically when compared to NIS data from the past (8.8% vs 13%; $P < .05$). The conversion rate is appreciably higher for LS than for other laparoscopic procedures, suggesting that splenectomies require advanced laparoscopic skills and that consideration should be given

to referring patients in need of the procedure to appropriately experienced surgeons.

Key Words: Conversion to open, Laparoscopy, NIS database, Splenectomy.

INTRODUCTION

Splenectomy is the preferred treatment for many hematologic diseases and is a necessary skill for any surgeon. In the early 1990s laparoscopic splenectomy (LS) took shape as a viable alternative to open surgery (OS) and quickly became the standard of care for many splenic disorders.¹

Previously published data have shown that LS is associated with decreased postoperative pain; shorter recovery time; decreased blood loss; and decreased pulmonary, wound, and infectious complications.^{2,3} A report published in 2009, based on cases recorded in the Nationwide Inpatient Sample (NIS) database, demonstrated that from 1998 through 2006 only 8.8% of splenectomies were performed with a laparoscopic approach, with no single year having greater than 12% of splenectomies performed laparoscopically.⁴ We used more recent data to update these statistics and identify any trends in the use of LS in the United States.

METHODS

The NIS was queried for both OSs and LSs performed from the beginning of 2005 through 2010.⁵ The ICD-9 diagnostic and procedure codes that were included covered all splenic diseases, abdominal pain diagnoses (789.00, 789.02, 789.07, and 789.09), and procedure codes (41.5 for splenectomy). Laparoscopic peritoneoscopy (54.21) and laparoscopic enterolysis (54.51) were used to capture the laparoscopic cases. We excluded partial splenectomies and those performed for traumatic injury and vascular anomaly and as part of a pancreatectomy. The remaining patients were examined for age, comorbid conditions, and conversion to open splenectomy (CS). We then evaluated for postoperative complications, including deep vein thrombosis,

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pulmonary embolus, hemorrhage, portal vein thrombosis, postoperative pneumonia, cardiac complications, stroke, shock, renal failure, wound dehiscence, fistula, mortality, and length of stay. Cases were weighted to arrive at the total number of projected cases.

The top 8 admitting diagnoses leading to splenectomy were identified (**Table 1**). A bivariate logistic regression was then performed to evaluate for factors that predicted morbidity, mortality, and conversion to an open procedure. Statistical analysis was performed with SPSS (IBM Corporation, Armonk, NY, USA). Statistical significance was calculated with the *t* test or χ^2 , as appropriate, with significance set at $P < .05$.

RESULTS

We identified 37,006 splenectomies performed during the 6-year study period. Fifty-three percent of the patients were women. Of the total cases, 30,108 (81.4%) patients had an open splenectomy (OS) and 4938 (13.3%) had a successful LS. Laparoscopic surgery was converted to open in 1960 (5.3%) patients. The most common indication for splenectomy was idiopathic thrombocytopenic purpura (ITP) with 10,554 (28.5%) cases (LS, 2144; OS, 7,909; CS, 501).

In 2007, the highest number of splenectomies was performed ($n = 7050$) with 1428 (20%) attempted laparoscopically and 420 (29.4%) converted to open. Each year had a conversion rate of at least 22.5% (**Table 2**). The average conversion rate for the study period was 28.4%.

The baseline characteristics of the patients were analyzed, and significant differences were found in 13 of the 14 que-

ried factors (**Table 3**). The CS group had significantly higher rates of hypertension (34.95%), diabetes mellitus (18.62%), hyperlipidemia (6.68%), obesity (8.83%), sleep apnea (3.83%), and mild (5.26%) or severe (7.3%) liver disease than those in the other 2 groups. The OS group had significantly higher rates of coronary artery disease (7.81%), congestive heart failure (4.78%), smoking (10.74%), COPD (7.45%), and chronic kidney disease (3.66%). The LS group had the highest rate of myocardial infarction (2.27%). The only comorbidity without significant difference between the groups was peripheral vascular disease.

The LS group had a lower rate of morbidity (7.37%) when compared to that in the OS (10.39%) and CS (14.59%) groups. When compared to OS, LS resulted in a significantly lower postoperative incidence of deep vein thrombosis (0.6% vs 0.93%), hemorrhage (2.49% vs 3.31%), portal vein thrombosis (0.12% vs 0.55%), pneumonia (1.34% vs 2.45%), shock (0% vs 0.49%), infection (0.91% vs 1.43%), fistula (0% vs 0.11%), overall morbidity (7.37% vs 10.39%), and mortality (1.32% vs 2.53%).

When compared to CS, successful LS results showed fewer postoperative incidences of deep vein thrombosis (0.6% vs 1.28%), hemorrhage (2.49% vs 9.29%), shock (0% vs 0.51%), and overall morbidity (7.37% vs 14.59%). There was no significant difference in the mortality rate between patients who underwent LS and those who had CS (1.32% vs 1.28%; NS).

Patients who underwent OS experienced less postoperative hemorrhage (3.31% vs 9.29%; $P < .05$) and decreased overall morbidity (10.39% vs 14.50%; $P < .05$) when com-

Table 1.
Indications for Splenectomy

Indication	Laparoscopic		Open		Converted	
	n	(%)	n	(%)	n	(%)
Idiopathic thrombocytopenic purpura	2144	(43.43)	7909	(26.27)	501	(25.56)
Hereditary spherocytosis	487	(9.86)	2048	(6.80)	127	(6.48)
Autoimmune hemolytic anemia	439	(8.89)	1810	(6.01)	166	(8.47)
Splenomegaly	258	(5.23)	2268	(7.53)	182	(9.29)
Splenic lymphoma	222	(4.50)	1889	(6.27)	107	(5.46)
Hypersplenism	177	(3.59)	1495	(4.97)	108	(5.51)
Nonsplenic lymphoma	109	(2.21)	796	(2.64)	88	(4.49)
Other diagnoses ^a	538	(10.90)	7192	(23.89)	386	(19.69)

^aOther diagnoses include: essential thrombocythemia, myelodysplastic syndrome, abdominal pain, Sezary's syndrome, Evans' syndrome, thrombocytopenias and reticulosarcomas of the spleen.

Table 2.
Annual Breakdown of Splenectomies From 2005 Through 2010

Year	Open n (%)	Completed Lap n (%)	Converted to Open n (%)	Total (n)	Conversion Rate (%)
2005	4,069 (85.6)	504 (10.6)	206 (4.3)	4,779	29.0
2006	5,501 (82.5)	930 (13.9)	270 (4)	6,701	22.5
2007	5,622 (80.2)	1,008 (14.4)	420 (6)	7,050	29.4
2008	4,971 (79.4)	1,015 (16.2)	318 (5.1)	6,304	23.9
2009	5,105 (83.2)	716 (11.7)	353 (5.8)	6,174	33.0
2010	4,840 (81.4)	765 (12.9)	393 (6.6)	5,998	33.9
Total	30,108 (81.4)	4,938 (13.3)	1,960 (5.3)	37,006	28.4

pared to those who whose laparoscopic procedure was converted to open. Patients who underwent CS had lower rates of postoperative portal vein thrombosis (0.20% vs 0.55%), pneumonia (1.43% vs 2.45%), and mortality (1.28 vs 2.53%) when compared to those who underwent OS. Length of stay was significantly less in the LS group when compared to that in both the OS and CS groups.

Factors that led to conversion to open surgery were analyzed with bivariate logistical regression. The results revealed that autoimmune hemolytic anemia (odds ratio [OR] 1.36; $P = .002$), nonsplenic lymphoma (OR 1.83; $P < .001$), splenomegaly (OR 1.30; $P = .007$), and hemorrhage (OR 3.23; $P < .001$) increased the risk for conversion to OS (Table 4).

Comorbid conditions significantly associated with an increased risk of death were chronic obstructive pulmonary disease (OR 2.22; $P < .005$), peripheral vascular disease (OR 2.15; $P < .005$), chronic kidney disease (OR 2.58; $P < .005$), congestive heart failure (OR 4.44; $P < .005$), and severe liver disease (OR 5.59; $P < .005$). Smoking, obesity, hypertension, and mild liver disease were not associated with increased postoperative mortality (Table 5).

Postoperative complications that portended an increased risk of death were identified by using bivariate logistical regression. Pulmonary embolus (OR 1.91; $P = 0.033$), infection (OR 2.53; $P < .005$), hemorrhage (OR 3.25; $P < .005$), wound dehiscence (OR 4.85; $P < .005$), cardiac complications (OR 4.98; $P < .005$), and shock (OR 11.38; $P < .005$) were found to significantly increase the risk of death after splenectomy (Table 6). The surgical approach did not predict mortality.

Postoperative morbidity associated with the method of splenectomy was analyzed by bivariate logistical regres-

sion, and CS (OR 2.45; 95% CI 2.058–2.906; $P < .005$) and OS (OR 1.61; 95% CI 1.422–1.817; $P < .005$) were found to increase the risk when compared to LS.

DISCUSSION

Although there has been a modest increase in the percentage of LSs, the overall rate remains low, relative to other advanced laparoscopic procedures (Table 7).^{1,4, 6–22} The average rate of successful LSs during the study period was 13.4% (range, 10.6%–16.2%). There was a small but significant increase in the rate of completed LSs over the study period. The rate is significantly higher when compared to NIS data from 1998 to 2006 (8.8% vs 13.4%, $P < .05$).⁴

We also found a high rate of conversion from laparoscopic to open surgery. The average rate in our study period was 28.4% (range, 22.5%–33.9%). The rate is considerably higher when compared to other basic and advanced laparoscopic operations. For example, laparoscopic colectomies and laparoscopic bariatric procedures have, at most, a reported conversion rate of 15.8% and 2.2%, respectively (Table 7). Our data suggest that bleeding and splenomegaly are intraoperative events that can lead to increased conversion, with ORs of 3.23 and 1.3, respectively (Table 6). In addition, the overall low number of splenectomies being performed may limit the development of the skill and familiarity needed for LS to be performed more often.

As reported in previous studies, we demonstrated several benefits of LS over OS. The data analysis shows that LS was associated with fewer postoperative complications, lower mortality, and a shorter length of stay when compared with the outcomes of OS and CS. Morbidity

Table 3.
Univariate Analysis of Baseline Characteristics

Factor	Laparoscopic		Open		Converted		Significance <i>P</i> < .05
	n	(%)	n	(%)	n	(%)	
Total	4,938 ^a	13.34	30,108 ^a	81.36	1,960	5.30	
Age (years)	48.8 ± 22		51.3 ± 21		51.7 ± 20		
Sex							
Male	2,221	45.46	13,859	46.31	988	50.41	
Female	2,665	54.54	16,067	53.69	972	49.59	
Comorbidities							
Hypertension	1,602	32.44	9,027	29.98	685	34.95	*†‡
Diabetes mellitus	709	14.36	4,583	15.22	365	18.62	†‡
Heart disease							
Coronary artery	309	6.26	2,350	7.81	138	7.04	*
Myocardial infarction	112	2.27	642	2.13	26	1.33	†‡
Congestive heart failure	140	2.84	1,439	4.78	87	4.44	*
Hyperlipidemia	326	6.60	1,440	4.78	131	6.68	*†
Peripheral vascular disease	59	1.19	365	1.21	15	0.77	NS
Obesity (BMI ≥ 30 kg/m ²)	341	6.91	2,048	6.80	173	8.83	†‡
Sleep apnea	94	1.90	507	1.68	75	3.83	†‡
Chronic obstructive pulmonary disease	268	5.43	2,244	7.45	96	4.90	*†
Chronic kidney disease	154	3.12	1,103	3.66	49	2.50	†
Liver disease							
Mild	83	1.68	1,126	3.74	103	5.26	*†‡
Severe	118	2.39	1,529	5.08	143	7.30	*†‡
Other risk factors							
Smoking	358	7.25	3,233	10.74	198	10.10	*‡

^aSex was not recorded in the database for some of the patients.

*Laparoscopic vs open group.

†Open vs converted group.

‡Laparoscopic vs converted group.

was highest in the CS group (14.6%) and was associated with a higher rate of hemorrhage (9.3%). Mortality was significantly lower in the LS group when compared to that in the OS group (1.32% vs 2.52%; *P* < .001).

Despite the potential for significantly reduced morbidity, mortality, and length of stay, most splenectomies continue to be open. A specific reason for this cannot be determined from the database, but it may be related to the surgeon's skill and comfort in performing the procedure, the relative scarcity of splenectomies overall, and the challenging anatomy and pathophysiology

that can coexist in a patient. Thrombocytopenia and splenomegaly are frequently encountered when performing splenectomy and, although challenging, the LS approach has been shown to be safe and associated with decreased length of stay, transfusion requirements, and mortality compared to those factors with OS.³ We must emphasize that patient safety is paramount, and if the surgeon elects to use an open procedure or converts to open, it should not be viewed as a failure.

To increase the number of cases being completed laparoscopically and decrease the conversion rate, we sug-

Table 4.

Bivariate Logistical Regression Analysis of Factors That Led to Conversion to Open Surgery

Factor	P	OR	95% CI	
			Lower	Upper
Hereditary spherocytosis	.546	0.94	0.756	1.16
Autoimmune hemolytic anemia	.002	1.36	1.117	1.657
Hypersplenism	.183	1.17	0.929	1.467
Nonsplenic lymphoma	.000	1.83	1.426	2.348
Splenomegaly	.007	1.30	1.075	1.577
Splenic lymphoma	.437	0.91	0.728	1.147
Idiopathic thrombocytopenic purpura	.195	0.91	0.782	1.052
Hemorrhage	.000	3.23	2.736	3.803
Other diagnoses	.223	0.91	0.776	1.061

Table 5.

Bivariate Logistical Regression Analysis of Comorbid Conditions That Increased the Risk of Mortality

Comorbidity	P	OR	95% CI	
			Lower	Upper
Diabetes mellitus	.143	0.858	0.700	1.053
Hypertension	.005	0.783	0.659	0.929
Chronic obstructive pulmonary disease	<.005	2.216	1.812	2.711
Peripheral vascular disease	<.005	2.146	1.423	3.236
Chronic kidney disease	<.005	2.579	2.036	3.265
Congestive heart failure	<.005	4.435	3.663	5.370
Severe liver disease	<.005	5.590	4.089	7.642

gest that fellowship-trained, advanced laparoscopic surgeons perform LS in most instances. It has been shown that the addition to a general surgery practice of a physician who is fellowship-trained in minimally invasive surgery increases the proportion of procedures that are completed laparoscopically.^{23,24} The advanced surgical training acquired during fellowship promotes meticulous dissection techniques, as well as a greater comfort level with the minimally invasive approach for more complex procedures and confidence in managing intraoperative complications without converting to open surgery. As the number of fellowship-trained, advanced laparoscopic surgeons increases, we anticipate that more LSs will be successfully completed.

Table 6.

Bivariate Logistical Regression Analysis of Postoperative Complications That Increased the Risk of Mortality

Complication	P	OR	95% CI	
			Lower	Upper
Pulmonary embolus	.033	1.91	1.054	3.458
Pneumonia	.738	0.92	0.582	1.467
Infection	<.005	2.52	1.678	3.797
Fistula	.998	0.00	0.000	—
Deep vein thrombosis	.691	0.87	0.446	1.708
Portal vein thrombosis	.145	1.70	0.833	3.446
Hemorrhage	<.005	3.25	2.301	4.589
Stroke	.998	0.00	0.000	—
Wound dehiscence	<.005	4.85	2.515	9.361
Cardiac complication	<.005	4.98	3.458	7.177
Shock	<.005	11.38	7.636	16.95
Renal failure	.169	0.52	0.202	1.323

However, the technical challenges associated with LS cannot be underestimated. Even in the most experienced hands, conversion to an open procedure will occur occasionally. This decision obviously requires consideration of the given disease process, individual patient factors, and intraoperative findings.

This study has limitations related to the deficiencies inherent in administrative databases. The NIS database used in this study (it was redesigned in 2012) is a record of data compiled from discharge and procedural diagnoses across 1000 hospitals of all types and sizes and in all types of locations. It is designed to capture data on a sample of 20% of the patients across the United States. The data are weighted to arrive at the total number of cases per year.⁵ This method is open to the over- and underreporting of data. It is dependent on the coders of the institution who base their codes on chart documentation. There is also a lack of standardization among some complications, which contain unquantifiable data such as hemorrhage. Although the NIS is a robust database, it is retrospective and nonrandomized, thus allowing the data to be marred with selection and input biases.

CONCLUSIONS

In recent years, the rate of LS has increased significantly. Although LS is regarded as the most desired approach, it remains underused for reasons that remain unclear. Successfully completed laparoscopies are associated with less mor-

Table 7.
Published Rates of Conversion Among Basic and Complex Laparoscopic Procedures

Laparoscopic Procedure	Year of Publication	First Author	Conversion Rate (%)	Patient Base
Cholecystectomy	2004	Livingston ⁶	5.0–10.0	National
	2010	Sakpal ⁷	4.9	Single institution
	2010	Kaafarani ⁸	9.0	VA system
Colectomy	2005	Tekkis ⁹	10.0	Single institution
	2012	Simorov ¹⁰	15.8	National
	2013	Prakash ¹¹	2.2–3.7	Single institution
Appendectomy	2008	Schick ¹²	6.2	Single institution
	2012	Sakpal ¹³	4.2	Single institution
	2013	Abe ¹⁴	10	Single institution
Sleeve gastrectomy	2008	Lalor ¹⁵	1.2	Single institution
	2011	Boza ¹⁶	0.7	Single institution
	2012	Boza ¹⁷	0.1	Single institution
	2013	Trastulli ¹⁸	0.0	Review
Roux-en-Y gastric bypass	2003	Podnos ¹⁹	2.2	Review
	2012	Boza ¹⁷	0.7	Single institution
	2013	Trastulli ¹⁸	0.0	Review
Adrenalectomy	2004	Gonzalez ²⁰	1.0	Single institution
	2011	Nguyen ²¹	0.2	Single institution
	2013	Tiberio ²²	6.1	Single institution

bidity and mortality. The rate of conversion to an open procedure in splenectomies is the highest among advanced laparoscopic procedures; splenomegaly and hemorrhage predict a conversion.

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