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Original Research

Application Value of Sonographic Scoring Method in the Diagnosis of Singleton Angular Pregnancy and Angular Villi or Placenta Accrete

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Abstract

Background: To explore the sonographic features of singleton angular pregnancy and angular villi or placenta accrete, and to put forward the standard of sonographic refined classification by sonographic score. **Methods**: The sonographic images and data of 59 cases of angular pregnancy diagnosed by gold standard were retrospectively analyzed, and the sonographic features and scores of different types of angular pregnancy, angular villi or placenta accrete were summarized. A new sonographic fine classification standard was proposed. **Results**: According to the gold standard, 59 cases of angular pregnancy were divided into three types: type I (endogenous type), type II (exogenous type) and type III (angular and interstitial type). All 59 cases were scored by ultrasound of angular pregnancy type and angular villi or placenta accrete. The median sonographic score of type I, II and III angular pregnancy was 3.0 [2, 3], 6.0 [4, 6] and 6.5 [6, 7.5], respectively, while the best cut-off value of villi or placenta accrete was 2.5, sensitivity 100%, specificity 98.0%. **Conclusions**: Ultrasonography can accurately diagnose angular pregnancy and provide fine classification, and is also of great application value for angular villi accrete in the first trimester, angular placenta accrete in the second and third trimester and postpartum angular placenta residual accrete.

Keywords: angular pregnancy; villi accrete; placenta accrete spectrum disorders; ultrasound

1. Introduction

Angular pregnancy, a rare form of ectopic pregnancy, is defined as an intrauterine pregnancy in which the embryo is implanted into the junction of the uterus and the opening of the fallopian tube and inside the insertion point of the round ligament [1–3]. The right and left angular pregnancies of normal uterus are different from those of bicorporeal uterus, hemi-uterus, rudimentary functional uterus and septate uterus. Placenta accrete spectrum (PAS) disorders, proposed by Luke *et al*. [4], provide standardized terminology covering the depth of villous invasiveness, lateral extension of accrete placentation, and the possible combination of different depths of invasiveness in the same placenta accrete. PAS disorders refer to a group of diseases in which placental villi abnormally invade beyond the basal decidua. According to the depth of invasion of placental villi, PAS disorders can be divided into placenta adhesion, placenta accrete and penetrating placenta accrete [5]. In the first trimester (less than 14 weeks of pregnancy), when the placenta has not been completely formed, the villi invade the myometrium, and the accrete is called villi accrete. After 14 weeks, when the placenta is completely formed, the accrete is called placenta accrete [6]. Angular pregnancy with villi accrete refers to cases when the embryo is implanted into the endometrium of the angle, and the chorionic villi invade the endometrium myometrium junction area and enter the uterine myometrium in the first trimester. Angular placenta accrete refers to instances when the placenta villi invade the myometrium, even as much as the full thickness of the myometrium (including the uterine serosa and, occasionally, adjacent pelvic organs) in the second and third trimesters. During delivery, the placenta remains in the angle and requires to be manually removed or retained in the angle.

Angular pregnancy constitutes a high-risk pregnancy. Angular villi or placenta accrete often leads to neglected induced abortion or uncontrollable bleeding during uterine curettage, irregular vaginal postoperative bleeding, spontaneous uterine rupture in the expectation process, and other adverse outcomes.

The purpose of this study is to analyze the sonographic characteristics of angular pregnancy and angular villi or placenta accrete, and put forward the fine classification of sonographic scoring method for the diagnosis of singleton angular pregnancy and angular villi or placenta accrete.

2. Materials and Methods

2.1 Study Design and Patients

This study is a retrospective and descriptive analysis of the data collected in routine ultrasound examination of pregnant women. The cases feature patients with angular pregnancy who were treated in the Department of Obstetrics and Gynecology of Tongji Hospital affiliated with Tongji Medical College of Huazhong University of Science and

Technology from January 2016 to July 2020. Inclusion criteria entailed the diagnosis of an angular pregnancy in early pregnancy by sonographic examination; the diagnosis of a normal early intrauterine pregnancy followed by the sonographic diagnosis of an angular pregnancy or angular placenta accrete during the middle or late pregnancy; or diagnosis postpartum by ultrasound of an angular pregnancy with portions of a retained placenta. Exclusion criteria entailed cases of angular pregnancy diagnosed by ultrasound in our institution but not observed, treated, or delivered in our hospital; malformed uterine anatomy; multiple gestation; or cases with absence of complete sonographic data.

2.2 Ultrasound Data from Routine Ultrasound Examination of Pregnant Women

GE Voluson E6/E8/E10, S6/S8 color Doppler ultrasound diagnostic instrument was used. The abdominal volume probe frequency was 2–5 mhz/4–8 mhz, and the vaginal volume probe frequency was 5–9 mhz. All sonographic images and measurement data were stored in the sonographic reporting system or sonographic instrument, with certain cases retained as dynamic images.

Transvaginal ultrasonography was the preferred method in the early stage of the first trimester ($\leq$10 weeks), combined with transabdominal ultrasonography, if necessary. In this stage of pregnancy, two-dimensional gray-scale ultrasonography was carried out first, with the uterus examined in continuous sagittal and cross sections, excluding uterine malformations and multiple pregnancies. An assessment was then made of the position of the pregnancy sac, the continuity between the pregnancy sac and the endometrium at the bottom of the uterine cavity, and degree of protrusion of the gestational sac. Measurements were taken for the inner diameter of the pregnancy sac as well as embryo length and the thickness of angular myometrium, along with judgment as to whether there was cardiac pulsation. The decidual wrapping sign around the gestational sac or the tubal interstitial line sign between the gestational sac and the endometrium of the angle were observed, together with whether the boundary between the villi of pregnancy sac and the myometrium of angular was clear, the villi layer was abnormally thickened, and whether there were lacunae within. Then, if villi implantation was suspected, color Doppler was initiated to observe the abundance of blood flow signals between villi and myometrium and the blood flow in villi; meanwhile, spectrum Doppler was initiated to measure blood flow spectrum. Lastly, taking the median sagittal section of the uterus as the reference plane, three-dimensional ultrasound was used to obtain the volume data of the uterus. Multi-plane and rendering modes were selected to observe the (1) position of the gestational sac, (2) continuity between the gestational sac and the endometrium at the bottom of the uterine cavity, (3) degree of external protrusion of the angle and gestational sac, and (4) sign of decidual wrapping around the gestational sac or the sign of tubal interstitial line. When the boundary between the villi and the corner muscle wall was unclear and the blood flow signal was abnormally rich as observed by two-dimensional ultrasound, the volume data of three-dimensional color Doppler was collected, and the number and distribution of abnormal blood flow between the corner villi and the muscle wall was observed by multi-plane and rendering modes.

Transabdominal ultrasonography was the first choice in the late stage of the first trimester, as well as the second and third trimesters. Two-dimensional gray-scale ultrasound was used to observe whether the two uterine angles were asymmetrically increased; whether the angle was protruded and if so, to what degree; whether the boundary between the placenta attached to the angle and the angle myometrium was clear; whether there were abnormal lacunae in the placenta, and to measure the thickness of the angle myometrium and the thickness of the placenta. Color Doppler was used to observe the abundance of blood flow signals between placenta and myometrium, and blood flow signals in placenta. Spectrum Doppler was then used to measure blood flow spectrum. When the boundary between placenta and angular myometrium was unclear and blood flow signals were abnormally rich as observed by two-dimensional ultrasound, the volume data of three-dimensional color Doppler was collected, and multi-plane and rendering modes were selected to observe the amount and distribution of abnormal blood flow between placenta and angular myometrium.

Transabdominal or vaginal ultrasonography was selected according to the size of uterus after operation or postpartum. Two-dimensional gray-scale ultrasound was used to observe whether there was asymmetric increase in the two angles; whether there was placental or villous tissue residue in the angle; whether there was protrusion in the angle and if so, to what degree; whether the boundary between the residual tissue and angular myometrium was clear; and to measure the thickness of the muscle wall of the angle and the three mutually perpendicular diameter lines of the placenta. Color Doppler was started to observe the abundance of blood flow signals between residual tissue and angular myometrium, and blood flow signals in residual tissue. Spectrum Doppler then measured blood flow spectrum. Taking the median sagittal section of the uterus as the reference plane, three-dimensional ultrasound was used to obtain the volume data of the uterus, with multi-plane and rendering modes selected to observe the position of residual tissue, the continuity with the bottom of the uterine cavity and the degree of corner protrusion. When the boundary between the residual tissue and the angular myometrium was unclear and the blood flow signal was abnormally rich, the volume data of three-dimensional color Doppler was collected, while multi-plane and rendering modes were selected to observe the amount and distribution of abnormal

blood flow between the angle residual tissue and angular myometrium.

2.3 Gold Standard Diagnosis

Diagnosis was made by direct vision, postoperative pathological examination or clinical comprehensive diagnosis, regarded as the gold standard of our research and the gold standard of our center's clinical practice. According to the gold standard diagnosis, angular pregnancy is divided into three types [7]: type I (endogenic type) with no or mild angular protrusion, wherein the majority (>50%) of the pregnancy sac is located in the uterine cavity; type II (exogenous type) with angular protrusion, wherein the majority (>50%) of the pregnancy sac (GS) is inside the round ligament and there is no fallopian tube abnormality; and type III (angular and interstitial type) with the protruding mass of pregnancy spanning both sides of the round ligament, wherein the outer boundary of the protruding mass extends to the opening of interstitial portion of fallopian tube. The clinical diagnostic criteria of angular villi or placenta accrete are the rich and thick angular subserosa vessels found during operation, or the angle placenta residual and accrete diagnosed by postpartum ultrasonography and clinic.

2.4 Statistical Analyses

The statistical software package SPSS26.0 (IBM SPSS Statistics for Windows, 26.0 version, Armonk, NY: IBM Corp; 2019) was used for data analysis. The data of classified variables are expressed in n (%); the data of continuous variables are expressed in median, quartile, maximum value and extreme value; and the results of data analysis are displayed in box diagram.

3. Results

A total of 59 cases were included in this study. The median age of pregnant women was 30 years (29–34), the median clinical gestational week was 8.4 weeks (7.0–9.7), and the median ultrasound gestational week was 6.5 weeks (6.0–7.9).

3.1 Sonographic Characteristics

The sonographic characteristics of different types of angular pregnancy and villi or placenta accrete diagnosed based on the gold standard are shown in Table 1.

The "decidual wrapping sign" of sonographic characteristics of angular pregnancy refers to the high echo uterine decidua surrounding the gestational sac [7]. When completely wrapped, the high echo around the gestational sac is in an "O" ring; when partially wrapped, the hyperechoic around the gestational sac is "C" shaped, semi annular, while the part without decidua is wrapped by hypoechoic muscle layer; when there is no decidua around the gestational sac, it is surrounded by hypoechoic muscle layer.

Sonographic features of angular villi or placenta accrete include the following aspects: two-dimensional gray-scale ultrasound imaging exposes loss of the "clear zone" behind placenta, abnormal placenta lacuna, thinning of uterine myometrium, placenta bulge and local tissue exogenesis of placenta (Fig. 1A); color Doppler ultrasound imaging shows angular myometrium and surface hypervascularity, subplacenta hypervascularity, bridging vessels, and tributary vessels of placenta lacuna (Fig. 1B); pulsed Doppler ultrasound imaging shows high-speed low-impedance spectrum or sawtooth spectrum at the entrance of placenta lacuna (Fig. 1C); three-dimensional color Doppler ultrasound images reveal hypervascularity of angular myometrium and surface, and hypervascularity in placenta (Fig. 1D).

3.2 Sonographic Scores

The sonographic scores of various angular pregnancies diagnosed based on the gold standard and the sonographic scores of villi or placenta accrete are shown in Fig. 2.

The sonographic scoring system of angular pregnancy type and villi or placenta accrete is explained in Table 2.

The highest and lowest scores of angular pregnancy type of all cases in this study were 8 and 2 respectively. Using ROC curve analysis and Youden index calculation, the best cut-off value of angular myometrium thickness to distinguish type I angular pregnancy and non-type I angular pregnancy is 3.5 mm, and the best cut-off value of angular myometrium to distinguish type II angular pregnancy and type III angular pregnancy is 1.0 mm. The median M (25th percentile, 75th percentile) of ultrasound scores of types I, II and III angular pregnancies were 3 (2, 3), 6 (4, 6) and 6.5 (6, 7.5), respectively. The scores of types I angular pregnancies were less than 4, type II angular pregnancies were 4–6, and type III angular pregnancies were $\geq$6.

The highest and lowest scores of villi or placenta accrete of all cases in this study were 8 and 2 respectively. Using ROC curve analysis and Youden index calculation, the best cut-off value for distinguishing whether there is implantation of villus or placenta is 2.5 points, rounded up to 3 points, with sensitivity of 100% and specificity of 98.0%.

4. Discussion

4.1 Sonographic Diagnosis and Classification of Angular Pregnancy

In 2020, the "expert consensus on diagnosis and treatment of angular pregnancy" issued by the expert group of family planning branch of Chinese Medical Association maintained that ultrasound is the first choice for the diagnosis of angular pregnancy [8]. The expert consensus divided angular pregnancy into two types according to ultrasound diagnosis. A recently published study [7] divided angular pregnancy into three types, and comprehensively described sonographic, clinical and differential diagnosis;

Table 1. Sonographic features of different types of angular pregnancy, angular villi or placenta accrete diagnosed based on the gold standard.

(n = 59, 100%), the data of classified variables are represented by (n, %), and the data of continuous variables are represented by median (25th percentile, 75th percentile)

Sonographic characteristics	Classification of angular pregnancy types Percentage of VA or PA in single group		
	Type I (n = 42, 71.2%) VA or PA (n = 2, 4.8%)	Type II (n = 13, 22.0%) VA or PA (n = 3, 23.1%)	Type III (n = 4, 6.8%) VA or PA (n = 4, 100%)
Median GS diameter	17.5 (10.0, 24.5)	30.0 (12.0, 37.0)	
Median mass diameter			30.0 (18.0, *)
Median embryo length	3.0 (0.0, 8.0)	1.0 (0.0, 14.0)	39.0 (0.0, 83.3)
Median UGA	6.4 (5.5, 7.4)	6.6 (6.2, 8.6)	13.5 (6.6, *)
Cardiac pulsation			
Yes	16 (38.10%)	5 (38.50%)	2 (50.00%)
No	26 (61.90%)	8 (61.50%)	2 (50.00%)
Decidual wrapping sign			
O-shaped wrapping	34 (81.00%)	5 (38.50%)	0 (0.00%)
C-shaped wrapping	8 (19.00%)	6 (46.20%)	2 (50.00%)
No decidual wrapping	0 (0.00%)	2 (15.40%)	2 (50.00%)
Interstitial line sign			
Yes	0 (0.00%)	1 (7.70%)	0 (0.00%)
No	42 (100.00%)	12 (92.30%)	4 (100.00%)
Angular protrusion			
No	37 (88.10%)	2 (15.40%)	0 (0.00%)
Mild (<50%)	5 (11.90%)	4 (30.80%)	1 (25.00%)
Obvious (≥50%)	0 (0.00%)	7 (53.80%)	3 (75.00%)
Median angular myometrium	4.0 (3.0, 5.3)	3.0 (1.0, 3.5)	0.0 (0.0, *)
The “clear zone”			
Yes	42 (100.00%)	10 (76.90%)	0 (0.00%)
No	0 (0.00%)	3 (23.10%)	4 (100.00%)
Villi or placenta thickness and lacunae			
Thickening	1 (2.40%)	3 (23.10%)	2 (50.00%)
Lacunae	1 (2.40%)	3 (23.10%)	2 (50.00%)
Color Doppler (blood flow of angular myometrium and surface and subplacenta)			
Small	40 (95.20%)	9 (69.20%)	0 (0.00%)
Medium	1 (2.40%)	1 (7.70%)	2 (50.00%)
Rich	1 (2.40%)	3 (23.10%)	2 (50.00%)
Pulse Doppler			
High-speed and low resistance blood flow	1 (2.40%)	2 (15.40%)	2 (50.00%)
Sawtooth spectrum	1 (2.40%)	1 (7.70%)	2 (50.00%)

VA, villi accrete; PA, placenta accrete; GS, gestational sac; UGA, ultrasound gestational age. The measurement units of gestational sac diameter, mass diameter, embryo length and wall thickness of uterine angular muscle are mm, and the unit of gestational week is week (W). *Because there are only four cases of type III angular pregnancy, and the gestational week of some cases was too large at the time of diagnosis, some data items are missing, resulting in the lack of 75th percentile.

clinical management; pregnancy outcome; and complications of each type of angular pregnancy. This study provides a method to judge whether it is angular pregnancy and proposes fine classification according to the score of gray-scale ultrasound characteristics of angular pregnancy.

According to the criteria, ultrasound examination in the first trimester shows that the gestational sac is in the decidua of the angle. First, one excludes the uterine malformation. After determining that the uterine morphology is normal, one carefully scans the inner side of the gestational sac to see whether there is tubal interstitial line sign.

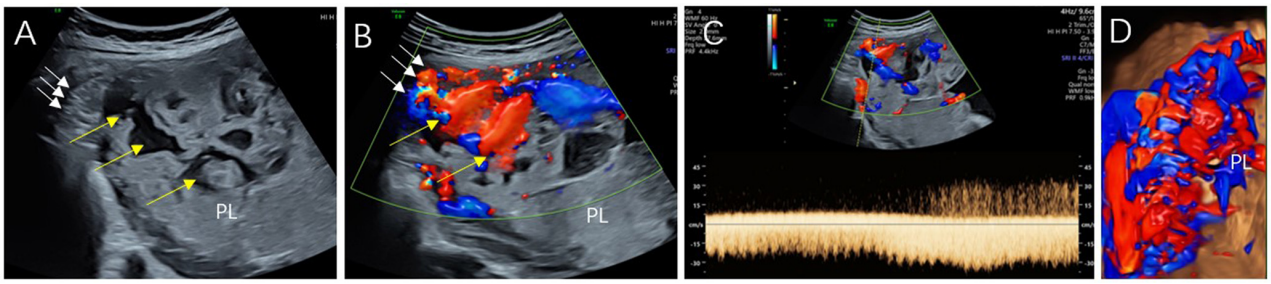

Fig. 1. Ultrasound image of placenta accrete in uterine angle (PL, placenta). (A) For two-dimensional gray-scale ultrasound imaging, the white arrows indicate that the right angle and placenta are slightly protruding outward, the "clear zone" behind the placenta in the corner disappears, the myometrium of angle becomes thinner, and bridging blood vessels are visible. The yellow arrows indicate that there are multiple abnormal placenta lacunae in the placenta. (B) For Color Doppler ultrasound imaging, the white arrows indicate the hypervascularity and bridging vessels on the surface of the angle and in the myometrium, while the yellow arrows indicate the tributary vessels of the placenta lacuna. (C) Pulse Doppler ultrasound imaging show sawtooth spectrum at the entrance of placenta lacuna. (D) Three-dimensional Color Doppler ultrasound images show high vascularization on the surface of the angle and in the myometrium, as well as high vascularization in the placenta.

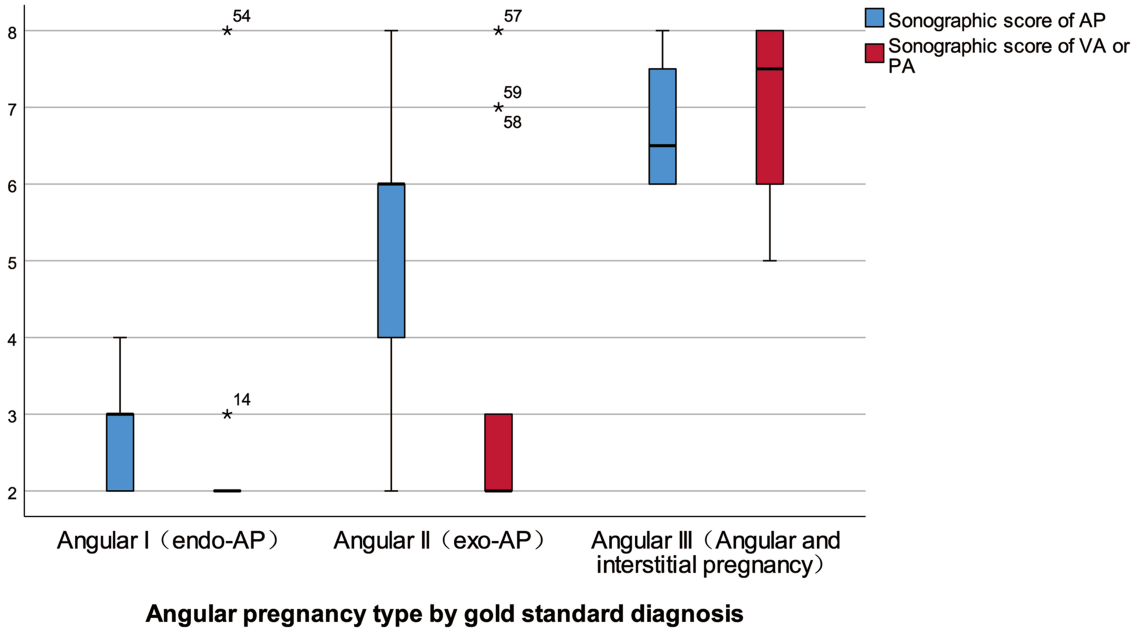

Fig. 2. Sonographic score of various angular pregnancies diagnosed based on the gold standard and sonographic score box diagram of villi or placenta accrete (n = 59). (AP, angular pregnancy; VA, villi accrete; PA, placenta accrete).

If so, it is diagnosed as tubal interstitial pregnancy [9,10]. If there is no interstitial line sign on the inner side of the gestational sac, but it is continuous with the endometrium of the uterine cavity; and further, if decidual wrapping sign can be seen around the gestational sac, angular pregnancy is diagnosed, and then is finely classified according to the sonographic score.

4.2 Sonographic Diagnosis of Angular Villi or Placenta Accrete

In 2018, the International Federation of Obstetrics and gynecology (FIGO) released "FIGO consensus guidelines on placenta accrete spectrum disorders", consisting of the following sections: introduction, epidemiology, prenatal diagnosis and screening, nonconservative surgical management, and conservative management [5,11–14]. The main purpose of this consensus guideline was to improve the diagnosis and treatment of PAS worldwide, and thus to reduce maternal mortality and long-term complications. This guideline was mainly aimed at the placenta accrete spectrum disorders of the lower anterior wall and cesarean scar. From our clinical experience, angular pregnancy and angular villi or placenta accrete have the same high pregnancy risk as cesarean scar pregnancy and villi or placenta accrete

Table 2. The sonographic scoring system of angular pregnancy type and villi or placenta accrete.

	Sonographic descriptor	Individual score (point)			
		0	1	2	3
Angular pregnancy type	Decidual wrapping sign		O-shaped wrapping	C-shaped wrapping	No decidual wrapping
	Tubal interstitial line sign	Absent	Visible		
	Degree of angular protrusion	No protrusion	Mild protrusion (<50%)	Obvious protrusion (≥50%)	
	Angular myometrium thickness		≥3.5 mm	1–3.5 mm	≤1 mm
Villi or placenta accrete	The "clear zone" behind placenta	Clear	Loss		
	Thinning of angular myometrium, placenta bulge, and local tissue exogenesis of placenta	No	Yes		
	Villi or placenta lacuna	No	Yes		
	Blood flow of angular myometrium and surface and subplacenta		Small blood flow	Medium blood flow	Rich blood flow
	Pulse Doppler ultrasound		High-speed and low resistance blood flow	Sawtooth spectrum	

The highest scores of angular pregnancy type and villi or placenta accrete are 9 and 8 points respectively.
The lowest scores of angular pregnancy type and villi or placenta accrete are all 2 points.

in the lower segment of the uterus. Most cases of cesarean scar pregnancy and placenta accrete have high-risk factors, but the anatomical characteristics of the angle are the high-risk factors of villi or placenta accrete. Due to the abundant blood supply at the beginning of the angle and the interstitial part of the fallopian tube, the hypoplasia of decidua and the thin muscular layer, the implantation of pregnancy sac in the angle is more prone to villi accrete than in the body decidua. The case in Fig. 1 has no uterine malformation, no history of pregnancy, no history of uterine surgery, and no uterine lesions that can be detected by ultrasound.

The diagnosis of villi accrete in angular pregnancy in the first trimester and angular placenta accrete in the second and third trimesters is a challenge to the diagnostic level of ultrasound doctors. As the guide strongly recommends, "Ultrasonography is a relatively inexpensive and widely available imaging modality and therefore should be the first line for the diagnosis of PAS disorders" [12]. The unified descriptors for ultrasound findings recommended in the guidelines are also applicable to angular villi or placenta accrete. This study provides a method to judge whether there is angular villi or placenta accrete according to the score of gray-scale ultrasound and Doppler ultrasound characteristics of angular villi or placenta.

4.3 Analysis of Possible Causes of Missed Diagnosis

A possible cause of missed diagnosis of type I angular pregnancy by ultrasound in first trimester is that although the implantation position of pregnancy sac is biased towards one corner, it grows towards the uterine cavity, which fails to arouse the vigilance of ultrasound doctors. Once the early ultrasound does not suggest type I angular pregnancy, it is easy to ignore the problem of angular placenta accrete in the second and third trimester. Especially for pregnant women with a history of cesarean section, ultrasound doctors may focus on the relationship between placenta and incision. If prenatal angular placenta accrete, especially placenta penetration, is missed, the best choice of delivery mode may not be made, and obstetric complications such as uterine rupture, placenta residue and massive hemorrhage may occur during delivery. If type II and type III angular pregnancy is missed due to ultrasonography in the early stage of pregnancy, it may be that the ultrasound doctor has no concept and risk awareness of angular pregnancy and no diagnostic experience. If there is no abnormality in the early stage of first trimester, the next ultrasound examination is at 11–14 weeks. If ultrasound doctors only pay attention to the examination of the fetus while ignoring the asymmetric enlargement of the uterus, angular bulge, and high fetal position, they are likely to miss the diagnosis of angular pregnancy. In the second and third trimester, the risk of sudden rupture of the angle is very high. Once the uterine rupture is not rescued in time, it will endanger the lives of pregnant women and fetuses.

4.4 Strength and Limitations

The main strength of our study is that we propose a new sonographic diagnostic method for angular pregnancy, typing and judging the presence or absence of angular villi or placenta accrete.

This study has two limitations. First, the interpretation and score of some sonographic signs is subjective. The second limitation concerns the pathological diagnosis of placenta accrete. Manual abruption of placenta or retained pla-

centa in situ limits the accuracy of microscopic diagnosis and micropathological diagnosis during pathological examination.

5. Conclusions

Ultrasonography can accurately diagnose angular pregnancy and provide fine classification, and is also of great application value for angular villi accrete in the first trimester, angular placenta accrete in the second and third trimester, and postpartum angular placenta residual accrete. Ultrasound doctors should strive for the correct classification of angular pregnancy and the diagnosis of villi or placenta accrete; their findings will aid clinicians in making the correct pregnancy risk assessment for patients, and then formulating the optimal personalized management plan.

Author Contributions

LZ designed the research study, and was responsible for ultrasonic diagnosis, collection, analysis of case data, writing and revision of the manuscript.

Ethics Approval and Consent to Participate

All patients involved in this study signed an informed consent and power of attorney before accepting an operation. This study is a retrospective and descriptive analysis of the data collected prospectively for routine clinical services. The study protocol was approved by the ethics committee of our institution (approval number: TJ-C20210403).

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Conflict of Interest

The author declares no conflict of interest.

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