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AUDIT AND QUALITY IMPROVEMENT

Improving placenta accreta spectrum diagnosis: impact of structured imaging protocols and multidisciplinary review in a tertiary service evaluation and re-audit

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Abstract

***Objective*:** The study aims to assess the impact of targeted diagnostic and organisational interventions on placenta accreta spectrum (PAS) screening performance in a tertiary referral centre.
***Design*:** Retrospective comparative audit.
***Setting*:** Liverpool Women's Hospital, UK.
***Methods*:** PAS screening outcomes from two periods (2017–2020 vs. 2022–2024) were compared. Interventions included standardised ultrasound reporting using the ISUOG proforma, dedicated placental imaging protocols, regional multidisciplinary team (MDT) review, enhanced sonographer training, and selective magnetic resonance imaging (MRI) in indeterminate cases. Screening sensitivity, specificity, predictive values, and diagnostic accuracy were calculated. Ultrasound features associated with true and false positive diagnoses were analysed, and the role of serial scans was assessed.
***Results*:** A total of 60 and 146 patients were screened in the first and second audit periods, respectively. Sensitivity improved from 60.0 to 92.3%, with a modest decrease in specificity from 100.0 to 94.0%. High-yield sonographic signs included bladder line disruption and bladder bulge (positive predictive value [PPV] 100%). Subplacental hypervascularity and lacunae had lower specificity (PPV 53–56%). Serial scanning improved sensitivity (from 69.2 to 92.3%) and accuracy (from 90.4 to 93.8%). False positives were more common with high- or low-lying placentas compared to placenta previa.
***Conclusions*:** Structured imaging protocols, serial scan review, and regional MDT collaboration significantly enhanced PAS detection, supporting safer delivery planning and improved maternal–neonatal outcomes. Future priorities include expanding specialist capacity, formalising care coordination, and implementing real-time data collection to sustain diagnostic gains and progress toward Level 3 PAS surgical centre capability.

Keywords: *placenta accreta spectrum*; *diagnostic accuracy*; *ultrasound*; *MRI*; *multidisciplinary team*; *obstetric imaging*; *maternal outcomes*; *service evaluation*

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Placenta accreta spectrum (PAS) refers to a disorder where the placenta fails to separate after birth, and when forcible removal risks life-threatening haemorrhage. [1]. Irving and Hertig first described the condition in 1937 as an abnormal adherence of the placenta to the myometrium in the absence of the underlying decidua [2]. In 1966, Luke et al. coined the term 'placental invasion', describing placental villi being implanted deeper into the myometrium rather than simply adhering to the surface.

In a modern context, the PAS is subdivided based on the depth of villous penetration into the myometrium and surrounding structures [3]. Placenta accreta or adherenta (FIGO Grade 1) refers to superficial adherence of the placental villi to the myometrium in the absence of underlying decidua, placenta increta (FIGO Grade 2) describes villi that penetrate the myometrium up to (but not including) the serosa, and placenta percreta (FIGO Grade 3) describes villi that perforate the serosa with or without invasion into surrounding structures such as the bladder or pelvic side wall [1]. The latter two conditions are also referred to as 'Abnormally Invasive Placenta' (AIP).

PAS is an iatrogenic disease, with most cases occurring following previous uterine surgery, including, but not limited to, caesarean sections (CS) [4]. As CS rates rise worldwide, so too does the incidence of PAS. Other procedures, such as myomectomy, curettage, and in vitro fertilisation (especially with cryopreserved embryos), have also been shown to increase the risk of PAS [5]. A total of 90% of women diagnosed with PAS also have a placenta previa [2].

Ultrasound imaging is the primary screening tool for PAS and is highly accurate when performed by a skilled operator experienced in diagnosing PAS [5, 6, 7]. Current guidelines suggest referring women with ultrasound features suggestive of PAS or a history of previous CS with anterior low-lying placenta/placenta previa to a specialist unit with imaging expertise [1, 2]. Magnetic resonance imaging (MRI) has been increasingly used alongside ultrasound imaging for the prenatal assessment of PAS, with studies finding the diagnostic value of both imaging modalities to be similar [8, 9]. Current guidelines recommend that MRI should not be conducted routinely but rather as a complementary adjunct to ultrasound in cases of diagnostic uncertainty [2].

PAS is a condition associated with adverse maternal outcomes. Prenatal diagnosis allows for planned obstetric care optimised for a patient with PAS; the patient can be referred to centres with clinicians experienced in diagnosing and managing PAS and benefit from coordinated care from an experienced multidisciplinary team (MDT), which has been shown to improve patient outcomes [2, 10, 11]. Diagnostic accuracy is therefore essential to minimise the morbidity associated with false negative diagnoses (obstetric haemorrhage, maternal death) as well as false positives (heightened maternal anxiety, iatrogenic preterm delivery, midline incision, unnecessary use of staff and theatre resources) [3, 12].

The European Working Group on Abnormally Invasive Placentas (EW-AIP) first standardised the list of ultrasound features to be used in assessing suspected PAS in 2016, with additional signs added in subsequent updates [1, 6, 13]. However, no single ultrasound finding demonstrates absolute sensitivity or specificity for PAS. Many imaging features associated with PAS can also be observed in unaffected pregnancies, especially among patients with prior uterine surgical history. Prenatal diagnosis, therefore, relies on ultrasound imaging performed by clinicians who are trained in PAS assessment and who understand the range of ultrasound appearances found in normal placentas, in addition to the potential pitfalls in PAS diagnosis [14].

Initial Audit of LWH PAS diagnostic performance

A previous retrospective audit assessing PAS diagnostic performance was conducted in the Foetal Medicine Unit (FMU) at Liverpool Women's Hospital (LWH) in 2021. Sixty patients were evaluated for PAS in the FMU from 11th January 2017 to 31st October 2020.

The results showed a high diagnostic specificity (100%), but with a low sensitivity (60%). There were several missed antenatal PAS diagnoses with a significant associated maternal morbidity. A total of six out of the 60 cases were correctly identified as being at intermediate-high risk of PAS on antenatal imaging (true positive cases). There were no false positive diagnoses. A total of 4/60 cases were incorrectly assessed as being low risk for PAS (false negative cases). A total of 3/4 false negative cases resulted in an unplanned emergency hysterectomy and were associated with significant maternal morbidity, including post-partum haemorrhage >1.5 L and high-dependency unit (HDU) admission in each case. The complete diagnostic performance data from the initial audit are presented in Table 1.

Improvements

Since the previous audit, several improvements have been made to the diagnostic service within the department, both locally and at the regional level, to reduce the number of false-negative antenatal diagnoses and their associated impact on morbidity.

At the departmental level, the standardisation of reporting ultrasounds has been improved by implementing the ISUOG proforma (Appendix 1) for ultrasound reports in suspected AIP, which has been added as a template in the Viewpoint reporting system [13, 15]. The FMU has also collaborated with ultrasound application specialists to develop a dedicated preset and annotation set for placental ultrasound machines, aiming to improve diagnostic workflow and efficiency.

Additionally, the Imaging Department has implemented a standard operating procedure (SOP) to enhance placental imaging accuracy and to standardise image archiving among sonographers. These measures also streamline referral pathways to the FMU for women at risk of PAS, support prioritisation of departmental workload, and ultimately improve patient and staff experience.

Although diagnosis of PAS by ultrasound can be highly accurate when performed by skilled, experienced sonographers, it requires a systematic approach with an understanding of routine placental imaging and the potential pitfalls in PAS diagnosis. In 2023, a Placental Imaging Working Group was established with the goal of enhancing ultrasound assessment by sonographers to

Table 1. Screening performance data comparing the 2021 audit and the 2024 re-audit

Screening performance	Number of cases	
	2021 (n = 60)	2024 (n = 146)
True positive	6	12
False positive	0	8
True negative	50	125
False negative	4	1
Sensitivity	60.00%	92.31%
Specificity	100.00%	93.98%
Positive predictive value	100.00%	60.00%
Negative predictive value	92.59%	99.21%
Accuracy	93.33%	93.84%

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ensure timely referrals for patients with risk factors and/or ultrasound features suggestive of PAS to the FMU. With improved oversight of training, outcome monitoring, reporting, and the introduction of tailored imaging learning resources for sonographers, this initiative aims to reduce the number of inappropriate referrals and ensure that cases of placenta praevia/PAS are not missed.

In addition to ultrasound imaging, placental MRI has also been used more frequently as a complementary imaging modality to aid in the diagnosis of PAS. This is often performed in indeterminate cases or where ultrasound assessment is suboptimal, such as with suspected PAS in lateral or posterior placentas, or in cases of suspected placenta percreta to assess for invasion into adjacent pelvic structures.

Studies have shown that PAS patient outcomes are improved when these patients are diagnosed before delivery and managed by a cohesive, experienced, and well-established MDT [2, 10–12]. At the regional level, the Northwest PAS MDT was established to aid not only with obtaining second opinions on PAS ultrasound imaging but also to share experiences between different hospitals and learn from the post-natal surgical and histopathological outcomes of these cases presented at monthly meetings.

Re-audit of LWH PAS diagnostic performance

A re-audit of PAS diagnostic performance was conducted, examining PAS screening examinations from October 2022 to September 2024. A total of 146 patients were screened, and 20 positive PAS screens were identified. Of these, 12/146 were true positive PAS cases and 8/146 were false positives. A total of 1/146 was a false negative diagnosis compared to 4/60 in the previous audit. There was no adverse maternal or neonatal outcome in the one false-negative case.

Comparing these results to the initial audit, the sensitivity of the screening has markedly improved from 60% in 2021 to 92.31% in 2024. Conversely, the specificity of the screening decreased from 100% in 2021 to 93.98% in 2024, with eight false-positive cases identified, compared to no false positives in the initial audit. Current RCOG guidelines suggest an ultrasound screening sensitivity of 90.72% (95% CI, 87.2–93.6) and specificity of 96.94% (95% CI, 96.3–97.5), based on a meta-analysis of 23 ultrasound studies [10]. Based on these figures, the screening sensitivity of the most recent audit falls within the recommended limits, while the specificity is just below the recommended threshold.

Analysis of false positive and true positive cases during the re-audit

False positives

Out of the eight false positive cases, five resulted in a preterm delivery. One of these was an extreme preterm delivery at 26 weeks secondary to placental abruption. The other four were delivered late preterm (34–36+6 weeks); one as an emergency secondary to a significant APH, and the other three were iatrogenic elective deliveries because of suspected accreta, which, with hindsight, could have been performed at a later gestation.

In seven of eight of the false-positive cases, delivery was via CS, and one patient delivered via spontaneous vaginal delivery. All the patients delivered by caesarean would have required a caesarean delivery regardless of the suspicion of PAS due to the presence of a placenta praevia or low-lying placenta. Out of the seven CS, five were elective and two were emergencies due to the presence of contractions and/or antepartum haemorrhage.

Among the false positive cases, there were no incidences of hysterectomy, bladder injury, ITU admission, or maternal or neonatal death. There was only one reported significant complication in the false positive group; a post-partum haemorrhage of 1600 mL secondary to bleeding from the lower segment with admission to HDU post-operatively. Three of eight babies were admitted to the neonatal intensive care unit (NICU) post-delivery due to prematurity at 26, 33, and 34 weeks, respectively.

True positives

Of the 12 true positive cases, three had their care transferred. They were delivered in St Mary's Hospital in Manchester (a tertiary hospital with on-site intensive care and interventional radiology) due to a high suspicion of placenta accreta. Detailed data regarding surgical outcomes for these cases were not available, and therefore they were excluded from the analysis of intraoperative and postnatal outcomes; this has likely skewed our data due to the exclusion of potentially high-risk cases.

All nine cases managed at LWH were delivered preterm; two were moderate preterm (32–33+6) due to recurrent antepartum haemorrhage, and seven were late preterm (34–36+6). All the deliveries were performed via CS. Eight of the nine LWH cases were elective, and one was delivered as an emergency due to antepartum haemorrhage. A midline skin incision was used in five cases and a lower transverse skin incision in the remaining four cases. A classical uterine incision was utilised in seven cases. In three cases, a hysterectomy was performed, with the other cases being conservatively managed through forced separation of the placenta +/- local resection, followed by insertion of a Bakri balloon. No cases were managed by leaving the placenta in situ.

Among the nine true positive cases managed by LWH, there were no incidences of bladder injury, ITU admission, or maternal or neonatal death. The most common complication was post-partum haemorrhage, present in five of nine cases. Three cases had an estimated blood loss (EBL) of between 1 and 1.5 L, one had an EBL of between 1.5 and 2.5 L, and one had an EBL of more than

2.5 L. In five of nine cases, the mothers were admitted to HDU post-delivery, and in two cases, the baby was admitted to NICU post-delivery due to prematurity.

Ultrasound features

The most common ultrasound findings in the false positive cases were placental lacunae (7/8 cases) and a hypervascular subplacental zone (7/8 cases). Bladder line disruption and a bladder 'bulge' were not found in any of the false positive cases.

The most common ultrasound findings in the true positive cases were myometrial thinning (12/12 cases), loss of the placental basal plate (11/12 cases), loss of the sub-placental 'clear zone' (11/12 cases), and placental lacunae (10/12 cases) (Figs. 1 and 2). The presence of an exophytic mass was the only sign not observed in either true or false positive cases.

Bladder line disruption and a bladder 'bulge' had the highest positive predictive value (PPV) of any sonographic PAS sign (100% PPV in each); however, these signs were present only in a small number of cases (identified in 1/12 and 5/12 of the true positive cases, respectively and not seen in any of the false positive cases). There were, however, no cases of uterine dehiscence in the false positive group, and it should be noted that both bladder line disruption and bladder 'bulge' have been reported in cases of uterine dehiscence without PAS.

Subplacental hypervascularity and the presence of placental lacunae demonstrated the lowest PPVs for the sonographic PAS signs (53 and 56% PPV, respectively). Subplacental hypervascularity was observed in seven of eight false-positive cases, compared to 11 of 12 true-positive cases. Placental lacunae were also seen in seven of eight false-positive cases, compared to 10 of 12 true-positive cases.

A retrospective review of placental imaging highlighted the subjectivity of subplacental vascularity as a sign of PAS, and the difficulty in differentiating the normal neovascularisation that occurs after a previous

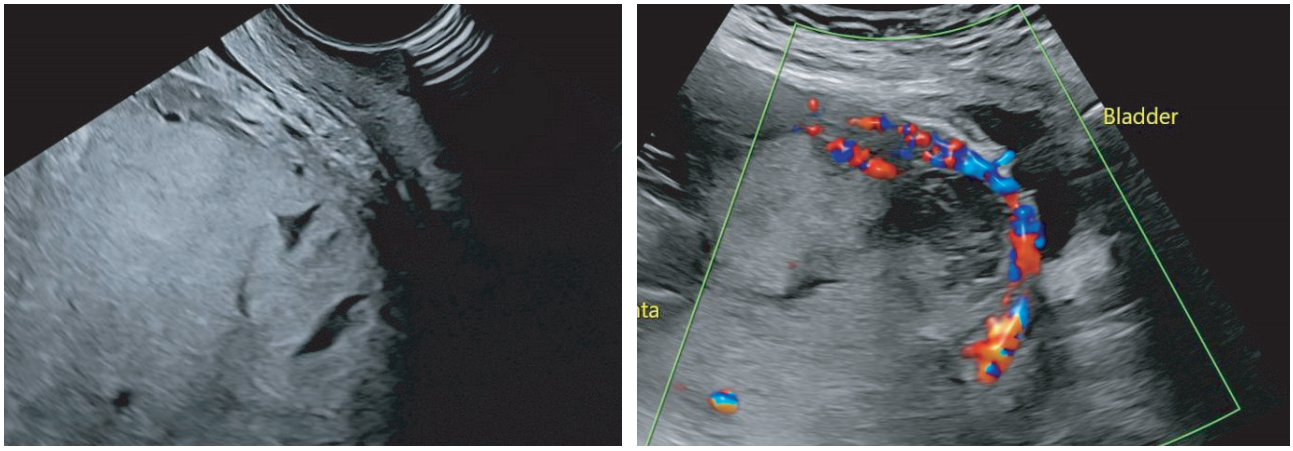

Fig. 1. Placenta increta. Left – focal placental lacunae, thin myometrium. Right – Subplacental hypervascularity, bridging vessels.

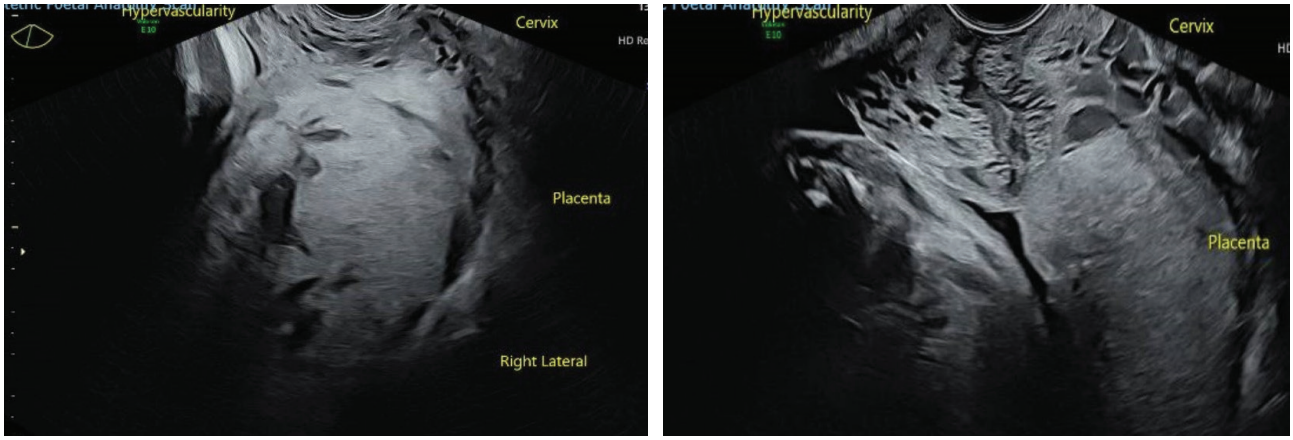

Fig. 2. Placenta percreta with cervical involvement. Left – diffuse placental lacunae, absent myometrium. Right – distortion of the cervix with associated hypervascularity.

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c-section from the hypervascularity associated with a PAS diagnosis.

The image review also identified the potential misclassification of placental sonolucencies as lacunae rather than other benign placental cystic lesions in five out of the eight false-positive cases, albeit with the benefit of hindsight (Fig. 3). In three cases, the placental sonolucencies identified on ultrasound were more consistent with intra-placental lakes (centrally located, more regular in shape and widely spaced), and in two cases, more consistent with echogenic cystic lesions (well-circumscribed cystic lesions with a hyperechoic rim, often related to foetal growth restriction and pre-eclampsia). In the other three false positive cases, the appearance remained consistent with lacunae (irregularly shaped, located close to the placental bed), despite knowledge of the subsequent clinical and histopathological outcome.

High-velocity flow within the lacunae showed a higher PPV for PAS (PPV 75%) compared to the presence of lacunae on their own (PPV 53%). Placental lacunae were observed in seven of eight false-positive cases, compared to 10 of 12 true-positive cases. However, high-velocity flow was present in only three of eight false-positive cases, versus nine of 12 true-positive cases. This demonstrates the role of Doppler in helping to differentiate PAS-related lacunae from other benign placental sonolucencies.

The results overall highlight the complexity of ultrasound diagnosis for PAS, as no single feature is both sensitive and specific for PAS diagnosis, and there are potential pitfalls and subjectivity in several of the ultrasound signs.

Placental location

In 10 of 12 true positive cases, the placenta was overlying or abutting the cervical os (placenta praevia). Of the remaining two cases, one had a low-lying placenta, and the other had a high-lying placenta. In comparison, the site of the placenta varied more in false positive cases, with three of eight cases being placenta praevia, three of eight cases having a low-lying placenta, and a further two cases having a high-lying placenta. These results indicate that false-positive diagnoses are more likely in cases where the placenta is high- or low-lying, as well as in cases where the placenta migrates upwards with advancing gestation, rather than in instances of praevia. These results align with previous findings, which show a strong correlation between PAS and placenta praevia [7].

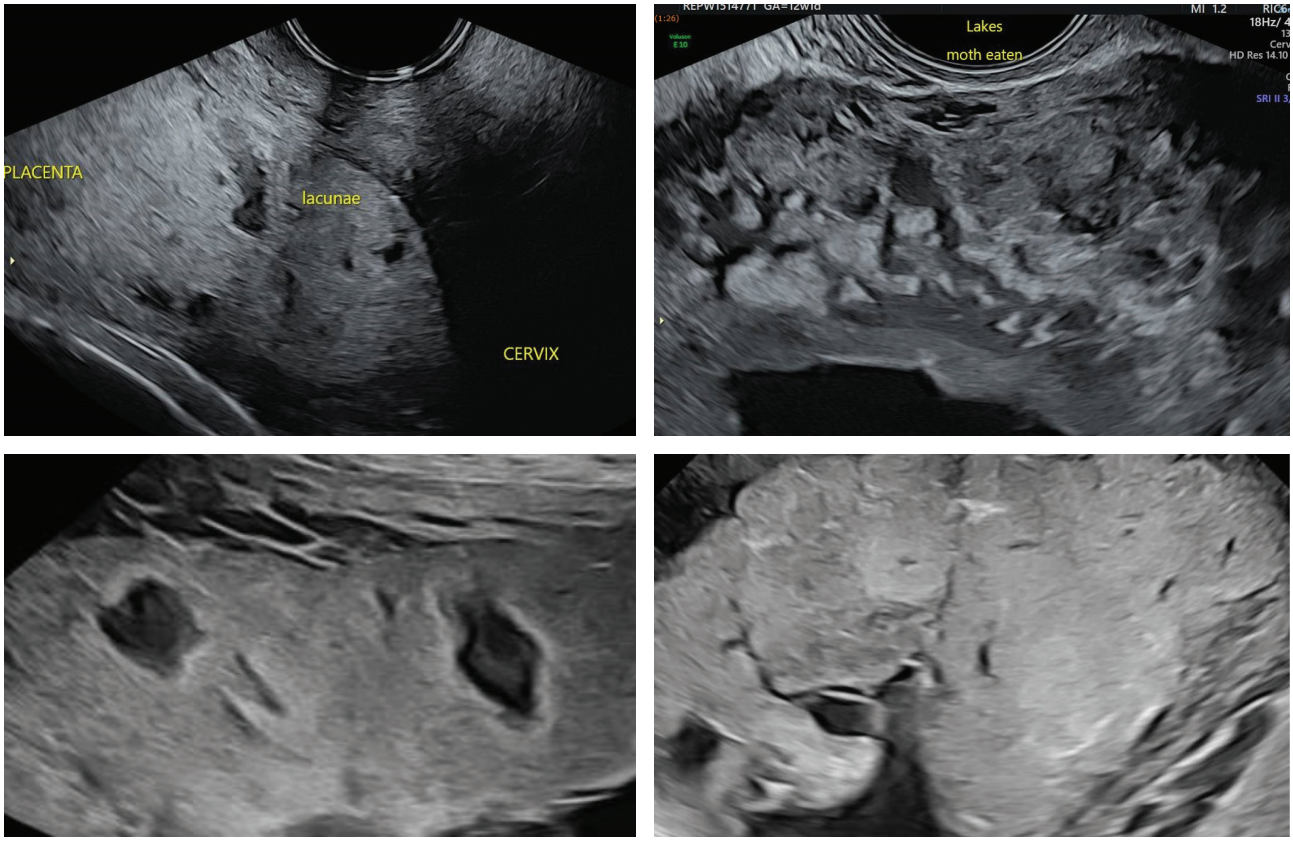

Fig. 3. Types of placental echolucencies. Top left – focal lacunae in a case of accreta. Top right – diffuse lacunae ('moth-eaten' placenta) in a case of percreta. Bottom left – echogenic cystic lucencies (placental infarcts) in a false positive case of PAS. Bottom right – scattered benign intra-placental lakes in a false positive case of PAS.

Previous caesarean section

The worldwide rise in the rates of CS has correlated with the rising incidence of PAS in recent years [5]. Every patient in the false positive group had a history of at least one previous Caesarean section, as did the one false negative case. In the true positive group, all but one patient had a history of previous CS; the one outlier patient instead had a history of an earlier myomectomy. The average number of previous CS among the true positive cases (1.83) was higher than the average among the false positive diagnoses (1.5). These results are consistent with studies showing that CS and other intrauterine procedures have been shown to increase the risk of PAS [5, 6].

Serial ultrasound assessment

Table 2 shows the full screening performance based on initial versus final ultrasound scans. The average number of ultrasound assessments was 2.16 in the true-positive group and 2.14 in the false-positive group.

Serial ultrasound assessments demonstrated a significantly increased sensitivity (from 69% sensitivity based on the initial scan to 92% sensitivity following serial ultrasound assessment) and PPV (from 47 to 60% PPV). The accuracy of the diagnosis was also increased when multiple ultrasound assessments were performed, resulting in three fewer false-negative cases and two fewer false-positive cases. The incidence of a false-positive diagnosis decreased if the subjective likelihood of PAS increased over serial scans.

Future improvements

Although multiple advancements have been made to the service since the previous audit, current limitations and areas for improvement still exist.

There is currently only a single foetal medicine consultant at LWH, with the majority of PAS ultrasound diagnostic experience, which provides a potential single point of failure in diagnosis and limits the capacity for PAS screening, especially in the event of annual leave or sickness. The introduction of an additional FMU consultant with experience scanning and diagnosing PAS would allow for increased capacity in the service and FMU lists dedicated to PAS screening and diagnosis.

The lack of a PAS specialist midwife or dedicated administrative assistant for PAS also creates difficulties in coordinating between the department, other specialities such as surgery and neonatology, and the patients themselves. Coordination of PAS surgical planning and administrative duties for the PAS MDT falls to the medical team, and the absence of a specialist midwife creates a lack of antenatal and postnatal support, with no direct line for patients to contact if they have questions. Funding for a dedicated administrative assistant to support the operation of a PAS service and the development of a PAS specialist midwife role would significantly contribute to the expansion and optimisation of the service.

Currently, there is no real-time collection of data on the diagnostic imaging and surgical outcomes of patients with suspected PAS, which limits the ability to monitor trends in patient and service-related outcomes continuously. Currently, any data collection must be done manually by reviewing individual patient records, and there is limited data sharing between hospitals covered by the Northwest PAS MDT. Implementation of a digital dashboard to collect PAS data in real-time, along with a PAS MDT portal to collect outcomes at a regional level with oversight provided by the Northwest PAS MDT, would improve efficiency, lower the chance of errors in data collection, and improve the ability to identify trends in diagnostic accuracy and/or surgical outcomes across the region.

Ultimately, the main limitation faced by the PAS service is that Liverpool Women's Hospital operates as a standalone unit with no ITU, interventional radiology services, or other surgical specialities on-site. This setting limits the service's ability to manage the delivery of placenta percreta patients (FIGO Grade 3), who must have their care transferred to St Mary's Hospital, and means that LWH does not meet the requirements for a PAS level 3 surgical

Table 2. Screening performance based on initial versus final ultrasound scan

	Screening performance based on initial scan	Screening performance based on final scan
	Number of cases	Number of cases
True positive	9	12
False positive	10	8
True negative	123	125
False negative	4	1
Sensitivity	69.23%	92.31%
Specificity	92.48%	93.98%
Positive predictive value	47.34%	60.00%
Negative predictive value	96.85%	99.21%
Accuracy	90.41%	93.84%

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centre. Although a significant limitation, the development of a pathway for delivering high-risk cases at the nearby Royal Liverpool University Hospital that complies with the commissioned PAS service specification would serve as a step towards developing a fully functional level 3 PAS surgical centre.

Conclusion

In conclusion, PAS is a serious condition associated with adverse maternal and neonatal outcomes which requires accurate prenatal diagnosis. The results of the recent audit of the PAS diagnostic service were compared to those of a previous audit in 2021, showing a significantly increased diagnostic sensitivity, a slight reduction in specificity, and an overall improvement in diagnostic accuracy. Several improvements have been made to the service since the initial audit, including the use of the ISUOG proforma to standardise ultrasound reports in suspected AIP, the implementation of a Placental Imaging Working Group, an increase in the use of placental MRI to aid diagnosis, and the establishment of the Northwest PAS MDT. Suggestions for improvement looking to the future include introducing an additional FMU consultant with experience in scanning and diagnosis of PAS, securing funding for a dedicated administrative assistant and a PAS specialist midwife, implementing a digital dashboard for real-time data collection, and developing a pathway for managing high-risk percreta cases locally. These findings support a model that other units can adapt to enhance accuracy and safety in managing PAS.

Conflict of interest and funding

The authors declare that they have no conflict of interest. This audit received no funding.

Ethical approval

Ethical approval was not required for this study.

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Appendix 1. Standardised ultrasound reporting proforma for suspected or confirmed PAS

Ultrasound Signs

Cervical length (without funnel or placental tissue)		**mm**	
Greyscale ultrasound parameters and definition	**Yes**	**No**	**Unsure**
Loss of 'clear zone' *- Loss, or irregularity, of the hypoechoic plane in the myometrium underneath the placental bed (the 'clear zone')*			
Myometrial thinning *- Thinning of the myometrium overlying the placenta to <1mm or undetectable*			
Abnormal placenta lacunae *- Presence of numerous lacunae including some that are large and irregular, often containing turbulent flow visible in greyscale imaging*			
Bladder wall interruption *- Loss or interruption of the bright bladder wall (the hyperechoic band or 'line' between the uterine serosa and the bladder lumen)*			
Placental bulge *- Deviation of the uterine serosa away from the expected plane, caused by an abnormal bulge of placental tissue into a neighbouring organ, typically the bladder. The uterine serosa appears intact but the outline shape is distorted*			
Focal exophytic mass *- Placental tissue seen breaking through the uterine serosa and extending beyond it. Most often seen inside a filled urinary bladder*			
Colour Doppler ultrasound parameters and definition	**Yes**	**No**	**Unsure**
Utero-vesical hypervascularity *- Striking amount of colour Doppler signal seen between the myometrium and the posterior wall of the bladder. This sign probably indicates numerous, closely packed, tortuous vessels in that region (demonstrating multi-directional flow and aliasing artefact)*			
Sub-placental hypervascularity *- Striking amount of colour Doppler signal seen in the placental bed. This sign probably indicates numerous, closely packed, tortuous vessels in that region (demonstrating multi-directional flow and aliasing artefact)*			
Bridging vessels *- Vessels appearing to extend from the placenta, across the myometrium and beyond the serosa into the bladder or other organs. Often running perpendicular to the myometrium*			
Placental lacunae feeder vessels *- Vessels with high velocity blood flow leading from the myometrium into the placental lacunae, causing turbulence upon entry*			
Parametrial involvement	**Yes**	**No**	**Unsure**
- Suspicion of invasion into parametrium			

Clinical Significance of Ultrasound Findings

Probability of clinically significant AIP High ☐ Intermediate ☐ Low ☐

Extent of AIP Focal ☐ Diffuse ☐

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