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ORIGINAL ARTICLE

Reoperation after Ladd's procedure in the neonatal period

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Abstract

Aim of the study To investigate (1) the indications for reoperation after neonatal Ladd's procedure, (2) the type of reoperation and (3) its outcome.

Methods We reviewed all neonatal Ladd's procedures in our hospital from 2003 to 2017 and the outcomes of reoperation in these patients.

Main results 252 neonates had Ladd's procedure: 59 were laparoscopic (23.4%) and 193 open (76.6%). 15 (6.0%) required reoperation with no difference between laparoscopic and open ($p=0.12$). Overall, the indications for reoperation were: adhesive intestinal obstruction ($n=10$, 4.0%), recurrent midgut volvulus ($n=4$, 1.6%), and missed diagnosis of associated anomaly ($n=1$, 0.4%). The incidence of recurrent midgut volvulus was higher after laparoscopic Ladd's procedure (3/59; 5.1%) compared to open Ladd's procedure (1/193; 0.5%) ($p=0.04$). Adhesive intestinal obstruction developed after both open (8/193, 4.1%) or laparoscopic Ladd's procedure (2/59, 3.3%). The duration of reoperation and the length of post-operative hospital stay were 63.4 ± 27.1 min and 10.1 ± 5.2 days, respectively. After reoperation, there were no post-operative complications. All children were well at follow-up (6 months–14 years).

Conclusions In neonates, laparoscopic Ladd's procedure compared to the open Ladd's procedure is associated with a significantly higher risk of recurrent volvulus. The risk of developing this potentially dangerous complication after laparoscopic Ladd's procedure raises doubts about the effectiveness and safety of the laparoscopic approach in neonates.

Keywords Intestinal malrotation · Ladd's procedure · Reoperation · Laparoscopy · Neonate

Introduction

Intestinal malrotation is a congenital anomaly that requires emergent surgical management to avoid the severe complications of midgut volvulus and bowel necrosis [1, 2]. Either conventional open or laparoscopic Ladd's procedure is recommended for the surgical treatment of malrotation in neonates and older children [3, 4]. However, post-operative complications can develop after Ladd's procedure requiring further operative management. Pediatric surgeons strive to minimize the complications occurring after Ladd's procedure and particularly to avoid a recurrence of the midgut volvulus as it can have very deleterious consequences for the child, the family and the society [1, 5].

It is well known that adhesive intestinal obstruction can develop after Ladd's procedure [6]. To reduce this incidence and to improve the cosmetic results, pediatric surgeons have relied on the application of laparoscopy [7]. However, it is debatable whether laparoscopic Ladd's procedure can offer the same protection against recurrent midgut volvulus as the open approach.

The aim of this study was to investigate in a single institution over the past 14 years the complications of Ladd's procedure in neonates focusing on (1) the type of operation performed (open or laparoscopic), (2) the causes for reoperation and (3) the outcome of reoperation.

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Methods

The Children's Hospital of Fudan University Institutional Review Board approval was obtained prior to initiation of this study. A single institution retrospective review was performed on all neonates who underwent Ladd's procedure for congenital intestinal malrotation with or without midgut volvulus, in the Department of Pediatric Surgery, Children's Hospital of Fudan University, between January 2003 and December 2017. The following details were reviewed including demographics, the type of the primary Ladd's procedure (open or laparoscopic), indication for reoperation, details of reoperation, and its post-operative course and outcome. Among all reoperative cases, follow-up information was collected from outpatient records along with telephone communication.

Continuous data were expressed as mean ± standard deviation (SD) and compared with *t* test. Qualitative data were reported as percentages and compared with the χ^2 test. Statistical analysis was performed using SPSS version 20.0 statistical software (SPSS, Inc., Chicago, IL). A *p* value of less than 0.05 was considered statistically significant.

Results

Patient demographics

A total of 252 neonates who had Ladd's procedure in the Department of Pediatric Surgery, Children's Hospital of Fudan University, during January 2003–December 2017 were included. The primary Ladd's procedure was laparoscopic ($n=59$, 23.4%) or open ($n=193$, 76.6%). 15 (6.0%) of these children required reoperation: 6 (10.2%) after initial laparoscopy and 9 (4.7%) after initial open laparotomy ($p=0.12$). Table 1 reports the demographics of neonates who underwent Ladd's procedure, according to the type of operation (laparoscopic or open). During the initial Ladd's procedure, an intestinal anastomosis was done in four patients (26.7%) with focal bowel necrosis or associated intestinal atresia.

Indications for reoperation

The most frequent indication for reoperation was adhesive intestinal obstruction ($n=10$, 66.7%), followed by recurrent midgut volvulus ($n=4$, 26.7%), and missed diagnosis of an associated anomaly ($n=1$, 6.7%). Reoperation for adhesive intestinal obstruction was done after 12.6 ± 10.7 months from initial Ladd's procedure. Adhesive intestinal obstruction developed after both open (8/193, 4.1%) or laparoscopic Ladd's (2/59, 3.3%). All patients with recurrent midgut volvulus and missed diagnosis of an associated anomaly ($n=5$, 33.3%) underwent reoperation within 1 month after primary Ladd's procedure. All the children who developed recurrent midgut volvulus had a midgut volvulus present at the first operation. The incidence of recurrent midgut volvulus was significantly higher after laparoscopic Ladd's procedure (3/59; 5.1%) compared to open Ladd's procedure (1/193; 0.5%) ($p=0.04$). Indications for reoperation are summarized in Fig. 1.

Reoperation and short-term outcomes

All children who required reoperation underwent laparotomy. Enterolysis was performed for adhesive intestinal obstruction. Children with recurrent midgut volvulus had a redo-Ladd's procedure including widening of the mesenteric base. Duodeno-duodenostomy was done in one child for the missed diagnosis of congenital duodenal atresia.

Reoperation was successfully in all cases. None of the children required intestinal resection. There were no intra or post-operative complications. The duration of reoperation ranged from 30 to 100 min, with a mean of 63.4 ± 27.1 min. None of these patients needed mechanical ventilation following surgery. The median time to full diet was 9.8 ± 5.8 days (range 5–21 days). The length of post-operative hospital stay ranged from 5 to 33 days, with an average of 10.1 ± 5.2 days. No recurrent midgut volvulus, wound complication or feeding issue was identified in any of the cases post-operatively during the hospital stay.

Table 1 Demographics of children who underwent primary Ladd's procedure

Characteristics	Laparoscopic ($n=59$, 23.4%)	Open ($n=193$, 76.6%)	*p* value
Male to female ratio	31:28	98:95	0.88
Gestational age (weeks)	34.7 ± 5.1	36.3 ± 4.3	0.03
Birth weight (g)	3040 ± 380	3219 ± 260	< 0.01
Percentage of associated anomalies (%)	7.2	5.1	0.77
Percentage of midgut volvulus (%)	53.1	64.5	0.13

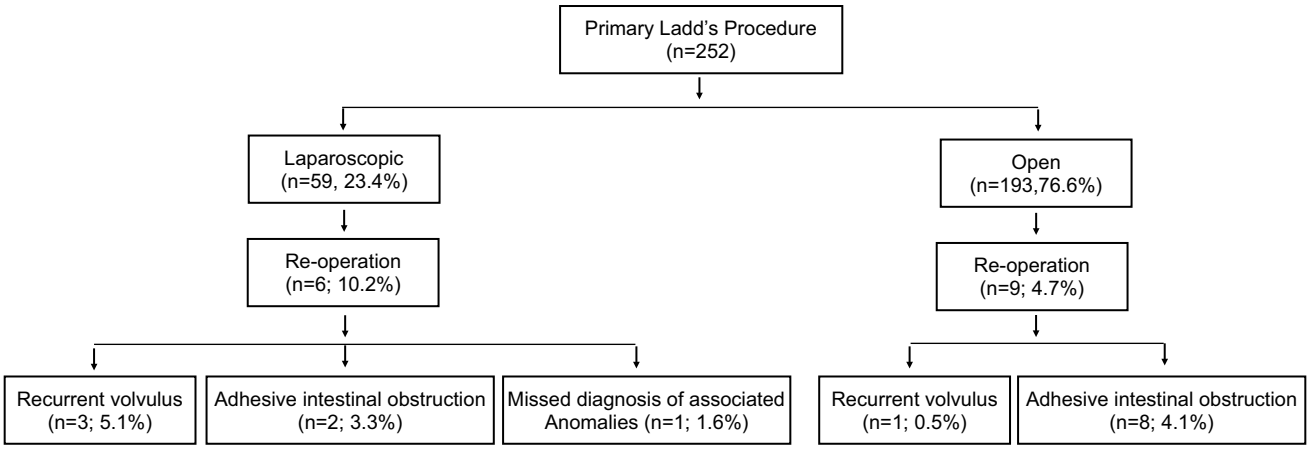

Fig. 1 A flow chart for reoperative indications among patients who underwent primary Ladd's procedure (laparoscopic or open)

Long-term follow-up

All children who underwent reoperation were followed-up until December 2017. The median duration of follow-up was 3.1 years (range 0.5–14 years). In our series, none of the patients died or experienced occlusive symptoms and no recurrent midgut volvulus was detected after hospital discharge. None of the children showed feeding intolerance or required total parenteral nutrition.

Discussion

This study reports the complications that can occur following Ladd's procedure in neonates. Adhesive bowel obstruction can develop after both laparoscopic (3.3%) or open (4.1%) Ladd's procedure. However, the laparoscopic Ladd's is associated with higher recurrence of midgut volvulus (5%) compared to open Ladd's (0.5%). This highlights the potential drawback of the minimally invasive approach to intestinal malrotation in neonates.

Congenital intestinal malrotation is characterized by a failure of rotation and fixation of bowel segments, leading to abnormalities in intestinal positioning and attachment with bands across the duodenum and a narrow pedicle for the midgut [5, 8]. The incidence of intestinal malrotation is about 1 in 500 live births [9]. Ladd's procedure is the definitive treatment for neonates with malrotation [4]. It consists of de-rotation, widening of the mesenteric base, and division of the Ladd's bands as well as incidental appendectomy [8]. Recently, there has been a growing concern about post-operative complications after Ladd's procedure since they can influence the prognoses of these patients and lead to unplanned reoperations. However, indications for reoperation and their outcomes are not well defined.

Multiple studies have reported a high incidence of morbidity associated with operative interventions for malrotation. Recurrence of occlusive symptoms, which result from post-surgical adhesive obstruction, is the most common post-operative complication that requires surgical management [4, 6, 10]. The results of the current study were similar to those reported in the literature. In our series, the most frequent indications for reoperation were adhesive intestinal obstruction, recurrent volvulus and missed diagnosis of associated anomalies. Interestingly, most patients with recurrent midgut volvulus needed earlier reoperations than patients with post-operative adhesive intestinal obstruction indicating that the malrotation was probably not corrected completely during the laparoscopic Ladd's procedure.

Recently, the laparoscopic Ladd's procedure has been performed in pediatric patients including neonates [7, 11–13]. The laparoscopic approach has multiple advantage including earlier full enteral feeding and shortened length of hospital stay [14]. However, laparoscopy is still controversial particularly in young children [15–19]. In our study, the incidence of reoperation was not significantly different between laparoscopy and conventional open surgery. Laparoscopy did not decrease the risk of developing adhesive intestinal obstruction after Ladd's procedure. However, the most concerning result of this study is the risk of developing recurrent midgut volvulus in children who underwent laparoscopic Ladd's procedure. This risk is significantly higher after laparoscopy (5%) compared to open surgery (0.5%). Although none of the children who developed recurrent midgut volvulus required intestinal resection, the risk of developing a recurrent volvulus should be considered by the surgeon planning to perform a laparoscopic Ladd's procedure in neonates. It is possible that various factors influence the risk of developing recurrent midgut volvulus after laparoscopic Ladd's procedure including the weight of the neonate, the presence of midgut volvulus at first operation and the

learning curve in laparoscopy. Further studies are needed to confirm these initial results and to evaluate whether the same risk applies to older children.

Open abdominal surgery is the most reliable and commonly used procedure for reoperation after Ladd's procedure. In our series, all reoperations were done via open laparotomy. All the children in this study had successful reoperations, and fortunately none of them required massive intestinal resection or developed short bowel following recurrent midgut volvulus. However, this study is limited by the small sample size and by the retrospective nature of the analysis.

Conclusions

The main indications for reoperation after Ladd's procedure in neonates are adhesive intestinal obstruction and recurrent midgut volvulus. The recurrent volvulus occurs primarily after laparoscopic Ladd's procedure, whereas the adhesive intestinal obstruction occurs after both open and laparoscopic Ladd's procedure. The incidence of recurrent volvulus after laparoscopic Ladd's procedure is disturbing as the volvulus exposes to serious consequences. This retrospective study raises doubts on the efficacy and reliability of laparoscopic Ladd's procedure in neonates. Our conclusions need to be confirmed by a multicenter prospective study.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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