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Laparoscopic versus Open Ladd's Procedure for Intestinal Malrotation in Adults

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Abstract

Background—Intestinal malrotation results from errors in fetal intestinal rotation and fixation. While most patients are diagnosed in childhood, some present as adults. Laparoscopic Ladd's procedure is an accepted alternative to laparotomy in children but has not been well-studied in adults. This study was designed to investigate outcomes for adults undergoing laparoscopic Ladd's repair for malrotation.

Methods—We performed a single-institution retrospective chart review over eleven years. Data collected included: patient age, details of pre-operative work-up and diagnosis, surgical management, complications, rates of re-operation, and symptom resolution. Patients were evaluated on an intent-to-treat basis based on their planned operative approach. Categorical data were analyzed using Fisher's exact test. Continuous data were analyzed using Student's T-test.

Results—Twenty-two patients were identified (age range 18-63). Fifteen were diagnosed pre-operatively; of the remaining seven patients, four received an intra-operative malrotation diagnosis during elective surgery for another problem. Most had some type of pre-operative imaging, with Computed Tomography being the most common (77.3%). Comparing patients on an intent-to-treat basis, the two groups were similar with respect to age, operative time, and estimated blood loss. Six patients underwent successful laparoscopic repair; three began laparoscopically but were converted to laparotomy. There was a statistically significant difference in length of stay (LOS) (5.0 ± 2.5 d vs 11.6 ± 8.1 d, $p=0.0148$) favoring the laparoscopic approach. Three patients required re-operation: 2 underwent side-to-side duodeno-duodenostomy and 1 underwent a re-do Ladd's

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procedure. Ultimately, 3 (2 laparoscopic, 1 open) had persistent symptoms of bloating (n=2), constipation (n=2), and/or pain (n=1).

Conclusion—Laparoscopic repair appears to be safe and effective in adults. While a small sample size limits the power of this study, we found a statistically significant decrease in LOS and a trend toward decreased postoperative nasogastric decompression. There were no significant differences in complication rates, re-operation, or persistence of symptoms between groups.

Keywords

Malrotation; Adult; Laparoscopy; Outcomes; Ladd's Procedure

Introduction

Intestinal malrotation is an uncommon congenital disorder resulting from errors in fetal intestinal rotation and fixation. Represented by a range of clinical presentations and aberrations in anatomy, most patients are diagnosed in infancy and early childhood, typically before two years of age.[1] In infancy, malrotation classically presents with bilious emesis, and the gold standard for diagnosis is an upper GI series which should demonstrate an abnormal location of the duodenal-jejunal junction and, in the case of volvulus, an abrupt cut-off of contrast in the small intestine.

Less commonly, patients may remain undiagnosed into adulthood. This population may present with a variety of symptoms including weight loss, vomiting, abdominal pain and other non-specific gastrointestinal complaints, often making diagnosis difficult.

Treatment of malrotation at any age is performed surgically via the Ladd's procedure. This operation is designed to treat both acute problems and reduce the potential for future volvulus. Its steps include: reduction of midgut volvulus, if present; complete lysis of adhesive colo-duodenal (Ladd's) bands, widening of the base of the mesentery, and prophylactic appendectomy. [2] Historically the open approach was favored for this procedure as development of post-surgical adhesions may actually benefit these patients by providing some degree of fixation for their large and small intestines, which do not demonstrate the normal retroperitoneal fixation points beyond the Ligament of Treitz. More recently, the laparoscopic approach has become an accepted alternative to laparotomy in children [3, 4] but the use of the laparoscopic approach in the adult patient has not been well-studied.

The aim of this study was to investigate the presentation, management, and outcomes of adult patients with malrotation and to determine if laparoscopic Ladd's procedure was a safe and effective treatment option for adults with intestinal malrotation.

Materials and Methods

After IRB approval was obtained, a retrospective chart review was performed for all patients ≥ 18 years of age treated for intestinal malrotation at a single tertiary-care academic institution. Patients were identified using CPT code 44055 ("correction of malrotation by lysis of duodenal bands and/or reduction midgut volvulus (e.g, Ladd Procedure)") through

surgical billing records between 2002 and 2013. Diagnosis of congenital malrotation or non-rotation was confirmed for each patient through chart review.

Data collected included demographic data such as patient sex and age at diagnosis, as well as details from pre-operative work-up, peri-operative management, and post-operative care. Pre-operative data included: pre-operative diagnosis, presence and type of pre-operative imaging, American Society of Anesthesiologists (ASA) Classification Score. Operative data consisted of type of procedure, operative time, estimated blood loss (EBL), presence of volvulus, whether a pediatric surgeon was consulted, and whether appendectomy was completed. Post-operative data included the presence and timing of any major and minor complications, length of nasogastric tube decompression, length of hospital stay (LOS), need for re-operation, and persistence of symptoms.

When comparing laparoscopic versus open Ladd's procedure, patients were evaluated on an intent-to-treat basis. Data were analyzed using SAS version 9.2 (SAS Institute Inc, Cary, NC). Categorical data were analyzed using Fisher's exact test. Continuous data were analyzed using Student's T-test. Time to first complication was analyzed using the methods of Kaplan and Meier and compared between groups using a Log-Rank test. A two-tailed p-value 0.05 was considered statistically significant.

Results

A total of twenty-two patients were identified (Table 1). Ten (45%) were male. The average age was 38.6 years, and ranged from 18 to 63. Fifteen patients were diagnosed with malrotation pre-operatively and underwent a planned Ladd's procedure. The remainder received an intra-operative diagnosis, including two originally diagnosed with small bowel obstruction, one who presented with pneumoperitoneum, and four patients who were found to have malrotation during an elective procedure for an alternative diagnosis (takedown of a gastro-cutaneous fistula (1); gastric bypass and repair of ventral hernia (2); laparotomy for an intra-abdominal mass (1)).

Twelve patients presented acutely, with pain, nausea and vomiting consistent with acute bowel obstruction (n=6); pain without evidence of obstruction (n=5) and intussusception (n=1). Seven patients presented with non-acute symptoms and generally had more than one complaint, the most common being pain (71.4%) and nausea/vomiting (51.7%). Other, less common complaints included reflux (42.9%), weight loss or constipation (28.6% each), and anorexia, diarrhea, or delayed gastric emptying (14.3% each).

Three patients denied any symptoms whatsoever. Two were diagnosed intra-operatively during another, elective procedure. The third underwent Computed Tomography (CT) of the abdomen and pelvis during a work-up for acute appendicitis at which time malrotation was found. After undergoing appendectomy, she was referred for elective correction of her malrotation.

Twenty patients underwent pre-operative imaging. CT of the abdomen and pelvis was the most common imaging modality at 81.8%.

Thirteen patients (59%) underwent laparotomy without attempt at laparoscopy. Six patients (27.3%) underwent successful laparoscopic Ladd's procedure; three patients (13.6%) began laparoscopically but converted to laparotomy (Table 2). There were no significant differences between type of repair based on patient acuity on presentation ($p=0.8637$). Attempted and successful laparoscopy became more common as time progressed (Figure 1). Conversions were all pre-emptive in nature and per the operative notes, were due to 'poor visibility', 'bowel distension', and 'concern for volvulus'. Conversion patients had statistically significant increased operative time (244.7 ± 39.9 minutes, $p=0.0184$) and higher estimated blood loss (250 ± 304.1) compared to laparoscopy patients (Table 3). A pediatric surgeon was involved in 18 (81.8%) of the twenty-two cases.

Twelve adult general surgeons and six pediatric surgeons were involved in these operations. The involved adult general surgeons completed between one and four cases each over the study time period; the pediatric surgeons were involved in between one and six cases. Table 6 lists the extent of pediatric surgery involvement, surgical approach, and complications. The most common level of involvement was enlisting a pediatric surgeon to scrub and assist with the Ladd's procedure. There were no significant differences in surgical approach ($p=0.4138$), when evaluated by the degree of pediatric surgeon involvement. The majority of complications also occurred in this patient cohort, which tended to present with acute symptoms and contained 67% of emergent cases.

Comparing patients undergoing laparoscopy versus laparotomy on an intent-to-treat basis, there were no significant differences in age, operative time, estimated blood loss, or need for nasogastric (NG) decompression (Table 4). Laparotomy patients had higher ASA scores ($p=0.0011$) than those who underwent laparoscopic Ladd's Procedure. There were no significant differences in complication rates, need for re-operation, or symptom resolution. There was a statistically significant decrease in length of stay following laparoscopy compared to open surgery (5.0 ± 2.5 d vs 11.6 ± 8.1 d, $p=0.0148$).

Table 5 lists all complications at the time of our chart review. 75% of patients undergoing laparotomy experienced at least one complication, compared to 50% of patients undergoing successful laparoscopy and 33% of patients who required conversion. There were no significant differences in rates for any complication when stratified by laparoscopic vs open approach on an intent-to-treat basis ($p=0.09$) or by degree of pediatric surgeon involvement ($p=0.4820$).

All patients had at least one follow-up appointment following their Ladd's procedure. Mean follow-up was 52.1 months (range 3.1 – 131.9). Three patients had undergone re-operation at the time of our chart review. One required a re-do Ladd's procedure 17 months after a previous open repair for persistent and worsening symptoms. Two patients required side-to-side duodeno-duodenostomy. The first had persistent high naso-gastric output after an open Ladd's procedure, with imaging demonstrating a high-grade duodenal obstruction. On re-operation she was found to have significant adhesions obstructing the third portion of her duodenum. The second presented several weeks after discharge from a laparoscopic Ladd's with right upper quadrant pain and intermittent emesis after ingestion of solid foods. Imaging was concerning for cholecystitis but also identified a sharp angulation at the second

portion of the duodenum. On operative exploration she was found to have significant retroperitoneal adhesions and relative decompression distal to these adhesions. Three patients (two laparoscopic, one open) had one or more persistent symptoms of bloating (n=2), constipation (n=2), and/or pain (n=1) (p=0.54).

Discussion

Management of intestinal malrotation in adult patients has not been extensively studied to date. The infrequency of this diagnosis and the myriad complaints and presentations of this patient population create multiple challenges for designing and executing a randomized controlled trial comparing surgical management techniques. While several retrospective cohorts of adult patients have been evaluated, [5, 6] the literature is scant on adult outcomes after open vs laparoscopic repair.

Conventional wisdom dictates that patients who have undergone laparotomy are at higher risk for forming post-operative adhesions than patients undergoing laparoscopy. Rates of adhesion formation after laparotomy range from 50-90%, [7] while studies indicate reduced frequency and severity of adhesions after laparoscopic procedures in animal models [8-10] and human studies [11, 12]. The importance of adhesion formation in Ladd's patients is unclear, as the pediatric population appears to do well after laparoscopic repair [3, 4]. If laparoscopy can provide adult as well as pediatric patients with an acceptable surgical repair, it would suggest that adhesions may not be critical to long-term success in this patient population. Many pediatric surgeons now feel that the true mechanism of repair in a Ladd's procedure is the widening of the mesentery and reducing the likelihood of volvulus, and that adhesion formation may actually be detrimental if it re-narrows the base of the mesentery. In that case, laparoscopy may not only represent a superior repair for this condition, but the approach may provide benefits seen in other types of laparoscopic surgery including decreased postoperative pain, [13, 14] improved cosmesis, [15, 16] and shorter hospital stays [14, 17].

In contrast to a similar retrospective review in which the majority of patients presented with chronic symptoms, [18] a significant fraction of our patients had either acute or non-existent symptoms. Only seven of our twenty-two patients presented with chronic symptoms. Notably, one of these patients also had an intra-abdominal tumor and received an intra-operative diagnosis of malrotation, making it difficult to ascertain the source of her symptoms.

Of the twelve patients who presented with acute symptoms, eight were taken for laparotomy including six who underwent emergent surgery. Laparoscopy has traditionally been contraindicated in high-acuity patients and those undergoing urgent or emergent surgery, although several studies have demonstrated non-inferiority for carefully-selected patients for management of acutely incarcerated [19, 20] and strangulated [21] inguinal hernias and acute small bowel obstruction. [22-24] Likewise, a retrospective review of patients in NSQIP undergoing emergent laparoscopic or open colectomy for diverticulitis found no significant differences in 30-day morbidity and mortality in a propensity-matched cohort. [25] The successful completion of three laparoscopic cases in patients with acute

presentation, including one with a partial small bowel obstruction, suggests that surgeons comfortable with complex laparoscopy may choose to consider a minimally invasive approach for patients with malrotation. As with other acute surgical problems, careful patient selection is vital, and there should be a low threshold for conversion to laparotomy.

Our older charts do not provide electronic copies of patient daily progress notes, but discharge summaries for several of our non-acute laparoscopic patients do note “bloating” and “prolonged ileus,” consistent with their 5-6 day hospitalizations. Based on our experiences, we would advocate for gentle handling of the duodenum to minimize the potential for ileus, but not at the expense of ensuring a thorough Kocherization and release of Ladd's bands as a key component of the surgical repair.

In our series, there were three conversions from laparoscopic repair to traditional laparotomy. All three conversions were pre-emptive, rather than reactive or due to iatrogenic injury. All three cases involved intra-operative consultation with, and assistance by, a pediatric surgeon. Nevertheless, comparison of these three patients to those who successfully underwent laparoscopic repair shows that the converted patients had longer operative times, greater EBL, and longer length of stay. The increased length of stay is not surprising given that these patients ultimately underwent laparotomy. Further investigation demonstrates that two of these patients underwent another procedure at the time of their Ladd's repair including a re-do Nissen (performed prior to conversion) and a partial colectomy (performed after conversion). It is therefore difficult to determine what role conversion, as opposed to these additional procedures, played in contributing to the unexpectedly high operative time and EBL in this small sub-group.

A notable proportion of patients undergoing surgery experienced some form of complication. Laparotomy patients were more likely to have major complications including unanticipated ICU stay and aspiration on induction of anesthesia. However, given that a large number of these patients needed urgent or emergent surgery, it is difficult to separate which complications are attributable to the nature of their presentation rather than the type of surgery received. Similarly, surgical approach, hospital length of stay, and rates of complications are tightly coupled with the severity of a patient's illness upon presentation. As such, it is difficult to determine how much the surgical approach, rather than sequelae of acute illness, contributed to length of hospitalization. Patients presenting acutely who underwent laparotomy had an average LOS of 12.5 versus 4.3 days for those undergoing successful laparoscopy. Similarly, patients with non-acute presentations and no symptoms also had decreased LOS associated with laparoscopic procedures. While even an attempt at laparoscopy may indicate a healthier patient, the differences seen here may give us some idea of the morbidity associated with various surgical approaches.

Patients undergoing laparoscopy or conversion, in general, had fewer complications. There were no wound problems in this group versus in the laparotomy group. It is unclear why conversion patients had such low rates of complications, although this finding may be partially explained by the fact that none of them underwent urgent or emergent surgery. As a whole, the cohort of laparoscopy and conversion patients were more likely to be re-admitted than laparotomy patients (3/9 vs 1/12). In light of the fact that laparoscopy patients had a

statistically shorter length of hospital stay, it may be that, in retrospect, some of these patients may have demonstrated that they were not yet ready for discharge; with such small numbers of patients it is difficult to know whether this pattern would be borne out in a larger patient cohort. In an era where reimbursement is dependent on avoiding readmissions, this warrants further study.

While this study represents one of the largest series of adults with malrotation, the retrospective and single-institution nature of this study makes generalization difficult. Additionally, the patient population remains small due to the overall rarity of this disease process. Patient acuity, surgical approach, and complications and length of stay are difficult to separate in a small retrospective study. Lastly, many of the acute procedures were performed by surgeons without significant advanced laparoscopic training and as such, the results may vary in the hands of expert laparoscopists. Despite these limitations, we conclude that the laparoscopic approach appears to be a safe and effective means to treat adult patients with intestinal malrotation. Additionally, the laparoscopic approach may lead to decreased length of stay and fewer wound complications while maintaining similar outcomes with respect to prevention of future risk of volvulus and symptom resolution.

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References

1. Sato, TT.; Oldham, KT. Pediatric Abdomen. In: Mulholland, MW.; Lillemoe, KD.; Doherty, GM.; Maier, RV.; Simeone, DM.; Upchurch, GR., Jr, editors. Greenfield's Surgery Scientific Principles and Practice. Lippincott Williams & Wilkins; Philadelphia, PA: 2011.
2. Ladd WE. Surgical diseases of the alimentary tract in infants. N Engl J Med. 1936; 215:705–708.
3. Bass KD, Rothenberg SS, Change JHT. Laparoscopic Ladd's procedure in infants with malrotation. J Pediatr Surg. 1998; 33:279–281. [PubMed: 9498402]
4. Mazziotti MV, Strasberg SM, Langer JC. intestinal rotation abnormalities without volvulus: The role of laparoscopy. J Am Coll Surg. 1997; 185:172–176. [PubMed: 9249085]
5. Nehra D, Goldstein AM. Intestinal malrotation: Varied clinical presentation from infancy through adulthood. Surgery. 2011; 149:386–393. [PubMed: 20719352]
6. Durkin ET, Lund DP, Shaaban AF, Schurr MJ, Weber SM. Age-related differences in diagnosis and morbidity of intestinal malrotation. J Am Coll Surg. 2008; 206:658–663. [PubMed: 18387471]
7. Parker J, Reid G, Wong F. Microlaparoscopic left upper quadrant entry in patients at high risk of periumbilical adhesions. Aust N Z J Obstet Gynaecol. 1999; 39:88–92. [PubMed: 10099758]
8. Tittel A, Treutner KH, Titkova S, Ottinger A, Schumpelick V. Comparison of adhesion reformation after laparoscopic and conventional adhesiolysis in an animal model. Lengenbeck's Archives of Surgery. 2001; 386:141–145.
9. Garrard CL, Clements RH, Nanney L, Davidson JM, Richards WO. Adhesion formation is reduced after laparoscopic surgery. Surg Endosc. 1999; 13:10–13. [PubMed: 9869679]
10. Krahenbuhl L, Schafer M, Kuzinkovas V, Renzulli P, Baer HU, Buchler MW. Experimental study of adhesion formation in open and laparoscopic fundoplication. Br J Surg. 1998; 85:826–830. [PubMed: 9667717]

11. Polymeneas G, Theodosopoulos T, Stamatidis A, Kourias E. A comparative study of postoperative adhesion formation after laparoscopic vs open cholecystectomy. *Surg Endosc.* 2001; 15:41–43. [PubMed: 11178760]
12. Hull TL, Joyce MR, Geisler DP, Coffey JC. Adhesions after laparoscopic and open ileal pouch-anal anastomosis surgery for ulcerative colitis. *Br J Surg.* 2012; 99:270–275. [PubMed: 22095139]
13. Liang JT, Huang KC, Lai HS, Lee PH, Jeng YM. Oncologic results of laparoscopic versus conventional open surgery for stage II or III left-sided colon cancers: a randomized controlled trial. *Ann Surg Oncol.* 2007; 14:109–117. [PubMed: 17066227]
14. Klarenbeek BR, Bergamaschi R, Veenhof AAFA, van der Peet DL, van den Broek WT, de Lange ESM, Bemelman WA, Heres P, Lacy AM, Cuesta MA. Laparoscopic versus open sigmoid resection for diverticular disease: follow-up assessment of the randomized control Sigma trial. *Surg Endosc.* 2011; 25:1121–1126. [PubMed: 20872022]
15. Polle SW, Dunker MS, Slors JF, Sprangers MA, Cuesta MA, Gouma DJ, Bemelman WA. Body image, cosmesis, quality of life, and functional outcome of hand-assisted laparoscopic versus open restorative proctocolectomy: long-term results of randomized trial. *Surg Endosc.* 2007; 21:1301–1307. [PubMed: 17522936]
16. Chan KL, Hui WC, Tam PK. Prospective randomized single-center, single-blind comparison of laparoscopic vs open repair of pediatric inguinal hernia. *Surg Endosc.* 2005; 19:927–932. [PubMed: 15920685]
17. Vignali A, De Nardi P, Ghirardelli L, De Palo S, Staudacher C. Short and long-term outcomes of laparoscopic colectomy in obese patients. *World J Gastroenterol.* 2013; 19:7405–7411. [PubMed: 24259971]
18. Matzke GM, Dozois EJ, Larson DW, Moir CR. Surgical management of intestinal malrotation in adults: comparative results for open and laparoscopic Ladd procedures. *Surg Endosc.* 2005; 19:1416–1419. [PubMed: 16151680]
19. Ferzli G, Shapiro K, Chaudry G, Patel S. Laparoscopic extraperitoneal approach to acutely incarcerated inguinal hernia. *Surg Endosc.* 2004; 18:228–231. [PubMed: 14639475]
20. Hoffman A, Leshem E, Zmora O, Nachtom O, Shabtai M, Ayalon A, Rosin D. The combined laparoscopic approach for the treatment of incarcerated inguinal hernia. *Surg Endosc.* 2010; 24:1815–1818. [PubMed: 20063015]
21. Yang GPC, Chan CTY, Lai ECH, Chan OCY, Tang CN, Li MKW. Laparoscopic versus open repair for strangulated groin hernias: 188 cases over 4 years. *Asian J Endosc Surg.* 2012; 5:131–137. [PubMed: 22776668]
22. Levard H, Boudet MJ, Msika S, Molkhov JM, Hay JM, Laborde Y, Gillet M, Fingerhut A. Laparoscopic treatment of acute small bowel obstruction: A multicentre retrospective study. *Aust N Z J Obstet Gynaecol.* 2001; 71:641–646.
23. O'Connor DB, Winter DC. The role of laparoscopy in the management of acute small-bowel obstruction: a review of over 2,000 cases. *Surg Endosc.* 2012; 26:12–17. [PubMed: 21898013]
24. Suter M, Zermatten P, Halkic N, Martinet O, Bettschart B. Laparoscopic management of mechanical small bowel obstruction Are there predictors of success or failure? *Surg Endosc.* 2000; 14:478–183. [PubMed: 10858476]
25. Turley RS, Barbas AS, Lidsky ME, Mantyh CR, Migaly J, Scarborough JE. Laparoscopic versus open Hartmann procedure for the emergency treatment of diverticulitis: A propensity-matched analysis. *Dis Colon Rectum.* 2013; 56:72–82. [PubMed: 23222283]

Figure 1. Initial Surgical Approach by Year. Laparoscopy includes cases ultimately converted to laparotomy.

Table 1
Baseline Demographics for Twenty-two Adult Patients with Malrotation

Male n (%)	10 (45)
Age (average, range)	38.8, 18 - 63
Pre-operative Diagnosis of Malrotation n (%)	15 (68.1)
Incidental Intra-Operative Finding of Malrotation n (%)	4 (18.2)
Emergent Operation n (%)	6 (27.3)
Volvulus Present n (%)	4 (18.2)

Table 2**Patient Acuity and Surgery Received**

Presentation	Number of Patients	Type of Repair n (%)			p value
		Laparotomy	Laparoscopy	Conversion	
Acute	12	8 (66.7)	3 (25)	1 (8.3)	0.8637
Non-Acute	7	3 (42.9)	2 (28.6)	2 (28.6)	
Incidental	3	2 (66.7)	1 (33.3)	0	

Table 3
Comparison of Patients Undergoing Successful Laparoscopy vs Conversion to Laparotomy

	Laparoscopy	Conversion	p value
Number of Patients	6	3	
Average Age (years)	32.8	39	0.3409
Pre-operative Diagnosis of Malrotation n (%)	6 (100)	2 (66.7)	0.3333
Volvulus Present n (%)	0 (0)	1 (33.3)	0.3333
Average Operative Time (minutes)	139.5 ± 52.1	244.7 ± 39.9	0.0184*
Average Estimated Blood Loss (cc)	29.2 ± 46.9	250 ± 304.1	0.3352
Average NG tube decompression (days)	0.8 ± 1.5	3.3 ± 3.5	0.3312
Average Length of Stay (days)	4.2 ± 2.6	6.7 ± 1.2	0.0891

* Significant at $p < 0.05$

Table 4
Intent-to-Treat Comparison of Patients Undergoing Open vs Laparoscopic Repair

	Laparotomy	Laparoscopy	p value
Number of patients	13	9	-
Average Age (years)	41.2 ± 14.4	34.9 ± 9.5	0.2686
Pre-operative diagnosis of Malrotation n (%)	7 (53.8)	8 (88.9)	0.5630
ASA Class n (%)			
1	0 (0)	5 (55.6)	0.0011 *
2	6 (46.2)	4 (44.4)	
3	7 (53.8)	0 (0)	
Average Operative Time (minutes)	200.5 ± 89.6	174.6 ± 69.7	0.4807
Average Estimated Blood Loss (cc)	99.2 ± 125.5	102.8 ± 191.6	0.9585
Average NG tube decompression (days)	5.7 ± 4.1	1.9 ± 2.7	0.0701
Average Length of Stay (days)	11.6 ± 8.1	5.0 ± 2.5	0.0148 *
Need for Re-Operation n(%)	2 (15.4)	1 (11.1)	1.00

* Significant at $p < 0.05$

Table 5

Major and Minor Complications and Surgery Received.

Type of Repair	Patients Experiencing Any Complication (n, %)	Patients Experiencing Major Complication(s) (n, %)	Description (n)	Patients Experiencing Minor Complication(s) (n, %)	Description (n)
Laparotomy (n=12)	9 (75%)	5 (41.7%)	Readmission within 30 d (1) Re-operation (2) Respiratory failure requiring ventilation (1) SMA syndrome (1) Aspiration on induction (1) Unanticipated ICU admission (1)	6 (50%)	Superficial surgical site infection (1) Prolonged ileus (3) Wound dehiscence (1) Acute kidney injury (1) Urinary tract infection (1) Urinary retention (1)
Laparoscopy (n=6)	3 (50%)	2 (33.3%)	Readmission within 30 d (2) Re-operation (1)	1 (16.7%)	Urinary retention (1)
Conversion (n=3)	1 (33.3%)	1 (33.3%)	Readmission (1)	1 (33.3%)	Prolonged ileus (1)

Table 6
Comparison of Surgical Approach and Complications Based on Pediatric Surgeon Involvement.

Degree of Involvement	None	Pre-Operative Consult; Did Not Scrub	Intra-Operative Consult; Did Not Scrub	Pediatric Surgeon as Assistant	Pediatric Surgeon as Primary	p-value
Patients, n	4	1	2	13	2	-
Approach						0.4138
Laparoscopy	1	0	0	3	2	
Laparotomy	3	1	1	8	1	
Conversion	0	0	1	2	0	