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# Peritoneal drainage vs. laparotomy as initial surgery for perforated necrotising enterocolitis or spontaneous intestinal perforation: experience from a level III Neonatal Intensive Care Unit in the largest paediatric hospital in southern Poland

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## ABSTRACT

**Introduction:** This retrospective cohort study was performed to compare the outcomes of primary peritoneal drainage (PD) vs. laparotomy (LAP) in patients with intestinal perforation due to necrotising enterocolitis (NEC) or spontaneous intestinal perforation. Additionally, it aims to identify demographic and clinical characteristics of eligible infants.

**Material and methods:** We identified infants hospitalised in the Neonatal Intensive Care Unit of the University Children's Hospital of Kraków between November 2014 and April 2022 and diagnosed with intestinal perforation due to NEC or spontaneous intestinal perforation. These infants underwent surgical intervention with either PD or LAP . The primary outcomes were death, short bowel syndrome (SBS), and combined outcome of death and/or short bowel syndrome. Odds ratios (OR) were calculated for these outcomes. Statistical significance was determined by a p-value < 0.05, with a 95% confidence interval (CI) other than 1.0.

**Results:** The primary outcome of death occurred in 8 (21%) of patients who had PD and in one (5.8%) of patient who had LAP as the initial surgery (OR = 0.23, 95% CI: 0.02–2). Short bowel syndrome occurred in 14 (36.8%) and 6 (35%) babies who had drainage and LAP, respectively (OR = 0.93, 95% CI: 0.28–3.0). Composite outcome of death and/or SBS occurred in 19 (50%) and 7 (41%) babies who had drainage and LAP as the initial surgery, respectively (OR = 0.70, 95% CI: 0.22–2.2).

**Conclusions:** Our findings indicate that the choice of initial surgical procedure does not significantly impact the combined outcome of death and/or short bowel syndrome. Further studies are necessary to assess the impact of initial surgery on survival, intestinal function, and long-term neurodevelopmental outcomes.

**Key words:** necrotising enterocolitis, intestinal perforation, drainage, laparotomy, mortality.

## INTRODUCTION

Necrotising enterocolitis (NEC) is an acute inflammatory necrosis of the intestines that mainly affects preterm infants. NEC occurs in 4–10% of infants weighing < 1500 g, with the highest incidence observed in the most premature infants [1]. However, the true incidence of NEC is challenging to determine due to inconsistencies in diagnosis and data collection. Despite advancements in neonatal care, mortality remains high. The risk of mortality varies, with average mortality rates ranging 20–30%, reaching up to 50% for extremely low birthweight infants

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who require surgical interventions [2–4]. Studies also indicate that a history of NEC requiring surgical intervention is a risk factor for growth delay and adverse neurodevelopmental outcomes [4, 5]. One of the most severe late gastrointestinal complication of NEC is short bowel syndrome [6].

The pathogenesis of NEC is multifactorial. Key risk factors include prematurity, low birth weight, and intestinal dysbiosis. Other factors include congenital heart disease, patent ductus arteriosus, ischaemia, sepsis, antibiotic exposure, neonatal anaemia, and red blood cell transfusions [2, 7]. In 1978, Bell's classification was proposed as a tool to assess the severity of NEC, based on clinical and radiographic signs, making it the most popular method for early assessment. Nowadays modified Bell staging criteria are the standard that is used in most neonatal intensive care units (NICU) [8, 9].

Medical management involves supportive care, antibiotic therapy, and surgical intervention in cases of intestinal perforation [3, 10]. Evidence of pneumoperitoneum on radiography is the definitive criteria for operative intervention, while deterioration of the general condition despite maximum medical therapy is a relative indication for surgery [11]. The optimal surgical approach remains unclear. Generally, the initial surgical options are laparotomy (LAP) or peritoneal drainage, with drainage followed by LAP if needed. The choice between these procedures depends on factors such as prematurity, weight, general patient condition, and local hospital practice [3, 10]. Over the years, multiple studies have evaluated the benefits and risks of LAP vs. peritoneal drainage (PD) as the initial surgical treatment for perforated NEC or spontaneous intestinal perforation (SIP) in infants [12–16].

The primary objective of this retrospective cohort study was to compare the outcomes of primary PD vs. LAP in patients with NEC or SIP in a level III Neonatal Intensive Care Unit at the University Children's Hospital of Kraków, the largest paediatric hospital in southern Poland. The secondary aim was to identify specific clinical characteristics of eligible infants. Notably, our NICU's unique proximity to surgeons and operating rooms means that the decision between these surgical interventions is based solely on the patient's clinical condition and is not influenced by logistical factors.

## MATERIAL AND METHODS

This retrospective cohort study took place at a level III academic NICU unit. We identified patients hospitalised between November 2014 and April 2022 who had intestinal perforation due to NEC or SIP and underwent surgical intervention with either PD or LAP. The diagnosis of NEC was based on clinical signs (bilious gastric aspirate or emesis, occult or gross blood in stool, abdominal distension), laboratory tests (elevated C-reactive protein, elevated white blood cell count with increased left shift, or depressed white blood cell count with neutropaenia, thrombocytopaenia), and radiographic abnormalities (pneumatosis intestinalis, hepatobiliary gas, or pneumoperitoneum). The diagnosis of SIP in infants was based on clinical signs (abdominal distension, often with the classical bluish discolouration of the abdominal wall) and radiographic abnormalities (signs of pneumoperitoneum in the absence of pneumatosis intestinalis and portal venous air).

Eligible infants were categorised into 2 groups based on their initial surgical intervention: PD or LAP. The peritoneal drainage group was further subdivided based on the need for secondary LAP. Laparotomy was performed by 2 methods – resection with enterostomy or resection with primary anastomosis.

Comparison between these groups was performed using criteria such as birth weight, gestational age, age on the day of perforation, whether the infant was small for gestational age, documentation of respiratory distress syndrome, intraventricular haemorrhage of grade III or IV (IVH) or haemodynamically significant patent ductus arteriosus (hsPDA).

All of the eligible infants were fed with mother's milk or formula, starting with trophic feed (minimal volumes of milk feeds, 10–15 ml/kg/day) and continuously increasing volumes if there were no signs of feeding intolerance, such as gastric residuals > 50% on a single occasion among infants who received nasogastric feeds, bilious/bloody gastric residuals among infants who received nasogastric feeds, abdominal distension (increase in abdominal girth by > 2 cm from baseline), emesis, or gross or occult blood in the stool. Generally, more than 80% of our patients are fed with mother's milk. Unfortunately, because of the retrospective character or our study, we are not able to establish which of the eligible infants were fed with mother's milk and which with formula.

The primary outcomes assessed were death, short bowel syndrome (SBS), and a combined outcome of death and SBS. Short bowel syndrome was defined as less than 25% of the normal small bowel length.

The primary outcomes were also compared in relation to 2 different methods of LAP used. Odds ratios (OR) were calculated for these outcomes, with statistical significance determined by a $p$-value < 0.05 and a 95% confidence interval (CI) other than 1.0.

## RESULTS

Between November 2014 and April 2022, 56 infants were diagnosed with intestinal perforation due to NEC or SIP. Twenty-two patients of our NICU experienced perforation during admission, while 27 infants were diagnosed with perforation in other hospitals and were subsequently transferred to our medical centre; in 7 infants diagnosed with NEC perforation occurred after transfer to our NICU. Among them, 8 patients were diagnosed with SIP,

**TABLE 1.** Demographic and clinical variables comparing laparotomy group and peritoneal drainage group

| Parameters | Laparotomy ($n = 17$) | Perinatal drainage ($n = 39$) | $p$-value |
|---|---|---|---|
| Birthweight [grams] | 1200 (1000–2050) | 870 (700–1000) | < 0.001 |
| Gestational age (weeks) | 30 (27–34) | 26 (24–28) | < 0.001 |
| Age on the day of perforation (day) | 9 (6–19) | 10 (5–19) | 0.77 |
| Male gender, *n* (%) | 11 (65) | 25 (64) | 1.0 |
| SGA, *n* (%) | 2 (12) | 9 (23) | 0.32 |
| SIP, *n* (%) | 3 (18) | 5 (13) | 0.15 |
| RDS, *n* (%) | 13 (76) | 34 (87) | 0.32 |
| IVH III/IV, *n* (%) | 7 (41) | 18 (46) | 0.73 |
| hsPDA, *n* (%) | 6 (35) | 16 (41) | 0.68 |

*hsPD – haemodynamically significant patent ductus arteriosus, IVH III/IV – intraventricular haemorrhage grade III or IV, RDS – respiratory distress syndrome, SGA – small for gestational age, SIP – spontaneous intestinal perforation*

**TABLE 2.** Demographic and clinical variables comparing secondary laparotomy group and peritoneal drainage group

| Parameters | Secondary laparotomy ($n = 21$) | Only peritoneal drainage ($n = 18$) | $p$-value |
|---|---|---|---|
| Birthweight [grams] | 880 (700–1000) | 835 (700–1000) | 0.89 |
| Gestational age (weeks) | 27 (25–28) | 26 (24–28) | 0.58 |
| Age on the day of perforation (day) | 13 (4–22) | 9 (6–13) | 0.19 |
| Male gender | 12 (57) | 13 (72) | 0.5 |
| SGA, *n* (%) | 3 (14) | 6 (33) | 0.26 |
| SIP, *n* (%) | 1 (5) | 4 (22) | 0.16 |
| RDS, *n* (%) | 20 (95) | 14 (78) | 0.11 |
| IVH III/IV, *n* (%) | 7 (33) | 11 (61) | 0.08 |
| hsPDA, *n* (%) | 9 (43) | 7 (39) | 0.80 |

*hsPD – haemodynamically significant patent ductus arteriosus, IVH III/IV – intraventricular haemorrhage grade III or IV, RDS – respiratory distress syndrome, SGA – small for gestational age, SIP – spontaneous intestinal perforation*

with 3 of them undergoing primary LAP and 5 infants receiving primary PD ($p = 0.69$). Of the total cohort, 39 infants received primary PD as their initial surgical procedure, while 17 infants underwent primary LAP.

Infants who underwent LAP had higher gestational age and birth weight compared to those who underwent PD. The mean birth weight was 1200 g for LAP and 870 g for PD ($p < 0.001$), and the mean gestational age was 30 weeks for LAP and 26 weeks for PD ($p < 0.001$). Small for gestational age was observed in 2 infants (12%) who underwent LAP compared to 9 (23%) who received PD ($p = 0.32$). The mean age on the day of perforation was 9 days for LAP and 10 days for PD ($p = 0.77$). Respiratory distress syndrome, IVH grade III or IV, and hsPDA were diagnosed accordingly in 13 (76%), 7 (14%), and 6 (35%) infants who underwent LAP compared to 34 (87%), 18 (46%), and 16 (41%) infants who underwent PD (Table 1).

A total of 21 (55%) infants in the PD group required secondary LAP. The secondary LAP group showed similar birth weight and gestational age to the PD-only group. Male gender was noted in 57% of secondary LAP patients compared to 72% in the PD-only group ($p = 0.5$). Small for gestational age was observed in 5% of secondary LAP patients compared to 33% in the PD-only group ($p = 0.26$), while SIP occurred in 5% of secondary LAP patients and 22% of PD-only patients ($p = 0.16$). Respiratory distress syndrome, IVH grade III or IV, and hsPDA were diagnosed accordingly in 20 (95%), 7 (33%), and 9 (43%) infants who underwent secondary LAP compared to 14 (78%), 11 (61%), and 7 (39%) infants who underwent only PD (Table 2).

The primary outcome of death occurred in 8 (21%) patients who had PD as the initial surgery and in one (5.8%) patient who had LAP (OR = 0.23, 95% CI: 0.02–2). Short bowel syndrome occurred in 14 (36.8%) babies who had PD and in 6 (35%) babies who had LAP (OR = 0.93, 95% CI: 0.28–3.0). The composite outcome of death or SBS occurred in 19 (50%) babies who had PD and in 7 (41%)babies who had LAP (OR = 0.70, 95% CI: 0.22–2.2). It is important to note that the lack of statistical significance may be due to the study's limited sample size.

There were 35 infants who underwent resection with enterostomy and 3 infants who underwent resection with primary anastomosis. The combined primary outcome of death or/and SBS occurred in 20 patients who underwent resection with enterostomy compared to 2 infants who underwent resection with primary anastomosis ($p = 0.7517$).

When comparing 3 groups (initial LAP, initial PD, and secondary LAP after PD), the primary outcome of combined death or SBS occurred in 41.2% of patients who underwent LAP as the initial surgery, 23.5% of patients who underwent primary peritoneal drainage, and 78.9% of patients who needed subsequent LAP after peritoneal drainage.

## DISCUSSION

Our findings suggest that there is no significant difference in mortality or the incidence of SBS between primary PD and primary LAP as initial surgical procedures. These results are consistent with recent studies and meta-analyses comparing these 2 surgical techniques [12–16]. A recent multi-centre prospective randomised clinical trial conducted in 20 United States centres also found no overall difference in the primary outcome of death or neurodevelopmental impairment between initial LAP and drainage in extremely low birthweight infants [17].

The meta-analysis further confirmed these findings, revealing no significant difference in mortality between PD and LAP as the initial surgical intervention for NEC [18].

Each method has its own advantages and disadvantages: initial LAP may be more beneficial for infants with multiple perforations, extensive intestinal necrosis, and peritonitis, while PD could suffice for infants with a single perforation. PD may be a better option for critically ill infants in unstable condition, as it can be performed within the NICU without inhalation anaesthesia.

Our study revealed that infants undergoing PD as the initial surgery had lower birth weight and were more premature (mean birth weight: 1200 g for LAP and 870 g for PD, $p < 0.001$; mean gestational age: 30 weeks for LAP and 26 weeks for PD, $p < 0.001$). This emphasises that PD is often chosen for the most vulnerable infants to minimise exposure to inhalational anaesthesia and LAP.

A study by Yanowitz *et al*. indicated that extremely low birthweight infants undergoing LAP as the initial procedure may face a higher risk of SBS [15]. However, another study suggested that infants undergoing primary PD took longer to achieve full enteral feeds. Interestingly, the study by Moss found that the mean length of hospital stay was similar between the primary PD and LAP groups [16].

It is important to consider the risk of subsequent LAP for initially drained patients. The Yanowitz *et al*. study reported that 22% of PD patients required second-look surgeries compared to 13% of LAP patients [15]. Similarly, the Ahle *et al*. study noted that 29% of primary drain failures ultimately required LAP [12]. In our study, 53.8% of patients who initially underwent surgery required subsequent LAP, and these patients were found to be at higher risk of death or short bowel syndrome.

This study has limitations, including its small sample size and retrospective nature. The choice between surgical interventions was not standardised, potentially leading to practice pattern influence and variation in patient condition assessment. Future prospective randomised-controlled studies with long-term follow-up are needed to confirm these results and evaluate neurodevelopmental and other clinically significant outcomes in infants receiving LAP or PD as initial surgery.

Our findings indicate that the choice of initial surgical procedure does not significantly impact the combined outcome of death or short bowel syndrome. This study does not definitively establish the advantages or disadvantages of either procedure. The decision on which procedure to choose as the initial surgery should be based on individual medical history, present health status, and the infant's stability. Further studies are necessary to assess the impact of initial surgery on survival, intestinal function, and long-term neurodevelopmental outcomes, aiming to establish optimal treatment approaches.

## CONCLUSIONS

The optimal surgical approach for perforated NEC or SIP remains unclear.

No significant difference of mortality and incidence of SBS between PD and LAP as initial surgical intervention was found.

Further prospective studies are needed to establish optimal treatment approaches.

## DISCLOSURES

1. Institutional review board statement: Not applicable.
2. Assistance with the article: None.
3. Financial support and sponsorship: None.
4. Conflicts of interest: None.

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