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Modified Delphi study of ultrasound signs associated with placenta accreta spectrum

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KEYWORDS: Delphi survey; placenta accreta spectrum; placenta previa accreta; systematic review; ultrasound imaging

CONTRIBUTION

What are the novel findings of this work?
Using a structured Delphi process informed by a systematic review, we found that targeted detailed sonography looking for most established standardized ultrasound signs of placenta accreta spectrum (PAS) and involvement of the cervix is recommended for the prenatal evaluation of pregnant patients at high risk for PAS.

What are the clinical implications of this work?
Pregnant women at high risk for PAS at birth should be referred to specialist centers with expertise in abnormal placentation. Prenatal evaluation should include transvaginal ultrasound to confirm the precise position of the placenta and anatomy of the cervix. New ultrasound signs that can be obtained using standard ultrasound equipment should be included in future clinical research.

ABSTRACT

Objective *To determine, by expert consensus through a modified Delphi process, the role of standardized and new ultrasound signs in the prenatal evaluation of patients at high risk of placenta accreta spectrum (PAS).*

Methods *A systematic review of articles providing information on ultrasound imaging signs or markers associated with PAS was performed before the development of questionnaires for the first round of the Delphi process. Only peer-reviewed original research studies in the English language describing one or more new ultrasound sign(s) for the prenatal evaluation of PAS were included. A three-round consensus-building Delphi method was then conducted under the guidance of a steering group, which included nine experts who invited an international panel of experts in obstetric ultrasound imaging in the evaluation of patients at high risk for PAS. Consensus was defined as agreement of ≥ 70% between participants.*

Results *The systematic review identified 15 articles describing eight new ultrasound signs for the prenatal evaluation of PAS. A total of 35 external experts were approached, of whom 31 agreed and participated in the first round. Thirty external experts (97%) and seven experts from the steering group completed all three Delphi rounds. A consensus was reached that a prior history of at least one Cesarean delivery, myomectomy or PAS should be an indication for detailed PAS ultrasound assessment. The panelists also reached a consensus that seven of the 11 conventional signs of PAS should be included in the examination of high-risk patients and the routine mid-gestation scan report: (1) loss of the 'clear zone', (2) myometrial thinning, (3) bladder-wall interruption, (4) placental bulge, (5) uterovesical hypervascularity, (6) placental lacunae and (7) bridging vessels. A consensus was not reached for any of the eight new signs identified by*

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the systematic review. With respect to other ultrasound features that are not specific to PAS but increase the probability of PAS at birth, the panelists reached a consensus for the finding of anterior placenta previa or placenta previa with cervical involvement. The experts were also asked to determine which PAS signs should be quantified and consensus was reached only for the quantification of placental lacunae using an existing score. For predicting surgical outcome in patients with a high probability of PAS at delivery, a consensus was obtained for loss of the clear zone, bladder-wall interruption, presence of placental lacunae and presence of placenta previa involving the cervix.

Conclusions *We have confirmed the continued importance of seven established standardized ultrasound signs of PAS, highlighted the role of transvaginal ultrasound in evaluating the placental position and anatomy of the cervix, and identified new ultrasound signs that may become useful in the future prenatal evaluation and management of patients at high risk for PAS at birth.*

INTRODUCTION

Placenta accreta spectrum (PAS) occurs when the gestational sac implants and the definitive placenta develops within a uterine scar area[1,2]. The loss and remodeling of the normal uterine wall structure following surgery allows the extravillous trophoblast to reach and contribute to the transformation of large peripheral uterine arteries under the scar area[3]. Continuous high-pressure arterial intervillous flow is likely to be the main cause of the increase in fibrinoid deposition at the uteroplacental interface with progressive distortion of the above cotyledonary architecture[4]. Loss of parts of the physiological placental detachment from the uterine site is associated with high maternal morbidity and sometimes mortality due to massive obstetric hemorrhage, particularly when the surgeon is unaware and attempts to detach the accreta area manually at delivery[5].

The prenatal diagnosis of PAS is associated with reduced hemorrhagic morbidity at delivery[6]. In 1982, Tabsh *et al.*[7] were the first to describe the ultrasound features of a case of placenta increta with gray-scale imaging (GSI). A decade later, using color Doppler imaging (CDI), Chou *et al.*[8] first reported on the changes in the uteroplacental circulation associated with PAS. There has been considerable variability in the ultrasound equipment and signs and diagnostic criteria used for the perinatal evaluation of PAS[9] and, in particular, of its most common form, i.e. placenta previa accreta[10]. In 2016, the European Working Group on abnormally invasive placenta (EW-AIP) proposed a list of standardized ultrasound signs for PAS, identified up to February 2013[11].

Over the last decade, new ultrasound signs of PAS have been reported in the international literature. Thus, we conducted a survey using a modified Delphi methodology including a systematic review to gain an expert consensus on the role of old and new ultrasound signs in the prenatal evaluation and management of patients at high risk of PAS at birth. The Delphi technique was selected because it has been widely used to generate robust consensus in healthcare research[12].

METHODS

Systematic literature review

A systematic review of articles providing data on ultrasound imaging signs or markers associated with PAS was performed before the development of the questionnaire for the first round of the Delphi procedure, as suggested by Sinha *et al.*[12]. PubMed, Google Scholar and MEDLINE were searched for studies published between the systematic review by Jauniaux *et al.*[9], which ended on 30 March 2016, and 31 May 2022. The search protocol was designed *a priori* by E.J. and A.B. and completed in compliance with the guidelines for Preferred Reporting Items for Systematic Reviews and Meta-Analysis[13]. The overall search strategy included Medical Subject Headings (MeSH) for the following terms: 'placenta accreta' OR 'placenta increta' OR 'placenta percreta' OR 'abnormally invasive placenta' OR 'morbidly adherent placenta' OR 'placenta adhesive disorder'. We combined these with terms related to 'sonography', 'ultrasound imaging', 'new ultrasound sign', 'gray-scale imaging', 'three-dimensional (3D) ultrasound' and 'color Doppler imaging (CDI)'. Searches of the title and abstract fields were performed. The reference lists of selected studies were searched manually for additional eligible papers. Only peer-reviewed original research studies in the English language describing one or more new ultrasound sign(s) for the prenatal evaluation of PAS were included. Exclusion criteria included reviews, opinions, letters, protocols, conference proceedings, articles published after 31 May 2022 and non-human studies. Retrieved papers were reviewed and information extracted independently by E.J. and A.B.. Any disagreement was resolved by consultation with a third author (Z.A.).

Steering group and expert panel

The steering group included nine experts; E.J. and Z.A. designed the questionnaires and seven members provided valuable feedback. The decision was made that E.J. and Z.A. would not participate in the Delphi process but the other seven members would remain eligible.

Thirty-five additional experts were subsequently invited by e-mail after recommendation by their colleagues on the steering group. Potential participants were sent the study information including an invitation letter and a copy of the Delphi protocol by e-mail.

Each member of the steering group was asked to provide the name(s) of up to four experts, defined as

clinicians with at least 10 years' experience in obstetric ultrasound imaging including PAS who had published at least one recent article on the use of ultrasound imaging in the prenatal evaluation of PAS and/or have an affiliation with a national or international organization dedicated to improving the diagnosis and management of PAS. The final list included individuals who replied to our invitation, citing an interest in being involved in the Delphi process. Once prospective panelists agreed to participate in the study, their e-mail addresses were added to the final participant list for survey distribution and were invited to be listed as collaborators on a future publication. All responses to the questionnaires were received through an independent third-party e-mail to ensure anonymity.

Overall, the final panel included 37 experts from 21 different countries, including four from low- and middle-income countries. Recruitment and the three rounds of Delphi questionnaires were completed over a 3-month period between August and November 2022.

Delphi rounds

A three-round Delphi consensus method was performed to identify the ultrasound signs or markers of PAS and evaluate the use of these signs in future clinical research studies. The questionnaires for the three rounds were developed by E.J. and Z.A., and reviewed and approved by the steering panel. These questions concerned: (1) clinical, demographic and sonographic criteria used to define patients at high risk of PAS at birth; (2) the relevance of each ultrasound sign in the prenatal evaluation of patients at high risk of PAS at birth; (3) the optimal gestational age at which to assess for signs suggesting PAS during the second half of pregnancy; (4) the relevance of various established ultrasound techniques available on standard ultrasound machines (such as transvaginal ultrasound (TVS), CDI, pulsed-Doppler ultrasound and three-dimensional (3D) (Doppler) ultrasound) and new ultrasound techniques in acquiring old and new ultrasound signs associated with PAS; and (5) the value of established and new ultrasound signs and other ultrasound features in the prenatal assessment and evaluation of surgical outcomes in patients at high risk for PAS at birth.

After the first round, the answers to each question from all the experts were analyzed and corresponding data were used to develop questionnaires for the second and third rounds. All the experts who agreed to participate in the Delphi procedure were invited to participate in the second and third rounds only if they had replied to the first questionnaire. The experts were given 10 days to provide their final responses to each questionnaire, and a single reminder was sent if no response was received within 2 weeks.

A consensus was predefined as proportion of agreement of $\geq 70\%$. The rate of agreement (RoA) was calculated for the third questionnaire as: RoA = (agreement – disagreement)/(agreement + disagreement + unsure) × 100.

In the Round 1 questionnaire, participants were asked to: (1) identify demographic and clinical characteristics that are associated with a higher risk of PAS at birth, based on which detailed PAS ultrasound assessment is indicated; (2) select the ultrasound signs that should be included in the routine mid-gestation scan report of high-risk patients based on risk factors and/or placental appearance; and (3) select second- or third-trimester non-PAS ultrasound features that increase the probability of PAS at birth.

In Round 2, the participants were asked to select the optimal gestational age at which to identify ultrasound signs associated with PAS and to determine which signs should be quantified. Participants were also asked to provide suggestions on how to quantify the different signs. Only ultrasound signs that reached an agreement of $\geq 70\%$ in Round 1 were included in Round 2.

In Round 3, the participants were sent a single questionnaire that focused on ultrasound signs of PAS and other features to be used for future clinical research on predicting surgical outcomes in patients with a high probability of PAS at birth. This questionnaire also included ultrasound signs of PAS from Round 1 for which no agreement was reached, but that could be obtained using standard ultrasound equipment.

RESULTS

Literature search

The initial database search identified 1248 articles, and manual reference checking provided an additional three studies, making a total of 1251 potentially relevant articles. After exclusion of duplicates and two articles that were not available, 880 remained, of which a further 793 were excluded after screening the titles and abstracts, as the data they reported were not relevant. The remaining 87 studies were retrieved for full-text review, of which 72 were excluded after in-depth review, leaving 15 studies describing eight new ultrasound signs for the prenatal evaluation of PAS[14–28]. The process of selection of these articles is summarized in Figure S1, and the characteristics of the 15 studies identified by the systematic review are presented in Table S1.

Delphi procedure

A total of 37 experts (seven from the steering group and 30 external) completed all three rounds of the Delphi questionnaires.

Delphi round 1

In the first round, 11 demographic and clinical characteristics were presented to the experts to determine which should be used to identify high-risk patients in whom detailed PAS ultrasound assessment is indicated (Table S2). A consensus was reached on four of the 11 characteristics, namely, a history of one Cesarean delivery (CD), multiple prior CDs, myomectomy or PAS.

Of the 11 established standardized ultrasound signs of PAS[11], a consensus of ≥ 70% was reached among the panelists for seven signs that should be assessed and included in the routine mid-gestation scan report of high-risk patients (Table 1). These comprised loss of the 'clear zone' (hypoechoic retroplacental zone), myometrial thinning, bladder-wall interruption, presence of a placental bulge, uterovesical hypervascularity, placental lacunae and bridging vessels. None of the eight new signs identified in the present systematic review[14–28] reached a predefined consensus threshold as ultrasound findings that increase the probability of PAS at birth (Table 1). In addition, the panel was queried about second- or third-trimester ultrasound findings that are not specific for PAS (i.e. placental position, placental thickness, anatomy of the cervix, multiple pregnancy and abnormal fetal growth) yet may increase the probability of PAS at birth (Table S3). A consensus was obtained for the presence of anterior placenta previa, defined as the placental edge being < 0.5 cm from the internal os or the placenta completely covering it[29], and placenta previa with cervical involvement.

Delphi round 2

No consensus was reached among the panelists regarding the optimal gestational age at which to identify the different ultrasound signs associated with PAS that

Table 1 Agreement, according to a Delphi consensus, of 37 experts regarding reporting of 11 established and eight new ultrasound signs at mid-gestation scan in pregnant patients at high risk of placenta accreta spectrum

Ultrasound sign	*Imaging method*	*Description*	*Agreement (n (%))*
Established signs			
Placental lacunae[11]	GSI and CDI	Large, irregular, hypoechoic (without a hyperechogenic halo) intraplacental spaces located above large feeder vessels, giving the placenta a 'moth-eaten' appearance (containing turbulent flow)	36 (97)
Loss of 'clear zone' (hypoechoic retroplacental zone)[11]	GSI	Loss or irregularity of normal hypoechoic interface between the uterine wall and placental basal plate	35 (95)
Bladder-wall interruption[11]	GSI	Partial or complete interruption, loss or irregularity of bladder wall or of the hyperechoic line between uterine serosa and bladder lumen	33 (89)
Placental bulge[11]	GSI	'Ballooning' of the uterus containing the placenta into surrounding pelvic structure	33 (89)
Uterovesical hypervascularity[11]	CDI	Striking amount of color Doppler signal seen in the placental bed of a low-lying placenta/placenta previa, and bladder wall demonstrating multidirectional flow and aliasing artifact	33 (89)
Myometrial thinning[11]	GSI	Myometrial thickness < 1 mm or undetectable	28 (76)
Bridging vessels[11]	CDI	Vessels appearing to extend from the placental bed, across the uterine wall into the bladder or other pelvic organs	28 (76)
Exophytic mass[11]	GSI	Focal area of myometrium at which placenta appears to protrude outside the uterine wall	25 (68)
Placental lacunae feeder vessel(s)[11]	CDI	Large vessel(s) located under lacuna(e)	25 (68)
Subplacental hypervascularity[11]	CDI	Striking amount of color Doppler signal seen in placental bed demonstrating multidirectional flow and aliasing artifact	22 (59)
Intraplacental hypervascularity[11]	3D-CDI	Complex, irregular arrangement of numerous placental vessels, exhibiting tortuous courses and varying calibers	21 (57)
New signs			
Intracervical lakes[22]	TVS-CDI	Tortuous hypervascularized anechoic spaces within cervix	25 (68)
Obliteration of retroplacental clear space (tramline appearance)[16,17,20,25]	3D-GSI and 3D-CDI/4D volume rendering (crystal vue/realistic vue)	'Partial obliteration' is defined as loss of some or part of the uterus–bladder interface; 'full obliteration' as complete obliteration of the uterus–bladder interface	17 (46)
Rail sign[24]	CDI	Two parallel enlarged vessels over the uterovesical junction and bladder mucosa, with interconnecting bridging vessels perpendicular to both	14 (38)
Increased parametrial vascularity[21]	CDI	Complex, irregular arrangement of vessels, exhibiting tortuous courses and varying calibers in the parametrial region	14 (38)
Pulsatile vessel at posterior bladder wall[26]	CDI	Pulsatile arterial vessels with low resistance index at the posterior bladder wall	12 (32)
Missing decidual signal[18,23]	SMI	Absence of Doppler signals under the basal plate and obliterated myometrium	3 (8)
Non-tapered placental edge[27]	GSI	Presence of blunt or wide amount of trophoblast at the placental edge in the sagittal plane	3 (8)
High ARFI elastography scores[14,15,19,28]	GSI/VTQ	Shear-wave elastography velocity evaluation of placental stiffness (mean > 1.92 m/s)	1 (3)

3D, three-dimensional; 4D, four-dimensional; ARFI, acoustic radiation force impulse; CDI, color Doppler imaging; GSI, grayscale imaging; SMI, Superb Microvascular Imaging; TVS, transvaginal sonography; VTQ, virtual touch quantification.

Table 2 Responses of 37 experts participating in Delphi process regarding ultrasound signs associated with a high probability of placenta accreta spectrum that should be quantified, and recommended quantitative assessment methods

	Need for quantitative assessment		
Ultrasound sign	*Yes*	*No*	*Recommended method (number of experts)*
Loss of 'clear zone'	4 (11)	33 (89)	TAS measurement of area size ($n=2$) and describe them as focal (< 5 cm in length) or diffuse (> 5 cm in length) ($n=1$) Score proposed by Del Negro *et al.*[31]: 0, present; 1, irregular; 2, absent ($n=1$)
Myometrial thinning	19 (51)	18 (49)	TAS measurement of RMT obtained perpendicular to long axis of uterus and measured at thinnest part with proposed cut-off of: < 1 mm ($n=9$); < 2.5 mm ($n=1$); and < 3 mm ($n=1$) TVS measurement of RMT at 5 cm from internal os ($n=1$) Average of three RMT measurements at different levels between internal os and top of bladder ($n=1$) RMT ratio between scar area and intact myometrium outside ($n=2$) TAS measurement of area size ($n=2$)
Bladder-wall interruption	5 (14)	32 (86)	TAS measurement of area size ($n=3$) Score proposed by Del Negro *et al.*[31]: 0, line clear and complete; 1, line vague or irregular; 2, line lost ($n=1$)
Placental bulge	7 (19)	30 (81)	TAS measurement of area size ($n=4$), categorized as follows: < 2 cm of bulge length and < 1 cm protrusion into partially/fully filled bladder; 2–5 cm of bulge length and 1–3 cm protrusion into bladder; > 5 cm of bulge length regardless of 'depth' of protrusion into the bladder ($n=1$) Evaluation of location: above bladder; below level of internal os or towards parametrium ($n=1$)
Uterovesical hypervascularity	13 (35)	24 (65)	TAS-CDI measurements of surface area of confluence (on 3D) or greatest linear extent (on 2D) ($n=1$) Score proposed by Del Negro *et al.*[31]: 1, increased flow, presence of numerous vessels, tortuous; 2, multidirectional flow or presence of bridging vessels ($n=1$)
Placental lacunae	27 (73)	10 (27)	TAS and TVS score proposed by Finberg and Williams[30]: 0, none; 1+, 1–3; 2+, 4–6; 3+, > 6 ($n=26$) Measurement of lacunae size > 20 mm ($n=1$)
Bridging vessels	15 (41)	22 (59)	TAS count of number of vessels ($n=7$) and measurement of surface area ($n=1$) Measurement of PSV ($n=2$)

Data are given as *n* (%). 2D, two-dimensional; 3D, three-dimensional; CDI, color Doppler imaging; PSV, peak systolic velocity; RMT, residual myometrial thickness; TAS, transabdominal sonography; TVS, transvaginal sonography.

reached a consensus in Round 1 (Table S4). Four experts recommended the 11–14-week scan period. There was a consensus to quantify the presence of placental lacunae, but no consensus was reached for any of the other signs (Table 2). The method of choice to quantify placental lacunae for 26 of the 37 (70%) of the panelists was the score proposed by Finberg and Williams[30]. Quantitative methods were also proposed for measuring the size of the area with loss of the clear zone, myometrial thinning, bladder-wall interruption, placental bulge, uterovesical hypervascularity and bridging vessels (Table 2). One expert suggested use of the scores proposed recently by Del Negro *et al.*[31] to quantify loss of the clear zone, bladder-wall interruption and uterovesical hypervascularity.

Delphi round 3

Table 3 displays the RoA among experts regarding the role of the standardized ultrasound signs that reached a strong consensus in Round 1, new signs identified by the systematic review that can be obtained using regular ultrasound equipment and other ultrasound features that may predict surgical outcome at delivery. A consensus was obtained for loss of the clear zone, bladder-wall

Table 3 Responses and rate of agreement (RoA) of 37 experts participating in Delphi process, regarding role of proposed ultrasound signs and features for future research in predicting surgical outcome in patients with high probability of placenta accreta spectrum at birth

Ultrasound sign	*Agree*	*Disagree*	*Unsure*	*RoA (%)*
Placenta previa with cervical involvement	34	1	2	89
Bladder-wall interruption	34	2	1	86
Loss of 'clear zone'	30	4	3	70
Placental lacunae	30	4	3	70
Bridging vessels	28	4	5	65
Placental bulge	28	5	4	62
Subplacental/uterovesical hypervascularity	27	5	5	59
Myometrial thinning	25	5	7	54
Intracervical lakes	22	7	8	41
Placenta previa reaching but not covering internal os	24	11	2	35
'Rail sign'	6	15	16	24
Cervical length/funneling	11	16	10	14
Placental lacunae feeder vessel(s)	14	10	13	11
Placental lacunae feeder vessel(s) with PSV ≥ 41 cm/s	11	12	14	3

PSV, peak systolic velocity.

interruption, presence of placental lacunae and placenta previa involving the cervix, i.e. partially or completely covering the internal os of the cervix.

DISCUSSION

Main findings

Consensus was reached for seven of the 11 standardized TAS signs currently used in the prenatal evaluation of patients at high risk for PAS at birth. The panel also agreed that TVS evaluation of the lower segment could contribute to both prenatal management and predicting surgical outcome. By contrast, none of eight new ultrasound signs associated with PAS identified in the systematic review was endorsed by more than 70% of the panelists, perhaps owing to technical limitations related to the availability of specific software on routine ultrasound equipment and/or limited prospective data on their use.

Comparison with other studies

Transabdominal sonography (TAS) descriptors of PAS proposed by the EW-AIP were developed in 2014 during a meeting of 29 European healthcare professionals and basic science researchers with an interest in abnormal placentation[11]. They used the antenatal ultrasound signs of PAS identified in a systematic review of 23 studies published before 7 February 2013[32]. Our modified Delphi process involved 37 experts in obstetric ultrasound imaging and included the evaluation of risk factors for PAS, both TAS and standardized TVS-PAS signs, the possible quantification of the signs and determination of the gestational age at which signs are best identified. We also evaluated the role of new ultrasound signs that can be obtained using regular ultrasound equipment in determining surgical outcomes.

The vast majority of PAS cases are now found in patients with at least one prior CD, presenting with placenta previa[5,10,33,34], and targeted ultrasound screening protocols for these patients improve perinatal outcomes[35]. In our Delphi study, the experts agreed that a higher risk of PAS is associated with a history of at least one previous CD, myomectomy or prior PAS (Table S2) and the presence of anterior placenta previa and placenta previa with cervical involvement on TVS (Table S3). Pregnant patients with a history of CD or PAS, presenting with an anterior low-lying placenta/placenta previa at the routine mid-pregnancy scan should be systematically referred to a specialist unit with expertise in the imaging of abnormal placentation[36]. The panel also advised screening for PAS in patients with prior myomectomy, however, the risk of PAS after myomectomy is low[37] and only nine cases of myomectomy scar pregnancies have been reported[38].

There are limited data on the evolution and changes of ultrasound signs associated with PAS with advancing gestation[3,39–44]. A multivariate analysis found that true-positive cases of PAS were more likely to present after 16 weeks' gestation with loss of the clear zone, myometrial thinning, irregular bladder wall, placental lacunae and vascular abnormalities on CDI[40]. Only a few of the panelists recommended the evaluation of PAS signs at 11–14 weeks (Table S4). Some panel members also advised measuring the corresponding surface area of the different signs (Table 2). These signs are likely to be more pronounced in the third trimester, in particular in patients with multiple prior CDs. Twenty-seven experts recommended a quantitative assessment for placental lacunae and use of the score of Finberg and Williams[30]. The definition of what constitutes subplacental or uterovesical 'hypervascularity' remains elusive. Haidar *et al.*[45] found that use of Virtual Organ Computer-Aided Analysis software to calculate the vascularization index of subplacental blood flow in high-risk patients at 28–32 weeks can predict PAS at birth. These new scores and index systems require independent evaluation and validation by other researchers before being recommended for clinical use.

Our systematic review identified eight new ultrasound signs of PAS at birth (Table 1). Three of these signs require ultrasound techniques and/or software that are not available on routine ultrasound machines, limiting their widespread use in clinical practice. A recent report by the Society for Maternal–Fetal Medicine[46], indicates that most studies on the prenatal ultrasound evaluation of PAS are retrospective in design and lack 'low-risk' control comparison groups. Of the 15 studies identified in the present systematic review, only five involved prospective cohorts and three were case–control studies (Table S1), indicating the need for further prospective case–control studies.

Strengths and limitations

The Delphi method used in our study is a well-established process for obtaining group consensus on complex topics, and it avoids situations in which the group is dominated by the views of a few individuals[12,47]. We included international experts in obstetric ultrasound, with different nationalities and with diverse expertise to ensure that multiple participant views would be captured. Some of the new ultrasound signs included in the questionnaire of the first round were obtained from articles published recently and thus may not have been tested by most of the panelists, thus limiting the generalizability of our results.

Future perspectives

PAS is a clinicopathologic diagnosis and, as such, prenatal imaging can only provide an estimation of the probability of finding abnormal attachment of one or more placental cotyledons to the uterine wall at birth. Ultrasound imaging can contribute to the preoperative evaluation of patients with a high probability of PAS[21,24,25,31,48–52]. Abnormalities of uteroplacental circulation[21,24,49,52] on TAS and short cervical length on TVS[48,50] increase the odds of intraoperative complications. Major disruptions of the uterine wall architecture, such as those associated with placental bulge, are also associated more strongly with intrapartum hemorrhage compared with the findings of accreta villous tissue[52]. Our panelists reached a consensus that loss of the clear zone, bladder-wall

interruption and the presence of placental lacunae and placenta previa involving the cervix can predict surgical outcomes (Table 3). A consensus was reached that the presence of placenta previa with involvement of the cervix (i.e. partially or completely covering the internal os) is associated with increased risk of PAS at birth (Table S3) and 25 out of 37 (68%) panelists identified intracervical lakes as a new ultrasound sign to be reported in patients at high risk for PAS (Table 1). These findings highlight the pivotal role of TVS in the prenatal evaluation of PAS.

Conclusions

Using a robust consensus technique, supported by a systematic review, we found that established standardized ultrasound signs continue to be used worldwide in the evaluation of patients at high risk for PAS, and we highlighted the role of TVS in this evaluation. Further research should include large, prospective, multicenter, international cohorts followed longitudinally with clear definitions of ultrasound signs that can be obtained using standard ultrasound equipment in the screening of patients at high risk for PAS.

PAS ultrasound imaging expert panel included in Delphi consensus

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SUPPORTING INFORMATION ON THE INTERNET

The following supporting information may be found in the online version of this article:

Figure S1 PRISMA flowchart summarizing inclusion of articles in systematic review.

Table S1 Characteristics of studies identified by systematic review

Table S2 Demographic and clinical characteristics presented in first Delphi round, to identify high-risk patients in whom detailed placenta accreta spectrum (PAS) ultrasound assessment is indicated

Table S3 Second- or third-trimester ultrasound findings that are not related to placenta accreta spectrum (PAS) but may increase the probability of PAS at birth, presented in first Delphi round

Table S4 Distribution of optimal gestational age at which to identify ultrasound signs associated with PAS, according to individual expert preference