RESEARCH ARTICLE

Single-site laparoscopic-assisted surgery for congenital intestinal atresia

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Abstract

Objective: To evaluate the efficacy and safety of single-site laparoscopy in the management of congenital intestinal atresia.

Method: The retrospective study was conducted from January to December 2024 at the Ganzhou Maternal and Child Health Care Hospital, China, and comprised data from January 2014 to December 2023 related to paediatric patients with congenital intestinal atresia who underwent surgical intervention. The patients were divided into laparotomy group A and laparoscopic group B. The two groups were compared in terms of general data, operating time, intraoperative blood loss, time-to-diet, length of hospital stay and postoperative complications. Data was analysed using SPSS 26.

Results: Of the 120 patients, 64(53.3%) were in group A; 40(62.5%) boys and 24(37.5%) girls with median age 3.0 years (interquartile range: 2.0-4.8 years). The remaining 56(46.7%) patients were in group B; 32(57.1%) boys and 24(42.9%) girls with median age 3.0 years (interquartile range: 2.0-4.0 years) ($p>0.05$). Group B had increased operating time and intraoperative blood loss, and reduced postoperative complications compared to group A ($p<0.05$). There was no significant intergroup difference in terms of time-to-diet and length of hospital stay ($p>0.05$).

Conclusion: Single-site laparoscopy was found to be a viable approach for treating neonatal congenital intestinal atresia, it was associated with a reduced incidence of postoperative complications.

Key Words: Newborn, Intestinal atresia, Laparoscopy, Laparotomy, Paediatrics.

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Introduction

Congenital intestinal atresia (CIA) represents a prevalent cause of intestinal obstruction in newborns, with an incidence rate of approximately one case in every 1,500 to 2,000 newborns, predominantly affecting preterm infants. This congenital anomaly can arise in any segment of the intestine, but it is most frequently observed in the small intestine.[1] Regardless of its location, intestinal atresia results in complete obstruction, necessitating surgical intervention postnatally.[2]

The conventional surgical approach involves an exploratory laparotomy, which is performed through a right upper abdominal transverse incision. This technique offers excellent exposure and remains a classic methodology employed by most paediatric surgeons. However, it has the drawback of leaving a prominent surgical scar on the abdominal wall.

Paediatric surgeons are constantly striving for minimally invasive and aesthetically pleasing surgical procedures for infants. Several scholars have documented the application of laparoscopy for treating duodenal obstruction[3,4] but only a handful of surgeons have employed laparoscopy to address intestinal atresia.[5] It is evident that this technology can lead to increased medical expenses, and requires a lengthy learning curve.

The current study was planned to evaluate the efficacy and safety of single-site laparoscopy in the management of congenital intestinal atresia.

Materials and Methods

The retrospective study was conducted from January to December 2024 at the Ganzhou Maternal and Child Health Care Hospital, China, and comprised data from January 2014 to December 2023. After approval from the institutional ethics review committee, the sample size was determined on the basis of the number of patients who met the inclusion and exclusion criteria within the study period. The sample was raised using consecutive sampling technique. Those included were paediatric patients with CIA who underwent surgical intervention. Patients with other severe malformations that could affect recovery and outcomes were excluded, and so were those having short bowel syndrome during surgery. Informed consent had been obtained at the time of procedure from the parents of the patients. The patients were divided into laparotomy group A and laparoscopic

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group B.

All surgical procedures had been conducted by the same group of surgeons, and all patients received standard preoperative therapy, including antibiotics, intravenous fluid administration, and the insertion of a gastric tube. The Bland Sutton Classification[6] was used to categorise the type of intestinal atresia.

In group A, a lateral incision was made on the right upper abdomen. The entire small intestine was extracted for identifying the atretic segment and eliminating any potential for other congenital malformations. Following this, the proximal portion of the atretic bowel underwent resection and was tapered to ensure compatibility with the size of the distal bowel. Ultimately, a primary end-to-end anastomosis was performed.

In group B, a 5mm operative trocar was introduced through an infra-umbilical incision with a 30-degree optic, while one or two 3mm working ports were positioned on the left and right umbilical cord (Figure 1A). Pneumoperitoneum was established utilising a pressure of 6-8mmHg and a flow rate of 1L/min of carbon dioxide. After the atresic segment was identified (Figure 1B), the pathological tract was exteriorised via the umbilical incision (Figure 1C). If abdominal distension was observed, or the expanded proximal bowel was taken out of the incision with difficulty, the expanded bowel was decompressed. The atresic proximal end of the bowel was resected and subsequently narrowed to match the size of the distal bowel. Subsequently, an end-to-end anastomosis was executed (Figure 1D), following which the bowel was repositioned back into the abdominal cavity. The laparoscope was reintroduced to verify the absence of any torsion at the anastomosis site (Figure 1E), and to ascertain that there were no obstructions in the distal small intestine and colon. Congenital malformations, including malrotation and annular pancreas, could be addressed upon discovery. Finally, an umbilical plastic surgery was performed (Figure 1F).

The primary outcomes evaluation encompassed the duration of the surgical procedure, the length of hospital stay (LOS), the volume of intraoperative blood loss, the time taken to resume diet, and the occurrence of postoperative complications. Outcome assessors were not formally blinded to the surgical method, as this was a retrospective study. However, outcomes were objectively measured to minimise bias. All patients were subject to a follow-up period of at least six months.

Data was analysed using SPSS 26. Descriptive statistical techniques were applied to encapsulate and delineate the distribution characteristics of continuous variables, with skewed data as median with interquartile range (IQR) (P25, P75). Categorical variables were expressed as frequencies and percentages. Data normality was evaluated both visually and by means of the Shapiro-Wilk test. Additionally, Levene's test was employed to assess the homogeneity of variances. For normally distributed data, independent two-sample t-tests were administered, whereas rank sum tests were utilised for skewed distributions. Chi-square tests were reserved for categorical variables. Complications were considered dependent variables, while variables having $p<0.2$ between the groups were treated as independent variables. Subsequently, a modified Poisson regression analysis was conducted to adjust the confounding between the groups, and to evaluate the factors affecting surgical complications. Multicollinearity was assessed using variance inflation factors. For Poisson regression, assumptions were verified and robust standard errors were utilised to account for over-dispersion. $P<0.05$ was taken as statistically significant.

Results

Of the 167 patients screened, 120(71.8%) were included (Figure 2). Of them, 64(53.3%) were in group A; 40(62.5%) boys and 24(37.5%) girls with median age 3.0 years (IQR: 2.0-4.8 years). The remaining 56(46.7%) patients were in group B; 32(57.1%) boys and 24(42.9%) girls with median age 3.0 years (IQR: 2.0-4.0 years). There were 26(21.7%) patients diagnosed with meconium peritonitis. Type I atresia was noted in 30(25%), Type II 47(39.2%), Type IIIa 30(25%), and Type IV 13(10.8%). There were no statistically significant differences between the groups with regard to gender, age, weight, gestational week, type of atresia, and the length of removed intestine ($p>0.05$). A significantly high incidence of meconium peritonitis group A compared to group B ($p=0.008$). The operating time for group B was longer than that of group A ($p<0.001$). Additionally, intraoperative blood loss was greater in group B than in group A ($p=0.004$). No significant differences were observed in the time-to-diet and LOS between the groups ($p>0.05$). However, a significant difference was noted in postoperative complications ($p=0.002$) (Table 1).

In Poisson regression analysis, the model's -2 log-likelihood ratio was 11.81 ($p=0.038$), indicating the model's success and general significance. After accounting for the effects of meconium peritonitis, operating time, length of the resected intestine, and intraoperative blood loss, it was statistically confirmed that there existed a significant relationship between the surgical approach and postoperative complications

Table-1: Intergroup comparison of patient characteristics and postoperative outcomes.

Factor	Grouping	Laparotomy group (n=64)	Laparoscopic group (n=56)	χ^2/Z	P
Gender n(%)	boysgirls	40(62.5%) 24(37.5%)	32(57.1%) 24(42.9%)	0.36	0.580*
Age[d, median (P_{25},P_{75})]		3.0 (2.00,4.8)	3.0 (2.00,4.0)	0.09	0.931#
Weight[Kg, median (P_{25},P_{75})]		3000 (2450,3412.50)	2925 (2450,3400)	0.11	0.916#
Gestational weeks[W, median (P_{25},P_{75})]		38.0 (36.00,39.8)	38.0 (36.0,39.0)	0.34	0.733#
Types of atresian(%)	IIIIIIaIV	13(20.3%) 24(37.5%) 18(28.1%) 9(14.1%)	17(30.4%) 23(41.1%) 12(21.4%) 4(7.1%)	3.16	0.374*
Meconium peritonitisn(%)	noyes	44(68.8%) 20(31.3%)	50(89.3%) 6(10.7%)	7.42	0.008*
Lengths of resected intestine[cm, median (P_{25},P_{75})]		10.0 (10.0,20.0)	22.5 (5.0,25.0)	1.50	0.134#
Operating time[min, median (P_{25},P_{75})]		100.0 (83.0,130.0)	133.5 (125.0,155.0)	5.69	<0.001#
Intraoperative blood loss[mL, median (P_{25},P_{75})]		3.0 (2.0,5.0)	5.0 (5.0,10.0)	2.89	0.004#
Time-to-diet[d, median (P_{25},P_{75})]		7.0 (5.0,17.0)	6.0 (4.0,19.0)	1.19	0.236#
Hospital stay[d, median (P_{25},P_{75})]		24.0 (19.0,41.0)	24.0 (18.0,44.0)	0.25	0.800#
Complicationsn(%)	noyes	42(65.6%) 22(34.4%)	50(89.3%) 6(10.7%)	9.35	0.002*

*Chi-square test, #Rank sum test.

Table-2: Multivariate modified Poisson regression analysis for potential confounders in both the groups.

Feature	Grouping	B	BE	RR and 95%CI	Wald	P
Meconium peritonitis	no					
	yes	0.66	0.33	1.94(1.01,3.71)	3.99	0.046
Surgical mode	Laparotomy					
	Laparoscopy	1.03	0.44	0.36(0.15,0.85)	5.40	0.020
Lengths of removed intestine		0.02	0.02	1.02(0.99,1.06)	1.43	0.232
Intraoperative blood loss		0.02	0.06	0.98(0.87,1.10)	0.14	0.710
Operating time		1.68	0.01	1.00(0.99,1.01)	0.00	0.998

CI: Confidence interval, RR: Relative risk.

(relative risk [RR]: 0.36; 95% confidence interval [CI]: 0.15-0.85; p=0.020). Compared to group A, the risk of complications decreased by 64% in group B (Table 2).

After meconium peritonitis was identified as a risk factor for postoperative complications (RR: 1.94; 95%CI: 1.01-3.71; p=0.046), patients with meconium peritonitis were excluded from the sample. Even after their removal, comparative analysis between the groups revealed that group B had lower incidence of postoperative complications (p=0.013) (Table 3).

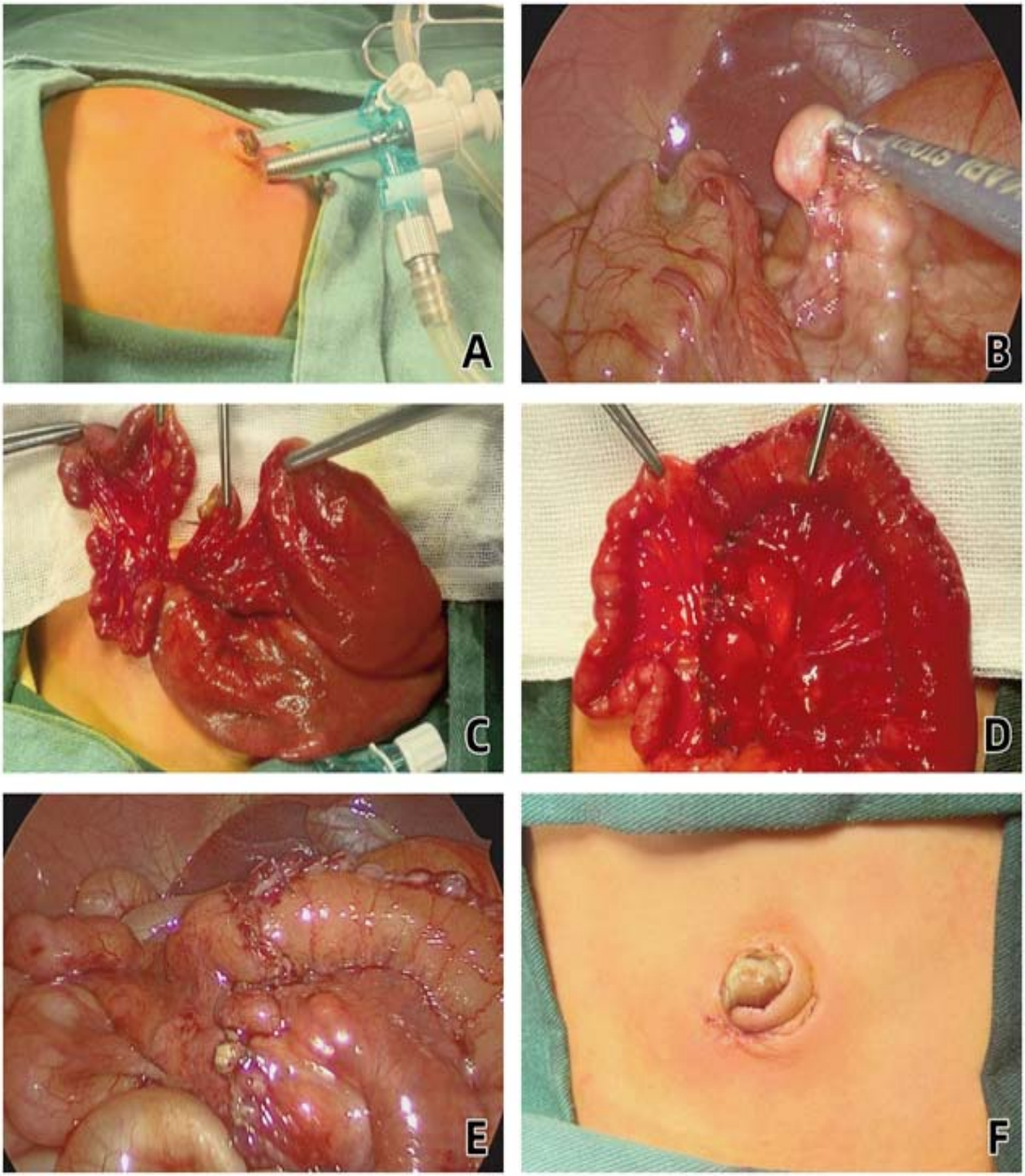

Figure-1: (A) Location of trocars; (B) Identification of the atresic segment; (C) Exteriorising the pathological tract through the umbilical incision; (D) Primary anastomosis; (E) Confirming no torsion of the anastomosis; (F) Appearance of the umbilicus after operation.

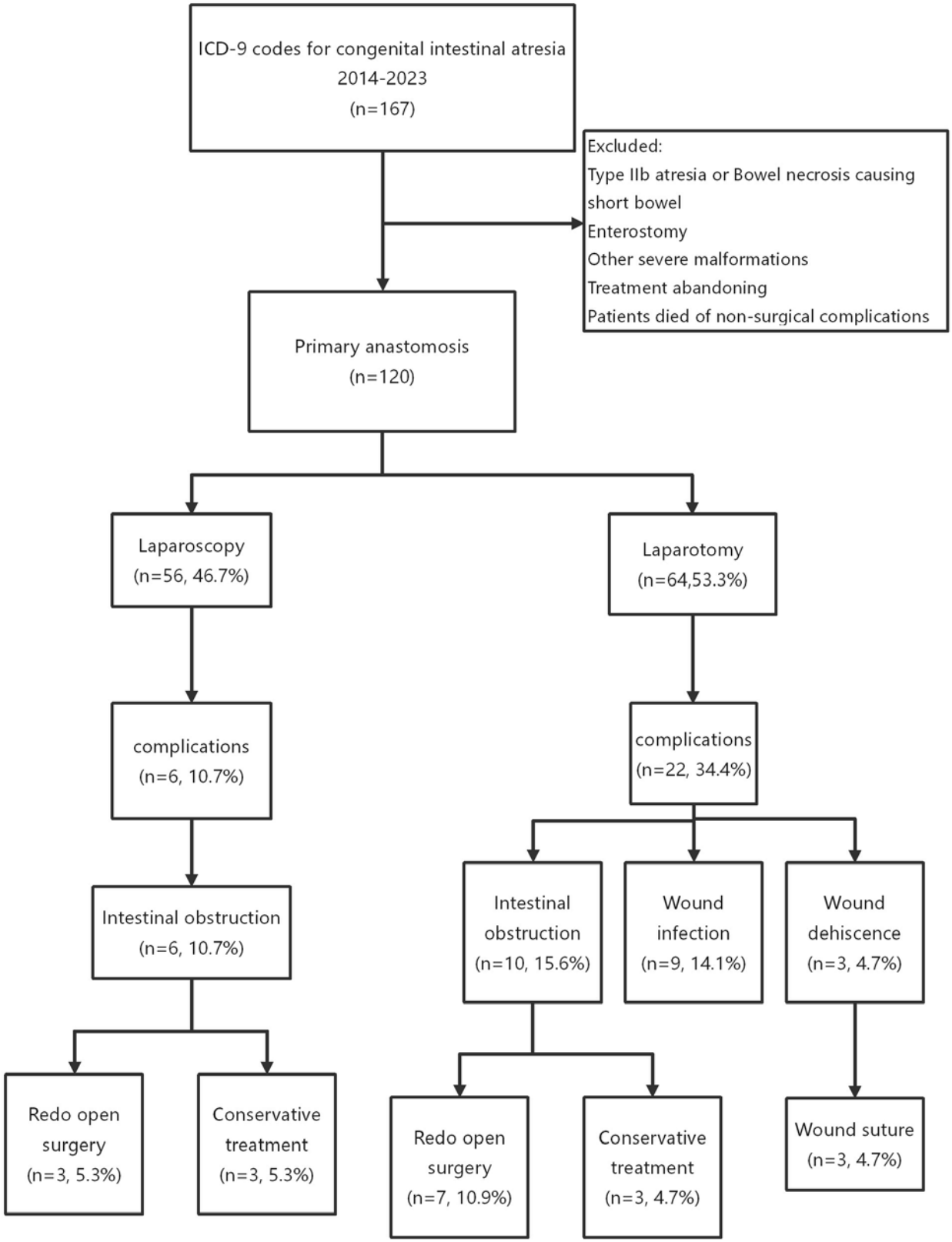

Figure-2: Flow diagram of analysis of patients who underwent primary anastomosis.

Table-3: Intergroup comparison of patient characteristics and postoperative outcomes after excluding cases of meconium peritonitis.

Factor	Grouping	Laparotomy group (n=44)	Laparoscopic group (n=50)	x^2/Z	P
Gender n(%)	boysgirls	30(68.2%) 14(31.8%)	26(52.0%) 24(48.0%)	2.55	0.111*
Age[d, median (P_{25},P_{75})]		4.0 (3.0,5.0)	3.0 (2.00,4.0)	1.27	0.203#
Weight[Kg, median (P_{25},P_{75})]		3000 (2200,3200)	3100 (2450,3400)	1.46	0.145#
Gestational weeks[W, median (P_{25},P_{75})]		37.0 (34.00,39.0)	38.0 (36.0,39.3)	1.47	0.142#
Types of atresian(%)	IIIIIIaIV	9(20.5%) 12(27.3%) 16(36.4%) 7(15.9%)	17(34.0%) 17(34.0%) 12(24.0%) 4(8.0%)	4.35	0.226*
Lengths of resected intestine[cm, median (P_{25},P_{75})]		10.0 (10.0,15.0)	20.0(4.3,26.3)	1.70	0.088#
Operating time[min, median (P_{25},P_{75})]		97.5(83.0,120.0)	132.0 (124.0,155.0)	5.37	<0.001#
Intraoperative blood loss[mL, median (P_{25},P_{75})]		3.0(3.0,5.0)	5.0 (4.3,6.3)	2.72	0.007#
Time-to-diet[d, median (P_{25},P_{75})]		7.0(6.0,18.0)	6.0 (4.0,19.3)	1.33	0.185#
Hospital stay[d, median (P_{25},P_{75})]		25.0(20.0,44.0)	23.0 (17.3,44.0)	1.39	0.166#
Complicationsn(%)	noyes	32(72.7%) 12(27.3%)	46(92.0%) 4(8.0%)	6.16	0.013*

*Chi-square test, #Rank sum test.

The umbilical cord in group B exhibited a normal appearance. During follow-up, the parents expressed satisfaction with the cosmetic outcome of the operation.

Discussion

Neonates born with CIA need surgical intervention for survival, primarily by primary anastomosis and temporary enterostomy.[7] The conventional surgical technique is a transverse supraumbilical laparotomy[8], which facilitates the removal of the entire small intestine from the abdominal wall for examination, and is conducive to performing intestinal resection and anastomosis. However, this approach results in an abdominal scar that gradually becomes more pronounced with age, posing a cosmetic concern. Laparoscopy has gained popularity in treating duodenal obstructions and intestinal malrotations due to the ample abdominal space. Some scholars have extracted the pathological intestine from the abdominal wall for treatment via the umbilicus after a transumbilical laparoscope-assisted procedure.[9] Nonetheless, this technology has mainly been applied to the treatment of neonatal jejunal atresia rather than ileal atresia, due to the challenging operating conditions. Laparoscopic surgery typically leaves one or two puncture scars on the abdominal wall. Therefore, the current study was planned to evaluate the efficacy and safety of single-site laparoscopy in neonates with jejuno-ileal atresia (JIA), which offers the advantage of fewer scars compared to both laparotomy and conventional laparoscopy.[10]

The study revealed that the proximal distal bowel could be exteriorised via the umbilical incision, and anastomosis could be performed with ease due to the elasticity of the neonatal umbilical ring. There was no significant difference in the time-to-diet and hospital stay between the two groups, suggesting that single-site laparoscopy could achieve therapeutic outcomes equivalent to those

of traditional laparotomy. Furthermore, the incision from single-site laparoscopy was minimal and situated at the umbilical cord, resulting in a scar that was hardly noticeable. The procedure offers superior cosmetic results.[11]

CIA is often complicated by meconium peritonitis, which arises from perforation of the foetal intestinal tract in utero, resulting in the flow of meconium into the abdominal cavity, and subsequently causing intestinal adhesions.[12] Laparoscopic surgery in neonates with meconium peritonitis is generally avoided possibly due to concerns about difficulties in obtaining adequate vision. The current study revealed that most of the intestinal perforation had been repaired in postnatal neonates with intestinal atresia and meconium peritonitis, and most of the meconium in the abdominal cavity had been absorbed. The adhesion between the intestines was not severe. After inserting a finger through the umbilical incision to separate the adhesion between the bowel and the abdominal wall, the dilated atresia intestine could be visualised through the lens. A portion of the hypertrophic intestinal wall was extracted through the umbilical incision, a small incision was made on the hypertrophic intestinal wall, and a gastric tube was inserted for intestinal decompression. When the digestive tract was emptied, it became easier to pull the hypertrophic intestine out of the abdominal wall. The small intestine near the atretic segment could also be freely pulled out of the abdominal wall to perform primary anastomosis. However, before anastomosis, the distal small intestine and colon must be irrigated with water to exclude any other atresia in these patients.

The incidence of meconium peritonitis, operating time, and intraoperative blood loss varied between the two groups in th current study. A refined Poisson regression model was utilised to adjust for the influences of meconium peritonitis, surgical duration and intraoperative blood loss. It was determined that the association between meconium peritonitis, surgical approach and postoperative complications exhibited statistical significance, with risk ratios of 1.94 and 0.36, respectively. The findings suggested that single-site laparoscopy could significantly lower the risk of surgical complications compared to laparotomy. Additionally, single-site laparoscopy was found to decrease wound-related complications[13], which is regarded as one of the benefits of laparoscopic surgery.[14]

Some surgeries managed CIA using an umbilical incision without the aid of a laparoscopic lens.[15] However, this method has the drawback of potentially overlooking other congenital malformations, such as intestinal malrotation and annular pancreas. In the laparoscopy group, two of the 56 patients were found to have intestinal malrotation, thereby avoiding the need for a reoperation, despite the low incidence of complex malformations.[16]

The current study has limitations, including the choice of the surgical model. Laparotomy was more frequently conducted on haemodynamically unstable neonates and patients presenting with overt abdominal distension due to meconium peritonitis. Randomised, controlled, prospective studies are needed to validate the current findings. Furthermore, since laparotomy was performed earlier than laparoscopy, the laparotomy group exhibited a prolonged follow-up duration and a heightened propensity for enduring long-term complications. An extended follow-up period is necessary to ascertain the actual complication rate, particularly within the laparoscopy group. Finally, due to the retrospective design of the study, the sample size was constrained by the available data.

Conclusion

Single-site laparoscopy technique was found to be safe and feasible in the treatment of CIA. The approach correlated with a reduced incidence of postoperative complications. It also led to superior cosmetic outcomes, warranting consideration as a viable alternative in the surgical management of CIA.

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Conflict of Interest: None.

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AUTHOR'S CONTRIBUTION:

SZ: Concept, design, data analysis, interpretation, drafting, revision and agreement to be accountable for all aspects of the work.

BZ, FS & PZ: Drafting, revision and agreement to be accountable for all aspects of the work.

SW: Concept, design, data analysis, interpretation, final approval and agreement to be accountable for all aspects of the work.