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TECHNICAL NOTE

Outcomes of end-to-side oblique anastomosis as a surgical technique for jejuno-ileal atresia

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Abstract

All of the anastomotic techniques used for jejuno-ileal atresia aim to overcome the size discrepancy between the resected bowel ends, lessen anastomotic complication and prevent development of short bowel syndrome. Aim of study was to evaluate the outcomes of end-to-side oblique anastomosis for jejuno-ileal atresia and verifying the risk factors for complications. A prospective study was conducted on patients with jejuno-ileal atresia managed by end-to-side oblique anastomotic technique over a 7-year period. Data were collected and analyzed to evaluate the outcomes of this surgical technique as morbidity and mortality. The study included 40 patients, 26 males and 14 females. The mean operation time was 105 minutes, the mean time for starting oral feeding was 5.7 days and the mean duration of hospital stay was 9.13 day. Postoperative complications occurred in 11 patients (27.5%). Death was recorded in six cases; survival rate was 85%. End-to-side oblique anastomosis is simple and effective surgical procedure for most types of jejuno-ileal atresia. The technique results in wide and early functioning anastomosis, relatively low morbidity and mortality. As with any neonatal surgery, the overall prognosis and outcomes is primarily dependent on prematurity, birth weight and associated anomalies in addition to the amount of residual bowel function that exist after surgery.

Keywords Jejuno-ileal atresia · Anastomotic technique · End-side oblique anastomosis · Outcomes

Abbreviations

ESO	End-to-side oblique
JIA	Jejuno-ileal atresia
LBW	Low birth weight
NG	Nasogastric
NICU	Neonatal intensive care unit
NPO	Nil per os
SBS	Short bowel syndrome
TPN	Total parenteral infusion

Introduction

Jejunoileal atresia (JIA) is the commonest cause of intestinal obstruction in neonates [1], it represents a congenital interruption in the continuity of the digestive tract with possibly lack of certain segments of the gut [2]. Grosfeld et al. [3] modified the Louw's original classification of intestinal atresia into four classes, which is currently the most commonly used classification scheme for both prognostic and therapeutic purposes [4].

The surgical techniques of correcting this anomaly depend on the site and type of atresia, the pathological status of the bowel, associated gastrointestinal anomalies and the length of the residual bowel. Several surgical options have been performed like bowel resection with primary end-to-end anastomosis, end-to-oblique anastomosis, tapering proximal enteroplasty, multiple anastomoses, and exteriorization of the bowel as temporary enterostomy [5]. All of these surgical techniques aim to overcome the size discrepancy and preserve the longest amount of bowel [6]. The difficult mission of restoring continuity between intestinal segments is faced after resection of the atretic segments with marked size differences [7, 8]. The primary anastomosis

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may prone to leak, stricture and potential dysmotility of the markedly dilated proximal segment. Nevertheless, primary anastomosis using different anastomotic techniques is still the recommended operation of choice whenever possible in contemporary practice [8–10].

In this paper, we focus on the applicability of end-to-side oblique anastomosis as a surgical technique for jejuno-ileal atresia with an evaluation of its outcomes and predictors of complications.

Patients and method

This is a prospective study of 34 neonates with jejuno-ileal atresia (JIA) who were operatively managed with end-to-side oblique (ESO) anastomotic technique at the department of pediatric surgery—central child teaching hospital over a 7-year period from March 2010 to March 2017. Data were collected about sex, gestational age, birth weight, age at the time of presentation, associated anomalies, type of JIA, operation time, time for oral feeding, postoperative complications, and duration of hospitalization. All patients were followed up for a period ranging from 6 months to 1 years after surgery to evaluate long-term morbidity and mortality. Additional information on those patients who discharged home about growth rate, nutritional habits, and frequency of bowel motion were obtained by scheduled visits or mobile phones.

We classified JIA as described by Grosfeld et al. [3]. Short bowel syndrome (SBS) was defined by "residual small bowel length less than 50 cm for premature newborns and less than 75 cm for term newborns" [6, 7]. Prematurity was defined by "gestation of less than 37 weeks at birth" and low birth-weight (LBW) was defined by "birth weight of less than 2.5 kg". Reoperation was defined by any re-exploration for complications related to initial surgical repair of the JIA.

Patients having the following conditions were excluded from the present study (regarded as confounding variables and influence the result):

- When the caliber discrepancy between the proximal and distal atretic bowels is not large and permit direct end-to-end anastomosis to be performed.
- Congenital abdominal wall defects (gastroschisis and omphalocele).
- Cases of intestinal perforation, bowel ischemia and peritonitis.
- Patients with additional gastrointestinal obstruction (esophageal atresia, malrotation of midgut, meconium ileus, and anorectal malformation).

All the patients in this study underwent the same management strategy, after initial evaluation by thorough physical examination, blood investigation, and abdominal film; the patients received maintenance fluid requirements, with a bolus of 20 ml/kg body weight of normal saline solution in case of dehydration. A preoperative antibiotic were administered in the form of ceftriaxone and metronidazole. Patients were kept nil per os (NPO) and a nasogastric (NG) tube (6–8 Fr.) was placed for gastric decompression and then they were taken for surgery after obtaining a written informed consent signed by the parents for surgical intervention and for their inclusion in the study. The study was approved by the medical college ethical and scientific committee.

Operative technique

All surgical procedures were performed by the same surgical team and all patients were explored through a supraumbilical transverse incision 2 cm above the umbilicus. The site and type of atresia were identified, the bowel length was measured and the distal collapsed bowel was injected with saline to rule out multiple atresias and to ensure patency of bowel down to the level of rectum. About 5–25 cm of the proximal dilated bowel was resected and the remaining distended segment was deflated, another 3–15 cm segment of distal atretic bowel was also resected. The discrepancy in diameter between the two bowel ends after resection was less than or equal to 4:1 ratio. Single-segment resection with single anastomosis rather than multiple anastomoses was performed in cases of multiple atresias if total usable small bowel length was adequate (> 75 cm). Perpendicular resection edge at the proximal bowel was done, while the cut end of the distal bowel was oblique and with a length equal to resection edge of proximal bowel. End of the proximal bowel was anastomosed to the side of the distal bowel at an angle of 100°–130° from longitudinal axis using 5/0 interrupted vicryl (polyglactin) suture as described in Fig. 1. Extreme care being taken to avoid narrowing at the corners of anastomosis, single layer anastomosis was done without reinforcing seromuscular sutures. The defect in the mesentery was then approximated with fine absorbable sutures and caution being taken to avoid twisting or kinking the anastomosis or to compromise the mesenteric vessels. No drain tube was left inside the abdomen.

Postoperatively the patients were kept on maintenance fluid of 1/5th glucose saline (0.18% saline in 5% dextrose solution) at 150 ml/kg/day with supplementary electrolytes, and plasma transfusion (10 ml/kg/day) on alternate days. Total parenteral nutrition (TPN) could not be offered to these patients after surgery, due to its unavailability in our region. The duration of hospital stay was ranging from 7 to 15 days.

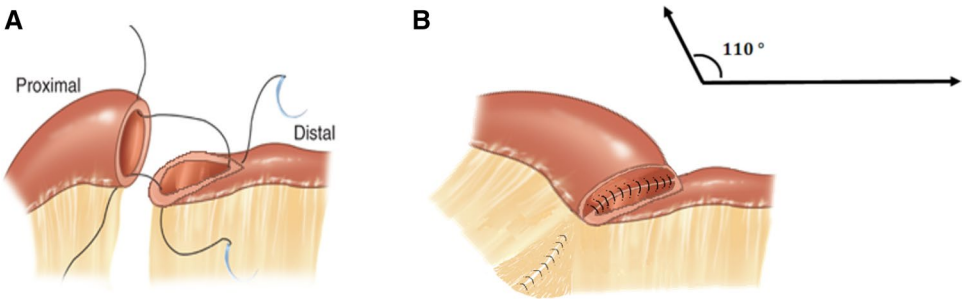

Fig. 1 Diagram of ESO (end-to-side oblique) anastomosis showing vertical resection edge of proximal bowel, oblique resection edge of distal bowel, obtuse angle of anastomosis

Table 1 Clinical characteristics of patients

Variable	Value
Gestational age (weeks)	
Mean (± SD)	38 (± 1.94)
Preterm (%)	9 (26.5)
Full-term (%)	25 (76.5)
Sex *N* (%)	
Male	23 (67.6)
Female	11 (32.4)
Birth weight (kg)	
Mean (± SD)	2.750 (± 0.85)
Low birth weight (%)	15 (44.1)
Age at presentation (days)	
Mean (± SD)	3.2 (± 2.05)
Less than 48 h (%)	10 (29.4)
More than 48 h (%)	24 (70.6)
Location of atresia *N* (%)	
Jejunal	23 (67.7)
Ileal	8 (23.5)
Both jejunal and ileal	3 (8.8)
Type of atresia *N* (%)	
Type I	14 (41.2)
Type II	6 (17.6)
Type IIIa	9 (26.4)
Type IIIb	2 (5.9)
Type IV	3 (8.8)
Associated anomaly	
Number (%)	6 (17.6)

Data analysis

Data were first entered in an Excel file, then transported into SPSS-v22 software for analysis. Discrete variables were presented as numbers and percentages while continuous variables were expressed as mean, standard deviation SD. Univariate analysis was used to test the risk factors for postoperative complication. The odds ratio (OR) and 95% confidence interval (CI) were calculated and *P* value equal or less than 0.05 was considered statistically significant.

Table 2 Postoperative complications

Complication	Number	Percent
Anastomotic stenosis	4	11.8
Wound infection	5	14.7
Sepsis	4	11.8
Anastomotic leak	2	5.9
Short bowel syndrome	3	8.8
Adhesive intestinal obstruction	3	8.8
Re-exploration	4	11.8
Malabsorption and failure to thrive	2	5.9
Total patients with complication	9	26.5
Death	5	14.7

Results

The clinical characteristics of the 34 Neonates included in this study are shown in Table 1. The mean gestational age was 38 weeks, preterm constituted 26.5% ($n=9$). Mean birth weight was 2.750 kg, LBW seen in 44% ($n=15$). Twenty-four patients (70.6%) presented late after 48 h of birth. Jejunum was the most common site of atresia encountered during laparotomy (67.7%) and the most common type of atresia seen according to Grosfeld et al. classification [3] was type I (41.2%, $n=14$). The total length of the resected bowel ranged from 8 to 35 cm. The incidence of associated congenital anomalies was 6/34 (17.6%).

After corrective surgery, the residual small intestinal length was adequate (> 75 cm for full-term and > 50 cm for preterm) in 30 patients. While significant shortening of small bowel length was seen in four patients included three patients with an intact ileocecal valve and one with an ileocolic anastomosis.

Postoperative complications occurred in 9/34 patients (26.5%). Table 2 demonstrates the type and frequency of complications. Four patients (11.8%) experienced features of anastomotic dysfunction after surgery. They developed feeding intolerance and recurrent bouts of abdominal distension when feeding increased with dilated small bowel loops on the plain abdominal radiograph. Contrast

follow-through study was performed and showed patent anastomosis but a transition from grossly dilated bowel on the proximal side to collapsed bowel on the distal side of the anastomosis. Three of them improved with non-operative management in the form of small frequent feeds and use of prokinetic agent.

Four patients (11.8%) required re-exploration for anastomotic stricture in one cases, anastomotic leak in two cases, adhesive intestinal obstruction in one case. During re-exploration, the patient with anastomotic stricture had resection of the previous anastomotic site and bowel re-anastomosis with the same technique with a successful result, while those with anastomotic leak, a temporary stoma was performed. One patient developed intestinal obstruction due to adhesion after 5 months from the primary operation, the release of peritoneal bands, adhesiolysis and unfolding of the mesentery was done during re-exploration.

Over a follow-up period ranging from 6 to 12 months, death was recorded in five cases out of 34 (14.7%), 27 out of the surviving 29 patients attained normal enteral feeding and present normal growth chart while two patients still complaining of malabsorption and poor weight gain with several times of hospital admission for diarrhea, dehydration and nutritional deficiencies. Three cases were admitted to the hospital with adhesive intestinal obstruction at ages of 6, 7 and 10 months, two of them were resolved on non-operative therapy and re-exploration was needed in the remaining one.

Table 3 shows that the statistically significant predictors of postoperative complications are prematurity, low birth weight and associated anomalies with *P* value of 0.018, 0.025 and 0.028, respectively. While variables of male sex, delayed presentation, site and type of atresia although seems to influence the rate of complication but not to the degree of statistical significance.

Discussion

All of the techniques used for JIA depend on two principles: (1) "caliber widening of the diminutive distal bowel (like Cheatle's maneuver and end-to-side anastomosis)" or (2) "reducing the caliber of the large proximal bowel (such as resection of the dilated proximal bowel and tapering enteroplasty followed by end-to-end anastomosis)" [9]. In Louw's earlier paper, the high mortality (90%) of his end-to-end anastomosis was explained by the preservation of dilated proximal bowel [11]. The smooth muscles hypertrophy with paucity of ganglion cells in the proximal bowel result in increased diameter and hence ineffective peristalsis at the lower pressures. According to Laplace's law (pressure is inversely proportional to the radius), increased diameter of the proximal segment leads to decreased intra-luminal pressure, a factor that leads to anastomotic dysfunction.

In our technique as described earlier, we did limit rather than free resection of the proximal dilated segment, Benson [12], Low [13], and Nixon [14] advised to do liberal resection of dilated proximal bowel segment before doing anastomosis. However, this is not applicable in cases of proximal jejunal atresia with its proximity to the ligament of Treitz or because excessive excision of the dilated bowel would compromise the amount of absorptive surface resulting in malabsorption.

We did not perform any plication or enteroplasty to decrease the lumen diameter, the technique of tapering jejunoplasty followed by end-to-end jejunal anastomosis still has the problem of bowel dysmotility and axial deviation [15, 16]. Moreover, high jejunal atresia that is very close to the ligament of Treitz limiting the extent of the tapering jejunoplasty [17].

We believe that after resection, the creation of a wide end-to-side oblique anastomosis with obtuse angle (Fig. 2b) reduces the risk of anastomotic dysfunction. In comparison to the classic end-to-side technique, there is 90° angulation

Table 3 Univariate analysis for predictors of complications

variable	Postop. Complication	OR	95% CI	*P*
Sex (male) (*N* = 23)	7	5.187	0.470–13.306	0.237
Prematurity (*N* = 9)	5	7.340	1.335–23.346	0.018*
Low birth weight (> 2.5 kg) (*N* = 15)	9	7.059	0.794–62.721	0.025*
Delayed presentation (< 48 h) (*N* = 24)	5	3.456	0.123–13.357	0.307
Associated anomaly (*N* = 6)	4	2.185	0.723–13.163	0.028*
Site of atresia				
Jejunum (*N* = 23)	5	0.265	0.062–1.142	0.067
Ileum (*N* = 8)	3	1.438	0.290–7.138	0.656
Type of atresia (IIIa, IIIb, IV) (*N* = 14)	4	0.935	0.222–3.944	0.927

*Statistical significant *P* value > 0.05

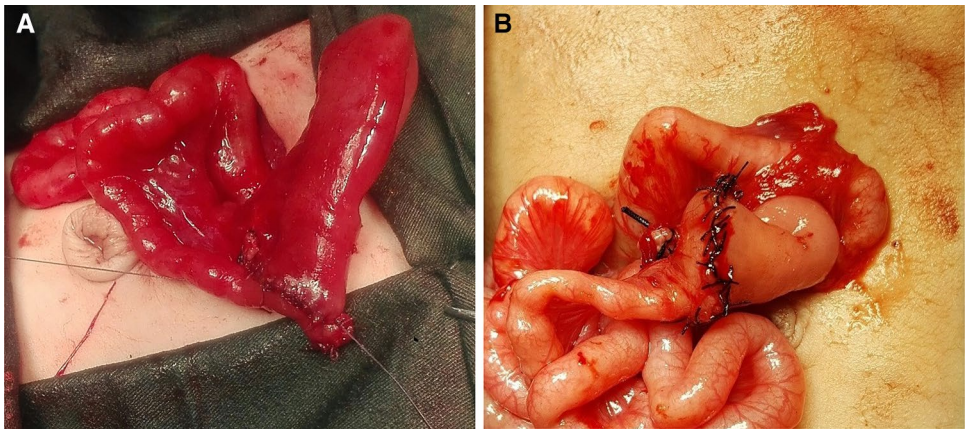

Fig. 2 **a** End-to-side technique with 90° angulation at the anastomosis. **b** The standard procedure of ESO (creation of a wide end-to-side oblique anastomosis)

at the anastomosis (Fig. 2a). "When fluid flows around a corner in near-non compressible system, additional hydrostatic pressure is exerted at the bend, this will act as a shearing force at the anastomotic site" (Bernoulli hydrodynamic equation) [18], this may lead to anastomotic dysfunction or leak.

We also aim to preserve the ileocecal valve as it plays an important role in limiting the reflux of colonic contents, including bacterial flora, into the small intestine. In addition, it helps with increasing absorption time of nutrients, including chyme, which is of greater importance in cases when extended segments of bowel have been resected [19].

In this technique, we did not face severe angulation or significant rate of anastomotic leak (only 5.9%), the simplicity of this technique result in relatively short operative time (mean = 105 min, 95% CI 104.904–118.253) due to omitting extensive resection and extra steps of tapering enteroplasty or plication. The relatively short operation time can help to enhance or restore normal peristaltic mechanisms and earlier function of the anastomosis.

In Hasan's concavoconvex oblique anastomotic technique [9], the oblique resection cut of proximal segment compromises the mesenteric vascular supply and predisposes for the higher rate of anastomotic dysfunction or leak [5], while the perpendicular resection margin of proximal bowel done in our technique help to preserve mesenteric vascular supply, in addition to that, we used fine absorbable sutures for the approximation of mesenteric defect with caution being taken not to kink the anastomosis or damage the mesenteric vessels. Louw et al. in their study concluded that compromised blood supply of bowel areas adjacent to the atretic segment that is not enough to cause necrosis will lead to functional problem with resultant defective peristalsis [11].

There are multivariate factors contribute to the morbidity and mortality in patients with intestinal atresia like prematurity, associated congenital anomalies, delayed presentation, intercurrent infection, anastomotic technique used, and creation of stomas [20]. Anastomotic technique-related complications deserve a special point of emphasis; since the construction of anastomosis is the one factor over which the surgeon has the most control. Thomas et al. concluded that the type of anastomosis performed was an important factor in the incidence of anastomotic complication [21].

We have followed the recommendations in performing primary anastomosis that the caliber discrepancy between the two ends of the bowel after resection should not exceed the ratio of 5:1 [7]. We believe that after limited resection of proximal bowel, oblique resection edge of distal bowel at the anti-mesenteric side until its length easily equals the diameter of the proximal bowel, yield a wide ESO anastomosis and minimizes the anastomotic dysfunction.

The functional status of the anastomosis and long-term outcomes was evaluated in those patients whose duration of survival and follow up period permitted such an appraisal. Of the 34 patients underwent an ESO anastomosis, only four patients (11.8%) developed anastomotic stenosis and dysfunction which is comparable to Yeung et al. who encountered 6/43 cases (14%) of persistent functional obstruction that required re-exploration after primary anastomosis [10], while Piper et al. reported 8% of their patients required re-exploration for anastomotic dysfunction [22]. It is apparent that anastomotic dysfunction still presents a problem even with this technique, it may be due to the underlying intestinal dysmotility associated with this anomaly. However, this complication may not be preventable completely by changes in surgical technique [23].

There were four cases (11.8%) of our patients needed re-exploration for postoperative complications. Indeed, the risk of re-exploration is substantial in any surgical technique for JIA but our finding seems to be less than the reported rates in the existing literature. A previous study reported that "15 of 60 patients (25%) with JIA required a second abdominal operation for complications" [22]. Another study including 83 patients stated that "14.5% required repeat laparotomy for adhesive intestinal obstruction and another 6% for anastomotic leakage or stricture" [24]. Recently Yeung et al.

recorded that ten patients (23.3%) required re-explorations after the primary anastomosis due to intra-abdominal complications [10].

The presence of associated anomalies affects the outcomes significantly, we encountered four cases of postoperative complications out of 6 cases of associated anomalies (OR 2.185, CI 0.723–13.163, $P=0.028$), this finding is agreed with Piper et al. [22]. From our data, it seems that prematurity and low birth weight were another significant predictors of postoperative complications especially anastomotic dysfunction ($P=0.018$ and 0.025, respectively, Table 3). We suggested that the immaturity of intestinal motility gives an explanation to this observation. The motor activity of small intestine has been found to be present at 16 weeks of gestation, but the coordinated contraction and peristalsis are not established until 36 weeks [25, 26]. Prematurity and low birth weight are regarded as significant predictors of increased mortality of JIA by Walker et al. who reported 98% survival rate in term infants compared to 87% for preterm infants [27].

Notably, several previous studies reported a variable incidence of adhesive intestinal obstruction requiring surgical exploration ranging from 7 to 24% as early as within a month after initial surgery [3, 22, 24]. While in this study, we faced three cases (8.8%) of adhesive intestinal obstruction over the period of follow up and only one of them required surgical intervention. During the second surgery, although diverting enterostomy is a good option, creation of a stoma can still be avoided, as re-anastomosis or refashioning of the original anastomosis is usually a safe surgical option [8, 28].

The postoperative mortality rate of 14.7% in this study is a little bit higher than data in the developed countries like Kumaran et al. in England and Stollman et al. in Netherlands who reported mortality rates of 10% and 11%, respectively [7, 24] but it is much less than reports from Nigeria by Chirdan et al. who reported mortality of 41.7% [29]. A study done in New Delhi [28] included 42 patients with small bowel and large bowel atresia reported an overall mortality of 13%, which is comparable with our rate. Mortality rate in our study could be attributed in part to the delayed presentation, as deliveries of some of our babies still occurred at home and lacking the proper care with miss interpretation of a passage of mucous as meconium by the parents and even by the primary health workers. Delay in presentation prior to admission is a significant factor responsible for the loss of many patients due to septicaemia, aspiration pneumonia and metabolic disturbance [30]. The majority of patients in this study (70%) presented after the 48 h of life during which time patients eventually developed repeated vomiting, aspiration pneumonia, sepsis, electrolytes imbalance and metabolic disturbance. Another fact that should be mentioned is that the beds in our NICU is usually either occupied or filled with a large number of infectious illnesses, which might increase mortality furthermore.

Conclusion

We believe that limited resection of proximal dilated bowel with ESO anastomosis is considered simple, safe and effective surgical option of treatment in JIA. The technique of ESO anastomosis results in wide and early functioning anastomosis with low morbidity and mortality, it is applicable in situations where there is limited resources like NICU and TPN. Although we applied this technique to limited number of patients, the technique is recommended in JIA especially for cases of proximal atresia where liberal resection is difficult. Prematurity, low birth weight and associated anomalies are risk factors for postoperative complications.

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Compliance with ethical standards

Conflict of interest None. We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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

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