

# The Ultrasound Features of Necrotic Bowel in Children: A Pictorial Essay

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## Introduction

Gangrenous necrotic bowel (NB) is a difficult diagnosis to make clinically. Although most patients are usually septic and very ill, symptoms are highly variable, depending on the cause and the acuteness of onset of the underlying pathology. Ultrasound (US) is usually performed to evaluate children suspected of having NB. In good hands, US may diagnose the condition early enough to prevent significant morbidity and even mortality. This pictorial essay will illustrate a wide range of causes of NB and highlight the suspicious imaging findings on ultrasound. Correlation with plain radiographs, computed tomography (CT) and pathological specimens will be shown where available.

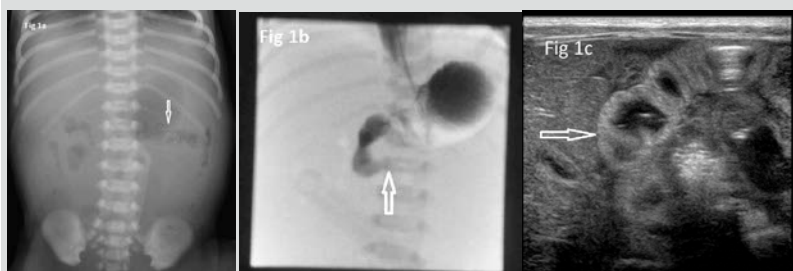
## Learning Objectives

1. To familiarize the reader with a wide range of conditions that may cause NB in children.
2. To recognize the imaging features suspicious for NB that will help to diagnose the condition early.

## Aetiology and Imaging findings

Common causes of NB in the neonatal period are necrotizing enterocolitis, malrotation and incarcerated inguinal hernia. In older children, intussusception, complications of Meckel's diverticulum, post-surgical adhesions, internal hernias and vasculitic causes are more common. Imaging findings suspicious for NB are persistent dilated loops of thick-walled bowel, intramural gas, portal venous gas and pneumoperitoneum. Altered Doppler signals may be detected within the bowel. CT scans may show bowel wall thickening, focal or generalized bowel dilatation and variable contrast enhancement.

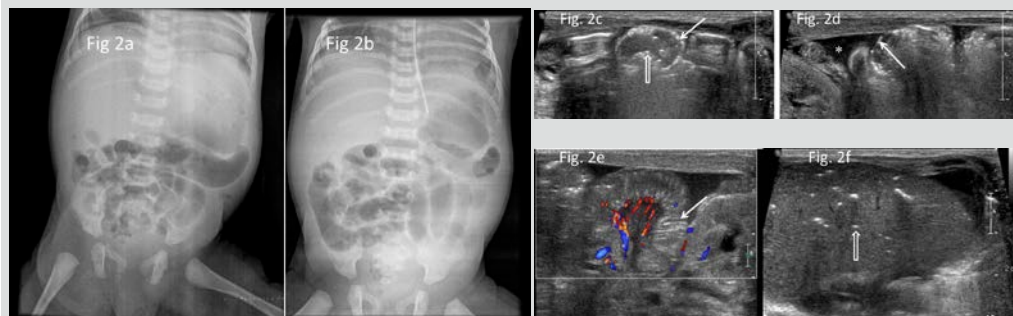
### Case 1: Malrotation with mid-gut volvulus



2-day old neonate with bilious vomiting. Malrotation was suspected. **Fig 1a.** Plain abdominal radiograph shows subtle mottled lucencies in a loop of bowel in the left upper abdomen (arrow). Some of these lucencies have a linear appearance whilst others appear as tiny bubbles. These findings are suspicious for intramural gas which is sign of NB. **Fig 1b.** Spot image

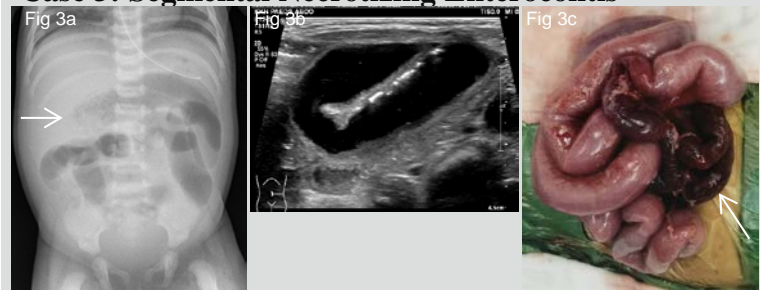
from an upper GI contrast study shows complete obstruction at the 3<sup>rd</sup> part of the duodenum (arrow) which is diagnostic of malrotation. **Fig 1c.** US image of the duodenal loops shows increased echogenicity and thickening of the bowel wall with no colour Doppler signals detected. These findings are suspicious for bowel gangrene which was found at surgery.

### Case 2: Necrotizing Enterocolitis



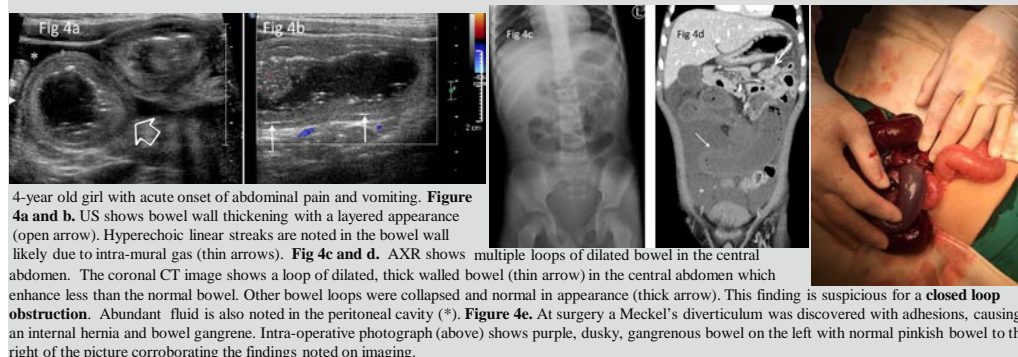
8-day old premature neonate (35 weeks gestational age) developed septic shock and bowel distension. **Fig 2a and b.** Serial AXRs over 6 hours show persistently dilated bowel loops throughout the abdomen. No definite intramural, free intra-peritoneal or portal venous gas is seen. **Fig 2c and d.** US shows the presence of intra-mural gas as hyperechoic, granular foci with posterior reverberation artefacts (thin arrows). Intra-luminal gas is also seen (open arrow) and can be distinguished from intramural gas by its location. Peritoneal fluid is also noted (\*). **Fig 2e and f.** US shows hyperechogenicity of the valvulae ('zebra' or 'herringbone' pattern). This is a sign of severe necrotizing enterocolitis. Gas in the portal hepatic system is also noted (open arrow). A large amount of clear peritoneal fluid was found at surgery. 2 areas of necrotic bowel with impending perforation were noted in the jejunum 90cm, from the DJ junction and in the terminal ileum, 15cm from the ileo-colic valve.

### Case 3: Segmental Necrotizing Enterocolitis



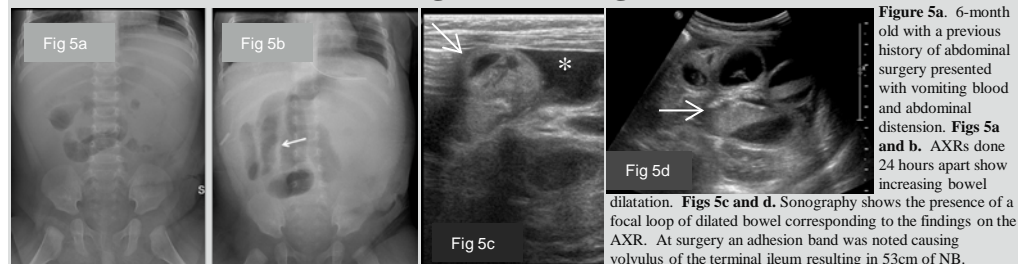
30-day old premature neonate developed sepsis and bowel distension. **Fig 3a** AXR shows a few dilated bowel loops with mottled lucencies suspicious for intra-mural gas. **Fig 3b** US shows the presence of a focal loop of dilated bowel without definite intra-mural gas. Colour Doppler flow was poorly demonstrated within this loop of bowel. **Fig 3c** At surgery a segment of dusky-coloured necrotic bowel was found (arrow) and resected. The other bowel loops were healthy.

### Case 4: Meckel's Diverticulum with adhesions causing an Internal Hernia with Closed Loop Obstruction



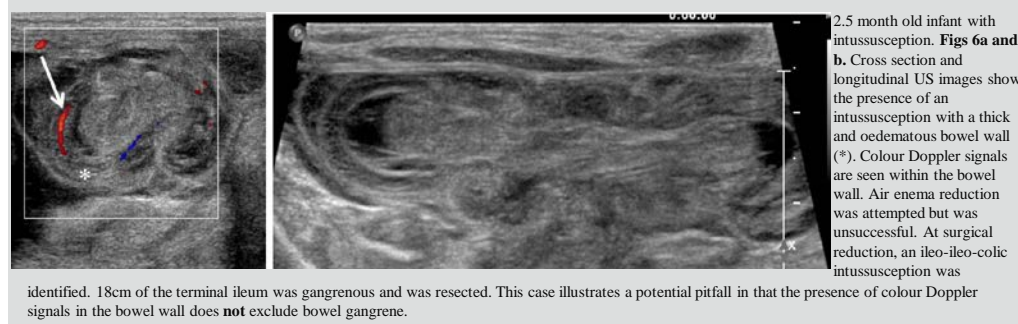
4-year old girl with acute onset of abdominal pain and vomiting. **Figure 4a and b.** US shows bowel wall thickening with a layered appearance (open arrow). Hyperechoic linear streaks are noted in the bowel wall likely due to intra-mural gas (thin arrows). **Fig 4c and d.** AXR shows multiple loops of dilated bowel in the central abdomen. The coronal CT image shows a loop of dilated, thick walled bowel (thin arrow) in the central abdomen which enhance less than the normal bowel. Other bowel loops were collapsed and normal in appearance (thick arrow). This finding is suspicious for a closed loop obstruction. Abundant fluid is also noted in the peritoneal cavity (\*). **Figure 4e.** At surgery a Meckel's diverticulum was discovered with adhesions, causing an internal hernia and bowel gangrene. Intra-operative photograph (above) shows purple, dusky, gangrenous bowel on the left with normal pinkish bowel to the right of the picture corroborating the findings noted on imaging.

### Case 5: Adhesive band causing bowel strangulation and necrosis



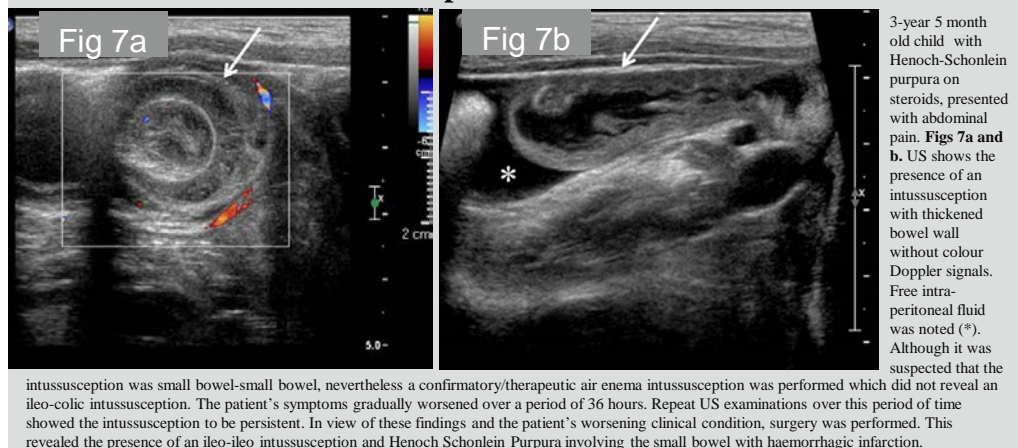
**Figure 5a.** 6-month old with a previous history of abdominal surgery presented with vomiting blood and abdominal distension. **Figs 5a and b.** AXRs done 24 hours apart show increasing bowel dilatation. **Figs 5c and d.** Sonography shows the presence of a focal loop of dilated bowel corresponding to the findings on the AXR. At surgery an adhesion band was noted causing volvulus of the terminal ileum resulting in 53cm of NB.

### Case 6: Ileo-ileo-colic intussusception with necrotic terminal ileum



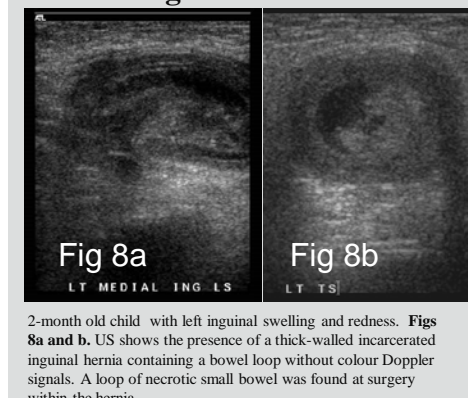
2.5 month old infant with intussusception. **Figs 6a and b.** Cross section and longitudinal US images show the presence of an intussusception with a thick and oedematous bowel wall (\*). Colour Doppler signals are seen within the bowel wall. Air enema reduction was attempted but was unsuccessful. At surgical reduction, an ileo-ileo-colic intussusception was identified. 18cm of the terminal ileum was gangrenous and was resected. This case illustrates a potential pitfall in that the presence of colour Doppler signals in the bowel wall does not exclude bowel gangrene.

### Case 7: Henoch-Schonlein Purpura



3-year 5 month old child with Henoch-Schonlein purpura on steroids, presented with abdominal pain. **Figs 7a and b.** US shows the presence of an intussusception with thickened bowel wall without colour Doppler signals. Free intra-peritoneal fluid was noted (\*). Although it was suspected that the intussusception was small bowel-small bowel, nevertheless a confirmatory/therapeutic air enema intussusception was performed which did not reveal an ileo-colic intussusception. The patient's symptoms gradually worsened over a period of 36 hours. Repeat US examinations over this period of time showed the intussusception to be persistent. In view of these findings and the patient's worsening clinical condition, surgery was performed. This revealed the presence of an ileo-ileo intussusception and Henoch Schonlein Purpura involving the small bowel with haemorrhagic infarction.

### Case 8: Inguinal Hernia



2-month old child with left inguinal swelling and redness. **Figs 8a and b.** US shows the presence of a thick-walled incarcerated inguinal hernia containing a bowel loop without colour Doppler signals. A loop of necrotic small bowel was found at surgery within the hernia.

## Summary

In the appropriate clinical setting, NB should be suspected if the following features are noted on US:

1. Thickened bowel wall – may be echogenic, hypoechoic or layered.
2. Air in the bowel wall appearing granular or linear hyperechoic foci with posterior reverberation artefacts.
3. Hyperechogenicity of the valvulae ('zebra' or 'herringbone' pattern). Colour Doppler signals may or may not be present in the bowel wall.
4. Fluid in the peritoneal cavity.
5. Pneumoperitoneum/Portal venous gas.

## References

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2. Hryhorczuk AL et al (2012) Imaging evaluation of bowel obstruction in children: updates in imaging techniques and review of imaging findings *Semin Roentgenol* 47:159.
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