Laparoscopic Ladd’s Procedure in Children: Challenges, Results, and Problems

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Background: Laparoscopic correction of malrotation in children is challenging. Authors review their experience with indications, results and problems of laparoscopic correction of malrotation.

Materials and Methods: This is a retrospective study of 41 cases of children who were diagnosed as Intestinal malrotation on clinical and radiological evaluation.

Results: Successful laparoscopic Ladd’s procedure was accomplished in 35 cases. There were six conversions to open surgery. The mean hospital stay was 4 days (range 3-12 days). Restoration of complete feed was achieved on an average of 3 days (range 2-4 days). Post-operative recurrence of symptoms was seen in nine cases. Of which, five cases had incomplete correction, three cases had duodenal kinking due to adhesive intestinal obstruction and one had intra luminal duodenal obstruction. All patients underwent open surgery for recurrent symptoms.

Conclusion: Laparoscopic Ladd’s procedure is feasible in children with intestinal malrotation with or without associated volvulus. However, some of them need conversion to open surgery due to difficult local anatomy. For persistent symptoms, they may require redo surgery, which may be due to incomplete correction, adhesive obstruction or intraluminal obstruction.

Keywords: Intestinal malrotation, Ladd’s procedure, laparoscopy, volvulus

INTRODUCTION

The classical presentation of intestinal malrotation in newborn period is bilious vomiting with scaphoid abdomen. They are frequently associated with volvulus of the midgut, which has disastrous consequences if the diagnosis is delayed. Children who do not present in early infancy have a multitude of vague abdominal complaints which delay the diagnosis and treatment. In older children, malrotation of gut may cause intermittent volvulus, resulting in a variety of symptoms from chronic intermittent pain, bilious vomiting, failure to thrive, and chronic intestinal blood loss. It may be associated with visible peristalsis in the upper abdomen if there is concomitant presence of intraluminal obstruction by fenestrated diaphragm.

Our institutional algorithm in a suspected malrotation of gut is to have plain abdominal radiograph, followed by ultrasonography and upper gastrointestinal contrast study followed beyond the cecum. In doubtful cases, computed tomography is advised. Upper gastrointestinal contrast study has sensitivity of 96% to detect malrotation. The sensitivity to diagnose midgut volvulus by upper gastrointestinal contrast study is 79%. Ladd’s procedure is the treatment of choice. We have retrospectively analyzed our data of children who underwent laparoscopic Ladd’s procedure and assessed the outcomes. We report our conversion rates and reoperation rates and compared them with the relevant literature.

MATERIALS AND METHODS

Patients

The institutional ethical committee approval was taken before the commencing the laparoscopy in young infants and neonates. The data pertaining to laparoscopic...
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correction of malrotation gut in children were collected and presented to the committee for review and their approval sought. After the approval, we retrospectively reviewed the case files of children who were diagnosed as intestinal malrotation between September 2007 and December 2015. All children who were septic, hemodynamically unstable, acidotic, with electrolyte imbalance, bleeding per rectum, devitalized bowel due to volvulus and babies with cardiac or other severe congenital anomalies were excluded from the study. Forty-four children underwent laparoscopy for suspected malrotation. The most common presentation was a bilious vomiting with scaphoid abdomen in 29 cases, followed by failure to thrive in 8 cases, and chronic abdominal pain in 5 cases. In seven children, the malrotation of gut was associated with nonbilious vomiting.

Methods
Open technique was used to create carboperitoneum, by insertion of the first 5 mm trocar at umbilicus under direct supervision. Ten-millimeter port can be used in bigger children. Two or three additional 3 mm ports were inserted under laparoscopic guidance, one in the left midclavicular line at the level of umbilicus, the second one in the midclavicular region onto the right side at the level of umbilicus as the second working port, and if required, then the a third port in the left subcostal region for retraction of colon. If ultrasonic shears are to be used then one or more, working ports have to be 5 mm [Figure 1].

Initially, diagnostic laparoscopy was performed using 30°, 5 mm telescope. Laparoscopy revealed classical findings of malrotation in 41 out of 44 patients. Three patients did not have malrotation and they were treated for gastroesophageal reflux. Principles of correction of malrotation as in open surgery were followed in all patients. Ladd’s bands were divided; cecum and colon were released medially from the duodenum and pancreas. Duodenum and jejunal loops were straightened. The base of mesentery was widened, and appendectomy was performed. The cecum and the colon were placed on the left of midline and the straightened duodenum, and the small bowel was placed on the right side.

In one patient, the dissection of duodenojejunal flexure was difficult due to a thick vascular band crossing the cecum into the retroperitoneum. In this child, the duodenojejunal junction was completely freed and straightened, and the entire small bowel along with the cecum was pulled through an opening to the right of the abdomen followed by safe division of the crossing band.

RESULTS
There were 29 boys and 12 girls with malrotation of gut. The median age was 3 days (range 1 day–13 years). There were 28 neonates, 7 infants, and 6 children [Table 1]. The median weight was 2.8 kg (range 2–44 kg) [Table 1]. In 35 patients, laparoscopic Ladd’s procedure was completed, and in six patients, conversion to open surgery was carried out due to problems with orientation and failure to progress due to difficult anatomy. All patients tolerated procedure well. Postoperatively, feeds were started on day 1. The peristalsis returned on an average of 1.9 days postoperatively (range 1–5 days). Full oral feeds were restored by third postoperative day 3 (range 1–6 days). The average hospital stay was 5 days (range 3–12 days).

The average operating time was 96 min (range 62–128 min). In six patients, the procedure was converted to open. All the six cases were neonates. In four cases, there was difficulty in orientation at the root of mesentery. One was converted to open for nonprogression of the surgery due to altered vascular anatomy. In one case, duodenum was inadvertently perforated; hence, it was converted to open and the

| Table 1: Demography |
|---------------------|
| **Patient characteristics** | **Number (%)** |
| Total cases evaluated (n) | 41 |
| Sex                  |                  |
| Male                | 29               |
| Female              | 12               |
| Age                 |                  |
| Median age (range)  | 3 days (1 day to 13 years) |
| <1 month            | 28               |
| 1-12 months         | 7                |
| 1-5 years           | 4                |
| 5-15 years          | 2                |
| Median weight (range), kg | 2.8 (2-44)  |

Figure 1: The port positions for laparoscopic correction of malrotation. The “C” depicts the position of the duodenum.
perforation was closed. Blood loss was minimal, and none of the patients required a blood transfusion.

Postoperative recurrences of symptoms were seen in nine children. Five children underwent open Ladd’s procedure for incomplete correction. Three children had adhesive intestinal obstruction due to kinking of the duodenum and underwent laparotomy, adhesiolysis, and straightening of the duodenum. One child had duodenal stenosis which was managed by an open gastrojejunostomy due to inflammation of duodenum. There were no deaths in this series, and all children are free of symptoms since last follow-up (6–48 months). Three patients had persistent upper abdominal pain which responded to proton-pump inhibitors and dietary modifications. There were three minor port-site infections which settled on oral antibiotics [Table 2].

**DISCUSSION**

The rapid advances in laparoscopy instruments and the pediatric anesthesia techniques have made laparoscopy in children extremely safe. Small caliber of the instruments allows laparoscopic surgery even in small babies.

Ladd’s procedure is a suitable procedure for adaptation to laparoscopy. The trauma of access to the target organ is disproportionately more than the trauma of the procedure itself. In the laparoscopic Ladd’s procedure, there is minimal handling of bowel, the abdominal incisions are small, and this translates to early return of peristalsis, lower incidence of bowel adhesions, and early discharge from the hospital.

On laparoscopy, it is difficult to diagnose the intraluminal obstructions in bowel. Laparoscopy also poses restriction in assessing the degree of rotation and its correction as the complete spreading of the intestine and its mesentery may be little difficult. We follow a modified version of the technique first described by van der Zee and Bax,[4] where the Ladd’s bands are dissected from proximal to distal direction, and the proximal jejunum is progressively pulled inferolaterally toward the right of midline. The volvulus gets corrected gradually. This technique needs a degree of expertise and excellent vision of the operative field. The end point of the derotation is not definite and is difficult to assess the derotated bowel due to limited vision. Kisku[5] described a novel “orbit technique” which addresses most of the technical difficulties faced during the derotation of nonobstructed volvulus. This technique uses suprapubic port for the camera to provide a zoomed out pan endoscopic view of the abdomen. The right iliac fossa port instrument is used as a stationary reference point in the midline, which is just above the bowel loops, overlying the mesentery. The operating surgeon moves the bowel counterclockwise in an orderly fashion around the stationary grasper. The derotation is precise and is completed under vision. Despite the limitations of the laparoscopic correction of malrotation, the literature is replete with articles and case series attesting the safety and excellent outcome of the procedure.[4,5] However, few authors suggest caution in performing laparoscopic correction of malrotation of bowel in neonates.[8]

We report our experience in 41 cases of laparoscopic Ladd’s procedure. The procedure was done in well-selected cases in both neonatal age group and in older children. All the studies report shorter time to full feeds and shorter hospital stay.

Two large series of unselected patients show similar findings of shorter hospital stay and early restoration to full feeds. They also report significant conversion rate and reoperation rate[8-11] [Table 3].

Our case series show that laparoscopic Ladd’s procedure is feasible in both neonates and in older children. The rate of conversion to open surgery is 14.6%, and reoperation rate is 22% and is comparable with the other published series.[8-11] The rate of conversion in our series is marginally low as our operative protocol allows the

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**Table 2: Results of surgery**

| Cases                                              | Number (%) | Remarks                                      |
|----------------------------------------------------|------------|----------------------------------------------|
| Confirmed to have malrotation (n)                  | 41         | Three cases did not have malrotation and were managed as gastro-esophageal reflux disease |
| Completed laparoscopic Ladd’s procedure (n)        | 35         | Six cases converted to open All cases were neonates |
| Conversion to open, n (%)                          | 6 (14.6)   | Difficult vascular anatomy - 1 Perforation of bowel-1 Non progression of the procedure due to orientation of the anatomy - 4 |
| Redo surgery, n (%)                                | 9 (21.95)  | Inadequate correction of malrotation - 5 Adhesive intestinal obstruction - 3 Missed duodenal stenosis - 1 |

**Average & SD**

| Operating time (min) | 96±18 min | 62-128 min |
|----------------------|-----------|------------|
| Return to peristalsis days | 1.9±1 | 1-5 |
| Mean hospital stay days | 5±1.8 | 3-12 |

SD: Standard deviation
Table 3: Comparative study

| Author           | Patients | Age (range)       | Conversion (%) | Reoperation (%) |
|------------------|----------|-------------------|----------------|-----------------|
| Miyano et al.    | 9        | Neonates & children | 22             | 11              |
| Fraser et al.    | 43       | 5.7 years         | 33             | 2.4             |
| Hagendoorn et al.| 45       | 4 days to 13 years | 25             | 19              |
| Kalfa et al.     | 5        | 9 days            | 20             | 20              |
| Stanfill et al.  | 36       | Children          | 8.3            | 0               |
| Draus et al.     | 8        | 10 weeks to 25 years | 12             | 0               |
| Bass et al.      | 12       | 5 days to 4 months | 0              | 0               |
| Timothy and Duncan | 10   | 3 months to 13 years | 0              | 0               |
| Palanivelu et al.| 7        | 7-12 years        | 0              | 0               |
| Mazzotti et al.  | 7        | 7 years           | 0              | 0               |
| Youssef et al.   | 3        | 3 weeks to 8 months | 0              | 0               |
| Present series   | 41       | 1 day to 13 years | 14.63          | 21.95           |

Long-term benefits in terms of recurrence, adhesive intestinal obstructions, and chronic abdominal pain are significantly less in laparoscopic Ladd’s procedure. The follow-up of our patients has shown high degree of parental satisfaction and no long-term morbidity (6 months–4 years). In the limited follow-up period, there are no neurological and psychological developmental issues in our patients.

The patients in our series were carefully selected, and all children with unviable bowel due to volvulus and children with other comorbid conditions were excluded from laparoscopic Ladd’s procedure. Despite the above limitations, laparoscopic Ladd’s procedure is a very safe and feasible option in the treatment of intestinal malrotation in neonates and in older children.

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Conflicts of interest

There are no conflicts of interest.

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