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

Shaoqi Chen¹, Qingzi Chen¹, Xiya Du¹, Sumin Chen¹, Weiping Li², Shigao Chen³

¹Department of Medical Ultrasound, The First Affiliated Hospital of Shantou University Medical College, 515041 Shantou, China, ²Department of Information Engineering, The First Affiliated Hospital of Shantou University Medical College, 515041 Shantou, China, ³Department of Radiology, Mayo Clinic College of Medicine, Rochester, USA

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-
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±4.0 years and 26.2±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 myo-
metrium [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 indicat-
ed 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 pla-
centa 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 distin-
guishing all types of PAS between 2D ultrasound alone
and the Crystal Vue technique combined with 2D ultra-
sound, 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 pla-
centa 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 misdiag-
nosed (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-
sound alone were substantially consistent with the post-
operative 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 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 myo-
metrium and the bladder; e) 2D color Doppler and f) Cystal Vue Flow showed regular and orderly blood flow signals between
the placenta and the myometrium.](image1)

![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 retro-
placental clear zone had visibly narrowed and the placenta had adhered to the myometrium.](image2)
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-
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 super-
impose 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 ultra-
sonographer 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 un-
necessary hysterectomy and loss of fertility in women of
childbearing age, as has been previously reported [30].
For patients with obvious bladder involvement, multidis-
ciplinary surgery is required to significantly reduce mor-
bidity 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. There-
fore, 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 preop-
eratively diagnosed as having only PA by the Crystal Vue
technique combined with 2D ultrasound. Because the de-
gree 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 posi-
tions 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 ultra-
sound examination including the Crystal Vue technique.
In obese pregnant women, ultrasound can lose visual ac-
curacy due to signal attenuation from absorption, scat-
tering, and reflection, producing suboptimal images and
consequent difficulty in diagnosing PAS [33]. In addi-
tion, 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 repre-
sent 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 pla-
centa position and previous C-section. However, PAS
also occurs to a pregnant woman with no risk factors of
these conditions [35]. Further large prospective multi-
center studies are needed to predict morbidity and evolu-
tion 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 con-
fers excellent reliability, which can improve the diagno-
sic accuracy of various types of PAS. Although currently
there is no “gold standard” imaging mode that can detect

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

Fig 6. A case of Crystal Vue corrected the over-diagnosis of 2D
ultrasound; a) 2D gray-scale showed a suspected case of pla-
centa 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 com-
plete 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.

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