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Adhesions are Common and Costly after Open Pouch Surgery

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Abstract
Purpose Open ileal pouch surgery leads to high rates of adhesive small-bowel obstruction (SBO). A laparoscopic approach may reduce these complications. We aimed to review the incidence of adhesive SBO-related complications after open pouch surgery and to model the potential financial impact of a laparoscopic approach purely as an adhesion prevention strategy.
Materials and Methods We reviewed cases of open ileal pouch patients kept on a database and examined annually. Case notes were studied for episodes of adhesive SBO requiring admission or reoperation. Similar parameters were studied in a small series undergoing laparoscopic pouch surgery. The financial burden of the open access complications was estimated and potential financial impact of a laparoscopic approach modeled.
Results Two hundred seventy-six patients were followed up after open surgery (median, 6.3; range, 0.2–20.1 years). There were 76 (28%) readmissions (median length of stay, 7.4 days) in 53 patients (19%) and 28 (10%) reoperations (43% within 1 year). Laparoscopic patients required less adhesiolysis at second-stage surgery (0% vs 36%, $p<0.0001$) and had less SBO episodes within 12 months of surgery (0% vs 14%, $p<0.0001$) than open patients. Modeling a laparoscopic approach cost $1,450 and saved $3,282, thus netting $1,832 per pouch constructed.
Conclusion Open ileal pouch surgery results in significant cumulative long-term access-related complications, particularly adhesions. These impose a large medical burden on patients and financial burden on health-care systems, all of which may be recouped by a laparoscopic approach, despite higher theater costs.

Keywords Ulcerative colitis · Adhesions · Small-bowel obstruction · Ileal pouch surgery · Laparoscopy

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Background

In the last two decades, proctocolectomy and ileal pouch has become the gold standard surgical treatment for ulcerative colitis.[1,2] Functional results and quality of life are good, although short-term complications are frequent and well described.[3] However, longer-term complications such as adhesive small-bowel obstruction (SBO) are common, problematic, and often overlooked.

Adhesions of some degree are present in virtually every patient after abdominal or pelvic surgery. A proportion will develop adhesive SBO requiring admission, some frequent costly multiple readmissions, and some will require reoperation with or without small bowel resection, incurring risk of further postoperative morbidity and mortality.[4–6]

Colorectal surgery has a recognized high risk of developing such adhesive SBO.

Patients undergoing total colectomy pose the highest risk. This is probably due to a combination of factors including long incisions, multiple quadrant surgery, retraction and packing, bleeding, and long duration of surgery. After ileal pouch surgery, adhesive SBO has been reported between 13% and 35%.[7] Most of these studies are small retrospective series with short or incomplete follow-up.

Because ileal pouch surgery is performed in young patients with benign disease, the recognition of the risk of adhesive SBO and the long-term medical and financial implication is essential. Consequently, this should prompt consideration of appropriate adhesion prevention strategies, and ileal pouch represents an excellent model for assessment of such strategies.

We aimed to evaluate adhesions and adhesive SBO in a cohort of patients undergoing open ileal pouch surgery over a 20-year period. We also aimed to compare these to a group of patients undergoing laparoscopic ileal pouch surgery and to model the potential financial impact of a laparoscopic approach as an adhesion prevention strategy.

Materials and Methods

Data of patients undergoing ileal pouch surgery at the John Radcliffe Hospital (Oxford, UK) were entered on a prospective pouch database and followed up annually in clinic. Patients with diagnosis of ulcerative colitis were included (patients with familial adenomatous polyposis, indeterminate colitis or Crohn's disease were excluded). We interrogated the database and analyzed the notes of all patients undergoing open ileal pouch between January 1984 and December 2003. Adhesive SBOs were documented from clinic notes and letters, local doctor correspondence, and inpatient and operation notes.

The diagnosis of SBO was defined by a combination of clinical criteria (pain, nausea, vomiting, cessation of stools, distension, and abnormal bowel sounds) and imaging (dilated loops of small bowel and air-fluid levels). All admissions for SBO with or without surgery were recorded. Data recorded included time interval of SBO since surgery, staging of ulcerative colitis surgery (single-stage, proctocolectomy and ileal pouch; two-stage, colectomy then subsequent proctectomy and ileal pouch), presence and severity of adhesions at second-stage surgery, length of readmission, and findings at adhesiolysis surgery.

We also assessed a small cohort of patients undergoing laparoscopic ileal pouch surgery between August 2003 and December 2004. Because of short follow-up in this cohort, the only two adhesion parameters chosen to be comparable with open surgery were presence and severity of adhesions at second-stage surgery and readmissions and reoperations for SBO in the first year after surgery (as about half of adhesive SBO episodes occurred within the first year after total colectomy).

Data were analyzed using Fisher's exact test, and the Kaplan–Meier curve was used to calculate the cumulative probability of developing SBO and needing surgery. We assumed costs of readmission (mean hospital stay, 7 days) and reoperation (mean hospital stay, 14 days) for adhesive SBO as estimated by Ellis.[5]

For economic modeling, we assumed the use of simple rather than ultrasonic dissection instruments (as we use). For infertility modeling, we assumed a reduction in fertility of 50%[8] for open pouch surgery, and that half of the female patient below the median patient age (36 years) were potentially affected.

Results

Patient Demographics

During this period, 404 patients underwent open ileal pouch surgery, and 276 satisfied the inclusion criteria for the study. Median follow up was 6.3±4.5 years (range 0.2–20.1 years). Patient characteristics are shown in Table 1.

Readmission for SBO after Open Surgery

Sixty-five patients (24%) developed 123 episodes of SBO (1.9 episodes per patient). Fifty-three patients (19%) developed 76 episodes of SBO (28%; 1.4 episodes per patient; range, 1–15) that required readmission (Table 1). The median length of stay for readmissions was 7.4 days. There were a further 47 episodes involving 13 patients of similar symptoms characteristic but not severe enough to warrant admission and were managed by their local doctor. Many of these non-admitted patients subsequently developed more severe episodes requiring admission.

Table 1 Patient Characteristics and Summary of Late Access-Related Episodes

Characteristics and Summary	Values
Total patients	276
Mean age at surgery (years)	36.3±12.1
Female/male ratio	1:1.3
Surgery: 1st vs 2nd stage	1:1.8
Mean follow-up (years)	6.3±4.5
Not readmitted (patients/episodes)	65/123
Adhesive SBO readmission (episodes, %)	76 (28%)
Wound complications (episodes, %)	
Incisional hernia	18 (7%)
Keloid scar	11 (4%)

Timing of Readmission for SBO after Open Surgery

Almost half of all readmissions for SBO (45%) occurred in the first year after pouch surgery. The remaining were fairly evenly distributed annually thereafter but continued to occur even up to 10 years postsurgery. Six patients (3%) developed seven episodes of SBO between stages 1 (colectomy) and 2 (proctectomy and ileal pouch; 9% of all SBO episodes). The annual cumulative risk of readmission for SBO post-ileal pouch surgery is illustrated in Fig. 1.

Reoperation for SBO after Open Surgery

Twenty-eight patients (10%) required reoperation and adhesiolysis (Table 2), including two patients needing small bowel resection for ischemia. The median length of stay for reoperation was 14.4 days. Of these 28 patients, 3 (11%) required reoperation for SBO between surgical stages 1 and 2.

Timing of Reoperation for SBO after Open Surgery

Twelve (43%) reoperations were performed within 1 year of ileal pouch surgery, six (21%) between 1 and 5 years, five (18%) between 6 and 10 years, and two (7%) over 10 years after ileal pouch surgery. The risk of reoperation for SBO was greatest in the first year after ileal pouch surgery, and the cumulative risk steadily rises every year thereafter (Fig. 1). The risk of reoperation is related to the number of readmissions for SBO, doubling after the fist episode and reaching 80% after the third.

Staging, Adhesions, and SBO after Open Surgery

A number of 100 patients (36%) had single-stage surgery, while 176 patients (64%) had two-stage surgery. At second-stage surgery, preliminary adhesiolysis was undertaken in 64 patients (36%). The adhesions were graded as severe in 20 patients (11%) and moderate in 44 (25%). A relationship between the degree of adhesions scored at the second-stage surgery, and the need of readmission was observed. Two thirds of SBO episodes requiring readmission (31 out of 51) occurred in these patients (66.6% vs 17.8%, $p=0.04$) without significant difference between adhesiolysis for adhesions scored as moderate or severe. There was no significant difference in the number of readmission episodes (25% vs 29%, $p=0.47$) nor the number of patients readmitted (18% vs 20%, $p=0.67$) for adhesive SBO between those who had undergone single- or two-stage surgery, respectively (Table 2). There was no significant difference in the proportion of patients who required adhesiolysis for SBO between those undergoing single-stage (9%) and two-stage surgery (11%; $p=0.59$).

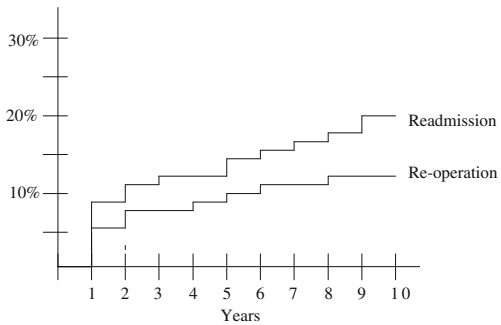

Figure 1 Cumulative risk of readmission and reoperation for adhesive SBO.

Table 2 Adhesive SBO: Single vs Two-stage Surgery

Severity	Single-Stage (%)	Two-Stage (%)	p value
Readmitted			
Episodes	25 (25%)	51 (29%)	0.47
Patients	18 (18%)	35 (20%)	0.67
Reoperated	9 (9%)	19 (11%)	0.59

Adhesions and SBO after Laparoscopic Surgery

Fourteen patients underwent urgent totally laparoscopic subtotal colectomy for acute severe ulcerative colitis between August 2003 and December 2004 (75% male; mean age, 42.0 years). There were no conversions. Median follow up was shorter than for open cases (2.0 vs 6.3 years). Nine patients came with proctectomy with or without ileal pouch. Abdominopelvic adhesions were virtually absent in all cases, with significantly fewer patients undergoing preliminary adhesiolysis for moderate or severe adhesions at second-stage surgery in the laparoscopic (0%) compared to the open group (36%; $p<0.0001$).

Significantly fewer patients developed 'early' SBO requiring readmission (before and in the first year after pouch formation) in the laparoscopic group (0%) compared to open patients (14%; $p<0.0001$). Significantly fewer patients developed SBO requiring reoperation (before and in the first year after pouch formation) in the laparoscopic group (0%) compared to open patients (4%; $p=0.001$).

Costs of Open Surgery: SBO

Assuming Ellis's costs for our population ($2,740 per readmission for mean hospital stay 7 days; $8,462 per reoperation for mean hospital stay 14 days), 76 readmissions would cost an estimated $208,240 (or $754 per pouch constructed) and 28 reoperations $236,936 (or $858 per pouch constructed), a total cost of $445,176 (or $1,612 per pouch constructed).

Costs of Open Surgery: Infertility

For infertility economic modeling, we assumed a reduction in fertility of 50% for open pouch surgery.[8] The success rate of in vitro fertilization (IVF) is mainly dependent on female age (the age of the oocytes) rather than cause of infertility. For women up to their mid-1930s, the live birth rate per IVF cycle is in the region of 25–30%, decreasing to <10% for women over 40.[9] Consequently, multiple treatment cycles are usually needed. The National Health Service funding for IVF is limited, meaning that most couples are forced to self-fund at a cost of $6,000–8,000 each cycle. We conservatively assumed half of women below the median patient age (36 years) were potentially affected.

Economic Modeling: Laparoscopic vs Open Approach

To examine the cost-effectiveness of laparoscopic approach as an adhesion prevention strategy, we calculated the extra cost of a laparoscopic approach and modeled the potential offset savings of a reduction in adhesions and adhesive complications (SBO and infertility; Table 3; this assessment ignores the additional potential savings from less incisional hernias and potentially earlier discharge if pouch surgery can be performed through a small Pfannensteil incision, as we do, after initial laparoscopic total colectomy). Modeling was undertaken assuming adhesion reduction of 25%, 50% and 100%, but 50% reduction was considered a reasonable estimate.

A laparoscopic pouch costs an extra $1,450 in disposables and extra theater time. A reduction in adhesive events of 50% would save an estimated $1,286 per pouch constructed in adhesive SBO costs and $1,996 per pouch constructed in infertility costs. This would provide a cost savings of $3,282 per pouch constructed, easily recouping the outlay costs of a laparoscopic approach, yielding a net surplus of $1,832 per pouch.

Table 3 Potential Costs and Savings of a Laparoscopic Approach ($ Per Pouch)

	Costs	Savings[a]		
		25%	50%	100%
Extra theater time (£ 250/h)	1,000			
Disposable ports	250			
Disposable clip applicator	200			
Reduction in adhesions				
Fewer readmission		378	566	754
Fewer reoperations		430	644	858
Faster stage 2 surgery		38	76	58
Less infertility		1,332	1,996	2,662
Earlier discharge stage 2 surgery			?	
Reduced incisional hernia			?	
Total	1,450	2,178	3,282	4,332

[a] Assuming reduction in adhesions by 25%, 50%, and 100%

Discussion

Adhesions formation after laparotomy occurs virtually in every patient as a response to peritoneal injury. This is an adaptive and protective process leading to subsequent repair of the peritoneal surface.[5] Based on autopsy and prospective clinical studies, the incidence of adhesion formation after abdominal surgery has been shown to range from 67% to 93%.[4,10] Similarly, adhesion formation after pelvic surgery has been reported to range from 51% to as high as 100%.[11,12]

Apart from the beneficial effects of the development of adhesions, the negative clinical consequences are very well documented.[13] Adhesions are the most common cause of SBO, contributing between 49 and 74% of cases of SBO.[14–16] Of all hospital admissions, up to 3% are due to adhesions.[13,17] Approximately 2–3% of all surgeries performed in major hospitals are for adhesive SBO with a morbidity rate that exceeds 50% and a mortality rate as high as 10%.[4,14,18] Furthermore one third of the patients who require adhesiolysis for SBO will be readmitted with further adhesive SBO.[19] The incidence of SBO ranges widely, from as low as 0.3% for gynecologic procedures without hysterectomy performed for benign disease to as high as 35% after total colectomy and ileal pouch formation.[7,20] The majority of the SBO episodes occur early within a year of index surgery, but the risk continues to increase with time steadily thereafter, SBO sometimes occurring decades after the original surgery.[6,21–23]

After colorectal surgery, particularly, the risk of development of adhesive SBO is high.[24,25] Parker et al. reported a readmission rate due to adhesions after colorectal surgery of 16%, with two thirds requiring adhesiolysis. In the longer-term, 50% of all patients were readmitted with adhesion-related problems at least twice in the 10-year study period.[21] Nieuwenhuijzen et al.[6] reported adhesive SBO overall in 18% of patients after total or subtotal colectomy with a mean follow up of 5 years. The incidence increased with length of follow-up, from 11% at 1 year rising to 30% at 10 years postsurgery.

Of all colorectal surgery, proctocolectomy and ileal pouch is associated with the highest incidence of adhesive SBO (Table 4). These patients require an abdominal and pelvic dissection, often with multiple-staged surgery. The mean risk of readmission for SBO after ileal-pouch-pooled reported patients is 18% (range 12 to 35%) and of reoperation, 6% (range, 3 to 19%).[3,7,22–38] However, many of these are small studies with limited follow-up. Studies with longer follow-up demonstrate a higher cumulative

Table 4 Incidence of SBO after Total Colectomy/Ileal Pouch Surgery

Author	Patients	Mean follow-up (Months)	Incidence SBO (%)	Incidence Reoperation (%)
Poppen	69	51	23	10
McMullen	73	38	16	10
Skarsgard	75	15	13	3
Becker	92	3	12	n/s
Oresland	100	20	n/s	6
Young	100	68	27	8
Vasilevsky	116	28	35	19
Nicholls	152	44	n/s	13
Fonkalsrud	184	n/s	n/s	9
Nyam	187	60	13	3
Marcello	460	36	20	7
Francois	626	28	17	8
Galandiuk	851	n/s	13	n/s
Fazio	1,005	35	25	7
McLean	1,178	104	23	7
Present study	276	75	19	10
Range (mean)	–	3–104 (45)	12–35 (18)	3–19 (6)

incidence of SBO. After ileal pouch, Fazio et al.[3] found early SBO in 15%, rising to 25% with longer follow-up, with adhesiolysis in 7%. At the Mayo Clinic, Francois et al.[37] observed SBO in 17% of patients and adhesiolysis in 8% at mean follow-up of 28 months after ileal pouch. Similarly, at the Lahey Clinic, Marcello reported an incidence of SBO of 20% with adhesiolysis in 7% at mean follow-up of 36 months.[38] The largest study from MacLean from Toronto prospectively analyzed 1,178 patients undergoing ileal pouch for mean follow-up of 8.3 years. They observed adhesive SBO in 23% and adhesiolysis in 7%.[7] In our study, almost 45% of SBO episodes occurred the first year after ileal pouch surgery.

Due to the frequency of adhesive SBO and the subsequent complications and costs, several preventive strategies have been developed and proposed to reduce their incidence and severity. Some of these are site-specific to prevent localized adhesive disease, while others work in a more generalized fashion to prevent adhesions throughout the peritoneal cavity.

Pharmacological agents that reduce the peritoneal inflammatory reaction and cytokine release or products, which stimulate the peritoneal fibrinolytic activity to enhance lysis of adhesions in their fibrinous stage, have been developed with variable degree of success on animal models and sparse successes after clinical application.[39–41] Recently, there has been an increasing interest in barrier adhesions prevention products (such as liquid/gel or absorbable/non-absorbable membranes), which work separating damaged peritoneal surfaces, some with encouraging clinical efficacy.[29,39]

However, follow-up are still short and many of these product are still under development, and further studies are need to prove a significantly decrease in adhesions formations and clinical effectiveness. The simplest, most practical prevention strategy is meticulous surgical technique. To reduce adhesion formations, the surgeons should minimize peritoneal injury, proceed with gentle tissue handling, recognize and respect surgical planes, minimize blood loss, and bacterial contamination. Because these principles are intrinsic to minimally invasive surgery, the use of this approach might, aside from the known pain and short-term recovery benefits, reduce the incidence of adhesions and adhesive SBO. Recent randomized animal studies have shown a reduction of up to 50% in adhesion formation in laparoscopy vs laparotomy.[42,43] Similar findings have been observed in human trials in gynecologic surgery[44] and after transperitoneal urologic laparoscopy.[11]

Potential shortcomings of our economic modeling are the time horizon and small number of laparoscopic surgeries performed with short follow-up. Most patients that undergo pouch surgery are relatively young and have a normal life expectancy. As a consequence, the ideal time horizon would be much longer. Furthermore, other potential cost savings might be taken into consideration. Reduced adhesions might allow safer, quicker second-stage surgery by avoiding or minimizing preliminary adhesiolysis with less operative time. The risk of incisional hernia development is significantly reduced with laparoscopic compared to open surgery.[45] We believe that these results are generalizable to centers with treatment strategies, probabilities of events, and costs that are similar to those incorporated into our analysis.

Adhesions affect female fertility through disruption of the relationship between the ovaries and fimbrial ends of the fallopian tubes, thus reducing gamete transport. The degree to which fertility is affected will depend on the degree of disruption. Dense pelvic adhesions affecting the adnexae will reduce the monthly chance of conception (fecundity) to almost zero, whereas flimsy adhesions leaving healthy fimbriae will have less effect. For women with dense adhesions, IVF, an expensive and invasive treatment, may be the only realistic option. When the degree of adhesions are less, then surgery to improve fertility may be appropriate. Adhesiolysis of adnexal adhesions has been shown to improve the conception rate after 24 months from 16% (untreated) to 45% (treated).[46]

Conclusion

Open ileal pouch surgery results in significant cumulative long-term access-related complications, particularly adhesions. These impose a large medical burden on patients and

financial burden on health-care systems, all of which may be recouped by a laparoscopic approach, despite higher theater costs.

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