MRI prenatal diagnosis for vasa previa when inconclusive ultrasonography results come, cons and pros?

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Abstract

[Abstract] Objective To explore the MRI assistance in diagnosing of vasa previa when inconclusive ultrasonography results come. Methods From January 2018 to December 2021, 12 patients with suspected vasa previa but inconclusive ultrasonography diagnoses at 23-25w or 31-33w were enrolled into the study group. 51 patients diagnosed by ultrasonography as mild ventriculomegaly with no vasa previa were enrolled into the control group. Both groups had taken MRI scanning during the 3rd trimester to check the existence of vasa previa. Placentas from both groups were checked to confirm the existences of vasa previa immediately at delivery, and postoperatively by pathology. Results In the 12 patients from the study group, MRI demonstrated vasa previa in 11 patients. The rest one was excluded of vasa previa by MRI. In all the 51 patients from the control group, MRI had excluded vasa previa. Pathology examination after delivery had confirmed these MRI diagnoses. Conclusion When inconclusive ultrasonography interpretations on vasa previa come, MRI may offer some assistance in diagnosis.

MRI prenatal diagnosis for vasa previa when inconclusive ultrasonography results come, cons and pros?

[**Abstract**] **Objective** To explore MRI assistance in diagnosing of vasa previa when ultrasonography is inconclusive.**Design** Apply MRI to identify vasa previa in cases that ultrasonography is inconclusive, and establish control group for comparison. **Setting** Vasa previa results in poor outcomes if not diagnosed prenatally, and ultrasonography usually can detect it, yet is inconclusive occasionally. Very few papers discussed advantages of MRI diagnosis on vasa previa. **Sample** From January 2018 to December 2021, 12 patients with suspected vasa previa but inconclusive ultrasonography diagnoses were enrolled into the study group. 51 patients diagnosed by ultrasonography as mild ventriculomegaly without vasa previa were enrolled into the control group. **Methods** Both groups took MRI scanning during the 3rd trimester to check the existence of vasa previa. Placentas from both groups were checked to confirm existences of vasa previa immediately at delivery, and postoperatively by pathology. **Main Outcome Measures** The vasa previa existences, types, positions and directions were checked in MRI. **Results** In the 12 patients from the study group, MRI demonstrated vasa previa in 11 patients. The rest one was excluded of vasa previa by MRI. In all the 51 patients from the control group, MRI had excluded vasa previa. Pathology examination after delivery had confirmed these MRI diagnoses.**Conclusions** When ultrasonography is inconclusive on vasa previa, MRI can offer some assistance in diagnosis. **Funding**Medical and Health Research Project of Zhejiang Province(2019ZH008).

[**Key words**] Vasa previa, Magnetic resonance imaging(MRI), Inconclusive ultrasonography, Parachute type of placenta, Mangrove placental vessels, Type III vasa previa

Introduction

Vasa previa is defined as placental vessels supported only by membranes, overlie the cervix, lie between the cervix and the presenting fetal part[1]. The prevalence of vasa previa is approximately 1 in 2500, but much higher among patients with low lying placenta, in vitro fertilization(IVF), or abnormal placental morphology, such as bipartite or succenturiate lobe placentas in the lower uterine segment[2]. These previa vessels are vulnerable not only to compression, which may lead to fetal anoxia, but also to laceration, which can lead to acute fetal blood loss or exsanguination[3]. That results in poor pregnancy outcomes if not diagnosed prenatally[4].

In a series of 12069 pregnancies screened, Baulies et al. were able to diagnose up to 78% of occurrences of vasa previa in asymptomatic pregnant women antenatally[5], which is the ideal time to reduce the risk of fetal bleeding and death[6]. Another search showed the rate of vasa previa visualization in ultrasonography at 15-20 weeks was 67%[7]. Thereby, vasa previa can be diagnosed antenatally, but missed diagnosis is still possible even when ultrasound is performed under the best circumstances in tertiary centers.

According to the guidelines, cesarean section should be probably accomplished for vasa previa at 34-36 weeks[8,9]. Suspected but inconclusive ultrasonography diagnosis is embarrassing, as unnecessary iatrogenic preterm labor brings more neonatal complications correlating with immaturity, while later cesarean section elevates the risk for suddenly laceration of potential vasa previa and exsanguination life-threatening to the newborn.

As severe complications and poor outcomes of potential vasa previa, when inconclusive ultrasonography results come, should find some way to reach more conclusive diagnoses. To explore the MRI assistance in diagnosing of vasa previa when inconclusive ultrasonography results come, the current study was conducted.

Methods

In our institute, high-definition(HD) ultrasonographic scannings are routinely offered at 23-25 and 31-33 weeks of gestation to each registered pregnancy screening fetal congenital malformations and ultrasonographic soft markers. Vasa previa is also screened concomitantly. These three-dimensional trans-abdominal and trans-vaginal ultrasound examinations are performed using GE Voluson E8 Expert systems.

From January 2018 to December 2021, 12 patients with suspected vasa previa but inconclusive ultrasonography diagnoses at 23-25w or 31-33w were enrolled into the study group. 51 patients diagnosed by ultrasonography as mild ventriculomegaly with no vasa previa were enrolled into the control group. Both the study and the control groups had taken MRI scanning during the 3rd trimester, performed by GE Brivo MR355 system. MRI sequences included the following: (1) multiplanar T_2WI single-shot fast spin echo(SSFSE), TR 2000ms, TE 68ms, matrix 288×256, gap 3 mm, slice interval 0, FOV 400×400mm; (2) T_2WI fast spin echo(FSE), TR 8181ms, TE 85ms, matrix 320×224, gap 3 mm, slice interval 0, FOV 400×400mm; (3) T_1WI Dual Echo Steady State(DESS), TR 180ms, TE 2.1ms, matrix 256×160, gap 3 mm, slice interval 0, FOV 400×400mm.

Placentas from all these enrolled patients were checked to confirm the existence of vasa previa immediately at delivery, and postoperatively by gross and microscopic pathology examinations. All the patients enrolled submitted written informed consent, and this study was approved by the Ethics Committee of the medical institute.

Results

4 patients in the study group as the 1st, and 7th to 9th, had inconclusive ultrasonic results for vasa previa at 23-25w of gestation, and still had suspicious ultrasonography diagnoses at 31-33w since the interpretation for vasa previa existence varied among ultrasonologists. 6 ones as the 2nd to 5th, 10th and 11th had no signs of vasa previa in ultrasonic scanning at 23-25w, however, detected of naked previa vessels once by a certain ultrasonologist at 31-33w, whilst another ultrasonologist couldn't confirm that in subsequent scanning. 2 patients as the 6th and 12th, had been diagnosed by ultrasonography as vasa previa at 23-25w, but previa vessels couldn't be reconfirmed by ultrasonography at 31-33w.

Maternal demographics, sonographic findings including placental position, umbilical cord insertion and ultrasonographic judgement of potential vasa previa for the study group are given in Table 1.

In the 12 patients enrolled into the study group with suspected vasa previa but inconclusive ultrasonic results, MRI demonstrated vasa previa in 11. The 12th patient had been excluded of vasa previa by MRI.

6 patients from 1st to 6th, had been identified as TypeIvasa previa in MRI scanning. The 1st patient's previa vessels just plastered to the fetal scalp (Figure 1). Velamentous portion of the 2nd patient was tiny and entering the lower pole of the low-lying placenta (Figure 2). 3rd patient's cord clearly diverged into velamentous form just before entering placenta, and at the same level of fetal lips as the fetus was facing down (Figure 3). From 4th to 6th patients, MRI also showed mangrove umbilical vessels without Wharton's jelly inserting placenta. The 4th patient's velamentous insertion was in a so large scale of mangrove form, that almost like a parachute (Figure 4). In both 5th and 6th patients, fetal heads were so low that compressed the previa vessel (Figure 5 & Figure 6).

The 7th patient was classified into Type IIvasa previa. MRI clearly displayed the mangrove bridge vessels connecting placental major and succenturiate lobes, and one of the vessels overlying the cervix (Figure 7).

4 patients from 8th to 11th, were demonstrated as Type III vasa previa by MRI with boomerang vessels beyond the edges without placental mass protection. The 8th patient's previa boomerang vessels formed a transverse V shape (Figure 8). Previa vessels in the 9th and 10th patients were close to the uterine lateral walls (Figure 9 & Figure 10). In the 11th patient, the boomerang vessel was slightly compressed by the fetal head (Figure 11).

MRI had excluded 12th patient of vasa previa diagnosis at 33 weeks of gestation, as the mangrove bridge vessels connecting placental major and succenturiate lobes, previously adjacent to the cervical internal orifice, had moved away from the cervix a little laterally and upward, because the lower uterine segment gradually formed and extended (Figure 12). And this phenomenon had been proved by pathology examination showing naked mangrove vessels away from the amnion split.

MRI findings including placental position with morphology, vasa previa types and directions, also pregnancy outcomes and pathology examinations of the study group are summarized in Table 2.

In the control group, MRI had excluded vasa previa in all the 51 patients.

Placentas from the study and control groups were checked to confirm the existences of vasa previa immediately at delivery, and postoperatively by macroscopic examination before pathological sectioning. Pathology examination showed no vasa previa was missed in MRI diagnosis, and all the vasa previa running courses were coincided with directions displayed in MRI.

Discussion

Main Findings

In the cases with suspected but inconclusive ultrasonography diagnosis of vasa previa, MRI was applied to further detect the existence of previa vessels and achieved satisfied results that confirmed by pathology examination.

Strengths and Limitations

In the study, MRI clearly showed the placental morphology, velamentous vessels position and courses of potential vasa previa. That implied the reasons why ultrasonography was unable to reach conclusive diagnosis of vasa previa occasionally. But limited by the low rate of vasa previa cases in pregnancies, the current study is not a large sample randomized controlled trial, so bias can not be fully avoided.

The prevalence rate of vasa previa is relatively low, and ultrasonography is most often used and commonly able to detect the disease. Thus the cases, in which ultrasound cannot reach conclusive diagnosis for vasa previa, will be even fewer. So future long term researches enrolling more additional similar cases are needed

to check MRI sensitivity and specificity in this field, though MRI already showed satisfied results in the current study. As MRI is not commonly applied in diagnosing vasa previa, future researches also need strong support from patients, ultrasonology and radiology specialists.

Interpretation

Vasa previa is traditionally classified into TypeIand Type II, whereas more recent papers have described Type III. TypeIvasa previa is with velamentous cord insertion (VCI), Type II shows interconnecting vessels between two lobes of placenta in a bipartite placenta or connecting vessel with a succenturiate lobe of the placenta[10], and Type III refers to boomerang vessels beyond the edges without placental mass protection[11].

The American College of Obstetricians and Gynecologists recommends the usage of color Doppler in patients who are at a tremendous risk for vasa previa[12,13]. TypeI vasa previa will be more easier to be detected by ultrasound, because it just forms at the velamentous part of the cord. Trials have shown Ultrasound performed best for the diagnosis of VCI with a sensitivity, specificity and positive predictive value of 100, 99.9 and 85.7%, respectively, with routine use of color Doppler[14]. TypeIIvasa previa is more difficult to be diagnosed by ultrasound, because the vasa previa forms between two lobes of placenta with normal umbilical insertion[15].

No large studies have been performed evaluating the effectiveness of MRI in detecting vasa previa[16]. There has been a case study by Kikuchi et al, in which MRI was used as a problem solving measure in identifying the placenta and expediting

management when ultrasonography proved to be inconclusive[17]. But studies have demonstrated MRI may aid in the assessment of placental structures, number of lobes and position, and can play an associated role when diagnosis by ultrasound evaluation is equivocal, especially in case of vasa previa associated with two lobed placentas[18].

In the 12 patients from the study group, MRI demonstrated vasa previa in 11 patients. The rest one was excluded of vasa previa and reached term delivery. In all the 51 patients from the control group, MRI had excluded vasa previa. Pathology examination after delivery had confirmed these MRI diagnoses. The study had shown excellent sensitivity for MRI in diagnosing potential vasa previa when no conclusive ultrasonic result returned, and specificity as well.

The reason we considered that ultrasonic examination had not detected the vasa previa may include the following, but not limited to these reasons:

Firstly, fetal vessels may run at an unfavorable insonation angle to the relatively fixed transducer. The most common sections for pelvic ultrasonography are standard horizontal, sagittal, coronal, and oblique sections originate from the standard ones[19,20]. Thereupon, if the previa vessel long axis was not just in the insonation plane, it would not form a curve image but only a tiny cross section. In this circumstance, the color Doppler could only catch a round red or blue signal in small diameter. Addionally, because of the patients' low-lying placentas like the 4th, 5th, 7th and 8th paitents, or even with really tiny velamentous parts like 2nd and 3rd patients (Figure 2 & Figure 3), the ultrasound could not distinguish the blood flow of vasa previa from that of the placenta.

Secondly, visualization of vasa previa may be difficult with transvaginal sonography alone. Even if the transvaginal probe actually rotated and remained at the previa vessel long axis direction, the ultrasonic definition of transvaginal gray scale might not be high enough to distinguish the vessel[21]. In this circumstance, the color Doppler could be beneficial, however, the color Doppler scanning should be turned on before the transvaginal probe rotation. Still, due to the low lying placenta making the lower uterine segment not formed well, the previa vessel was not just over the cervical internal os, but posterior to the relatively thick cervical tissue in transvaginal scanning, bringing in further obstacle to identify it, like the 2nd, 4th, 5th, 7th and 8th paitents. Similarly, ultrasound could not clearly exclude vasa previa that with velamentous vessel moving laterally away from cervix as the lower uterine segment extended during the third trimester, like the 12th patient (Figure 12).

Thirdly, in some cases, the vasa previa just carried only a small portion of blood flow, as in TypeIIand III. And recognized from ultrasonologists' feedback, in other cases, the fetal heads may be so low that compress the previa vessels, making them really difficult be seen. If that happens in TypeIvasa previa only with three umbilical vessels in the velamentous part, two umbilical arteries and one umbilical vein, the continuous fetal heart rate monitoring should show fetal distress. But if that is in TypeIwith mangrove or even parachute morphology like 4th patient (Figure 4), and merely a tiny branch compressed, or in TypeIIand III, no fetal distress would display. Thus, the blood flow in that previa vessel might be very slow, or not be continuous but intermittent. If there was too low velocity signal that the ultrasonic Doppler sampling gate could not fit well to distinguish it, or even no flow at the time gap during ultrasonic scanning, the vasa previa could still not be identified[22], like 5th and 6th patients (Figure 5 & Figure 6).

Addionally, from this study, it shows that when the vasa previa is close to lower uterine lateral wall, the vessel signal might disguise itself among the uterine blood flow signals. That causes some TypeIIand III cases more difficult to be identified, like 7th to 11th patients.

MRI can be an alternative in identifying vasa previa, if the ultrasound scanning results are inconclusive, owing to some advantages it possesses in this field[23].

Firstly, MRI is independent of the placental location, the maternal obesity, the maternal bladder, the operator, and the directions of velamentous vessels, unlike ultrasound[24]. It may be most useful as an adjunct in difficult cases where ultrasonography is equivocal, the patient is difficult to scan, or if the placenta is implanted in the posterior uterus[25].

Secondly, MRI is tomography, so the image definition for spatial structures and soft tissues will be able to detect absolutely thin vessels[26].

Thirdly, MRI can reconstruct images in three dimensions[27]. A single ultrasonic image only shows one certain plane. While in MRI, the coronal, horizontal and sagittal aspects can be exhibited as 3 simultaneous images within a single display. That assists to determine the vessels positions, within amnion or intramuscular, regardless of different vascular directions. Therefore, any direction of the previa vessels path can be confirmed, not like the ultrasonography that needs the previa vessel's long axis within the certain scanning plane to see the vessel curve.

Traditional conceptions claimed MRI with several disadvantages, include cost, time, patient monitoring, and the general lack of expertise in interpreting the studies[28]. However, these disadvantages diminished in recent years.

Firstly, MRI costs higher than ultrasound. As the 3-D and 4-D techniques have been widely applied in ultrasonic equipment and elevated the individual scan cost, the financial gap between MRI and ultrasonography is less obvious nowadays[29].

Secondly, MRI is relatively unfit to emergent cases comparing with ultrasound. In real clinical work, if there's suspected vasa previa with emergent issues such as vaginal bleeding, the most imminent management is cesarean section, not either ultrasound or MRI scanning[30].

Thirdly, MRI is not so available as ultrasound in underdeveloped areas as our country. But accurate ultrasonography diagnosis also needs well experienced and skilled ultrasonologists, which would not be so available in remote hospitals. As more MRI devices widely deployed in recent years, MR scanning might be possible there. Specialists at tertiary centers can analyse the images uploaded from hundreds of miles away. Advanced than ultrasound, MRI digital evidence is fully kept, so any colleagues can review and discuss the previous scanning results at any time when preferred and reach more accurate diagnoses[31].

Conclusion

In summary, vasa previa results in poor pregnancy outcomes if not diagnosed prenatally. Ultrasonography, specifically transvaginal scan with color Doppler is commonly utilized as diagnostic method. We have presented a series of cases with suspected but inconclusive ultrasonography diagnosis of vasa previa. MRI

was applied to further detect the existence of vasa previa and achieved satisfied results that confirmed by pathology examination. Therefore, when inconclusive ultrasonography results come in such cases, MRI may offer some assistance in diagnosis.

Disclosure of interests

No conflict of interest exits.

Contribution to authorship

Wu Jiahan offered the prenatal care visits for the patient, analyzed the patient's MRI and ultrasonography results, and wrote the report. Fatma Gahman assisted in writing the paper, planning the treatment, also editing the pictures.

Details of ethics approval

All the patients enrolled submitted written informed consent, and this study was approved by the Ethics Committee of Ningbo Women and Children Hospital(January 1st, approval number 2018No.28).

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Table 1 Maternal demographics and sonographic findings

Case	Age (years)	G	P	Sonographic findings at 23-25w Placental position	Sonographic findings at 23-25w Cord insertion	S V

1	32	4	1	anterior to posterior via right	velamentous	in
2	29	2	0	anterior low-lying	normal	no
3	36	3	1	anterior to posterior via right	normal	no
4	36	2	0	anterior low-lying	velamentous	no
5	34	3	0	posterior low-lying	velamentous	no
6	30	1	0	posterior	velamentous	di
7	38	4	1	right-anterior and posterior bilobes, posterior low-lying	normal	su
8	31	3	0	left low-lying	normal	in
9	32	3	0	MCDA anterior to posterior	normal	in
10	36	4	1	anterior to posterior	normal	no
11	30	1	0	anterior to right	normal	no
12	35	3	1	anterior and posterior bilobes, anterior low-lying	normal	bi

Table 2 MRI findings and course of pregnancy

Case	Age (years)	G	P	MRI findings at 31-33w	MRI findings at 31-33w	MRI findings at 31-33w	Pregnancy outcomes	Pregnancy outcomes	Pregnancy outcomes	Pregnancy outcomes	Pregnancy outcomes	P o
				Placental position	Cord insertion	Vasa previa type and direction	EGA at delivery (week)	Indication for delivery	Placenta pathology	Neonatal weight(g)	Apgar scores	A s
1	32	4	1	anterior to posterior via right	mangrove velamentous vessels	TypeI, posterior to anterior	34 6/7	maturation	velamentous, mangrove vessels, TypeIvasa previa	3140	8	9
2	29	2	0	anterior low-lying	tiny velamentous	TypeI, anterior to posterior	34 0/7	bleeding	tiny velamentous, TypeIvasa previa	2650	7	9
3	36	3	1	anterior to posterior via right	tiny velamentous	TypeI, anterior to right-posterior	35 0/7	maturation	tiny velamentous, TypeIvasa previa	3050	8	9

4	36	2	0	anterior low-lying	parachute velamentous vessels	TypeI, mid-anterior to right-posterior	39 0/7	term	velamentous, parachute vessels, Type-I vasa previa	3800	9	1
5	34	3	0	posterior low-lying	mangrove velamentous vessels	TypeI, right-anterior to left-posterior bent by fetal head	36 2/7	late preterm	velamentous, mangrove vessels, Type-I vasa previa	2750	8	9
6	30	1	0	posterior	mangrove velamentous vessels	TypeI, right-anterior to right-posterior bent by fetal head	35 5/7	maturation	velamentous, mangrove vessels, Type-I vasa previa	2520	7	9
7	38	4	1	bilobes posterior low-lying	normal cord, bridge vessels linking lobes	Type II, right to posterior	36 5/7	late preterm	bilobed, Type II vasa previa	2600	8	9
8	31	3	0	left low-lying	normal	Type III boomerang, diverged, left to anterior & posterior	34 6/7	maturation	Type III boomerang vasa previa	2600	8	9

9	32	3	0	MCDA anterior to posterior	normal	Type III boomerang, left-anterior to mid-posterior	34 3/7	MCDA and one distress	Type III boomerang vasa previa	2100/ 2150	7/7	8
10	36	4	1	anterior to posterior	normal	Type III boomerang, bilateral posterior to anterior	34 2/7	maturation	Type III boomerang vasa previa	2750	8	9
11	30	1	0	anterior to right	normal	Type III boomerang, ritht-anterior to right-posterior	34 0/7	maturation	Type III boomerang vasa previa	2500	7	9
12	35	3	1	major and succenturiate lobes	normal cord, bridge vessels linking lobes	no sign, mangrove vessels over 6cm away from cervix	38 0/7	term	bilobed, mangrove bridge vessels away from amnion split	3700	9	1