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# The value of 3-dimensional color Doppler in predicting intraoperative hemorrhage for cesarean scar pregnancy

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**Abstract**

The aim of this study is to evaluate the efficacy of 3-dimensional (3D) ultrasonography and 3D color power Doppler ultrasound in the management of cesarean scar pregnancy (CSP).

A case–control study enrolled 190 CSP patients who underwent uterine artery embolization (UAE) in combination with dilatation and curettage (D&C). The maximum diameter of gestational sac or CSP mass, uterine scar thickness, and resistance index (RI) were measured by 2D ultrasound. The lesion volume, vascular index (VI), flow index (FI), blood vessels, and blood flow index (VFI) were assessed by 3D ultrasound. The changes of these parameters before and after UAE were analyzed. Then, the patients were divided into bleeding group and control group according to the intraoperative hemorrhage during D&C to access and compare the significance of 2D and 3D parameters in intraoperative hemorrhage.

The mean VI and the mean VFI were significantly reduced after embolization ($P < .01$). In the bleeding group, the lesion volume and diameter of gestational sac or CSP mass were significantly larger, VI and VFI were significantly higher, the uterine scar thickness was thinner, and RI was lower ($P < .05$). The best indicator for prediction of massive intraoperative bleeding was the VI with an area under the curve of 0.870, the best cut-off value of VI was 7.500, and the sensitivity and specificity were 88.2% and 82.4%, respectively. In comparing the receiver operating characteristic curves among 2D and 3D ultrasound parameters, the diagnostic efficacy of lesion volume was significantly higher than maximum diameter ($P < .001$). The diagnostic efficacy of VI was significantly higher than maximum diameter ($P = .020$) and RI ($P = .011$).

UAE reduces the number of vessels and the blood flow perfusion obviously; however, it does not reduce lesion size or increases myometrial thickness. Three-dimensional ultrasonography and power Doppler, especially VI, lesion volume may be helpful in predicting excessive bleeding during D&C after UAE.

**Abbreviations:** β-HCG = beta-human chorionic gonadotropin, 3D-CPA = 3-dimensional color power angio, AUC = area under the curve, BMI = body mass index, CSP = cesarean scar pregnancy, D&C = dilatation and curettage, FI = flow index, RI = resistance index, ROC = receiver operating characteristic, UAE = uterine artery embolization, VFI = vessels and flow index, VI = vascular index.

**Keywords:** 3-dimensional color Doppler ultrasound, 3-dimensional color power Doppler ultrasound, cesarean scar pregnancy ;

## 1. Introduction

Cesarean scar pregnancy (CSP) is defined as a gestational sac located in the scar of a previous cesarean section. It was a rare form of ectopic implantation in the past, but the number of reported cases has increased significantly in recent times. This is mainly due to the increasing number of cesarean deliveries, with advanced imaging technologies making it easier to be diagnosed.[1,2] There are several complications such as serious bleeding, uterine rupture, and hemorrhagic shock, which may require hysterectomy and even lead to maternal mortality.[3–5] Termination of pregnancy is recommended soon after the diagnosis, to avoid severe complications. Dilatation and curettage (D&C) are common treatments for CSP, while uterine artery embolization (UAE) has been adopted to minimize the blood loss during curettage, but massive bleeding and uterine rupture can still be frequently encountered.[6–8]

Ultrasound examination plays an important role in CSP diagnosis and treatment monitoring. Currently, 3D ultrasonography and 3D color power angio (CPA) have become available in practice; they can provide quantitative parameters for peritrophoblastic perfusion. This research estimated and compared the value of 2D and 3D sonographic parameters in predicting huge hemorrhage during D&C; it may help diagnosing CSP patients with high risk of intraoperative hemorrhage, so that it may give guidance for CSP management. To the best of our knowledge and review of literature, this is the first study on this subject.

## 2. Materials and methods

### 2.1. Patients and methods

The study collected the data of 213 CSP women who received UAE in combination with D&C treatment, in Tianjin Central

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This research project was approved by the Ethics Committee of Tianjin Central Hospital of Gynecology Obstetrics.

Written consents were obtained from each patient.

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Hospital of Gynecology Obstetrics from June 2013 to December 2016, aged from 21 to 47 years (M = 32.81, standard deviation [SD] = 5.10), and interval between current CSP and last cesarean was 9 to 243 months. All patients had at least 1 previous cesarean section, and always the lower uterine segment cesarean section. The exclusion criteria included coagulation disorders, severe cardiovascular disease and uterine malformation, pregnancy with intrauterine device, and used other pretreatments except for UAE, such as using methotrexate or intrasac injection of methotrexate. Finally, 23 women were ruled out due to the exclusion criteria and 190 women were included in this study.

Informed verbal consent was obtained from all participants, and the Human Research Ethics Committee of Tianjin Central Hospital of Gynecology Obstetrics approved all aspects of this study.

Catheterization of the uterine arteries was performed through a transfemoral approach; both uterine arteries were embolized with gelatin sponge particles (0.5–1.0 mm in diameter). Subsequently, postembolization angiography could be done to validate the obstruction of the arteries. D&C were carried out under the guidance of ultrasonic within 72 hours after UAE.

### 2.2. Sonography

A GE produced VOLUSON E8 ultrasound system equipped with a 5- to 9-MHz vaginal volume probe was used. The uterine cavity, adnexa, fallopian tube, and pelvic cavity were observed by transvaginal ultrasound in 2D mode. The CSP was diagnosed when the following criteria were met: a history of lower segment caesarean section, positive serum beta-human chorionic gonadotropin (β-HCG) level, and fulfillment of the following ultrasonography standard: there was no gestational sac in uterine cavity and cervical canal; detection of the gestational sac or the inhomogeneous mass embedded in the hysterotomy scar; a visible myometrial defect (obviously thinner or even disappeared) at the site of the previous cesarean section scar; and color Doppler flow imaging showed high-velocity and low-resistance blood flow around the pregnancy sac or the inhomogeneous mass.[9] Identical preinstalled settings were used for all patients: frequency "mid," pulse repetition frequency 0.9 kHz, gain −3.2, quality "norm," wall motion filter "low 1." The maximum diameter of the lesion, the myometrial thickness between the CSP and the bladder, and resistance index (RI) were detected. A 2D ultrasound image of CSP is shown in Fig. 1. Thus, maximum diameter, thickness of residual muscle, and RI were 2D ultrasound parameters for CSP.

Then, the 3D and 3D-CPA mode were activated, with the setting "Quality high 1." Lesion volume and 3D power Doppler indices, vascular index (VI), flow index (FI), and vessels and flow index (VFI), were analyzed off line using a software system (The Virtual Organ Computer-Aided Analysis). The manual mode was set, and the regions of interest in each lesion were manually encircled by 6 rotational steps (60° apart). Tracing the perimeter of the segmentation, including the hyperechoic region representing villus tissue to get the volume of the lesion (Fig. 2). 3D-CPA flow indices are shown in Fig. 3, the outer boundaries of the vascular "ring" were followed. All measurements were made by the same physician; each item was measured 3 times and an average of all the results was calculated. The patients underwent sonographic examinations within 24 hours prior to UAE or D&C. The lesion volume, VI, FI, and VFI were 3D ultrasound parameter for CSP.

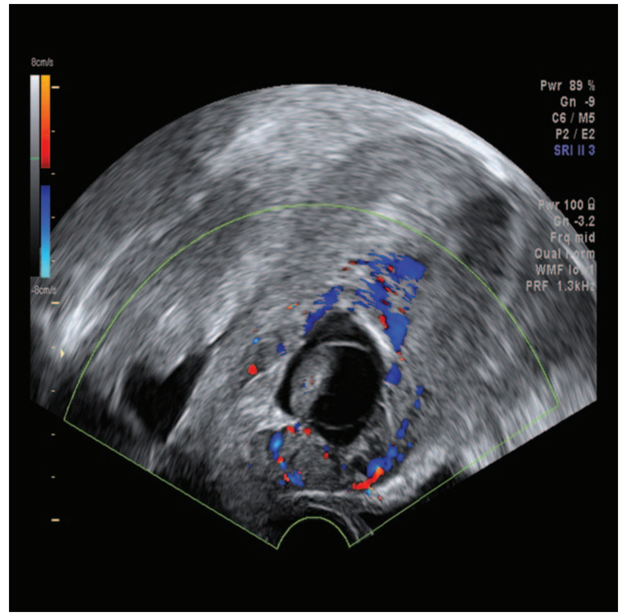


Figure 1. Transvaginal 2-dimensional color ultrasound image of cesarean scar pregnancy.

Each parameter was compared before and after UAE. All patients were divided into 2 groups according to the hemorrhagic amount during operation in order to analyze the relationship between ultrasound indices and massive bleeding. In this study, excessive hemorrhage was defined as a blood loss ≥200 mL during the suction curettage, and it was concurred with the previous literature,[10,11] see Table, Supplemental Digital Content 1, http://links.lww.com/MD/C410, which illustrates the detailed data of excessive hemorrhage patients. All the operations were done by 1 experienced physician who also calculated the hemorrhagia amount. The hemorrhagia amount consists of 2 parts: after the material aspirated from the uterus, a metal screen was used to filter pregnancy tissue and decidua from the blood, then the blood was measured by a graduated container, the assessment of additional blood by weighting the operating gauze.

RI reflects the resistance to blood flow in the vessel influenced by vasoconstriction, dilation, or external vascular compression. VI is the ratio of the number of color voxels to the total number of voxels and it represents the percentage of blood vessels. FI is the mean color value of all color voxels; thus, it describes the average velocity of blood flow. VFI is the mean color value of all color and grey voxels, and represents a combination of vascularity and flow intensity.[12–14]

### 2.3. Statistical analysis

Statistical analysis was performed using the Statistical Package for Social Sciences, version 17.0 (SPSS Inc, Chicago, IL). We applied Shapiro–Wilk test (W test) to analyze the distribution of the data. Normal distribution variables were described by mean ± SD and compared by *t* test. The non-normal distribution variables were described as median (first quartile, third quartile) and compared by Mann–Whitney *U* test. Receiver operating characteristic (ROC) curve analysis was performed to identify the best cut-off value of ultrasound indexes for prediction of excessive intraoperative blood loss, the best cut-off value was

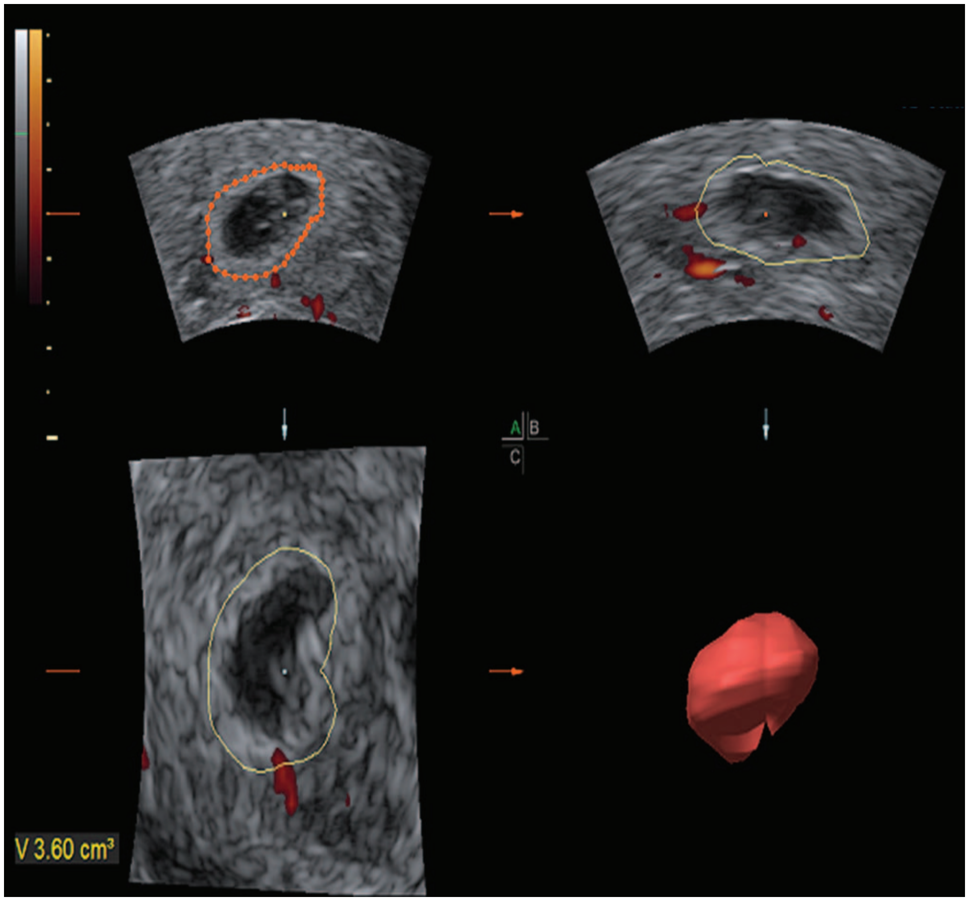


**Figure 2.** Virtual organ computer-aided analysis of lesion volume. Tracing the outer edge of the lesion, including the hyperechoic region which representing villus tissue.

defined by the point on the ROC curve with the minimum distance between the 0% false-positive rate and the 100% true-positive rate, and the highest value of the area under the curve (AUC). A $P$ value $<.05$ was considered statistically significant. The pair-wise comparisons of ROC curves were performed using MEDCALC software based on Hanley and McNeil method.

## 3. Results

A total of the 190 women enrolled in the study, out of which 34 patients were included in bleeding group with ≥200 mL intraoperative hematoma volume while 156 controls with hemorrhagia amount <200 mL. In Shapiro–Wilk test, the variables including age, body mass index (BMI), gestational age, maximum diameter, thickness of residual muscle, VI, FI, and RI were fitted normal distribution. While gravidity, parity, interval between current CSP and last cesarean, intraoperative blood loss, lesion volume, and VFI were not consistent with normal distribution, see Table, Supplemental Digital Content 2, http://links.lww.com/MD/C410, which illustrates the distribution of the data.

1. Statistical analyses showed no significant differences between the bleeding group and the control group in the general information of patients, including the patients' age at diagnosis, the gravidity, the parity, the BMI, and the interval between current CSP and last cesarean. The gestational age at diagnosis was significantly different between the 2 groups. Overall, the mean intraoperative blood loss was 1575.00 (1062.50, 1962.50) mL versus 170.00 (160.00, 180.00) mL for the bleeding group versus the control group, showing significant statistical difference with $P<.001$ (Table 1).

1. The VI and the VFI were significantly reduced after UAE ($P<.05$). The lesion volume, maximum diameter of the lesion, RI, FI, and thickness of myometrial layer did not differ significantly ($P>.05$) (Table 2).
2. The lesion volume, maximum diameter of the lesion, uterine scar thickness, VI, RI, and VFI were significantly different between the bleeding group and the control group ($P<.05$), whereas, the FI had no significant difference between the 2 groups ($P>.05$) (Table 3).
3. The diagnostic performance of statistically significant markers was illustrated in Table 4. The best marker for prediction of hemorrhage was the VI with an AUC of 0.870, the best cut-off value of VI was 7.500. The sensitivity, the specificity, the positive predictive value, the negative predictive value, the likelihood ratio of a positive test, and likelihood ratio of a negative test were 88.2%, 84.6%, 55.6%, 97.0%, 5.01, and 1.04, respectively. The following variables added information to VI when calculating the risk of intraoperative hemorrhage for CSP. The lesion volume with an AUC of 0.846, the VFI with an AUC of 0.820, the thickness of residual muscle with an AUC of 0.785, the RI with an AUC of 0.770, the maximum diameter with an AUC of 0.761, and the gestational age, where

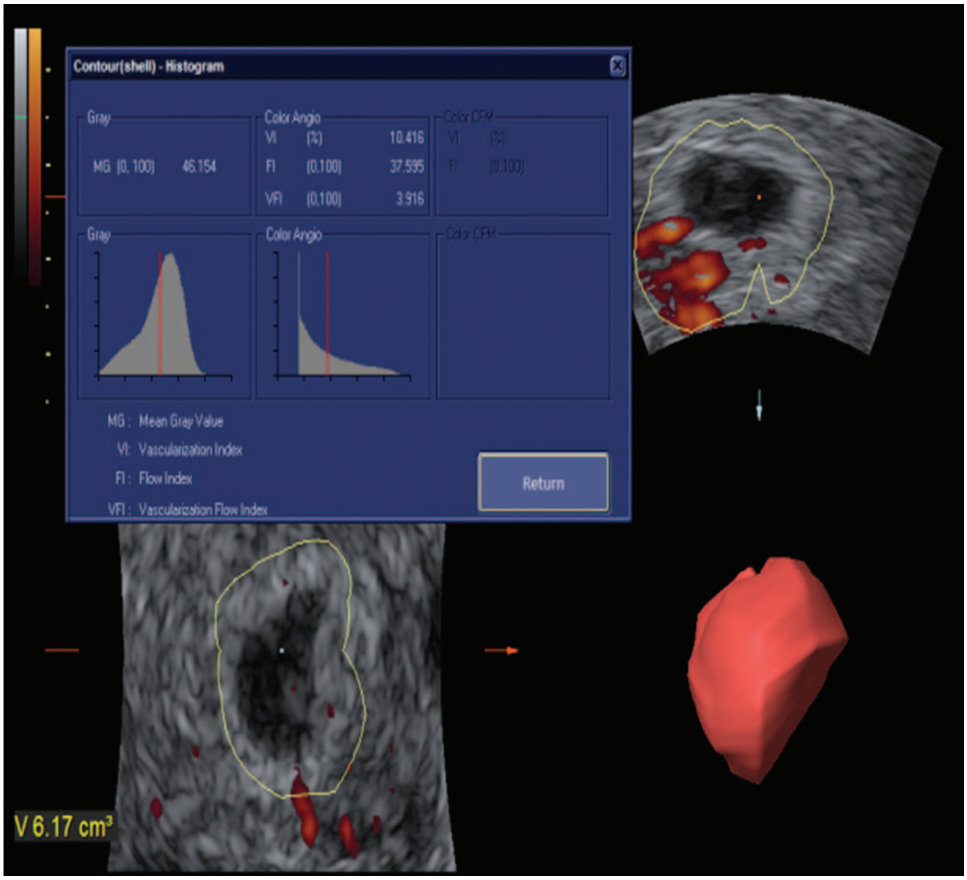


Figure 3. Three-dimensional power Doppler flow indices of cesarean scar pregnancy. The outer boundaries of the vascular "ring" were traced.

**Table 1**

**CSP patients' baseline characteristics and intraoperative blood loss.**

| Characteristics | Control group (n=156) | Bleeding group (n=34) | t/z | *P* |
|---|---|---|---|---|
| Age, y* | 31.20±7.20 | 34.56±6.90 | 0.483 | .630 |
| BMI, kg/m$^2$* | 21.38±2.63 | 21.09±2.75 | 0.546 | .586 |
| Gravidity† | 3 (2, 4) | 3 (2, 4) | 0.642 | .430 |
| Parity† | 2 (1, 2) | 2 (1, 2) | 0.103 | .748 |
| Gestational age, d* | 58.70±8.81 | 62.12±9.49 | 2.019 | .045 |
| Interval between current CSP and last cesarean, mo† | 26 (19, 84) | 25 (16, 86) | 0.802 | .371 |
| Intraoperative blood loss, mL† | 170 (160, 180) | 1575 (1063, 1963) | 86.448 | <.001 |

CSP = cesarean scar pregnancy, BMI = body mass index.
* Normal distribution variables were described by mean±standard deviation and compared by *t* test (*t*).
† The non-normal distribution variables were described as median (first quartile, third quartile) and compared by Mann–Whitney *U* test (z).

**Table 2**

**Comparison of ultrasound parameters before and after UAE for CSP patients.**

| Ultrasound parameters | Before UAE | After UAE | t/z | *P* |
|---|---|---|---|---|
| Maximum diameter, mm* | 36.20±19.30 | 33.40±16.10 | 1.249 | .212 |
| Lesion volume, cm$^3$† | 27.95 (13.70, 91.90) | 20.70 (13.40, 78.40) | 1.123 | .289 |
| Thickness of residual muscle, mm* | 2.50±0.80 | 2.50±0.90 | 1.169 | .243 |
| VI* | 8.875±2.027 | 6.655±1.539 | 3.882 | <.001 |
| FI* | 41.974±8.028 | 39.807±8.338 | 1.901 | .058 |
| VFI† | 2.247 (1.896, 3.216) | 2.442 (1.902, 3.108) | 2.204 | .028 |
| RI* | 0.39±0.11 | 0.37±0.09 | 1.742 | .082 |

CSP = cesarean scar pregnancy, FI = flow index, RI = resistance index, UAE = uterine artery embolization, VFI = vessels and flow index, VI = vascular index.
* Normal distribution variables were described by mean±standard deviation and compared by *t* test (*t*).
† The non-normal distribution variables were described as median (first quartile, third quartile) and compared by Mann–Whitney *U* test (z).

**Table 3**

**Comparison of ultrasound parameters between the bleeding group and the control group in CSP patients.**

| Ultrasound parameter | Control group | Bleeding group | t/z | P |
|---|---|---|---|---|
| Maximum diameter, mm* | 33.39±16.12 | 44.79±14.86 | 3.316 | .001 |
| Lesion volume, cm3† | 17.65 (12.80, 40.20) | 123.05 (60.90, 144.48) | 40.153 | <.001 |
| Thickness of residual muscle, mm* | 2.64±0.78 | 1.70±1.00 | 5.161 | <.001 |
| VI* | 6.179±1.021 | 8.840±1.641 | 9.081 | <.001 |
| FI* | 43.830±7.148 | 47.579±11.964 | 1.760 | .086 |
| VFI† | 2.351 (1.872, 2.822) | 4.123 (3.201, 5.340) | 54.352 | <.001 |
| RI* | 0.39±0.09 | 0.30±0.09 | 4.894 | <.001 |

CSP = cesarean scar pregnancy, FI = flow index, RI = resistance index, VFI = vessels and flow index, VI = vascular index.
* Normal distribution variables were described by mean±standard deviation and compared by *t* test (*t*).
† The non-normal distribution variables were described as median (first quartile, third quartile) and compared by Mann–Whitney *U* test (*z*).

**Table 4**

**Diagnostic performance of statistically significant parameters for the risk of excessive hemorrhage during D&C.**

| Parameters | Maximum diameter, cm | Volume, cm3 | Thickness of residual muscle, mm | VI | VFI | RI | Gestational age |
|---|---|---|---|---|---|---|---|
| AUC | 0.761 | 0.846 | 0.785 | 0.870 | 0.820 | 0.770 | 0.630 |
| Cut-off value | 40 | 55.3 | 2.20 | 7.500 | 3.263 | 0.32 | 60.0 |
| Sensitivity, % | 70.6 | 82.4 | 70.6 | 88.2 | 76.5 | 70.6 | 64.7 |
| Specificity, % | 78.2 | 79.5 | 80.8 | 82.4 | 76.9 | 76.9 | 67.9 |
| PPV, % | 41.3 | 56.0 | 44.4 | 55.6 | 40.0 | 33.3 | 30.5 |
| NPV, % | 92.4 | 95.4 | 84.6 | 97.0 | 92.3 | 91.5 | 89.8 |
| LR+ | 3.24 | 4.02 | 3.68 | 5.01 | 3.31 | 3.06 | 2.02 |
| LR− | 0.38 | 0.22 | 0.36 | 0.14 | 0.31 | 0.38 | 0.52 |

AUC = area under the curve, LR = likelihood ratio, NPV = negative predictive value, PPV = positive predictive value, RI = resistance index, VFI = vessels and flow index, VI = vascular index.

AUC was 0.630 (Table 4). The ROC curve was shown in Fig. 4.

4. In Table 5, we directly compared the ROC curves among 2D and 3D ultrasound parameters for the risk of excessive hemorrhage during D&C. The diagnostic efficacy of lesion volume was significantly higher than maximum diameter ($P<.001$). The diagnostic efficacy of VI was significantly higher than maximum diameter ($P=.020$) and RI ($P=.011$).

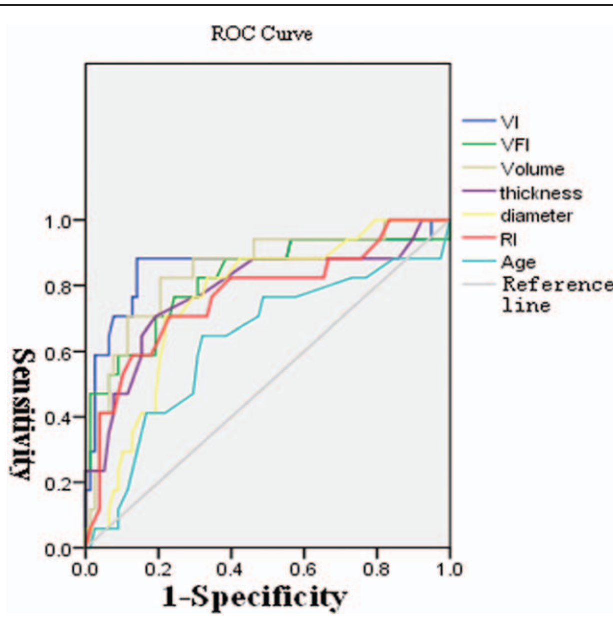


**Figure 4.** The receiver-operating characteristic (ROC) curve illustrates ultrasound parameter values in predicting intraoperative hemorrhage for cesarean scar pregnancy patients who underwent dilatation and curettage.

## 4. Discussion

Ultrasonography is the preferred diagnostic and treatment monitoring meaning for CSP. It can provide information about the size of CSP mass, the thickness of residual muscle, and visualization of blood supply. Three-dimensional (3D) ultrasonography has become currently available in practice. Three-dimensional CPA can appraise the vascularization in the whole lesion. The most important advantage of 3D-CPA is that it can detect even low blood flow without being affected by the angle of ultrasonic. Computer technology makes the assessment more objective. The feasibility and reproducibility of Doppler signal quantification by calculating VI, FI, and VFI were found to be satisfactory in vitro and in vivo.[15] Three-dimensional CPA should be a useful tool to assess the blood circulation of CSP and surrounding tissues.

It has been shown previously that UAE helps to temporarily block uterine perfusion and control bleeding following evacuation of CSP.[7,16–19] The outcomes of this study showed that the VI and the VFI were significantly reduced after pretreatment ($P<.05$). It illustrates that UAE reduces the number of vessels and the blood flow perfusion obviously, but it does not reduce lesion size or intensity of blood flow and does not increase myometrial thickness either, which imply that successful treatment would result in a reduction of the decrease of VI and VFI.

According to the experience of our hospital and other literatures, the cumulative incidence of intraoperative bleeding

**Table 5**

**The comparison of ROC curves among 2D and 3D ultrasound parameters for the risk of excessive hemorrhage during D&C.**

| ROC curves comparison | | 2D ultrasound parameters: Maximum diameter, mm | | Thickness of residual muscle, mm | | RI | |
|---|---|---|---|---|---|---|---|
| | | z | P | z | P | z | P |
| 3D ultrasound parameters | Volume, $cm^3$ | 5.062 | <.001 | 0.925 | .3550 | 1.648 | .099 |
| | VI | 2.327 | .020 | 1.193 | .2329 | 2.556 | .011 |
| | VFI | 1.292 | .196 | 0.449 | .6538 | 1.306 | .192 |

RI = resistance index, ROC = receiver operating characteristic, VFI = vessels and flow index, VI = vascular index.

among patients receiving UAE is very different[6,7,17]; thus, a thorough preoperative assessment is very important.

In this study, we compared multiple indices potentially related to intraoperative hemorrhage in scar pregnancies, the results showed that the bleeding group had larger gestational age and lesion size, thinner uterine scar thickness, and richer peritrophoblastic perfusion. The results were consistent with several previous studies.[8,10,11]

In this study, the thickness of residual myometrium was significantly different between bleeding group and control group. This result suggested that when the implantation of the embryo is shallower, it can be easily removed with little bleeding, and when the embryo is embedded deeper in the scar, it is more difficult to be removed and lead to massive bleeding.

Previous reports estimated that the size of the gestational sac was associated with intraoperative hemorrhage of CSP. In these studies, the lesion size was summarized with the longest diameter or mean diameter.[10,11,20,21] Our findings explored that the lesion volume and maximum diameter were both positively related to the risk of intraoperative massive hemorrhage, and it also explored that since the lower uterine segment is lengthening and thinning by the large lesions, it is difficult to construction and lead to massive bleeding. Further comparison of our study showed that the lesion volume had a better predictive value than the maximum diameter; it may because the volume scans to know the lesion with a 3D shape space, so it is more comprehensive than the diameter.

Previous studies showed that the trophoblasts around scar can invade the myometrium and form peritrophoblastic perfusion.[2,11,21,22] The vessel density and blood perfusion can predict the risk of vascular rupture and bleeding. The limitations of these researches are that the blood flow was assessed qualitatively or semiquantitatively; consequently, the results might be guided by subjective views. VI, FI, VFI, and RI are quantitative hemodynamic predictors. Our data showed that VI, VFI, and RI were positively correlated with massive bleeding during D&C. The VI was the most significant predictor of excessive blood loss, and the AUC of VI was 0.870 at a cut-off value of 7.500. In this study, the predictive value of 3D blood flow indexes VI and VFI was superior to RI in evaluating hemodynamic changes after UAE and predicting hemorrhage during D&C. Analysis indicated that RI only reflects the blood flow in general, while 3D-CPA flow indexes provide a detailed description of the number of vessels and the intensity of blood flow.

The relationship between gestational age and hemorrhoea is still controversial.[10,22] In this research, the gestational age could be used to predict severe intraoperative bleeding, but with a lower predictive value with an AUC of 0.630. It may be supposed that development of chorion is dysplastic and disproportion to the gestational age due to implantation occurs in the cesarean scar.

Our study also had some limitations. First, in some of the patients bleeding prior to D&C, we failed to calculate these hemorrhagic amount; we just focused on the intraoperative hemorrhage. Second, although multiple independent risk factors for excessive hemorrhage were identified, our study did not put forward a practicable and easy-to-use evaluation protocol that could help clinicians to assess and identify patients at a high risk of massive bleeding. Third, because ultrasonic indicators were the keystone of this article, we did not consider the other clinical predictors such as β-HCG.

In summary, UAE decreases the blood vessel mass and the blood flow perfusion obviously. The best marker for prediction of massive intraoperative bleeding during D&C is the VI. Three-dimensional ultrasonography and power Doppler may be helpful in the management of CSP.

## Author contributions

**Conceptualization:** Jie Liu.
**Data curation:** Jie Liu, Yiqing Chai, Yang Yu, Liping Liu.
**Formal analysis:** Jie Liu.
**Investigation:** Jie Liu.
**Methodology:** Jie Liu.
**Project administration:** Jie Liu.
**Software:** Jie Liu.
**Writing – original draft:** Jie Liu.
**Writing – review and editing:** Jie Liu.

## References

[1] Riaz RM, Williams TR, Craig BM, et al. Caesarean scar ectopic pregnancy: imaging features, current treatment options, and clinical outcomes. Abdom Imaging 2015;40:2589–99.
[2] Litwicka K, Greco E. Caesarean scar pregnancy: a review of management options. Curr Opin Obstet Gynecol 2011;23:415–21.
[3] Shi JR, Qin JJ, Wang WM, et al. Clinical study on 57 cases with caesarean scar pregnancy. J Chi Obstet Gynecol 2014;49:18–21.
[4] Moschos E, Sreenarasimhaiah S, Twicker DM. First-trimester diagnosis of cesarean scar ectopic pregnancy. J Clin Ultrasound 2008;36: 504–11.
[5] Timor-Tritsch IE, Khatib N, Monteagudo A, et al. Cesarean scar pregnancies: experience of 60 cases. J Ultrasound Med 2015;34:601–10.
[6] Birch Petersen K, Hoffmann E, Rifbjerg Larsen C, et al. Cesarean scar pregnancy: a systematic review of treatment studies. Fertil Steril 2016;105:958–67.
[7] Li Y, Wang W, Yang T, et al. Incorporating uterine artery embolization in the treatment of cesarean scar pregnancy following diagnostic ultrasonography. Int J Gynaecol Obstet 2016;13:202–7.
[8] Wang JH, Qian ZD, Zhuang YL, et al. Risk factors for intraoperative hemorrhage at evacuation of a cesarean scar pregnancy following uterine artery embolization. Int J Gynaecol Obstet 2013;123:240–3.
[9] Fylstra DL. Ectopic pregnancy within a cesarean scar: a review. Obstet Gynecol Surv 2002;57:537–43.
[10] Ma Y, Shao M, Shao X. Analysis of risk factors for intraoperative hemorrhage of cesarean scar pregnancy. Medicine (Baltimore) 2017;96: e7327.
[11] Wang Q, Ma H, Peng H, et al. Risk factors for intra-operative haemorrhage and bleeding risk scoring system for caesarean scar

pregnancy: a case-control study. Eur J Obstet Gynecol Reprod Biol 2015;195:141–5.
[12] Morel O, Grangé G, Fresson J, et al. Vascularization of the placenta and the sub-placental myometrium: feasibility and reproducibility of a three-dimensional power Doppler ultrasound quantification technique. A pilot study. J Matern Fetal Neonatal Med 2011;24:284–90.
[13] Raine-Fenning NJ, Clewes JS, Kendall NR, et al. The interobserver reliability and validity of volume calculation from three-dimensional ultrasound datasets in the in vitro setting. Ultrasound Obstet Gynecol 2003;21:283–91.
[14] El-Sharkawy M, El-Mazny A, Ramadan W, et al. Three-dimensional ultrasonography and power Doppler for discrimination between benign and malignant endometrium in premenopausal women with abnormal uterine bleeding. BMC Womens Health 2016;16:1–6.
[15] Raine-Fenning NJ, Nordin NM, Ramnarine KV, et al. Determining the relationship between three-dimensional power Doppler data and true blood flow characteristics: an in vitro flow phantom experiment. Ultrasound Obstet Gynecol 2008;32:540–50.
[16] Zhuang Y, Huang L. Uterine artery embolization compared with methotrexate for the management of pregnancy implanted within a cesarean scar. J Obstet Gynecol 2009;201:1–3.
[17] Gao L, Huang Z, Gao J, et al. Uterine artery embolization followed by dilation and curettage within 24 hours compared with systemic methotrexate for cesarean scar pregnancy. Int J Gynaecol Obstet 2014;127:147–51.
[18] Sugawara J, Senoo M, Chisaka H, et al. Successful conservative treatment of a cesarean scar pregnancy with uterine artery embolization. Tohoku J Exp Med 2005;206:261–5.
[19] Yang H, Li S, Ma Z, et al. Therapeutic effects of uterine artery embolisation (UAE) and methotrexate (MTX) conservative therapy used in treatment of cesarean scar pregnancy. Arch Gynecol Obstet 2016;293:819–23.
[20] Li KN, Dai Q, Liu ZZ, et al. Clinical value of ultrasonography in predicting massive hemorrhage during cesarean scar pregnancy. ACTA Acad Med Sin 2015;37:585–90.
[21] Jurkovic D, Knez J, Appiah A, et al. Surgical treatment of cesarean scar ectopic pregnancy: efficacy and safety of ultrasound-guided suction curettage. Ultrasound Obstet Gynecol 2016;47:511–7.
[22] Gui T, Peng P, Liu X, et al. Clinical and ultrasound parameters in prediction of excessive hemorrhage during management of cesarean scar pregnancy. Ther Clin Risk Manag 2017;13:807–12.