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Iatrogenic bowel injury (early vs delayed)

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ABSTRACT

Iatrogenic bowel injury is a challenging issue that will be encountered by most general and colon and rectal surgeons. The timing of diagnosis of iatrogenic bowel injury (early vs delayed) will affect the management options and patient outcomes. In this chapter, we will review the risk factors for iatrogenic bowel injury and various causes of iatrogenic bowel injury. The diagnosis of bowel injury, workup and management will also be addressed.

Introduction

Iatrogenic bowel injury may occur during a wide variety of procedures and operations. The vast majority of these injuries go unreported, and those that are included in the literature, are often presented as case reports or case series. Due to the heterogeneous nature of the type of injury, the lack of publications reporting iatrogenic injury, and the retrospective nature of trials analyzing inadvertent enterotomies and colotomies, it is challenging to ascertain risk factors and recommend management strategies. This chapter will review the current literature regarding risk factors and etiology of iatrogenic injury, discuss work up and management strategies, and explore the impact of iatrogenic bowel injury on patient outcomes. Of note, endoscopic injuries will not be addressed in this chapter as it represents a specific set of injury patterns with distinct treatment algorithms.

Risk factors

Prior abdominal surgery and subsequent adhesions increase the difficulty of an operation by altering abdominal anatomy and obliterating natural planes. When dense scar tissue fuses the bowel wall to intra-abdominal structures, attempting to isolate a portion of intestine can be very challenging, leaving the bowel vulnerable to iatrogenic injury. It is not surprising, therefore, that prior abdominal surgery has been associated with increased rates of enterotomy during subsequent surgical intervention.[1–5] A single institution study based in the Netherlands comparing patients with and without iatrogenic bowel injury during adhesiolysis in patients undergoing reoperative abdominal surgery identified a history of 3 or more prior abdominal surgeries as an independent risk factor for enterotomy.[6] However, in a case matched study of 100 patients, simply having had a prior midline laparotomy was not associated with an increased rate of enterotomy.[7] It is likely that increased abdominal surgery results in increased adhesions which leads to difficulty distinguishing and avoiding injury to the bowel wall. This is corroborated by multiple studies demonstrating that when adhesiolysis is required, the number of enterotomies and seromuscular injuries increase.[1,2] Patient characteristics including obesity and advanced age were identified as additional risk factors for iatrogenic bowel injury,[6] but these were not substantiated by other studies.[8]

Laparoscopic surgery has also been investigated as a risk factor for intestinal injury. Despite multiple trials evaluating the morbidity associated with laparoscopic surgery, the data is somewhat variable regarding the impact of laparoscopic surgery on rate of iatrogenic bowel injury. The relationship between enterotomy rate and laparoscopic versus open surgery was compared in patients undergoing intervention for adhesive bowel obstruction. A large retrospective study of surgeries performed for adhesive small bowel obstruction demonstrated a statistically significant increase of bowel repair and bowel resection in the laparoscopic compared to the open intervention group.[8] Conversely, a systematic review of 14 studies, 6 of which reported data regarding intraoperative bowel injury, did not demonstrate a difference in bowel injury rates between the laparoscopic and open groups.[9] An additional study examining colorectal cancer patients with previous laparotomy demonstrated equivalent enterotomy rates in the laparoscopic and open surgery groups.[10] Interestingly, the association between previous laparotomy and subsequent increased enterotomy rates was not substantiated in two studies which examined enterotomy rates specifically in laparoscopic surgery performed after prior laparotomy.[11] The heterogenicity in the data may be related to bias in selecting candidates for laparoscopic adhesiolysis, or variability in the threshold to convert to laparotomy in the setting of intraabdominal adhesions.

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There is less variability in the results of studies assessing enterotomy rates in laparoscopic hernia repair. A 2007 literature review comparing enterotomy rates in laparoscopic incisional and ventral hernia repairs did not identify a statistically significant difference between initially recognized or unrecognized enterotomy in the laparoscopic and open intervention groups.[12] A Cochrane review in 2011 comparing laparoscopic versus open hernia repair was also unable to identify a statistically significant difference between enterotomy rates in the laparoscopic and open groups.[13] A more recent prospective randomized control trail for laparoscopic vs hybrid approach for incisional ventral hernias did not demonstrate a difference in rate of enterotomies between the two operative techniques.[14] This is convincing evidence that laparoscopy is not a risk factor for iatrogenic bowel injury during ventral hernia repair compared to open surgery.

There are a wide range of procedures and percutaneous interventions that may result in iatrogenic intestinal injury. Each may be associated with inherent risk factors specific to the procedure related to the relative anatomy. For example, when performing a barium enema, high introduction of the catheter, and patient characteristics including advanced age, inflammatory bowel disease, ischemic colitis, colonization by intestinal parasites, recent deep biopsy, presence of fistula or fissure, rectal stricture, and previous intestinal radiotherapy predispose patients to perforation.[15,16] During percutaneous nephrolithotripsy, retrorenal colon, horseshoe kidney, previous renal surgery, previous intestinal bypass, and colonic distension increase the risk of iatrogenic bowel injury.[17] During gynecologic surgery, there is an increased rate of enterotomy during surgical resection of ovarian cancer compared to other oncologic surgeries.[18] Although it is not possible to address all procedure-specific risk factors in this chapter, in general, a thorough understanding of the underlying anatomy and procedural steps when iatrogenic injury could occur will help to reduce the risk of incidental injury to the small and large intestine.

Etiology

The small and large intestine occupy sizable portions of the abdominal and pelvic cavities. They contain intraperitoneal and extraperitoneal components, are prone to dynamic motion, have variable lengths, and remain in close proximity to numerous intraabdominal, retroperitoneal, and pelvic organs. The intestine, therefore, is vulnerable to injury during a wide range of operations and procedures. During intra-abdominal surgery, intestinal injury rates have been reported to occur during 0.1–9.2% of surgeries.[2,3,5,19–22]

Injury to the intestine may occur at various points during the procedure beginning with entry to the peritoneal cavity. Multiple studies have attempted to assess the effect of laparoscopic entry technique on enterotomy rate. A Cochrane review did not demonstrate superiority of any particular entry technique when visceral injury rate was compared, but overall evidence quality was poor.[23] A 2002 meta-analysis of laparoscopic abdominal access techniques revealed a rate of bowel injury of 0.04% with Veress needle entry, 0.05% with direct entry (trocar insertion prior to pneumoperitoneum) and 0.11% with Hasson open entry.[24] The authors concluded that Hasson technique for entering the abdomen was statistically more likely to be associated with bowel injury, but appeared to minimize the risk of vascular injury. Few studies other than those specifically dedicated to assessing trocar-related injury reported the mechanism of bowel injury and these studies paint a heterogenous picture. In a review of the causes of bowel injury during gynecologic laparoscopy, Llarena et al. reported 55% of bowel injuries occurred during Versess needle or trocar placement, 29% occurred during use of electrocautery, 11% occurred during lysis of adhesions and 4.1% of bowel injuries occurred during utilization of grasping forceps or scissors.[25] This was supported by a large literature review of laparoscopic surgery that reported 41.8% of bowel injuries occurred during trocar or Veress needle placement and 25.6% of bowel injuries occurred during use of a coagulator or laser.[26] This may be interpreted with caution as there is substantial overlap of primary literature in both review studies. Other studies by Binenbaum, Nielsen, Yamamoto, and O'Connor reported that trocar/entry related injuries represented the minority of iatrogenic bowel injuries (14%,18%, and 43% respectively), whereas injury more commonly occurred during laparoscopic manipulation or adhesiolysis.[3,19,22,27]

Injury may additionally occur during organ dissection, visceral manipulation, or abdominal wall closure. Within the general surgery scope, site-specific intestinal injury rates have been published. Diagnostic laparoscopy resulted in intestinal injury in 0.07% of cases.[26] Ventral hernia repair has a wide range of reported iatrogenic intestinal injury rates. In a review of thirty-four studies, enterotomy rate ranged from 0–14% with a rate of 1.78% when study results were combined.[12,21] Small bowel injury during cholecystectomy is reported as 0.16%–4.5%.[22,26,28–30] Surgery for small bowel resection resulted in a relatively high injury rate at 7%.[26] During colorectal surgery, inadvertent enterotomy rate ranged from 0.1%–1.4%.[3,11] During emergency abdominal surgery with attempted laparoscopic repair, a 1.5% rate of bowel injury was reported in a population based cohort study.[19] Specific details identifying the cause of bowel injury during the operation were not generally provided.

Enterotomies and colotomies occur during a wide range of urologic procedures as well. The proximity of the kidneys and ureters to the colon as well as the bladder's variable relationship to the small bowel put the intestine at increased risk of injury when these organs undergo intervention. Suprapubic catheter insertion is associated with a 2.5% rate of bowel injury.[31,32] Colonic injury during nephrolithotripsy occurs at a rate of 0.3–1.6%.[17,33] Bowel injury during partial and total nephrectomy is relatively uncommon. Even in the setting of previous abdominal surgery, the rate of bowel injury during partial nephrectomy is 2.4%.[34] Although the rate of rectal injury is generally lower than other portions of the intestine, the close proximity of the low bladder and prostate to the rectum place it at increased risk of injury during dissection. During radical prostatectomy the rate of rectal injury is 1.5%.[35]

The proximity of the uterus and ovaries to the sigmoid colon, cecum, and rectum, and tendency of the small bowel to develop adhesions to the pelvis increase the risk of intestinal injury during gynecologic surgery. During hysterectomy, a 0.1%–1%[36,37] rate of intestinal injury has been reported, with variable data regarding increased risk of injury during trans-abdominal compared to transvaginal resection.[36,38,39] When the indication for surgery was described as gynecologic cancer a 4% rate of visceral injury was identified. The highest reported rate of enterotomy in gynecologic surgery was associated with open cytoreductive surgery at 5.2%.[4] Intestinal injury during benign gynecologic surgery is considerably less frequent. The rate of intestinal injury during cesarean section is 0.8%.[40] Bowel injury is reported to be <2% for dissection prior to mesh placement for pelvic organ prolapse.[41] While some studies report that the colon is the bowel most likely to incur an iatrogenic injury,[40] the majority of studies report that the rate of small bowel injury exceeds colonic and rectal injury.[4,12,25,26,42] Similar to rates of bowel injury during laparoscopy for general surgery procedures, laparoscopic surgery for gynecologic procedures results in a 0.33% injury rate.[36] It is notable that diagnostic laparoscopy for gynecologic purposes had a lower rate of iatrogenic bowel injury than diagnostic laparoscopy for gastrointestinal reasons.[26] Additional procedures including dilation and curettage, morcellation, and even uterine manipulation have been reported to result in bowel injury.[43]

Although general surgery, urologic surgery, and gynecologic surgery are the most common causes of iatrogenic bowel injury, intestinal injury may occur during a wide variety of procedures. Case reports of bowel injury during orthopedic surgery including

microdiscectomy, guidewire positioning, and pedicle screw placement have been published in the literature.[44–47]

Radiographic procedures including percutaneous intervention involving the abdomen[48–51] and barium enema have also resulted in bowel perforation (0.02–0.23%).[15] Given the wide variety of procedures during which the bowel may experience injury, it is essential that practitioners exercise caution during operative intervention, maintain a high index of suspicion for injury when the patient's post-operative course is non-routine, and have an effective strategy for diagnosis and repair.

Diagnosis

The timing of the diagnosis of iatrogenic bowel injury is typically characterized as early (intraoperative identification of injury) or delayed (postoperative identification of injury). The literature provides an unclear picture as to when iatrogenic bowel injuries are most commonly diagnosed. Many studies indicate hollow viscus injury is predominantly diagnosed intraoperatively and rarely post-operatively with postop rates ranging from 0%–19%.[4,5,12,14,18–22,27,36,52,53] Conversely, a number of studies have found delayed diagnosis is nearly as common as, or more common than, early diagnosis with post-operative diagnosis rates ranging from 41%–75.9%.[17,24,25,40,54] The etiology of this discrepancy is unclear as all of these studies include a wide range of procedures, executed by a wide range of specialties. Of enterotomies and colotomies diagnosed post-operatively, mean time to diagnosis was 2.1–3.5 days with ranges from 0 to 13 days.[17,22,24,25,40]

The timing of bowel injury diagnosis is of consequence because patients diagnosed after surgery suffered significantly worse outcomes than individuals who were diagnosed with bowel injury intraoperatively.[36] Patient's with a late diagnosis underwent more surgical procedures, required longer length of stay, and had overall higher mortality rates than their intraoperatively diagnosed counterparts.[12,21,22,24,25,54] Two review articles cited mortality in the intraoperatively diagnosed group as 0% and 1.7% versus 3.2% and 7.7% in the post operatively diagnosed group, respectively.[12,25] LeBlanc et al. was the only study to compare timing of diagnosis between laparoscopic and open procedures, but did not detect a statistically significant difference between these two groups.[12]

Although intraoperative recognition of bowel injury simply involves visualization of a defect in the bowel wall or extrusion of enteric contents, post-operative diagnosis of iatrogenic bowel injury can be considerably more difficult. Symptoms may include abdominal pain or distension, nausea, vomiting, ileus, bleeding, fecal incontinence, drainage of enteral contents through the skin, urethra, or vagina, or drainage of urine through the rectum. Signs include fever, tachycardia, hypotension, leukocytosis, and leukopenia.[1,17,22,25,32,36,40,41,55–58] Of the aforementioned presentations, peritonitis, fever, and abdominal pain/distension are the most common.[1,25] It is essential that procedure-specific considerations be accounted for when attempting to diagnose iatrogenic injury, for example, aspiration of fecal material during suprapubic cystostomy tube placement is indicative of iatrogenic injury even when other symptoms are absent.

Once signs and symptoms of bowel perforation are recognized, or iatrogenic injury is suspected, it is recommended to closely monitor vital signs, obtain laboratory studies, and pursue imaging. An upright abdominal x-ray may reveal free air. After percutaneous gastrostomy tube placement, free air on x-ray had a 100% sensitivity and 96% specificity for bowel injury especially when the subdiaphragmatic air pocket was $>$ 2 cm or did not resolve within 72 h.[51]

CT of the abdomen and pelvis is generally indicated when late bowel injury is suspected and was used for diagnosis in the majority of studies where diagnostic tools were reported. Literature assessing CT scan for diagnosis of traumatic bowel injury has established that a triple phase contrast CT has a 98% specificity for intraperitoneal and extraperitoneal visceral injury. CT with IV contrast only has a reported 90% sensitivity and 96% specificity, but avoids delays related to enteral contrast administration.[59] The choice of contrast administration may be made on a case by case basis with consideration for the patient's clinical status and likely location of suspected injury. Excessive free air, free fluid, and extravasation of contrast likely indicate bowel injury. In patients with symptoms extremely concerning for bowel injury, imaging may not be necessary. In a study assessing missed enterotomy during abdominal surgery, there was no difference in outcome in terms of morbidity, mortality, or time to operation between patients who were diagnosed based on clinical exam versus imaging.[1] If distal colon injury is expected, for example after pelvic surgery, flexible sigmoidoscopy or colonoscopy may be of value. Intraoperatively, endoscopy with an air leak test may help identify the site of perforation.[39,56] Again, procedure-specific diagnostic methods must be addressed. Post evacuation X-rays after barium enema may reveal intraperitoneal or extraperitoneal air or contrast. Incomplete perforation may be diagnosed when a thin longitudinal layer of barium is witnessed abutting both sides of the bowel wall, or a transverse striation pattern.[15] After percutaneous nephrolithotripsy with suspected bowel injury, a CT with antegrade/retrograde nephrostography should be employed and flexible cystourethroscopy, and retrograde urethrogram may be of use.[17] In patients with a urorectal fistula as a result of iatrogenic injury cystoscopy, retrograde urethrogram, pelvic MRI, and barium enema vs CT with rectal contrast may be useful for diagnosis and surgical planning.[55]

Treatment

Treatment options for iatrogenic bowel injury are diverse and treatment algorithms should be selected based on the location of injury, extent of injury, timing of diagnosis, and clinical status of the patient. Although many studies report the technique utilized to address the iatrogenic injury, few report the underlying algorithm used for decision making, and several note decisions were made at the discretion of the operating surgeon.[5] There are no prospective randomized studies to guide management of iatrogenic bowel injury; however, the trauma literature regarding management of acute bowel injury is a useful surrogate. Traumatic bowel injury would be most akin to early recognized iatrogenic bowel injury. In the field of trauma surgery, multiple studies from the 1990's randomized patients with acute colonic trauma to primary repair versus diversion and they did not demonstrate worse outcomes in the primary repair group.[60–62] A 2001 prospective study analyzing resection and anastomosis vs diversion in destructive colon injuries, similarly concluded that outcomes were not inferior for primary repair.[63] Studies by Miller and Lazovic did include iatrogenic injuries in their analysis of colonic trauma. Lazovic prospectively treated colonic injuries with a nonselective primary repair approach. Of 30 primary repairs, 25 (83%) were successful. Five resulted in patient death, but mortality was related to concomitant injury and no evidence of anastomotic leak was identified.[64] In a retrospective study performed by Miller and Schache, 18 out of 30 (60%) patients with iatrogenic injuries were treated with primary repair or anastomosis. Of those treated with primary repair or anastomosis 2 (11%) experienced a leak and both were located in the transverse colon. In this study, all rectal injuries were treated with diversion. The trauma literature seems to clearly suggest that when iatrogenic injury is noted early (intraoperatively) primary repair of the defect is generally appropriate. If the defect is large, in close proximity to additional injuries, or the associated bowel appears unhealthy, then resection and primary anastomosis is an effective strategy.

Regarding iatrogenic injuries that are recognized late, there is no clear algorithm of management defined in the surgical literature. However, the literature regarding management of colorectal anastomotic leak could be seen as somewhat analogous to management of

delayed iatrogenic injury. In general, colonic anastomotic leaks are managed by resection of the anastomosis with or without fecal diversion depending on the degree of inflammation encountered at the time of surgery and this would seem to be a solid strategy for delayed management of iatrogenic bowel injury. In contrast, rectal anastomotic leaks are managed with drainage and fecal diversion and a similar management plan could be employed with delayed iatrogenic rectal injury.[65] On some occasions, localized abscesses of either colonic or rectal anastomotic leaks are managed with percutaneous drainage. There are also times when anastomotic leak may present very late as an enterocutaneous fistula and managed in that typical way.[66]

There are several special cases of iatrogenic injury whose treatment merit a specific approach. Patients with rectal injuries which result in rectocutaneous fistulas after perineal prostatectomies may be treated successfully with antibiotics and supportive care.[58] The data supporting this management strategy is a small volume case series, but is supported by trauma literature which advocates conservative treatment of rectal injuries below the peritoneal reflection.[67,68] Fistulas that are refractory to traditional management in otherwise stable patients may benefit from fibrin glue injection, or stent placement, but studies supporting this therapy are small and retrospective in nature.[69,70] Urorectal fistulas resulting from surgical trauma represent a challenging problem. In two small retrospective reviews, 85% and 100% success rates were encountered with colostomy, urinary diversion and operative reconstruction via a transperineal or abdominoperineal approach with or without a vascularized tissue flap.[55,71] Retrospective data supports gracilis muscle transposition in patients with prior radiation or failed attempts at repair.[72] Iatrogenic bowel injury resulting from percutaneous nephrolithotripsy requires a different algorithm as well. Conservative management with double j stents or separate nephrostomy tube, foley catheter, and broad spectrum antibiotics is effective in patients who are otherwise stable.[17] Patients presenting with peritonitis, or signs of sepsis require urgent surgical intervention regardless of the etiology of iatrogenic bowel injury.

Outcomes

Overall mortality rate for iatrogenic bowel injury in large review articles was 0.8%–8.7%.[12,24,25,73] Smaller retrospective reviews reported a wider range of mortality 0%–21%.[1,5,6,21,22,53,54] As previously stated, patients with delayed diagnosis of bowel injury had worse outcomes. Although many studies reported a high rate of conversion from laparoscopy to open surgery when enterotomy was diagnosed intraoperatively (16%–100%), there was no statistical analysis performed to assess the comparative rate of conversion when iatrogenic bowel injury was encountered.[19,22,26,27,52,74,75] Two studies performed statistical analysis of outcomes in cases with and without enterotomy, and identified enterotomy as a significant risk factor for worse outcomes. Kin et all and van der Krabben et al. reported increased length of stay, increased rates of sepsis, and increased rates of reoperation in patients with enterotomy.[5,6] van der Krabben et al. also reported an increased rate of additional post-operative complications including bowel obstruction, anastomotic leak, wound dehiscence, and pneumonia, as well as increased admission to the intensive care unit and delivery of parenteral nutrition in the patients who suffered intraoperative bowel injury.[6] Of note in the study performed by Kin et al., patients with serosal tears had outcomes similar to those without intraoperative bowel injury whereas worse outcomes were associated with enterotomies.

Conclusions

Iatrogenic bowel injury is a well described complication of a wide variety of operations and procedures. Despite this, high quality literature regarding diagnosis and treatment of this entity is sparse. The nature of the complication and lack of incentive to publish enterotomy rates in the literature make studying this complication particularly difficult. Overall, prospectively obtained data had increased reporting of intraoperative bowel injury compared to retrospective studies.[25] Additional prospective research regarding diagnosis, treatment, and outcome of bowel injury is necessary to fully understand the impact of this complication. It is clear from current studies that iatrogenic bowel injury is associated with increased complications, particularly when there is failure to recognize injury intraoperatively. Additional trials are required to direct ideal treatment strategies to improve patient outcomes.

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