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Ultrasound diagnosis of midgut volvulus: the "whirlpool" sign*

J. P. Pracros[1], L. Sann[2], G. Genin[1], V. A. Tran-Minh[1], C. H. Morin de Finfe[1], P. Foray[1], and D. Louis[3]

[1] Department of Pediatric Radiology, [2] Department of Neonatology
[3] Department of Pediatric Surgery, Hôpital Debrousse, 29 rue soeur Bouvier, F-69322 Lyon cedex O5, France

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Abstract. The authors present their US findings in 24 patients with proved complicated midgut malrotation: volvulus in 18 and occlusive Ladd's bands in 6. All the 24 patients have had US examination prior to surgery. Contrast examinations were performed in only 9 patients, always after US and before surgery. The sonographic "whirlpool" pattern of the superior mesenteric vein and mesentery around the superior mesenteric artery was detected in 15 of the 18 patients with midgut volvulus, and was best seen using Doppler color. Embryological signification of midgut malrotation is discussed.

Midgut volvulus is an abdominal surgical emergency occuring mainly in the neonatal period but sometimes presenting late [1]. It is a potential complication of midgut malrotation which can be either non-rotation or an incomplete rotation of the primitive intestinal loop during the fetal life [2]. Midgut volvulus is usually secondary to a clockwise rotation around the axis of the superior mesenteric artery (SMA). Bile-stained vomiting is an acute clinical sign leading us to suspect midgut volvulus, which requires rapid radiological investigation and treatment. Unfortunately, these radiological investigations are not always reliable and well tolerated, and are time consuming [3, 4]. Previous reports describe an abnormal position of the mesenteric vessels which can indicate malrotation of the midgut [5–9] which is seen mostly in neonates and infants without abdominal mass lesions [10]. Therefore, it was our aim to study the usefulness of ultrasound (US) in the diagnosis of midgut volvulus, because it is easy to carry out in intensive care units.

Patients and methods

Abdominal US was performed in 24 patients (15 male and 9 female neonates, from the age of one day to sixteen months), all confirmed as having an acute complication of midgut malrotation at surgery. Upper gastrointestinal series and/or barium enema were performed in only 9 patients after sonographic examination and before surgery. US studies were performed with two different commercial units (ATL and Hitachi) using high frequency sector or curved transducers. Color Doppler examination was carried out in two patients with a Toshiba unit. Special attention was given in this study to localize the superior mesenteric vessels. Transverse sections of the epigastrium were the most useful. In most cases, the superior mesenteric vein (SMV) is located normally on the right side of the SMA (Fig. 1). Sometimes, two veins are seen lateral to the SMA: the vein on the right side is the SMV, while the vein on the other side corresponds to the inferior mesenteric vein.

Results

In all 24 patients, an abnormal position of the SMV in respect to the SMA was observed, suggesting midgut malrotation: the SMV was located on the left side (Fig. 2) or sometimes in front (Fig. 3) of the SMA in every patient. Eighteen patients presented at surgery with volvulus; in 15 of them a "whirlpool" pattern of SMV and mesentery was detected by an US examination. This sign corresponds to a clockwise wrapping of the SMV and the mesentery

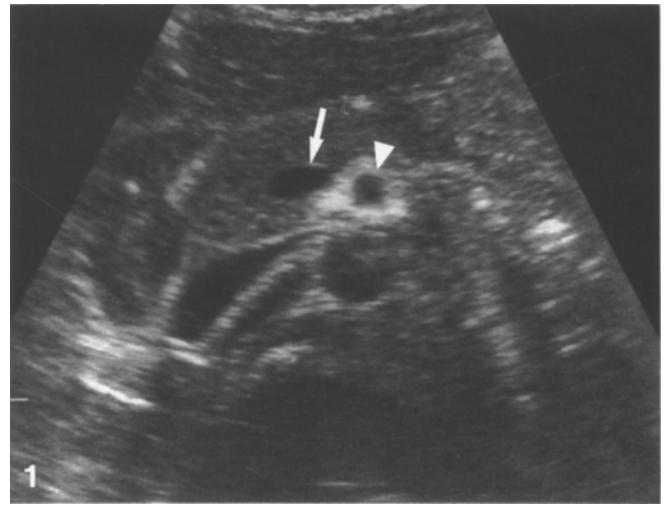

Fig. 1. US transverse section shows the normal position of SMV *(arrow)* on the right side of SMA *(arrowhead)*. SMA is surrounded by an echogenic ring

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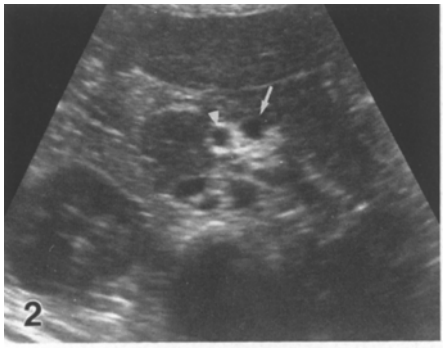

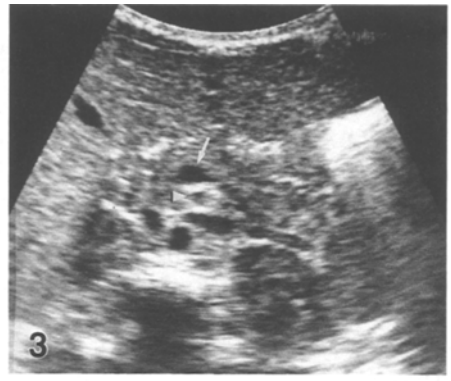

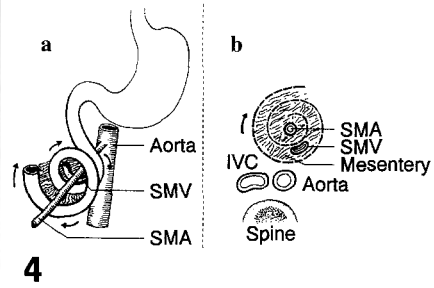

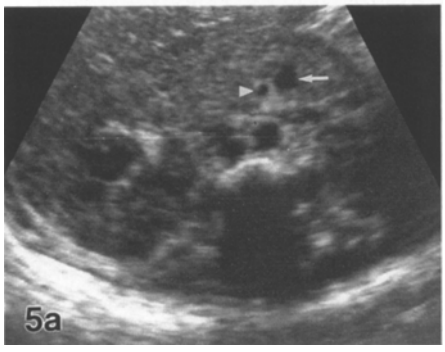

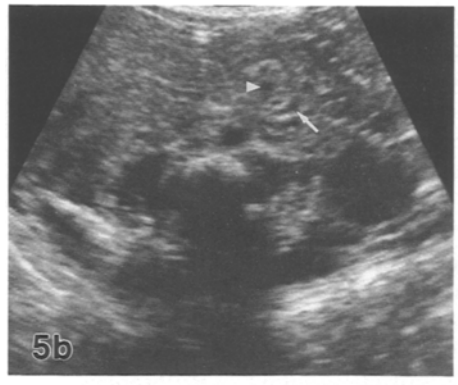

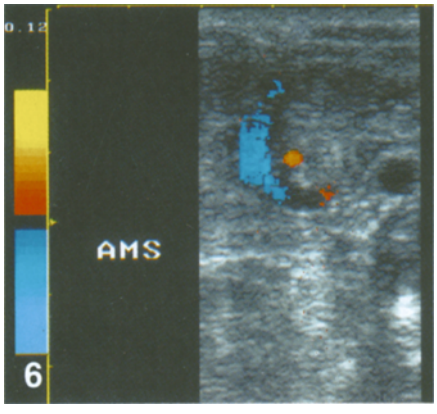

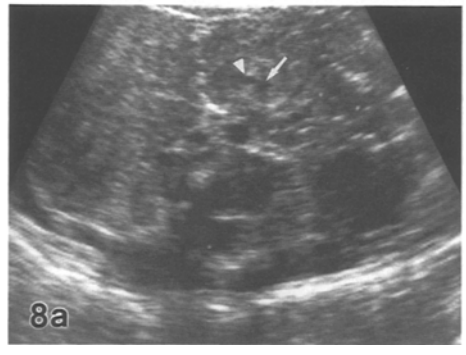

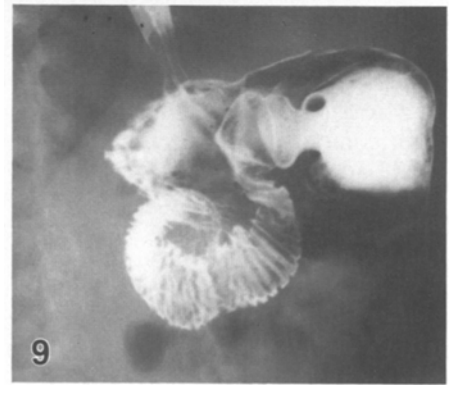

Fig. 2. US transverse section. SMV *(arrow)* on the left side of SMA *(arrowhead)* in a case of malrotation (nonrotation in this case)

Fig. 3. US transverse section. SMV *(arrow)* in front of SMA *(arrowhead)*. Malrotation was present in this patient and confirmed by gastrointestinal opacifications

Fig. 4 a, b. Diagram of the whirlpool sign
a Diagram of the midgut volvulus wrapping of the gut, the mesentery and the SMV around the SMA, which is the axis of the clockwise rotation of gut
b Corresponding diagram of the whirlpool sign: US transverse section of the midgut volvulus centered by the SMA, with the mesentery and the SMV coiling around, in front of the aorta

Fig. 5 a, b. Two transverse US scans in a patient with midgut volvulus **a** The SMV *(arrow)* is located on the left side of the SMA *(arrowhead)* **b** More caudally: the whirlpool sign. The SMV *(arrow)* is coiled with mesentery around the SMA *(arrowhead)*

Fig. 6. US color doppler. Whirlpool with complete wrapping of the SMV around the SMA in clockwise rotation of the mesentery. SMV *(in blue)* is seen behind and on the right side of the SMA *(in red)*

Fig. 7. US whirlpool sign with dilated SMV *(arrow)*

Fig. 8 a, b. Two US transverse scans, up **a**, and more caudally **b** in a patient with tumour-like pattern of the volvulus *(open arrow)* in front of the aorta. SMV *(arrow)*, SMA *(arrowhead)*

Fig. 9. Upper gastrointestinal radiological opacification after US diagnosis of midgut volvulus. Pigtail aspect of the duodenum

around the SMA (Fig. 4 and 5). This was confirmed by color Doppler in two patients (Fig. 6). The SMV could be collapsed or dilated (Fig. 7). In addition, an heterogeneous tumour-like appearance was seen more caudally and around the SMA (Fig. 8) in three patients, who were found to have an ischemic bowel at surgery. In the other six patients with complicated malrotation, obstructed duodenum by Ladd's bands without volvulus was proved at surgery; in none of them, the "whirlpool" sign was present at the US examination.

Discussion

Midgut volvulus is one of the most life-threatening abdominal emergencies in the neonatal period. Bile-stained vomiting and sometimes bloody stools must be considered as immediate alarm. Until recently, only gastro-intestinal contrast examinations were used to prove a malrotation before surgery in such acute situations. Upper gastro-intestinal series may confirm the diagnosis of volvulus showing a pigtail aspect of the distal duodenum and proximal jejunum (Fig. 9). However radiological examinations may cause deterioration of the clinical condition of these unstable newborns and may delay urgent surgical treatment. Radiological misinterpretation of the position of the duodenojejunal junction or cecal position may lead to errors, because there is a pattern of non-rotation of the normal presentation after a 270° rotation of the primitive gut [1, 3]. Ultrasound was recently proposed for the diagnosis of midgut malrotation [6, 7] and volvulus [5, 11, 12] and can be performed in intensive care units without delaying surgery. But, US has the disadvantage of being operator-dependent. Most publications on US report only few patients. The US diagnosis of dilated duodenum [11] is not a specific sign of midgut volvulus and may be absent in a vomiting patient. This pattern was observed in only five of our patients. Recently, Leonidas [12] reported dilated thick-walled bowel loops, mainly on the right of the spine, and peritoneal fluid in three patients with midgut malrotation complicated by volvulus. These anomalies are probably only present in advanced volvulus and were not observed in our cases. Patent fluid effusion was noted in only four cases of our study. The clinical relevance of these signs deserves further investigations. Nevertheless, the US signs of Hayden [11] and Leonidas [12] may indicate a need for urgent treatment. Our present study suggests that volvulus due to midgut malrotation can be detected by the "whirlpool" US sign. The "whirlpool" sign in the complications of midgut malrotation with volvulus was found during a systematic study of the SMA and the SMV positions in more than 5000 patients. The sign appeared specific for midgut volvulus since it was not observed in other complications of midgut malrotations, such as isolated Ladd's bands. In every patient, the specificity of this US finding, which was seen more clearly by using color Doppler, was confirmed by surgery. In our experience, the normal anatomical position of the SMV is on the right side of SMA, but sometimes also in front of the SMA. Superior mesenteric vessels must be studied by US as caudally as possible to appreciate completely the respective position of the SMV and the SMA. When the SMV is located on the left side of the SMA, intestinal malrotation is frequently associated, with complete absence of embryological rotation of the primitive intestinal loop (nonrotation). In addition, the SMV was detected by ultrasound in front of the SMA in some patients with 180° malrotation. The malposition of SMV and SMA is not only specific of midgut malrotation, but can also be induced by tumours or tumour-like lesions [6]. One patient who was operated on in the neonatal period for midgut volvulus without Ladd's procedure developed a recurrence of volvulus two months later which was diagnosed by US and showed a "whirlpool" sign, but with an unusual counter clockwise rotation of SMV around SMA. Volvulus was confirmed at surgery. In six patients who were re-examined with US after surgery for a complicated midgut malrotation with Ladd's procedure, the SMV was located on the left side of the SMA, similar to patients with non-rotation.

The results of our study suggest new concepts about embryology of the gut. The SMV could develop from the left vitelline vein and not the right one, as suggested by some authors [13, 14]. During the normal double clockwise rotation of the primitive gut, the SMV probably crosses in front of the SMA (rotation of 90°) to reach its final position on the right side of the SMA when complete rotation of 270° occurs. In the absence of rotation of the gut (nonrotation), the SMV retains its position on the left side of the SMA. The SMV may be observed in an intermediate position in front of the SMA, if incomplete rotation of the gut occurs. Further embryological, anatomical and radiological studies are necessary to confirm our results, in order to identify earlier the newborns with high risk for midgut volvulus.

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J. P. Pracros, MD
68 avenue Charles de Gaulle
F-69160 Tassin la demi lune
France