

Accreta Placentation: A systematic review of Prenatal Ultrasound Imaging and Grading of Villous Invasiveness

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The authors report no conflict of interest

No funding was obtained for this study.

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Word count: 4250

Condensation: Heterogeneity in terminology and study designs on ultrasound diagnosis of placenta accreta limit the evaluation of the depth of myometrial villous invasion and management strategies

Short title: Grading of accreta placenta on ultrasound imaging

Abstract

Objective: Determining the depth of villous invasiveness before delivery is pivotal in planning individual management of placenta accreta (PA). We have evaluate the value of the various ultrasound signs described in the literature for the diagnosis of PA and in the assessment of the depth of villous invasiveness.

Data sources: We undertook a PubMed and MEDLINE search of the relevant studies published between the first prenatal ultrasound description of PA in 1982 and 30 March 2016 using key words “placenta accreta”, “placenta increta”, “placenta percreta”, “abnormally invasive placenta”, “morbidly adherent placenta” and “placenta adhesive disorder” as related to “sonography”, “ultrasound diagnosis”, “prenatal diagnosis”, “grey-scale imaging”, three-dimensional (3D) ultrasound and “colour Doppler imaging”.

Study eligibility criteria: All articles which correlated prenatal ultrasound imaging with pregnancy outcome.

Study appraisal and synthesis methods: Eighty-three studies, including 30 cases reports describing 38 cases of PA and 53 series describing 1078 cases were analysed. PA was subdivided in placenta creta (PC) to describe superficially adherent placentation and placenta increta (PI) and percreta (PP) to describe invasive placentation.

Results: Out of 53 study series, 23 did not provide data on the depth of villous myometrial invasion on ultrasound imaging or at delivery. Detailed correlations between ultrasound findings and PA grading were found in 72 cases. A loss of clear zone (62.1%) and the presence of bridging vessels (71.4%) were the most common ultrasound signs found in cases of PC. In PI, a loss of clear zone (84.6%) and subplacental hypervascularity (60%) were the most common ultrasound signs whereas, placental lacunae (82.4%) and subplacental hypervascularity (54.5%) were the most

common ultrasound signs in PP. No ultrasound sign or a combination of ultrasound signs were specific of the depth of accreta placentation.

Conclusions: The wide heterogeneity in terminology used to describe the grades of accreta placentation and differences in study design limits the evaluation of the accuracy of ultrasound imaging in the screening and diagnosis of PA. This review emphasizes the need for further prospective studies using a standardised evidence-based approach including a systematic correlation between ultrasound signs of PA and detailed clinical and pathologic examinations at delivery.

Key words: Placenta, accreta, increta, percreta, ultrasound imaging, villous myometrial invasion, accreta placentation.

Introduction

Placenta accreta (PA) is an iatrogenic 20th century disorder of human placentation, which is characterized by the abnormal attachment or invasion of placental tissue to the underlying uterine musculature.¹ PA may have been observed before the 20th century⁶ but all epidemiologic studies have shown a direct association between the increase in caesarean delivery (CD) and the increased incidence of PA in subsequent pregnancies.^{1,3-7} PA is not exclusively a consequence of CD and much smaller surgical damage to the integrity of the uterine lining, such as following uterine curettage, manual delivery of the placenta, post-partum endometritis and previous hysteroscopic surgery, endometrial resection and uterine artery embolization, has been associated with PA in subsequent pregnancies.^{1,3-8} The development of PA has also been reported in women with no surgical history but presenting with uterine pathology such as bicornuate uterus, adenomyosis, submucous fibroids and myotonic dystrophy.^{1,3,4} These individual case reports, suggest that intra-myometrial implantation of villous tissue is not always secondary to uterine surgery and may explain the few cases rare cases of PA observed before the 20th century.

PA was first defined in 1937 by Irving and Hertig, as the “abnormal adherence of the afterbirth in whole or in parts to the underlying uterine wall”.² The failure of the placenta to separate normally from the uterus after delivery is typically accompanied by severe postpartum haemorrhage (PPH), and attempts to remove a PA typically provokes further major haemorrhage which is associated with increased maternal morbidity and mortality. Modern pathologists have graded PA into placenta creta (PC) or vera, placenta increta (PI) and placenta percreta (PP) according to the depth of

villous invasiveness.^{3,4} In PC, the villi adhere to the myometrium with no intermediate decidual layers between the tip of the anchoring villi and the muscular cells but do not invade the myometrium. In PI, the villi penetrate deeply into the myometrium up to the external layer whereas in PP, the invasive villous tissue reaches and/or penetrates through the uterine serosa. The PA spectrum can therefore be subdivided into PC for abnormally adherent placentation and PI and PP for abnormally invasive placentation. Cases of PA are also often subdivided into total, partial or focal according to the amount of placental issue involved. More recently, it has been suggested that cesarean scar pregnancy CSP represents a precursor of one of the different grades of PA¹⁰⁻¹²

Several concepts have been proposed to explain the pathophysiology of PA. The oldest is based on a theoretical primary defect of the biological functions of the trophoblast, leading to excessive adherence or invasion of the myometrium. The other prevailing hypothesis is that of a secondary defect of the endometrium-myometrial interface leading to a failure of normal decidualization in the area of the uterine scar allowing trophoblastic infiltration beyond the superficial myometrium and villous development inside the myometrium.^{1,3,4} Although, the pathogenic mechanisms of the different types of accreta placentation, including scar pregnancies, are similar, the anatomical and clinical consequences vary widely. In placenta vera, the villi simply adhere to the superficial layer of the myometrium whereas in placenta increta and percreta the villous tissue invades into and may penetrate through the entire uterine wall thickness and reach the surrounding pelvic tissues and organs.

The worst clinical outcome arises when PA and in particular, when PI or PP is unsuspected at the time of delivery and the surgeon attempts to remove the invasive

part of the placenta leading immediately to major haemorrhage and an increasing need for emergency hysterectomy.¹³⁻¹⁵ Prenatal diagnosis of PA has therefore become essential for the safe management of this increasingly common obstetric complication.¹⁶⁻¹⁸ However, recent studies from UK and USA show that PA was undiagnosed before delivery in between half¹⁹ and a third²⁰ of the cases. Determining the depth of placental invasion is essential for planning of individual management of women diagnosed with PA.

The objective of this review is to evaluate the value of the various ultrasound signs described in the international literature for the diagnosis of PA in general and for the assessment of the depth of villous invasiveness in the uterine wall in particular.

Methods

Information sources and search strategy

We conducted a systematic review of the literature and selected relevant studies that have been published between the first prenatal ultrasound description of PA by Tabsh et al²² in 1982 and 30 March 2016. We undertook a PubMed and MEDLINE search using combinations of key words of “placenta accreta”, “placenta creta”, “placenta increta”, placenta percreta”, “abnormally invasive placenta”, “morbidly adherent placenta” and “placenta adhesive disorder” as related to “sonography”, “ultrasound diagnosis”, “prenatal diagnosis”, “grey-scale imaging”, three-dimensional (3D) ultrasound and “colour Doppler imaging.” We limited the search to studies published in English.

Eligibility creteria

The primary eligibility criteria were articles which correlated prenatal ultrasound imaging with pregnancy outcome. We used ultrasound signs from the standardized descriptions proposed recently by the European Working Group on Abnormally Invasive Placenta (EW-AIP) and the AIP international expert group.^{23,24} On gray-scale imaging the signs of PA are: loss of the clear zone in the myometrium under the placental bed (“clear zone”); myometrial thinning to <1mm or undetectable; intra-placental lacunae often large and irregular (“moth eaten” areas); bladder wall interruption or loss (hyperechoic line between serosa and bladder lumen); placental bulge distorting the extrauterine organs; and focal exophytic mass of placental tissue extending beyond the serosa. On colour Doppler imaging (CDI) the signs used are: uterovesical hypervascularity between the myometrium and the posterior wall of the bladder; subplacental hypervascularity (placental bed); bridging vessels across the myometrium and beyond the serosa; and lacunae feeder vessels with high velocity (turbulent) flow from the arterial vasculature of myometrium.

Study selection

The initial database search provided 338 reports of which only 129 included information on ultrasound imaging using the key words described above (Figure 1). Cross-referencing provided an additional 12 reports, making a total of 141 records. After the second selection, letters with no description of the case, case reports with inconclusive diagnosis, commentaries and reviews (n= 49) were excluded. A further 9 reports with no description of ultrasound features were further excluded leaving 83 reports for analysis.

The articles were separated into case reports (n= 30)²⁵⁻⁵⁵ and series (n= 53)^{20,56-107}, and were reviewed independently. PA was subdivided in placenta creta (PC) to

describe superficially adherent placentation and placenta increta (PI) and percreta (PP) to describe invasive placentation.

Synthesis of results

Data containing study setting, study type, characteristics of study population, definition of PA, terminology, grading, ultrasound description of placental structure were obtained for each 83 studies selected. To evaluate the relationships between the depth of villous invasiveness, ultrasound signs and clinical findings management procedures including caesarean section hysterectomy (CSHT), focal myometrial resection (FMR), uterine artery embolization (UAE), uterine artery balloon occlusion (UABO), uterine artery ligation (UAL) intrauterine balloon tamponade, methotrexate (MTX), B-Lynch suture and lesions described during pathological examination were also extracted.

The case reports data were analysed using the StatGraphic data analysis and statistical software package (Manugistics, Rockville, MD).

Results

Case reports characteristics

The case reports included 38 individual cases with prenatal ultrasound findings. There were four case reports presenting findings on 2 individual cases^{25,34,36,45} and one including 3 individual cases.⁴⁶ The PA grading was confirmed clinically or histopathologically as PC in 13 cases, PI in 16 cases and PP in 9 cases.

A planned CD hysterectomy with or without UAE or UAL was performed in two PC, nine PI and seven PP.^{20,22,32,35-39,41,46,48,52,53} In the other 20 cases a conservative management was attempted including FMR with or without suture or MTX^{29,31,34,43,46,50}

uterine curettage⁵⁵ and the placental left in situ with MTX or UAE.^{25,27,28,30,41,42,45-47,49,51}

The conservative management was unsuccessful in 12 cases, including five PC, 6 PI and one PP, and required a secondary hysterectomy.^{25,27,28,30,34,41,42,44,45,49,55} A

dissection or partial resection of the bladder was required in four cases of PP.^{33,35,42,54}

The mean gestational age at delivery was 30.6 weeks (SD: 7.5; range 15-39 weeks). A detailed description of the pathologic findings was available in 28 cases. In the remaining 10 cases it was not available following successful conservative management but the PA grading was described at delivery.

Case reports synthesis of results

The terminology “placenta accreta” was used by 27 authors of case reports^{25-44,46-48,50-52,54,55}, “morbidly adherent placenta” by two^{45,49} and “abnormal placentation” in one report.⁵³ Two authors reporting on three cases did not describe the past surgical history.^{25,40} In five (14.3%) cases there was a previous history of uterine curettage only^{28,30,31,50,51} and in seven (20.0%) the women presented with a combined history of CD, myomectomy and/or curettage.^{30,32,36,39,45,46,55} A past obstetric history of CD was reported in 23 out of 35 remaining cases (65.7%).

Gray-scale imaging was used by all authors. In eight cases, including two PC, five PI and one PP only gray-scale imaging signs were described^{25,27,33,47,48,52,55} whereas in the remaining 30 cases, including 11 PC, 11 PI and eight PP, both gray-scale and color Doppler imaging were reported. Table 1 displays the ultrasound signs identified in the diagnosis of the 38 cases reports included in the review according to the depth of villous myometrial invasion. The mean gestational age at diagnosis was 24.3 weeks (SD: 6.8; range 13-36 weeks). A loss of clear zone (92.3%) and bridging vessels

(90.9%) were the most common ultrasound signs for PC. In cases of PI, the loss of clear zone (87.5%) and subplacental hypervascularity (81.8%) were the most common signs whereas for PP, placental lacunae were found in all cases (100%) and subplacental hypervascularity was found in six cases (75%).

Series characteristics

The 53 series included 24 prospective^{58-62,65,66,70-72,76,80,83,85,89-91,93,98,101,102,105-107} and 29 retrospective studies with a total of 1078 cases of PA. All series except eight, which did not report data on previous surgical history^{63,66,72,81,97,98,101,106}, included women presenting with placenta praevia and a history of CD and/or other uterine surgeries. In 21 series, including 568 cases of PA, the depth of villous invasiveness was not described.^{20,59,66-69,71,72,75,76,78,81,82,85,90,91,94,96,100,104,106} In the other 32 series, the distribution of the different categories of PA were reported, including 240 PC, 112 PI and 158 PP.

A planned CD hysterectomy, with or without UAE or UAL, was the primary management option in 44 series. In 13 series, conservative management was attempted depending on the degree of myometrial invasion with secondary hysterectomy in cases of failure^{20,56,62,63,71,73,75,80,84,87,92,95,97} and in one series conservative management was successful in all cases.⁹⁹ In seven series, no information was available on the outcome and management.^{20,65,85,91,98,100,107} Overall, a CD hysterectomy was performed in 597 out of 806 (74.1%) for which the data were available. The mean gestational age range at delivery was 34-37 weeks. A detailed description of the pathologic findings was available in 29 series. In 11 series, the pathologic examination was reported as performed but no data were

provided^{58,59,65,67,69,81,82,87,100,104,106} and in 12 series there was no histopathologic information.^{20,56,68,75,85,90,91,95,96,98,99,103}

Series synthesis of results

The terminology used to describe PA was diverse. Seven studies used the term “morbidly adherent placenta”^{66,86,89,97,100,103,106}, two used “placental adhesive disorders”^{70,101}, two used “abnormally invasive placentation”^{92,104}, two used “abnormally adherent placenta” or “abnormal placental adherence”^{79,83}, one use “advanced invasive placentation”⁹⁶ and one used the term “abnormal myometrial invasion”.⁶¹

Gray-scale ultrasound was used, and the corresponding data presented by all authors except one.¹⁰⁴ In ten series, gray-scale imaging only was used^{56-58,64,65,75,84,89,90,103}, in one series sequential two- dimensional (2D) and three-dimensional (3D) ultrasound were used.⁷⁷ In the remaining 41 series, data from both 2D grey-scale ultrasound and CDI were available. The gestational mean range at diagnosis in 31 series for which the information was available was 20-34 weeks. Table 2 displays the ultrasound signs used by authors to diagnosed PA in the 53 series. The most commonly used signs were loss of clear zone (98%) and placental lacunae (96.1) for grey-scale imaging and subplacental hypervascularity (85.7%) and bridging vessels (61.9%) for CDI. The authors of eight series provided detailed data on 2D ultrasound examination and placental grading.^{65,79,84,89,95,98,102,107} The corresponding data are presented in Table 3. The presence of placental lacunae (78.9%) and subplacental hypervascularity (36.7%) were the most common ultrasound signs found. In three of these series^{65,84,102} the authors provided details of the placental grading for each individual standard ultrasound sign. These data were combined with those from the cases reports (Table 4)

raising the number of cases available for analysis to 72. This analysis confirmed that a loss of clear zone (62.1%) and the presence of bridging vessels (71.4%) were the most common ultrasound signs found in cases of PC, that a loss of clear zone (84.6%) and subplacental hypervascularity (60%) were the most common signs in PI whereas placental lacunae (82.4%) and subplacental hypervascularity (54.5%) were the most common signs for PP. There were no ultrasound sign or combination of ultrasound signs were specific of the depth of accreta placentation. No series reported on the lateral extension of the accreta placentation and in particular on the involvement of the cervix.

Comments

Main findings

Although some ultrasound signs are more often associated with PA, no ultrasound sign or combination of ultrasound signs are specific of the depth of accreta placentation. The wide heterogeneity in terminology and study designs in the published reports on the prenatal ultrasound diagnosis of PA could explain the low detection rate during routine ultrasound examination.

Comparison with existing literature

The origin and first use of the terminology “placenta accreta” is unknown. Langhans¹⁰⁸ and Hart¹⁰⁹, who first described the histology of PA, also used the term “adherent placenta”. On the basis that the depth of the villous penetration of the myometrium is rarely uniform, Luke et al, suggested the name “adherent or invasive placenta” instead

of PA²¹ and the first author to use the term “placenta accreta” was Baisch in 1907.¹¹⁰ Up to the 1920s, most authors used the term “adherent placenta”, whereas after that and until the present review most authors used placenta “accreta” or “increta” whereas the term “percreta” was only used regularly to describe case reports from the 1950s onwards.¹¹¹ By contrast, the term “morbidly adherent placenta” dates back to the 19th century to describe placental retention¹¹², and has been very rarely used to describe PA until recently. Our review finds that this terminology has been increasingly used over the last decade, by authors of case reports and series of prenatal ultrasound diagnosis of PA to describe both abnormally adherent and invasive placentas.^{45,49,66,86,89,97,100,103,106} This terminology is inaccurate and misleading and for our analysis of the literature we have used the standard anatomical definition i.e. creta, increta & percreta which describes accurately the depth spectrum of villous myometrial invasion.

Only one of the 20 cases personally treated by Irving and Hertig occurred after a previous CD.⁹ Similarly, in their review of 86 cases reports up to 1935, only one was found after a CD. Predisposing factors at the time were a previous manual delivery and/or “vigorous” uterine curettage. Three decades later, CD was found in the history of around half of the women presenting with PC or PI in subsequent pregnancy.²¹ In the present review and in population studies, a history of one or more CD is reported as the main predisposing factor in more than 90% of the cases of PA.^{5-7,13,14} The risks of both placenta praevia and PA in subsequent pregnancies increase with the number of previous CD^{7,13,114} and is higher in women with a previous classical CD.¹¹⁵ Among women with placenta praevia, 40% of those with two previous CD and 61% of those with three previous CD develop a PA.⁷ This risk is independent of other maternal

characteristics, such as parity, body mass index, tobacco use, and coexisting hypertension or diabetes. Although PA only complicates about 5% of pregnancies with placenta praevia¹³, and around 0.5% of women undergoing their second or third CD¹¹⁴, the identification during the second trimester of a placenta praevia on ultrasound examination in a woman with a history of CD should prompt a more detailed search for signs of PA and evaluation of the depth of villous myometrial invasion.

The first antenatal grey-scale imaging descriptions of PA were reported 25 years ago by Tabsh *et al*²² and ultrasonography is now the most commonly used modality for diagnosing PA. The first ultrasound sign described was the “loss of the hypoechoic retroplacental (clear) zone” found to represent an abnormal extension of the placental villi through the decidua basalis into the myometrium.^{25,56} This probably corresponds the placental basal plate or utero-placental plate described by placental anatomists.^{3,4} In 1992, Finberg and Williams⁵⁸ using higher resolution grey-scale imaging identified further signs including marked thinning or absence of the myometrial zone; thinning, irregularity, or focal disruption of the utero-placental bladder zone; intraplacental vascular lacunae and presence of focal mass-like elevations or extension of placental echogenicity (exophytic) beyond the uterine serosa. The advent of CDI enabled access to visualization of the utero-placental circulation, and indicated that most cases of PA are associated with hypervascularisation patterns within the placenta and below the placental bed or subplacental zone.²⁵ Our review indicates that these signs have been commonly used since their first description and that the loss of clear zone, the presence of placental lacunae and hypervascularity of the subplacental zone were the most frequently found ultrasound signs in PA (Table 3). When analyzed for the depth of

villous myometrial invasion, a loss of clear zone was the most common grey-scale imaging sign found for PC and PI and the presence of placental lacunae for PP. On CDI, bridging vessels are more commonly reported in PC, whereas subplacental hypervascularity was the most common sign found in PI and PP (Table 4). Although placental lacunae were reported in all case reports of PP (Table 1), we found that no ultrasound sign or combination of ultrasound signs were specific of the depth of accreta placentation. This can be explained by the absence of standardised description of ultrasound signs in previous studies, the high proportion of retrospective studies and the lack of PA grading confirmed by histopathology in many series.

There is increasing evidence that multidisciplinary management of patients with suspected PA is superior to standard obstetric care.^{16-18,116-119} For such care to be organized, the diagnosis must be made prenatally. We found that most authors of series published in the last decade have used both the gray-scale and CDI ultrasound signs to evaluate retrospectively or prospectively the sensitivity of ultrasound in the prenatal diagnosis of PA. A recent systematic review and meta-analysis by D'Antonio et al¹²⁰ of 23 of these studies involving 3707 pregnancies at risk of PA found that the overall performance of ultrasound is excellent (sensitivity 90.7%; specificity 96.9%), and that CDI has the best predictive accuracy. However, these studies may overestimate accuracy because they were conducted in centers specialized in prenatal diagnostics, and the number of cases of PA diagnosed prenatally were small. Out of the 22 series from D'Antonio et al review that were also included in the present review, eight did not present with information on the depth of villous invasion^{58,59,62,67,71,72,81,82} and one did not present any histopathologic data at all.⁸⁵ This suggests that many imaging specialty

centers may not have access to specialist perinatal pathology. Overall, only three of the series included in our review provided with a full correlation between standard 2D ultrasound signs and PA grading, and were included in Table 4.^{65,84,102} More prospective studies with detailed evaluation of the depth of accreta placentation at delivery are needed to better evaluate the accuracy of these ultrasound signs not only in screening for PA, but also in differentiating between the different levels of depth of myometrial invasion.

Around 75% of women with PA included in the present review were managed with planned CD hysterectomy. However, in more than half of these cases, the depth of villous invasiveness was not described. In those series in which all⁹⁹, or a high proportion^{75,80,87,95} of cases were successfully treated conservatively without the need for a secondary hysterectomy, it cannot be established if the corresponding PA cases were mainly superficially adherent to the myometrium or truly invasive. Ideally, the standard of reference for the different grading of PA is confirmation of the final histology after hysterectomy has been performed. The quality of the pathological examination is essential to provide feedback on the accuracy of the prenatal diagnosis of PA. A standardized method for gross and microscopic pathological examination of hysterectomy specimens with PA has recently been proposed¹²¹, and likewise the standardized ultrasound descriptions of abnormally invasive placenta^{22,24} should be used in the study design of further studies. Hysterectomy is not always clinically required as the bleeding can be avoided or controlled using conservative methods. In cases where a final histopathology examination is not available, the diagnosis can be based on detailed clinical information provided at the time of delivery. In women with

severe PP, where there is deep invasion of the adjacent organs or structures, the clinical diagnosis is usually straightforward. By contrast, the differential diagnosis between PC and focal PI can be more difficult, in particular in the absence of pathological examination. The differential diagnosis between a difficult placental manual removal and an abnormally adherent placenta is also difficult in the absence of histopathological confirmation. In their classical study, Irving and Hertig highlighted this issue, and stated that “placenta accreta is not to be confused with simple retention of the after-birth either through failure of the normal mechanism of separation in a healthy uterus or through its imprisonment behind an hour glass contraction”.⁹ The use of a standardized clinical terminology and in particular the use of “accreta” to define abnormally adherent PA and increta and percreta to describe abnormally invasive forms PA is essential to the precise evaluation of perinatal data.

Histopathologically, PA is now universally defined by a partial or complete absence of decidua basalis, resulting in placental villi being attached to or invading the scarred myometrium underneath.^{1,3,4} Luke et al²¹ argued against the classification of PA proposed by some pathologists, and the further subdivision of PA into total and partial or focal, on the basis that the histological examination in cases of abnormally adherent placenta is “often distorted by attempt at manual placental delivery and/or post-partum uterine curettage”. In these cases, the utero-placental interface is inevitably damaged, impairing the histological examination and making it impossible to make the diagnosis of abnormal adherent placenta or PC and evaluate its lateral extension. Deeper invasion of the trophoblast into the myometrium and infiltration of chorionic villi into myometrial vascular spaces have recently been documented in PI and PP.¹²² These changes

provoke a shift in placental blood supply from a spiral artery as found in normal placentation to a supply from larger, deeper arteries, i.e. radial or arcuate, in abnormally invasive placentas. These major transformations of the uteroplacental circulation can explain the high frequency of profound vascular alterations, such as placental blood lacunae caused by blood entering the placenta at high velocity⁸⁹ and hypervascularisation patterns under the placental bed found on ultrasound in PI and PP (Table 4). These findings suggest that the more invasive the placentation the more pronounced the utero-placental vascular changes are, and confirms the value of CDI in the screening of PA and in the evaluation of the depth of villous myometrial invasion.

MRI is increasingly used for the diagnosis of PA and has been reported to be useful in assessing the depth and lateral extension of myometrial invasion, especially with posterior placentation and/or in obese women. Recent systematic reviews have found that prenatal MRI is highly accurate in diagnosing disorders of invasive placentation and that ultrasound and MRI have comparable predictive accuracy.^{123,124} However, cost and limited access to MRI makes it impractical as a screening tool for PA and ultrasound imaging remains the primary screening tool for population-based studies.

Conclusions and implications

With the increasing numbers of CD worldwide and the long-term consequences of uterine scars, accurate prenatal diagnosis is a pivotal factor in optimizing the counseling, treatment, and outcome of women presenting with PA. Determining the

depth and extension of accreta placentation is essential in planning individual management. Ultrasound signs of PA have a rather subjective quality and may not be reproducible. The use of different ultrasound equipment used may also influence the results of ultrasound examinations. Many series published in the literature over the last three decades do not provide detailed data linking prenatal ultrasound signs and clinical and histopathological findings at delivery. In addition, the inclusion of the three grades of accreta placentation into one category has led to heterogeneous data which are difficult to interpret. This can explain the major variability in terms of prenatal diagnosis accuracy, outcome and management in specialist centres, and can also explain why antenatal detection rates remain low in recent general population studies.

Pathological studies and the data of the present review suggest that PA should be separated into abnormally adherent and abnormally invasive placental tissues as these are anatomically different entities with different clinical outcomes. The term “morbidly adherent placenta” is inaccurate and misleading and should refer only to the first degree of accreta placentation where the villi simply adhere to the myometrium. PI and PP represent the most severe degree of PA and should be referred to as abnormally invasive placentation. We therefore recommend that sonographers use the term placenta “creta” if they think placentation is superficial and invasive if they think it is deep to discriminate when they are reporting their ultrasound findings. Further prospective studies that present for each individual case standardised ultrasound signs and complete clinical and pathological data are now essential to take the prenatal screening of PA from specialist centres to the general population, and to improve the outcome of this increasingly common major obstetric complication.

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Table 1: Ultrasound signs identified in the diagnosis of 38 cases reports ranked according to the depth of villous myometrial invasion.

| Ultrasound signs | PC n(%) | PI n(%) | PP n(%) |
|-------------------------------|-------------------|-------------------|-------------------|
| <u>Grey-scale Parameters</u> | (n=13) | (n=16) | (n=9) |
| Loss of clear zone | 12(92.3) | 14(87.5) | 5(55.6) |
| Myometrial thinning | 6(46.2) | 11(68.8) | 3(33.3) |
| Placental lacunae | 5(38.5) | 9(56.3) | 9(100) |
| Bladder wall interruption | 1(7.7) | 2(12.5) | 2(22.2) |
| Placental bulge | - | 1(12.5) | 1(11.1) |
| Focal exophytic mass | - | - | 1(11.1) |
| <u>CDI Parameters</u> | (n=11) | (n=11) | (n=8) |
| Uterovesical hypervascularity | 1(9.1) | 2(18.2) | 2(25.0) |
| Subplacental hypervascularity | 5(45.5) | 9(81.8) | 6(75.0) |
| Bridging vessels | 10(90.9) | 7(63.6) | 2(25.0) |
| Lacunae feeder vessels | 2(18.2) | 6(55.5) | 4(50.0) |

CDI= Color Doppler Imaging; PC= placenta creta or vera; PI= placenta increta; PP= placenta percreta.

Table 2: Distribution of the ultrasound sign used in the diagnosis of PA in 53 series.

| Ultrasound signs | n (%) |
|-------------------------------------|--------------|
| <hr/> | |
| <u>Grey-scale Parameters (n=52)</u> | |
| Loss of clear zone | 50(98.0) |
| Myometrial thinning | 34(66.7) |
| Placental lacunae | 49(96.1) |
| Bladder wall interruption | 30(58.8) |
| Placental bulge | 11(22.0) |
| Focal exophytic mass | 13(25.5) |
| | |
| <u>CDI Parameters (n=42)</u> | |
| Uterovesical hypervascularity | 20(47.6) |
| Subplacental hypervascularity | 36(85.7) |
| Bridging vessels | 26(61.9) |
| Lacunae feeder vessels | 22(52.4) |
| <hr/> | |
| CDI= Color Doppler Imaging | |

Table 3: Distribution of standard ultrasound signs found in eight studies presenting detailed data on depth of villous myometrial invasion.

| Variables | References | | | | | | | | |
|--------------------------------|------------|----|----|----|----|----|-----|-----|------|
| | 65 | 79 | 84 | 89 | 95 | 98 | 102 | 107 | T |
| | n | n | n | n | n | n | n | n | n |
| No of cases | 15 | 10 | 9 | 41 | 26 | 32 | 10 | 9 | 152 |
| <u>Placental grading</u> | | | | | | | | | n |
| PC | 8 | 8 | 5 | 15 | 16 | 16 | 3 | 1 | 72 |
| PI | 3 | 1 | 3 | 9 | -- | 12 | 4 | 2 | 34 |
| PP | 4 | 1 | 1 | 17 | 10 | 4 | 3 | 6 | 46 |
| <u>Grey-scale Parameters</u> | | | | | | | | | % |
| Loss of clear zone | 7 | 10 | 4 | 37 | 23 | 20 | 5 | | 69.7 |
| Myometrial thinning | | | | | 19 | 32 | 3 | | 51.0 |
| Placental lacunae | 10 | 10 | 5 | 30 | 23 | 28 | 5 | 9 | 78.9 |
| Bladder wall interruption | 3 | | | | 15 | 16 | 1 | | 23.0 |
| Placental bulge | | | 1 | | 9 | | | | 6.6 |
| Focal exophytic mass | | | 1 | | 11 | | | | 7.9 |
| <u>CDI Parameters (n= 128)</u> | | | | | | | | | % |
| Uterovesical hypervascularity | | | | | 11 | 30 | 2 | 6 | 11.3 |
| Subplacental hypervascularity | | 10 | | | | 30 | | 7 | 36.7 |
| Bridging vessels | | | | | 12 | | | | 9.3 |
| Lacunae feeder vessels | | | | | | | 5 | 6 | 8.6 |

CDI= Color Doppler Imaging; ; PC= placenta creta or vera; PI= placenta increta; PP= placenta percreta.

References 65 and 83 included only grey-scale imaging data.

Table 4: Ultrasound signs identified in the diagnosis of 38 cases reports and in 3 series^{65,84,102} including 34 cases ranked according to the depth of villous myometrial invasion.

| Ultrasound signs | PC | PI | PP |
|-------------------------------|-----------|-----------|-----------|
| | n(%) | n(%) | n(%) |
| <u>Grey-scale Parameters</u> | (n=29) | (n=26) | (n=17) |
| Loss of clear zone | 18(62.1) | 22(84.6) | 8(47.1) |
| Myometrial thinning | 6(20.7) | 12(46.2) | 4(23.5) |
| Placental lacunae | 16(55.2) | 16(61.5) | 14(82.4) |
| Bladder wall interruption | 2(6.9) | 2(7.7) | 5(29.4) |
| Placental bulge | - | 1(3.9) | 2(11.8) |
| Focal exophytic mass | - | - | 2(11.8) |
| <u>CDI Parameters</u> | (n=14) | (n=15) | (n=11) |
| Uterovesical hypervascularity | 3(21.4) | 2(13.3) | 2(18.2) |
| Subplacental hypervascularity | 5(35.7) | 9(60.0) | 6(54.5) |
| Bridging vessels | 10(71.4) | 7(46.7) | 2(18.2) |
| Lacunae feeder vessels | 4(28.6) | 8(53.3) | 5(45.5) |

CDI= Color Doppler Imaging; PC= placenta creta or vera; PI= placenta increta; PP= placenta percreta.

Figure legend

Fig 1: Flow diagram for the selection of cases reports and series on ultrasound imaging of PA.