

ORIGINAL ARTICLE

Surgical strategies for necrotising enterocolitis: a survey of practice in the United Kingdom

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Background: Strategies for the surgical management of necrotising enterocolitis are various and controversial.

Objective: To characterise variation in surgical management of this disease across the United Kingdom.

Methods: Postal survey of 104 consultant paediatric surgeons with a 77% response rate.

Results: Duration of antibiotic treatment (median 10 days, range 6–14), time until the start of enteral feeding (median 10 days, range 4–21), and absolute indications for surgery all vary between surgeons. Peritoneal drainage is used by 95% of surgeons. Forty two percent use it in neonates of all weights, whereas 36% restrict its use to those <1000 g. Peritoneal drainage is used for stabilisation by 95% and as definitive treatment by 58%. At laparotomy, operative procedures include diverting jejunostomy, resection and stoma, resection with primary anastomosis, and "clip and drop". All procedures are used in infants of all weights except resection and primary anastomosis, which is used predominantly in larger infants (55% in <1000 g; 77% in >1000g; $p = 0.005$). Infants may be considered too unwell for peritoneal drainage by 11% of surgeons compared with 90% for laparotomy ($p < 0.0001$).

Conclusions: There is considerable variation in surgical strategies for necrotising enterocolitis. Peritoneal drainage is used by most surgeons, with controversial indications and expectations. The use of resection and primary anastomosis is influenced by the weight of the neonate.

Necrotising enterocolitis (NEC) is the most common gastrointestinal emergency in the neonatal population, with a mortality of 20–40% despite advances in neonatal intensive care. Up to 49% of confirmed cases of NEC may require surgical management¹ but there are many controversies in the surgical management of NEC, especially in infants weighing less than 1000 g. In this era of evidence based medicine, we felt it was important to characterise current practice, as this forms the foundation of ongoing research and clinical trials.

We report the findings of a survey to characterise the variation in surgical management of NEC in the United Kingdom, with particular focus on the current role of peritoneal drainage and the type of procedure performed at laparotomy.

METHODS

A questionnaire was sent in December 2002 to all consultant paediatric surgeons in the United Kingdom who are members of the British Association of Paediatric Surgeons ($n = 104$). Eighty were returned (77% response rate). The questionnaire included questions about current management of NEC, including referral pattern, duration of antibiotic treatment, duration of withholding enteral feeding, indications for surgical treatment, use of peritoneal drainage, and type of operations performed. Specific questions relating to peritoneal drainage included the weight of infants in whom peritoneal drain is used, whether the drain is used as a definitive treatment or to stabilise for transfer or laparotomy, the type of drain used, the anatomical site of drain insertion, and timing and reasons for delayed laparotomy.

With respect to laparotomy, surgeons were asked which procedures were performed in infants of different weights (differentiating between those <1000 g and those >1000 g), where neonatal laparotomies were performed (in the neonatal unit or operating theatre) and whether they ever

considered patients too unwell for laparotomy or peritoneal drainage.

All questions had "tick box" answers or space for free text; multiple answers were allowed. All questionnaires were completed appropriately; where the answer was left blank we calculated the percentage of responders who replied to the question (where appropriate). Questionnaires returned unanswered because the surgeon did not practice neonatal surgery were excluded from the analysis.

The answers from the questionnaire were checked manually, and data entered into an Excel spreadsheet. Responses to each question were analysed and compared using GraphPad InStat v3.05 and GraphPad Prism 4 (GraphPad Software, Inc). Data were compared using the χ^2 test, two sided p values being given when significant to at least $p < 0.05$. Data are given as median and range or percentages of responders.

RESULTS

Referral pattern and conservative management

Infants with NEC are referred to surgeons at various stages in the progression of their disease: 60% of surgeons are referred neonates with Bell's stage I disease² (suspected NEC), whereas many are referred neonates with Bell's stage II (93%, mild to moderate NEC) or Bell's stage III (89%, severe NEC with or without perforation) disease. There is considerable variation in the non-operative management of these neonates. In cases of confirmed NEC, antibiotics are prescribed for a minimum of six and a maximum of 14 days (median 10). There is greater variation in the duration of withholding enteral feeding (range 4–21 days, median 10).

Abbreviations: NEC, necrotising enterocolitis; ELBW, extremely low birth weight

Table 1 Absolute indications for surgical intervention

Absolute indication	Percentage of surgeons using indication	
	Laparotomy	Peritoneal drain
Clinical findings		
Failure of medical therapy	71	14
Abdominal mass	36	1
Thrombocytopenia	3	4
Raised inflammatory markers	3	1
Radiological findings		
Pneumoperitoneum	75	53
Fixed intestinal loop	39	6
Portal venous gas	8	4
Pneumatosis intestinalis	3	0

Indications for surgery (table 1)

The most common clinical indications for surgical intervention were: failure to improve with maximal medical treatment (71% consider this an absolute indication for laparotomy compared with only 14% for peritoneal drainage), and the presence of an abdominal mass (36% for laparotomy compared with 1% for peritoneal drainage). A small number of surgeons consider thrombocytopenia and raised inflammatory markers absolute indications for surgical intervention.

Of the radiological features of NEC, free intraperitoneal gas is considered an absolute indication for laparotomy by 75% of surgeons and for drainage by 53%. A fixed intestinal loop is considered an absolute indication for laparotomy by 39% of surgeons compared with 6% for peritoneal drainage. Three percent of surgeons consider pneumatosis intestinalis an indication for laparotomy.

Role of peritoneal drainage

Ninety five percent of surgeons use peritoneal drainage as an option in the management of patients with NEC. Forty two percent of surgeons consider using peritoneal drainage in all patients; others restrict its use to infants weighing less than 1500 g (19%) or less than 1000 g (36%) (table 2). Fifty eight percent of surgeons consider using peritoneal drainage as a definitive treatment, 57% to stabilise neonates before transfer, and 95% to stabilise them before laparotomy. Those surgeons who responded always inserted peritoneal drains on the neonatal unit rather than in the operating theatre.

Most surgeons insert the drain into either iliac fossa, but the right side is used more commonly than the left (86% compared with 56% of surgeons). The right upper quadrant is used by 9% and the left upper quadrant by 5%. Twenty percent of surgeons use a single drain with two exit sites.

Table 2 Use of peritoneal drainage and weight of patient

Weight category	Number of surgeons (n = 74)	%
All weights	31	42
<1000 g	27	36
<1500 g	14	19
<2000 g	2	3

Question asked: In which of these weight categories of infants would you use peritoneal drainage? (tick one only): All; <2000 g; <1500 g; <1000 g.

Delayed laparotomy after peritoneal drainage

Sixty four percent of surgeons would perform a delayed laparotomy within 12 hours, and 37% between 12 and 24 hours after drainage. The most common indications for delayed laparotomy are clinical deterioration (87%), radiological evidence of bowel obstruction (61%), and palpable abdominal mass (32%). However, 8% of surgeons would never perform delayed laparotomy after primary peritoneal drainage.

Operative procedure at laparotomy

There is considerable variation in the procedures that individual surgeons perform at laparotomy. Approximately one third use “clip and drop” (a procedure in which non-viable bowel is resected, the remaining bowel ends being clipped or stapled and replaced in the abdomen with a planned second laparotomy performed 48–72 hours later),³ whereas bowel resection and stoma formation is used by the majority (92%). Furthermore, some surgeons reserve resection and primary anastomosis for infants weighing more than 1000 g (77% in >1000 g v 55% in <1000 g; p = 0.005).

The laparotomy is usually performed in an operating theatre (62% in an operating theatre in the same building, 38% in another building, and 3% in an operating area in the neonatal unit). Fourteen percent of surgeons operate on infants who are in their cot on the neonatal unit.

Too unwell for surgery

Eleven percent of surgeons sometimes consider neonates too unwell for peritoneal drain compared with 90% who may consider them too unwell for laparotomy (p<0.0001).

DISCUSSION

There is a lack of consensus on the surgical management of NEC and a need for ongoing clinical research to identify the most appropriate methods for managing this challenging group of patients. To identify precisely current techniques and opinions, we have performed a survey of neonatal surgeons practising within the United Kingdom and are able to discuss our findings in relation to evidence from the recent literature.

The response rate for this survey was high (77%), suggesting that it reflects current practice. It is striking that such a large variation exists in both conservative and operative management of NEC. This may be due in part to the variation in clinical presentations of NEC: infants may present at any stage of the disease with a variety of signs and symptoms. They may also have considerable co-morbidities which influence treatment decisions. We must also bear in mind that answers to questionnaires may imply artificial rigidity in clinical practice, as all scenarios cannot be covered in a simple questionnaire.

The decision of when to operate is often difficult but a number of indications have been evaluated in the literature. Kosloske² found that clinical deterioration was only a poor indicator of the need for laparotomy yet it is used as an absolute indication for operation by 71% of surgeons. However, thrombocytopenia, also a poor indicator of the need for surgery,⁴ is regarded as an absolute indication by 3%, as is the presence of raised inflammatory markers (table 1).

A number of papers have highlighted the difficulty of relying on radiological features to make a definitive diagnosis of NEC.⁵⁻⁷ Current evidence does support pneumoperitoneum as an absolute indication for operative intervention.^{4 8-10} Portal venous gas is only considered an absolute indication for laparotomy by 8% of surgeons, despite evidence that it is a marker for significant disease (with a mortality of up to 71% in some series).¹¹⁻¹³

Since it was first described by Marshall in 1975,¹⁴ peritoneal drainage has become a useful tool in the armamentarium of the paediatric surgeon, but surgeons' expectations seem to vary considerably. This survey highlights that the role of peritoneal drainage in perforated NEC is becoming established, as 53% of surgeons would consider pneumoperitoneum an absolute indication for its use. (In the extremely low birthweight (ELBW) infant, pneumoperitoneum may sometimes result from spontaneous gastrointestinal perforation, which may also be treated by peritoneal drainage.)

Ein *et al*⁵ reported that peritoneal drainage should only be used in the presence of free air and should always be followed by a laparotomy if there is no improvement. These authors also recommended that it be restricted to infants weighing less than 1500 g. Azarow *et al*¹⁵ showed a clear survival benefit of laparotomy over peritoneal drain in all infants over 1000 g, but improved survival in the ELBW infants treated with a peritoneal drain. This survey found that 42% of surgeons would consider a drain in all weights of infants (table 2), despite this not being supported by current evidence. This response may reflect the use of peritoneal drainage as a stabilising procedure, for example to allow transfer for operation. The role of peritoneal drainage as a definitive procedure or method of stabilisation is also controversial. There is published literature to suggest that peritoneal drainage can be a satisfactory definitive procedure, particularly in the ELBW infant,^{16–18} but other authors recommend its use as a method of stabilising unstable infants before definitive laparotomy.^{19–23} This controversy is reflected in the finding that only 58% of surgeons in this survey use peritoneal drainage as a definitive procedure. In a meta-analysis of peritoneal drainage versus laparotomy for perforated NEC, Moss *et al*²⁴ concluded that the only way to answer this question conclusively is by conducting a randomised trial. Two randomised trials are in progress to address this issue: NECSTEPS (<http://necsteps.stanford.edu>) and the NET trial (<http://www.nettrial.net>). The latter is an international trial which we are coordinating.

The preferred site of insertion of peritoneal drains has usually been described as the right or left iliac fossa, and the original descriptions of the procedure usually refer to the right lower quadrant as the preferred site for insertion.²⁵ However, 9% of surgeons would place a drain in the right upper quadrant of the abdomen, a manoeuvre that could cause bleeding from the liver. The concept of peritoneal drainage is linked to that of delayed laparotomy, but the timing and indications for this have always been controversial. Most advocates of peritoneal drainage caution against the risk of waiting too long before performing a delayed laparotomy. Dimmitt *et al*²⁶ suggest that death may be avoided by performing a timely laparotomy. Interestingly, some surgeons (8%) would never perform a delayed laparotomy after drain insertion.

It is not within the scope of this paper to debate the concept of surgery in the neonatal unit, but our findings suggest that this practice is becoming widespread. The beneficial effect on neonatal morbidity and mortality is increasingly being recognised.²⁷ However, very few units have a specialised operating area on the neonatal unit for this purpose. When laparotomies are performed on the neonatal unit, they are undertaken in the cot.

The procedure performed at laparotomy varies between surgeons, reflecting the clinical condition of the infant and the extent of disease (localised, diffuse, or pan-intestinal NEC). This also highlights the controversies surrounding the concept of resection of the diseased area—some surgeons consider this the key to recovery²⁸—and whether to perform a stoma or primary anastomosis.^{29–31} We found that the weight

of the infant significantly influences the surgical options, many surgeons reserving primary anastomosis for infants weighing more than 1000 g, even though current evidence (from retrospective series) does not support this.³⁰ As many as 90% of surgeons feel that there are occasionally patients who are too unstable for a laparotomy, and 11% of surgeons may consider patients too unwell even for peritoneal drain. This may be because in some cases it is felt appropriate to withdraw active care because of co-morbidities.

Our survey shows variation in current surgical management of NEC and inconsistencies between surgical practice and current evidence. The reasons for this variation are not known, but we hypothesise that the lack of clear guidance from the existing literature may be contributory. A number of surgical techniques are available, but none have been shown unequivocally to be superior. Most of the published literature in this field represents retrospective data based on clinical case series, and not prospective data from randomised trials, so it is difficult for the surgeon to make informed decisions about best practice. These findings emphasise the need for randomised trials and guidelines in this field.

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REFERENCES

- 1 Coombs RC. The prevention and management of necrotizing enterocolitis. *Current Paediatrics* 2003;**13**:184–9.
- 2 Bell MJ, Ternberg JL, Feigin RD, *et al*. Neonatal necrotizing enterocolitis. Therapeutic decisions based upon clinical staging. *Ann Surg* 1978;**187**:1–7.
- 3 Vaughan WG, Grosfeld JL, West K, *et al*. Avoidance of stomas and delayed anastomosis for bowel necrosis: the 'clip and drop-back' technique. *J Pediatr Surg* 1996;**31**:542–5.
- 4 Kosloske AM. Indications for operation in necrotizing enterocolitis revisited. *J Pediatr Surg* 1994;**29**:663–6.
- 5 Ein SH, Shandling B, Wesson D, *et al*. A 13-year experience with peritoneal drainage under local anesthesia for necrotizing enterocolitis perforation. *J Pediatr Surg* 1990;**25**:1034–6.
- 6 Hwang H, Murphy JJ, Gow KW, *et al*. Are localized intestinal perforations distinct from necrotizing enterocolitis? *J Pediatr Surg* 2003;**38**:763–7.
- 7 Tam AL, Camberos A, Applebaum H. Surgical decision making in necrotizing enterocolitis and focal intestinal perforation: predictive value of radiologic findings. *J Pediatr Surg* 2002;**37**:1688–91.
- 8 Chwals WJ, Blakely ML, Cheng A, *et al*. Surgery-associated complications in necrotizing enterocolitis: a multi-institutional study. *J Pediatr Surg* 2001;**36**:1722–4.
- 9 Horwitz JR, Lally KP, Cheu HW, *et al*. Complications after surgical intervention for necrotizing enterocolitis: a multicenter review. *J Pediatr Surg* 1995;**30**:994–8.
- 10 Robertson JF, Azmy AF, Young DG. Surgery for necrotizing enterocolitis. *Br J Surg* 1987;**74**:387–9.
- 11 Cikrit D, Mastandrea J, Grosfeld JL, *et al*. Significance of portal vein air in necrotizing enterocolitis: analysis of 53 cases. *J Pediatr Surg* 1985;**20**:425–30.
- 12 Grosfeld JL, Cheu H, Schlatter M, *et al*. Changing trends in necrotizing enterocolitis. Experience with 302 cases in two decades. *Ann Surg* 1991;**214**:300–6.
- 13 Molik KA, West KW, Rescorla FJ, *et al*. Portal venous air: the poor prognosis persists. *J Pediatr Surg* 2001;**36**:1143–5.
- 14 Marshall DG. Peritoneal drainage under local anesthesia for necrotizing enterocolitis perforation. Presented at the 7th Annual Meeting of Canadian Association of Pediatric Surgeons, Winnipeg, Manitoba, January 1975.
- 15 Azarow KS, Ein SH, Shandling B, *et al*. Laparotomy or drain for perforated necrotizing enterocolitis: who gets what and why? *Pediatr Surg Int* 1997;**12**:137–9.
- 16 Lessin MS, Luks FI, Wesselhoeft CW, *et al*. Peritoneal drainage as definitive treatment for intestinal perforation in infants with extremely low birth weight (<750 g). *J Pediatr Surg* 1998;**33**:370–2.

- 17 **Morgan LJ**, Shochat SJ, Hartman GE. Peritoneal drainage as primary management of perforated NEC in the very low birth weight infant. *J Pediatr Surg* 1994;**29**:310–14.
- 18 **Takamatsu H**, Akiyama H, Ibara S, *et al*. Treatment for necrotizing enterocolitis perforation in the extremely premature infant (weighing less than 1,000 g). *J Pediatr Surg* 1992;**27**:741–3.
- 19 **Ahmed T**, Ein S, Moore A. The role of peritoneal drains in treatment of perforated necrotizing enterocolitis: recommendations from recent experience. *J Pediatr Surg* 1998;**33**:1468–70.
- 20 **Cass DL**, Brandt ML, Patel DL, *et al*. Peritoneal drainage as definitive treatment for neonates with isolated intestinal perforation. *J Pediatr Surg* 2000;**35**:1531–6.
- 21 **Cheu HW**, Sukarochana K, Lloyd DA. Peritoneal drainage for necrotizing enterocolitis. *J Pediatr Surg* 1988;**23**:557–61.
- 22 **Dzakovic A**, Notrica DM, Smith EO, *et al*. Primary peritoneal drainage for increasing ventilatory requirements in critically ill neonates with necrotizing enterocolitis. *J Pediatr Surg* 2001;**36**:730–2.
- 23 **Rovin JD**, Rodgers BM, Burns RC, *et al*. The role of peritoneal drainage for intestinal perforation in infants with and without necrotizing enterocolitis. *J Pediatr Surg* 1999;**34**:143–7.
- 24 **Moss RL**, Dimmitt RA, Henry MC, *et al*. A meta-analysis of peritoneal drainage versus laparotomy for perforated necrotizing enterocolitis. *J Pediatr Surg* 2001;**36**:1210–13.
- 25 **Ein SH**, Marshall DG, Girvan D. Peritoneal drainage under local anesthesia for perforations from necrotizing enterocolitis. *J Pediatr Surg* 1977;**12**:963–7.
- 26 **Dimmitt RA**, Meier AH, Skarsgard ED, *et al*. Salvage laparotomy for failure of peritoneal drainage in necrotizing enterocolitis in infants with extremely low birth weight. *J Pediatr Surg* 2000;**35**:856–9.
- 27 **Gavilanes AW**, Heineman E, Herpers MJ, *et al*. Use of neonatal intensive care unit as a safe place for neonatal surgery. *Arch Dis Child Fetal Neonatal Ed* 1997;**76**:F51–3.
- 28 **Camberos A**, Patel K, Applebaum H. Laparotomy in very small premature infants with necrotizing enterocolitis or focal intestinal perforation: postoperative outcome. *J Pediatr Surg* 2002;**37**:1692–5.
- 29 **Ade-Ajayi N**, Kiely E, Drake D, *et al*. Resection and primary anastomosis in necrotizing enterocolitis. *J R Soc Med* 1996;**89**:385–8.
- 30 **Fasoli L**, Turi RA, Spitz L, *et al*. Necrotizing enterocolitis: extent of disease and surgical treatment. *J Pediatr Surg* 1999;**34**:1096–9.
- 31 **Griffiths DM**, Forbes DA, Pemberton PJ, *et al*. Primary anastomosis for necrotizing enterocolitis: a 12-year experience. *J Pediatr Surg* 1989;**24**:515–18.

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