European Journal of Obstetrics & Gynecology and Reproductive Biology 242 (2019) 86–91

Contents lists available at ScienceDirect

European Journal of Obstetrics & Gynecology and Reproductive Biology

journal homepage: www.elsevier.com/locate/ejogrb

Full length article

Ultrasound accuracy in prenatal diagnosis of abnormal placentation of posterior placenta previa

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ARTICLE INFO

Article history:
Received 4 July 2019
Received in revised form 13 September 2019
Accepted 20 September 2019

Keywords:
Ultrasound
Placenta previa
Placenta accrete spectrum
Ultrasound accuracy
Posterior placenta

ABSTRACT

Objectives: To evaluate the accuracy of ultrasound in prenatal diagnosis of Placenta accrete spectrum disorders in patients with posterior placenta previa, and to assess the impact of prenatal diagnosis in our population.

Study Design: We prospectively enrolled 198 women with posterior placenta previa from 2011 to 2017. We performed transabdominal and transvaginal ultrasound examinations (Grey-scale and colour/power Doppler). The diagnosis of placenta accreta spectrum disorders was based on detection of at least two of the following criteria: loss of retroplacental clear zone, interruption of uterine serosa–bladder wall interface, turbulent placental lacunae with high velocity flow, myometrial thickness <1 mm, increased vascularity of uterine serosa–bladder wall interface, loss of vascular arch parallel to basal plate and/or irregular intraplacental vascularization. Definitive diagnosis was made at delivery with Caesarean section. Furthermore, we compared maternal outcomes in cases diagnosed antenatal versus that one's diagnosed at delivery.

Results: There were 20/198 cases of placenta accreta spectrum disorders. The two-criteria system identified 12 cases of placenta accreta, providing a 60.0% of sensitivity, 98.8% of specificity, 85.7% of positive and 95.7% of negative predictive value. Maternal outcomes were better in women with prenatal diagnosis of placenta accreta spectrum disorders, although not statistical significant.

Conclusions: Our data showed that grey-scale and Color-Doppler ultrasound evaluation for detecting placenta accreta spectrum disorders on posterior placenta previa have high specificity, positive and negative predictive value, but a low sensitivity. Nevertheless, an antenatal diagnosis of placenta accreta spectrum disorders for posterior placenta previa should be encouraged.

Introduction

Placenta accrete spectrum (PAS) disorders are characterized by an abnormal adherence to the implantation site by placenta, with three major variants of adherent placentation: placenta accreta, placenta increta and placenta percreta [1].

PAS are associated with a significant increase in maternal mortality (7%) and morbidity, especially due to blood loss, damage to surrounding organs, increase rate of intensive care admission, need for urgent hysterectomy and postoperative complications [2,3].

Placenta previa and previous caesarean section (CS) represent the two major risk factors for invasive placentation. The risk of PAS disorders on a placenta previa is 5%; prior CS increases this risk up to 20%, 40% and even higher respectively with one, two or more prior CS. Additional risk factors for PAS include previous uterine surgery [4]. Maternal outcomes are significantly improved when PAS is diagnosed prenatally as it allows planning a caesarean delivery in a tertiary center [5,6].

Ultrasound (US) is usually the first step tools for antenatal diagnosis of placenta accreta and magnetic resonance imaging (MRI) is reserve for equivocal findings [7,8]. Although grey-scale and Color-Doppler ultrasound are valuable tools to evaluate PAS, diagnostic criteria and accuracy are still under debate. This is most probably owing to a combination of limited sample size, retrospective design, and variability of inclusion criteria and definition of invasive placentation [9–11]. Furthermore, ultrasound prediction of placental invasions is more challenging with posterior or lateral implantation [12,13].

The main goal of this study is to evaluate the accuracy of grey-scale and colour-Doppler ultrasound in prenatal diagnosis of PAS for posterior placenta previa and the impact of prenatal diagnosis on maternal outcomes.

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https://doi.org/10.1016/j.ejogrb.2019.09.021
0301-2115/

Materials and methods

It is a prospective observational study carried out from January 2011 to December 2017 enrolling 198 women with posterior placenta previa. The inclusion criteria were: more than 26 weeks' gestation; placenta localized mainly (more than 50% of its whole part) on the uterine posterior wall; placenta was defined as previa when it covered the internal os and low-lying when the placental edge was <20 mm from the internal os [14,15]and who delivered at Sant'Anna Hospital in Turin, a tertiary centre hospital. We consecutively enrolled these patients and followed them at our Ultrasound Centre for Prenatal Diagnosis of Sant'Anna University Hospital. At least two different operators between 26 and 36 weeks' gestation, using two-dimensional (2D) grey-scale and colour/power Doppler imaging, performed Transabdominal (USTA) and transvaginal (USTV) ultrasound examinations on each woman until delivery. We collected women's clinical data regarding previous history of uterine surgery (mainly caesarean section, miomectomy or uterine curettage), age, ethnicity, parity and gestational age at delivery.

The Grey-scale and Colour/Power Doppler six criteria used for PAS disorders are the following: 1. Loss or irregularity of the hypoechoic area between the uterus and placenta, the 'retro-placental clear zone' (Fig. 1A–C. In Fig. 1B and C is clearly shown by the yellow line drawn the irregularity and progressively loss of the retroplacental clear zone); 2. Thinning or interruption of the uterine serosa–bladder wall interface (Fig. 1D and E. In Fig. 1E the yellow lines show how thinner is this interface compared to the upper part of the interface highlighted in green); 3. Myometrial thickness <1 mm (Fig. 1A, C and F. In Fig. 1C and F arrows show the area of myometrial thinning and the yellow lines drawn highlight how this myometrium progressively reduce until the arrows area of <1 mm and even disappear in Fig. 1F); 4. Turbulent placental lacunae with high velocity flow (>15 cm/s) (Fig. 1G and H); 5. Increased vascularity of the uterine serosa–bladder wall interface (Fig. 1I shows how there is an increasing in number and vessel size caring a higher amount of blood at the level of this interface. In this picture we use Power Doppler); 6. Loss of vascular arch parallel to the basal plate and irregular intraplacental vascularization (Fig. 1J, shows with transabdominal probe, the loss of a vascular area normally present between placenta and uterine wall that normally result in 2D grey scale as the retroplacental clear zone - arrows and yellow lines). The presence of at least two of the aforementioned characteristics ('two-criteria system') were considered diagnostic for placenta accreta, increta and percreta. Excluding the two criteria that take into account the bladder line (thinning or interruption of the uterine serosa–bladder wall interface and increased vascularity of the uterine serosa–bladder wall interface) the other four criteria was always detected in the posterior part of the placenta.

Examinations were performed using an ultrasound system equipped with a 4–8-MHz transabdominal transducer and a 5–9-MHz transvaginal transducer (Voluson 730, GE Medical Systems, Zipf, Austria, and HD 11 or Affinity 70, Philips, Amsterdam, The Netherlands).

All patients enrolled in this study delivered by Caesarean section in our Hospital (tertiary centre). A definitive diagnosis of PAS disorders was made at delivery: if no peripartum hysterectomy was performed the diagnosis was both on placenta specimen (absent of entire cotyledon of part of it on placenta surface or presence of myometrial tissue in the placenta specimen) and surgically when it was difficult for the surgeon to remove the placenta after foetus extraction leaving in some cases part of the placenta in situ; in cases of peripartum hysterectomy, definitive diagnosis of PAS disorders was made on uterus and placenta hystopatologically examination by analysing the degree of myometrial invasion. The pathologist was blinded to the ultrasound diagnosis.

Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of the two-criteria system and each of the six features involved were calculated separately.

According maternal morbidity we recorded for each patient the following outcomes: need for hysterectomy, blood loss, need for blood transfusion, urgent/planned caesarean section, days in intensive care unit (ICU), infection and the 5-min Apgar score.

For statistical analysis, we used Mann–Whitney *U*-test to compare continuous variables and Fisher's exact test for categorical variables.

Each patients signed a written informed consent for the study.

Results

Table 1 shows the maternal socio-demographic characteristic and type of placenta previa by ultrasound diagnosis.

During the 7-years study period, we enrolled 198 women with posterior placenta previa and PAS (accrete, increta and percreta) were confirmed histopathologicaly in 20/198 (10.1%) patients at the time of delivery: 11 placenta accrete, 7 placenta increta and 2 placenta percreta. Considering the localization of the placenta, 102 (51%) where posterior placenta previa and 96 (49%) where low-lying posterior placenta. In the group of patients with PAS, 17/20 (85%) placenta were previa and 3/20 (15%) were low-lying posterior placenta; whereas in the group of patients without PAS, 85/178 (47%) vs 93/178 (53%) patients had respectively previa and low-lying posterior placenta previa, with a statistical significance between the two group (p-value 0.0017). The average age at diagnosis was 36.5 (35–37) years and 85 (43%) women had a history of uterine surgery (at least one Caesarean section, uterine curettage or myomectomy). There was a higher rate of PAS in women who reported having had a previous uterine surgery (17/85; 20%) than in those with no previous uterine surgery (3/113; 2.6%), with a statistical significance (p-value 0.0001). There was no statistical significant difference in our patients' ethnicity and the majority of them where Caucasic (p-value 0.15). However, we recorded a higher rate of Asian in the group of PAS (2/20) compared the group without PAS (4/178), but this difference doesn't reach the statistical significance (p-value 0.11)

The two-criteria system antenataly diagnosed 12/20 women with confirmed PAS at delivery, providing a sensitivity of 60.0%, a specificity of 98.9%, a PPV and NPV of 85.7% and 95.7%, respectively (Table 2).

We performed an MRI in four doubtful cases for PAS at ultrasound examination, all confirmed then at delivery. In three cases, where ultrasound scan suspected placental accretism with 2, 3 and 4 US criteria detected, MRI suspected placenta accreta respectively in the first and in the third case; whereas in the second patient with three US criteria for PAS, MRI described no placental accretism. In one case where only one criterion was identified at US, MRI assessed no PAS disorders too. All of these four patients underwent peripartum hysterectomy and the histopathological examination, definitive diagnose a placenta increta in the two cases where MRI and US suspected PAS, and placenta accreta in the two cases where MRI did not suspect any PAS. It was not the purpose of this study to assess the accuracy of MRI for PAS in posterior placenta previa, so the radiologist was not blinded to the ultrasound diagnosis.

We had two false-positive cases, that showed two ultrasound criteria for PAS, and eight false-negative cases of PAS. Three false negative cases showed just one ultrasound criterion, which was in one case the loss/irregularity of retroplacental clear zone, in one other the loss of vascular arch parallel to basal plate and irregular intraplacental vascularization and in the last the thinning/

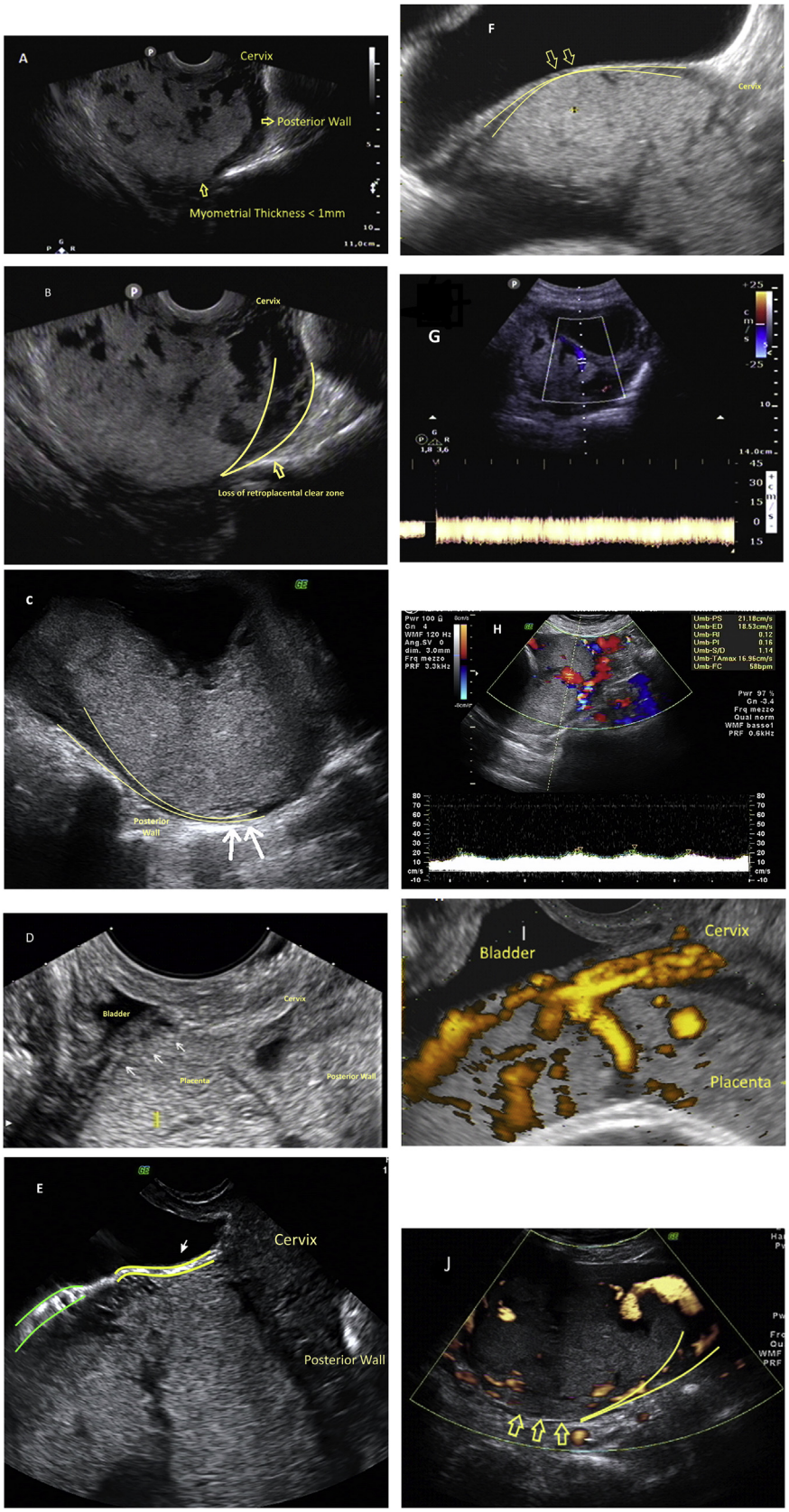

Fig. 1. Greyscale (a–f) and power Doppler (g–j) ultrasound images, showing the ultrasound criteria used for diagnosing placenta accreta spectrum disorders:
(A) Placental lacunae and myometrial thickness <1 mm (arrow); placenta was found to be percreta at the histopathological examination on uterus and placenta specimen, performed after a peripartum hysterectomy.
(B) Loss/irregularity of retroplacental clear zone (arrow and yellow lines); peripartum hysterectomy was performed at Cesarean section for heavy bleeding, and pathological examination identified placenta accreta and increta.
(C) Loss/irregularity of retroplacental clear zone and Myometrial thickness <1 mm (arrows and yellow lines): Histopathological examination identified placenta accreta.

Table 1
Socio-demographic characteristics of the studied patients (n = 198).

	Accrete (n = 20)	No Accrete (n = 178)
Type of previa, n (%)	17 (85%) previa 3 (15%) low-lying	85 (47%) previa 93 (53%) low-lying*
Age (years), median(range)	37 (35-38)	365 (34,5-37)
Ethnicity n (%)	17 (85%) Caucasic 1 (5%) Afro-Americans 2 (10%) Asiatics	167 (94%) Caucasic 7 (4%) Afro-Americans 4 (2%) Asiatics
Parity, median(range)	1 (1-2)	2 (1-3)
P0, n (%)	7 (35%)	35 (20%)
P1, n (%)	6 (30%)	44 (25%)
P2, n (%)	6 (30%)	80 (45%)
P>3, n (%)	1 (5%)	19 (10%)
Previous Uterine Surgery (CS, uterine curettage, myomectomy), n (%)	17 (85%)	68 (34%)*
No. previous CS, median (range)	1 (0-2)	0 (0-0,5)
CS 0, n (%)	8 (40%)	120 (675%)*
CS 1, n (%)	5 (25%)	52 (29%)
CS 2, n (%)	6 (30%)	6 (3,5%)
CS 3, n (%)	1 (5%)	0 (0%)
Previous uterine curettage, n (%)	12 (60%)	62 (35%)*
Previous myomectomy, n (%)	0 (0%)	16 (9%)

No., Number; CS, Cesarean section; P, parity. *p-value < 005: this resulted significant for placenta localization (previa vs low lying); any previous surgery; at least one previous caesarean section; and previous uterine curettage. Mann–Whitney *U*-test was used to compare continuous variables and Fisher's exact test was used for categorical variables.

Table 2
Accuracy of two-criteria system and individual ultrasound characteristics for diagnosing placenta accreta spectrum disorders in 198 pregnant women with placenta previa with posterior insertion.

	N.				%			
Diagnostic criteria	TP	TN	FP	FN	SENS	SPEC	PPV	NPV
Two-criteria system	12	176	2	8	60,0%	98,9%	85,7%	95,7%
Thinning/interruption of uterine serosa–bladder interface	4	175	3	16	20,0%	98,3%	57,1%	91,6%
Myometrial thickness<1 mm	7	178	0	13	35,0%	100,0%	100,0%	93,2%
Turbulent placental lacunae	10	167	11	10	50,0%	93,8%	47,6%	95,4%
Increased vascularity of uterine serosa–bladder wall interface	0	178	0	20	0,0%	100,0%	NS	89,9%
Loss of vascular arch parallel to basal plate and irregular intraplacental vascularization	11	172	6	9	55,0%	96,6%	64,7%	95,0%
Loss/irregularity of retroplacental clear zone	13	173	5	7	65,0%	97,2%	72,2%	96,1%

FN, false negative; FP, false positive; NPV, negative predictive value; PPV, positive predictive value; TN, true negative; TP, true positive; SENS, sensitivity; SPEC, specificity.

interruption of uterine serosa–bladder interface. However, five false negative cases showed no ultrasound criteria at all. The majority of the true-positive cases had a median of four (3–4 first and third quartile) ultrasound criteria. The only two cases with placenta percreta (Fig. 1A, B, G and J) had respectively four and five diagnostic ultrasound criteria.

Evaluation of accuracy for individual sonographic signs demonstrated that loss/irregularity of the retroplacental clear zone has the highest sensitivity and NPV, even higher to the two-criteria system, confirming the importance of this criteria for the suspicion of abnormal placentation (Table 2). All other five criteria have a considerably lower sensitivity than the two-criteria system.

Concerning maternal outcomes, patients on which a PAS was antenataly US diagnosed, had less blood loss and consequently less blood transfusion, less urgent CS, lower rate of infection and required a shorter period in the ICU (intensive care unit) compared to patients where PAS was not diagnosed during pregnancy (Table 3). A preventive hysterectomy was planned in 7/12 (57%) subjects in the true-positive group and no attempt was made to remove the placenta. The median (range) of gestational age at cesarean delivery was 34.5 (32.75–36) weeks. Pathological examination of the uterus after hysterectomy confirmed the diagnosis of PAS in each of the seven cases in which it was performed (one placenta accreta, four-placenta increta and two-placenta percreta). Nevertheless, four patients of the false negative group (50%), had an urgent peripartum hysterectomy: three of them resulted increta at the histopathological examination and one of them accreta.

Regarding gestational age at ultrasound PAS diagnosis in posterior placenta, we have observed in our sample, that patient with prenatal US diagnosis of PAS, true positive cases, had an earlier gestational age at first ultrasound screening (26 weeks of median; 25–28 weeks of range), compared to those patient with PAS diagnosis at surgery (32 weeks of median; 28–33 weeks of

(D) Thinning of the uterine serosa–bladder interface (arrows); at Cesarean section, no attempt was made to remove the placenta, and hysterectomy was performed. Pathological examination identified placenta increta and percreta.
(E) Thinning of the uterine serosa–bladder interface (arrow); at Cesarean section, no attempt was made to remove the placenta, and hysterectomy was performed. Pathological examination identified placenta increta.
(F) Myometrial thickness <1 mm (even absent myometrial tissue in this picture, arrows and yellow lines); at Cesarean no attempt was made to remove the placenta, and hysterectomy was performed. Pathological examination identified placenta increta.
(G) Placental lacunae with high velocity flow (16.9 cm/s); hysterectomy was performed at Cesarean section for heavy bleeding, and pathological examination identified placenta percreta.
(H) Placental lacunae with high velocity flow: hysterectomy was performed at Cesarean section for heavy bleeding, and pathological examination identified placenta increta.
(I) Increased vascularity of uterine serosa–bladder wall interface and placental lacunae using Power Doppler that show intense vascularisation with the presence of high diameter vessels; at Cesarean no attempt was made to remove the placenta, and hysterectomy was performed. Pathological examination identified placenta increta.
(J) Loss of vascular arch parallel to basal plate (arrows and yellow lines) and irregular intraplacental vascularization; at Cesarean section no attempt was made to remove the placenta, and hysterectomy was performed due to heavy bleeding. Pathological examination identified placenta percreta.

Table 3
Maternal outcome in 20 pregnancies placenta accreta spectrum disorders on posterior insertion, according to whether they were diagnosed prenatally by ultrasound (US).

	US prenatal diagnosis of PAS (n = 12)	Non-US prenatal diagnosis of PAS (n = 8)	p-value*
Hysterectomy, n (%)	7 (57%)	4 (50%)	1
Blood loss (mL), median (range)	2000 (1100–2975)	2850 (1975–5000)	0,1
Blood transfusion, n (%)	8 (66%)	8 (100%)	0,11
Days in ICU, median (range)	2 (1,75–4,25)	3 (3–4)	0,25
Infection, n (%)	1 (8%)	2 (25%)	0,53
Emergency CS, n (%)	5 (41%)	4 (50%)	1
5-min Apgar score, median (range)	8 (7–8)	8 (7–9)	0,25

PAS, placenta accreta spectrum; CS, cesarean section; ICU, intensive care unit. Data are given as *n* (%) or median (range). *Mann–Whitney *U*-test was used to compare continuous variables and Fisher's exact test was used for categorical variables.

range), false negative cases. We suppose that this finding can be explained by the fact that at earlier gestational age the uterine wall and placenta itself are better visualized at ultrasound scan, thanks a more represented amniotic fluid compared to foetus dimensions, allowing an easier study of placenta implantation site especially for posterior insertion.

Comment

Ultrasound suspected PAS in 12/20 women who showed at least two out of six criteria for PAS, with overall sensitivity of 60.0%, a specificity of 98.9%, a PPV and NPV of 85.7% and 95.7%, respectively, (Table 2). The single criterion with the greatest sensitivity was loss/irregularity of retroplacental clear zone (SE of 65.0%).

The impact of antenatal diagnosis of PAS shows that there is a clinical difference of maternal outcomes between patients with US prenatally diagnosed placenta accreta compared to those diagnosed at delivery, with less peripartum blood loss (2000 *vs* 2850 mL) and shorter hospitalization in the ICU (2 *vs* 3 days). However, considering the small number of patients, these results do not reach the statistical significance (p-value 0.1 and 0.25 respectively).

Most of the study published on antenatal ultrasound accuracy of PAS on placenta previa were conducted using different techniques (grayscale ultrasound, Color-Doppler and/or three-dimensional ultrasound or the all three together) and criteria (only one criterion or two criteria), often analyzing small cohorts of patients. The two studies with the largest cohorts in literature included 39 cases [16] and 41 cases [17] and they considered only anterior placenta, like most studies [10,11,18,19], so that nowadays there is no precise accuracy of antenatal ultrasound diagnosis of PAS in posterior placenta previa.

In our study the criterion of loss/irregularity of retroplacental clear zone is the criterion with the best sensitivity (SE of 65.0%) alone, which resulted higher than the two criteria system. This interesting result differ from what we observed in our previous study analysing also anterior placenta previa where the two criteria system have had the same sensitivity (81.1%) of the irregularity of retroplacental clear zone criterion alone (81.1%) [13]. We suppose that this difference is due to hemodynamic reason [20] leading to a more vascularised lower uterine segment on the posterior wall, compared to lower uterine segment on the anterior wall. From a sonographic point of view, this result in a better-defined retroplacental clear zone of the posterior lower uterine segment, compared to the retroplacental clear zone on the anterior lower uterine segment. Thus, in case of loss of integrity of retroplacental clear zone for placental accretism, the US alteration is better visible for sonographer posteriorly compared to the anterior wall, especially between 26–28 weeks of gestation.

The impact of antenatal diagnosis of PAS on maternal outcomes (Table 3) shows that our findings are in agreement with those of Tikkanen et al [21]. Fifty-five percent of patients with placenta accrete in our study group had peripartum hysterectomy for PAS, in agreement with rates reported in literature [22]. We surprisingly observed a higher rate of hysterectomy in the ultrasound diagnosis group compared to the false-negative cases (*57%* vs 50%), probably influenced by the higher rate of placenta percreta and increta.

Sensitivity of examination is very important, because a correct early diagnosis of PAS before Cesarean section reduce maternal and fetal morbidity if delivery is planned in tertiary hospitals [5,6,11,14,15]. However, specificity and PPV shouldn't be underestimated because patients with an antenatal diagnosis of placenta accreta may require invasive procedures, such as artery embolization or ureteral stents [23–25] or even preventive hysterectomy 14,15]. Considering both the importance of sensitivity, specificity and PPV in this population of patients with placenta previa at high risk, we decide to define PAS at ultrasound antenatal diagnosis, when at least two criteria occur. If we had used only one criterion, we would have seen 22 false positives instead of two, risking overtreatment. A statistical analysis on our patients of ultrasound accuracy using only one criteria, revealed actually a higher sensitivity (75.0%), but with lower sensitivity (87.6%) and very poor PPV (40.5%), confirming that the two-criteria system has the best balance in ultrasound accuracy. To better understand our choice of the two-criteria system, we made also an analysis of maternal outcomes difference between true positive and false negative, if we have used one criterion or the best criterion (loss of retroplacental clear zone): there aren't any improvement concerning maternal outcomes with even worse results in term of statistical significance.

Our MRI data, which are only on patients with PAS, aren't actually sufficient to draw any conclusion on prenatal MRI diagnosis of PAS, and it wasn't our study purpose too. Nevertheless they are in agree with present literature showing that prenatal MRI is complementary to US and can help in diagnosis invasive placentation especially in those condition when US is not conclusive to assess invasion degree [26,27]. MRI can predict degree and topography of invasion especially in presence of parametrial invasion 27]. This is particular important because surgical approach is mainly dependent on size and exact anatomy of invasion. A limit of ultrasound in posterior insertion of placenta previa is the difficult to evaluate the entire placenta in all of its part. Further studies comparing MRI and US both in posterior placenta previa with and without PAS should be needed.

Our study is the first in literature to describe the real accuracy of ultrasound in antenatal diagnosis of PAS regarding only posterior placenta previa with such a large number of patients. A limit of ultrasound in posterior insertion of placenta previa is the difficulty to evaluate the entire placenta in all of its part.

Our data show that grey-scale and Color-Doppler ultrasound evaluation for detecting PAS on posterior placenta previa have high specificity, positive and negative predictive value, but low sensitivity.

We think that to all women, with almost one previous caesarean section and posterior placenta previa, an antenatal ultrasound scan for PAS disorders should be encouraged to evaluate the clinical role that ultrasound may play in these patients. In doubtful cases, MRI can be useful especially to evaluate the degree and topography of placental invasion.

Further multicenter studies in referral centers using specific and homogeneous procedures PAS disorders management [28] should be carried out on larger study groups, to confirm data obtained in our study.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We are grateful to Drs P. Gaglioti, S. Bastonero, G. Errante, E. Gullino, M. Pagliano and S. Sdei, for performing some of the ultrasound examinations and Dott. G Botta for pathological analyses. Drs acknowledged report no funding and no conflict of interest.

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