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Necrotising Enterocolitis case study from a nurse's perspective

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ABSTRACT

This case study reviews the Neonatal journey of Ava who received a diagnosis of Necrotising Enterocolitis (NEC). Ava was born at 24 + 1 weeks gestation via normal vaginal delivery (NVD) weighing 615 g. Prior to her delivery, her mother received two doses of antenatal steroids and magnesium sulphate. When Ava was born, she was intubated, received surfactant and prepared for transport to the neonatal unit via the transport incubator. NEC continues to be a challenging and common condition. The specific cause of NEC remains unknown, however there are many risk factors that predispose infants to NEC, particularly those born prematurely or low birth weight. This case study explores the pathophysiology and the symptoms of NEC and analyses the nursing care and conservative treatment provided. This condition can have lifelong complications on the gastrointestinal system and have a damaging effect on the neurodevelopment of infants.

1. Introduction

Necrotising Enterocolitis (NEC) is defined as inflammation of the intestine leading to mucosal damage and necrosis (Alexander et al., 2021). NEC continues to be a common and challenging surgical emergency and it has been noted that it occurs in 1–3 per 1000 live births (Calvert et al., 2020). The specific cause of NEC remains unknown, however there are many risk factors that predisposes infants to NEC, particularly those born prematurely or low birth weight. The MBRRACE-UK perinatal mortality surveillance Report, in 2020, identified that 47% of neonatal deaths were the result of gastrointestinal issues (Draper et al., 2022). Although it does not specifically mention NEC, this would certainly have contributed to this figure. Prevention is key with NEC and there have been many studies conducted to find methods of preventing this devastating condition. The effects of breast milk on NEC have been widely studied and have been shown to lower the incidence of NEC, due to its protective factors. It contains bioactive substances including bactericidal and immune-modulating activities (Altobelli et al., 2020). Therefore, breast milk is the preferred milk for those more at risk of developing NEC, as formula fed infants have a higher incidence of NEC (see Tables 1 and 2).

2. Case study

To maintain confidentiality and privacy, the pseudonym 'Ava' has been used throughout this case study (Nursing and Midwifery Council., 2015). Ava was born at 24 + 1 weeks gestation via normal vaginal delivery (NVD) weighing 615 g. Prior to her delivery, her mother received two doses of antenatal steroids and magnesium sulphate. When Ava was born, she was intubated, received surfactant and prepared for transport to the neonatal unit via the transport incubator. During Ava's neonatal journey, she was found to have a patent ductus arteriosus (PDA) on an echocardiogram (ECHO) ultrasound scan, which was treated with ibuprofen. She was also diagnosed with a grade 3 intraventricular haemorrhage (IVH) on the left side of her brain. Ava has been treated on multiple occasions with antibiotics, with one occasion being confirmed as Escherichia coli (E-Coli) sepsis.

Ava is currently 26 + 5 weeks corrected gestation in this particular episode of care. Ava initially presented with frequent episodes of apnoeas, bradycardias and desaturations requiring increased oxygen requirement. It was noted before commencing a feed that she had abdominal distension and tenderness, she was not tolerating her feeds and her aspirates were bile-stained. Over the next few hours, Ava appeared to show signs of infection, increased heart rate, hyperthermia, continued apnoeic episodes and a low blood pressure mean; her blood gas showed a mixed acidosis. An X-ray was taken showing dilated bowel loops and confirmed NEC with no perforation.

Ava presented with many signs of NEC, however throughout this, discussion, the focus will be on abdominal distension and raised lactic acid, the pathophysiology involved will be explored. Ava was treated

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Table 1
Ava's blood gas.

Blood Gas Value	Patient value	Normal Values (Petty, 2015)	High or Low
pH	7.17	7.35–7.45	Low
PCO2	9.4	4.6–6 kPa	High
PO2	3.9	6.5–10.5 kPa	Low
BE	−12.0	+2 to −2	Low
HCO3	17.7	22–26 mmol	Low
LAC	8.1	1–1.8 mmol/L	High

Table 2
Ava's Observations.

Observation	Patient value	Normal Values (Boxwell et al., 2020; Rennie and Kendall, 2013; Tarnow-Mordi et al., 2016)	High or Low
Heart Rate	195	120-180 beats per minute	High
Respiratory Rate	85	30-60 breaths per minute	High
02 Saturations	88%	91–95%	Low
BP	37/18 (24)	Systolic- 50-62 Diastolic- 25-30 Mean - 25-47	Low
Axilla Temp	38.0	36.5–37.5	High

with triple antibiotic therapy, nursed Nil by mouth (NBM). Parenteral Nutrition (PN) was administered due to enteral feeds being withheld for a long period of time to rest the bowel whist providing adequate nutrition and hydration.

3. Pathophysiology

Ava primarily presented with abdominal distension. It has been noted that a distended abdomen is not a specific sign of NEC particularly if the abdomen is soft and non-tender as this can be an associated problem with infants receiving respiratory support such as Continuous Positive Airway Pressure (CPAP) (Boxwell et al., 2020). It can also be an indicator of other conditions such as septic ileus or a bowel obstruction as these can present similar to NEC, however these conditions are not associated with the radiological findings of NEC (Verma and Kota, 2019). Ava has an immature gut due to prematurity with impaired intestinal motility, and because of this, when enteral feeds are introduced, there is a possibility the gut may not be able to digest and absorb nutrients sufficiently. Ava was born at 24 + 1 which predisposes her to NEC as gastrointestinal motility begins to develop in the second trimester but does not mature until the third trimester. As a result of this motility, immaturity effects peristalsis and overgrowth of anaerobic bacteria in the small intestine such as Escherichia coli (Schnabl et al., 2008). Any unabsorbed nutrients in the intestine result in an accumulation of gas causing abdominal distension which develops into necrosis of the bowel, alongside decreased blood flow as a result of the increased pressure caused by the distension (Macdonald and Green, 2018). Rapid increases in enteral feeds may affect intestinal absorption especially if there is altered motility leading to malabsorption. This is supported by Gregory et al. (2011), noting that unabsorbed nutrients in the intestine can lead to rapid growth of enteric bacteria, producing intraluminal gas.

Dysbiosis caused by infection or antibiotic use can make the gut more susceptible to bacterial invasion (Pi et al., 2022), any malabsorbed carbohydrates are fermented by the bacteria, and in turn produces hydrogen gas (Clark and Munshi, 2014). This is why Ava presented with abdominal distension as this produces pneumatosis intestinalis which was evident on Ava's abdominal x-ray, similar to that shown in Fig. 1. The time, rate, volume and type of feeds has been extensively researched, however there is still much conflict on the most beneficial method on how to prevent NEC. Oddie et al. (2021) argued that slow advancement of enteral feeds did not reduce the risk of NEC. This is

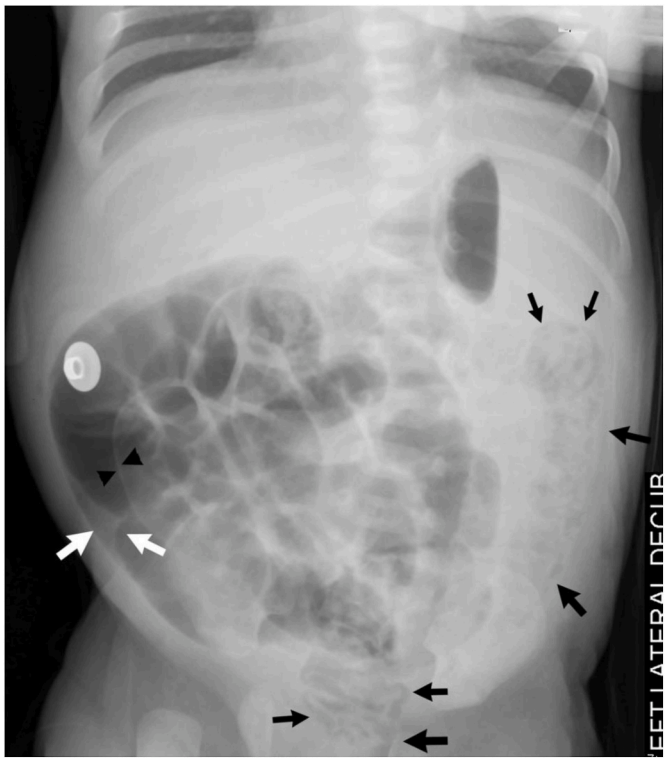

Fig. 1. Abdominal x-ray showing NEC with pneumatosis intestinalis shown by the arrows (Radiology Key, 2021).

supported by Dorling et al. (2019) who found that in the SIFT trial, there was no significant difference in the infants fed at a slower rate or faster rate in developing NEC.

Ava presented with a raised lactate level on her blood gases. Due to impaired blood flow and oxygen delivery, pyruvic acid is converted into lactic acid during anaerobic glycolysis. During a hypoxic event, lactic acid is the by-product of cellular metabolism of glucose (Marieb and Hoehn, 2016). Increased lactate levels may also be an indication of progressive ischaemic injury to the mesentery with mucosal damage making the intestine more susceptible to bacterial invasion. According to El- Abd et al. (2020) changes to the homeostasis of the intestinal flora leads to bacterial translocation, a result of an immature intestinal barrier and inflammation of the intestine causing sepsis (Burge and Markel, 2022).

Due to the disruption of the intestinal microbiome from gram-negative bacteria such as E-Coli, which was found in Ava's blood culture, Toll like receptor 4 (TLR4) levels are activated (Denning and Prince, 2018). These receptors play an important role in normal gut growth whilst in utero, however levels should fall as an infant reaches 40 weeks gestation. However, as Ava was born prematurely, this has not happened and expression of TLR4 in the intestinal epithelium are still high. There is evidence showing that this activates mutations in the TLR4 signalling (Hackman and Sodhi, 2018) and subsequently leads to an exaggerated inflammatory response resulting in cell death within the intestinal wall and impaired mucosal repair. Nino et al. (2016) also notes that's the translocation of gram-negative bacteria in the mucosa leads to TLR4 activation and reduced mesenteric blood flow causing ischemia and necrosis to the intestine as shown in Fig. 2.

As raised lactic acid is a result of poor tissue perfusion, this could be an implication of a PDA due to the left to right shunting, resulting in lower systemic diastolic pressure leading to end- organ hypoperfusion; the larger the PDA, the greater association and higher risk of NEC (Parkerson et al. (2021). Ava was diagnosed with a large PDA, making her more susceptible to NEC, due to the decreased blood flow to the mesenteric vessels as a consequence of the left-to- right shunting in the

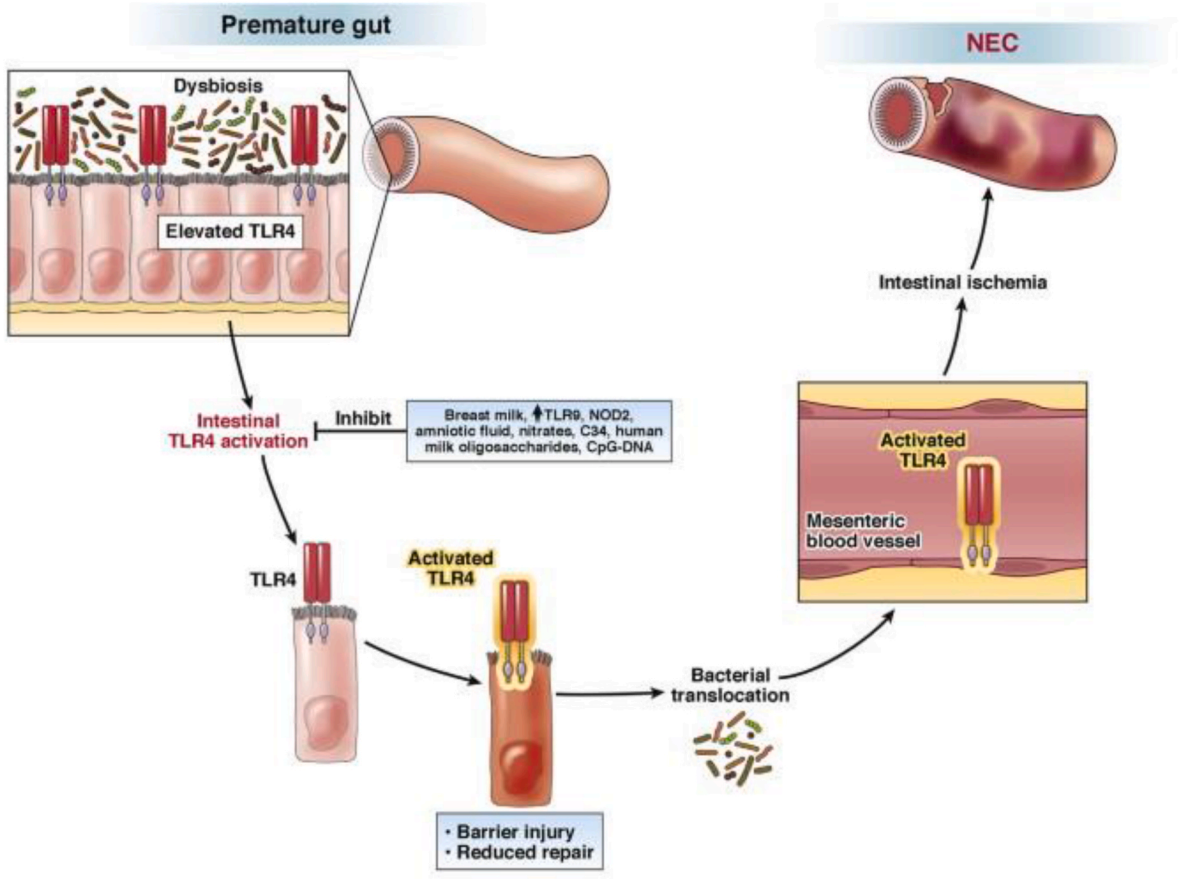

Fig. 2. Role of TLR4 in NEC (Hackman and Sodhi, 2018).

abdominal aorta which is related to the hypoxic compensatory mechanism known as the 'Diving Reflex' (Canesin et al., 2021). This blood is subsequently shunted away from the intestine which is considered as a non-vital organ and diverted to the vital organs, exacerbating ischemia in the intestine (Lee and Polin, 2003). Despite this, there has been little research conducted on the association of PDA and raised lactate levels. Okur et al. (2018) conducted a study to determine the significance of high lactate levels as a biomarker in haemodynamically significant PDA's that could result in tissue perfusion defects, however the study found that a large PDA does not cause significant increase in anaerobic metabolism and that high levels of lactic acid, and are more likely multifactorial such as, sepsis or inborn errors of metabolism.

4. Treatment

From Ava's clinical and abdominal x-ray findings, using the Modified Bell's Criteria she was diagnosed with NEC Stage 3A (as shown in Fig. 3.) and was treated conservatively (no surgical intervention). Ava received triple antibiotic cover; was put NBM and given intravenous fluids. A central line was then inserted, and she was commenced on PN. Standard treatment for NEC is to withhold enteral feeds for 7–10 days, depending on the severity (Christian et al., 2018) (see Fig. 4).

Feeds should be held in order to minimise further bacterial translocation and reduce the potential damaging effects of feeds on the inflamed gut, however it has been highlighted by Hackman et al. (2019) that although initially being treated conservatively for NEC, 50% of infants will still require surgical intervention. There is still some dispute on the duration of fasting (Zozaya et al., 2020), as it has both benefits and risks. Prolonged fasting could lead to further complications such as atrophy of the gut epithelium, increased risk of feed intolerance and bacterial translocation (Rooy, 2014), therefore increasing the chance of reoccurrence of NEC. In view of this, fasting should be minimised, and feeds should be introduced once the infant begins to stabilise. Savarino et al. (2021) suggested that there is no significant difference with complications when feeds are introduced before the fifth day of fasting.

To note, this was the third episode of treatment for NEC for Ava, therefore she was NBM for 10 days. Ava also had a wide bore nasogastric tube (NGT) inserted which was regularly aspirated to observe gastric residue and then put on free drainage. A wider bore NGT can also be useful in the decompression of the bowel in view of Ava's distended abdomen and reduce mucosal damage (Meeks et al., 2010). Although this reference is more than 10 years old, it is still relevant as this is still used in current practice.

As a result of the prolonged fasting, Ava received PN. Ou et al. (2020) suggested that PN should be introduced early with adequate proteins to allow for repair of tissue injury. As Ava is NBM, the PN would also help with minimising tissue loss and promoting growth (Perks et al., 2022). Although PN plays an important role in maintaining nutrition whilst resting the bowel, Hu et al. (2024) noted that PN did not remarkably improve the prognosis or mortality rates of NEC, therefore suggesting the role of PN need to be further studied. Prolonged use of PN can also cause further complications, such as central line infections, alteration of the intestinal flora and PN- related cholestasis (Akinkuotu et al., 2015). The hepatobiliary function can be altered due to NEC leading to cholestasis. This can also predispose the liver to further damage from PN. However it has been indicated that cholestasis that has derived as a result of PN, most likely developed cholestasis due to severe NEC (Veenstra et al., 2014), therefore it is important that feeds were resumed once Ava's condition had improved due to the protective factors of breast milk such as immunoglobulins, lactoferrin, oligosaccharides, lysozyme, fatty acids, growth factors and anti-inflammatory components which promote the growth and development of the microbiome

Stage	Systemic signs	Abdominal signs	Radiographic signs	Treatment
IA Suspected	Temperature instability, apnea, bradycardia, lethargy	Gastric retention, abdominal distention, emesis, heme-positive stool	Normal or intestinal dilation, mild ileus	NPO, antibiotics x 3 days
IB Suspected	Same as above	Grossly bloody stool	Same as above	Same as IA
IIA Definite, mildly ill	Same as above	Same as above, plus absent bowel sounds with or without abdominal tenderness	Intestinal dilation, ileus, pneumatosis intestinalis	NPO, antibiotics x 7 to 10 days
IIB Definite, moderately ill	Same as above, plus mild metabolic acidosis and thrombocytopenia	Same as above, plus absent bowel sounds, definite tenderness, with or without abdominal cellulitis or right lower quadrant mass	Same as IIA, plus ascites	NPO, antibiotics x 14 days
IIIA Advanced, severely ill, intact bowel	Same as IIB, plus hypotension, bradycardia, severe apnea, combined respiratory and metabolic acidosis, DIC, and neutropenia	Same as above, plus signs of peritonitis, marked tenderness, and abdominal distention	Same as IIA, plus ascites	NPO, antibiotics x 14 days, fluid resuscitation, inotropic support, ventilator therapy, paracentesis
IIIB Advanced, severely ill, perforated bowel	Same as IIIA	Same as IIIA	Same as above, plus pneumoperitoneum	Same as IIA, plus surgery

DIC: disseminated intravascular coagulation
NPO: "nil per os" or nothing by mouth

Fig. 3. Modified Bell's criteria (Aydemir et al., 2012).

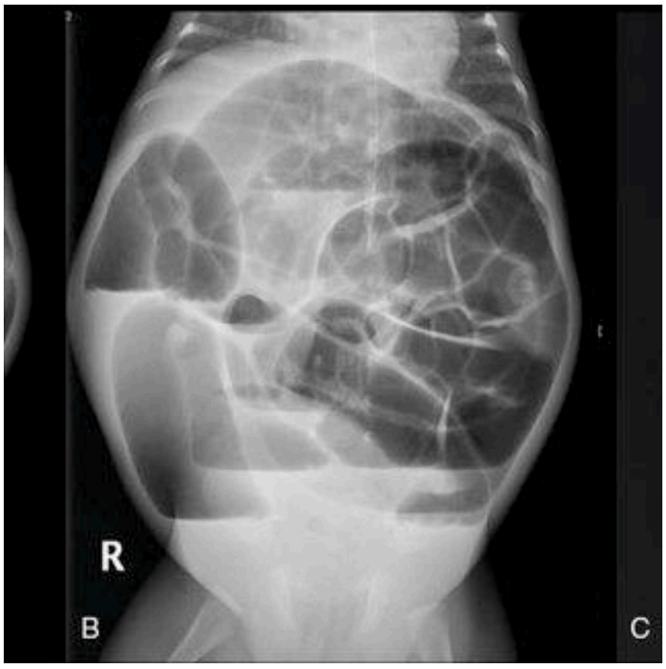

Fig. 4. Abdominal x-ray showing a post- NEC stricture (Liu et al., 2020), This is similar to Ava's x-ray when it was suspected she may have a stricture, however Ava's x-ray could not be used due to consent being unavailable and patient confidentiality (NMC, 2015).

(Dimitroglou et al., 2022).

5. Nursing care

Ava continued to be closely monitored by nurses to observe for any further signs of deterioration. Nurses will also ensure intravenous fluids and antibiotics are commenced; careful documentation is vital throughout the treatment given to Ava. As nurses are seen as first responders to clinical changes, their role in critical assessments can significantly improve recognition and management of NEC (Gregory et al., 2011). As Ava first presented with abdominal distention, this can be an indicator of NEC and nurses would have acted as an advocate for Ava in a timely manner, thus reducing the need for surgery (Gephart et al., 2014). Ava cannot verbalise that she is in pain, therefore the use of pain assessment tools and advocating for her is an important role in pain management, Barge et al. (2023) suggests that due to the excessive inflammation and ischemia in the intestine, severe visceral pain is experienced.

It was important to continue implementing developmental care. Minimal handling, positioning and minimising the environment such as reducing noise and dimmed lighting was utilised in order to decrease stress and allow optimal neurobehavioural development (Soni and Tscherning, 2020). Ava was initially handled a lot through repeated procedures therefore she would have experienced many stressors that would raise cortisol levels which in the long term could result in adverse neurodevelopment outcomes, for example, poorer cognitive and motor scores, reduced white matter and subcortical grey matter maturation (Altimier and Phillips, 2016).

Family Integrated Care (FIC) is always vital. The nurse's role in FIC is important to be supportive for parents, encouraging parents to continue being involved in Ava's care in order for them to feel empowered and

confident in their parenting skills (Adama et al., 2021). Encouraging Ava's mother to continue expressing breast milk would be essential for when enteral feeds were introduced back into Ava's care once treated for NEC and highlighting the importance of breastmilk. Preterm breast milk contains higher levels of bioactive components, which are thought to reduce the risk of NEC (Granger et al., 2021). Nurses had a vital role in informing parents at all times on Ava's condition therefore sharing information plays a huge role in FIC (Family Integrated Care, 2024).

As the onset of NEC and deterioration can be so rapid it is paramount to have good communication with Ava's parents. As decision making is also time critical, parents may not always be involved and this may be seen as a significant ethical issue (Gibbins et al., 2008), but should be addressed at the earliest opportunity.

6. Long- term complications

As a result of NEC, Ava and her family faced many long-term complications. Significant morbidity and mortality remain associated with NEC, infants who did not require emergency surgery, later required operations for management of strictures or stoma complications (Calvert et al., 2020). It has been reported that like Ava who was born at 24 + 1 weeks, there is an increased risk of significant neurodevelopmental delay associated with NEC for neonates born below 29 weeks gestation with rate being between 25 and 61% (Jones and Hall, 2020), which is relevant to Ava as she was born at 24 + 1 weeks.

Ava developed a stricture in her bowel and was transferred to the local surgical centre, where she had a laparotomy to repair the stricture, which resulted in a colostomy. Strictures are the most common complication of NEC, particularly in the later stages, with the incidence ranging from 11 to 35% (Liu et al., 2020). As Ava was diagnosed with Stage 3A, she was at higher risk of developing strictures due to the attempt of tissue healing after severe ischaemic damage (Federici and De Biagi, 2019). Verma and Kota (2019) suggest that around 24% of infants treated either medically or surgically develop strictures, however they argue that it is unrelated to the severity of NEC or gestation but acknowledged the risk could be increased if the infant received surgery, due to the inflammation of bowel post-anastomosis (Heida et al., 2016).

Due to multifactorial reasons such as extreme prematurity and NEC, infants are at an increased risk of developing an IVH, which lead to long-term neurodevelopmental delay. Ava was diagnosed with a grade 3 IVH prior to her diagnosis of NEC, therefore she was at higher risk of developing a more severe IVH thus predisposing her to long term neurological complications. It has been reported by Lu et al. (2023) that infants with severe NEC or those who are treated surgically had worsening neurodevelopmental impairments with 20% of infants diagnosed with NEC also diagnosed with cerebral palsy. There are many longitudinal studies of neurodevelopmental delay between 18 and 22 months, however this may not be an appropriate predictor for later childhood (Bazacliu and Neu, 2019), although infants treated medically for severe NEC are at high risk of neurodevelopmental impairment like Ava around 18 months of age, there may be improvement overtime. Vaidya et al. (2022) conducted a study showing that at 10–15 years old, found there was no difference in motor skills. Not only can NEC survivors suffer with cerebral palsy, but it has also been reported that 45% of survivors may experience visual, hearing, cognitive and psychomotor impairments (Wang et al., 2023). This may be due to the link between the intestinal injury and brain toxicity, however, there needs to be more studies conducted to verify this correlation.

During Ava's neonatal stay, she was transferred to multiple hospitals, including in and out of region for investigations. Ava's parents struggled with travelling as they did not drive and had two other children and had limited support with childcare. Therefore, it was difficult to visit Ava for long periods of time especially when she was at other hospitals. This would have greatly impacted Ava's parents as they may have experienced a sense of loss of parental responsibility and not being involved in decision making, thus impacting infant health and family outcomes (Lean et al., 2018). Ava's parents also found it difficult to understand why she had recurrent NEC. Canvasser et al. (2023) found in a study that parents needed more information about NEC and the long-term outcomes with 52% of parents reporting that they were not provided with any information on the long-term impacts. However, this may have been difficult at times when Ava's parents could not always be present on the NICU.

Ava's mother had support from a psychologist whilst on the neonatal unit as a result of the many stressors she faced whilst on the unit, particularly as this was Ava's third episode of NEC,resulting in high levels of parental anxiety. A study conducted by Bry and Wigert (2019) found that some parents felt more comfortable talking about how they felt to another professional who was not primarily involved in their infant's daily care. However, it can be difficult to have access to psychologist support. Griffiths (2018) highlighted that the Bliss charity found 62% of parents had no access to formal psychologist support. Ava's mother did not receive this support until they were transferred to another neonatal unit.

A dietitian was also involved in Ava's care due to long term PN administration and her history of feed intolerance and NEC. The dietitian's role is important to ensure that individualised nutritional care is consistently provided through evidence-based protocols and the use of monitoring tools (Olsen et al., 2005), this remains current practice. BAPM (2022) highlights that a dietitian's role is not only to manage the nutritional care needs, but to support the medical team to make effective feeding decisions with regards to gastrointestinal conditions, feed types and methods, and transition from PN to enteral feeding which would have been important throughout Ava's care, particularly with her stoma.

7. Conclusion

To conclude, it is evident that there were multifactorial risk factors that predisposed Ava to develop NEC such as extreme prematurity, repeated courses of antibiotics, PDA and repeated episodes of feeds being withheld. There have been many trials conducted to find ways to prevent NEC, for example, the WHEAT trial which looked at withholding enteral feeds or not during transfusion of packed red blood cells, however there is still no preventative measure in place with high quality evidence (Gale et al., 2019). There has also been a substantial amount of research into probiotics in order to reduce the risk of NEC and many studies have shown that supplementation of probiotics can in fact reduce this risk (Wang et al., 2023), although it has been argued in a Cochrane review by Sharif et al. (2023) that much larger and high quality studies need to be carried out to show sufficient evidence that probiotics should be implemented into current policies and practice. All of these practices were carried out throughout Ava's care, and unfortunately she still developed NEC, which may be due to the risk factors but may also prove that more research needs to be carried out to look at more preventative measures. Ava and her family will need long-term support from allied healthcare professionals, this is particularly important as it is unknown what her neurodevelopmental outcomes and future health needs will be. Therefore, regular follow-ups will need to be done to put the appropriate support in place. More research also needs to be carried out on the survivors of NEC adolescence and adulthood so parents can be prepared for the potential long-term complications of NEC.

Declaration of Competing interest

I can confirm that there is no conflict of interest.

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