Surgical treatment of necrotizing enterocolitis: single-centre experience from Saudi Arabia

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Aim **The aim of this study was to investigate our indications of laparotomy, surgical procedures and their results, and to compare our results with those of others. In necrotizing enterocolitis (NEC), indications of surgery, surgical strategy and results vary.**

Materials and methods **This study was conducted at the regional tertiary care referral centre. The study design was a retrospective one. Case records of 24 patients with advanced NEC who underwent laparotomy over a 7-year period were analysed. Demographic data, clinical features, laboratory and skiagram findings, indication for surgery, operative findings, procedures performed, immediate surgery-related complications and postoperative survival were studied.**

Results **The mean age was 20.29 days (range = 3–82 days). The mean birth weight was 1810.5 g (range = 660–3000 g). Seventy-five percent of babies were premature. Indications of surgery were as follows: pneumoperitoneum (16), failure to improve with adequate medical treatment (three), abdominal tenderness and rigidity (two), abdominal wall oedema and erythema (two), and acute intestinal obstruction (one). Peritoneal drainage was carried out in five patients, of whom two (40%) survived after laparotomy. Thirteen (54.17%) patients had focal, nine (37.5%) multifocal and two (8.33%) had panintestinal NEC. Six patients underwent resection anastomosis (RA) and 16 underwent enterostomy. Surgery-related complications occurred in six patients. The overall mortality was eight (33.33%). Two (33.33%) of the six RA patients, four (25%) of 16 stoma patients and two (100%) with corporation panintestinal disease died.**

Conclusion **The most common indication for laparotomy in NEC was pneumoperitoneum. We performed laparotomy in drain-managed patients when stable; 40% of such patients survived. We preferred gangrene resection and enterostomy to RA. Mortality and morbidity in the RA group were higher than that in the stoma group; dead RA patients had multifocal disease. Survival rate of laparotomy-NEC patients (66.66%) was comparable to that of other centres.** ***Ann Pediatr Surg*** **12:43–46 © 2016 Annals of Pediatric Surgery.**

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Introduction

Necrotizing enterocolitis (NEC) is an acquired inflammatory disease that affects the gut of newborn infants, particularly preterm and low birth weight (LBW) infants. It is now the most common newborn surgical emergency and is associated with higher morbidity and mortality compared with all other gastrointestinal (GI) conditions requiring surgical intervention [1]. Patients with modified Bell's stage III NEC have evidence of bowel necrosis or perforation; such advanced disease requiring surgical intervention develops in up to 50% of infants with NEC [1].

Indications for surgery include the presence of pneumoperitoneum indicating perforation of intestine, clinical deterioration despite maximal medical treatment, abdominal mass with intestinal obstruction, and development of intestinal stricture. Relative indications include fixed dilated intestinal loop, presence of portal gas, thrombocytopenia, and rapid fall in platelet count [2,3]. The indications for operation in the acute phase of NEC in the series reported by Nam *et al.* [4] were pneumoperitoneum, clinical deterioration and abdominal mass. The most commonly used surgical strategies for perforated NEC are laparotomy and bowel resection plus enterostomy, and peritoneal drainage (PD). According to Sato and Oldham [5], there are no compelling, prospective, controlled data supporting one procedure over the other. PD for perforated NEC may help to resuscitate and treat a critically ill infant initially, and, in some instances, may be a definitive operative intervention [5]. In the UK [3], PD was used for stabilization by 95% of surgeons and as definitive treatment by 58%. The majority of surgeons use it in neonates of all weights, whereas others restrict its use to those less than 1000 g. Infants were considered too unwell for laparotomy by 90% of surgeons. In infants undergoing laparotomy, resection of the involved intestine necessitates enterostomy, primary anastomosis [resection and anastomosis (RA)] or delayed anastomosis 48–72 h later. At laparotomy, all procedures including 'clip and drop' were used in infants of all weights except RA, which was used predominantly in larger infants (> 1000 g).

Thus, the indications for surgery, the surgical strategy and their results vary in different centres. In this background, we analysed the cases of NEC that were subjected to

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laparotomy in our department to find out the indications for operation, type of surgery performed and the results. We compared our results with those of other centres.

Materials and methods

This was a retrospective analysis of case records of patients with advanced NEC (Bell's stage III) who underwent laparotomy. Cases that were conservatively treated by means of PD without laparotomy and those who died before laparotomy were excluded from the study. The period of study was 7 years from November 2006 to October 2013. The demographic data of patients, clinical features at the time of laparotomy, laboratory findings, abdominal skiagram findings, operative findings, procedure performed, survival and surgery-related complications within 90 days after surgery were collected from the case records. The demographic data collected were age, sex, birth weight, and gestational age. The clinical features included symptoms, signs, whether or not ventilated, presence of and type of comorbid conditions and congenital anomalies. Investigation results included total and differential leucocyte counts, platelet count, capillary blood gas analysis results, blood chemistry results, abdominal skiagram (supine and lateral decubitus/erect), and ultrasound examination. From these data, indication for surgery was evident. Whether or not primary peritoneal drainage (PPD) was performed was checked. If performed, it was carried out in the neonatal intensive care unit, on the bedside, under local anaesthesia, as an emergency procedure. From the laparotomy findings, the site and extent of intestinal necrosis and perforations were noted. On the basis of the extent of involvement, NEC was classified as unifocal, multifocal, or panintestinal [1]. NEC was unifocal if there was only one area of necrosis/single perforation present. It was multifocal if there were multiple areas of necrosis/multiple perforations separated by normal intestine; in multifocal disease, there was viable intestine more than 50% of total. NEC was classified as panintestinal if there was extensive involvement of intestine by way of necrosis/perforation and less than 25% of intestine was viable. As regards surgical procedures, if excision of necrotic/perforated segment was performed, the following details were collected: the site as well as the length of excision; whether RA or enterostomy was performed; and whether or not second-look laparotomy was performed. This study was approved by our institute review board.

Results

A total of 24 patients were studied (Table 1). Their mean birth weight was 1810.5 g (range = 660–3000 g). In all, 75% were premature. Twelve babies were preterm with a gestational age of 22–37 weeks. Eleven patients (45.83%) had associated major congenital anomalies; eight patients (33.33%) had 10 cardiac anomalies. Other associated anomalies were genitourinary (three), GI (two), Talipes equinovarus (two) and Bochdalek diaphragmatic hernia (one). Indications for surgery were as follows: pneumoperitoneum (16 cases); failure to improve with adequate medical treatment (three cases); abdominal tenderness and rigidity (two cases); abdominal wall oedema and erythema (two cases); and acute intestinal obstruction confirmed by radiological evidence of dilated intestines + air-fluid levels (one case). Pneumatosis intestinalis (15%) and fixed bowel loop (5%) were other significant radiologic findings.

PPD was performed in five (21%) out of 24 patients. Thirteen (54.17%) patients had focal disease, nine (37.5%) had multifocal and two (8.33%) had panintestinal NEC. In all patients with focal disease and multifocal disease, resection of the necrotic/perforated intestine was performed. Eleven out of the 13 patients with focal disease underwent enterostomy (ileostomy/colostomy) and two patients underwent RA. Five out of the nine patients with multifocal disease underwent enterostomy (ileostomy/colostomy), and four patients underwent RA. In the two patients with panintestinal disease, no therapeutic procedure was performed. In total, six patients underwent RA and 16 underwent enterostomy. In nine patients, resection of the ileum, caecum, and a part of the colon was performed. Surgery-related complications occurred in six patients. Anastomotic leak occurred in two patients with multifocal disease in whom RA was performed; one patient died, whereas the other underwent relaparotomy and conversion to ileostomy.

The overall mortality was eight (33.33%) out of 24 (Fig. 1): one (7.69%) in the focal disease group, five (55.56%) in the multisegment disease group, and two (100%) in the panintestinal disease group. Two (33.33%) out of six patients who underwent RA died; both patients had multisegment disease. One of them underwent transverse colon RA plus caecal perforation closure; the other underwent multiple small bowel RA. Four (25%) out of the 16 patients who underwent stoma died. Out of the five patients who underwent PPD, three (60%) died after laparotomy; they had multifocal (two) or panintestinal (one) disease, whereas survivors (two) had focal disease.

Discussion

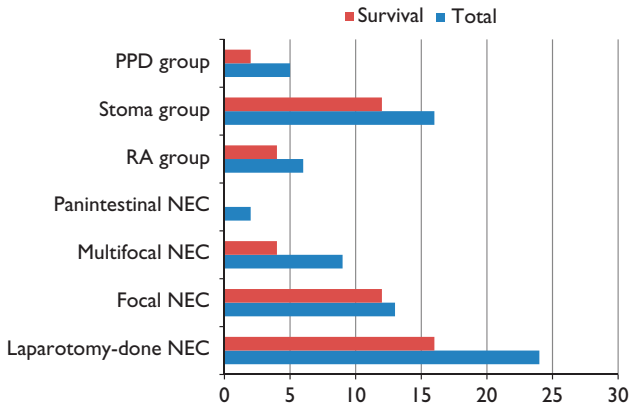
The most widely accepted indication for operation in NEC is pneumoperitoneum. Relative indications are positive paracentesis, palpable abdominal mass, abdominal wall erythema, portal vein gas, fixed intestinal loop, and clinical deterioration despite maximal medical therapy [2–4,6]. Exploration should not be undertaken until gangrene is present but should be performed before perforation occurs. Unfortunately, no combination of clinical examination or laboratory tests can diagnose early intestinal gangrene [1]. Therefore, there are controversies as regards indications for operation and optimal surgical treatment. The indication for laparotomy in a vast majority of our patients was pneumoperitoneum. Tepas *et al.* [7] evaluated seven critical metabolic derangements in a retrospective study; these were a positive blood culture within 96 h of diagnosis, acidosis (pH < 7.25 or receiving bicarbonate), bandemia more than 20%, thrombocytopenia (< 50 000 cells/mm^3), hyponatremia (< 130 mEq/l), hypotension (mean arterial pressure < gestational age or on any pressors), and

Table 1 Clinical characteristics of the patients who underwent laparotomy in acute stage (*N*=24)

Parameters	*n* (%)
Sex	
Male	13
Female	11
Gestational age (weeks)	
Mean	35.04 (23–40)
Preterm (<37)	12
Term (37–42)	12
Birth weight (g) (%)	
Mean	1810.5 (660–3000)
Premature	75
MLBW (1501–2500)	20
VLBW (1000–1500)	40
ELBW (<1000)	15
Mature	25
Patients with major congenital anomalies	11
Indications for surgery	
Pneumoperitoneum	16
Failed medical treatment	3
Abdominal tenderness and rigidity	2
Abdominal wall oedema and erythema	2
Acute intestinal obstruction	1
Mean age at laparotomy (days)	20.29 (3–82)
Disease distribution and surgery	
Focal NEC	13 (54.17)
Right hemicolectomy and ileocolic anastomosis	1
Ileal RA	1
Right hemicolectomy and ileostomy	7
Ileal resection and ileostomy	1
Colon resection and colostomy	3
Multifocal NEC	9 (37.5)
Jejunal RA + colon resection and colostomy	1
Two RA of ileum	1
Multiple small bowel RA	1
Colon RA + caecal perforation closure	1
Jejunal resection and jejunostomy	1
Ileal resection and ileostomy	3
Colostomy + ileoplasty	1
Panintestinal NEC	2 (8.33)
Open drainage only	1
Second-look laparotomy and no procedure	1
Surgical morbidity (complications)	6
Anastomotic leak and peritonitis	2
Wound infection	2
Wound gaping	1
Necrosis of colostomy	1
Mortality	8 (33.33)
Focal NEC	1 (7.69)
Multifocal NEC	5 (55.56)
Panintestinal NEC	2 (100)

ELBW, extremely low birth weight; MLBW, moderate low birth weight; NEC, necrotizing enterocolitis; RA, resection and anastomosis; VLBW, very low birth weight.

Fig. 1



Survival data of patient groups within NEC patients who underwent laparotomy. NEC, necrotizing enterocolitis; PPD, primary peritoneal drainage; RA, resection and anastomosis.

neutropenia (< 2000). Using any three of these critical metabolic derangement as indications for operative intervention resulted in better surgical outcomes (in terms of mortality and need for postoperative parenteral nutrition) than did delaying operation until radiographic evidence of perforation with pneumoperitoneum. Parikh *et al.* [6] concluded that neonates with persistently low pH, higher base deficit and presentation with shock needed laparotomy; these factors also lowered the survival in PPD-managed patients. Coursey validated a radiographic scale, the Duke abdominal assessment scale (DAAS) [8], for predicting the severity of disease in NEC. Fixed bowel loops, highly probable or definite pneumatosis, or portal venous gas present in initial radiographs had progressed to pneumoperitoneum on the follow-up series in 20 (46.5%) study group patients but not in the control group. In all, 93% of operated patients had DAAS scores of 7 or above. For every one-point increase in the DAAS score, patients more likely needed surgical intervention [8].

Lin *et al.* [9] observed that, compared with the nonsurgery group, the surgery group had significantly higher rates of respiratory distress syndrome, gurgling sound disappearance, C-reactive protein increase, platelet count decrease, positive blood culture, pneumoperitoneum and fixed intestinal loop on radiography, and mechanical ventilation.

Paracentesis was not performed and portal vein gas was not present in our series. Fixed bowel loop (5%) and pneumatosis intestinalis (15%) were detected along with other indications for operation. In the presence of pneumoperitoneum, if the patient was in poor physiological state and unfit for laparotomy, we performed emergency bedside PD followed by laparotomy if the condition improved, as done in some centres [10]. Our five (21%) patients in whom PPD was performed, do not indicate the full number of patients who underwent PPD, because those patients who did not survive PPD were not included in the study. However, it is worth mentioning that the majority (60%) of our PD patients died after laparotomy. Currently, most surgeons propose PD as the initial treatment in extremely LBW infants with perforated NEC to allow resuscitation and stabilization before definitive laparotomy [1]. However, some reports do not see advantages of PPD over laparotomy. A multicentre randomized trial [11] compared outcomes of PPD ($n = 55$) with laparotomy and bowel resection ($n = 62$) in preterm, LBW infants (< 1500 g) with perforated NEC at 15 pediatric centres. Primary outcome was survival at 90 days postoperatively. Secondary outcomes included dependence on parenteral nutrition 90 days postoperatively and length of hospital stay. This and another study concluded that the type of operation performed for perforated NEC does not influence survival or other clinically important early outcomes in preterm infants [11,12]. Other most recent studies bring out no significant benefits or harms of PD over laparotomy [13,14]. Thus,

controversies exist in performing PPD for stabilization before laparotomy [1].

Enterostomy was the most common surgical procedure in our patients, whereas RA was performed in minority. The RA group had slightly higher mortality compared with the enterostomy group (33.33 vs. 25%). Four out of the six RA patients had multifocal disease; two (50%) of them died and one developed anastomotic leak, which needed conversion to stoma. Thus, RA in multifocal NEC had poor outcome. Hofman *et al.* [15] compared the results of RA with those of resection and enterostomy in neonates with NEC in the acute phase. Mortality, complication rate, and postoperative weight gain were not significantly different between the groups; but the enterostomy group had a significantly longer primary hospital stay and needed a second hospital stay for restoring GI continuity. For both reasons, RA is superior to enterostomy after resection. RA was used predominantly in infants weighing more than 1000 g by 77% of surgeons in the UK [3]; however, Hall *et al.* [16] found that RA is a valid surgical option for infants weighing less than 1000 g. Nam *et al.* [4] found that resection and enterostomy were the preferred procedures, but RA did not increase morbidity or mortality.

To perform RA, the following criteria must be met [1]: (a) a sharply localized, usually proximal segment of disease; (b) undamaged appearance of the remaining intestine; and (c) stable overall patient physiology without evidence of rapidly progressive sepsis or coagulopathy. RA may be performed in any part of the intestinal tract from the jejunum to the sigmoid colon. In multifocal NEC, some authors advice against performing more than two RA because of a high risk for complications [17]. Multiple RA in one of our patients with multifocal disease may be a cause of death. Probably, the 'clip and drop-back' technique [1], rather than RA, might have improved the outcome in our patients with multifocal disease. In patients with pannecrosis, there was 42–100% mortality rate, and almost all survivors were left with short-bowel syndrome; the mortality rate was nearly 100% for extremely LBW infants [1]. This truth prompted us to perform no procedure in our two patients with panintestinal NEC. Other options in such cases are 'clip and drop-back' and high jejunostomy without resection. Kling [18] performed high jejunostomy in cases of multifocal and panintestinal disease. He obtained high survival (65%). The majority of survivors did not require resection of diseased bowel, indicating a high capacity for recovery of defunctioned bowel. Overall survival in our laparotomy-NEC patients was 66.66%, and if mortality of panintestinal disease is excluded, survival was 75%. This survival rate is comparable to that of other reported series. Snyder *et al.* [19] reported a postoperative survival of 64% in non-very LBW newborns (> 1000 g) and 48% in very LBW newborns (< 1000 g). Badowicz [20] reported 53.4% and Cleeve *et al.* [21] reported 68% overall survival in neonates treated surgically. Erhlich *et al.* [1] demonstrated that infant survival was independent of the type of surgical treatment (PD vs. laparotomy), but was inversely related to the number of comorbid conditions.

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Conflicts of interest

There are no conflicts of interest.

References

1 Sylvester KG, Liu GY, Albanese CT. Necrotising enterocolitis. In: Coran AG, Adzick NS, Krummel TM, Laberge JM, Shamberger RC, Caldamone AA, editors. *Pediatric surgery*, 7th ed. Atlanta, GA: Elsevier, Saunders; 2012. pp. 1187–1207.

2 Patel BK, Shah JS. Necrotizing enterocolitis in very low birth weight infants: a systemic review. *ISRN Gastroenterol* 2012; **2012**:562594.

3 Rees CM, Hall NJ, Eaton S, Pierro A. Surgical strategies for necrotising enterocolitis: a survey of practice in the United Kingdom. *Arch Dis Child Fetal Neonatal Ed* 2005; **90**:F152–F155.

4 Nam SH, Kim DY, Kim SC, Kim IK. The experience of surgical treatment of necrotizing enterocolitis. *J Korean Surg Soc* 2009; **76**:246–251.

5 Sato TT, Oldham KT. Abdominal drain placement versus laparotomy for necrotizing enterocolitis with perforation. *Clin Perinatol* 2004; **31**:577–589.

6 Parikh M, Samujh R, Kanojia RP, Rao KL. Decision-making in surgical neonatal necrotizing enterocolitis. *J Indian Assoc Pediatr Surg* 2009; **14**:102–107.

7 Tepas JJ 3rd, Sharma R, Leaphart CL, Celso BG, Pieper P, Esquivia-Lee V. Timing of surgical intervention in necrotizing enterocolitis can be determined by trajectory of metabolic derangement. *J Pediatr Surg* 2010; **45**:310–313. discussion 313–314.

8 Coursey CA, Hollingsworth CL, Wriston C, Beam C, Rice H, Bisset G 3rd. Radiographic predictors of disease severity in neonates and infants with necrotizing enterocolitis. *Am J Roentgenol* 2009; **193**:1408–1413.

9 Lin HJ, Ma XL, Shi LP, Luo F. Clinical analysis of surgical intervention in the treatment of necrotizing enterocolitis in neonates. *Zhongguo Dang Dai Er Ke Za Zhi* 2012; **14**:906–909.

10 Eicher C, Seitz G, Bevot A, Moll M, Goelz R, Arand J, *et al.* Surgical management of extremely low birth weight infants with neonatal bowel perforation: a single-center experience and a review of the literature. *Neonatology* 2012; **101**:285–292.

11 Moss RL, Dimmitt RA, Barnhart DC, Sylvester KG, Brown RL, Powell DM, *et al.* Laparotomy versus peritoneal drainage for necrotizing enterocolitis and perforation. *N Engl J Med* 2006; **354**:2225–2234.

12 Hunter CJ, Chokshi N, Ford HR. Evidence vs experience in the surgical management of necrotizing enterocolitis and focal intestinal perforation. *J Perinatol* 2008; **28** (Suppl 1):S14–S17.

13 Schanler RJ. Management of necrotising enterocolitis in newborns. Up-to-date; 2013.

14 Rao SC, Basani L, Simmer K, Samnakay N, Deshpande G. Peritoneal drainage versus laparotomy as initial surgical treatment for perforated necrotizing enterocolitis or spontaneous intestinal perforation in preterm low birth weight infants. *Cochrane Database Syst Rev* 2011.

15 Hofman FN, Bax NMA, van der Zee DC, Kramer WL. Surgery for necrotising enterocolitis: primary anastomosis or enterostomy? *Pediatr Surg Int* 2004; **20**:481–483.

16 Hall NJ, Curry J, Drake DP, Spitz L, Kiely EM, Pierro A. Resection and primary anastomosis is a valid surgical option for infants with necrotizing enterocolitis who weigh less than 1000 g. *Arch Surg* 2005; **140**:1149–1151.

17 Hall NJ, Pierro A. Necrotising enterocolitis. In: Spitz L, Coran AG, editors. *Operative pediatric surgery*, 7th ed. Boca Raton, FL: CRC Press – Taylor & Francis Group; 2013. pp. 487–497.

18 Kling J. Surgical procedure effectively treats severe necrotizing enterocolitis in neonates. Presented at American Academy of Pediatrics 2010 National Conference and Exhibition; 2 October 2010. Abstract 9438.

19 Snyder CL, Gittes GK, Murphy JP, Sharp RJ, Ashcraft KW, Amoury RA. Survival after necrotizing enterocolitis in infants weighing less than 1000 g: 25 years' experience at a single institution. *J Pediatr Surg* 1997; **32**:434–437.

20 Badowicz B. NEC – neonatal necrotising enterocolitis – methods of treatment and outcome: a comparative analysis of Scottish (Glasgow) and Polish (Western Pomerania) cases. *Ann Acad Med Stetin* 2000; **46**:137–149.

21 Cleeve S, Ward H, Hird M. Necrotising enterocolitis that requires surgery has a significant impact on survival. Presented at the Neonatal Society 2011 Spring Meeting; 10th March 2011.