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Original Article

Prenatal diagnosis of midgut volvulus using two-dimensional and three-dimensional ultrasound

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Abstract: Objective: Fetal midgut volvulus is rare and fatal, which can be easily missed on prenatal two-dimensional (2D) ultrasonography. The purpose of this study was to review our experience in prenatal diagnosis of midgut volvulus using 2D and three-dimensional (3D) ultrasound, so as to assess the diagnostic value of the two ultrasonic methods in fetal midgut volvulus. Methods: The retrospective study was conducted on 355 fetuses with intestinal dilatation diagnosed with 2D ultrasonography in the First Affiliated Hospital of Anhui Medical University from January 2017 to December 2019. All cases underwent 3D volume-rendered imaging. The diagnostic value of the two ultrasonic methods in fetal midgut volvulus was assessed. Results: Twelve cases of midgut volvulus were confirmed during postnatal surgery, 11 of which were correctly identified by prenatal imaging. On 2D ultrasound images, the whirlpool sign was observed in 5/12 (41%) fetuses, and of these 5 fetuses, one case also showed the coffee-bean sign. Two weeks later, another fetus showed the coffee-bean sign on ultrasound. The coffee-bean sign without the whirlpool sign was observed in two fetuses. The spiral sign was observed in 9 of the 12 cases (75%) with 3D imaging using the inversion mode. The sensitivity, specificity and accuracy of 2D ultrasound diagnosis were 83.3%, 93.3% and 93.0%, respectively. The sensitivity, specificity and accuracy of 3D ultrasound diagnosis were 91.7%, 98.3% and 98.0%, respectively. Conclusion: Midgut volvulus should be highly suspected in the presence of intestinal dilatation and positive spiral sign on 3D volume-rendered images. Absent or decreased intestine wall echo on 2D and 3D images may be indicative of intestinal necrosis.

Keywords: Three-dimensional, two-dimensional, ultrasonography, fetal midgut volvulus, crystal Vue, realistic Vue

Introduction

Fetal midgut volvulus is a rare and life-threatening condition usually secondary to intestinal malrotation, cystic fibrosis, and mesenteric dysplasia. However, sometimes it also occurs for no apparent reason [1]. Intrauterine volvulus can induce ischemic necrosis and may be complicated with intestinal atresia [2]. Volvulus could also lead to necrotic intestinal perforation, hemorrhagic ascites and anaemia [3]. Cloutier *et al.* first reported ultrasonic features for the prenatal diagnosis of midgut volvulus [4].

The whirlpool sign on prenatal two-dimensional (2D) ultrasound is considered to indicate midgut volvulus [5]. However, the 2D ultrasound features are largely nonspecific and are therefore often underdiagnosed. Three-dimensional (3D) ultrasound, on the other hand, can not only provide better visualization of fetal malformation, but also improve diagnostic ability. 3D inversion mode ultrasonography is a volumetric analytic approach that can enhance the visualization of fluid-filled fetal structures [6]. In some Chinese hospitals of poor areas, especially township hospitals, prenatal diagnosis mainly relies on 2D and 3D ultrasound. Therefore, in this study, we retrospectively reviewed our experience in prenatal diagnosis of midgut volvulus using 2D and 3D volume-rendered imaging, especially the 3D inversion mode, so as to provide a basis for the application of ultrasound in prenatal diagnosis of fetal midgut volvulus.

Participants and methods

This retrospective study was approved by the Ethics Committee of the First Affiliated Hospital of Anhui Medical University (YYLL2018-hwk2018zc002-01-01). All the pregnant women and their families agreed and signed the informed consent form. In this retrospective study, 355 cases (355/97,297) of intestinal dilatation diagnosed by ultrasound examination at our hospital from January 2017 to August 2019 were enrolled. Inclusion criteria: (1) pregnant woman with singleton pregnancy; (2) pregnant woman with complete prenatal ultrasound examination data; (3) fetal midgut volvulus confirmed by examination after delivery. Exclusion criteria: (1) pregnant woman with incomplete prenatal examination data; (2) pregnant woman who had induced labor. All examinations were performed during middle and late pregnancy using a Samsung WS80A Elite Color Doppler ultrasound unit equipped with a CV1-8A volume probe and a C2-6 convex array probe. This machine has Crystal Vue and Realistic Vue rendering modes, which are two new volume rendering techniques that preserve context and surface information. With the application of Crystal Vue and Realistic Vue, the interior and exterior structures can be visualized while preserving the precise shape and giving meaningful information to assist morphologic diagnosis. These rendering modes allowed us to easily differentiate the soft tissue and structure with an automated setting for an optimal image in a complex situation. The sub-menu of Crystal Vue contains two post-processing modes: grayscale and inversion.

2D ultrasound

2D ultrasound was performed first. Fetal biological indicators and umbilical and middle cerebral artery blood flow were recorded. A detailed intestinal assessment was performed on fetuses with intestinal dilatation. The movement of intestinal contents was evaluated, and the echo of the intestinal layers was examined after local amplification. The position and relationship between the superior mesenteric vein (SMV) and the superior mesenteric artery (SMA) were determined by color Doppler imaging.

3D ultrasound

3D volumetric ultrasound imaging was performed on the cross-section of the dilated fetal intestine. Under the surface mode, the scan angle was set as 60°, high scan quality was chosen, and the sampling frame was enlarged to include the skin of the whole abdomen. In this mode, the probe scans automatically completed the acquisition. During image acquisition, the fetal spine was kept between 3 and 9 o'clock as far as possible to reduce the acoustic shadow of the spine. The position of the probe was kept unaltered during data acquisition. After imaging, the data obtained were displayed in the form of four figures: Plane A (initial 2D section of volume sampling data), Plane B (perpendicular to Plane A, showing thickness information in the volume), Plane C (perpendicular to Planes A and B), and 3D images. The 3D images were adjusted using a combination of Crystal Vue and Realistic Vue. In Crystal Vue, both grayscale mode and inversion mode were used for imaging. In the grayscale mode, the sampling line was placed inside the dilated intestine to observe the inner boundary/contents of the intestine and the condition of the intestinal wall. In the inversion mode, the sampling line was placed close to the outer surface of the dilated intestine to allow observation of the outer boundary of the intestine. The light source was adjusted to optimize the display of lesions.

Follow-up

All pregnant women were followed up every two weeks up to 28 weeks of gestation. After 28 weeks, those suspected of midgut volvulus were followed up weekly. Fetal heart rate monitoring was performed weekly from 30 weeks. Prenatal diagnosis was cross-checked with postnatal operation results. Newborns undergoing surgery were followed up for 10 months.

Outcome measures

The primary outcome measures were the diagnostic characteristics and diagnostic value of 2D and 3D ultrasound images. Among them, the diagnostic value was evaluated by sensitivity, specificity and accuracy. Specificity = true positives/(true negatives + false positives) *100%. Sensitivity = true positives/(true positives + false negatives) *100%. Accuracy = (true positives + true negatives)/(true positives + true negatives + false positives + false negatives) *100%.

Table 1. Prenatal ultrasonographic manifestations of 12 newborns with confirmed midgut volvulus

NO.	1	2	3	4	5	6	7	8	9	10	11	12
Age (years)	26	28	21	34	23	28	26	27	32	24	25	30
Gestational age (weeks)	35^{+2}	37	28^{+2}	33^{+4}	36	30	35^{+2}	27	28	22	32	21
Intestinal dilatation	+	+	+	+	+	+	+	+	+	+	+	+
Whirlpool sign	-	+	+	-	+	-	-	+	-	-	-	+
Coffee bean sign	-	+	-	+	-	-	-	After 2 w	-	-	+	-
Change in intestinal movement	+	+	-	+	After 2 w	-	-	After 2 w	After 3 w	After 10 w	+	-
Hydramnios	+	-	-	+	-	-	+	+	-	+	+	-
Change in intestinal wall echo												
2D	+	+	-	+	-	-	-	+	-	+	+	-
3D	+	+	-	+	+	-	-	+	+	+	+	-
Meconium peritonitis	+	+	+	+	+	+	+	+	+	+	+	+
Ascites	+	+	+	+	+	+	+	+	+	+	+	+
Fluid-filled levels	+	+	-	+	-	-	-	-	-	-	-	+
MCA-PSV>95th percentile	+	-	-	+	+	-	-	-	-	+	+	-
Spiral sign												
3D	+	+	+	+	+	-	+	+	+	-	-	+
Prenatal diagnosis	IV	IV	IV	IV	IV	IA	IV	IV	IV	IV	IV	IV

Note: W: weeks; 2D: two-dimensional; 3D: three-dimensional; MCA-PSV: middle cerebral artery peak systolic velocity; IV: intestinal volvulus; IA: intestinal atresia.

Statistical analysis

SPSS 24.0 software was used for statistical analysis. The measured data were expressed as mean ± standard deviation (SD), and the differences were compared using the *t*-test. The counted data were expressed as percentages, and the differences were compared by the chi-square test. $P<0.05$ indicated that a difference was statistically significant.

Results

General information

A total of 12 cases of midgut volvulus were confirmed by postnatal operation, of which 11 cases were correctly diagnosed by prenatal ultrasonography, with 1 missed. The accuracy of 2D and 3D ultrasonography was 93.0% and 98.0%, respectively. The characteristics of the 12 cases are shown in **Table 1**. The maternal age ranged from 21 to 32 years old (average: 27.19±5.43 years old). The gestational age of the first prenatal ultrasonography was 21-37^{+1} weeks (average: 30^{+4}). The gestational age at birth was 31^{+3}-37^{+2} weeks (average: 34^{+5}). There was no response to the non-stress test (NST) in three cases.

Diagnostic characteristics of ultrasonic images

The degree of intestinal dilatation varied in patients with intestinal malrotation and midgut volvulus (**Figure 1F**). There was hyper-echogenicity (equal to that of the bone) in the dilated intestine in 3 cases. The whirlpool sign presented in 5 cases (41%; **Figure 1A**), which disappeared two weeks later (**Figure 1D**). In 4 of these cases, color Doppler flow imaging showed the SMV surrounding the SMA at the center (**Figure 1B**). 3D inversion mode ultrasonography showed the presence of spiral sign (**Figure 1C**), which still presented at week 2 (**Figure 1E**).

In mesenteric stenosis with midgut volvulus (**Figure 2D**), 2D ultrasound showed a whirlpool sign on the cross-section of the abdomen (**Figure 2A**); color Doppler showed normal SMV and SMA (**Figure 2B**), and 3D inversion mode ultrasonography showed a spiral sign (**Figure 2C**).

Coffee-bean and whirlpool signs co-existed in patients with mesenteric dysplasia and midgut volvulus (**Figure 3D**). The coffee-bean sign was seen in 4 cases (33%). In one of these cases, the coffee-bean sign and whirlpool sign presented together (**Figure 3A**, **3B**). In another case, the coffee-bean sign appeared two weeks after the appearance of the whirlpool sign. In the remaining two cases, the coffee-bean sign appeared separately. In one of these latter two cases, the coffee-bean sign no longer presented in the follow-up scan performed 2 weeks later. In addition, 3D inversion mode ultraso-

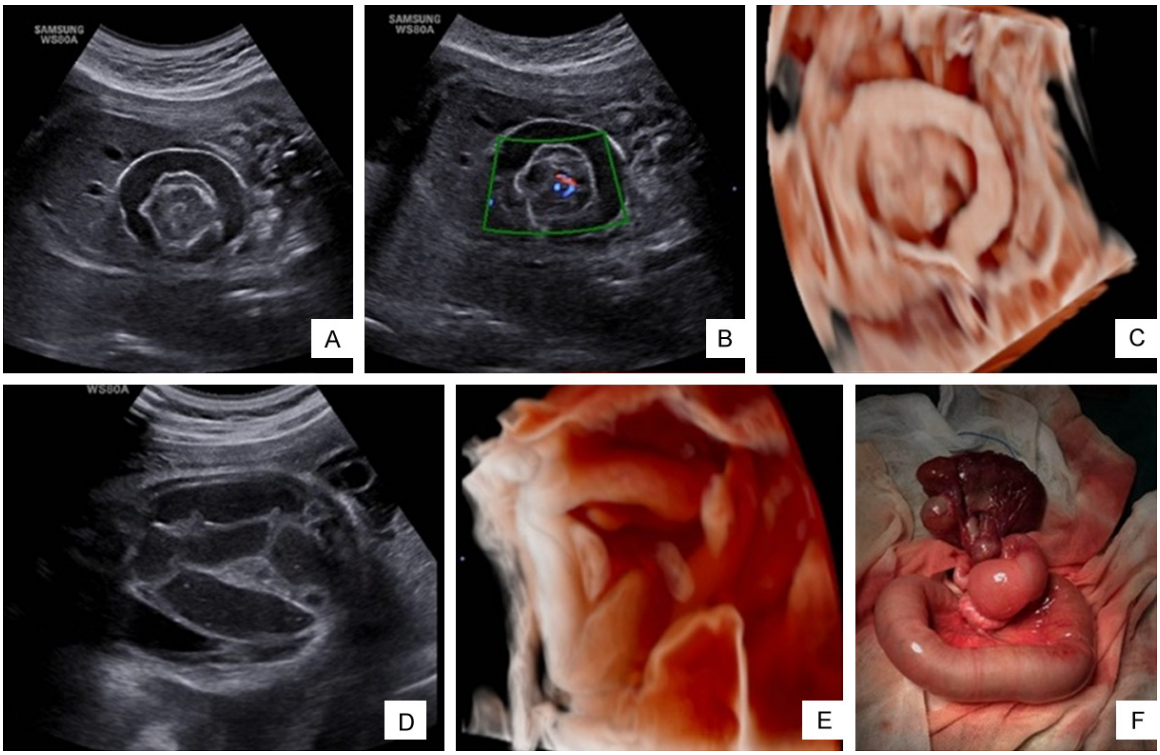

Figure 1. Intestinal malrotation with midgut volvulus. A: Cross-sectional view of the abdomen showed the whirlpool sign; B: Color Doppler showed the superior mesenteric vein running around the superior mesenteric artery; C: Inversion mode showed the spiral sign; D: The whirlpool sign disappeared after 2 weeks; E: Inversion mode still showed the spiral sign; F: Intestinal malrotation with midgut volvulus was confirmed during surgery.

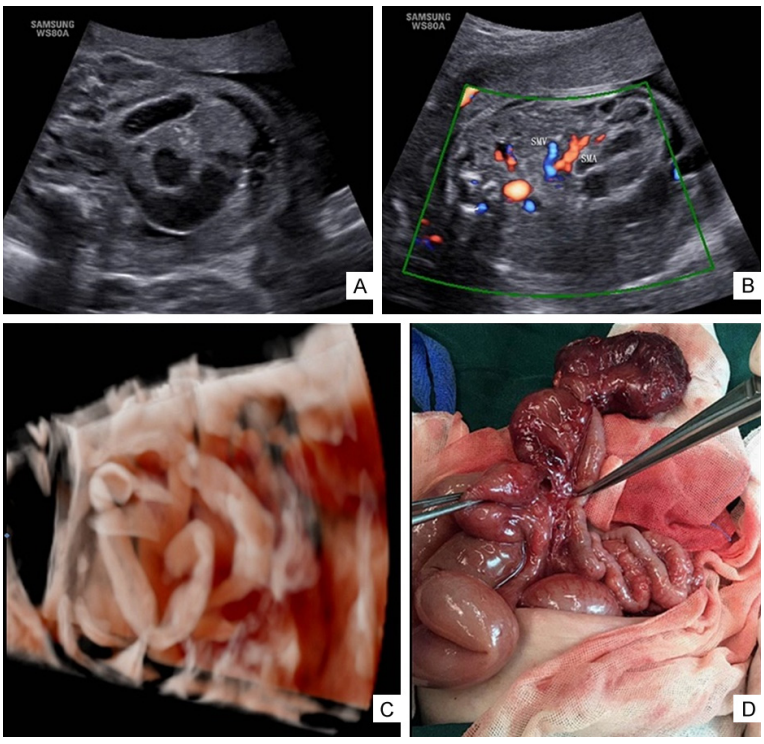

Figure 2. Mesenteric stenosis with midgut volvulus. A: Cross-sectional view of the abdomen showed the whirlpool sign; B: Color Doppler showed normal superior mesenteric vein and superior mesenteric artery; C: Inversion mode showed the spiral signs; D: Mesenteric stenosis with midgut volvulus was confirmed during surgery.

nography showed that the spiral sign still presented (**Figure 3C**).

Midgut volvulus with fetal anemia and intestinal necrosis occurred at 32 weeks of gestation (**Figure 4F**). 2D ultrasound showed no typical signs, but 6 cases (50%) had weakened bowel wall echoes and local monolayer changes (**Figure 4A**), and the peak contraction velocity of middle cerebral artery was observed to be 85 cm/s (**Figure 4B**). 3D images showed that the jejunum was dilated but in normal shape (**Figure 4C**); the gray-

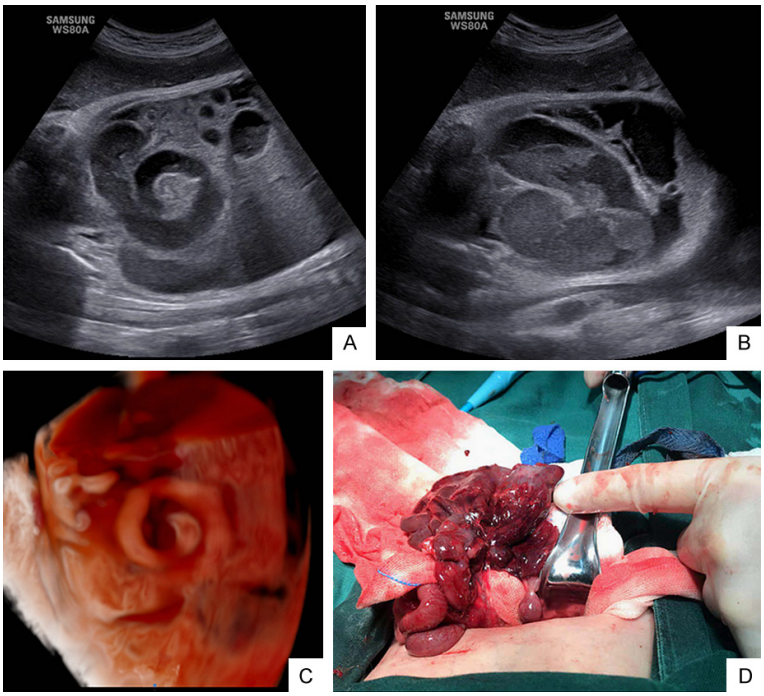

Figure 3. Coffee-bean sign and whirlpool sign co-existed in a patient with midgut volvulus. A, B: Whirlpool and coffee-bean signs in two-dimensional ultrasound images; C: Inversion mode showed the spiral sign; D: Mesenteric dysplasia with midgut volvulus was confirmed during surgery.

scale mode showed that 8 cases (67%) had structural disorder and abnormal echo of the right intestinal wall (**Figure 4D**), and the inversion mode showed 9 cases (75%) with spiral sign (**Figure 4E**).

Diagnostic value of 2D and 3D ultrasound

The diagnostic sensitivity, specificity, and accuracy of 2D ultrasound were 83.3%, 93.3% and 93.0%, respectively. While the diagnostic sensitivity, specificity and accuracy of 3D ultrasound were 91.7%, 98.3% and 98.0%, respectively. The sensitivity, specificity, and accuracy of 3D ultrasound in the diagnosis of intestinal volvulus were higher than those of 2D ultrasound (**Table 2**).

Complications

While one pregnant woman had vaginal delivery, the other eleven underwent cesarean section. All 12 newborns underwent surgery within 1-3 days of delivery. Intestinal necrosis was found in 10 newborns and anaemia was found in 4 (**Table 3**). In addition, jejunal volvulus was identified in 3 newborns (25%) and ileal volvulus in 9 (75%). Volvulus was caused by intestinal malrotation in 5 cases (42%), mesenteric dysplasia in 3 cases (25%), intestinal atresia in 3 cases (25%), and no apparent cause in 1 case (8%). In three newborns, the necrotic site was too close to the ileocecal valve, and resection resulted in short bowel syndrome. These infants showed no improvement even after ten months. In the infant with a substantial cystic mass identified in the prenatal examination, the necrotic intestine was found to have separated into two sections, and the intestine was seriously adhered and cocooned. Biliary atresia (type III) was also present. In this infant, intestinal obstruction recurred three weeks after surgery.

Discussion

Midgut volvulus may affect the intestine from the ligament of Treitz to the mid-transverse colon. It is easily missed or misdiagnosed in prenatal ultrasound examination because of the nonspecific signs. Delays in diagnosis or intervention can result in neonatal death. In this study, we reported the 2D and 3D ultrasonic features of 12 fetuses with midgut volvulus, which, as far as we know, is the most significant sample reported to date for 3D ultrasound diagnosis of fetal midgut volvulus.

The specificity and sensitivity of the whirlpool sign on postpartum 2D ultrasonography in the diagnosis of volvulus were reported to be 92% and 89%, respectively [7]. The sign appears when the intestine rotates around its mesentery, causing the mesenteric vessels to twist around each other [8]. Bartholmot *et al.* have found the whirlpool sign in 77% of fetuses with midgut volvulus [2]. However, Sciarrone *et al.* have reported that only 1 of the 8 cases had the whirlpool sign [9]. The whirlpool sign was present in 5 of the 12 cases (41%) in this study. However, only 4 cases showed the SMV running around the SMA in the center of the whirlpool sign, while the others had normal

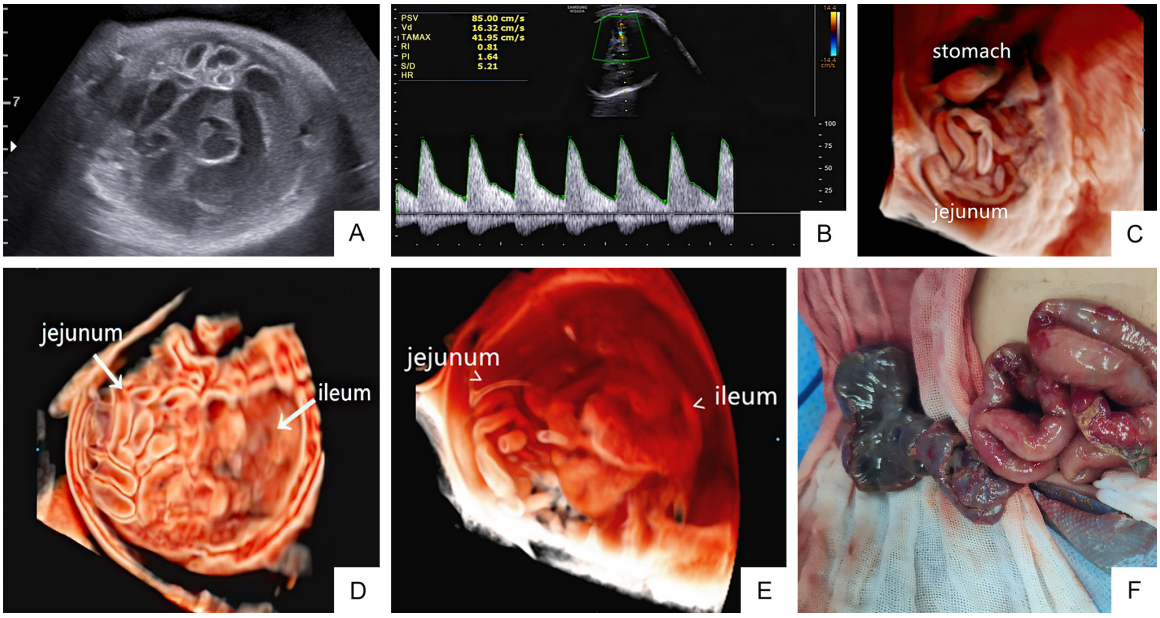

Figure 4. Intestinal volvulus with fetal anemia and intestinal necrosis (at 32 weeks). Note: 3D, three-dimensional. A: Two-dimensional ultrasound showed no typical signs, but there was reduced echo of the bowel wall and localized monolayer changes; B: The middle cerebral artery peak systolic velocity was 85 cm/s; C: The jejunum was dilated but the shape was normal; D: The grayscale mode of 3D imaging showed structural disorder and abnormal echo of the intestinal wall on the right side; E: Inversion mode showed the spiral sign; F: Idiopathic volvulus and intestinal necrosis were confirmed during surgery.

Table 2. Diagnostic value of 2D and 3D ultrasound images in midgut volvulus

Indicators	Nature	Midgut volvulus (n=12)	Non-midgut volvulus (n=343)	Specificity	Sensitivity	Accuracy
2D	Positive	10 (83.3)	23 (6.7)	93.3%	83.3%	93.0%
	Negative	2 (16.7)	320 (93.3)			
3D	Positive	11 (90.32)	6 (1.7)	98.3%	91.7%	98.0%
	Negative	1 (9.68)	337 (98.3)			

Note: 2D: two-dimensional; 3D: three-dimensional.

mesenteric vessels. During the operation, 4 cases with abnormally arranged mesenteric vessels were found to have midgut malrotation, while the other case had mesenteric dysplasia and stenosis. It has been reported that the absence of an identifiable flow signal on Doppler may be due to malperfusion of mesenteric vessels [10, 11]. However, in our study, the fetus without the whirlpool sign had normal superior mesenteric arteries and veins. We believe that the whirlpool sign is a sign of volvulus due to malrotation and other reasons. The difference is that midgut malrotation is often associated with the abnormal pathway of mesenteric vessels. In addition, in our experience, the whirlpool sign is inconsistent, and it will change or even disappear as the disease progresses.

Coffee-bean sign, an indirect and nonspecific ultrasonic feature of midgut volvulus, occurs in volvulus cases with strangulation obstruction, which makes the inner walls of the closed loop intestinal flexure thicken and close to each other due to edema, forming a dense hyperechoic zone similar to coffee beans [12]. The coffee-bean sign was detected in 4 (33%) fetuses in our study. In one fetus, the coffee-bean sign and the whirlpool sign appeared together. In another fetus, the coffee-bean sign appeared two weeks after the appearance of the whirlpool sign. The loop of the bowel assumes the shape of a coffee bean on ultra-

Table 3. Follow-up results of 12 cases of midgut volvulus

Gestational age at birth (w)	Mode of delivery	Surgical results		Outcome
35^{+3}	CS	Idiopathic	Terminal ileum volvulus 1.5 cm from ileocecal junction; necrotic segment length 35 cm; preoperative hemoglobin 92 g/L	Short bowel syndrome
37^{+2}	CS	Mesentery dysplasia	Terminal ileum volvulus 1 cm from ileocecal junction; necrotic segment length 35 cm	Short bowel syndrome
31^{+3}	CS	Midgut malrotation	Ileum volvulus 30 cm from ileocecal junction; necrotic segment length 20 cm	Good
33^{+5}	CS	Mesentery dysplasia	Ileum volvulus 25 cm from ileocecal junction; necrotic segment length 35 cm; preoperative hemoglobin 103 g/L	Good
36^{+2}	CS	Midgut malrotation	Ileum volvulus 30 cm from ileocecal junction; and necrotic segment length 20 cm; preoperative hemoglobin 98 g/L	Good
34^{+2}	CS	Ileum atresia	Ileum volvulus 10 cm distance from ileocecal junction; 40 cm of intestine resected	Short bowel syndrome
36^{+5}	VB	Mesentery dysplasia	Jejunum volvulus 40 cm from ligament of Treitz; 35 cm of intestine resected	Good
34^{+1}	CS	Midgut malrotation	Ileum volvulus 20 cm from ileocecal junction; necrotic segment length 20 cm	Good
34^{+2}	CS	Midgut malrotation	Jejunum volvulus 45 cm from ligament of Treitz; necrotic segment length 30 cm	Good
33^{+4}	CS	Ileum atresia	Ileum volvulus 35 cm from ileocecal junction; necrotic segment length 30 cm	Good
35^{+2}	CS	Jejunal atresia	Jejunum volvulus 25 cm from Treitz ligament; necrotic segment length 30 cm; the intestine was broken into two segments; large ascites and severe adhesions of intestine were present; preoperative hemoglobin 95 g/L	Ileus recurred 3 weeks after operation. With biliary atresia type III
33	CS	Midgut malrotation	Ileum volvulus 40 cm from ileocecal junction; necrotic segment length 35 cm	Good

Note: CS: cesarean section; VB: vaginal birth; W: weeks.

sound images [13], which is a sign of strangulated intestinal obstruction of progressive midgut volvulus.

The bowel movements of fetuses with midgut volvulus can predict intestinal necrosis to some extent. In our study, changes in the bowel movements were observed in all fetuses (100%). All cases presented with increased peristalsis in the proximal intestine and absence of peristalsis in the distal intestine. This disturbance of intestinal movement can affect the whirlpool sign. During the operation, intestinal necrosis was found in all the eight cases. While 2D ultrasound showed changes in intestinal wall echo in six of the eight cases, 3D ultrasound showed changes in all the eight cases, indicating that changes of intestinal wall echo, which are related to intestinal necrosis, can be more sensitively captured by 3D ultrasound.

3D ultrasound imaging technology has certain application value in the identification of intestinal wall changes. Before 20 weeks of gestation, the fetal intestines are in a collapsed state, and the intestinal wall as well as its structure cannot be seen on ultrasound images [14]. However, when there is intestinal dilatation, the layers of the intestinal wall may be more clearly seen [15]. When intestinal wall necrosis occurs, this sense of stratified boundaries disappears [16]. Ultrasonic echo of intestinal necrosis is more intuitive in 3D ultrasound. Crystal Vue and Realistic Vue are volume rendering techniques. Their combined use can provide a realistic volumetric description of fetal anatomy and clearly show the boundaries of soft tissue and anatomical structures. We found that the boundary information was completely lost in the necrotic segments after applying these two rendering modes in our cases, which is consistent with the previous conclusion.

The inversion mode in 3D imaging is a post-processing tool that inverts the grayscale of the volume voxels [17]. The anatomy and the

pathologic characteristics of fluid-filled fetal structures, which cannot be obtained with conventional 2D ultrasound, can be well displayed using 3D inversion mode ultrasonography [18-22]. Hata *et al.* used the inversion mode to show the morphology of the stomach and the spatial relationship between the intestine and ascites in a patient with meconium peritonitis [18]. In this study, we used the inversion mode to study the shape of the bowel in cases of midgut volvulus. It was found that even without typical signs of volvulus being present in 2D imaging, the dilated bowel in 3D imaging inversion mode was still coiled into a spiral. We are the first to report this "spiral sign". In this study, 9/12 (75%) fetuses were positive for the spiral sign, suggesting that midgut volvulus should be suspected in those fetuses with positive spiral signs on 3D imaging.

Intestinal dilatation, meconium peritonitis, ascites, and anemia are common complications in fetal midgut volvulus [23]. All 12 fetuses in this study had intestinal dilatation, meconium peritonitis, and ascites. In a previous study, total morbidity and survival rates of infants with gastrointestinal volvulus and meconium peritonitis are 37.8% and 91.9%, respectively [24]. Fluid-filled level within a dilated loop of the intestine is identified as an ultrasound sign of midgut volvulus [2]. This sign, which is caused by blood and meconium sedimentation to the bottom of the intestine, was observed in 4 cases in our study, suggesting that midgut volvulus should be suspected if the dilated loop reaches the fluid-filled level. Fetal anaemia is also related to intestinal volvulus, especially in the presence of strangulated intestinal obstruction, when blood and plasma enter the intestine and abdominal cavity. Some authors have reported that monitoring the MCA-PSV can help predict fetal anaemia associated with midgut volvulus [25, 26]. In this study, five fetuses had MCA-PSV higher than 95%, and anaemia was confirmed in four cases after delivery, suggesting that MCA-PSV is closely associated with fetal anemia, with a certain predictive value for fetal anemia. However, the specific value needs to be further evaluated in future studies.

The follow-up showed that postoperative prognosis may be directly related to the degree of intestinal dilatation. One fetus with extremely dilated bowels had ruptured intestine. It appeared as a substantial cystic mass in the abdomen in prenatal ultrasound but was actually an encapsulating effusion. This infant also had biliary atresia type III (confirmed postpartum), which made postoperative feeding difficult. Three weeks after operation, intestinal obstruction recurred, suggesting that extreme intestinal dilatation may be associated with a large number of fetal abdominal cystic masses and may be a risk factor for poor fetal outcome.

There are some limitations in this study. The sample size is small. However, this was unavoidable due to the condition's rarity. Midgut volvulus can be secondary to cystic fibrosis [27], but our study did not include any such case. Intestinal hyper-echogenicity (equal to that of the surrounding bone tissue) and intestinal loop dilation are common signs of cystic fibrosis on fetal ultrasound scans [27]. When midgut volvulus occurs, appropriate genetic consultation is also necessary. Our sample also did not include any case of colonic volvulus. However, we are continuing to document all cases of fetal midgut volvulus to further refine this study.

Conclusion

In conclusion, dilated bowel with meconium peritonitis should raise the suspicion of midgut volvulus. The typical signs of volvulus in 2D ultrasound may change with disease progression. However, the spiral sign in 3D ultrasound is likely to persist and may be a more reliable sign of midgut volvulus in fetuses. Rapid dilation of the intestine over a short period may indicate the occurrence of intestinal rupture. Changes in the echogenicity of the intestinal wall in 2D and 3D images are highly suggestive of intestinal necrosis.

Disclosure of conflict of interest

None.

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