

Resection and Primary Anastomosis Is a Valid Surgical Option for Infants With Necrotizing Enterocolitis Who Weigh Less Than 1000 g

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Hypothesis: Primary anastomosis following intestinal resection is a valid surgical option in the treatment of infants with necrotizing enterocolitis (NEC) who weigh less than 1000 g.

Design: Retrospective case series.

Setting: Tertiary neonatal surgery referral center.

Patients: All infants with confirmed NEC weighing less than 1000 g admitted to our intensive care unit over 4 years.

Intervention: For infants requiring laparotomy and intestinal resection, primary anastomosis was performed whenever the clinical condition permitted.

Main Outcome Measures: Short- and long-term survival, length of intensive care unit stay, and complications.

Results: Fifty-one infants with NEC who weighed less than 1000 g were admitted during the study period. Twelve infants underwent intestinal resection and primary anastomosis (median weight at surgery, 0.83 kg; range, 0.6-0.96 kg). One infant developed recurrent NEC,

requiring further surgery, but there were no anastomotic leakages and no strictures. The median postoperative stay on our intensive care unit was 14 days (range, 2-49 days). All 12 infants survived their episode of acute NEC, and 8 are alive, with a median follow-up of 34.2 months (range, 4.7-48.4 months). Only 1 death was related to NEC. During the same period, 14 infants underwent intestinal resection and stoma formation. Ten survived the acute episode, and 6 are alive at a median follow-up of 24.0 months (range, 13.1-33.9 months). The median postoperative intensive care unit stay was 18 days (range, 2-74 days). Necrotizing enterocolitis-related complications occurred in 8 of these infants.

Conclusions: The outcome of infants with NEC who weigh less than 1000 g and undergo primary anastomosis is comparable to that of infants treated using alternative techniques. It is, therefore, a valid surgical option in selected infants. The mortality in this group of infants is high.

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WHICH OPERATION should be performed in infants with necrotizing enterocolitis (NEC) who require an intestinal resection? The objectives of surgery in this challenging group of patients are to control sepsis, remove gangrenous intestine, and preserve as much bowel length as possible.¹⁻³ Following intestinal resection, the surgeon is left with a choice of performing a primary anastomosis or fashioning a stoma.

The conventional view of stoma formation followed by restoration of intestinal continuity at a later stage has been challenged by proponents of primary intestinal anastomosis. Primary anastomosis avoids the numerous potential complications of stoma formation and may avoid a second operation. Yet, this technique has not gained widespread support, particularly in infants weighing less than 1000 g.⁴

We have been satisfied with the outcome of patients treated with primary anastomosis such that at our institution this technique has become the surgical procedure of choice

during laparotomy whenever the perioperative condition of the infant permits. In an attempt to prove the validity of this procedure even in small infants, we reviewed the outcome of infants weighing less than 1000 g who were admitted to our surgical intensive care unit.

METHODS

A retrospective review of all infants with confirmed NEC (modified Bell stage II or III)⁵ admitted to the surgical intensive care unit at Great Ormond Street Hospital from January 1, 2000, through December 31, 2003, was undertaken. All infants were referred to our tertiary referral center for consideration of surgical intervention. Only infants weighing less than 1000 g at admission were included in this analysis. Data relating to clinical course and relevant outcome measures, including length of postoperative stay, length of total parenteral nutrition (TPN) dependency, surgical complications, and mortality, were documented. Included in this group are infants who were subsequently proved to have a focal intestinal perforation.

Infants requiring surgical intervention were treated as deemed appropriate by the attending

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Table 1. Demographic Variables and Outcome of the 12 Infants Treated by Intestinal Resection Followed by Primary Anastomosis*

Variable	Value
No. of males	10
Birth weight, kg	0.80 (0.55-0.97)
Gestational age at birth, wk	25 (23-28)
Weight at surgery, kg	0.83 (0.60-0.96)
Age at onset of NEC, d	8 (3-38)
No. with Bell stage III	10
No. (%) who required inotropes at surgery	3 (25)
Length of small intestine resected, cm	6 (2-23)
Length of postoperative TPN requirement, d	19.5 (10.0-160.0)
Length of ICU stay for survivors, d	14 (2-49)
No. of NEC-related complications	1
Length of follow-up, mo	34.2 (4.7-48.4)
No. (%) with long-term mortality	4 (33)
No. with a final diagnosis of FIP	4

Abbreviations: FIP, focal intestinal perforation; ICU, intensive care unit; NEC, necrotizing enterocolitis; TPN, total parenteral nutrition.

*Data are given as median (range) unless otherwise indicated.

surgeon. If a laparotomy was performed and intestine resected, primary anastomosis was performed whenever the clinical condition of the infant permitted. If the infant was deemed to be too unstable, if the infant had a complicated perioperative course (eg, due to excessive hemorrhage), or if the distal intestine was of doubtful integrity, a stoma was fashioned. A final diagnosis of either NEC or focal intestinal perforation was assigned to each infant based on findings at laparotomy and histological appearance of the resected intestine. Data are expressed as median and range.

RESULTS

During the 4-year study period, 51 infants with Bell stage II (n=21) or III (n=30) disease who weighed less than 1000 g were admitted. The demographic variables of this group are as follows. The median birth weight was 0.73 kg (range, 0.53-1.20 kg); and the median weight at admission was 0.81 kg (range, 0.50-0.99 kg). The median gestational age at birth was 25 weeks (range, 23-34 weeks); and the age at onset of NEC was 9 days (range, 1-60 days). Six infants had no indication for surgical intervention and were successfully treated conservatively. One infant with multisystem organ failure on admission died before stabilization for surgery. The remaining 44 infants underwent surgical intervention. These included 3 infants who were critically unwell, lacked specific indications for surgery, underwent diagnostic laparoscopy with peritoneal drain insertion, and required no further intervention; and 6 infants who underwent primary peritoneal drainage. A total of 35 infants underwent primary laparotomy (including an "open-and-close" technique [n=5], oversew of the perforation [n=2], a high jejunostomy [n=2], resection and stoma formation [n=14], and resection and primary anastomosis [n=12]). The 26 infants who underwent intestinal resection followed by either stoma formation or primary anastomosis form the basis of the remainder of this report. There were no statistically significant differences in the demographic variables between infants undergoing primary anastomosis and those

undergoing stoma formation (Mann-Whitney or Fisher exact test, $P > .05$).

INFANTS UNDERGOING PRIMARY ANASTOMOSIS

Twelve infants underwent intestinal resection and primary anastomosis, including 2 infants with multifocal disease who underwent resection and multiple primary anastomoses (2 each). Data relating to patient demographics, severity of illness, and outcome are shown in **Table 1**. All infants required mechanical ventilation, and 3 required inotropic support at the time of surgery. The median length of small intestine resected was 6 cm. There were no anastomotic leakages and no anastomotic strictures. One infant who had 2 anastomoses developed recurrent NEC with an intestinal perforation requiring laparotomy. The anastomoses were intact, and a stoma was fashioned. All 12 infants survived the acute episode, but 4 of these have since died (3 of causes not related to NEC and 1 secondary to complications of TPN dependency) at a median follow-up of 34.2 months. The median postoperative stay on our intensive care unit was 14 days. The length of postoperative TPN dependency was available for 10 of these infants (2 were transferred to other hospitals while still receiving TPN), and was a median of 19.5 days.

INFANTS UNDERGOING STOMA FORMATION

Fourteen infants underwent intestinal resection and stoma formation. Five required inotropic support at the time of surgery, and the median length of small intestine resected was 6 cm (**Table 2**). All stomas were situated in the ileum. Ten infants survived the acute episode of NEC, and 6 are alive with a median follow-up of 24.0 months. Necrotizing enterocolitis-related complications occurred in 8 infants, including stomal prolapse or stricture (n=3), recurrent NEC (n=4), and death related to NEC (n=5). The median postoperative stay on our intensive care unit was 18 days, and the median length of postoperative TPN dependency (available for 8 of the 10 survivors) was 15.5 days.

COMMENT

Following intestinal resection for NEC, the surgeon faces a decision of stoma formation or primary anastomosis. The conventional view is that it is safer to exteriorize the bowel ends because the presence of peritonitis, inflammation of the bowel wall, and reduced intestinal blood supply in patients with NEC are unfavorable factors for the healing of the anastomosis.⁶ The stoma also allows for adequate healing and rests the distal bowel before subsequent reanastomosis.²

However, stoma formation does not always provide a straightforward solution. Stomas may be complicated by poor weight gain, electrolyte imbalance due to high intestinal output, stenosis, prolapse, and excoriation of the surrounding skin. Restoration of intestinal continuity involves a second anesthetic and is usually performed once the infant is thriving and fully recovered from the acute stage of the illness. Metabolic or physical problems, however, may demand earlier surgery. In one series,⁷ the incidence of complications in infants with enterostomies for NEC was as high as 68%.

The alternative to stoma formation is resection followed by primary anastomosis. This was once considered a hazardous option because of the risk of anastomotic leakage due to poor healing of intraperitoneal anastomoses, but in recent years, several centers have published encouraging reports in support of this technique.^{2,8-14} Rates of anastomotic leakage and stricture do not seem to be as high as anticipated, and primary anastomosis has been reported as a valid treatment option for severe NEC and even for multifocal disease.³

However, the technique of resection and primary anastomosis does not have widespread support, particularly in extremely low-birth-weight infants who weigh less than 1000 g. In a recent survey of 80 pediatric surgeons from the United Kingdom,¹⁵ just 55% reported that they would consider using resection and primary anastomosis in infants weighing less than 1000 g compared with 77% who would use it in larger infants. More than 90% of surgeons responded that they would consider fashioning a stoma in infants of all weights.

This review of surgically treated infants with NEC following stoma formation and primary anastomosis reveals comparable outcomes with both techniques. In particular, there were no complications related to the anastomoses. In fact, NEC-related morbidity and short- and long-term mortality was greater in infants who underwent stoma formation compared with those undergoing primary anastomosis. This may be used as evidence to suggest that primary anastomosis confers a benefit over stoma formation. However, this study does not take into account any differences in severity of disease between the 2 groups that may exist. Given that our intention was to perform primary anastomosis whenever possible and to reserve stoma formation for those in whom primary anastomosis was either not possible or believed to confer too great an intraoperative risk, it is possible that infants who received a stoma were in a worse clinical state than those undergoing primary anastomosis. For this reason, we have not attempted any formal statistical comparison between the 2 groups. However, subjective measures of severity of illness suggest that the 2 groups were at least comparable; there was a similar proportion of infants with a final diagnosis of focal intestinal perforation (which some investigators have suggested is a less severe clinical entity than NEC), a similar proportion of infants requiring inotropic support during surgery, a similar incidence of Bell stage III disease, and a similar length of small intestine resected in each group. To determine which approach confers a more favorable outcome, a randomized controlled trial comparing primary anastomosis with stoma formation would be required.

A result from this review that should not be overlooked is the high mortality rate in this group as a whole. The mortality during the acute stage of the illness for infants treated with either primary anastomosis or stoma formation was 15% (4/26), increasing to 46% (12/26) at the time of this review (median follow-up, 28.7 months; range, 4.7-48.4 months). In the whole group of 51 infants who weigh less than 1000 g, the mortality is even higher: 27% (14/51) during the acute phase of NEC, increasing to 49% (25/51) at a median follow-up of 24 months (range, 2.3-48.4 months). This high mortality is a reflection of the complex comorbidities when treating premature infants and the need for long-term follow-up data to fully review outcomes.

Table 2. Demographic Variables and Outcome of the 14 Infants Treated by Intestinal Resection Followed by Stoma Formation*

Variable	Value
No. of males	7
Birth weight, kg	0.70 (0.54-0.98)
Gestational age at birth, wk	25 (23-28)
Weight at surgery, kg	0.76 (0.60-0.98)
Age at onset of NEC, d	14 (5-60)
No. with Bell stage III	8
No. (%) who required inotropes at time of surgery	5 (36)
Length of small intestine resected, cm	6 (0-31)†
No. who died during the acute episode	4
Length of postoperative TPN requirement, d	15.5 (11.0-67.0)
Length of ICU stay for survivors, d	18 (2-74)
No. of NEC-related complications	8
Length of follow-up, mo	24.0 (13.1-33.9)
No. (%) with long-term mortality	8 (57)
No. with a final diagnosis of FIP	6

Abbreviations: See Table 1.

*Data are given as median (range) unless otherwise indicated.

†One infant had only colon resected.

The debate as to which surgical procedure is most appropriate in this challenging group of infants will undoubtedly continue. We have shown that outcome following intestinal resection and primary anastomosis when used in selected infants is comparable to that following stoma formation, and conclude that this technique is a valid surgical option even in infants weighing less than 1000 g.

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