

## Value of Crystal Vue technique in detecting the placenta accreta spectrum located in c-section scar area

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### Abstract

**Aims:** Excessive placental invasion is a life-threatening obstetric disease. Determining the extent of placental villi invasion prenatally is crucial for formulating a surgical plan for pregnant women. The objective of this study was to explore the diagnostic accuracy of the Crystal Vue technique combined with two-dimensional (2D) ultrasound in detecting the degree of placenta accreta spectrum (PAS) located in the C-section scar area. **Materials and methods:** Twenty-seven pregnant women with a strong suspicion of PAS underwent 2D ultrasound combined with a Crystal Vue examination. The diagnosis of 2D ultrasound alone and Crystal Vue combined with 2D ultrasound was statistically calculated, respectively. Cohen's kappa (k) was used to measure the consistency between these two ultrasound diagnosis and the postoperative diagnosis. **Results:** The postoperative diagnosis of 27 pregnant women was as follows: 6 cases of placental accreta, 11 cases of placental increta, 2 cases of placental percreta, 2 cases of placental accrete and placental increta, 2 cases of placental accreta and placental percreta, and 4 cases without PAS. Compared with the postoperative diagnosis, 20 cases (74.07%) were correctly diagnosed by 2D ultrasound alone, 6 cases were misdiagnosed, and one case the diagnosis was incomplete, which were substantially consistent with the postoperative diagnosis ( $k=0.612$ ,  $p<0.01$ ). Twenty-six cases (96.30%) were correctly diagnosed by Crystal Vue combined with 2D ultrasound; only one case was incomplete diagnosed which was almost perfectly consistent with the postoperative diagnosis ( $k=0.934$ ,  $p<0.01$ ). **Conclusions:** Combining the Crystal Vue technique with 2D ultrasound can improve the diagnostic accuracy of ultrasound for detecting all types of PAS located in C-section scar area.

**Keywords:** placenta accreta spectrum; prenatal diagnosis; ultrasound; Crystal Vue technique; obstetrics

### Introduction

Placenta accreta spectrum (PAS) is a common serious complication of obstetrics, which includes placenta accreta (PA, attachment of the placenta to myometrium without intervening decidua), placenta increta (PI, invasion of the trophoblast into the myometrium) and placenta percreta

(PP, invasion through the myometrium, serosa, and into surrounding structures) [1]. With the increasing number of surgeries that damage the endometrium such as C-section, abortion curettage and myomectomy, the incidence rate of PAS is also increasing correspondingly [2]. The most common risk factors are C-section and placenta previa, and the risk of PAS is greater when both factors are present, or even when the placenta previa covers a C-section scar. Forced removal of the implanted placenta may lead to catastrophic maternal hemorrhage, uterine perforation, secondary infection, multiorgan failure, shock and even death [3]. Maternal hemorrhage also is expected to result in fetal compromise, with perinatal mortality as high as 25% [4]. Accurate prenatal diagnosis of PAS for optimal management, has been demonstrated to re-

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duce maternal and fetal morbidity [5]. Prenatal diagnosis methods include ultrasound, magnetic resonance imaging (MRI) and cystoscopy, but the gold standard is always the pathologic examination of the myometrium, with a record of placental villi invasion into the myometrium.

More than 3000 cases of prenatal diagnoses of PAS by ultrasound have been reported in the literature over the last 30 years [6,7]. The appearance of more and more signs on two-dimensional (2D) ultrasound image suggest PAS, such as the loss of the retroplacental clear zone, abnormal placental lacunae, bladder wall interruption, myometrial thinning, placental bulge, focal exophytic mass, uterovesical or subplacental hypervascularity, bridging vessels and placental lacunae feeder vessels [8]. However, no specific ultrasound image or combination of ultrasound images is further found to be accurate enough to identify all types of PAS [7,9-10]. MRI is usually used as an auxiliary means for ultrasound diagnosis of PAS. As it is able to draw the anatomical structure of placenta involved tissues, it tends to predict the difficulty of surgery and plan the surgical program [11]. Considering that MRI is a high cost examination and is often not immediately available, the method is not suitable as a routine screening method. Cystoscopy can be used to estimate the severity of PP preoperatively [12]. However, for cases of PA or PI, cystoscopy is of little value [13].

Three-dimensional (3D) ultrasound provides additional information from 2D ultrasound in the diagnosis of soft tissue abnormalities [14]. Some studies have shown that 3D color power Doppler ultrasound (3D-PDU) increases the positive rate of diagnosis of PAS compared with 2D ultrasound [15,16]. The contrast enhancement rendering algorithm (the Crystal Vue technique) is another application of 3D ultrasound imaging. By enhancing the contrast between tissues, the Crystal Vue technique is easy to distinguish between different echogenic tissues, such as the boundaries of soft tissues and bony structures [17]. The main advantage of this technique is that it can simultaneously display the external contour and internal structure of the volume image with a perspective effect to obtain more intuitive diagnostic information. In the published case reports, Crystal Vue provided valuable diagnostic information in the evaluation of fetal lip and palate, fetal spine and ribs, fetal genitalia, fetal optic chiasm and nerve, and female adnexal masses [17-22].

Dall'Asta et al conducted an initial study on the cases of abnormally invasive placenta using the Crystal Vue technique [23]. In order to further explore the diagnostic performance and clinical value of the Crystal Vue technique in distinguishing types of PAS, we compared the diagnostic accuracy of PAS patients with and without the Crystal Vue technique on the basis of 2D ultrasound.

## Materials and methods

### *Patient information*

The study included a total of 27 pregnant women with a strong suspicion of PAS on the basis of history and prenatal conventional ultrasound screening, between January 2018 and May 2019 in the First Affiliated Hospital of Shantou University Medical College. The mean maternal age and gestational age at the time of examination was  $33.5 \pm 4.0$  years and  $26.2 \pm 6.8$  weeks, respectively. Inclusion criteria were pregnant women with at least one C-section and an abnormal placental position during this pregnancy (22 patients with complete placenta previa, 3 patients with low-lying placenta and 2 patients with cesarean scar pregnancy, but pregnancies were not terminated). Crystal Vue examinations were conducted in all cases. The ultrasound examination was performed by two sonologists with more than 10 years' experience in obstetric scanning. If two sonologists disagreed with each other, the ultrasound diagnosis was made through consultation. If the patient was diagnosed as PP by ultrasound, cystoscopy was performed before surgery to determine whether the placenta had infiltrated into the bladder. All patients were tracked throughout delivery outcomes and postoperative diagnosis.

The study was approved by the local Ethics Committee and written informed consent was obtained from all participants.

### *Instruments and equipment*

Prenatal ultrasound diagnosis of PAS was made by using a 2.0-7.0 MHz transabdominal transducer (Samsung WS80A with Elite, Samsung). The patient was in a supine position with a well-filled bladder (200-300 cc) and underwent transabdominal 2D ultrasound examination. After the area suspected of PAS in the 2D image was found, they subsequently went into 3D mode, selected the use of dual screen imaging and used the "Crystal Vue" and "Realistic Vue" modes. Ultrasound examination focused on the position, thickness and internal echo of the placenta, the retroplacental clear zone, the thickness of retroplacental myometrium, and the blood flow in the placenta and the uterus-bladder junction.

### *Postoperative diagnostic criteria for PAS*

According to the surgical records or pathologic results, we defined the postoperative diagnosis of patients as follows: 1) no PAS - the placenta can be delivered without difficulty in separation naturally or after active treatment by the administration of intravenous oxytocin or transabdominal manual massage of the uterus; 2) PA - no evidence of placental separation at least 20 minutes after the above active treatment, needed obstetricians to manually remove the placenta, and active bleeding oc-

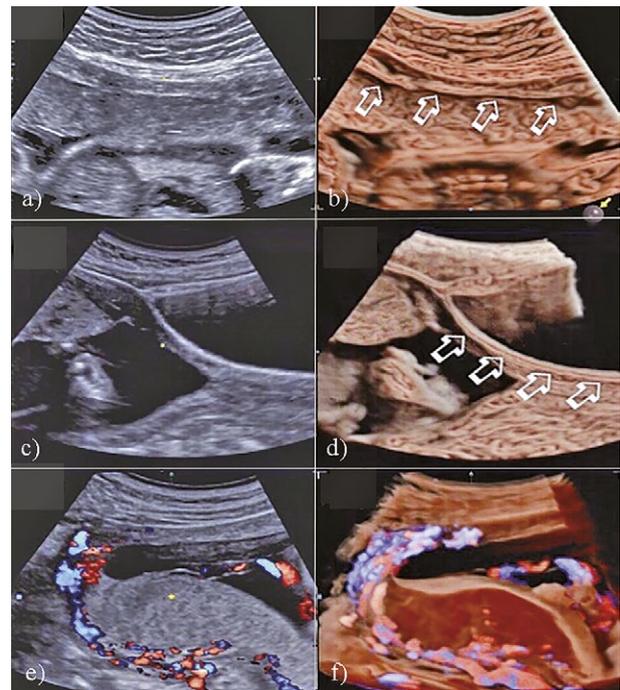
curred at the adhesion between the placenta and the myometrium [24]; 3) PI - difficulty in manual separation of the placenta and myometrium and the pathologic result of excised tissue (the tissue should contain parts of the decidua or the myometrium) or the entire uterus indicated that the placenta implanted into the myometrium; 4) PP - during surgery it was observed that placental tissue penetrated the whole myometrium or even adhered to the bladder and the pathologic result indicated that the placenta penetrated to the whole myometrium [25].

#### Statistical analysis

The data were statistically categorized and analyzed using SPSS software version 22 (IBM SPSS Statistics, Armonk, NY, USA). To compare the potential for distinguishing all types of PAS between 2D ultrasound alone and the Crystal Vue technique combined with 2D ultrasound, the consistency between ultrasound results and postoperative results was estimated with the Cohen's kappa ( $k$ ).

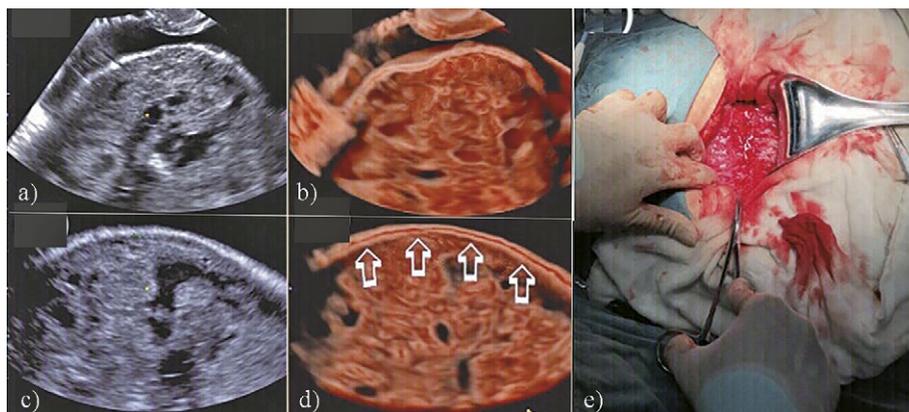
#### Results

All patients chose an elective C-section and in 8 patients a hysterectomy was performed. In 27 patients, postoperative results showed 4 cases of complete placenta previa without PAS (fig 1), 6 cases of PA (fig 2), 11 cases of PI (fig 3), 2 cases of PP (fig 4), 2 cases of PA and PI and 2 cases of PA and PP. Compared with the postoperative results, 20 cases (74.07%) were correctly diagnosed by 2D ultrasound alone, 6 cases were misdiagnosed (one case of PI was misdiagnosed as PA, one case of PI was misdiagnosed as PP and 4 cases without PAS was misdiagnosed as PA) and in one case with PA and PI the diagnosis of PI was missed. The results of 2D ultra-

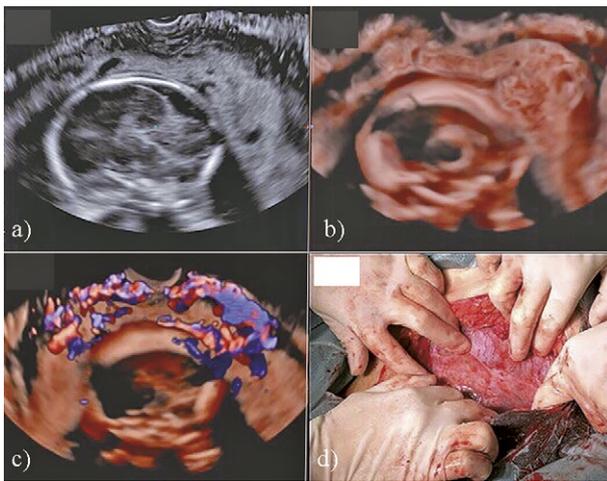


**Fig 1.** Two cases of normal placenta: a) 2D gray-scale and b) Crystal Vue showed the retroplacental clear zone (arrows); c) 2D gray-scale and d) Crystal Vue showed the “tramline”-like (arrows) appearance of the normal interface between the myometrium and the bladder; e) 2D color Doppler and f) Crystal Vue Flow showed regular and orderly blood flow signals between the placenta and the myometrium.

sound alone were substantially consistent with the postoperative diagnosis ( $k=0.612$ ,  $p<0.01$ ). By using Crystal Vue combined with 2D ultrasound, 26 cases (96.3%) were properly diagnosed and in one case of PA and PI the diagnosis of PI was missed. Results of Crystal Vue com-



**Fig 2.** A case of placenta accreta: a) and c) 2D gray-scale showed that the retroplacental clear zone was fuzzy and the myometrium was thinner, being  $<1$  mm; b) and d) Crystal Vue showed that the retroplacental clear zone was very thin and the tramline (arrows) was complete; e) During the surgery, it could be seen that the uterine surface was intact without dilated blood vessels, but the retroplacental clear zone had visibly narrowed and the placenta had adhered to the myometrium.



**Fig 3.** A case of placenta increta; a) 2D gray-scale showed the loss of the retroplacental clear zone and numerous placental vascular lacunae; b) Crystal Vue showed the complete tramline; c) Crystal Vue Flow showed disorder vessels in the base of the placenta; d) During the surgery, it could be observed that the serosa of the uterus was intact without penetration, but there were dilated blood vessels on the surface of the uterus. Postoperative pathology suggested that the placenta had implanted into the myometrium but had not penetrated the whole myometrium.

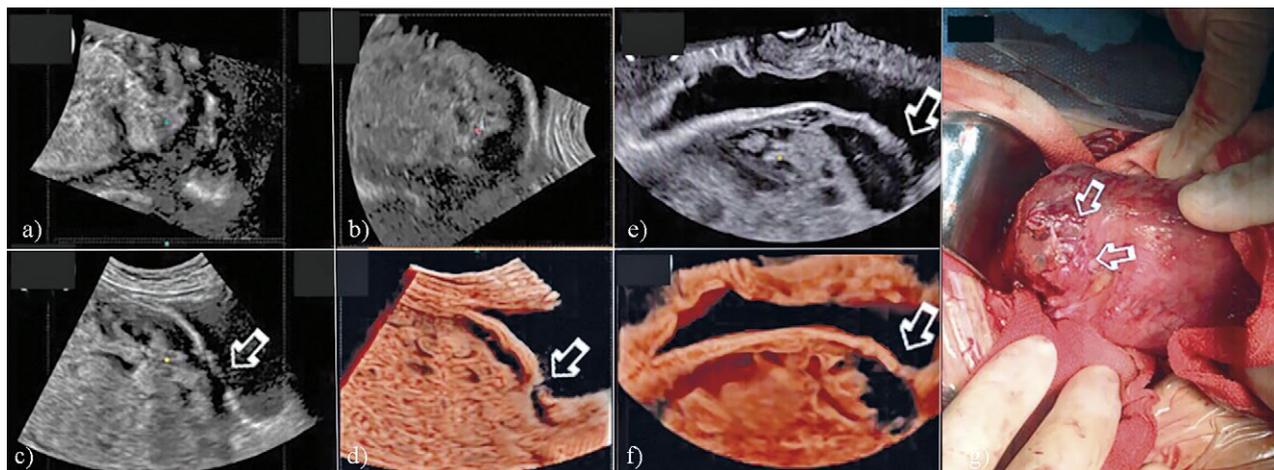
combined with 2D ultrasound were almost perfectly consistent with the postoperative diagnosis ( $k=0.934$ ,  $p<0.01$ ).

### Discussion

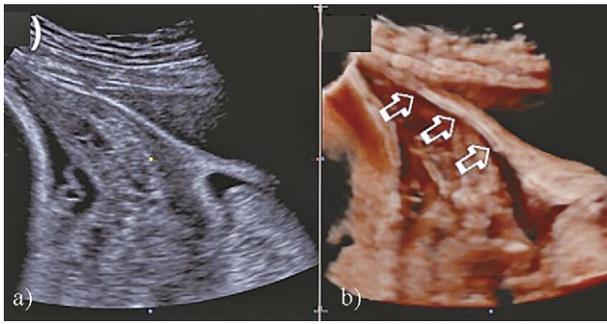
Many studies have indicated that the overall sensitivity of 2D ultrasound in the diagnosis of PAS is generally good, but there are differences in published values [26]. These may be caused by differences in image

quality, ultrasonographer skill and diagnostic level. For example, in the case of PAS, loss of the retroplacental clear zone is the first signal identified by 2D gray-scale ultrasound [27], but its detection is related to the skill of the ultrasonographer. As shown in figure 5, if the probe is pressed too hard, sometimes the retroplacental clear zone may disappear, so a false-positive diagnosis may be given. Bowman et al reported that there was considerable interobserver variability for the diagnosis of PAS by ultrasound [28]. The reason for this phenomenon may be that the interpretation of what constitutes each marker suggesting PAS depends largely on the experience and diagnostic level of the sonologists. For example, the interruption or irregularity of the bladder wall in 2D gray-scale may be a direct result of placental villi invasion into the bladder wall [8] or it may be an ultrasound artifact formed by the increased vessels at the uterovesical fold [25]. These increased vessels at the uterovesical fold may be mistaken by inexperienced sonologists for placental vessels penetrating the myometrium, resulting in a misdiagnosis of PAS.

Aryananda et al showed that the Crystal Vue technique has a promising application for the preoperative diagnosis and staging of PAS [29], but their study did not use the Crystal Vue Flow to observe the degree of vascular invasion as an aid in diagnosing various types of PAS. The presence of a large number of neovascularization in the uteroplacental region is part of the characteristics of placental invasion. Shih et al used the 3D-PDU technique to analyze the patterns of placental vasculature to distinguish between non-invasive placenta and abnormal invasive placenta [15]. However, while highlighting the presence of blood vessels, 3D-PDU weakens the dis-



**Fig 4.** A case of placenta percreta: a-c) and e) 2D gray-scale evidenced the interrupted bladder line; d) and f) The interrupted tramline (arrows) was also shown in the Crystal Vue image, indicating that the degree of placenta invasion was severe; g) Surgery demonstrated that the serosa of the uterus was ruptured (arrows).



**Fig 5.** A case of Crystal Vue corrected a false positive diagnosis of 2D ultrasound: a) 2D gray-scale indicated placenta accreta because of the loss of retroplacental clear zone; b) Crystal Vue showed the retroplacental clear zone (arrows) was normal.

play of soft tissue structures, so sometimes the source of the disordered vessels cannot be determined. The Crystal Vue Flow based on the Crystal Vue technique is to superimpose the color blood flow on the soft tissue structures, so the display of the source of abnormal blood vessels and the degree of placental vascular invasion are more comprehensive than 3D-PDU.

In Crystal Vue images, the utero-bladder interface has a similar “tramline” appearance [23]. The tramline is a stereoscopic sign, so it is less affected by the ultrasonographer skill. The continuity or interruption to the tramline facilitates determining whether the placenta has invaded the bladder as we exemplified in figure 6, which can enhance the diagnostic confidence of sonologists and reduce over-diagnosis. Over-diagnosis may cause unnecessary hysterectomy and loss of fertility in women of childbearing age, as has been previously reported [30]. For patients with obvious bladder involvement, multidisciplinary surgery is required to significantly reduce morbidity or mortality due to maternal hemorrhage [31,32]. In addition, the key point of a uterine incision is to avoid the placenta, and the Crystal Vue technique is also helpful in designing the uterine incision in each patient. Therefore, the Crystal Vue technique has a significant clinical value in making surgical plans.

In this study, one patient who had a postoperative pathologic diagnosis of coexisting PA and PI, was preoperatively diagnosed as having only PA by the Crystal Vue technique combined with 2D ultrasound. Because the degree of villi adhesion or invasion of the myometrium is rarely uniform, an accurate distinction between PA and PI may be difficult. Therefore, we should be carefully and repeatedly observing the relationship between the placenta and the myometrium from multiple body positions and multiple planes.

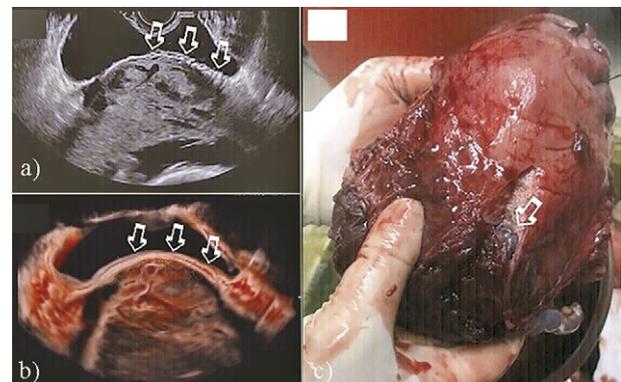
When the placenta is attached to the posterior wall of the uterus, the penetrating power of the ultrasound is

reduced due to the obscurity by the fetus, so the lesion is often unclear, which is one of the limitations of all ultrasound examination including the Crystal Vue technique. In obese pregnant women, ultrasound can lose visual accuracy due to signal attenuation from absorption, scattering, and reflection, producing suboptimal images and consequent difficulty in diagnosing PAS [33]. In addition, it is often difficult to confirm parametrial invasion and possible urethral involvement by ultrasound, which is why it cannot replace MRI [34].

We acknowledge some limitations to our study as well. Retrospective design and small sample size represent the main limitations and our data may overstate or understate the practical value. The results of our study are applied only to pregnant woman with abnormal placenta position and previous C-section. However, PAS also occurs to a pregnant woman with no risk factors of these conditions [35]. Further large prospective multicenter studies are needed to predict morbidity and evolution of PAS and to provide optimal prenatal counselling and management for PAS patients.

## Conclusion

The overall results of our study demonstrate that the Crystal Vue technique combines with 2D ultrasound confers excellent reliability, which can improve the diagnostic accuracy of various types of PAS. Although currently there is no “gold standard” imaging mode that can detect



**Fig 6.** A case of Crystal Vue corrected the over-diagnosis of 2D ultrasound; a) 2D gray-scale showed a suspected case of placenta percreta: the loss of retroplacental clear zone; numerous vascular lacunae in the placenta; the bladder wall appeared to be irregular and suspiciously interrupted (arrows); b) The complete tramline (arrows) was shown in the Crystal Vue image, suggesting that the placenta had not penetrated the serosa of the uterus; c) Placenta increta was confirmed during surgery. The serosa of the uterus was intact without penetration, but there were dilated blood vessels on the surface of the uterus. Note: The surface of the uterus was artificially cut (arrows).

the depth of PAS, the Crystal Vue technique combines with 2D ultrasound can be a valuable option to determine whether placenta percreta has bladder involvement.

**Conflicts of interest:** none.

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