Title
Adhesive Small Bowel Obstruction in the United States: Has Laparoscopy Made an Impact?

Journal
The American surgeon, 81(10)

ISSN
0003-1348

Authors
Jafari, Mehraneh D
Jafari, Fariba
Foe-Paker, Jennifer E
et al.

Publication Date
2015-10-01

DOI
10.1177/000313481508101023

Peer reviewed

Adhesive Small Bowel Obstruction in the United States: Has Laparoscopy Made an Impact?

Mehraneh D. Jafari, M.D., Fariba Jafari, B.S., Jennifer E. Foe-Paker, M.D., Michael J. Phelan, Ph.D., Joseph C. Carmichael, M.D., Alessio Pigazzi, M.D., Ph.D., Steven Mills, M.D., Michael J. Stamos, M.D.

From the Department of Surgery, University of California, Irvine, Orange, California

---

Adhesions account for 74 per cent of admissions for small bowel obstruction (SBO). There is a lack of data regarding the usage and outcomes of laparoscopy (LS) for SBO. A retrospective review of urgent admissions for SBO using the Nationwide Inpatient Sample 2001 to 2011 was conducted. Among the estimated 3,948,987 SBO admissions, 36.7 per cent underwent operative management and LS was performed in 26.5 per cent with a 22.5 per cent conversion rate. Admissions increased by 3.1 per cent annually, whereas nonoperative management increased by 3.8 per cent annually. Operative management increased by 1.8 per cent annually, whereas LS increased by 8.9 per cent annually and open surgery decreased by 0.6 per cent annually. LS small bowel resection increased by a mean of 25 per cent annually. LS was associated with a 24.4 per cent in-hospital morbidity with intra-abdominal abscess/enteric fistulas (8.3%) and ileus (8.9%) as the most common complications. In-hospital mortality was 0.9 per cent with length of stay of 13 6 9 days and a hospital charge of $80,080 6 6,634. The majority of patients were operated on hospital day (HD) 1 (43.0%). Patients who underwent LS on HD >7 had a higher risk-adjusted mortality compared with earlier HD (odds ratio 5 2.63; 95% confidence interval: 2.40–2.89; P < 0.01). There has been an increase in admissions for SBO and an increase in LS over the past 11 years. There seems to be an increase in mortality and morbidity with a later HD operation.

Adhesions are caused by injury to the peritoneum secondary to an inflammatory process or surgical interventions.[1–4] Adhesions occur in an estimated 93 per cent of patients who undergo abdominal surgical interventions[1–3] and can cause significant morbidity and mortality, including accounting for the majority of cases of small bowel obstruction (SBO)—74 per cent[5] to 83 per cent[6] of cases.[7–9] This has a substantial impact on healthcare costs secondary to a high incidence of readmissions and the possible need for emergent operations.[9]

In the past two decades, the laparoscopic (LS) approach to abdominal operations has gained wide acceptance in the surgical community. It has been hypothesized that LS induces less trauma to the peritoneal cavity, thereby resulting in decreased adhesions. However, there continues to be conflicting reports regarding the effects of LS on the rate of adhesions.[4, 10, 11] There is also a lack of data regarding the usage and outcomes of LS surgery for SBO. Since the first reported successful use of LS adhesiolysis for SBO in 1991,[10] the use of LS for SBO has been accepted by a larger proportion of surgeons.[11] The usage of LS has been associated with fewer subsequent intra-abdominal adhesions, lower morbidity, shorter length of stay and

faster recovery.[11] However, these data are restricted to small sample size and single institution studies. To date, there are no studies evaluating the trends of usage of LS for SBO in the United States.

The controversy regarding both the effects of LS on the formation of adhesions and the use of LS for the surgical treatment of SBO continues to exist. Therefore, the purpose of this study was to 1) analyze the trends of admissions of small obstruction, 2) to analyze the trends of surgical cases for SBO, 3) describe the outcomes of LS treatment of SBO, and 4) analyze outcomes in terms of timing of operation for SBO in the United States during the past decade.

Methods

The Healthcare Cost and Utilization Project Nationwide Inpatient Sample (NIS) is the largest all-payer inpatient care database in the United States. The data set approximates a 20 per cent stratified sample of American community, nonmilitary, and nonfederal hospitals, resulting in a sampling frame that comprises approximately 95 per cent of all hospital discharges in the United States. All statistical analysis was conducted on raw numbers and raw numbers were weighted to reflect national averages. Weight is based on sampling probabilities for each stratum to ensure that hospitals studied are representative of all hospitals in the United States. Approval for the use of the NIS patient-level data in this study was obtained from the institutional review board of the University of California, Irvine Medical Center, and the NIS.

The discharge data on patients who were admitted with the diagnosis of adhesive SBO between January 1, 2001 and December 31, 2011 using appropriate diagnostic and procedural codes as specified by the ICD-9-CM was analyzed. Patients admitted with the diagnosis of adhesive SBO (560.81, 568.0, 614.6) were sampled. Patients undergoing s (LOAs) (54.5, 54.59) and LS LOA (54.51) were selected. Patients with concomitant open small bowel resection (SBR) (45.6, 45.61, 45.6, 45.91) and LS SBR using the modifier (54.21) were selected. To ensure purity of our sample all patients with colorectal cancer, diverticulitis, and inflammatory bowel disease and those undergoing elective admissions were excluded. Converted cases were also analyzed.

The temporal trends in the overall number of hospital admissions for adhesive small bowel obstructive over an 11-year study period were analyzed. The usage of LS, the rate of mortality and morbidity per year in each group were also analyzed. The average change per year as indicated by the variation of trends per year was calculated using a geometric mean to describe the constant proportional growth.

LS LOA, SBR, and converted cases were analyzed. Given that the patient populations are not comparable, we provide a description of patient outcomes including total charge, length of stay, postoperative complications, and in-hospital mortality were also analyzed. The ICD-9 codes for anastomotic leak included the most commonly used code, 997.4, and because of the vague nature of this code, this was paired with 567.22 and 569.81.

Timing of operation for LS cases was analyzed. Morbidity and mortality rates were analyzed in terms of the timing of operation relative to admission date, specifically day of admission compared with hospital day (HD) 1, day 2–4, day 4–7, and >7 days.

Statistical Analysis

All statistical analyses were conducted using SAS® (Cary, NC) version 9.3 and the R statistical environment. For the main analysis, logistic regression analysis was used for binary end points (in-hospital mortality and morbidity). Age, gender, hospital characteristics, comorbidities (anemia, congestive heart failure, chronic pulmonary disease, uncomplicated and complicated diabetes, valvular heart disease, liver disease, peripheral vascular disease, renal failure, obesity, weight loss/malnutrition, and smoking), procedure type, hospital status, and admission diagnosis were adjusted for. Holm's method was used to account for multiple comparisons in the form of adjusted P values.12–14 A comparison was declared statistically different than 0 (formean difference) or 1 [for odds ratio (OR)] at the family-wise error level of 0.05 if an adjusted P value is less than 0.05.

Results

Trends

In the United States, a total of 3,948,987 patients with SBO required admission during 2001 to 2011. On average, there was a 3.1 per cent increase per year in the rate of admission. Operative management was conducted in 36.7 per cent of cases (n 4 1,448,234) with a 1.8 per cent increase per year. LS was used in 26.5 per cent (n4384,213) of cases (Fig. 1). There has been on average an 8.9 per cent annual increase in the usage of LS, from a baseline rate of 17.9 per cent in 2001 to the rate of 35.3 per cent in 2011. There was a decrease of 0.6 per cent per year in open cases (Fig. 2). LS-SBR was performed in 0.4 per cent (n 4 5,334) and open SBR was performed in 5.7 per cent (n 4 82,403) of cases. The rate of mortality for operative management was 3.4 per cent with an increase per year of 0.6 per cent. The rate of morbidity was 37.7 per cent, which increased from 32.5 per cent in 2001 to 44.3 per cent in 2011, for an increase per year of 5.6 per cent.

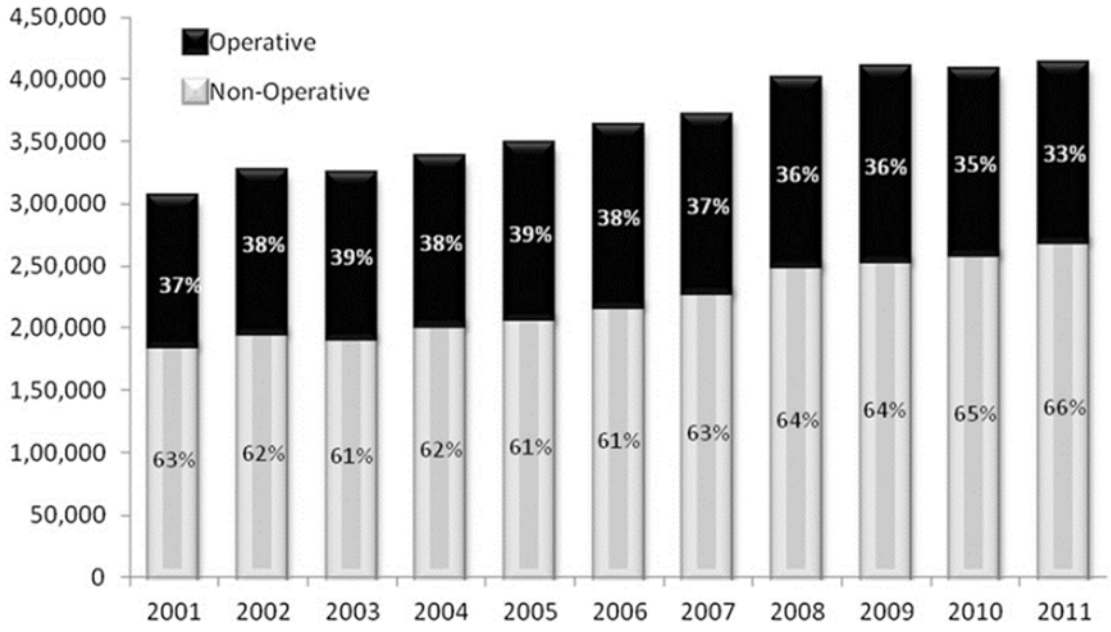

FIG. 1. Total number of admissions, surgical cases and approach of SBO in United States during 2001–2011.

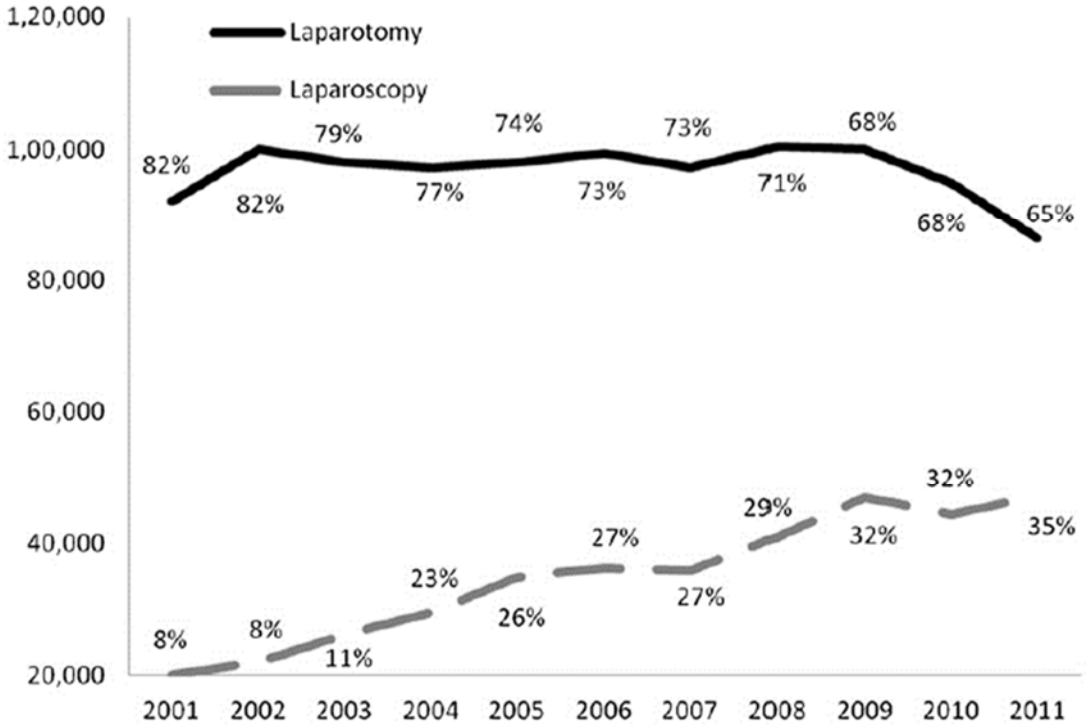

FIG. 2. The trend of surgical approach (LS and open) for SBO in the United States during 2001–2011.

TABLE 1. Outcomes of Patients Undergoing LS Management of SBO in the United States during 2001–2011

	LS LOA (n = 378,879)	LS SBR (n = 5,334)	Converted (n = 86,719)
Anastomotic leak/abdominal abscess (%)	7.1	16.9	13.5
Wound complications (%)	2.4	8.1	5.1
Ileus/bowel obstruction (%)	7.4	17.8	15.5
Urinary tract infection (%)	5.5	7.2	5.6
Pneumonia (%)	2.3	4.9	3.1
Respiratory failure (%)	2.4	4.2	2.8
Acute renal failure (%)	5	9.7	6.4
Cardiac complications (%)	0.8	1.6	1.3
Deep vein thrombosis (%)	0.2	0.7	0.3
Patient disposition (%)			
Routine	2.7	70.4	75.6
Short term	5.6	10.6	7.6
Home health	5.6	11.8	10.3
Hospice	0.2	1.6	0.3
Other	1.2	2.8	1.4
Missing	4.7	2.8	4.9
Ileostomy (%)	0.3	1.2	0.7
Colostomy (%)	0.5	1.9	1
Overall morbidity (%)	22.2	45.5	33.2
In-hospital mortality (%)	0.8	2.8	0.9
Length of stay (days)	6 ± 7	11 ± 10	8 ± 7
Total charge ($)	38,669 + 50,096	71,218 + 74,821	50,273 + 53,930

Outcomes

LS had an 8.3 per cent anastomotic leak rate/ abdominal abscess, 8.9 per cent ileus, and obstruction with an overall morbidity of 24.4 per cent. Length of stay was 13 ± 9 days (Table 1). Data regarding day of operation was available for 80.4 per cent of cases. Forty-three percent of patients (n 4 132,909) were operated on the day of admission and 4.7 per cent (n414,554) were operated after HD 7. Majority of patients who underwent LS were operated on HD #7 (95.3%) (Table 2). On risk-adjusted multivariate analysis, patients who were operated at a later date than the admission date had a higher risk-adjusted in-hospital morbidity with an OR of 1.24 [95% confidence interval (CI): 1.17–1.30] for day 2–4, 1.60 (95% CI: 1.48–1.72) for day 5–7, and 2.63 (95% CI: 2.40–2.89) for day >7 ($P < 0.01$). Patients who were operated on HD >7 days had a higher risk-adjusted in-hospital mortality with an OR of 2.28 (95% CI: 1.67–3.12; $P < 0.01$). Table 3 lists the multivariate risk-adjusted analysis for the morbidity and mortality according to HD.

Discussion

Controversy continues to exist regarding the use of LS in adhesive SBO and on its effects on the overall incidence of SBO. This stems mainly from the lack of a large national database that would examine the trends of SBO admission and the small sample size provided in the literature providing such data.[11] Using NIS to examine trends of SBO over the past decade, we found an increase in number of admissions (3.1% per year) and an overall increase in the use of LS (an average of 8.9% per year) for patients who underwent surgical management. We also observed an increase in the rate of successful nonoperative management of SBO. An open approach continues to be the preferred method of operation (73.5%), and patients were more likely to undergo LS approach if

they were operated on within 4 days of admission. The overall morbidity after LS was 24.4 per cent, with a low rate of mortality at 0.9 per cent. Patients who were operated on at a later date than the first 24 hours have higher rate of risk adjusted in-hospital morbidity compared with those operated at a later date.

Adhesions are the primary cause of SBO and pose a great challenge to surgeons. The past two decades have seen dramatically increased the use of LS, which has been reported to decrease the incidence of SBO.[4, 15] Since the introduction of LS in 1983, it has become the standard of care in the most common general surgery procedures.[16] The increase in usage of LS would lead us to hypothesize that the number of admissions for SBO should be on the decline. However, we found that there has been a steady increase in the number of admission and surgical cases for SBO, albeit less than the overall population growth of 9.7 per cent[17] over the past decade. Given that the proportion of operative cases did not increase at the same rate as that of admissions, we can assert that a lower proportion of patients required an operation. The rate of nonoperative management was 62.7 per cent in 2001 and increased to 67.2 per cent in 2011. These factors may indicate that perhaps LS has a small effect on the severity of adhesive small bowel disease. In a review of secular trends during 1988 to 2007 using the National Hospital Discharge Survey, Scott et al.[9] concluded that there was no significant change in the overall rate of SBO. Our study shows a slight increase in the number of admissions over the past decade. Our use of more specific codes for SBO, as well as exclusions of cancer and any inflammatory diseases, may explain the difference in results. Unfortunately, given the limitation of a large database, we cannot furthermore delineate whether our sampled population had previous open or LS procedures. Given the large sample size and specific ICD-9 codes, we would expect that there would be fewer admissions for SBO in 2011 compared with 2001, with the hypothesis that the effects of LS would be more prevalent in 2011. However, there were approximately 100,000 more admissions for SBO in 2011 compared with 2001. We note the findings of previous studies that illustrated decreased formation of adhesions in LS compared with OS.[18–20] We also have a fairly heterogeneous population, and as stated by Tsui et al.,16 although the rate of usage of LS is increasing, its adoption in certain subspecialties such as colorectal surgery is much slower. Additionally, we lack data on the number of patients who had previous surgery as well as the timing of the previous surgery. Also, the impact of LS may be diluted by an increased overall number of operations and by the overall population growth.

TABLE 2. Distribution of LS Management from Day of Admission and Associated Morbidity and Mortality for the Management of SBO in the United States during 2001–2011

	Admission (n = 132,909)	Hospital day 1 (n = 61,394)	Hospital day 2–4 (n = 75,548)	Hospital day 5–7 (n = 24,610)	Day ≥7 (n = 14,554)
Procedure (%)					
Converted	20.9	17.2	16.6	18.2	17.9
LOA	78.7	82.1	82.8	80.9	80.8
SBR	0.4	0.7	0.6	0.9	1.4
Mortality (%)	0.4	0.6	1.0	1.8	4.1
Morbidity (%)	17.6	22.5	29.3	39.0	54.5

TABLE 3. *Risk-Adjusted Surgical Outcomes of SBO Based on Operative Day (Using Day 0 or Earlier as a Reference). Adjusted P Value Denotes Adjustment for Multiple Comparisons*

	Adjusted OR (95% CI)	Naive *P* value	Adjusted *P* value
In-hospital mortality			
Day 1 *vs* Day <1	0.87 (0.64–1.20)	0.40	0.94
Day 2–4 *vs* Day <2	0.98 (0.75–1.28)	0.90	0.94
Day 5–7 *vs* Day <5	1.18 (0.86–1.62)	0.31	0.94
Day 7 + *vs* Day <7	2.28 (1.67–3.12)	0.00	0.00
Morbidity			
Day 1 *vs* Day<1	1.07 (1.01–1.13)	0.018	0.073
Day 2–4 *vs* Day <2	1.24 (1.17–1.30)	0.000	0.000
Day 5–7 *vs* Day <5	1.60 (1.48–1.72)	0.000	0.000
Day 7 + *vs* Day <7	2.63 (2.40–2.89)	0.000	0.000

Despite the wider adoption of LS, open procedure may still be the preferred method of many surgeons. In fact, as reported by Kang et al.[21] in a recent study of national trends, LS was used successfully in only 35 per cent of colorectal operations. However, despite these limitations, given our large sample population and specific use of procedure and diagnosis codes, we can state that if LS does indeed decrease the rate of SBO, its effect on the American population is yet to be clearly seen. Despite the preference for the open approach, the usage of LS to treat SBO has increased over the past decade. There has been on average an 8.9 per cent increase yearly in the usage of LS. The increased adoption of LS may be attributed to the fact that most surgeons want to avoid possible complications of subsequent laparotomy, which may in fact increase risk of more adhesions and furthermore episodes of SBO. Recurrence after open surgery has been reported in 10 to 30 per cent of patients.[22–24] To date, multiple small series have been published comparing LS to OS.[23, 25–28] However, these data are scant and provides conflicting results. This may be due to a selection bias and patients who are healthier are less likely to undergo open surgery compared with their higher risk counterparts.[11] Given this inherent selection bias for patient who present with SBO, we opted to review only the LS outcomes over the past decade. We found conversion rates of 22.5 per cent, which is lower than that reported in the literature (46–87%).[4, 6, 29] Patients who were converted had a higher rate of complications at 45.5 per cent compared with 24.4 per cent. This rate of morbidity is consistent with those reported in literature.[25] Our study generally supports the smaller studies that LS for a select group of patients with SBO is safe and feasible.

Surgical approach is not the only controversy that exists with regards to the management of SBO. Surgical teaching has traditionally been “to never let the sun rise and set on a small bowel obstruction” for many years, although this dogma has relaxed in the past two decades. However, with the advent of new diagnostic modalities such as CT, we are better able to assess the severity of disease. This may allow a route of conservative management to avoid a repeated surgical procedure with ensuing adhesions and readmissions for SBO. Recent best practice guidelines have proposed that nonoperative management is safe.[30–32] Despite these guidelines, there continues to be

controversy regarding the exact timing of operative management of SBO. Our study found that 63.3 per cent of patients were managed successfully conservatively. In patients who required an operation, delay in management of SBO was associated with higher risk-adjusted mortality and morbidity. In fact, the longer the delay, the worse the outcomes. This was confirmed by Schraufnagel et al. using NIS 2009 data, who also observed that most patients who underwent successful conservative management were discharged on day 4. Unfortunately, the NIS data are limited in terms of reason for operative management. We can only observe that in patients who required operative management, a delay in management was associated with higher rates of in-hospital mortality and morbidity.

Limitations

This study is limited by the inherent biases of a large retrospective review. The NIS database are compiled from discharge abstract data and is limited to in-hospital morbidity and mortality without outpatient follow-up data such as postdischarge complications, readmission, or long-term outcomes and survival benefits. The NIS lacks clinical information such as degree of obstruction, the use of nasogastric tubes, and reoperation. We also do not have information on laboratory and or radiological findings that may have influenced surgical decision making. We also cannot discern whether an SBR was secondary to inadvertent enterotomy secondary to adhesions and/or gangrenous bowel. Coding for certain comorbidities and postoperative complications can be vague and subjectively defined. Despite these limitations, this study is the largest to date to report the national trends and outcomes on the usage of LS for SBO.

Conclusion

Using a national inpatient database, we examined the trends and outcomes of patients with SBO who underwent operative management, and found a steady increase in the number of SBO admissions in the United States. There seems to be a plateauing effect during the years of 2009 to 2011, which may indicate that the rate of SBO may be stabilizing. Open surgical approach to SBO continues to be the preferred surgical approach. However, there has been a steady increase in the rate of successful nonoperative management of SBO and the usage of LS over the last decade. In patients requiring surgical management, delay in surgical management was associated with higher risk-adjusted in-hospital mortality and morbidity.

REFERENCES

1. Menzies D. Postoperative adhesions: their treatment and relevance in clinical practice. Ann R Coll Surg Engl 1993;75:147–53.
2. Menzies D, Ellis H. Intestinal obstruction from adhesions–how big is the problem? Ann R Coll Surg Engl 1990;72:60–3.
3. Parker MC, Ellis H, Moran BJ, et al. Postoperative adhesions: ten-year follow-up of 12,584 patients undergoing lower abdominal surgery. Dis Colon Rectum 2001;44:822–9, discussion829–30.
4. Gutt CN, Oniu T, Schemmer P, et al. Fewer adhesions induced by laparoscopic

surgery? Surg Endosc 2004;18:898–906.
5. Miller G, Boman J, Shrier I, et al. Etiology of small bowel obstruction. Am J Surg 2000;180:33–6.
6. Ellis H, Moran BJ, Thompson JN, et al. Adhesion-related hospital readmissions after abdominal and pelvic surgery: a retrospective cohort study. Lancet 1999;353:1476–80.
7. Foster NM, McGory ML, Zingmond DS, et al. Small bowel obstruction: a population-based appraisal. J Am Coll Surg 2006; 203:170–6.
8. Ghosheh B, Salameh JR. Laparoscopic approach to acute small bowel obstruction: review of 1061 cases. Surg Endosc 2007; 21:1945–9.
9. Scott FI, Osterman MT, Mahmoud NN, et al. Secular trends in small-bowel obstruction and adhesiolysis in the United States: 1988-2007. Am J Surg 2012;204:315–20.
10. Bastug DF, Trammell SW, Boland JP, et al. Laparoscopic adhesiolysis for small bowel obstruction. Surg Laparosc Endosc 1991;1:259–62.
11. Li MZ, Lian L, Xiao LB, et al. Laparoscopic versus open adhesiolysis in patients with adhesive small bowel obstruction: a systematic review and meta-analysis. Am J Surg 2012;204:779–86.
12. Holm S. Proceedings of the fifth Berkeley symposium on mathematical statistics and probability. Scand J Stat 1979;6:65–70.
13. Huber PJ. Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability Vol 1 (221–33), 1967.
14. Wright SP. Adjusted P-values for simultaneous inference. Biometrics 1992;48:1005–13.
15. Taylor GW, Jayne DG, Brown SR, et al. Adhesions and incisional hernias following laparoscopic versus open surgery for colorectal cancer in the CLASICC trial. Br J Surg 2010;97:70–8.
16. Tsui C, Klein R, Garabrant M. Minimally invasive surgery: national trends in adoption and future directions for hospital strategy. Surg Endosc 2013;27:2253–7.
17. Population Distribution and Change. 2000 to 2010. 2010. Available at: http://www.census.gov/prod/cen2010/briefs/c2010br-01.pdf. Accessed July 22, 2015.
17. Audebert AJ, Gomel V. Role of microlaparoscopy in the diagnosis of peritoneal and visceral adhesions and in the prevention of bowel injury associated with blind trocar insertion. Fertil Steril 2000;73:631–5.
18. Polymeneas G, Theodosopoulos T, Stamatiadis A, et al. A comparative study of postoperative adhesion formation after laparoscopic vs open cholecystectomy. Surg Endosc 2001;15:41–3.
19. Tittel A, Treutner KH, Titkova S, et al. Comparison of adhesion reformation after laparoscopic and conventional adhesiolysis in an animal model. Langenbecks Arch Surg 2001;386: 141–5.
20. Kang CY, Chaudhry OO, Halabi WJ, et al. Outcomes of laparoscopic colorectal surgery: data from the Nationwide Inpatient Sample 2009. Am J Surg 2012;204:952–7.
21. Barkan H, Webster S, Ozeran S. Factors predicting the recurrence of adhesive small bowel obstruction. Am J Surg 1995; 170:361–5.

22. Grafen FC, Neuhaus V, Schob O, et al. Management of acute small bowel obstruction from intestinal adhesions: indications for laparoscopic surgery in a community teaching hospital. Langenbecks Arch Surg 2010;395:57–63.
24. Mucha P Jr. Small intestinal obstruction. Surg Clin North Am 1987;67:597–620.
25. Khaikin M, Schneidereit N, Cera S, et al. Laparoscopic vs. open surgery for acute adhesive small-bowel obstruction: patients' outcome and cost-effectiveness. Surg Endosc 2007;21:742–6.
26. Zanghi G, Di Stefano G, Benfatto G, et al. Laparoscopic surgery in acute small bowel obstruction: our experience. G Chir 2012;33:38–40.
27. Chopra R, McVay C, Phillips E, et al. Laparoscopic lysis of adhesions. Am Surg 2003;69:966–8.
28. Wullstein C, Gross E. Laparoscopic compared with conventional treatment of acute adhesive small bowel obstruction. Br J Surg 2003;90:1147–51.
29. Sato Y, Ido K, Kumagai M, et al. Laparoscopic adhesiolysis for recurrent small bowel obstruction: long-term follow-up. Gastrointest Endosc 2001;54:476–9.
30. Diaz JJ Jr, Bokhari F, Mowery NT, et al. Guidelines for management of small bowel obstruction. J Trauma 2008;64: 1651–64.
31. Catena F, Di Saverio S, Kelly MD, et al. Bologna Guidelines for Diagnosis and Management of Adhesive Small Bowel Obstruction (ASBO): 2010 Evidence-Based Guidelines of the World Society of Emergency Surgery. World J Emerg Surg 2011;6:5.
32. Maung AA, Johnson DC, Piper GL, et al. Evaluation and management of small-bowel obstruction: an Eastern Association for the Surgery of Trauma practice management guideline. J Trauma Acute Care Surg 2012;73(Suppl 4):S362–9.

This work received departmental support.
Address correspondence and reprint requests to Michael J. Stamos, M.D., Professor and the John E. Connolly Chair in Surgery, 333 City Boulevard West, Suite 1600, Orange, CA 92868. E-mail:mstamos@uci.edu.