

Intussusception Following the Ladd Procedure

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Hypothesis: The Ladd procedure for malrotation predisposes children to postoperative intussusception (POI).

Design: Retrospective case-control review.

Setting: University-affiliated tertiary care pediatric hospital.

Patients: Five of 159 patients undergoing the Ladd procedure between 1995 and 1998 developed POI. Predisposing factors were sought by comparison with age-matched controls who underwent the Ladd procedure during the same period. The entire Ladd group was compared with all 1717 patients undergoing any other laparotomy during the same period for incidence of POI.

Main Outcome Measures: Differences in weight, percentile weight, age, length of nasogastric suction, time to oral intake, and length of stay between Ladd patients developing POI and age-matched controls from the Ladd group were compared using the Mann-Whitney *U* test.

Incidence of POI after the Ladd procedure and "other laparotomy" was compared using χ^2 analysis.

Results: In the Ladd group, there were 5 cases of POI (3.1%). There was 1 case of POI (0.05%) after all other laparotomies ($P < .001$). Symptoms developed at a mean \pm SD of 7.2 ± 2.1 days. Upper gastrointestinal tract with small bowel follow-through showed partial bowel obstruction in 4 cases and was normal in 1 case. Reexploration took place at a mean \pm SD of 9.2 ± 2.8 days. Children developing POI after undergoing the Ladd procedure were less likely to be small for their age ($P = .03$) than age-matched controls undergoing the Ladd procedure.

Conclusions: The Ladd procedure predisposes children to POI. Aggressive investigation, including reexploration, should not be delayed if a child has symptoms of prolonged ileus within 2 weeks after undergoing a Ladd procedure.

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POSTOPERATIVE intussusception (POI) is a recognized cause of intestinal obstruction in the child during the early postoperative period. It is reported to occur after 0.08% to 0.8% of all laparotomies^{1,2} and to account for 5% to 15% of postoperative bowel obstructions in children.^{3,4} Recent series^{2,3,5,6} have described the typical clinical course of these patients. Most had undergone a major abdominal or retroperitoneal procedure within the last 2 weeks. Most had had return of bowel function when they subsequently develop bilious emesis, abdominal distension, and irritability. Diagnosis may be delayed due to the nonspecific nature of the symptoms, which resemble a prolonged postoperative ileus. At reoperation, most intussusceptions can be manually reduced, and no lead point is found. Delay in diagnosis may result in the need for bowel resection and an increased risk of death.³

Several mechanisms of enteric intussusceptions have been proposed. Many series^{2,3} report an increased incidence after retroperitoneal procedures, blaming an uneven return of peristalsis. Others^{4,6} cite lengthy cases that involve extensive bowel manipulation, re-

sulting in serosal exudate or edema and drying of the bowel wall. Some authors³ have found an increased incidence in children with other primary motility disorders of the bowel, as in Hirschsprung disease or gastroesophageal reflux. Yet, there have been only 2 reported cases of POI after a Ladd procedure, an operation with all these risk factors.^{2,7}

This study examines our experience with POI after Ladd procedures from 1995 to 1998, reviews reported risk factors for POI, and discusses the possible pathophysiological mechanisms of intussusception formation.

RESULTS

Of 159 Ladd procedures performed at the Arkansas Children's Hospital, there were 15 cases (9.4%) of postoperative bowel obstruction. Of these, 7 were due to adhesions, 5 were due to enteric intussusception, 2 were due to recurrent volvulus, and 1 was due to an ileocolic intussusception. Enteric intussusception developed after 3.1% of Ladd procedures. In the group of all 1717 patients undergoing laparotomy for any other reason at the Arkansas Children's Hospital,

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PATIENTS, MATERIALS, AND METHODS

From 1995 to 1998 at Arkansas Children's Hospital, Little Rock, 159 children underwent the Ladd procedure for malrotation. All procedures were performed by 1 of 3 attending surgeons (R.J., C.W., and S.D.S.). The procedure included the following: (1) evisceration of the bowels through a transverse right upper quadrant incision, (2) division of the Ladd bands, (3) mobilization of the duodenum, (4) inversion appendectomy, (5) passage of the nasogastric tube through the duodenum to rule out a duodenal web, and (6) replacement of the intestines in a position of nonrotation. Cecopexy was not performed. Thirty-seven cases (23%) were performed for acute symptoms. The **Table** lists the other indicated procedures that were performed at the discretion of the operating surgeon as well as other medical conditions.

The charts of all children undergoing surgery for malrotation were reviewed. We defined POI as an enteroenteric intussusception confirmed at laparotomy. To determine if there was a subgroup of malrotation patients at particular risk, children who developed POI were compared with age-matched controls who also underwent Ladd procedures for weight, percentile weight, age, and other medical conditions. Physician-controllable factors, including concomitant surgical procedures, length of procedure, length of gastric decompression, time to oral intake, and length of stay, were also compared. Comparison between these groups was made using the Mann-Whitney *U* test.

During the same period, 1717 laparotomies were performed by the same surgeons at the Arkansas Children's Hospital. The total number of resulting bowel obstructions and POIs was tallied from the database of the Department of Pediatric Surgery. This group was compared with the group undergoing Ladd procedures for incidence of bowel obstruction and POI. Comparison between groups was made using χ^2 analysis. Statistical analysis was performed on GB-Stat software (Dynamic Microsystems, Silver Spring, Md).

there were 39 resultant small bowel obstructions. Of these, 1 was due to POI (0.05% of all other laparotomies and 2.5% of all bowel obstructions). This difference in the rate of POI was statistically significant ($P < .001$). The relative risk for intussusception after the Ladd procedure compared with any other laparotomy was 54 (95% confidence interval, 42-61).

Children with POI developed symptoms of distension, bilious emesis, and irritability between 5 and 8 days (mean, 6.3 days) after undergoing the Ladd procedure. Four of the children were discharged before symptom onset, all on postoperative day 4. The other child developed abdominal distension and emesis 3 hours before his planned discharge. A second operation took place 6 to 13 days (mean, 9.2 days) after the Ladd procedure.

Initial management included nasogastric suction and intravenous hydration. Contrast studies were obtained in all 5 patients because of lack of clinical improvement. The decision to reexplore was based on the results of the con-

Other Indicated Procedures and Medical Conditions

Concomitant Procedures		Other Medical Conditions	
Procedure	No.	Diagnosis	No.
Gastrostomy tube	27	Premature birth	25
Nissen fundoplication	20	Cardiac defects	20
Bowel resection	11	Down syndrome	6
Central venous line	10	Hernia	5
Abdominal wall hernia	5	Chromosome defect	3
Circumcision	4	not otherwise specified	
Lysis of adhesions	3	Cerebral palsy	3
Gastroplasty	2	Pierre Robin syndrome	2
Ectopic pancreas resection	1	Torticollis	2
Hepaticojejunostomy	1	Twin	1
Repair gastric perforation	1	Omphalocele	1
Soave pull through	1	Hirschsprung disease	1
Colostomy closure	1	Imperforate anus	1
		Phenylketonurea	1
		Choledochal cyst	1
		Henoch-Schönlein purpura	1
		Inflammatory bowel disease	1

trast study in 4 patients, which showed partial small bowel obstructions. The child with a negative upper gastrointestinal tract series underwent exploration 4 days later because of persistent lack of clinical improvement. There were 2 jejunojejunal and 3 ileoileal intussusceptions. All were reduced manually without the need for bowel resection. There were no identifiable lead points. All intussusceptums were associated with filmy adhesions to the intussusciptens.

The POI group and the controls did not differ according to weight, length of nasogastric suction, time to first oral intake, or length of stay ($P > .99$). There was no correlation between concomitant procedures and the development of POI after the Ladd procedure in our study group or controls. There was 1 child in each group with developmental delay. The groups differed in regard to percentile weight, with the POI group being less likely to be small for their age (means of 39.4% vs 9.4%; $P = .03$).

COMMENT

There are 2 reported cases of enteric intussusception after a Ladd procedure.^{2,7} Between 1995 and 1998, there was a substantial increase in the number of Ladd procedures performed at Arkansas Children's Hospital. The reasons are 2-fold. First, aggressive investigation of gastroesophageal reflux-type symptoms has increased the use of upper gastrointestinal tract series with small bowel follow-through. Second, our radiologists expanded criteria to define malrotation and its variants with this study in early 1996.⁸ The traditional criteria include (1) duodenum descending in a tortuous pattern to the right of the midline and (2) jejunum located in the right upper quadrant. The expanded criteria include (1) duodenojejunal junction not located to the left of the spine and level with the gastric outlet; (2) duodenojejunal junction overlying the left vertebral pedicle and inferior to the plane of the gastric outlet; (3) duodenojejunal junction turning medial to left vertebral pedicle at any height; and (4) duodenojejunal junction overlying the left thoracic vertebral pedicle with normal elevation (borderline) (T. Vanderzalm, Arkansas Children's Hospital, Department

of Radiology, oral communication, October 8, 1999). This resulted in a 2.5-fold increase in the annual rate of the diagnosis of malrotation and has given us an opportunity to evaluate the efficacy and complications of the Ladd procedure.

Several operations are repeatedly mentioned in all large series¹⁻⁷ of POI.

Procedure	No. of Procedures
Rectal pull through	25
Wilms tumor	21
Resection neuroblastoma	19
Ileocolic intussusception	18
Appendectomy	18
Nissen fundoplication	14
Small bowel procedures	7
Ureterostomy	7
Inguinal hernia	3
Ladd procedure	2
Gastrocystoplasty	2
Hepatic resection	1
Other	21

The most frequently cited procedures (abdominoperineal pull through, Wilms tumor resections, neuroblastoma resections) have in common some form of retroperitoneal dissection and a requirement for a large amount of bowel manipulation. Also, some form of autonomic or enteric nervous system abnormality underlies many of these conditions.

The Ladd procedure obviously satisfies the first 2 criteria. The role of the enteric nervous system in the formation of malrotation is not clearly defined. The mechanism that determines the orientation of the intestines is not known.⁹ The bowel normally returns to the abdominal cavity at 12 weeks' gestation. By this time, enteric neurons have populated the gastrointestinal tract from mouth to anus. These neurons have not formed their ultimate interconnections until approximately 18 to 20 weeks' gestation, so correct intestinal rotation cannot depend on a completely mature enteric nervous system.¹⁰ However, it is conceivable that maldevelopment of the enteric nervous system may lead to abnormal motor activity, which in turn may cause malrotation. This same as-yet-undefined motor abnormality may persist and predispose these children to POI. The relatively frequent appearance of POI after antireflux procedures supports this contention. In the review by West et al⁶ of 36 POIs, there were 12 patients who underwent procedures for abnormal esophageal motility, none of which involved retroperitoneal dissection or extensive bowel handling.

Small bowel motility in children who have undergone a Ladd procedure has been investigated manometrically.^{9,10} All but 1 child studied had manometric abnormalities of phase III migrating motor complex contractions, which were classified as neurogenic. These included nonpropagation, reverse propagation, prolonged phasic contractions, and random disorganized contractions. So, abnormal enteric motility probably accounts for some of the increased risk of POI after the Ladd procedure.

The diagnosis of POI is difficult. In a group of collected series, the diagnosis was made before reexploration in only 3% to 5% of cases.⁵ In our series, upper gastrointestinal tract with small bowel follow-through showed partial small bowel obstruction in 4 of 5 cases. In the fifth case, the study was interpreted as normal. That child returned to the operat-

ing room 4 days after the study because of persistent abdominal distension and high nasogastric output. Other investigators report good results with abdominal ultrasound. In one series,³ ultrasound was 80% sensitive for enteric intussusception. However, even the radiology literature states that intussusception cannot be ruled out by a negative ultrasound finding, and other findings can mimic the "doughnut" or "pseudokidney" sign, including necrotizing enterocolitis or volvulus.^{11,12} Computed tomography was successful in 2 cases when the diagnosis was suspected preoperatively in one adult series.¹³ The resolution of computed tomography in children is limited by the decreased amount of mesenteric fat, however, and may not be as accurate in this group.

Clearly, no one study will make the diagnosis in all cases. In our experience, the ileus from a Ladd procedure lasts an average of 3 days. Children who develop intussusception begin having symptoms at an average of 7 days. This is consistent with all other series of POI. In a child who has undergone a Ladd procedure and regains bowel function, the symptoms of abdominal distension and emesis within 2 weeks of the procedure should prompt an aggressive investigation for POI. Contrast studies may show partial or complete obstruction, prompting reexploration. An experienced ultrasonographer may be more accurate, depending on institutional experience. Laparotomy is the only definitive test and should not be delayed by a negative study with persistent symptoms.

Mollitt et al³ showed that diagnostic delay affects the outcome of POI. They showed that a 0% mortality after simple manual reduction increased to a 7% mortality when resection of necrotic bowel became necessary.³ Because diagnosis remains difficult, a high index of suspicion is necessary for correct treatment. By identifying risk groups, the clinician can institute aggressive investigation to shorten the time to definitive therapy. Children undergoing a Ladd procedure are now defined as a high-risk group for POI.

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