Published in final edited form as:

Dis Colon Rectum. 2009 November ; 52(11): 1815–1823. doi:10.1007/DCR.0b013e3181b327a6.

Long-term Direct Costs Before and After Proctocolectomy for Ulcerative Colitis: A Population-based Study in Olmsted County, Minnesota

Stefan D. Holubar, MD¹, Kirsten Hall Long, PhD², Edward V. Loftus Jr., MD³, Bruce G. Wolff, MD¹, John H. Pemberton, MD¹, and Robert R. Cima, MD, MA¹

¹Division of Colon and Rectal Surgery, Mayo Clinic, Rochester, Minnesota

²Division of Healthcare Policy and Research, Mayo Clinic, Rochester, Minnesota

³Division of Gastroenterology and Hepatology, Mayo Clinic, Rochester, Minnesota

Abstract

PURPOSE—We hypothesized that patients undergoing definitive surgery for chronic ulcerative colitis have reduced direct medical costs after, as compared with before, total proctocolectomy.

METHODS—A population-based cohort who underwent proctocolectomy for ulcerative colitis from 1988–2007 was identified using the Rochester Epidemiology Project. Total direct healthcare costs were estimated from an administrative database. The primary outcome was the observed cost difference between a 2-year period before surgery and the 2-year period after a surgery/recovery period (surgery+180 days). Statistical significance was assessed using paired *t*-tests and bootstrapping methods. Demographic data were presented as median (interquartile range) or frequency (proportion). Mean costs are reported in 2007 constant dollars.

RESULTS—Sixty patients were Olmsted County, Minnesota residents at operation and for the entire period of observation. Overall 40 patients (66%) were men, median age of 42 years (31–52), median colitis duration of 4 years (1–11). Operations included ileal-pouch anal anastomosis (n=45, mean cost of surgery/recovery period \$50,530) or total proctocolectomy with Brooke ileostomy (n=15, mean cost of surgery/recovery period \$39,309). In the pouch subgroup, direct medical costs on average were reduced by \$9,296 (P<0.001, bootstrapped 95% CI: \$324 to \$15,628) in the 2-years after recovery. In the Brooke ileostomy subgroup, direct medical costs on average were reduced by \$12,529 (P<0.001, bootstrapped 95% CI: \$6467 to \$18,688) in the 2-years after recovery.

CONCLUSIONS—Surgery for chronic ulcerative colitis resulted in reduced direct costs in the 2-years after surgical recovery. These observations suggest that surgical intervention for ulcerative colitis is associated with long-term economic benefit.

Correspondence and reprints to: Robert R. Cima, M.D., Associate Professor of Surgery, Mayo Clinic, 200 First Street SW, Rochester MN, 55905, cima.robert@mayo.edu, Phone 507-284-9079, Fax 507-284-1794.

Author Contributions:

Conception: Holubar, Cima, Loftus, Long, Pemberton, Wolff

Data analysis and Interpretation: Holubar, Cima, Long

Drafting of manuscript: Holubar, Cima, Long

Critical Revision: Holubar, Cima, Loftus, Long, Wolff, Pemberton

Disclosures: Dr. Loftus has consulted for (fees to Mayo) the following pharmaceutical companies: Abbott, UCB, Procter & Gamble, and Shire. In addition Doctor Loftus has received research support from Schering-Plough, PDL Biopharma, Abbott, UCB, and Otsuka.

This manuscript has been accepted for podium presentation at the American Society of Colon and Rectal Surgery Annual Meeting, May 2nd – 6th 2009, Fort Lauderdale, Florida.

Keywords

cost analysis; ulcerative colitis; proctocolectomy; ileal pouch-anal anastomosis; population-based; epidemiology

BACKGROUND

The economic burden of chronic ulcerative colitis (CUC) in the United States (US) is estimated to be \$2.1 billion dollars annually.¹ Patients with this chronic illness, which affects approximately 500,000 people in the US, are known to consume increased healthcare resources including both direct and indirect costs (*e.g.*, costs of hospitalization and missed work-sick days, respectively). Moreover, CUC impairs quality of life compared to reference populations.^{2–5} Although the mainstay of treatment for CUC is pharmacologic therapy, approximately 30% of these patients will require surgical intervention throughout their lifetime.

The surgical therapy of choice for CUC is total proctocolectomy with ileal pouch-anal anastomosis (IPAA) or Brooke ileostomy (TPC-BI). These operations are curative of the colonic manifestations⁶ and result in quality of life equivalent to healthy patients without CUC.^{7, 8} Nevertheless, the timing of surgery is controversial with patients, gastroenterologists, and colorectal surgeons all differing in their view of the appropriateness and timing of surgery for CUC.^{9, 10} In general, surgery for CUC has been relegated to a therapy of last resort. Two recent population-based studies suggest that surgery should not be a therapy of last resort, as this strategy may increase mortality.^{11, 12} Performing surgery for CUC in an elective setting avoids the added costs and complications associated with maximal medical therapy such as high-dose corticosteroids or monoclonal anti-tumor necrosis factor alpha antibodies (anti-TNF- α -Ab).¹³ Patients who receive maximal medical therapy pre-operatively are at increased risk of complications including pelvic sepsis, which may have long-term adverse effects on pouch function and health-related quality of life (QOL).^{14–16}

Although surgery and its complications are known to be costly,^{17–19} few studies address the direct costs of medical therapy as compared with surgical therapy for CUC, and those studies report conflicting results.^{20, 21} In addition, there are limited population-based data regarding the cost of medical care for CUC. It is in this context that we aimed to quantify direct costs and associated healthcare resource utilization before and after definitive surgery in a well-defined population of CUC patients. We hypothesized that definitive surgery in the form of total proctocolectomy for CUC results in decreased direct costs and healthcare resource utilization after, as compared with before, surgical intervention.

PATIENTS AND METHODS

Study Setting

Our study population was based in Olmsted County, Minnesota (Figure 1). Currently, there are approximately 139,747 residents of Olmsted County based on the US Census Bureau data estimates for 2007 (<http://quickfacts.census.gov/qfd>). The urban center of Olmsted County is Rochester, with an estimated 2007 population of 96,975 persons. The remaining population is mostly rural. From within this population, a cohort who underwent surgery for CUC was identified using the Rochester Epidemiology Project (REP).

Rochester Epidemiology Project

The REP is a unique, NIH-sponsored (5R01AR030582-43 [2008]), medical-records linkage system that organizes and provides access to information about the vast majority of healthcare that Olmsted County residents receive by linking and indexing the records of virtually all

providers of medical care to Olmsted County residents.²² This linkage system allows all residents who received a diagnosis in a particular time period to be identified by an electronic search. Virtually all medical records (including outpatient, clinic, and emergency department visits, hospitalizations in the county's three hospitals, inpatient and outpatient laboratory results, and correspondence) from all sources of medical care within the county are indexed and retrievable through this system. Previous studies have shown that >96% of all care provided to Olmsted County residents is provided within the county, and 94% of residents have provided research authorization to participate in this long-term cohort-based project.²² Thus, the REP provides population-based medical data on the residents of Olmsted County, MN. Since its inception in 1966, the REP has resulted in over 1900 biomedical publications.

Olmsted County Healthcare Expenditure and Utilization Database

An extension of the REP is the Olmsted County Healthcare Expenditure and Utilization Database (OCHEUD). OCHEUD provides a standardized inflation-adjusted estimate of the costs of each service or procedure provided since 1987 at Mayo Clinic, Rochester and Olmsted Medical Center (OMC) and affiliated hospitals in constant dollars. Economic costs are estimated for each line item in the billing record allowing for the aggregation of costs into clinically relevant categories. More specifically, the OCHEUD uses a "bottom-up" costing approach; the database categorizes resource utilization based on the Medicare Part A and B classification scheme. Part A billed charges are adjusted by using hospital cost-to-charge ratios and wage indexes, and Part B physician services are costed using Medicare reimbursement rates. Although the services provided represent the clinical practice patterns of Mayo Clinic and OMC providers, the value of each unit of service has been adjusted to national norms by use of widely accepted valuation techniques.²³ Services delivered to non-hospitalized patients that may have been delivered by providers other than Mayo Clinic or OMC (*e.g.*, dental procedures, ambulance services, stoma supplies, or outpatient pharmacy costs) are not included; infliximab infusion costs are also not included.

Study Subjects

After Institutional Review Board approval, International Classification of Disease revision 9 (ICD-9) codes were used to identify a cohort of patients with CUC (556.X) who underwent any colectomy (45.X) or any ileostomy (46.X) between January 1st 1988 and December 31st 2006 in Olmsted County. Of these, only adult patients who were Olmsted County residents at the time of primary or staged total proctocolectomy were included; subjects who underwent segmental colectomy, stoma, or stoma- or IPAA-revision without concurrent or subsequent proctocolectomy were excluded. Olmsted County residency status was then verified for the date of surgery and for the follow-up periods of interest (Figure 2) to decrease the likelihood of missing economic data. Subjects who were not residents for the entire period of observation (defined below) were excluded.

Study subjects were stratified into two subgroups based on surgical procedure performed (IPAA and TPC-BI subgroups). Demographic and treatment-related variables were retrospectively abstracted. These included age, gender, body mass index, date of CUC diagnosis, number/types of CUC-related medications, age-adjusted Charlson Comorbidity Index²⁴, American Society of Anesthesiology (ASA) classification, technical surgical details, post-operative lengths of stay, and post-operative morbidity (severity graded according to the modified Clavien scale).²⁵ This scale categorizes complications according to the required management: Grade 1 or 2 are minor (non-life threatening) and require only medical management, while Grade 3 are major complications which require endoscopic, percutaneous, or operative re-intervention, and Grade 4 are life-threatening requiring critical care; Grade 5 complications result in death.

Statistical Analysis

The overall statistical approach was a matched-paired design in which each patient served as his or her own control for two 2-year periods of observation. The periods of observation (Figure 2) were defined as follows: Period Before (2-years prior to first surgery minus 1 day), Surgery/Recovery Period (date of first surgery to date of last surgery plus 180 days), and Period After (2-year period after the date of last surgery plus 1 day). Descriptive data were presented as median (interquartile range) or frequency (proportion). Descriptive differences in baseline characteristics between the IPAA and TPC-BI subgroups were assessed using Wilcoxon rank-sum or Fisher's exact tests as appropriate.

The primary analysis assessed the mean difference in total estimated healthcare cost (in inflation-adjusted 2007 dollars standardized to national norms) between Period Before and Period After using paired two-sided *t*-tests and nonparametric bootstrapped 95% confidence intervals.^{26, 27} Costs are reported as mean (median) $\pm$ standard deviation. Results for the IPAA subgroup and the TPC-BI subgroup were analyzed and reported separately. The costs associated with the Surgery/Recovery Period (costs of all surgeries and surgical recovery) were reported separately.

Secondary measures included the number of hospitalizations, the number of inpatient days, number of endoscopic procedures, and abdominal radiographic procedures; utilization of these services was categorized using Current Procedure Terminology Revision 4 (CPT-4) codes as follows: lower endoscopic procedures (443XX, 453XX), and abdominal imaging (74XXX, 721XX). Differences in these measures were compared using paired two-sided *t*-tests. Bonferroni corrected *P* values <0.05 were considered statistically significant. All descriptive and comparative statistical analyses were performed using SAS version 9.1 and JMP version 8.0 (SAS Institute Inc., Cary, NC).

RESULTS

Over a period of 18 years, a total of 60 Olmsted County residents with CUC were residents for at least 2 years before they underwent TPC, were residents at the time of TPC, and remained residents for at least two years after recovery from surgery. Of these, 45 (75%) underwent IPAA and 15 (25%) underwent TPC-BI.

Demographics

Baseline characteristics by surgical subgroup are shown in Table 1. TPC-BI patients were more likely to be older, male, Olmsted County residents at time of diagnosis of CUC, and have higher ASA and Charlson scores. In addition there was a trend towards TPC-BI patients having a shorter duration of CUC. The indication for surgery and median number of CUC medications did not differ between subgroups; however, patients in the TPC-BI subgroup were more likely to be receiving corticosteroids ($P < 0.001$).

The duration of the periods of observation are summarized in Table 2. As per study design, the duration of Period Before and Period After was 2 years for each period for all subjects in this study. The Surgery/Recovery Period for the IPAA subgroup, which included patients who underwent 1-, 2-, or 3-stage restorative proctocolectomy, was significantly longer as compared with the 1-, or 2-stage TPC-BI subgroup (8.9 months vs. 6 months, $P = 0.007$); hence, the total period of observation was longer for the IPAA subgroup compared with the TPC-BI subgroup (4.7 years vs. 4.5 years, $P < 0.001$).

Operative Variables and Outcomes for Primary Surgery

Technical details of surgery and outcomes of the first stage of surgery (STC in the case of 3-stage IPAA, IPAA with diverting loop ileostomy in the case of 2-stage IPAA, total abdominal colectomy [followed by completion proctectomy] in the case of 2-stage TPC-BI, and IPAA or TPC-BI in the case of 1-stage procedure) are summarized in Table 3. The median duration between STC and IPAA ($n = 4$) was 4.7 (2.7 – 8.2) months, and the median duration between IPAA and ileostomy reversal ($n = 43$) was 3.3 (2.3 – 3.4) months. The overall morbidity after IPAA or TPC-BI was 62% and 60%; however, a minority were Grade 3 / 4 and required intervention (8.9% and 13%, respectively). No patients died within 30 days of surgery.

Direct Costs and Healthcare Resource Utilization

Total observed direct medical costs of Period Before versus Period After for both subgroups are shown in Table 4. The costs after IPAA were reduced on average by \$9,296.3 ($P < 0.001$), while costs after TPC-BI were reduced by \$12,529 ($P < 0.001$). The costs associated with IPAA surgery and surgical recovery were on average \$50,530 (39,094) $\pm$ 29,012, and the costs associated with TPC-BI and surgical recovery were on average \$39,309 (22,674) $\pm$ 34,593. The combined mean costs for the entire period of observation for the IPAA subgroup were \$72,697, yielding a mean annual cost of \$15,337 over the period of observation. The combined mean costs for the entire period of observation for the TPC-BI subgroup were \$67,041 yielding a mean cost of \$14,890 per year of observation.

Healthcare resource utilization is shown in Table 5. Both subgroups had significant reductions in the mean number of hospital admissions, hospital days, and lower endoscopic procedures. Average numbers of abdominal imaging procedures were also lower, with a trend towards significance in both subgroups.

DISCUSSION

These results demonstrate and quantify that patients who undergo surgery for CUC have significantly lower direct medical costs and consume less healthcare resources in the 2-year period after recovery from surgery as compared with the 2-year period before surgery. However, the observed cost reduction and potential long-term economic benefit must be viewed in light of the significant expense of surgery and recovery. Nonetheless, CUC patients who came to surgery required significantly more hospitalizations, inpatient hospital days, lower endoscopic procedures, and radiographic procedures before, as compared with after, proctocolectomy. Thus, increased healthcare utilization may be a marker for patients who may benefit from early surgery.

Critics may argue that the results of this study are not surprising, and that it is increased disease activity that drives both costs and the need for surgery. Indeed increased disease activity was the indication for surgery in a majority (87%) of patients in this study; as such our results may only be generalizable to patients who ultimately undergo surgery, which currently is unpredictable. On the other hand, one may conclude that patients with increased disease activity required additional drug therapy (corticosteroids) to manage their symptoms pre-operatively, and hence were at increased risk of post-operative complications^{28, 29} and potentially increased costs after surgery. Our results suggest that this is not the case, and that any economic burden associated with surgical complications either does not extend beyond the 6 month recovery period after surgery, or if they do extend beyond 6 months they are insignificant in comparison to the costs associated with increased pre-operative disease activity. However, comparative analysis of the economic burden of surgery and its complications in this population is not the aim of the present study.

Our results confirm those of others and add incrementally to the literature that describes the cost of healthcare for CUC patients.^{1, 30–34} The estimated annual costs of healthcare as reported by these studies, inflated to 2007 US dollars so as to be directly comparable to our results, are summarized in Table 6. Reporting in 1990 US dollars, Hay and Hay reported that the annual costs for CUC patients was \$1488 (\$3208 in 2007 US dollars), with surgery accounting for 50% of the costs.³⁰ A subsequent study from the UK described the annual costs of £2512 (\$5090 in 2007 US dollars)³¹, while the European Collaborative IBD project (which included patients from 9 countries over 10 years), reported annual costs of €524 (\$2363 in 2007 US dollars).³² Finally, a more recent study Kappelman *et al.* used a national healthcare insurance claims database to determine the mean annual costs of care for patients with CUC. Based on private insurance records on >10,000 patients, they reported annual mean costs of \$7948, of which \$5066 was UC-attributable, with 1/3 of costs attributable to 3 categories: hospitalization, outpatient visits, and pharmaceutical costs. Excluding the 15.9% attributable to surgery, this represents \$6684, which compare favorably with those observed in the present population-based study. In our study, 70% of costs over the 4½ year period were attributable to surgery, but this figure is not comparable to other studies which include both medical and surgical patients, while in our study all patients (100%) underwent at least one major surgical procedure.

Apart from studies describing costs of medical and surgical care for CUC, there are conflicting results regarding costs differences between medical and surgical therapy for CUC. In 2006 Bernstein *et al.* assessed cost differences in 556 inpatient admissions for CUC at a referral center.³⁵ They found that the average cost of a medical admission was \$2186 (in 1995 Canadian dollars) while that of a surgical admission was \$4635 ($P<0.001$), a 47% difference; they also reported that TPN was a marker for patients who required longer lengths of stay and who consumed the most financial resources. In contrast Sher *et al.* reported the results of a matched-case control study of severe CUC which assessed cost differences in 20 medically-treated and 20 patients who underwent 3-stage restorative proctocolectomy.²⁰ They reported no significant difference in mean inpatient hospital costs (\$28,477 vs. \$33,041). However, the medical group patients continued to suffer from their chronic illness as demonstrated by a significantly higher transfusion requirement, more weight loss, steroid-dependency, and steroid-related complications. This study, despite a relatively small sample size, provides evidence that patients with severe CUC may benefit from earlier surgical consultation and intervention.

Several strengths and weaknesses of the present study merit discussion. Being population-based it is not subject to sampling and/or selection bias, but the relatively small cohort size limited our ability to perform secondary analyses. In addition, practice patterns have changed significantly over the 18 years of the study, especially in regards to biologic therapy and laparoscopic surgery, and the influence of these advances on healthcare resource utilization and costs is complex. In recent years, up to 30% of referral CUC patients at our institution received infliximab pre-operatively.^{14, 36} This biologic agent is administered by outpatient intravenous infusion at weeks 0, 2, and 6, and then every 8 weeks (average retail wholesale cost of \$2800 per infusion [5mg/kg dose for a 70 kg person] in 2007 dollars), yielding an approximate annual cost of \$22,400. However, the cost associated with infliximab may be offset by its ability to decrease the risk of colectomy and hospitalization as shown in a secondary analysis of the ACT 1 and ACT 2 trials.^{27, 37} On the other hand patients who do not respond may have increased direct and indirect costs (*e.g.*, those related to staged surgery^{13, 15}, post-operative complications^{14, 16} or missed time from employment). Thus the effects of increasing use of infliximab has as yet unpredictable effects on costs. Regarding laparoscopic colectomy, although operating room costs may be increased, these additional expenses are offset by savings associated with short lengths of stay^{36, 38, 39} and are therefore cost-effective.^{40–42} Given the recent increased usage of both infliximab and laparoscopic surgery, further study is needed to better define the economic impact of these changes, as well as the impact of non-surgical and

surgery therapy on QOL in this population. Only then will we be able to determine at what point in the natural history of CUC surgery becomes a cost-effective therapeutic option.

In summary, this study has demonstrated that following post-operative recovery patients who undergo surgery for CUC have a significant reduction in healthcare resource utilization and total direct medical costs. These observations suggest that surgical intervention for ulcerative colitis may be associated with long-term economic benefit for those who require surgery.

Acknowledgments

This publication was made possible by Grant Number R01-AR30582 from NIAMS. The authors would like to acknowledge the assistance of the REP staff including Barbara P. Yawn MD, MS, as well as thank Eric Barnitt and Kandace Lackore for data analysis support.

REFERENCES

1. Kappelman MD, Rifas-Shiman SL, Porter CQ, et al. Direct health care costs of Crohn's disease and ulcerative colitis in US children and adults. *Gastroenterology* 2008;135:1907–1913. [PubMed: 18854185]
2. Loftus CG, Loftus EV Jr, Harmsen WS, et al. Update on the incidence and prevalence of Crohn's disease and ulcerative colitis in Olmsted County, Minnesota, 1940–2000. *Inflamm Bowel Dis* 2007;13:254–261. [PubMed: 17206702]
3. Kappelman MD, Rifas-Shiman SL, Kleinman K, et al. The prevalence and geographic distribution of Crohn's disease and ulcerative colitis in the United States. *Clinical Gastroenterology and Hepatology* 2007;5:1424–1429. [PubMed: 17904915]
4. Bernklev T, Jahnsen J, Henriksen M, et al. Relationship between sick leave, unemployment, disability, and health-related quality of life in patients with inflammatory bowel disease. *Inflamm Bowel Dis* 2006;12:402–412. [PubMed: 16670530]
5. Irvine EJ. Quality of life of patients with ulcerative colitis: past, present, and future. *Inflamm Bowel Dis* 2008;14:554–565. [PubMed: 17973299]
6. Pemberton JH. Surgery for ulcerative colitis. *Surg Clin North Am* 1987;67:633–650. [PubMed: 3589903]
7. Holubar S, Hyman N. Continence alterations after ileal pouch-anal anastomosis do not diminish quality of life. *Dis Colon Rectum* 2003;46:1489–1491. [PubMed: 14605567]
8. Larson DW, Davies MM, Dozois EJ, et al. Sexual function, body image, and quality of life after laparoscopic and open ileal pouch-anal anastomosis. *Dis Colon Rectum* 2008;51:392–396. [PubMed: 18213489]
9. Arseneau KO, Sultan S, Provenzale DT, et al. Do patient preferences influence decisions on treatment for patients with steroid-refractory ulcerative colitis? *Clin Gastroenterol Hepatol* 2006;4:1135–1142. [PubMed: 16829206]
10. Reddy SI, Friedman S, Telford JJ, Strate L, Ookubo R, Banks PA. Are patients with inflammatory bowel disease receiving optimal care? *Am J Gastroenterol* 2005;100:1357–1361. [PubMed: 15929770]
11. Hutfless SM, Weng X, Liu L, Allison J, Herrinton LJ. Mortality by medication use among patients with inflammatory bowel disease, 1996–2003. *Gastroenterology* 2007;133:1779–1786. [PubMed: 18054550]
12. Roberts SE, Williams JG, Yeates D, Goldacre MJ. Mortality in patients with and without colectomy admitted to hospital for ulcerative colitis and Crohn's disease: record linkage studies. *Bmj* 2007;335:1033. [PubMed: 17977817]
13. Holubar SD, Cima RR, Pemberton JH. Does infliximab increase complications after surgery for inflammatory bowel disease? *F1000 Medicine Reports* 2008;1:10.
14. Selvasekar CR, Cima RR, Larson DW, et al. Effect of infliximab on short-term complications in patients undergoing operation for chronic ulcerative colitis. *J Am Coll Surg* 2007;204:956–962. [PubMed: 17481518]discussion 62-3

15. Mor IJ, Vogel JD, da Luz Moreira A, Shen B, Hammel J, Remzi FH. Infliximab in ulcerative colitis is associated with an increased risk of postoperative complications after restorative proctocolectomy. *Dis Colon Rectum* 2008;51:1202–1207. [PubMed: 18536964]discussion 7–10
16. Schluender SJ, Ippoliti A, Dubinsky M, et al. Does infliximab influence surgical morbidity of ileal pouch-anal anastomosis in patients with ulcerative colitis? *Dis Colon Rectum* 2007;50:1747–1753. [PubMed: 17704969]
17. Swenson BR, Hollenbeak CS, Koltun WA. Hospital costs and risk factors associated with complications of the ileal pouch anal anastomosis. *Surgery* 2002;132:767–773. [PubMed: 12407364]discussion 73–4
18. Swenson BR, Hollenbeak CS, Koltun WA. Factors affecting cost and length of stay associated with the ileal pouch-anal anastomosis. *Dis Colon Rectum* 2003;46:754–761. [PubMed: 12794577]
19. Swenson BR, Hollenbeak CS, Poritz LS, Koltun WA. Modified two-stage ileal pouchanal anastomosis: equivalent outcomes with less resource utilization. *Dis Colon Rectum* 2005;48:256–261. [PubMed: 15711857]
20. Sher ME, Weiss EG, Nogueras JJ, Wexner SD. Morbidity of medical therapy for ulcerative colitis: what are we really saving? *Int J Colorectal Dis* 1996;11:287–293. [PubMed: 9007625]
21. Bernstein CN, Nabalamba A. Hospitalization, surgery, and readmission rates of IBD in Canada: a population-based study. *Am J Gastroenterol* 2006;101:110–118. [PubMed: 16405542]
22. Melton LJ 3rd. History of the Rochester Epidemiology Project. *Mayo Clin Proc* 1996;71:266–274. [PubMed: 8594285]
23. Lipscomb J, Ancukiewicz M, Parmigiani G, Hasselblad V, Samsa G, Matchar DB. Predicting the cost of illness: a comparison of alternative models applied to stroke. *Med Decis Making* 1998;18:S39–S56. [PubMed: 9566466]
24. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;40:373–383. [PubMed: 3558716]
25. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004;240:205–213. [PubMed: 15273542]
26. Briggs AH, Wonderling DE, Mooney CZ. Pulling cost-effectiveness analysis up by its bootstraps: a non-parametric approach to confidence interval estimation. *Health Econ* 1997;6:327–340. [PubMed: 9285227]
27. Rutgeerts P, Sandborn WJ, Feagan BG, et al. Infliximab for induction and maintenance therapy for ulcerative colitis. *N Engl J Med* 2005;353:2462–2476. [PubMed: 16339095]
28. Lim M, Sagar P, Abdulgader A, Thekkinkattil D, Burke D. The impact of preoperative immunomodulation on pouch-related septic complications after ileal pouch-anal anastomosis. *Dis Colon Rectum* 2007;50:943–951. [PubMed: 17525860]
29. Heuschen UA, Hinz U, Allemeyer EH, et al. Risk factors for ileoanal J pouch-related septic complications in ulcerative colitis and familial adenomatous polyposis. *Annals of Surgery* 2002;235:207–216. [PubMed: 11807360]
30. Hay JW, Hay AR. Inflammatory bowel disease: costs-of-illness. *J Clin Gastroenterol* 1992;14:309–317. [PubMed: 1607607]
31. Bassi A, Dodd S, Williamson P, Bodger K. Cost of illness of inflammatory bowel disease in the UK: a single centre retrospective study. *Gut* 2004;53:1471–1478. [PubMed: 15361497]
32. Odes S, Vardi H, Friger M, et al. Cost analysis and cost determinants in a European inflammatory bowel disease inception cohort with 10 years of follow-up evaluation. *Gastroenterology* 2006;131:719–728. [PubMed: 16952541]
33. Stark R, König HH, Leidl R. Costs of inflammatory bowel disease in Germany. *Pharmacoeconomics* 2006;24:797–814. [PubMed: 16898849]
34. Gibson TB, Ng E, Ozminkowski RJ, et al. The Direct and Indirect Cost Burden of Crohn's Disease and Ulcerative Colitis. *Journal of Occupational and Environmental Medicine* 2008;50:1261–1272. [PubMed: 19001952]

35. Bernstein CN, Papineau N, Zajackowski J, Rawsthorne P, Okrusko G, Blanchard JF. Direct hospital costs for patients with inflammatory bowel disease in a Canadian tertiary care university hospital. *Am J Gastroenterol* 2000;95:677–683. [PubMed: 10710056]
36. Holubar SD, Larson DW, Dozois EJ, Pattana-Arun J, Pemberton JH, Cima RR. Minimally invasive subtotal colectomy and ileal pouch-anal anastomosis for fulminant ulcerative colitis: a reasonable approach? *Dis Colon Rectum* 2009;52:187–192. [PubMed: 19279410]
37. Sandborn W, Rutgeerts P, Feagan BG, et al. Infliximab Reduces Colectomy in Patients with Moderate-to-Severe Ulcerative Colitis: Analysis from ACT 1 and ACT 2. *Am J Gastroenterol* 2007;102:S479. (abstract).
38. Larson DW, Cima RR, Dozois EJ, et al. Safety, feasibility, and short-term outcomes of laparoscopic ileal-pouch-anal anastomosis: a single institutional case-matched experience. *Ann Surg* 2006;243:667–670. [PubMed: 16633002]discussion 70-2
39. Holubar SD, Privitera A, Cima RR, Dozois EJ, Pemberton JH, Larson DW. Minimally invasive total proctocolectomy with Brooke ileostomy for ulcerative colitis. *Inflamm Bowel Dis*. 2009
40. Hayes JL, Hansen P. Is laparoscopic colectomy for cancer cost-effective relative to open colectomy? *ANZ J Surg* 2007;77:782–786. [PubMed: 17685959]
41. Ridgway PF, Boyle E, Keane FB, Neary P. Laparoscopic colectomy is cheaper than conventional open resection. *Colorectal Dis* 2007;9:819–824. [PubMed: 17477851]
42. Koopmann MC, Harms BA, Heise CP. Money well spent: a comparison of hospital operating margin for laparoscopic and open colectomies. *Surgery* 2007;142:546–553. [PubMed: 17950347]discussion 53-5

Rochester Epidemiology Project

Figure 1.

The geography of the REP. Inset box depicts the 300-mile radius surrounding Olmsted County, MN.

Figure 2.
Schematic representation of the periods of observation.

Table 1

Pre-operative characteristics of 60 Olmsted County residents with CUC who required colectomy*

Variable	IPAA subgroup (n = 45)	TPC-BI subgroup (n = 15)	P value [†]
Age at diagnosis (years)	30.5 (20.8 – 38.7)	53.4 (48.9 – 67.8)	< 0.001
County resident at diagnosis (%)	38 (84%)	14 (93%)	< 0.001
Duration of CUC (years)	4.4 (1.4 – 11.6)	1.8 (0.43 – 5.1)	0.06
Age at surgery (years)	38 (27.4 – 45)	61.5 (49.4 – 72.3)	< 0.001
County resident at surgery (%)	45 (100%)	15 (100%)	1.0
Male gender (%)	26 (58%)	14 (93%)	0.01
BMI (kg/m ²)	25.9 (23.7 – 28.4)	26.7 (24.6 – 30.4)	0.68
Indication for surgery (%)			1.0 [§]
Refractory or complicated colitis	39 (87%)	13 (87%)	
Dysplasia, DALM, or cancer	6 (13%)	2 (13%)	
ASA score (%)			0.04
2	34 (76%)	7 (46%)	
3	11 (24%)	7 (46%)	
4	--	1 (6.7%)	
Charlson score ^{**}	0 (0 – 0)	3 (1 – 4)	< 0.001
Number of medications	2 (1 – 2)	2 (1 – 2)	0.60
30 day medications (%)			
5-ASA	31 (68%)	9 (60%)	0.53
Steroids	30 (67%)	15 (100%)	0.01
Azathioprine or 6-MP	11 (24%)	2 (13%)	0.49
Ever infliximab usage	3 (6.7%)	--	0.56

* Numbers represent frequency (proportion) for categorical variables and median (interquartile range) for continuous variables unless otherwise indicated.

[†] Wilcoxon rank-sum test or Fisher's exact test, P < 0.05 statistically significant.[§] Dysplasia, DALM, or Cancer versus other indication.^{**} Age-adjusted Charlson Comorbidity Index.

Table 2

Duration of observation and Olmsted County residency information

Variable	IPAA subgroup (n = 45)	TPC-BI subgroup (n = 15)	P value [*]
Duration of Observation (years)			
Period Before	2 (2 – 2)	2 (2 – 2)	--
Surgery/Recovery period	0.74 (0.67 – 0.77)	0.5 (0.5 – 0.5)	0.007
Period After	2 (2 – 2)	2 (2 – 2)	--
All Periods	4.74 (4.67 – 4.78)	4.5 (4.5 – 4.5)	< 0.001
Duration of follow-up after Period After (years)	3.47 (1.42 – 10.6)	3.89 (1.46 – 10.4)	0.73
Confirmed county resident at last follow-up (%)	40 (90%)	12 (80%)	0.23

* Wilcoxon rank-sum test or Fisher's exact test, P < 0.05 statistically significant.

Table 3**Primary Surgical Operative Variables and Outcomes***

Variable	IPAA subgroup (n = 45)	TPC-BI subgroup (n = 15)	P value [†]
Stages (%)			--
3	4 (8.8%)	--	
2	40 (89%)	3 (20%) [§]	
1	1 (2.2%) ^{**}	12 (80%)	
Laparoscopic (%)	11 (24%)	2 (12%)	0.46
Operative time (minutes)	268 (225 – 333)	268 (193 – 300)	0.58
Duration between operations (months)			
Total colectomy to proctectomy (n = 3)	--	8.3 (6.6 – 21.4)	--
STC to IPAA (n = 4)	4.7 (2.7 – 8.2)	--	--
IPAA to stoma closure (n = 43) ^{††}	3 (2.3 – 3.4)	--	--
LOS Total (days)	12 (9 – 15)	7 (5 – 12)	0.007
TPC-BI or Total Colectomy-BI (n = 15)	--	7 (5 – 9)	
Completion proctectomy (n = 3)	--	4 (0 – 9)	
STC-BI (n = 4)	6 (3.5 – 7.75)	--	
IPAA (n = 45)	7 (5 – 9)	--	
DLI reversal (n = 43)	5 (3 – 7)	--	
30 days morbidity after IPAA or TPC (%)	28 (62%)	9 (60%)	1.0
Grade 1 or 2 ^{§§}	25 (56%)	7 (46%)	0.55
Grade 3 or 4 ^{§§}	4 (8.9%)	2 (13%)	0.63
Re-operations	2 (4.4%)	1 (6.7%)	1.0
Re-admissions	16 (36%)	1 (6.7%)	0.05
Mortality	--	--	--

* Numbers represent frequency (proportion) for categorical variables and median (interquartile range) for continuous variables.

[†] Wilcoxon rank-sum test or Fisher's exact test, P < 0.05 statistically significant.

[§] Completion proctectomy.

^{**} One LAP-IPAA rapidly converted for adhesions from prior open cholecystectomy.

^{††} 1 patient had a one-stage procedure, 1 patient never had stoma closure and had pouch excision instead.

^{§§} According to the Clavien grading system.

Table 4Direct Healthcare Costs of Before and After Surgery for Ulcerative Colitis^{*}

Subgroup	Period Before Mean total costs ^{*,†}	Period After Mean total costs ^{*, †}	Mean Cost Difference (95% C.I.) [§]	p-value ^{**}
IPAA (<i>n</i> = 45)	\$15,732 (10,194) ± 14,943	\$6,436 (1,961) ± 9820	\$9,296 (\$324 to \$15,628)	< 0.001
TPC-BI (<i>n</i> = 15)	\$20,131 (17,254) ± 10,241	\$7,602 (5,781) ± 6,784	\$12,529 (\$6,467 to \$18,688)	< 0.001

^{*} Estimated costs per patient are reported in 2007 constant dollars.

[†] Values are presented as mean (median) ± standard deviation.

[§] Bootstrap 95% C.I. using the percentile method.

^{**} Paired *t*-test.

Table 5**Hospital Admissions and Procedures***

Subgroup	Variable	Period Before	Period After	p-value [†]
<i>IPAA (n = 45)</i>	Hospital days (no.)	13.2	2.0	< 0.001
	Hospital admissions (no.)	4.8	1.4	0.02
	Lower endoscopies (no.)	2.6	0.5	< 0.001
	Abdominal imaging (no.)	2.3	1.3	0.06
<i>TPC-BI (n = 15)</i>	Hospital days (no.)	14.3	0.6	< 0.001
	Hospital admissions (no.)	4.6	0.3	0.05
	Lower endoscopies (no.)	2.4	0.7	0.01
	Abdominal imaging (no.)	4.5	0.1	0.08

* Values are presented as mean number of hospital days, admissions (episodes), or procedures.

[†] Paired *t*-test.

[§] One patient had stomal enteroscopy to rule-out stomal stenosis as cause of PSBO.

Table 6

Summary of Reported Direct Costs of Medical Care for CUC

Study	Year	Country	Sample (period)	N	Total Mean Annual * Direct Medical Costs	Data Source
Hay ³⁰	1990	USA	1 year (1988–89)	770	\$1604	Private insurance database; excluding cost of surgery (50%).
Bassi ³¹	2004	UK	6 months (2000–01)	307	\$5090 [†]	Referral center administrative database
Odes ³²	2006	EU+	10 years (1991–04)	1321	\$2363 [§]	Population-based administrative database
Stark ³³	2006	Israel Germany	4 weeks (2001–04)	242	\$7428 [§]	Referral center; prospective patient diary
Kappelman ¹	2008	USA	1 year (2003–04)	10,364	\$7619	Private insurance database; surgical costs (15.9%) excluded.
Gibson ³⁴	2008	USA	1 year (2000–04)	8640	\$13,962	Private insurance database; surgical costs excluded
Holubar (present study)	2009	USA	4 years (1988–07)	60	\$6238 (\$8966 before surgery, outpatient drug costs \$3510 after surgery)	Population-based administrative database; surgical costs, outpatient drug costs (<i>i.e.</i> infliximab) not included

* Converted to 2007 US dollars using the United States Department of Labor medical care component of the Consumer Price Index.

[†] UK Pounds Sterling-to-US 2001 dollars exchange rate = 1.49.

[§] European Currency €to-US 2004 dollars exchange rate = 1.36.