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REVIEW

Gastrointestinal pathology in neonates: new imaging strategies

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Abstract The mainstay of imaging of gastrointestinal (GI) pathology in infants has always been and still is the plain radiograph of the abdomen and conventional contrast studies. In this review emphasis is placed on the situations where there are new imaging strategies and alternative modalities of imaging, including US, CT, MRI and radionuclide studies. This review will deal with GI pathology in the newborn and in the older neonate. It will also refer to any new approaches to imaging GI pathology in the premature infant. Finally the review will address how antenatal diagnosis of gastrointestinal tract abnormalities has changed the imaging strategy and management of the neonate.

Keywords Gastrointestinal · US · MRI · CT · Radioisotope · Neonate · Infant

Introduction

The mainstay of imaging of gastrointestinal (GI) pathology in infants has always been and still is the plain radiograph of the abdomen and conventional contrast studies. In this review emphasis is placed on the situations where there are new imaging strategies and alternative modalities of imaging, including ultrasound, CT, MRI and scintigraphy, and these shall be put into context of management of neonates and the role of alternative imaging will be defined in reference to the plain film and contrast studies.

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This review will deal with GI pathology (excluding liver, biliary system and pancreas) in the newborn—mostly obstruction such as atresia, meconium ileus and Hirschsprung disease (HD)—and also duplication cysts. It will also deal with GI pathology in the older neonate such as pyloric stenosis, malrotation and volvulus and feeding difficulties. It will also refer to any new approaches to imaging GI pathology in the premature infant especially necrotising enterocolitis (NEC) and its complications.

Lastly this review will address how antenatal diagnosis of GI tract abnormalities by US, MRI and amniotic fluid digestive enzyme (AFDE) assays has changed the imaging strategy and management of the neonate.

Gastrointestinal pathology in the term newborn

Intestinal obstruction

When a baby presents with abdominal distension and failure to pass meconium, a clinical diagnosis of intestinal obstruction is made. A plain abdominal radiograph can distinguish between duodenal obstruction, jejunal atresia and more distal atresia.

It is not usually possible to distinguish ileal obstruction from colonic obstruction on the plain radiograph alone. Traditionally the next investigation has been a contrast enema. An abdominal US may have a role here. With US one can distinguish dilated from collapsed loops (Fig. 1). One can often distinguish ileal loops from colon and it is also possible to distinguish the dilated fluid-filled loop proximal to an atresia from the dilated meconium-filled loop of a meconium ileus [1]. It may be possible to proceed directly to surgery for jejunal or ileal atresia or to proceed to reduction of a meconium ileus by contrast enema.

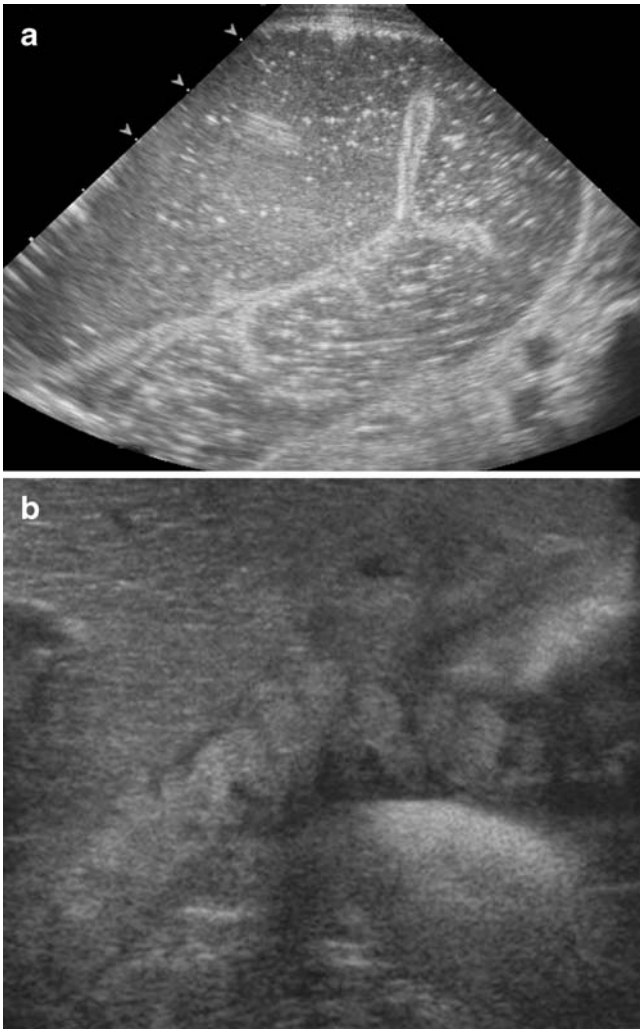

Fig. 1 US in intestinal obstruction in a newborn shows (**a**) dilated fluid-filled jejunal loops. **b** Elsewhere in the abdomen collapsed jejunal loops are identified consistent with jejunal atresia

In babies with meconium ileus there has been a change in imaging strategy from attempted reduction of the obstruction by contrast enema towards multiple attempts at reduction with reported increase in success rate of non-invasive reduction (Fig. 2) [2].

Hirschsprung disease

Some doubt has been cast on the value of contrast enema for definition of the transition zone in HD, especially in the newborn [3]. Changes in biopsy technique and surgical procedures have also changed the role of imaging in HD. In the past confirmation of diagnosis of HD required a full thickness biopsy that was an invasive procedure performed under general anaesthetic. With the introduction of the bedside mucosal biopsy, the importance of imaging in diagnosis of this disease was diminished. More recently the possibility of transanal primary resection in those babies

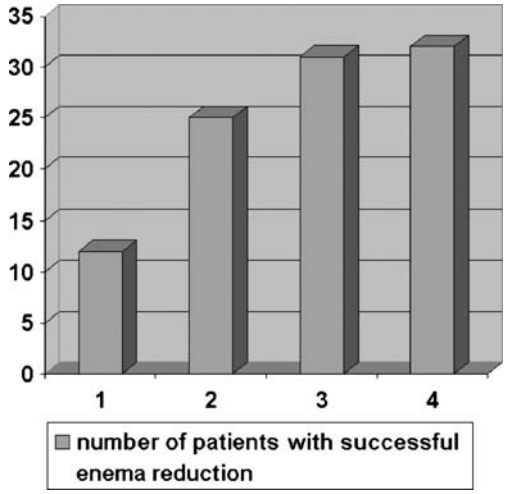

Fig. 2 This graph shows the cumulative number of successful reductions against number of attempts of reduction, in a study of 42 neonates with simple meconium ileus. Overall successful relief of obstruction was achieved in 32 (76.2%) cases [2]

with a short aganglionic segment makes preoperative imaging diagnosis of the level of transition important again, since it is on the basis of this information that babies are selected as suitable for this surgical approach [4].

Anorectal anomalies

In imperforate anus, imaging may have a role in determining whether the bowel ends above the pelvic floor (high imperforate anus) or below it (low imperforate anus). A lateral radiograph of the inverted or semi-inverted infant, the invertogram, was traditionally used for this but may be inaccurate if the blind-ending bowel contains semisolid material rather than air or if the air-filled blind-ending bowel pushes distally against the pelvic floor as the infant cries or strains. US of the perineum has been used to determine the position of the bowel with respect to the pelvic floor and bony landmarks [5].

In anorectal anomalies MR imaging may be useful for the evaluation of the anal muscle rings, especially in the postoperative infant [6].

Tracheo-oesophageal fistula

The diagnosis of tracheo-oesophageal fistula, when it is associated with oesophageal atresia, can be made with a radiograph alone. The diagnosis of the less common tracheo-oesophageal fistula without atresia, the H-type fistula, can however be difficult. Contrast oesophagogram and tube oesophagogram, including the use of prone fluoroscopy, are the traditional first choice of imaging. Laffan et al. [7] proposed that a tube oesophagogram is not necessary if the contrast oesophagogram is normal. If suspicion of a fistula

remains, other imaging strategies that have been proposed include multiplanar or three-dimensional CT, MRI and even radioisotope studies [8, 9].

Duplication cysts

These are often detected antenatally as abdominal or pelvic cysts. In the newborn, US is the best initial imaging technique (Fig. 3) [10]. The US appearance of cysts in the neonatal abdomen is however often nonspecific. Duplication cysts may not have the classic layered hyper- and hypoechoic wall and may be difficult to distinguish from the more common ovarian cysts in girls. The best imaging strategy in asymptomatic neonatal abdominal cysts is follow-up US at 3 weeks and 6 months to document reduction in size of ovarian cysts.

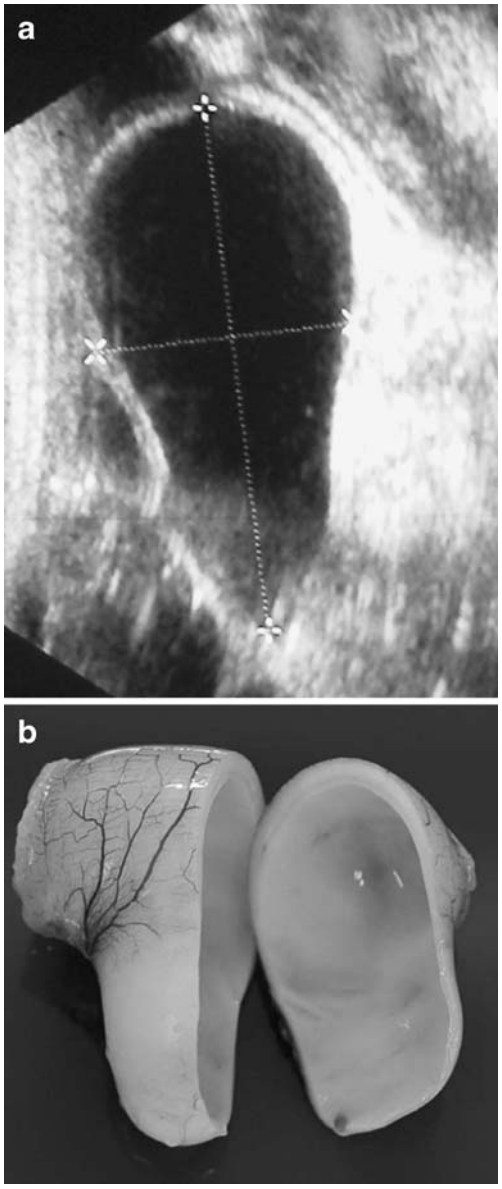

Fig. 3 Duplication cyst of the ileum presenting as neonatal intestinal obstruction. When the US image (**a**) is compared with the surgical specimen (**b**) one can see that the upper part of the cyst as seen on US corresponds to the cyst invaginated into the ileum so that two layers of bowel wall drape over the upper part of the cyst, while the lower part of the cyst is made of the cyst wall alone

Gastrointestinal pathology in the older neonate

Pyloric stenosis

US remains the standard technique for diagnosis of pyloric stenosis in neonates. Huang et al. [11] have defined a US-measured ratio to evaluate the regression of pyloric stenosis after pyloromyotomy.

A high concordance rate of hypertrophic pyloric stenosis is seen in twins. It has been suggested that one consider scanning the asymptomatic co-twin when one twin presents with pyloric stenosis [12].

Malrotation and volvulus

A diagnosis of malrotation or volvulus cannot be made on a radiograph alone and contrast studies should be performed, especially where there is any suspicion of volvulus. The radiograph may be useful nonetheless. In the neonate who is not severely ill the presence of multiple dilated loops of bowel throughout the abdomen makes duodenal obstruction unlikely and a more distal obstruction can be considered.

US of the position of the superior mesenteric artery (SMA) and vein (SMV) is useful in the non-acute situation to raise the possibility of malrotation. US of the acute or vomiting baby may identify a “whirlpool sign” in volvulus due to clockwise wrapping of bowel, mesentery and SMV around the SMA [13].

More recently Yousefzadeh [14] has proposed that US demonstration of the position of the third part of the duodenum between the aorta and the SMA in transverse and sagittal plains is the most reliable diagnostic method for malrotation rather than the position of the duodenojejunal flexure. CT or MRI could also be used to confirm the retroperitoneal position of the duodenum.

Gastro-oesophageal reflux

In addition to the conventional contrast study, radioisotope scanning has a role in detection of gastro-oesophageal reflux and aspiration even in the neonate [15]. In this age group mild reflux is common, but so also is reflux and aspiration associated with significant hypoxic events.

Feeding difficulties

Swallowing dysfunction with aspiration is a common cause of feeding-related difficulties including hypoxic events during feeding in infancy. In infants with feeding difficulties a videofluoroscopic feeding study may demonstrate aspiration when the standard contrast study is negative (Fig. 4) [16].

Gastrointestinal pathology in the baby born preterm

Necrotising enterocolitis

The plain radiograph is used to detect intramural air in the diagnosis of NEC. However, US is increasingly being used to make the diagnosis. US can detect intramural air and define its mural location with greater confidence than radiographs [17, 18]. US can also detect bowel wall thickening and thinning, intrabdominal fluid and abnormal bowel wall perfusion where radiographs are negative [Fig. 5]. US findings in NEC have been found to correlate with prognosis [19].

Intestinal motility disturbances in preterm infants

Doppler study of blood flow parameters in the SMA has been shown to be useful for prediction of intestinal motility disturbances in preterm infants. Infants with pathological blood flow parameters show poor tolerance of enteral feeding during the first week of life [20].

Fig. 4 Aspiration of contrast into the trachea in a 10-day-old neonate seen on a videofluoroscopic feeding study performed to evaluate hypoxic episodes during feeding

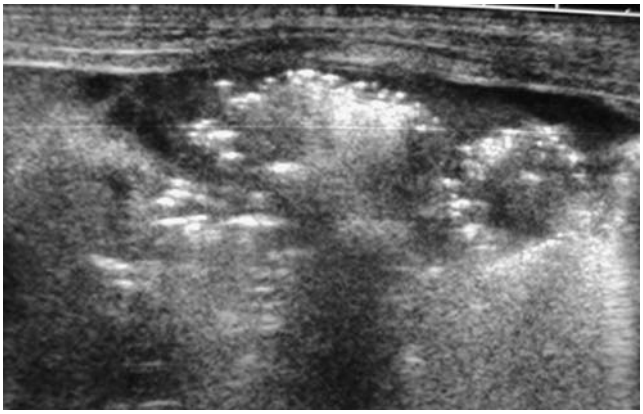

Fig. 5 US in a premature infant at 5 days of age showing intramural gas and free fluid due to NEC

Evaluation of gastric emptying and small intestinal transit time in preterm infants

Feeding difficulties in preterm infants are often related to abnormalities of gastric emptying and bowel transit time. In some babies this may be due to a stricture as a complication of prior NEC but in many no definite obstruction is identified. Management is very different depending on whether a stricture is present or not. Assessment is traditionally by oral or rectal contrast studies. Bode et al. [21] have proposed a radioisotope method to determine gastric emptying and small intestinal transit time in preterm infants that produces minimal radiation exposure and physical disturbance in these infants.

The effect of antenatal diagnosis on the imaging of neonates

When an infant with an antenatal diagnosis of gastrointestinal pathology is born with symptomatic intestinal obstruction or a symptomatic mass, their initial imaging management may be unaffected by the antenatal diagnosis. Thus a baby with an antenatal diagnosis of duodenal atresia is imaged by plain radiograph of the abdomen just as a baby whose duodenal atresia is diagnosed because of neonatal vomiting.

In some babies however, an antenatal diagnosis may significantly affect postnatal management. In some cases antenatal diagnosis may make one aware of disease that would otherwise be asymptomatic in the newborn. One has then to develop new imaging or management strategies to manage such babies. The postnatal importance of the finding

of echogenic bowel antenatally, for example, has not been well established. Many are transient, but more than 10% will have an abdominal abnormality at birth and imaging may be required to evaluate many of these babies [22].

A diagnosis of meconium peritonitis may be made antenatally on the basis of linear calcification and fluid in the peritoneum. This may be due to prior intrauterine bowel perforation that may in turn be due to intestinal obstruction in the fetus. If the baby has neither clinical peritonitis nor clinical intestinal obstruction when born, one has a dilemma whether to feed the baby or whether to do contrast studies to look for obstruction or perforation before feeding [23]. Some authors advocate the use of neonatal CT to define persistent intestinal perforation invisible with prenatal US [24].

Antenatal US and MRI may correctly diagnose other intestinal pathology including anorectal anomalies, but associated urodigestive fistulas can really only be diagnosed by postnatal imaging [25]. Enterolithiasis (multiple calcifications of intraluminal meconium) is a rare prenatal US finding and raises the possibility of an urodigestive fistula, although the fistula cannot be demonstrated antenatally. This antenatal finding directs postnatal imaging towards the detection of such a fistula [26].

Conclusion

The mainstay of imaging of gastrointestinal (GI) pathology in infants remains the plain radiograph of the abdomen and conventional contrast studies. Alternative modalities of imaging, including US, CT, MRI and radioisotope studies, may contribute to diagnosis in certain situations. Antenatal imaging may allow diagnosis of asymptomatic disease and requires a new approach to postnatal imaging.

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