Abstract

Necrotising Enterocolitis (NEC) is a neonatal surgical emergency with a high mortality. It is primarily seen in premature neonates with a low-birth weight and is characterised by intestinal ischaemia, infection and inflammation. The clinical features of NEC can be staged accordingly to Bell's Classification (1978). Biochemical anomalies include an elevated CRP associated with thrombocytopenia suggesting the presence of a necrotic process with consumptive coagulopathy. Plain abdominal radiography is usually sufficient in establishing the radiological diagnosis of NEC. There is however an emerging role for ultrasound scanning in predicting the need for intervention and identifying the “at-risk” neonate. Early management of NEC is usually conservative with a period of gut rest and intravenous antibiotics. The only absolute surgical indication to intervene is a perforation. However, relative indications for surgery include failure of medical management with increasing ventilatory requirements and/or haemodynamic support. The aims of surgery include resecting necrotic bowel whilst aiming to preserve intestinal length. An enterostomy is commonly fashioned as a means of diversion. A peritoneal drain may also be sited as a means of resuscitation prior to formal laparotomy. Mortality from NEC still remains between 30-40% despite several advances in neonatal care.

Keywords: NEC, Bell, USS, laparotomy, enterostomy, clip and drop

Introduction
Necrotising enterocolitis (NEC) is a neonatal surgical emergency. Despite several advances in neonatal intensive care and extensive research in the field, the mortality from this condition remains high. 90% of infants who develop NEC are premature with a 12% incidence amongst those with a birth weight of less than 1500g [1]. The mortality amongst this group of patients can be as high as 30%. Approximately 20% of the cost of running a NICU can be due to the disease and its complications [1]. NEC also has significant long-term morbidity including short bowel syndrome and neuro-disability.

Aetiology
Several risk factors have been attributed to its development with prematurity and low-birth weight the most commonly recognised [1]. The concept of altered intestinal colonisation (dysbiosis) has been proposed as an initiating mechanism for infection and inflammation that are seen as part of this condition [2]. Colonisation of the newborn gut takes places within the first few weeks of life. Pre-term infants admitted to the neonatal intensive care unit (NICU) are however at risk of acquiring nosocomial infections. On a background of poor innate immunity, pathogenic flora trigger an inflammatory cascade that damage the mucosal lining of the intestine and propagate the subsequent pathology.

Enteral feeding is another recognised risk factor with no cases of NEC reported antenatally [3]. Breast milk which contains Bifidobacteria is believed to be protective and was shown in the 1990s to be 6 to 10 times safer than using formula [4]. Other reported risk factors include absent or reversed end diastolic flow, a patent ductus arteriosus and red cell transfusion fuelling the theory of altered mesenteric blood flow, hypoxia and ischaemia seen as part of NEC [2].
Clinical Features
In 1978, Martin Bell proposed a clinical staging system for NEC based on examination findings, biochemical markers and radiological appearances [5]. In its early stages (Stage I), infants present with irritability, lethargy, temperature instability, bradycardia, apnoea and increased gastric aspirates. Radiologically there may be an appearance of distended bowel loops.
Stage II disease progresses onto abdominal distension with either occult or gross gastrointestinal bleeding. The classical radiological signs of a fixed bowel loop, pneumatosis intestinalis and portal venous gas may also be seen (Fig. 1).
Stage III is the most severe with evidence of septic shock and a pneumoperitoneum on plain radiography (Fig. 2).
In the initial series described by Bell, all Stage I and 85% of Stage II and III patients survived the acute episode of NEC [5].

Investigations
The commonest biochemical and haematological findings in NEC include neutropenia, thrombocytopenia, metabolic acidosis and an elevated serum C-reactive protein [3]. Endotoxin released by gram-negative bacteria induces platelet aggregation that can rapidly cause a decline in its level. Metabolic acidosis is usually seen as part of sepsis resulting in compensatory diversion of blood flow from the mesenteric circulation and worsening ischaemia. Other markers that are also being investigated from a research perspective to help screen for NEC include intestinal fatty acid binding protein, urinary D-lactate, faecal calprotectin and hydrogen in the breath [3]. Blood cultures are positive in a third of cases [3] with Escherichia coli, Klebsiella pneumoniae and Staphylococcus species the most commonly found pathogens.
Plain abdominal radiography continues to remain the most commonly used tool used for imaging the affected bowel. Distension with or without a fixed loop is often accompanied with pneumatosis. In more severe cases there may also be evidence of portal venous gas. A pneumoperitoneum which is often suspected on clinical examination can also be seen on either anterior/posterior or lateral views of the abdomen.
More recently, the use of ultrasound (US) in the assessment of NEC has been described. US can detect all the signs described above [6] and has the advantage of a bedside assessment which can be repeated without the risks of irradiation. US has also been shown to have a higher sensitivity and specificity compared with plain radiography when evaluating bowel wall perfusion [6]. A recently published study has also shown superiority of radiological imaging including US in predicting the need for intervention [7]. It is likely this will continue to develop further in the future and potentially help identify the neonate “at-risk”.

Management
In the early stages of NEC, treatment usually consists of gut rest, nasogastric decompress-
Clinical | Metabolic | Radiological
---|---|---
Abdominal wall erythema | Thrombocytopenia | Fixed loop of bowel
Palpable abdominal mass | Metabolic acidosis | Profound pneumatosis
Hypotension | Hyponatraemia | Portal venous gas
| Elevated C-reactive protein (CRP) | Pneumoperitoneum

**Table 1.** Clinical, metabolic and radiological features of an “at-risk” infant

<table>
<thead>
<tr>
<th>Indication</th>
<th>Surgery</th>
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| Pneumoperitoneum | a) Laparotomy  
| | b) Peritoneal drain |
| Necrotic bowel - limited disease | a) Stoma  
| | b) Primary anastomosis |
| Necrotic bowel - extensive disease | a) High-jejunostomy  
| | b) Clip-and-drop |
| Any of the above | *Laparoscopy - limited scope but reported to be useful by some authors for assessment |

**Table 2.** The indications for surgery and potential surgical management options

sion, broad-spectrum intravenous antibiotics for 7-10 days and total parenteral nutrition. Regular surgical review is warranted to ensure the patient is responding to these measures and early surgical intervention can be initiated if necessary. In one-third to one-half of medically managed cases, a surgical complication occurs requiring emergency surgery [8]. Pneumoperitoneum is the only accepted absolute indication for surgery, whereas relative indications include sudden or worsening acidosis, hyponatraemia, thrombocytopenia and an increasing dependency on cardiorespiratory support. Table I below summarises the features seen in the “at-risk” infant.

**Aims of Surgery**
- To resect any necrotic bowel or create a diversion whilst;
- Maintaining as much intestinal length as possible;
- Reduce the risk of short bowel syndrome.

There are several well-recognised options in surgery (Table II) that depend on the clinical situation of the patient as well as the pathology in question.

**Pneumoperitoneum**
This is the only widely accepted indication for surgery and there are two main approaches that can be taken.

1. **Laparotomy**
The advantages of this approach are to provide the surgeon with access to thoroughly assess the bowel and to eliminate peritoneal contamination. The stress from surgery is however significant and the infant will most likely need to be transferred to theatre which can be challenging in those needing high-frequency oscillatory ventilation.

2. **Peritoneal drain**
Specifically in the case of a pneumoperitoneum, another well-recognised approach is the insertion of a peritoneal drain. This can prove to be a life-saving resuscitative intervention in infants that cannot be adequately ventilated due to increased intra-abdominal pressure. The drain can be inserted at the bedside and permeates the release of air and faecal content, which also reduces the degree of contamination. In a recently conducted survey of European Surgeons, 27% of respondents reported using primary peritoneal drainage as definitive treatment for intestinal perforation in extremely low birth weight infants [9]. 95% of UK surgeons also report using peritoneal lavage as a stabilisation measure compared with 58% for definitive treatment [10].
Necrotic bowel - limited disease
There are again two approaches when faced with limited disease (Fig. 3). The formation of a stoma versus performing a primary anastomosis remains contentious.
1. Enterostomy
The advantage of a stoma is that it is potentially quicker and safer to perform in an unstable infant. It can be combined with bowel resection but can also be performed as a diversion to minimise further progression of the disease. There are however several disadvantages that include stoma prolapse, retraction, localised excoriation, para-stomal hernia, electrolyte losses and need for a reversal. In many cases the stoma losses are unacceptably high and early stoma closure is warranted.
2. Primary anastomosis
The advantage of a primary anastomosis is to avoid the morbidity associated with a stoma as well as the need for reversal surgery and its potential complications. However, it is also accepted that an anastomosis may be contra-indicated in a septic, hypotensive patient and can be time consuming. There may also be further progression of the disease causing intestinal strictures that are more readily identified with the presence of a stoma.

Necrotic bowel - multi-segment disease
This is potentially difficult to manage, as the infant is a significant risk of short bowel syndrome due to the need for extensive bowel resection. As with the previous two cases, there are different options for management that can be applied.
1. High-jejunostomy
In multi-segment disease, it may be necessary to fashion a high jejunostomy [11]. The advantage of this is to create a diversion and reduce further propagation of the disease. The biggest disadvantage is however managing a high-output stoma. This can be particularly problematic and as with other stomas, sodium supplementation is recommended in addition to using loperamide, which can reduce gut transit time and permeate the absorption of some nutrients.
2. Clip-and-drop
An alternative approach is to perform a “clip and drop” of affected bowel segments with a view to performing a re-look laparotomy in 24-48 hours (Fig. 4). This technique allows the surgeon to assess the true extent of the disease whilst resecting any necrotic segments prior to performing the required number of anastomoses with or without a covering stoma. The disadvantage of this procedure is the need for further surgery and the need for several anastomoses before restoring bowel continuity.
Laparoscopy
The role of laparoscopy in NEC is questionable. Some authors have described it as a useful tool in selected patients to prevent the need for a formal laparotomy [13]. Less than 10% of European surgeons however use this technique in the content of NEC [9].

Prognosis
Mortality from NEC still stands between 30%-40% despite several advances in neonatal intensive care treatment. Complications specifically from surgery include anastomotic leak, strictures, morbidity from an enterostomy and short bowel syndrome. In the longer-term, there are studies emerging reporting poor neurodevelopmental outcomes, particularly amongst those infants treated surgically [14].

REFERENCES