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A retrospective analysis of the characteristics of acquired uterine arteriovenous malformations associated with retained products of conception

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ABSTRACT

Objectives: To compare the clinical characteristics and imaging manifestations of retained products of conception (RPOC) with retained products of conception combined with uterine arteriovenous malformation (UAVM-RPOC), to provide a basis for the early identification and clinical treatment of UAVM-RPOC.

Material and methods: A retrospective analysis was conducted on women of reproductive age (89 cases) for retained products of conception. Among the cases, 28 were identified with UAVM-RPOC through ultrasound diagnosis, while 61 were diagnosed with RPOC. The clinical and imaging characteristics of the two groups of women were analyzed, and the treatment methods and prognosis of UAVM-RPOC were also analyzed.

Results: 71.43% women with UAVM-RPOC had a history of two or more previous pregnancies, which was significantly higher than the 45.8% observed in the RPOC group ($p < 0.05$). The median serum level of β-human chorionic gonadotropin (β-HCG) was 128.7

(16.32–977) mIU/mL. The median time for detecting RPOC in women was 23 days, while the median time to diagnose UAVM-RPOC was 39.5 days. In transvaginal sonography (TVS), 92.86% of women with UAVM-RPOC exhibited low-resistance (RI < 0.5) ultrasound manifestations of the lesion, which was significantly higher than that in the RPOC group (32.79%), $p < 0.0001$. The contrast-enhanced ultrasound (CEUS) features of UAVM-RPOC were characterized by early-stage lesions showing rapid enhancement, which was followed by a late-stage delay in the washout of the contrast agent compared to the myometrium, leading to sustained enhancement. Out of 28 cases, only one woman underwent hysteroscopic surgery following pre-treatment with uterine artery embolization; the remaining female did not receive pre-treatment, and the surgical success rate for all women was 100%.

Conclusions: Our study revealed the clinical and imaging characteristics of UAVM-RPOC. Transvaginal ultrasound is the preferred examination for diagnosing UAVM-RPOC, but for cases with rich local blood flow signals, further refinement with CEUS examination can be beneficial. The combined examination can better assess the depth of muscle layer infiltration of the lesion, further evaluate the risk level of UAVM-RPOC, and guide clinical treatment.

Keywords: UAVM-RPOC; CEUS; PROC

INTRODUCTION

Uterine arteriovenous malformation (UAVM) is a rare condition that can occur after abortion and is defined as acquired abnormal connections between arteries and veins [1–3]. Based on etiology, UAVM can be categorized into two types. Congenital UAVM, which is mostly caused by developmental abnormalities of the primitive vascular endothelium during the embryonic period, is extremely rare in clinical settings. Acquired UAVM is more common and refers to vascular malformations caused by postnatal factors. It is generally believed that trauma (abortion, surgery, childbirth, curettage), infection, and tumors are important etiological factors. The primary pathological alteration involves the presence of small arteriovenous fistulas between the branches of traumatized arteries and the veins within the myometrium. Due to the lesion's highly vascular characteristic, it poses a life-threatening condition that could potentially lead to massive genital hemorrhage. Females with acquired

uterine arteriovenous malformations associated with retained products of conception (UAVM-RPOC) may be at a high risk of bleeding; consequently, the management modality should be carefully chosen [4].

Retained products of conception (RPOC) often cause postabortion or postpartum hemorrhage [5–6]. Transvaginal ultrasonography (TVS) is characterized by being non-invasive and convenient, making it the primary method for post-abortion follow-up and also the main method for diagnosing UAVM-RPOC. In cases of UAVM-RPOC, the mass appears as mildly echogenic tissue interspersed with multiple hypoechogenic spaces of varying sizes along with a tangle of tortuous vessels exhibiting multidirectional, high-velocity, and turbulent flow. Although transvaginal ultrasound (TVS) is the preferred screening method for UAVM-RPOC, when suspicious UAVM is detected by TVS, it is necessary to differentiate it from intrauterine retention, placenta accreta, trophoblastic tumors, and malignant endometrial tumors. In nearly 20% of cases, RPOC were accompanied by abnormal hypervascularity and doppler ultrasound findings manifested as enhanced endometrial/myometrial vascularity with high systolic velocity [7]. These nonspecific imaging features contribute to the overdiagnosis of uterine arteriovenous malformations [8]. Thus, some investigators recommended the diagnosing of acquired uterine arteriovenous malformations associated with retained products of conception (UAVM-RPOC) for these women to distinguish them from other UAVMs [4]. Digital subtraction angiography (DSA) is the gold standard for diagnosing uterine arteriovenous malformations (UAVMs). Although this invasive procedure can simultaneously complete diagnosis and embolization, there is still debate on whether it will affect women's long-term fertility [9–11]. From a purely diagnostic perspective, the practicality of DSA for diagnosis is not high. Studies have shown that UAVMs may recur after embolization, and there is a possibility of lesion expansion [12]. The UAVM-RPOC predominantly occurs in women of reproductive age. Most women have mild symptoms, and there are fewer cases of severe bleeding that require emergency treatment [13]. Therefore, except for cases where massive hemorrhage necessitates urgent intervention, the number of women requiring embolization treatment is low [14]. Additionally, embolization has been associated with premature ovarian failure and infertility, which is not conducive to preserving women's

fertility. Therefore, many studies do not support the routine use of DSA for all patients with abnormal blood flow detected by ultrasound [15].

Contrast-enhanced ultrasound (CEUS) is an advanced diagnostic imaging technique that uses microbubble contrast agents to improve the visualization of blood vessels and tissues during an ultrasound examination. This method enhances the ultrasound images by providing more detailed information about blood flow and the vascularity of tissues, which can be particularly useful for the detection and characterization of various conditions, including tumors, inflammation, and vascular abnormalities. The CEUS is widely applied in various medical fields, including imaging of the liver, kidney, and thyroid, and serves as a valuable tool in both diagnostic and interventional radiology [16]. In principle, compared to TVS, CEUS can more clearly display the extent of myometrial involvement in uterine arteriovenous fistulas. By observing the characteristics of contrast agent perfusion and washout under CEUS, it offers significant clinical guidance for diagnosing the disease and assessing the activity of the villi. Therefore, CEUS holds the potential to emerge as a novel diagnostic method for UAVM [17, 18]. This study summarized the characteristics of UAVM-RPOC and reported its imaging characteristics of contrast-enhanced ultrasound. It provides a scientific basis for the subsequent diagnosis of UAVM-RPOC using contrast-enhanced ultrasound.

MATERIAL AND METHODS

Study design

We conducted a retrospective study from January 2018 to December 2023 at our Hospital in China. The study was approved by the Ethics Committee of our Hospital (ITT2024-068-002). The ethics committee approved, and informed consent was waived.

Subjects

We collected the medical data of individuals from reproductive age who visited our hospital for retained products of conception.

The inclusion criteria were as follows: (1) a history of pregnancy termination within the past 3 months with β-HCG levels > 5 mIU/mL; (2) Confirmation by ultrasound of RPOC or UAVM-RPOC. The obtained ultrasound images were assessed, and the ultrasound diagnosis

was determined by two senior sonographers. Cases with incomplete medical records were excluded. Finally, the RPOC group consisted of 61 women, while the UAVM-RPOC group had 28 women (Fig. 1).

Subjects' characteristics were recorded, including age, causes of retained products of conception, marital and childbirth history, history of cesarean section, prior hysteroscopy or dilation and curettage, clinical manifestations, surgical methods, and intraoperative bleeding. All subjects were retrieved from the ultrasound database to obtain information on the lesion's location, size, blood flow velocity, flow resistance, and typical imaging characteristics. Serum levels of β-HCG were tested at the time of the RPOC/UAVM-RPOC diagnosis.

Diagnosis of RPOC/ UAVM-RPOC

RPOC was indicated in cases with a history of miscarriage within the past 90 days, accompanied by β-HCG levels > 5 mIU/ml. Additionally, the ultrasound examination should meet the following criteria: the presence of uneven endometrial echoes, thickening, or irregular masses within the uterine cavity. Correlatively, in cases with UAVM-RPOC, these masses appear as mildly echogenic tissue interspersed with multiple hypoechogenic spaces of varying sizes, along with a tangle of tortuous vessels exhibiting multidirectional, high-velocity, and turbulent flow (Fig. 2A).

Contrast-enhanced ultrasound

Fourteen women with RPOC underwent further CEUS examinations due to low RI values. Eighteen women with UAVM-RPOC also underwent CEUS examinations. The CEUS was performed using an ultrasound system with a 7.5 MHz intracavitary linear transducer. The contrast agent SonoVue (Bracco SpA, Milan, Italy) was used in the CEUS scan. Multiplane scanning was used to show all features accurately. The following ultrasound planes were chosen for CEUS targeted sections: those with the richest blood supply, or, if no lesions with abundant blood were present, those with the most irregular shape. At this point, the SonoVue contrast agent was injected through the elbow vein. After 4.8 mL of the contrast agent was injected, followed by 5 mL of saline flush with an intravenous cannula, the CEUS scan began

immediately. Real-time side-by-side loops were stored for up to 180 seconds for further analysis. The observation indicators include enhancement time, enhancement level, and the characteristics of contrast agent distribution, all of which are referenced against the uterine muscle layer. The start of enhancement time was defined as the time when the contrast agent began to perfuse and appear within the lesion area after the injection of the contrast agent. If the enhancement appeared earlier than the perfusion of the uterine muscle layer, it was considered “fast in”; if it appeared synchronously with the uterine muscle layer, it was considered synchronous enhancement; and if it appeared later than the perfusion of the uterine muscle layer, it was considered “slow in” enhancement. The enhancement level was characterized as high enhancement when the perfusion imaging of the contrast agent in the observation area was stronger than the uterine muscle layer, as equal enhancement when it was equivalent to the uterine muscle layer, as low enhancement when it was weaker than the uterine muscle layer, and as no enhancement when there was no perfusion imaging. Due to the different tissue structures within the observation area, the distribution of contrast agent perfusion was also different, manifesting as uniform and non-uniform distribution. The ultrasound contrast appearance of UAVM-RPOC was recorded and described.

Statistical analysis

IBM SPSS (version 23.0) statistical software was used for the analysis. Continuous variables, such as lesion size, were represented by the mean ± standard deviation ($x \pm s$), while categorical variables, including obstetric history, history of uterine surgery, etiology, and clinical manifestations, were presented as frequencies and percentages. Statistical analysis was conducted using the Student's t-test for continuous variables, the chi-squared (χ^2) test for categorical variables, and Fisher's exact test for categorical variables with sample sizes where $n < 5$. A p-value of less than 0.05 was considered to indicate statistically significant differences.

RESULTS

General characteristics of the subjects

Characteristics of the study population are summarized in Table 1. The average age of the 89 females was 32.98 ± 4.76 years. Among the women in the study, 28.09% (25 out of 89) had experienced at least three pregnancies, while 40.45% (36 out of 89) had never given birth. A total of 28 women (31.46%) had a history of two miscarriages, and 6 women (6.74%) had suffered three or more miscarriages. Additionally, 20.22% (18 out of 89) of these females had a history of cesarean section.

Inducement of RPOC/UAVM-RPOC

The causes of retained products of conception are shown in Table 1. A 50.56% (45 out of 89) of the females underwent induced abortion, 46.07% (41 out of 89) had a medical abortion, 2.25% (2 out of 89) experienced mid-trimester induction, and 1.12% (1 out of 89) had a spontaneous abortion. The median blood β-HCG level was 128.7 (16.32–977) mIU/mL, and the median time from miscarriage to the detection of residual products of conception was 30 (17–48.75) days. 46.07% (41 out of 89) of the females had residual lesion sizes of 25 mm or greater. Based on the ultrasound imaging and findings during hysteroscopy, 32 cases of retained products of conception were located in the cornual region, 12 cases were in the fundus, 29 cases were in the posterior wall of the uterus, 16 cases were in the anterior wall of the uterus, and 1 case was at the site of a previous cesarean section scar. Among these women, 28 women (31.46%) had UAVM.

Comparison of clinical characteristics between RPOC and UAVM-RPOC

A comparison of the clinical characteristics between the RPOC and UAVM-RPOC groups of females is shown in Table 2. The mean age of females in the UAVM-RPOC group was 32.07 ± 4.29 years, and for the RPOC group, it was 33.3 ± 4.86 years. There was no statistically significant difference between the two groups. In the UAVM-RPOC group, 71.43% of females had a history of two or more pregnancies, which was significantly higher than the 45.8% observed in the RPOC group. The difference between the two groups was statistically significant, $p = 0.0385$. Comparing prior uterine surgical interventions, 42.86% of women in the UAVM-RPOC group had undergone two or more previous induced abortions, which was a

higher proportion than the 32.79% (20 out of 61) observed in the RPOC group, though this difference was not statistically significant ($p > 0.05$). Moreover, approximately 25% (7 out of 28) of the women in the UAVM-RPOC group had a history of cesarean section, exceeding the 14.75% found in the RPOC group.

Analyzing the contributing factors to RPOC/UAVM-RPOC, no significant disparities were found between the two groups regarding surgical interventions leading to residual products of conception, the timing from the most recent miscarriage to the diagnosis of these residuals, β-HCG levels, or the size of the residual products of conception lesion. The median time for detecting RPOC in women was 23 days, while the median time to diagnose UAVM-RPOC was 39.5 days. It was worth noting that there was a significant difference in the RI (resistive index) values in ultrasound findings between the two groups of women, with 92.86% of women in the UAVM-RPOC group having an RI value less than 0.5, which was significantly higher than that in the RPOC group (32.79%). There was a significant statistical difference between the two groups ($p < 0.0001$).

In the CEUS manifestations of the two groups, women in the UAVM-RPOC group showed early-stage lesions with high enhancement and late-stage contrast agent washout that was delayed compared to the myometrium, showing persistent enhancement (Fig. 2B–C). In contrast, in the RPOC group, the contrast agent showed “fast in” enhancement, and in the late enhancement stage, the washout speed of the contrast agent was synchronized with the myometrium.

Clinical characteristics and management of UAVM-RPOC women

Clinical characteristics and management of women with UAVM-RPOC are shown in Table 3. 75% (21/28) of the women were aged less than 35 years, 71.43% had a history of more than two pregnancies, 46.43% (13/28) had a history of induced abortion surgery, and 25% had a history of cesarean section surgery.

Among the causes attributed to UAVM-RPOC, 13 cases occurred following induced abortions, 13 were after medical abortions, and 2 were the result of mid-trimester inductions. The median size of the residual lesion was 24.5 mm (18.25 ~ 30.75). In the clinical

manifestations of these women, 5 women presented with heavy vaginal bleeding, while 20 women only had light vaginal bleeding, and another 3 women were asymptomatic, with none of the women experiencing pelvic pain symptoms. In the treatment of these 28 women, 1 opted for hysteroscopic surgery following uterine artery embolization, 23 selected direct hysteroscopic surgery, 3 underwent dilation and curettage under ultrasound guidance, and 1 received conservative treatment with medication. Notably, none of the 28 women experienced significant bleeding during their surgical procedures.

DISCUSSION

Uterine arteriovenous malformation presents diverse clinical manifestations; some patients are asymptomatic, while others may exhibit a range of symptoms or a combination of them, such as lower abdominal pain, anemia, vaginal bleeding, or even heavy vaginal bleeding. In this study, we found that most women had mild clinical manifestations, and those with the typical “on-off” bleeding pattern were not common. Most women only exhibited light vaginal bleeding or had no obvious symptoms. This finding was consistent with the results of several previous studies [19–21]. Compared to women with RPOC, this study found that UAVM-RPOC was more likely to occur in women with a history of multiple pregnancies, especially those with a pregnancy history of two or more times, and the incidence of UAVM-RPOC was increased in women with a history of scar pregnancy, which was consistent with previous findings [22, 23]. This study found that the median time to detect residual products of conception in the RPOC group was 23 days, while for women with UAVM-RPOC, the median time to detect UAVM was 39.5 days. Although this study did not establish a direct link between the time from the last miscarriage to the first ultrasound examination and the risk of UAVM, it is noteworthy that Bazeries et al. [24] observed that the five cases of UAVF they reported were not treated until more than 3 months after the end of pregnancy. Similarly, Goya et al. [25] reported a case where UAVF was identified in trophoblastic tissue 6 months following a miscarriage. These findings suggest that a delay in the management of residual products of conception after miscarriage might be associated with an increased risk of UAVM. Consequently, early and active management of residual products of conception could

potentially prevent the development of UAVM in women who have experienced a miscarriage.

Transvaginal ultrasound is recommended as the first-line diagnostic method for pregnancy-related UAVMs. This study found that, compared to RPOC, the RI values in women with UAVM-RPOC were significantly lower than those in the RPOC group, with 92.86% of women having an RI less than 0.5. For women with abundant local blood flow signals and an RI less than 0.5, CEUS was performed. By comparing the CEUS imaging characteristics of blood-rich RPOC and UAVM-RPOC, this study, for the first time, demonstrated the CEUS presentation of UAVM-RPOC and summarized the characteristics of CEUS imaging for UAVM-RPOC. The study found that in women with UAVM-RPOC, the lesions showed high enhancement in the early phase and the contrast agent washout was later than the myometrium in the late phase, showing persistent enhancement, and the lesions presented with blood flow signals of high velocity and low resistance. In contrast, in women of the RPOC group, the contrast agent showed rapid heterogeneous high enhancement, and in the late phase of enhancement, the washout speed of the contrast agent was synchronized with the myometrium. This feature will help differentiate UAVM-RPOC, prevent overdiagnosis of UAVM-RPOC using ultrasound alone, and reduce the application of the invasive procedure of digital subtraction angiography (DSA). Among patients diagnosed with UAVM by TVS, a high proportion were secondary to pregnancy or pregnancy-related diseases, and the patients were mostly young women with fertility needs. Therefore, overdiagnosis and overtreatment should be avoided to reduce the fertility and economic burden on the patients, as well as to minimize the threat of potential sudden bleeding to their life safety. We tend to further conduct CEUS examinations for women with a history of multiple pregnancies and special ultrasound manifestations, with an RI less than 0.5, to gain more information about the lesions.

A positive β-HCG is associated with active villous tissue, which erodes the vascular wall, leading to the formation of arteriovenous malformations [26]. It is suggested that residual products of conception are key to the formation of pregnancy-related UAVMs, so managing these residuals is crucial for treatment [11, 19]. In this study, only one case underwent pre-

treatment with DSA before hysteroscopic surgery. Twenty-three cases selected direct hysteroscopic surgery, three cases opted for ultrasound-guided curettage, and one case received conservative treatment with medication. All patients had intraoperative bleeding of less than 20 mL. In this study, the female patients with UAVM-RPOC had lesions located in the uterine cavity or in the part of the myometrium close to the endometrium, which were relatively limited. Hysteroscopic surgery could remove the residual products of conception and also resect the lesions located in the superficial myometrium. For the very few cases with extensive lesions that penetrate the myometrium or invade surrounding tissues, hysteroscopic surgery is not suitable. This study did not involve UAVM lesions with extensive penetration into the myometrium; therefore, intraoperative hysteroscopic surgery or ultrasound-guided curettage can quickly and completely remove residual products of conception.

CONCLUSIONS

In summary, for the preliminary diagnosis of UAVM-RPOC, TVS is easy to operate and can be used as the first choice. For women with abundant local blood flow signals and difficult differentiation, CEUS examination can still be further improved. The combination of TVS and CEUS can improve the assessment of the depth of myometrial infiltration in UAVM-RPOC, further evaluate the risk level of UAVM-RPOC, and help to make clinical treatment plans.

Limitations of the study

There were also several limitations in this current study. This was a retrospective study, there was some bias in the condition of the two groups. A prospective randomized controlled study in the future is suggested. Additionally, due to the small number of subjects, it is difficult to evaluate the diagnostic value of CEUS. Therefore, further prospective, large-sample, multicenter clinical studies are needed for validation.

Article information and declarations

Data availability statement

Not applicable.

Ethical statement

This study has been approved by the Ethics Committee of Beijing Shijitan Hospital, and its number is 2024–068. The study was approved by the ethics committee with a waiver of informed consent.

Author contributions

Yu Sun is responsible for study design and writing manuscript. Min Yang is responsible for check results of TVS and CEUS. Wenpei Bai was responsible for patient recruitment and study design.

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Conflict of interest

The authors declare that they have no conflicts of interest and nothing to disclose.

Supplementary material

None.

Conflict of interest

All participants provided consent for their participation in the study and for the use of their anonymized data and images for publication purposes.

REFERENCES

1. Yazawa H, Soeda S, Hiraiwa T, et al. Prospective evaluation of the incidence of uterine vascular malformations developing after abortion or delivery. J Minim Invasive Gynecol. 2013; 20(3): 360–367, doi: 10.1016/j.jmig.2012.12.008, indexed in Pubmed: 23352580.
2. Hugues C, Le Bras Y, Coatleven F, et al. Vascular uterine abnormalities: Comparison of imaging findings and clinical outcomes. Eur J Radiol. 2015; 84(12): 2485–2491, doi: 10.1016/j.ejrad.2015.10.005, indexed in Pubmed: 26476825.

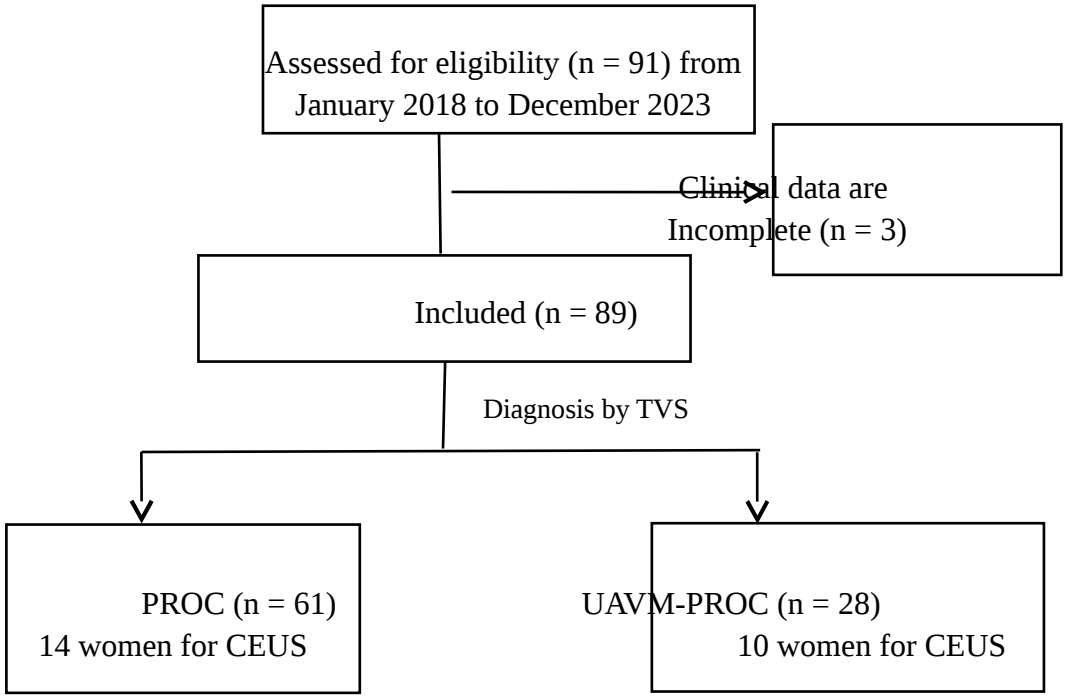
3. Vandenbroucke L, Morcel K, Bruneau B, et al. Acquired uterine arteriovenous malformations. Gynecol Obstet Fertil. 2011; 39(7-8): 469–472, doi: 10.1016/j.gyobfe.2011.05.008, indexed in Pubmed: 21752685.
4. Timor-Tritsch IE, Haynes MC, Monteagudo A, et al. Ultrasound diagnosis and management of acquired uterine enhanced myometrial vascularity/arteriovenous malformations. Am J Obstet Gynecol. 2016; 214(6): 731.e1–731.e10, doi: 10.1016/j.ajog.2015.12.024, indexed in Pubmed: 26873276.
5. Hoveyda F, MacKenzie IZ. Secondary postpartum haemorrhage: incidence, morbidity and current management. BJOG. 2001; 108(9): 927–930, doi: 10.1111/j.1471-0528.2001.00230.x, indexed in Pubmed: 11563461.
6. Takahashi H, Ohhashi M, Baba Y, et al. Conservative management of retained products of conception in the normal placental position: A retrospective observational study. Eur J Obstet Gynecol Reprod Biol. 2019; 240: 87–92, doi: 10.1016/j.ejogrb.2019.06.016, indexed in Pubmed: 31238204.
7. Hoang VT, Van HA, Trinh CT, et al. Uterine arteriovenous malformation: a pictorial review of diagnosis and management. J Endovasc Ther. 2021; 28(5): 659–675, doi: 10.1177/15266028211025022, indexed in Pubmed: 34142901.
8. Müngen E. Vascular abnormalities of the uterus: have we recently over-diagnosed them? Ultrasound Obstet Gynecol. 2003; 21(6): 529–531, doi: 10.1002/uog.163, indexed in Pubmed: 12808667.
9. Capmas P, Levaillant JM, Teig B, et al. Uterine arteriovenous malformation involving the whole myometrium. Ultrasound Obstet Gynecol. 2013; 41(6): 715–717, doi: 10.1002/uog.12432, indexed in Pubmed: 23404809.
10. Ghai S, Rajan DK, Asch MR, et al. Efficacy of embolization in traumatic uterine vascular malformations. J Vasc Interv Radiol. 2003; 14(11): 1401–1408, doi: 10.1097/01.rvi.0000096761.74047.7d, indexed in Pubmed: 14605105.
11. Delplanque S, Le Lous M, Proisy M, et al. Fertility, pregnancy, and clinical outcomes after uterine arteriovenous malformation management. J Minim Invasive Gynecol.

2019; 26(1): 153–161, doi: 10.1016/j.jmig.2018.05.001, indexed in Pubmed: 29772406.

12. Ruiz Labarta FJ, Pintado Recarte MP, González Leyte M, et al. Uterine artery embolization of uterine arteriovenous malformation: a systematic review of success rate, complications, and posterior pregnancy outcomes. J Pers Med. 2022; 12(7), doi: 10.3390/jpm12071098, indexed in Pubmed: 35887595.
13. Gilbert A, Thubert T, Dochez V, et al. Angiographic findings and outcomes after embolization of patients with suspected postabortion uterine arteriovenous fistula. J Gynecol Obstet Hum Reprod. 2021; 50(7): 102033, doi: 10.1016/j.jogoh.2020.102033, indexed in Pubmed: 33301980.
14. Shim DaJ, Choi SJ, Jung JiM, et al. Uterine arteriovenous malformation with repeated vaginal bleeding after dilatation and curettage. Obstet Gynecol Sci. 2019; 62(2): 142–145, doi: 10.5468/ogs.2019.62.2.142, indexed in Pubmed: 30918884.
15. O'Donnell JM, Al-Shahi Salman R, Manuguerra M, et al. Quality of life and disability 12 months after surgery vs. conservative management for unruptured brain arteriovenous malformations: Scottish population-based and Australian hospital-based studies. Acta Neurochir (Wien). 2018; 160(3): 559–566, doi: 10.1007/s00701-017-3451-2, indexed in Pubmed: 29327142.
16. Dietrich CF, Nolsøe CP, Barr RG, et al. Guidelines and good clinical practice recommendations for contrast-enhanced ultrasound (CEUS) in the liver-update 2020 WFUMB in cooperation with EFSUMB, AFSUMB, AIUM, and FLAUS. Ultrasound Med Biol. 2020; 46(10): 2579–2604, doi: 10.1016/j.ultrasmedbio.2020.04.030, indexed in Pubmed: 32713788.
17. Stoelinga B, Juffermans L, Dooper A, et al. Contrast-Enhanced ultrasound imaging of uterine disorders: a systematic review. Ultrason Imaging. 2021; 43(5): 239–252, doi: 10.1177/01617346211017462, indexed in Pubmed: 34036872.
18. Woo J, Kahn B. Enhanced myometrial vascularity: case presentation and review. Fertil Steril. 2021; 116(3): 912–914, doi: 10.1016/j.fertnstert.2021.05.097, indexed in Pubmed: 34217488.

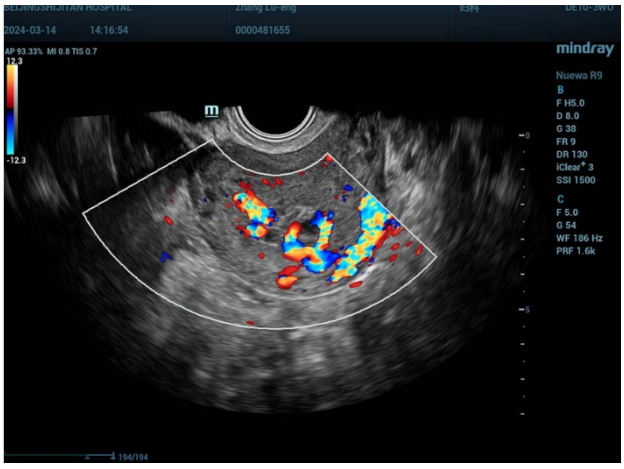
19. Zhang W, Cui S, Mao Z, et al. Effect of direct surgical treatment in pregnancy-related uterine arteriovenous malformation. BMC Pregnancy Childbirth. 2023; 23(1): 673, doi: 10.1186/s12884-023-05961-3, indexed in Pubmed: 37726661.
20. Gao F, Ma X, Xu Y, et al. Management of acquired uterine arteriovenous malformations associated with retained products of conception. J Vasc Interv Radiol. 2022; 33(5): 547–553, doi: 10.1016/j.jvir.2022.01.004, indexed in Pubmed: 35093540.
21. Shim DaJ, Choi SJ, Jung JiM, et al. Uterine arteriovenous malformation with repeated vaginal bleeding after dilatation and curettage. Obstet Gynecol Sci. 2019; 62(2): 142–145, doi: 10.5468/ogs.2019.62.2.142, indexed in Pubmed: 30918884.
22. Gao F, Ma X, Xu Y, et al. Management of acquired uterine arteriovenous malformations associated with retained products of conception. J Vasc Interv Radiol. 2022; 33(5): 547–553, doi: 10.1016/j.jvir.2022.01.004, indexed in Pubmed: 35093540.
23. Nakashololo T, Khan N, Dunn Z, et al. Uterine arteriovenous malformations, clinical and radiological considerations: A report of two cases. Radiol Case Rep. 2021; 16(7): 1924–1929, doi: 10.1016/j.radcr.2021.02.018, indexed in Pubmed: 34149976.
24. Bazeries P, Paisant-Thouveny F, Yahya S, et al. Uterine artery embolization for retained products of conception with marked vascularity: a safe and efficient first-line treatment. Cardiovasc Intervent Radiol. 2017; 40(4): 520–529, doi: 10.1007/s00270-016-1543-7, indexed in Pubmed: 28004170.
25. Goyal S, Goyal A, Mahajan S, et al. Acquired uterine arteriovenous malformation developing in retained products of conception: a diagnostic dilemma. J Obstet Gynaecol Res. 2014; 40(1): 271–274, doi: 10.1111/jog.12139, indexed in Pubmed: 24033740.
26. Sahoo B, Jena SK, Mishra SK, et al. Uterine arteriovenous malformation with raised serum beta-human chorionic gonadotropin (β-hCG) levels: a diagnostic and therapeutic dilemma. Cureus. 2024; 16(7): e64209, doi: 10.7759/cureus.64209, indexed in Pubmed: 39130918.

Figure 1. A flow chat of enrollment



PROC — retained products of conception with no UAVM; UAVM-RPOC — uterine arteriovenous malformation associated with retained products of conception; CEUS — contrast-enhanced ultrasound

Figure 2. Image of uterine arteriovenous malformation associated with retained products of conception (UAVM-RPOC); **A.** transvaginal ultrasonography image of UAVM-RPOC; **B.** contrast-enhanced ultrasound image of UAVM-RPOC (the stage of start enhancement) (the stage of start enhancement — early-stage lesions with rapid and high enhancement); **C.** contrast-enhanced ultrasound image of UAVM-RPOC (the stage of final enhancement) (the stage of final enhancement — in the late enhancement stage, the washout speed of the contrast agent was synchronized with the myometrium and showed persistent enhancement)



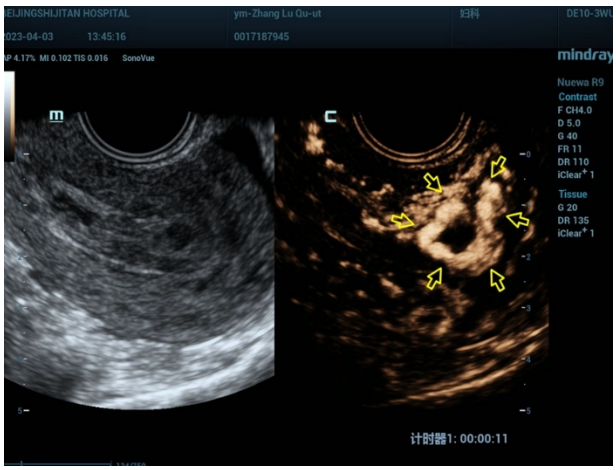


Table 1. Clinical characters of patients with incomplete abortion

Patients characteristics	**Case number（n, %）**
Age (year)	
< 35	63 (70.79%)
≥ 35	26 (29.21%)
Reproductive history	
Number of pregnancy	
< 3	64 (71.91%)
≥ 3	25 (28.09%)
Number of bearing birth	
0	36 (40.45%)
1	39 (43.82%)
2	12 (13.48%)
≥ 3	2 (2.25%)
Number of abortion	
0	40 (44.94%)
1	18 (20.22%)
2	25 (28.09%)
≥ 3	6 (6.74%)
Operation history	
Caesarean section	18 (20.22%)
Uterine curettage	41(46.07%)
Manual placenta extraction	1 (1.12%)
Drug abortion	11(12.36%)
Mid-term induction of labor	3 (3.37%)
Hysteroscopic surgery	2 (2.25%)
Inducement	
Uterine curettage	45 (50.56%)
Drug abortion	41 (46.07%)
Spontaneous abortion	1 (1.12%)
Mid-term induction of labor	2 (2.25%)
Time to diagnosis of RPOC after delivery or abortion [d]	30(17–48.75)
Lesion size [cm]	
≤ 2.5	48 (53.93%)
> 2.5	41(46.07%)
β-HCG [mIU/mL]	128.7 (16.32–977)
Embryo residue in the uterus	
Uterine horn	32
Fundus uterus	12
Posterior wall of uterus	29

Anterior wall of uterus	16
Caesarean section scar	1
UAVM-RPOC	28 (31.46%)

Data are expressed as the median (range) or n (%); CS — cesarean section; UAVM-RPOC — uterine arteriovenous malformation associated with retained products of conception; β-HCG — beta-human chorionic gonadotropin

Table 2. Factors between retained products of conception (RPOC) group and retained products of conception combined with uterine arteriovenous malformation (UAVM-RPOC) group

Clinical factor	UAVM-RPOC group (28 cases)	RPOC group (61 cases)	p
Age [year]	32.07 ± 4.29	33.3 ± 4.86	0.25
Reproductive history			
Number of pregnancy			0.0385
< 2	8 (28.57%)	33 (54.10%)	
≥2	20 (71.43%)	28 (45.90%)	
Number of bearing birth			0.491
< 2	26 (92.86%)	52 (85.25%)	
≥ 2	2 (7.14%)	9 (14.75%)	
Number of abortion			0.813
< 2	18 (64.29%)	41 (67.21%)	
≥ 2	10 (35.71%)	20 (32.79%)	
Operation history			
Number of abortion			0.43
< 2	16 (57.14%)	41 (67.21%)	
≥ 2	12 (42.86%)	20 (32.79%)	
Caesarean history	7 (25%)	9 (14.75%)	0.251
Inducement			
Uterine curettage	13 (46.43%)	33 (54.10%)	0.526
Drug abortion	13 (46.43%)	25 (40.98%)	1
Spontaneous abortion	0	1 (1.64%)	
Embryo termination	4 (14.29%)	13 (21.31%)	0.566
Mid-term induction of labor	2 (7.14%)	0	
Time to diagnosis of UAVM-RPOC after delivery or abortion [d]	39.5 (22.5 ~ 48.5)	23(16 ~ 45)	0.09
β-HCG [mIU/mL]	116.2(9 ~ 591)	165(17.5 ~ 1361)	0.17
Lesion size [mm]	26.80 ± 12.46	26 ± 12.32	0.78
RI			< 0.0001
< 0.5	26 (92.86%)	20 (32.79%)	
≥ 0.5	2 (7.14%)	41 (67.21%)	

Enhanced ultrasonic characteristics		
The stage of start enhancement	Early enhancement and high enhancement	Equal enhancement
The stage of final enhancement	The resolution was later than that of the myometrium and showed continuous enhancement	The regression rate is synchronized with the myometrium

Data are expressed as the median (range) or n (%); CS — cesarean section; D&C — dilation and curettage; β-HCG — beta-human chorionic gonadotropin; UAVM-RPOC — uterine arteriovenous malformation associated with retained products of conception; RI — resistance index

Table 3. Clinical characters of patients with UAVM-RPOC

Patients characteristics	**Case number**
Age [year]	
< 35	21 (75%)
≥ 35	7 (25%)
Reproductive history	
Number of pregnancy	
< 2	8 (28.57%)
≥ 2	20 (71.43%)
Number of bearing birth	
0	10 (35.71%)
1	13 (46.43%)
2	5 (17.86%)
Number of abortion	
0	12 (42.86%)
1	8 (28.57%)
2	7 (25%)
≥ 3	1 (3.57%)
Operation history	
Caesarean section	7 (25%)
Uterine curettage	13 (46.43%)
Manual placenta extraction	1 (3.57%)
Drug abortion	4 (14.29%)
Mid-term induction of labor	1 (3.57%)
Hysteroscopic surgery	1 (3.57%)
Inducement	
Uterine curettage	13 (46.43%)
Drug abortion	13 (46.43%)
Mid-term induction of labor	2 (7.14%)
Lesion size (cm)	

≤ 2.5	14 (50%)
> 2.5	14 (50%)
CEUS characteristics	
The stage of start enhancement	Fast in and high enhancement
The stage of final enhancement	Slow in and showed continuous enhancement
Clinical symptoms	
Vaginal bleeding	
Massive vaginal bleeding	5 (17.86%)
Minor vaginal bleeding	20 (71.43%)
Pelvic pain	0
Asymptomatic	3 (10.71%)
Treatment method	
Hysteroscope	24 (85.71%)
Ultrasound guided dilation and curettage	3 (10.71%)
Medicine	1 (3.57%)

Data are expressed as the median (range) or n (%); β-HCG — beta-human chorionic gonadotropin; CEUS — contrast-enhanced ultrasound; UAVM-RPOC — uterine arteriovenous malformation associated with retained products of conception