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CLINICAL ARTICLE

Development of a training program for the ultrasound screening of placenta accreta spectrum disorders

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Keywords

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Synopsis

A training program for detecting the ultrasound signs associated with placenta accreta spectrum using a standardized protocol improves the diagnostic accuracy.

ABSTRACT

Objective: To evaluate the impact of a training program using a systematic protocol on ultrasound signs of placenta accreta spectrum (PAS).

Methods: Intra- and inter-observer variability rates and sensitivity were tested, before and after additional training, by two research fellows with a prior basic training in obstetric ultrasound using digitally recorded second-trimester ultrasound images from cases of anterior placenta previa with and without PAS.

Results: Fifty-two cases of anterior placenta previa with PAS (n=26) and without PAS (n=26) were included in the study. The highest level of inter-observer agreement for ultrasound signs was found for the absence of placental bulge and/or focal exophytic mass on gray-scale imaging and the absence of subplacental hypervascularity, bridging vessels and lacunar feeder vessels on color Doppler imaging. The level of inter-observer agreement increased from 39% before training to 40% after training; the numbers agreed as PAS by both trainees increased from four to 20. No cases were classified as inconclusive after training. There was a significant ($P<0.001$) change in sensitivity for both trainees after training.

Conclusion: Additional training in detecting the ultrasound signs associated with PAS using a standardized protocol improves the diagnostic accuracy of operators with only a basic obstetric ultrasound training.

1 INTRODUCTION

When undiagnosed antenatally, placenta accreta spectrum (PAS) is often associated with massive obstetric hemorrhage due to attempts by the surgical operator to detach the placenta from the uterine wall during delivery [1, 2]. Prenatal diagnosis has been shown to lead to better maternal outcomes and has thus become essential in improving the management of PAS [3, 4]. However, recent large prospective population studies have shown that PAS remains undiagnosed before birth in one-half [2] to two-thirds of cases [5].

The first prenatal ultrasound description of placenta accreta was reported by Tabsh et al. [6] in 1982. In the following 25 years, 1078 cases, including 38 case reports and 53 series of PAS diagnosed during pregnancy by expert operators, were reported in the international literature [7]. Placenta previa accreta has become the most common presentation of PAS [8] and the overall performance of ultrasound in diagnosing accreta placentation in patients presenting with low-lying/placenta previa in expert centers is excellent, with a sensitivity of 88%–97% and specificity of 90%–97% [9].

In most countries, screening for fetal abnormalities with ultrasound is now an integral part of routine antenatal care and many high- and middle-income countries have specific prenatal ultrasound training courses for healthcare professionals. The majority of routine anomaly scanning around the world is still performed in the second trimester, at 18–22 weeks. Over the last two decades, an increasing number of fetal abnormalities have been detected at 11–14 weeks of gestation with rates of detection of first-trimester fetal anomalies ranging from 32% in low-risk groups to more than 60% in high-risk groups [10]. Of the factors examined for their impact on the rate of detection, the use of

standardized anatomical protocols has been shown to significantly improve the sensitivity of ultrasound examination for the detection of fetal anomalies in all subgroups [11].

Until recently, there was no standardized protocol for the ultrasound diagnosis of PAS. Many two-dimensional (2D) gray-scale and color Doppler imaging (CDI) signs were reported in the literature with varying descriptions as to their sensitivity and specificity, confusing terminology and, in many cases, a lack of confirmation of diagnosis at birth [7, 11]. To improve consistency and allow appropriate comparison of different imaging markers, panels of experts have published consensus statements aiming to standardize the descriptions and minimum requirements for an ultrasound scan to diagnose PAS [12]. The incidence of each of these ultrasound signs in cases of PAS has recently been evaluated, with detailed clinical and pathologic diagnosis and the proportion of agreement between experts. It was found that most of these signs are useful in the prenatal diagnosis of PAS [13]. The aim of the present study was to prospectively evaluate the impact of additional training and the use of a standardized examination protocol on the diagnostic accuracy of ultrasound in PAS and how this training could be used for the ultrasound screening of women at risk of PAS in the general population.

2 MATERIALS AND METHODS

The ultrasound images of 52 cases of placenta previa with (n=26) and without PAS (n=26) were reviewed at the Fetal Medicine Research Institute (FMRI) by two newly appointed research fellows (LFDB and WA) who had only a basic training in routine obstetric ultrasound. All prenatal ultrasound records were examined within the research center, basic clinical data were collected using a standard clinical audit protocol, and all images were anonymized for data analysis. This study was approved by the NHS Research Ethics committee (reference 18/WM/0328).

For each case, the trainees were given access to 15–20 2D gray-scale and CDI digitally recorded images per case obtained at 20–28 weeks of gestation by both

transabdominal and transvaginal sonography (TVS) using standard ultrasound equipment (GE Voluson® 730, GE Medical System, Zipf, Austria) and a standard protocol [13]. The images were reviewed by the trainees before and after additional specific training. For the review of ultrasound images, ultrasound signs from the standardized descriptions were used [12], including: for gray-scale imaging: loss of clear zone, myometrial thinning, the presence of placental lacunae, bladder wall interruption, placental bulge, and focal exophytic mass; and for CDI: utero-vesical hypervascularity, subplacental hypervascularity, bridging vessels, and lacunae feeder vessels. The trainees were instructed to identify at least two ultrasound markers to make a diagnosis of PAS. They were blind to the clinical diagnosis at birth and to each other's examination results.

Six weeks after their first examination, the research fellows independently repeated their examination, following an expert tuition session modelled on the online training modules for the diagnosis of fetal abnormalities from the Fetal Medicine Foundation (www.fetalmedicine.org).

Statistical analysis

The data were analyzed using Stata/IC version 15.0 (StataCorp LLC, TX, USA). As the distributions were skewed, continuous data are presented as medians and interquartile ranges (IQR). Because of the uneven distribution of values among cells, some of the kappa values are unstable, as indicated by negative values despite high agreement; the percentage agreement was used, as previously described [15, 16]. A binomial test of significance was conducted to assess whether there was evidence of higher agreement in the third trimester rather than the second trimester. A χ^2 test was conducted to compare sensitivity before and after training. A *P* value less than 0.05 was considered significant.

3 RESULTS

The PAS study group included 10 cases of placenta creta (Adherenta), 10 cases of placenta increta, and six cases of placenta percreta confirmed clinically at delivery and by subsequent detailed histopathological examination by a perinatal pathologist. All cases of PAS were managed by primary peri-partum hysterectomy. In all cases, the placenta was mainly anterior reaching or covering the internal cervical os on TVS at mid-gestation and confirmed at 32–34 weeks of gestation. The non-accreta study group included 26 cases of anterior placenta previa classified using the same ultrasound criteria. All women in both groups had an obstetric history of one or more prior cesarean deliveries (median 2; IQR 1–2) and were all delivered by cesarean. All cases in the PAS group had a planned cesarean-hysterectomy. All the ultrasound images reviewed by the trainees were obtained during the mid-pregnancy (median 21 weeks; IQR 20–22) detailed fetal anatomy scan using the same ultrasound equipment (GE Voluson® 730, GE Medical System, Zipf, Austria).

The results of the independent examination by the trainees before and after the additional training are presented in Table 1. Before training, the highest level of inter-observer agreement for ultrasound signs was found for the absence of placental bulge and/or focal exophytic mass on gray-scale imaging and the absence of subplacental hypervascularity, bridging vessels and lacunar feeder vessels on CDI. The inter-observer degree of agreement increased after training for the presence of myometrial thinning, placental lacunae, utero-vesical and subplacental hypervascularity. After training, both trainees also agreed in all cases, that there was placental bulge and/or focal exophytic mass on gray-scale imaging.

Table 2 displays the overall classification made by the trainees before and after training. The level of agreement increased from 39% before training to 40% after training; the numbers agreed as PAS by both trainees increased from four to 20. No cases were classified as inconclusive after training compared to four graded inconclusive by trainee 1

and one graded inconclusive by trainee 2, both before training. Before training, trainee 1 had no false-positive cases and 18 false-negative cases; trainee 2 had three false-positive cases and 21 false-negative cases. After training, trainee 1 had six false-positive cases and five false-negative cases; trainee 2 had six false-positive cases and seven false-negative cases. For both trainees, there was a statistically significant (P<0.001) change in sensitivity after training (Table 3).

4 DISCUSSION

The present study is the first to evaluate the impact of a specialist training for the prenatal diagnosis modelled on existing training modules for the diagnosis of fetal anomalies. Overall, we found that an additional training in detecting the ultrasound signs associated with PAS using a standardized protocol significantly improves the diagnostic sensitivity of operators with only a basic obstetric ultrasound training.

A recent prospective longitudinal study including women with placenta previa and at least one prior cesarean delivery or uterine surgery showed that using three ultrasound signs improved the rate of detection for placenta percreta with a sensitivity of 100% (95% confidence interval [CI] 92.6–100) and a specificity of 77.2% (95% CI 69.9–83.4) [17]. This study and the cohort studies included in recent systematic reviews are reported expert teams and thus these data cannot be applied to the general population of women who are provided with a routine mid-trimester fetal anatomy scan by non-expert ultrasonographers. The data from the present study show that an additional training modelled on an existing teaching module developed to improve the knowledge of sonographers in the diagnosis of fetal anomalies is associated with increased diagnostic sensitivity of PAS in women presenting with anterior placenta previa and history of prior cesarean delivery.

In the present study, we used the standardized descriptions of the ultrasound markers associated with PAS and the corresponding reporting protocol proposed recently by the European Working Group on Abnormally Invasive Placenta (EW-AIP) and the AIP international expert group [12, 13]. Using the same descriptions, we have previously reclassified the ultrasound findings of case reports and cohort studies on the prenatal ultrasound diagnosis of PAS [7]. It was found that in the 72 cases that provided detailed correlations between ultrasound findings and PAS grading, a loss of clear zone (62.1%) and the presence of bridging vessels (71.4%) are the most common ultrasound signs found in cases of placenta adherenta or creta (non-invasive PAS) whereas a loss of clear zone (84.6%) and subplacental hypervascularity (60%), and placental lacunae (82.4%) and subplacental hypervascularity (54.5%) are the most common ultrasound signs found for placenta increta and placenta percreta, respectively. No ultrasound sign or a combination of ultrasound signs are specific to the depth of accreta placentation. The detection of these signs with transabdominal ultrasound varies with maternal bladder filling, direct pressure of the ultrasound probes, myometrial contractions, and gestational age [11, 18]. TVS can circumvent some of these issues and is essential to locate the edge of the placenta in cases of placenta previa accreta; however, its use is only reported by less than-half of authors of expert cohort studies [9]. For each case, the trainees were provided with images obtained with both transabdominal ultrasound and TVS, suggesting that both ultrasound techniques should be included in a training program.

The impact of invasive PAS is mainly at the level of the deep uterine circulation, and transformation of the radial and arcuate arteries and the development of neo-vascularization lead to major anatomical changes under the placental bed and in the placental cotyledon above the accreta area [11]. The corresponding signs—i.e. loss of clear zone, intraplacental lacunae, and lacunar feeder vessels—were the most commonly identified signs in the present study and in previous studies [7]. It was recently found that these signs are associated with the highest level of inter-observer agreement between experts [14]. In the

present study, there was complete agreement between the trainees for the absence of placental bulge and/or focal exophytic mass on gray-scale imaging after training. These signs are almost exclusively seen in the most invasive and extended cases of PAS [7] and were only found in around 10% of cases during the third trimester ultrasound examination [14]. By contrast, myometrial thinning is a consequence of prior cesarean scar [11] and not a consequence of accreta placentation but this ultrasound sign has been commonly reported in retrospective observational cohort studies [7]. Not surprisingly, due to the strong association between prior caesarean deliveries and anomalies of placentation, this sign is associated with a high level of inter-observer of agreement between experts in both the second and third trimesters [14]. However, the trainees agreed on the absence of myometrial thinning in only 32/52 of the cases included in the present study and the corresponding level of agreement did not change after training. These findings suggest that the development of a protocol for screening PAS during routine mid-trimester scans would require a simplified version of the list of ultrasound signs reported by experts.

In the UK, most routine prenatal ultrasound examinations are performed by ultrasonographers with no medical training; thus, they are less likely to be aware of the risk factors associated with the development of PAS. The risk of both placenta previa and PAS is higher in women with a history of cesarean delivery [8, 19–21]. The incidence of placenta previa accreta increases with the numbers of prior cesarean deliveries from 4.1% in women with one prior cesarean to 13.3% in women with two or more previous cesareans [9]. These risks are independent of other maternal characteristics, such as parity, body mass index, tobacco use, and coexisting hypertension or diabetes [8]. Cesarean deliveries are not the only cause of PAS [22, 23] but following the exponential rise in the rate of cesarean delivery in many countries around the world, placenta previa accreta has become the most common

presenting type of PAS, found in more than 95% of the cases [9]. Thus, ultrasound operators should be made aware that women with a previous history of cesarean deliveries, presenting with an anterior low-lying placenta or placenta previa in the second trimester of pregnancy, have become the largest group of women with the highest risk of PAS.

Our study is limited by the number of trainees involved and the present data need to be evaluated on a larger scale. The strengths of the present study included the use standardized ultrasound signs and reporting protocol for the pre- and post-training diagnostic evaluations. The increase in sensitivity of the two research fellows with only a prior basic training in general obstetric ultrasound indicates that, as for fetal structural defects, the prenatal detecting of PAS can be improved using a similar training strategy. The results of well-conducted prospective cohort studies [24,25] have shown that the sensitivity and specificity of gray-scale imaging alone in diagnosing placenta previa accreta are high when performed by experienced operators, suggesting that CDI and three-dimensional ultrasound may not be essential for the screening of accreta placentation. These findings and our data indicate that operators in low-resource countries with access to basic ultrasound equipment only can be trained remotely using on-line training programs to diagnose PAS prenatally and thus improve the management and outcome of this complex obstetric complication.

In conclusion, the vast majority of women at high risk of PAS will have a routine mid-trimester fetal anatomy scan in a local hospital by ultrasonographers with no or limited experience of examining the placenta. High reproducibility and low inter-observer variability of ultrasound imaging of PAS are essential to implement a screening program for women at high risk of PAS. Unlike magnetic resonance imaging, ultrasound imaging is operator-dependent; thus, the additional training based on ultrasound signs with excellent or good inter-observer agreement should improve the diagnostic accuracy of ultrasound in women with PAS.

Author contributions

EJ and NZ designed the study and developed the training protocol. ID coordinated the data collection and supervised the trainees LBDS and WA. CB and EB carried out the statistical analysis. EJ and ID drafted the manuscript. EJ is the guarantor of the study. All authors in the critical discussion and approved the final version of the manuscript for publication.

Conflicts of interest

The authors have no conflicts of interest.

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Table 1. Inter-observer agreement for the ultrasound signs used in the diagnosis of PAS in the second trimester before and after training.

Ultrasound signs	Pre-training agreement (%)	Post-training agreement (%)
Gray-scale parameters		
1. Loss of clear zone	67.3	67.3
2. Myometrial thinning	71.1	86.5
3. Placental lacunae	88.5	88.5
4. Bladder wall interruption	86.5	88.5
5. Placental bulge	94.2	100
6. Focal exophytic mass	94.2	100
CDI parameters		
7. Utero-vesical HV	63.5	75.0
8. Subplacental HV	71.1	80.8
9. Bridging vessels	86.5	80.8
10. Lacunae feeder vessels	75.0	73.1

Abbreviations: CDI, color Doppler imaging; HV, hypervascularity.

Table 2. Overall classification made by the trainees before and after training.

Variable	Placenta previa	PAS	Inconclusive
Before training			
Placenta previa	35	4	4
PAS	4	4	0
Inconclusive	1	0	0
After training			
Placenta previa	20	5	-
PAS	7	20	-

Table 3. Accuracy for diagnosis of PAS before and after training for both trainees.

Variable	Before training (% (95% CI))	After training (% (95% CI))
Trainee 1		
SN [a]	30.8 (14.3–51.8)	80.8 (60.6–93.4)
SP	100.0 (86.8–100.0)	76.9 (56.4–91.0)
PPV	100.0 (63.1–100.0)	77.8 (57.7–91.4)
NPV	59.1 (43.2–73.7)	80.0 (59.3–93.2)
PLR	-	3.5 (1.69–7.24)
NLR	0.69 (0.54–0.89)	0.25 (0.11–0.57)
Trainee 2		
SN [b]	19.2 (6.6–39.4)	73.1 (52.2–88.4)
SP	88.5 (69.8–97.6)	76.9 (56.4–91.0)
PPV	62.5 (24.5–91.5)	76.0 (54.9–90.6)
NPV	52.3 (36.7–67.5)	74.1 (53.7–88.9)
PLR	1.67 (0.44–6.26)	3.17 (1.51–6.63)
NLR	0.91 (0.72–1.15)	0.35 (0.18–0.68)

Abbreviations: SN, sensitivity; SP, specificity, PPV, positive predictive value; NPV, negative predictive value; PLR, positive likelihood ratio; NLR, negative likelihood ratio.

[a] Comparison in SN. Trainee 1: χ^2 15.94; df=2; *P*=0.00034.

[b] Comparison in SN. Trainee 2: χ^2 14.05; df=2; *P*=0.00088