Published in final edited form as:
Colorectal Dis. 2015 March ; 17(3): 257–264. doi:10.1111/codi.12800.

Factors Associated with Conversion from Laparoscopic to Open Colectomy using the National Surgical Quality Improvement Program (NSQIP) Database

Anuradha R. Bhama, M.D.[1], **Mary E. Charlton, Ph.D.**[2], **Mary B. Schmitt**[1], **John W. Cromwell, M.D., FACS, FASCRS**[1], and **John C. Byrn, M.D.**[1]

[1]Department of Surgery, Division of Gastrointestinal, Minimally-invasive, and Bariatric Surgery, University of Iowa Hospitals and Clinics, Iowa City, IA 52241

[2]Department of Epidemiology, University of Iowa College of Public Health, Iowa City, IA 52245

Abstract

Aim—Conversion rates from laparoscopic to open colectomy and associated factors are traditionally reported in clinical trials or reviews of outcomes from experienced institutions. Indications and selection criteria for laparoscopic colectomy may be more narrowly defined in these circumstances. With increased adoption and liberalized use of laparoscopy, conversion rates using national data need to be closely examined. The purpose of this study was to use data from ACS-NSQIP to identify factors associated with conversion of laparoscopic to open colectomy on a national scope.

Methods—The ACS-NSQIP Participant Use Data Files for 2006–2011 were used to identify patients who had undergone laparoscopic colectomy. Converted cases were identified using open colectomy as the primary procedure and laparoscopic colectomy as “other procedure”. Preoperative variables were identified and statistics were calculated using SASv9.3. Logistic regression was used to model the multivariate relationship between patient variables and conversion status.

Results—Laparoscopy was successfully performed in 41,585 patients, while 2,508 (5.8%) patients required conversion to an open procedure. On univariate analysis, the following factors were significant: Age, BMI, ASA class, presence of diabetes, smoking, COPD, ascites, stroke, weight loss, and chemotherapy ($p<0.05$). The following factors remained significant on multivariate analysis: age, BMI, ASA class, smoking, ascites and weight loss.

Corresponding Author: John C. Byrn, M.D., 200 Hawkins Drive 4577 JCP, Iowa City, IA 52242, Phone: 319-384-7359, Fax: 319-356-4609, john-byrn@uiowa.edu.

Authorship credit:

- Bhama: Acquisition of data, analysis and interpretation of data, drafting article, revising article, final approval
- Charlton: Analysis and interpretation of data, revising article, final approval
- Schmitt: Acquisition of data, revising article, final approval
- Cromwell: Conception and design, analysis and interpretation of data, revising article, final approval
- Byrn: Conception and design, analysis and interpretation of data, revising article, final approval

Conclusions—Multiple significant factors for conversion from laparoscopic to open colectomy were identified. A novel finding was the increased risk of conversion for underweight patients. As laparoscopic colectomy is become increasingly utilized nationally, factors predictive of conversion to open procedures should be sought via large, national cohorts.

Introduction

Laparoscopic colon resection was first pioneered in the 1990s. Since that time, several studies have examined the benefits of laparoscopic colon and rectal surgery. In colon cancer, laparoscopic surgery has been shown to have equivalent oncologic outcomes as open resection, and suggested benefits of laparoscopic colon resection include: lower mortality, lower morbidity, decreased length of stay, and lower costs (1–5). Laparoscopic proctectomy has also been examined, though long term results regarding locoregional recurrence and long term survival are still under investigation. Several groups have demonstrated short-term postoperative benefits with equivalent oncologic resection (5–8). Laparoscopic colectomy and proctectomy may also be associated with decreased anastomotic leak, ileus, urinary tract infection (UTI), pneumonia, respiratory failure and wound infections (9, 10). The need to convert to an open procedure can negate these benefits and has been independently linked to increased anastomotic leak, wound infection, ileus, and UTI (11).

As recently as 2007, reports in the literature suggested low laparoscopic adoption rates for colectomy nationwide (12). More recent reports, however, are showing widespread employment of laparoscopy for colorectal resections – a recent examination of national trends reported 42% of colectomies are attempted laparoscopically with a reported conversion rate of 15.8% (13). With recent national data showing widespread adoption of laparoscopy, reports related to conversion remain focused on limited patient populations from individual institutions (14–17). As expected, the conversion rates from laparoscopic to open procedure for colectomy have varied widely from 2 and 77% (11). Though outcomes of conversion from laparoscopic to open colorectal surgery have been reported at a national level, the risk factors associated with conversion need to be studied on this scale.

The goal of this study was to utilize national data from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) to identify the factors that are associated with the need to convert to from laparoscopic to open colectomy for patients undergoing laparoscopic colectomy of all anatomic locations.

Materials and Methods

Data Acquisition

University of Iowa Institutional Review Board approval was obtained for this study. The American College of Surgeons – National Surgical Quality Improvement Program (ASC-NSQIP) participant use data files for the years 2006–2011 were used to identify patients who underwent colectomy. Colectomy procedures were defined by Current Procedure Terminology (CPT) codes: 44204, 44205, 44206, 44207, 44208, 44210, 44140, 44141, 44143, 44144, 44145, 44146, 44147, 44150, and 44160. Emergency procedures were excluded. To select the patients in this group who underwent a laparoscopic converted to

open procedure, “open colectomy” was identified as the primary procedure with “laparoscopic” procedure identified as any “other procedure”. In order to validate this method of identifying converted cases, an internal review was performed at our institution.

Patients who underwent successful laparoscopic colectomy were also identified. All preoperative variables provided in the NSQIP Participant Usage Data File (PUF) database were reviewed and variables were chosen based on clinical applicability and completeness of the data set. These variables were assigned as independent variables. The need to convert to an open procedure was chosen as the dependent variable. Preoperative factors available through the NSQIP PUF were analyzed and included: sex, age (stratified in groups of 15 years; the age of 50 was used as the initial cutoff given that this is the recommend age for first screening colonoscopy in the general population), height, weight, body mass index (BMI) (based upon World Health Organization categorization(18): Underweight: <18.5 kg/m^2, Normal: 18.6–24.9 kg/m^2, Overweight: 24.9–30.0 kg/m^2, Obese: >30 kg/m^2), body surface area (BSA), diabetes, smoking history, chronic obstructive pulmonary disease (COPD), presence of ascites, history of congestive heart failure (CHF), history of recent myocardial infarction (MI), presence of renal failure, current dialysis treatment, history of stroke, recent weight loss, chemotherapy within 30 days preoperatively or radiation treatment within 90 days preoperatively, and ASA class (American Society of Anesthesiologists; 1= normal healthy patient, 2 = patient with mild systemic disease, 3 = patient with severe systemic disease, 4= patient with severe systemic disease that is constant threat to life). Standard definitions for all variables are provided by NSQIP(19).

Statistical Analysis

Chi-square tests for categorical variables and t-tests for continuous variables were used to compare groups (laparoscopy and laparoscopy converted to an open procedure) on key variables obtained from the NSQIP data set. Logistic regression was used to model the multivariate relationship between patient characteristics and conversion status. The set of candidate variables for the model include those listed in Table 1. The final model was developed using a backward selection process to retain all variables with an adjusted p-value of less than 1.0. Subjects with missing values for selected variables of interest were excluded from the logistic regression model (n=220). Also, those with height values less than 4 feet (n=424) were excluded because they were likely indicative of measurement or data input error and caused extreme values of BMI. Finally, six subjects with ASA class five were excluded. Selected variables thought to have substantial clinical importance were forced into the final model. All statistical analyses were performed in SAS v9.3 (Cary, NC).

Results

The ACS-NSQIP data set from the years 2006–2011 was used to identify 94,464 colectomy patients. 50,371 patients underwent open colectomy and 44,093 patients were identified as having undergone attempted laparoscopic colectomy, resulting in a laparoscopic colectomy rate of 46.7%. Of these patients, 2,508 (5.8%) patients were identified as having undergone conversion to open from a laparoscopic procedure. 41,585 (94.2%) patients were identified as having undergone successful laparoscopic colectomy (Figure 1)

A chart review was completed on all colectomies performed at the University of Iowa Hospitals and Clinics between 2009–2012 (n=301). Operative notes were reviewed to identify those cases that were unplanned conversions to open procedures. 47 procedures were identified as unplanned conversion to open procedures. These cases were then compared to the data in our NSQIP database using the coding strategy described above, which correctly identified 42 of the 47 (89.4%) of unplanned conversion from laparoscopic to open procedures.

Univariate analysis was performed on the following preoperative variables: age, gender, BMI, ASA class, history of diabetes, smoking, chronic obstructive pulmonary disease (COPD), presence of ascites, congestive heart failure (CHF), recent myocardial infarction (MI), renal failure, current dialysis, recent stroke, steroid use, weight loss, recent chemotherapy and radiation treatment. Table 1 outlines the comparison of these variables within laparoscopic and conversion groups. All variables were found to be significant except for gender, CHF, recent MI, renal failure, current dialysis, steroid use and radiation treatment.

A multivariate analysis was performed using a backwards selection model, which is summarized in Table 2. Several characteristics remained significant on multivariate analysis. The odds of conversion to an open procedure was higher with age over 50 years, and was highest in those over 80 years (OR=1.73; 95% CI: 1.45, 2.04). Using normal BMI as a reference, the odds of converting to an open procedure increased in obese patients, but not overweight patients (Overweight: OR=1.02; 95% CI: 0.91, 1.13; Obese: OR=1.31; 95% CI: 1.18, 1.47). Additionally, being underweight also resulted in an increased odds of conversion (OR=37.00, 95% CI: 1.06, 1.79). ASA class 3 and 4 were also identified as having increased odds for conversion when compared to ASA class 1 (ASA 3: OR=1.35; 95% CI: 1.05, 1.75; ASA 4: OR=1.68; 95% CI: 1.22, 2.31). ASA class 2 did not differ significantly from ASA class 1. Smoking (OR=1.20; 95% CI: 1.07, 1.34) and presence of weight loss (OR=1.24; 95% CI: 1.01, 1.54) were both associated with increased odds of conversion. The most significant variable identified was the presence of ascites, which resulted in a three-fold increased odds of converting to an open procedure (OR=3.4; 95% CI: 2.18, 5.20); however, the number of subjects with ascites was very small (n=26). Radiation treatment did not increase the odds of conversion to open procedure, and there was no difference between genders.

Discussion

The goal of this study was to identify risk factors associated with conversion from laparoscopic to open colectomy at the national level using NSQIP data. To our knowledge, this is the largest study to date that examines risk factors for conversion for laparoscopic colectomy. Our data demonstrates that age, BMI, ASA class, smoking, weight loss, and ascites were all associated with an increased odds of conversion from laparoscopic to open colectomy.

In our study we hoped to capture factors pertinent to laparoscopic colectomy conversion to open on a national level over a time period in which the rapid expanse of the technique of

laparoscopy was occurring. For this reason we broadly defined laparoscopic colectomy by CPT code and included all anatomic locations, including transverse colon resection. The inclusion of laparoscopic transvers colectomy is somewhat controversial as these procedures were traditionally excluded from initial studies examining laparoscopic colectomy. Importantly, CPT codes do not allow for the specific identification of transverse colectomy and in our cohort NSQIP defined discharge diagnosis identified 1.3% of converted cases and 1.1% of laparoscopic cases (total n=563; data not shown) were performed for malignant neoplasm of the transverse colon. Recently, oncologic outcomes of laparoscopic transverse colectomy have been shown to be equivalent to laparoscopic resection of the remainder of the colon when compared to open resection (20). Newer studies have demonstrated that, though technically challenging, laparoscopic transverse colectomy offers equivalent oncologic outcomes and some improved short-term postoperative outcomes (21–23). Given these recent findings, the limitations of CPT coding, the small percentage of total cases transverse colectomy likely represented, and our goal to capture a picture of the “real world” employment of laparoscopy for colon resection, transverse colectomy was not excluded from our study group.

Taylor et al have reported no difference in age in regards to conversion for patients undergoing resection for colorectal cancer in the United Kingdom (24), while other groups have reported conversion rates as low as 6.1% in octogenarians (25). Our data demonstrated a somewhat comparable 7.3% rate of conversion among those over 80. This rate of conversion was substantially higher than that in patients under 50 (3.9% conversion rate). After controlling for other relevant risk factors, age greater than 80 increases the odds of converting to an open procedure by 73% compared to those under 50.

Laparoscopy in obese patients has been shown to be safe and not associated with increase in postoperative morbidity or mortality (26). Multiple studies have reported a wide range in conversion rates for obese patients ranging from 1.1% to 18% (27, 28) with the most common reason for conversion being obesity-related difficulty with visualization and dissection. Vaccaro et al suggested body surface area (BSA) is a more accurate predictor for conversion (16). In our study, the mean BSA for the laparoscopic group was significantly less than that for the conversion group (1.92 m^2 vs. 1.95 m^2; p=0.0002). Furthermore, in some of our multivariate modeling (data not shown) BSA had a very similar concordance with conversion as BMI. Because BMI is clinically more usable, and the total BSA difference was small (0.03m^2), we opted to examine BMI classification in our multivariate analysis, using the standardized definition provided by the World Health Organization. Prior examinations of the NSQIP database have shown no statistical difference in BMI between patients undergoing either laparoscopic or open colon resection (29). Our data demonstrates an unadjusted rate of 6.3% in obese patients compared to 5.0% among normal weight patients, and an increased odds of conversion in obese patients (BMI > 30kg/m^2) after controlling for other factors. Though the conversion rates are higher in obese patients, case-matched studies have demonstrated that laparoscopy can be performed safely with shorter postoperative recovery compared to those undergoing open colon resection (30). Patients with BMI >30kg/m^2 can be offered laparoscopic resection, but should be counseled as to the possible increased risk of requiring an open procedure.

Conversely, our data demonstrated those with weight loss had an unadjusted conversion rate of 6.58% compared to a rate of 5.66% among those without weight loss. This resulted in a 24% increased odds of conversion after adjusting for other factors in the model. Likewise, those with an underweight BMI (<18.5 kg/m^2) had an unadjusted rate of 7.06% compared to 4.95% among normal weight patients, and a 37% increased odds of conversion. This could signify that patients with potentially more advanced malignancy, generalized poor performance status, history of cancer, or history of prior bowel resections have an increased rate of conversion. Though weight loss has not been studied extensively in relation to laparoscopic surgery, one prospective multi-center study demonstrated that weight-loss was associated with increased morbidity and mortality, when defined to be >10% loss in preceding 6 months (31). It is well known that malnutrition is related to poor postoperative outcomes (32); however, the relation to conversion to open procedure has not been previously shown. One hypothesis is that standard port placement may not be adequate in patients with underweight BMI as their abdominal wall dimensions differ from normal and obese patients (33). In our study, laparoscopic colectomy in underweight individuals is associated with an increased rate of conversion to an open procedure. Further studies are required to elucidate the need for conversion in these underweight patients.

The effects of smoking in the perioperative period have been studied extensively. When smokers are categorized as high-risk patients, laparoscopic colorectal surgery is considered safe, albeit associated with increased postoperative complications (34, 35). Our data demonstrated an increased risk of conversion in smokers, with an unadjusted rate of 7.35% compared to non-smokers (5.67%) and a significant odds ratio of 1.20 after accounting for other factors in the model. Although not explanatory for all colectomy cases in this study, smokers with diverticular disease have been found to have greater rates of perforation and recurrent diverticulitis episodes when compared to nonsmokers (36). While the direct mechanism by which smoking results in increased conversion in colectomy has not been definitively elucidated, smoking cessation perioperatively has been demonstrated to decrease postoperative complications in numerous studies (37–39). The additional knowledge of a 20% increased odds of needing to convert to open surgery may warrant preoperative counseling, as it has been demonstrated to improve smoking abstinence at time of the surgery (40).

The presence of ascites has been shown to have a strong association with 30-day mortality following colorectal resection (41). NSQIP defines the presence of ascites only if there is a preexisting diagnosis of malignant ascites or liver disease. In this patient population ascites may represent underlying primary liver disease or malignant ascites secondary to peritoneal carcinomatosis. Our data suggests that the strongest association for conversion was the presence of ascites (OR 3.40, 95% CI 2.18–5.20), although in a small number of patients (n=145). In our study, 26 out of a total of 141 patients (18.44%) with ascites underwent conversion of attempted laparoscopic resection compared to 5.65% without ascites. While the proportion of patients with ascites in this study was small, taking into consideration the strong association with conversion to an open procedure and increased postoperative mortality, the rare patient with ascites should be counseled appropriately.

There are several limitations to the ACS-NSQIP data reviews that deserve specific mention for our study. First, a selection bias is inherent to the retrospective design and patient selection criteria for the laparoscopic approach are impossible to assess in this large, multi-institutional and de-identified data set. Selection bias can be expected to contribute to the low conversion rates in this patient population. Surgeon bias is generally to offer laparoscopy to the healthiest patients with greatest chance of success(13). It is likely that laparoscopy was offered to patients without history of prior cancers or prior abdominal operations. Unfortunately it is not possible to identify each surgeon's case-by-case reason for offering laparoscopy or for conversion, as it would not be possible to review all patient charts on a national level and due to the de-identified nature of the NSQIP data. However, this study provides an initial understanding of patient-specific characteristics that may influence the need to convert to an open procedure.

Another limitation to our study is the method by which converted cases were determined, which relied heavily on the accuracy of CPT coding within the NSQIP database. Within the confines of NSQIP data entry protocols, it was necessary to classify conversion based on cases categorized "laparoscopy" as a secondary procedure and "open" as the primary procedure. The assumption is that the surgeon intended on completing the colectomy laparoscopically. This coding strategy was verified to be approximately 90% accurate at identifying unplanned conversions in review of colectomies at our institution.

Conclusion

Based on our review of the ACS-NSQIP data set, it is difficult to predict who will require laparoscopic conversion to an open colectomy on the national scale. Laparoscopic colectomy patients should be counseled that individual risk of conversion for colectomy is not easy to predict, but associated risk factors can be discussed. A novel finding was the increased risk of laparoscopic conversion to open colectomy for underweight patients. As laparoscopic colectomy is becoming increasingly utilized nationally, factors predictive of conversion to open procedures should be sought via large, national cohorts. Future studies are necessary to confirm risk factors associated with conversion from laparoscopic to open colectomy in more homogeneous patient populations.

References

1. Lacy AM, Garcia-Valdecasas JC, Delgado S, Castells A, Taura P, Pique JM, et al. Laparoscopy-assisted colectomy versus open colectomy for treatment of non-metastatic colon cancer: a randomised trial. Lancet. 2002 Jun 29; 359(9325):2224–9. Epub 2002/07/10. eng. [PubMed: 12103285]
2. Buunen M, Veldkamp R, Hop WC, Kuhry E, Jeekel J, et al. Colon Cancer Laparoscopic or Open Resection Study G. Survival after laparoscopic surgery versus open surgery for colon cancer: long-term outcome of a randomised clinical trial. The lancet oncology. 2009 Jan; 10(1):44–52. Epub 2008/12/17. eng. [PubMed: 19071061]
3. Guillou PJ, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AM, et al. Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. Lancet. 2005 May 14–20; 365(9472): 1718–26. Epub 2005/05/17. eng. [PubMed: 15894098]

4. Ng SS, Lee JF, Yiu RY, Li JC, Hon SS, Mak TW, et al. Long-term Oncologic Outcomes of Laparoscopic Versus Open Surgery for Rectal Cancer: A Pooled Analysis of 3 Randomized Controlled Trials. Annals of surgery. 2013 Apr 23. Epub 2013/04/20. Eng.

5. van der Pas MH, Haglind E, Cuesta MA, Furst A, Lacy AM, Hop WC, et al. Laparoscopic versus open surgery for rectal cancer (COLOR II): short-term outcomes of a randomised, phase 3 trial. The lancet oncology. 2013 Mar; 14(3):210–8. [PubMed: 23395398]

6. Braga M, Frasson M, Vignali A, Zuliani W, Capretti G, Di Carlo V. Laparoscopic resection in rectal cancer patients: outcome and cost-benefit analysis. Diseases of the colon and rectum. 2007 Apr; 50(4):464–71. [PubMed: 17195085]

7. Lujan J, Valero G, Hernandez Q, Sanchez A, Frutos MD, Parrilla P. Randomized clinical trial comparing laparoscopic and open surgery in patients with rectal cancer. The British journal of surgery. 2009 Sep; 96(9):982–9. [PubMed: 19644973]

8. Denoya P, Wang H, Sands D, Nogueras J, Weiss E, Wexner SD. Short-term outcomes of laparoscopic total mesorectal excision following neoadjuvant chemoradiotherapy. Surgical endoscopy. 2010 Apr; 24(4):933–8. [PubMed: 19851807]

9. Kang CY, Chaudhry OO, Halabi WJ, Nguyen V, Carmichael JC, Stamos MJ, et al. Outcomes of laparoscopic colorectal surgery: data from the Nationwide Inpatient Sample 2009. American journal of surgery. 2012 Dec; 204(6):952–7. Epub 2012/11/06. eng. [PubMed: 23122910]

10. Arezzo A, Passera R, Scozzari G, Verra M, Morino M. Laparoscopy for rectal cancer reduces short-term mortality and morbidity: results of a systematic review and meta-analysis. Surgical endoscopy. 2013 May; 27(5):1485–502. Epub 2012/11/28. eng. [PubMed: 23183871]

11. Marusch F, Gastinger I, Schneider C, Scheidbach H, Konradt J, Bruch HP, et al. Importance of conversion for results obtained with laparoscopic colorectal surgery. Diseases of the colon and rectum. 2001 Feb; 44(2):207–14. discussion 14–6. Epub 2001/03/03. eng. [PubMed: 11227937]

12. Masoomi H, Buchberg BS, Magno C, Mills SD, Stamos MJ. Trends in diverticulitis management in the United States from 2002 to 2007. Archives of surgery. 2011 Apr; 146(4):400–6. Epub 2010/12/22. eng. [PubMed: 21173283]

13. Simorov A, Shaligram A, Shostrom V, Boilesen E, Thompson J, Oleynikov D. Laparoscopic colon resection trends in utilization and rate of conversion to open procedure: a national database review of academic medical centers. Annals of surgery. 2012 Sep; 256(3):462–8. Epub 2012/08/08. eng. [PubMed: 22868361]

14. Gervaz P, Pikarsky A, Utech M, Secic M, Efron J, Belin B, et al. Converted laparoscopic colorectal surgery. Surgical endoscopy. 2001 Aug; 15(8):827–32. Epub 2001/07/10. eng. [PubMed: 11443444]

15. Rabasova M, Martinek L. Conversion risk factors in laparoscopic colorectal surgery. Wideochirurgia i inne techniki malo inwazyjne = Videosurgery and other miniinvasive techniques/ kwartalnik pod patronatem Sekcji Wideochirurgii TChP oraz Sekcji Chirurgii Bariatrycznej TChP. 2012 Dec; 7(4):240–5. Epub 2013/01/31. eng.

16. Vaccaro CA, Vaccarezza H, Rossi GL, Mentz R, Im VM, Quintana GO, et al. Body surface area: a new predictor factor for conversion and prolonged operative time in laparoscopic colorectal surgery. Diseases of the colon and rectum. 2012 Nov; 55(11):1153–9. Epub 2012/10/10. eng. [PubMed: 23044676]

17. Schwandner O, Schiedeck TH, Bruch H. The role of conversion in laparoscopic colorectal surgery: Do predictive factors exist? Surgical endoscopy. 1999 Feb; 13(2):151–6. Epub 1999/01/26. eng. [PubMed: 9918619]

18. WHO. Report of a WHO Consultation. Geneva: World Health Organization; 2000. Obesity: preventing and managing the global epidemic. WHO Technical Report Series 894

19. Surgeons ACo. ACS NSQIP User Guide for the Participant Use Data File. 2007

20. Clinical Outcomes of Surgical Therapy Study G. A comparison of laparoscopically assisted and open colectomy for colon cancer. The New England journal of medicine. 2004 May 13; 350(20): 2050–9. [PubMed: 15141043]

21. Fernandez-Cebrian JM, Gil Yonte P, Jimenez-Toscano M, Vega L, Ochando F. Laparoscopic colectomy for transverse colon carcinoma: a surgical challenge but oncologically feasible.

Colorectal disease: the official journal of the Association of Coloproctology of Great Britain and Ireland. 2013 Feb; 15(2):e79–83. [PubMed: 23078032]

22. Akiyoshi T, Kuroyanagi H, Fujimoto Y, Konishi T, Ueno M, Oya M, et al. Short-term outcomes of laparoscopic colectomy for transverse colon cancer. Journal of gastrointestinal surgery: official journal of the Society for Surgery of the Alimentary Tract. 2010 May; 14(5):818–23. [PubMed: 20224982]
23. Schlachta CM, Mamazza J, Poulin EC. Are transverse colon cancers suitable for laparoscopic resection? Surgical endoscopy. 2007 Mar; 21(3):396–9. [PubMed: 17103274]
24. Taylor EF, Thomas JD, Whitehouse LE, Quirke P, Jayne D, Finan PJ, et al. Population-based study of laparoscopic colorectal cancer surgery 2006–2008. Br J Surg. 2013 Mar; 100(4):553–60. Epub 2013/01/05. eng. [PubMed: 23288592]
25. Vignali A, Di Palo S, Tamburini A, Radaelli G, Orsenigo E, Staudacher C. Laparoscopic vs. open colectomies in octogenarians: a case-matched control study. Dis Colon Rectum. 2005 Nov; 48(11): 2070–5. Epub 2005/08/09. eng. [PubMed: 16086219]
26. Makino T, Shukla PJ, Rubino F, Milsom JW. The impact of obesity on perioperative outcomes after laparoscopic colorectal resection. Ann Surg. 2012 Feb; 255(2):228–36. Epub 2011/12/23. eng. [PubMed: 22190113]
27. Canedo J, Pinto RA, Regadas S, Regadas FS, Rosen L, Wexner SD. Laparoscopic surgery for inflammatory bowel disease: does weight matter? Surg Endosc. 2010 Jun; 24(6):1274–9. Epub 2010/01/02. eng. [PubMed: 20044772]
28. Nitori N, Hasegawa H, Ishii Y, Endo T, Kitagawa Y. Impact of visceral obesity on short-term outcome after laparoscopic surgery for colorectal cancer: a single Japanese center study. Surg Laparosc Endosc Percutan Tech. 2009 Aug; 19(4):324–7. Epub 2009/08/21. eng. [PubMed: 19692882]
29. Senagore AJ, Stulberg JJ, Byrnes J, Delaney CP. A national comparison of laparoscopic vs. open colectomy using the National Surgical Quality Improvement Project data. Dis Colon Rectum. 2009 Feb; 52(2):183–6. Epub 2009/03/13. eng. [PubMed: 19279409]
30. Delaney CP, Pokala N, Senagore AJ, Casillas S, Kiran RP, Brady KM, et al. Is laparoscopic colectomy applicable to patients with body mass index >30? A case-matched comparative study with open colectomy. Dis Colon Rectum. 2005 May; 48(5):975–81. Epub 2005/03/29. eng. [PubMed: 15793638]
31. Alves A, Panis Y, Mathieu P, Mantion G, Kwiatkowski F, Slim K. Postoperative mortality and morbidity in French patients undergoing colorectal surgery: results of a prospective multicenter study. Arch Surg. 2005 Mar; 140(3):278–83. discussion 84. Epub 2005/03/23. eng. [PubMed: 15781793]
32. Garth AK, Newsome CM, Simmance N, Crowe TC. Nutritional status, nutrition practices and post-operative complications in patients with gastrointestinal cancer. J Hum Nutr Diet. 2010 Aug; 23(4):393–401. Epub 2010/03/27. eng. [PubMed: 20337847]
33. Ambardar S, Cabot J, Cekic V, Baxter K, Arnell TD, Forde KA, et al. Abdominal wall dimensions and umbilical position vary widely with BMI and should be taken into account when choosing port locations. Surg Endosc. 2009 Sep; 23(9):1995–2000. Epub 2008/06/17. eng. [PubMed: 18553206]
34. Kang CY, Halabi WJ, Chaudhry OO, Nguyen V, Ketana N, Carmichael JC, et al. A nationwide analysis of laparoscopy in high-risk colorectal surgery patients. J Gastrointest Surg. 2013 Feb; 17(2):382–91. Epub 2012/12/06. eng. [PubMed: 23212528]
35. Kakarla VR, Nurkin SJ, Sharma S, Ruiz DE, Tiszenkel H. Elective laparoscopic versus open colectomy for diverticulosis: an analysis of ACS-NSQIP database. Surgical endoscopy. 2012 Jul; 26(7):1837–42. [PubMed: 22258301]
36. Turunen P, Wikstrom H, Carpelan-Holmstrom M, Kairaluoma P, Kruuna O, Scheinin T. Smoking increases the incidence of complicated diverticular disease of the sigmoid colon. Scand J Surg. 2010; 99(1):14–7. Epub 2010/05/27. eng. [PubMed: 20501352]
37. Lindstrom D, Sadr Azodi O, Wladis A, Tonnesen H, Linder S, Nasell H, et al. Effects of a perioperative smoking cessation intervention on postoperative complications: a randomized trial. Ann Surg. 2008 Nov; 248(5):739–45. Epub 2008/10/25. eng. [PubMed: 18948800]

38. Hawn MT, Houston TK, Campagna EJ, Graham LA, Singh J, Bishop M, et al. The attributable risk of smoking on surgical complications. Ann Surg. 2011 Dec; 254(6):914–20. Epub 2011/08/27. eng. [PubMed: 21869677]

39. Turan A, Mascha EJ, Roberman D, Turner PL, You J, Kurz A, et al. Smoking and perioperative outcomes. Anesthesiology. 2011 Apr; 114(4):837–46. Epub 2011/03/05. eng. [PubMed: 21372682]

40. Webb AR, Robertson N, Sparrow M. Smokers know little of their increased surgical risks and may quit on surgical advice. ANZ J Surg. 2013 Feb 17. Epub 2013/02/19. Eng.

41. Cone MM, Herzig DO, Diggs BS, Rea JD, Hardiman KM, Lu KC. Effect of surgical approach on 30-day mortality and morbidity after elective colectomy: a NSQIP study. Journal of gastrointestinal surgery: official journal of the Society for Surgery of the Alimentary Tract. 2012 Jun; 16(6):1212–7. Epub 2012/03/10. eng. [PubMed: 22402957]

What does this paper add to the literature?

This article is the largest assessment of laparoscopic colorectal procedures in the United States to date. This analysis provides insight as to patient-specific risk factors contributing to need to convert to an open procedure.

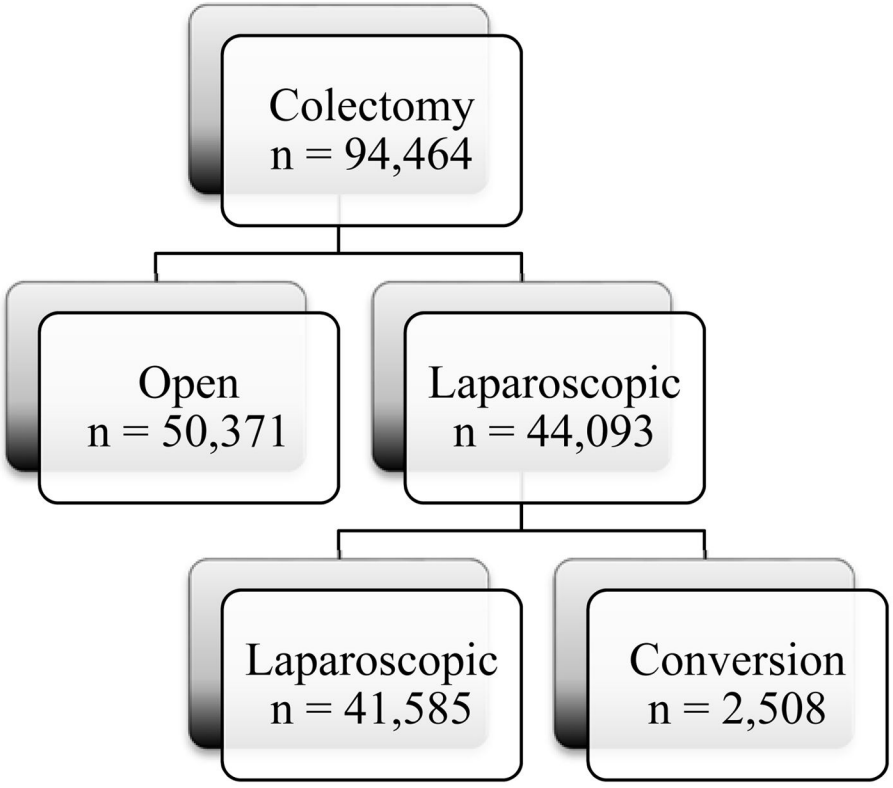

Figure 1.
Distribution of procedures for colectomy in NSQIP database 2006–2011

Table 1

Characteristics of patients undergoing laparoscopic colectomy in 2006–2011 by conversion status. (n=44,093).

Factor	Laparoscopic Group (n=41,585) n (%)	Conversion Group (n=2,508) n (%)	p value
Age			
<50 years	8501 (20.6)	348 (14.6)	<0.001
50–65 years	15006 (36.4)	881 (36.9)	
65–80 years	13105 (31.8)	788 (33)	
>80 years	4666 (11.3)	368 (15.4)	
Male Gender	19605 (47.7)	1169 (49.3)	0.12
BMI (kg/m^2)			
Underweight (<18.5)	909 (2.2)	69 (2.9)	<0.001
Normal (18.6–24.9)	12423 (30.1)	647 (27.2)	
Overweight (25.0–30.0)	14772 (35.8)	773 (32.5)	
Obese (>30.0)	13144 (31.9)	889 (37.4)	
ASA class			
1	1779 (4.3)	76 (3.2)	<0.001
2	23733 (57.5)	1146 (48.1)	
3	14698 (35.6)	1058 (44.4)	
4	1041 (2.5)	102 (4.3)	
Diabetes	5321 (12.9)	387 (16.2)	<0.001
Smoking	6536 (15.8)	418 (17.5)	0.03
COPD	1603 (3.9)	128 (5.4)	<0.001
Ascites	115 (0.3)	26 (1.1)	<0.001
CHF	223 (0.5)	19 (0.8)	0.10
Recent MI	118 (0.3)	9 (0.4)	0.42
Renal Failure	42 (0.1)	5 (0.01)	0.11
Dialysis	164 (0.4)	10 (0.4)	0.87
Stroke	555 (1.3)	44 (1.8)	0.04
Steroid	1804 (4.4)	100 (4.2)	0.68
Weight Loss	1391 (3.4)	98 (4.1)	0.05
Chemotherapy	252 (0.6)	24 (1.0)	0.02
Radiation	432 (1.1)	31 (1.3)	0.24

Table 2

Logistic regression model of patient factors and conversion from laparoscopic to open colectomy (n=44,443).

Factor	Odds Ratio (95% CI)	Increased odds of conversion compared to reference (REF)
Age		
<50 years	**REF** (1.0)	
50–65 years	1.35 (1.19, 1.54)	35%
65–80 years	1.35 (1.18, 1.55)	35%
>80 years	1.73 (1.45, 2.04)	73%
Male Gender	1.07 (0.98, 1.16)	NS
BMI (kg/m^2)		
Underweight <18.5	1.37 (1.06, 1.79)	37%
Normal 18.6 – 24.9	**REF** (1.0)	
Overweight 25.0 – 30.0	1.02 (0.91, 1.13)	NS
Obese >30	1.31 (1.18, 1.47)	31%
ASA Class		
1	**REF** (1.0)	
2	1.02 (0.8, 1.3)	NS
3	1.35 (1.05, 1.74)	35%
4	1.68 (1.22, 2.31)	68%
Smoking	1.20 (1.07, 1.34)	20%
Ascites	3.4 (2.18, 5.20)	240% increased odds of converting to open compared to patients without ascites
Weight Loss	1.24 (1.0,1.54)	24% increased odds of converting to open compared to patients who did not experience recent weight loss
Chemotherapy	1.51 (0.97, 2.37)	NS
Radiation	1.0 (0.68, 1.49)	NS