Congenital Intestinal Malrotation in Newborns: Laparoscopic Ladd's Procedure versus Open Laparotomy

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ABSTRACT

Objective: To assess the efficacy and safety of laparotomic or laparoscopic Ladd's procedure in newborns with congenital malrotation.

Study Design: Descriptive study.

Place and Duration of Study: Department of Pediatric Surgery, Ganzhou Maternal and Child Health Care Hospital, Ganzhou JiangXi province, China, from January 2015 to December 2021.

Methodology: The clinical data of newborns with malcorrection were retrospectively analysed. Patients were divided into laparotomy group (64 cases) and laparoscopy group (30 cases), according to the surgery they had been subjected. The patients who had the severe malformations, underwent the laparoscopic Ladd's procedure at the first 10 cases, and had found bowel necrosis during operation were excluded. The general data such as lengths of operation, intraoperative blood loss, time-to-diet, lengths of hospital stay, and postoperative complications were compared between the two groups.

Results: Crude comparisons showed that the laparoscopy increased the lengths of operative time (70.0 *vs.* 110.0 minutes, p <0.001) but decreased the postoperative complications (25.0% *vs.* 6.7%, p=0.035). The intraoperative blood loss, time-to-diet, and lengths of hospital stay between the two groups were not statistically significant (p=0.109, 0.065, and 0.858 respectively). The intestinal volvulus in the two groups (43.8% *vs.* 80.0%, p=0.001) had statistical differences. Using modified Poisson regression analysis, adjusting for confounding differences of midgut volvulus, lengths of operation time and intraoperative blood loss, and laparoscopic Ladd's showed a significant decrease in postoperative complications (RR=0.13,95%CI 0.03-0.54, p=0.005).

Conclusion: Laparoscopic Ladd's procedure is feasible to treat neonatal malrotation and is associated with lower postoperative complications of newborns with congenital malrotation.

Key Words: *Newborns, Congenital malrotation, Laparoscopy, Laparotomy, Complications.*

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INTRODUCTION

Congenital intestinal malrotation is one of the common gastrointestinal malformations in newborns. The abnormalities contain the disposition of the intestine, mesentery incomplete covering, duodenal obstruction and midgut volvulus. Surgery is the only effective treatment method.[1] Ladd's procedure has become a classic surgical method for treating intestinal malrotation since William E. Ladd performed the first intestinal malrotation surgery in 1936. The first laparoscopy of Ladd's appeared in 1995 with the development of pediatric laparoscopy. The debate about the safety and efficacy between laparotomy and laparoscopy has not been stopped since then.[2]

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Laparoscopy can reduce the length of stay, time-to-diet, and postoperative pain. But some pediatric surgeons think that correcting the intestinal twisting in infants by laparoscopy is difficult, the rate of lap-to-open is high, and laparoscopy increases operative time and complications.[3] The patients in the most of reports about malrotation are the children aged from 0 to 14,[4] and there is less data on efficacy and safety in newborns. The aim of this study was to assess the efficacy and safety of laparoscopic Ladd's procedure in newborns with congenital malrotation.

METHODOLOGY

This study included a comparative analysis of newborns with congenital intestinal malrotation who underwent Ladd's procedure between January 2015 to December 2021 in Ganzhou Maternal and Child Health Care hospital. This study was conducted following the Helsinki Declaration and approved by the Ethics committee of the Ganzhou Maternal and Child Health Care Hospital(Ethical approval number: 2022-27). All patients provided written informed consent.

Inclusion criteria were neonates aged less than 1 month who underwent Ladd's procedure. The patients who underwent

laparotomic Ladd's procedure were included in the laparotomy group. The patients who underwent laparoscopic Ladd's procedure were included in the laparoscopy group. Patients were excluded in case of severe malformations affecting recovery and outcomes if they had undergone the laparoscopic Ladd's procedure at the first 10 cases in order to exclude the influence of surgical learning curve, and who had bowel necrosis found during the operation.

The primary outcomes measured were operative time, intraoperative blood loss, time-to-diet, postoperative complications, degree of intestinal malrotation, readmission, and reoperation. The outcomes of patients who underwent laparoscopy were compared with that of patients who underwent laparotomy. The clinical characteristics of both groups were compared, and the outcomes were reassessed with a multivariate regression to adjust for the potentially confounding differences between the two groups.

Laparotomic Ladd's procedure consisted of volvulus detorsion (if present), Ladd's bands' division, straightening of the duodenum, widening of mesentery root, and positioning of the bowel in a systematic position within the abdominal cavity with large bowel to the left and small bowel to the right.[5] If there were any other malformations, it was treated at the same time.

Laparoscopic Ladd's procedure was the same as the laparotomy but done through three passages in the abdominal wall. Referring to the volvulus detorsion, it could be considered to complete the detorsion when the small intestine mesentery spread completely without torsion and the colon and ileocecum were free.[6]

All patients were followed for 3 months to 5 years and observed for complications such as vomiting, adhesive intestinal obstruction and intestinal volvulus recurrence.

Concerning statistical analysis, the SPSS 26 statistical software was used. Descriptive statistics were used to summarise and describe the distribution of continuous variables which were assessed by Shapiro-wilk test (normal distribution data expressed as mean±standard, skewed data as median (P_{25},P_{75}) and categorical variables (expressed as counts and percentages). Normal distribution data were analysed using independent two-sample *t*-test, skewed distribution using rank sum test and categorical variables using chi-square test. The authors used a modified Poisson regression analysis to adjust the confounding between the two groups and evaluate the factors affecting the surgical complications. The $p < 0.05$ was considered to be statistically significant.

RESULTS

A total of ninety-four patients were included and of these, sixty-six patients (70.2%) were boys, six patients (6.4%) were premature newborns, and thirty patients (31.9%) underwent by laparoscopy. The median age was 6.0 (4.0,8.0) days, the weight was 3.10±0.45 kg, six patients (6.4%) had preoperative gastrointestinal haemorrhages, 82 patients (87.2%) had bilious vomiting, and forty-six patients (48.9%) had duodenal obstructions on the preoperative upper gastrointestinal contrast study.

All patients were divided into two groups (laparotomy or laparoscopy) according to the operation. The gender, age, weight, pregnancy, gastrointestinal haemorrhages, bilious vomiting, upper gastrointestinal contrast, and operating blood loss between the two groups were not statistically significant ($p>0.05$). The rate of intestinal twists between the two groups was statistically significant ($p=0.001$). The operating time in the laparotomic group was 70(60, 110) minutes, while the operating time in the laparoscopic group was 110(90,130) minutes ($p<0.001$).

The differences in time-to-diet and hospital stay between the two groups were no statistically significant ($p> 0.05$), but the difference in postoperative complications between the two groups was statistically significant ($p =0.035$). The characteristics of patients and postoperative outcomes between the two groups are summarised in Table I.

Complications were taken as dependent variables, those whose p-value was less than 0.2 in the differences between the two groups were taken as independent variables, and a modified Poisson regression analysis was applied then. The -2 log-likelihood ratio of the model omnibus tested was 13.19 ($p=0.010$). The model was successful and generally significant. After adjusting for the influence of intestinal volvulus, operating time and blood loss, it was found that the association of surgical mode and postoperative complications were statistically significant (RR=0.13, 95% *CI* 0.03-0.54, $p=0.005$). Laparoscopic Ladd's procedure could reduce the risk of complications by 87% compared with laparotomic Ladd's procedure. The results of multivariate modified Poisson regression analysis were shown in Table II.

Sixteen patients had postoperative complications in the laparotomy group. Four patients had wound infected and were cured by dressing. Two patients had wound dehiscence and were cured by emergency wound sutures. Ten patients had recurrent vomiting and intestinal obstructions after discharge, the symptoms of 3/10 patients disappeared after conservative treatment, and a secondary surgery was performed in each 7/10 patients. Among seven patients subjected secondary surgery, four patients had underwent by intestinal adhesion releases, and three patients by the intestinal adhesion releases and duodenal jejunal lateral anastomoses. Two patients underwent redo open surgery in the laparoscopy group because of the recurrence of intestinal volvulus. Indications for complications are summarised in Figure 1.

DISCUSSION

Laparoscopic Ladd's procedure for intestinal malrotation is being performed more and more widely in children with the development of minimally invasive techniques. Many studies have proved that laparoscopic Ladd's procedure can shorten the time of complete enteral feeding and hospital stay in older children, and reduce postoperative pain.[7]

Table I: Characteristics of patients and Postoperative outcome between the two groups.

Factor	Grouping	Laparotomy group (n=64)	Laparoscopy group (n=30)	c^2/t/Z	p
Gender n(%)	Boys Girls	46(71.9%) 18(28.1%)	18(60.0%) 12(40.0%)	1.33	0.250*
Age [d, M (P_{25},P_{75})]		5.0(4.5,6.5)	6.0(3.0,11.0)	0.69	0.491#
Weight [Kg, (mean±SD)]		3.12±0.47	3.05±0.41	0.77	0.443&
Pregnancy n(%)	Mature Premature	4(6.3%) 60(93.8%)	2(6.7%) 28(93.3%)	Fisher	>0.999$
Gastrointestinal haemorrhages n(%)	No Nes	60(93.8%) 4(6.3%)	28(93.3%) 2(6.7%)	Fisher	>0.999$
Bilious vomiting n(%)	No Yes	8(12.5%) 56(87.5%)	4(13.3%) 26(86.7%)	Fisher	>0.999$
Duodenum obstruction n(%)	No Yes	32(50.0%) 32(50.0%)	16(53.3%) 14(46.7%)	0.09	0.763*
Intestinal twist n(%)	<360 360	36(56.3%) 28(43.8%)	6(20.0%) 24(80.0%)	10.86	0.001*
Operating time [min, M (P_{25},P_{75})]		70.0(60.0,110.0)	110.0(90.0,130.0)	4.56	<0.001#
Operating blood loss [mL, M (P_{25},P_{75})]		2.0(1.0,2.0)	2.0(2.0,2.0)	1.60	0.109#
time-to-diet [d, M (P_{25},P_{75})]		7.0(7.0,8.0)	6.0(5.0,9.0)	1.84	0.065#
Hospital stay [d, M (P_{25},P_{75})]		19.5(17.5,24.0)	21(17.0,23.0)	0.18	0.858#
Complications n(%)		16(25.0%)	2(6.7%)	4.43	0.035*

**Chi-square test, #Rank sum test, &Independent two-sample t-test, $Fisher exact probability test.*

Table II: Results of multivariate modified Poisson regression analysis for potential confounders in both groups.

Feature	Grouping	B	BE	RR and 95%CI	Wald	p
Intestinal twist	<360*					
	≥360	1.29	0.51	3.64(1.33,9.98)	6.33	0.012
Operating time#		0.01	0.01	1.02(1.01,1.02)	17.92	<0.001
Surgical mode	Laparotomy *					
	Laparoscopy	-2.04	0.72	0.13(0.03,0.54)	7.93	0.005
Blood loss#		-0.27	0.19	0.77(0.53,1.11)	1.97	0.160

**Control group, #Both groups.*

However, the application of this technology in newborns is controversial: most scholars believe that it is feasible to perform laparoscopic Ladd's procedure in the newborns with intestinal rotation,[8] but the procedure might be difficult because of the small abdominal cavity space and narrow vision. So the laparoscopic Ladd's procedure is recommended to be performed by experienced teams.[2]

In this study, the median laparoscopic operating time was more than that of the laparotomic group, and the most of operating time was spent in intestinal volvulus reduction. Considering that the increased operating time in laparoscopic appendectomy was 58.9% in children,[9] this increased operating time is acceptable.

Many scholars have also found that the rate of lap-to-open was very high at the beginning of laparoscopic Ladd's procedure, especially in the first year.[10] The rate even reached 50% in children with intestinal volvulus.[11] Four patients had converted to open procedures in the first 10 patients' laparoscopic procedures, as mentioned in the article. The reasons are insufficient visual field, the doctor's own technical problems, intraoperative intestinal injury, and circular pancreas existing. With the surgical techniques developing, none of the 30 laparoscopy converted to open procedure. Here are two recommendations. The first is the adequate anaesthesia and muscle loosening, that can take enough space in the abdominal cavity; the second is the technique of intestinal volvulus reduction. Taking the mesenteric roots as the midpoint, the left and right laparoscopic forceps clamp the mesentery near the intestinal canal, and then perform a steering-the-wheel type counterclockwise reduction with both hands. If the mesentery is flattened and the colon is visible throughout the entire course, the reduction of volvulus could be considered complete.

With the laparoscopic technology becoming mature, other congenital malformations such as the annular pancreas and duodenal atresia may also be handled together. But it is still worth noting that other congenital malformations should be carefully examined during operation to avoid missing.[12]

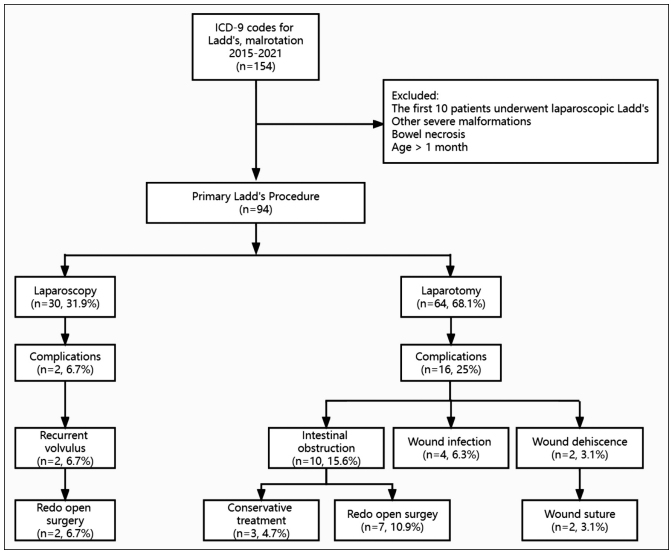

Figure 1: Flow diagram of analysis of patients who underwent Ladd's procedure.

Although a part of studies do not recommend laparoscopic Ladd's procedure in infants with congenital intestinal malrotation.[13] Most scholars believe that laparoscopic Ladd's procedure in newborn is feasible,[14] and laparoscopic Ladd's procedure can shorten the feed time and hospital stay and reduce the occurrence of complications.[15] It is worth noticing that most of the studies included newborns and older children, did not consider the effect of unbalanced grouping such as age. For example, laparoscopic Ladd's procedure is more likely performed in the older children group, while laparotomy is performed in neonatal group more frequently.[16] In addition, most children with suspected intestinal volvulus underwent laparotomic Ladd's procedure, and laparoscopic Ladd's procedure was mainly performed in children without intestinal volvulus.[17] These factors of unbalanced grouping can lead to unreliable conclusions. This study found that there were no statistical differences in the time-to-diet and hospital stay between the laparotomy and laparoscopy groups; another study had the same result.[18]

The degree of volvulus and operating time in two groups are different. The degree of volvulus and operating time are associated with postoperative complications.[19] A modified Poisson regression equation was used to adjust the effect of degree of volvulus, operating time, and blood loss in operation, and it was found that the association between operation method and postoperative complications had statistical significance and the risk value was 0.13. The result indicates that laparoscopic Ladd's procedure could significantly reduce the risk of surgical complications compared with laparotomy. It was also found that laparoscopic Ladd's procedure could reduce wound-related complications and postoperative intestinal adhesion obstruction, which is considered as one of the advantages of laparoscopic surgery.[20]

However, the risk of intestinal volvulus recurrence seems to be higher in the laparoscopy group than in the laparotomy group. Almost all of the current studies have found this phenomenon.[21] Laparoscopy is less prone to intestinal adhesions than laparotomy, but this advantage could also be a factor of intestinal volvulus recurrence.[22] In addition, some surgeons believe that the incomplete reduction of intestinal volvulus in laparoscopic surgery and the poor expansion of the small mesenteric root are also the reasons for the early postoperative recurrence of intestinal volvulus.[23] Although most volvulus recurrence occurs within 6 months after surgery, it also has been reported that volvulus recurrence could be happened in 10 years after surgery.[24] Therefore intestinal volvulus recurrence is a complication that needs long-term observation no matter the patient is treated by laparoscopy or laparotomy.

For the shortcomings of this study, the non-randomised controlled study inevitably has some confounder which can affect the conclusion. The sample size was small and it may lead to affect certain variables such as the time-to-diet of the patients even though the p-value was close to 0.05. If the sample size is large enough, it is possible to get the statistical difference in feeding time between the two groups. In addition, the laparotomy was performed earlier than the laparoscopy, so the patients of the laparotomy group had longer follow-up time and more chances of long-term complications. The realistic rate of complications, especially in the laparoscopy group, needs a longer follow-up.

CONCLUSION

This present study demonstrated that laparoscopic Ladd's procedure was feasible to treat neonatal malrotation and is associated with lower postoperative complications of newborns with congenital malrotation. However, laparoscopic Ladd's procedure seems to increase the recurrence rate of intestinal volvulus, and a wider investigation is still needed to verify the findings.

ETHICAL APPROVAL:

This study was conducted following the Helsinki declaration and approved by the Ethics committee of the Ganzhou Maternal and Child Health Care Hospital (Ethical Approval No. 2022-27).

PATIENTS' CONSENT:

Informed consent was obtained from all individual participants included in the study.

COMPETING INTEREST:

The authors declared no competing interest.

AUTHORS' CONTRIBUTION:

SW, BZ, FS: Conception or design of the work, analysis or interpretation of data for the work.
SW, BZ, PZ, YX: Drafting the work or revising it critically for important intellectual content.
SW: Final approval of the version to be published.
All authors agreed to be accountable for all aspects of the

work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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