

# Inadvertent Enterotomy in Minimally Invasive Abdominal Surgery

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## ABSTRACT

**Background:** Inadvertent enterotomy (IE) in laparoscopic abdominal surgery is underreported. Patients with a prior history of laparotomy are at significantly increased risk of enterotomy if another operation is needed. The incidence of enterotomy in laparoscopic surgery may even be greater than that during an open procedure and may go unrecognized due to the limited field of vision. The purpose of this study was to report the incidence of inadvertent enterotomy in a variety of laparoscopic abdominal procedures at our institution and discuss ways to minimize the risk of this complication.

**Methods:** Using the data from morbidity and mortality conferences, we retrospectively reviewed all complications from 3,613 consecutive patients who had laparoscopic abdominal surgery from November 1998 through November 2004. Patients with inadvertent enterotomy were divided into 4 groups according to the type of laparoscopic procedure. Inadvertent enterotomy was defined as any transmural penetration of any part of the intestine. All inadvertent enterotomies that occurred during laparoscopic abdominal surgery were analyzed for mechanism of injury and method of repair, whether diagnosis was made intraoperatively or postoperatively, clinical presentation, conversion rate, and whether a second procedure was necessary.

**Results:** Laparoscopic operations were performed in 3,613 persons. Patients diagnosed with IE were divided into 4 groups: Group #1: cholecystectomy; Group #2: all patients requiring intestinal resection with or without primary anastomosis; Group #3: patients with any type of hernia repair; Group #4: all patients that had adhesiolysis as a primary indication for the operation. The incidence of IE according to each group was 0.39% (8/2,016), 0.8% (3/375), 1.9% (6/312), 100% (4/4), respectively. Twenty patients had 21 inadvertent enterotomies (4 men, 16 women; mean age, 60.9 years). One patient had 2 operations

and had an enterotomy both times. Four patients (4/21, 19%) with unrecognized IE were diagnosed postoperatively. The overall incidence of IE was 0.58%. No deaths occurred.

**Conclusion:** Inadvertent enterotomy in laparoscopic abdominal surgery is especially dangerous if unrecognized during the primary operation. The incidence of IE can be significantly reduced with careful individualized risk assessment. Only surgeons who are trained in advanced laparoscopy should attempt complicated cases and must always be wary of possible bowel injury. Any patient with signs of peritonitis, sepsis, or increased abdominal pain after laparoscopic surgery must promptly be investigated. The department culture of intraoperative cooperation helped improve outcomes.

**Key Words:** Inadvertent enterotomy, Unrecognized enterotomy, Laparoscopic injury, Complication analysis, Trocar injury.

## INTRODUCTION

Minimally invasive abdominal surgery is a relatively new field, and some complications are seldom collated in the current surgical literature. Complications in abdominal laparoscopic surgery can be devastating, especially if not promptly recognized and treated. Delay in diagnosis, reoperation, increased operative time, and increased length of hospital stay are consequences of most complications encountered in laparoscopic surgery.

Inadvertent enterotomy (IE) is one of the underreported complications in abdominal surgery. Krabben et al<sup>1</sup> reported a 19% incidence of IE in patients who had a repeat laparotomy. The incidence of and risk factors for IE during enterolysis were reported in a cohort of patients reoperated on. According to Krabben et al,<sup>1</sup> the risk of inadvertent enterotomy in open surgery is more than 10-fold in patients with a history of 3 or more previous laparotomies. Van Goor<sup>2</sup> reviewed the impact of previous laparotomies in intestinal perforation at the time of repeat laparotomy. He found that the risk of adhesion-related bowel perforation was 20%.

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Bhoynul et al<sup>3</sup> analyzed all complications resulting from laparoscopic trocar insertions. He described the major types of trocar injuries and analyzed them with respect to the type of trocar and type of operation. The mortality rate from unrecognized bowel injury was 21%.

Inadvertent enterotomy is a serious cause of morbidity and mortality in laparoscopic abdominal surgery. IE is a complication that may not be immediately recognized and treated. Our series analyses the incidence of IE in a variety of laparoscopic abdominal surgeries.

**METHODS**

We retrospectively reviewed data from 3613 consecutive patients who had laparoscopic surgery at Monmouth Medical Center between 1998 and 2004. All cases were performed either by a surgeon credentialed in laparoscopic surgery or in advanced cases, by laparoscopic fellowship trained surgeons.

Complications were listed on a bulletin board in the residents' library on a daily basis by the surgical residents. Then each week, surgical residents presented all of the complications. Surgical residents were solely responsible for independently reporting complications for the weekly morbidity and mortality conferences, during the 7-year period. In addition, the quality improvement nurses at Monmouth Medical Center surveyed the surgical floors and charts, to double-check our system. The quality improvement nurses were also present at our morbidity and mortality conferences.

Diagnosis of IE was made during the primary surgical procedure, postoperatively in the same hospitalization, or during a separate admission in the postoperative period. Inadvertent enterotomy was defined as any transmural penetration of any part of the intestine.

Preoperative data including age, sex, number of previous abdominal surgeries, type of prior abdominal procedures, preoperative surgical diagnosis, and comorbidities were assessed. Perioperative and intraoperative data included indications for surgical intervention, the type of the surgical procedure, conversion to an open abdominal exploration, and method of repair. Also analyzed was the postoperative time to the diagnosis of an unrecognized IE and if an IE was diagnosed during the primary operation.

**RESULTS**

The operative experience of 11 surgeons includes 3,613 abdominal laparoscopic cases performed at Monmouth

Medical Center (MMC) from 1998 through 2004. Laparoscopic procedures were divided into 7 groups: cholecystectomy, any intestinal resection with anastomosis, appendectomy, any type of hernia repair, obesity surgery, splenectomy, and a variety of other laparoscopic explorations including adrenalectomy, nephrectomy, resection of abdominal mass, and lymphadenectomy. The number of surgical procedures in each group is represented in **Table 1**.

Inadvertent enterotomy was the most common laparoscopic complication at our hospital. Twenty-one inadvertent enterotomies were diagnosed in 20 patients. There were 4 men and 16 women with the mean age of 60.9 years (range, 32 to 89). The incidence of IE was 0.58%. All patients except 1 had at least 1 prior abdominal surgery (95%), and 1 patient had 7 prior abdominal explorations. In 4 patients (19%), IE was not recognized during the primary procedure. One unrecognized IE was diagnosed on postoperative day one, 2 others on postoperative day 2, and the fourth on postoperative day 9. Three (3/21) enterotomies were caused by trocar placement. Eighteen (18/21) enterotomies were the direct result of adhesiolysis. Inadvertent enterotomies were repaired either with a 2-layered suture closure of the intestinal wall in 12 patients or partial resection of the intestine with stapled side-to-side primary anastomosis in 9 patients. No deaths occurred. All cases were converted to an open procedure for the repair of an IE except one in which laparoscopic repair was performed. Two (2/20) patients developed enterocutaneous fistula as a complication of the IE (**Table 2**).

Eight (8/21) inadvertent enterotomies occurred among 2,016 laparoscopic cholecystectomies performed during that time period. The incidence of IE in this group was 0.39%. Three (3/8) IEs were due to Hasson trocar inser-

**Table 1.**  
Type and Number of Procedures

Laparoscopic Procedure	N
Cholecystectomy	2016
Intestinal resection with anastomosis	375
Appendectomy	326
Hernia repair (any type)	312
Obesity surgery (gastric bypass/band)	256
Splenectomy	34
Other (adrenalectomy, nephrectomy, resection of abdominal mass and lymphadenectomy)	294

**Table 2.**  
Overview of Results (N = 20)

Gender	
Males	4
Females	16
Mean age	60.9 (32–89)
Previous abdominal surgery	
None	1
1	5
>1	14
Mean per patient	2.6
Type of repair	
2-layer suture repair	12
Bowel resection/1°anastomosis	9
Inadvertent enterotomy	
Recognized n (%)	17 (80.9%)
Unrecognized n (%)	4 (19%)
Trocar injury	3
Adhesiolysis	18
Mortality	0

tion, and 5 (5/8) were due to enterolysis. One patient had an IE during both trocar insertion and adhesiolysis. The enterotomies were repaired by primary stapled anastomosis in 3 patients, and 2-layered suture closure in 5 patients. All of these IEs were diagnosed during the primary procedure.

Six (6/21) enterotomies occurred in 312 laparoscopic hernia repairs. The incidence of IE in this group was 1.9%. Five (5/6) small bowel enterotomies occurred due to adhesiolysis and 1 (1/6) large bowel enterotomy. In 1 patient undergoing laparoscopic repair of recurrent ventral hernia, IE was unrecognized during the primary procedure. This patient had 7 prior abdominal surgeries. After developing peritonitis and sepsis, she was re-explored on postoperative day 3 and underwent a partial small bowel resection with primary stapled anastomosis to repair the enterotomy. Three patients had small bowel resections with primary stapled anastomosis. The remaining 3 patients had 2-layered suture repairs. One patient in this group was operated on twice for an incarcerated ventral hernia, and both times had inadvertent enterotomies. Two patients developed enterocutaneous fistulas that subsequently healed.

At our institution, 375 intestinal surgeries were performed. Three (3/21) patients had an IE, an incidence of 0.8%. One (1/3) patient had a cecal perforation diagnosed at reop-

eration on postoperative day 9 and required bowel resection with primary stapled anastomosis. The other 2 (2/3) patients had a 2-layered repair of their enterotomies. One of these 2 patients had a laparoscopic repair of the enterotomy and did not require conversion to laparotomy.

Four (4/21) enterotomies resulted from initial lysis of adhesions. Three patients had surgery to relieve small bowel obstruction, and 1 patient suffered from chronic pelvic pain. In 2 (2/4) patients, IE was not recognized during the primary procedure. Both patients were re-explored because of worsening abdominal pain and increasing peritoneal signs. One patient was re-explored on postoperative day 1, and the second patient on postoperative day 2. In 2 (2/4) patients, the enterotomy was repaired by partial bowel resection with stapled primary anastomosis. The other 2 patients underwent a 2-layer suture repair.

Of the 3613 laparoscopic patients who had appendectomy, gastric bypass, gastric banding procedure, splenectomy, and other procedures, there were no IEs. The overview of the incidence of IE by procedure is represented in **Table 3**.

During this study period, 5 patients had 5 unrecognized IEs consequent to 8862 open abdominal operations. One patient died from an unrecognized IE after exploratory laparotomy for an accessory spleen. The 4 other patients also with unrecognized IEs during open abdominal operations had the following procedures: subtotal colectomy, nephrectomy, ruptured appendicitis, mesh ventral hernia repair. The group of patients with recognized and repaired IEs, had no mortalities and were not presented during morbidity and mortality conferences.

## DISCUSSION

Those patients who have had more than 2 prior abdominal procedures should be considered at higher risk of having an IE. In our review, only 5 patients who suffered an IE had a single prior abdominal procedure and 14 had a minimum of 2 previous abdominal surgeries.

In our study, the largest number of IEs occurred during laparoscopic cholecystectomy. Laparoscopic cholecystectomy was the most common operation associated with fatal trocar injuries in a study by Bhojru et al.<sup>3</sup> Of 629 trocar injuries, 182 involved bowel injury. Twenty-eight enterotomies went unrecognized during the initial procedure. Shamiyeh et al<sup>4</sup> in their review of complications related to laparoscopic cholecystectomy reported a 0.87% incidence of bowel injuries. The incidence of IE during laparoscopic cholecystectomy in our study was 0.39%. All

**Table 3.**  
Overview of the Incidence of Inadvertent Enterotomy (IE)

	Cholecystectomy (n = 2016)	Intestinal (n = 375)	Hernia Repair (n = 312)	Adhesiolysis (n = 4)
Incidence of IE (n)	8 (0.39%)	3 (0.8%)	6 (1.9%)	4 (100%)
Unrecognized IE (n)	0	1	1	2
Mechanism of injury				
Trocar	3	0	0	0
Adhesiolysis	5	3	6	4
Type of repair				
2-layer suture repair	5	2	3	2
Bowel resection/1°anastomosis	3	1	3	2

patients except 1 had a previous laparotomy. The average number of previous operations was 2.6 per person.

Intestinal surgery represents the second largest group of laparoscopic procedures performed at our institution with an incidence of IE at 0.8%. Intraoperative intestinal injury is one of the most commonly reported complications in laparoscopic incisional and ventral hernia repair, with the incidence of 1% to 3.5%, according to LeBlanc.<sup>5</sup> Heniford et al<sup>6</sup> reported a 1.23% incidence of enterotomy in 407 patients who had laparoscopic ventral and incisional hernia repairs. Eighty-nine percent of those patients had previous abdominal surgeries. In our experience, the incidence of IE in patients who had laparoscopic hernia repair was 1.9%. But in our study, we include all inguinal, ventral, hiatal, and paraesophageal hernias. Each patient had an average of 3.8 prior laparotomies, and this was the only group in which 2 patients developed enterocutaneous fistula after laparoscopic hernia repair complicated by IE. These fistulas eventually healed without further surgery.

We had only 4 patients who had lysis of adhesions performed either for small bowel obstruction or chronic pelvic pain and all had an IE. The success and safety of laparoscopic surgery in patients with bowel obstruction remains dubious. According to Shayani et al,<sup>7</sup> laparoscopic adhesiolysis for chronic abdominal pain and recurrent bowel obstruction is safe and effective. However, all patients in their study who underwent adhesiolysis after hospitalization for acute bowel obstruction, sustained enterotomies. Swank et al<sup>8</sup> studied laparoscopic adhesiolysis in 157 patients with chronic pain. Four of 11 inadvertent enterotomies of the bowel went unrecognized during the procedure, and 1 patient died on the second postoperative day. Laparoscopic treatment of acute small bowel

obstruction was only possible in half of the patients, in a study by Wullstein et al.<sup>9</sup> After comparing laparoscopic treatment of acute adhesive small bowel obstruction with conventional laparotomy, he concluded that even though the postoperative recovery was improved, the risk of intraoperative complications increased. Furthermore, he noted that intraoperative bowel perforations were more frequent in patients with more than one previous open abdominal operation. Four patients who had an unrecognized IE at our institution, presented with fever, tachycardia, increasing abdominal pain, peritonitis, and other signs of sepsis. Increased vigilance against any signs of sepsis during the postoperative period leads to rapid recognition of a problem and avoids disastrous delays in treatment. Based on the literature and the review of our complications, we no longer offer laparoscopic surgery to patients with acute bowel obstruction.

Inadvertent enterotomy potentially is a lethal complication of laparoscopic surgery. Even though no deaths were reported at our institution, death from inadvertent enterotomy is not uncommon. Van der Voort et al<sup>10</sup> found that the mortality rate associated with intestinal injury during laparoscopy was 3.6%. A number of studies also reported mortality rates ranging from 0.6% to 3.4% after laparoscopic ventral hernia repair.<sup>11</sup>

Inadvertent enterotomy is the most common serious complication in laparoscopic ventral hernia repair that may result in sepsis and death if not recognized in a timely fashion.<sup>12</sup> It should be stressed that an IE may not be recognized in laparoscopic abdominal surgery, because of intestine retracting out of the field of vision, unlike in open surgery when intestinal injury is more easily seen and can be repaired.

We feel that our experience in laparoscopic abdominal surgery and frequent departmental review of complications has led to better patient selection and increased vigilance. Given the complexity and the learning curve of advanced laparoscopic surgery, surgeons are strictly credentialed and monitored. The Director of Laparoscopy and Chairman of Surgery credential all surgeons performing laparoscopic surgery. Other safety measures include:

- Trained surgeons scrub directly with surgeons to be credentialed.
- Surgeons should seek help in difficult cases, and all surgeons must be willing to scrub in and help each other as necessary.
- All outcomes are followed.
- Patients with a history of multiple open abdominal surgeries should have the initial trocar placed away from any scars to avoid bowel injury.
- In patients with extensive intraabdominal adhesions, difficult anatomy or bleeding, failure to progress during dissection is an indication for expedient conversion to an open procedure.
- The presence of bile or enteric contents not secondary to dissection should alert the surgeon to a possible intestinal injury.
- Any suspected areas of injury or ischemia should be checked and rechecked.
- All gastric anastomoses should be tested for a leak by distention with air under saline submersion and then methylene blue dye. All low colonic anastomoses should be tested by distention with iodine prep solution.
- Patients with sudden onset of tachycardia, unexplained fever or any other signs of sepsis postoperatively, require an immediate investigation for unrecognized intraoperative injuries such as inadvertent enterotomy.
- We do not advise laparoscopic operations for patients with either acute or chronic bowel obstruction with massive distention.

Since the results of this study were presented to surgeons at Monmouth Medical Center, over the past year there was only one IE, from a trocar insertion recognized at the time of surgery. It appears that there has been significant benefit from tracking and reporting IE.

This is a vigilant study of inadvertent enterotomy enabled by the system of independent complication reporting by the surgical residents at Monmouth Medical Center. The corrective process of presenting complications at morbidity and mortality conferences and personal counseling by the Chairman have contributed to our current experience of 1 inadvertent enterotomy over the past year. The department culture of intraoperative surgeon cooperation has also improved our outcomes. We encourage the adoption of this approach for any hospital practicing laparoscopic surgery. We continue to try to make surgery a “concert” and not a “contest.”

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