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# Angiographic Classification of Vascularized Retained Products of Conception and Uterine Artery Embolization Outcomes: A Single-Center Study of 106 Patients

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**Research Article**

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# Abstract

**Purpose:** To propose a novel 4-stage angiographic classification of highly vascularized retained products of conception (hvRPOC) and to evaluate the clinical efficacy, safety, and predictive value of proximal uterine artery embolization (UAE) with gelatin sponge (GS) torpedoes.

**Materials and Methods:** This retrospective single-center study included 106 consecutive women who underwent proximal UAE with GS torpedoes for haemorrhagic hvRPOC at Grenoble Alpes University Hospital between November 2017 and September 2024. Patients with arteriovenous malformations (AVMs) and non-vascularized RPOC were excluded. A 4-stage angiographic classification was applied: Stage 0 (normal arteriography), Stage 1 (localized arterial blush), Stage 2 (blush with hypertrophic transmyometrial vessels and/or hypertrophic uterine artery), and Stage 3 (Stage 2 features plus early venous return). The primary endpoint was clinical success (cessation of bleeding at 4–6 weeks). Secondary endpoints included imaging success, safety (CIRSE classification), agreement between angiographic and MRI-based staging and predictive factors of failure.

**Results:** Clinical success was achieved in 95 patients (89.6%) at 4–6 weeks and in 96 patients (91%) at 3 months. Imaging success (disappearance of RPOC at W4-W6) was achieved in 55 patients (53%) at first follow-up and in 78 patients (82%) at 3 months. No major or moderate complications (CIRSE Grades 2–6) occurred; minor complications (CIRSE Grade 1) were reported in 40 patients (37.5%). Angiographic stage was significantly associated with complete RPOC disappearance at 4–6 weeks ($p = 0.004$). MRI-based staging showed good agreement with angiographic staging in 21 patients ($\kappa = 0.77$).

**Conclusion:** Proximal UAE with GS torpedoes is safe and effective for haemorrhagic hvRPOC. The proposed 4-stage angiographic classification correlates with imaging response and, when estimated via MRI, may support non-invasive pre-procedural patient stratification or combined approaches.


# Key Points

• Proximal uterine artery embolization (UAE) with gelatine sponge torpedoes is safe and effective for haemorrhagic highly vascularized retained products of conception (hvRPOC), achieving clinical success in 91% of patients at 3 months with no major complications.

• A novel 4-stage angiographic classification of hvRPOC correlates significantly with complete RPOC disappearance after embolization ($p = 0.004$), demonstrating its potential value as a prognostic tool.

• MRI-based staging shows good agreement with angiographic staging ($\kappa = 0.77$), supporting its role as a non-invasive pre-procedural stratification tool to identify patients who may be managed conservatively or by a planned combined approach.

# Introduction

Retained products of conception (RPOC) are among the most common causes of secondary haemorrhage after abortion, miscarriage, or delivery, occurring in approximately 1% of all pregnancies and in up to 15% of cases following pregnancy termination. (1, 2) Diagnosis relies primarily on transabdominal and transvaginal Doppler ultrasonography (US), which identifies highly vascularized RPOC (hvRPOC) as tissue with low resistance index (RI < 0.5) and high peak systolic velocity (PSV ≥ 0.7 m/s), corresponding to Gutenberg classification types 2 and 3.(3–5)

Surgical management—dilatation and curettage (D&C) or hysteroscopic resection—carries risks of acute haemorrhage and long-term sequelae including intrauterine adhesions and Asherman's syndrome, which may compromise future fertility. (6–9) Uterine artery embolization (UAE) has emerged as an effective and fertility-preserving alternative for hvRPOC, with high clinical success rates and low complication profiles reported in both single-center and multicenter series. (10–16) However, no international guidelines currently exist regarding the indications for UAE, D&C, or a combined approach.

Proximal UAE using gelatine sponge (GS) torpedoes achieves temporary ischemia and allows spontaneous RPOC expulsion, avoiding the risks of distal embolization with permanent agents. (11, 15, 16) Our team previously reported clinical success rates of 100% in a monocentric cohort of 24 patients (15) and 94.2% in a French multicenter study including 224 patients (16) but also the persistence of an avascular RPOC during follow-up in 34.5% of cases, raising questions about the value of additional procedures such as aspiration in situations requiring a rapid return to contraception (post-abortion) or a desire to try for another pregnancy (post-miscarriage). Nonetheless, no standardized angiographic classification currently exists to describe the spectrum of vascular anomalies observed during UAE for hvRPOC, and its potential value for predicting treatment outcomes has not been systematically explored.

The main aims of this study were: 1. to evaluate the efficacy and safety of proximal UAE with GS torpedoes in a large monocentric cohor and 2. to propose a novel 4-stage angiographic classification of hvRPOC.

## Materials and Methods

# Study Design and Population

This retrospective observational study was approved by the national institutional review board (Comité d’éthique de la recherche en imagerie médicale, CERIM). All consecutive women who underwent proximal UAE for hvRPOC with vaginal bleeding—after medical or surgical abortion, miscarriage, or delivery—at Grenoble Alpes University Hospital (CHUGA) between November 2017 and September 2024 were included. Patients with authentic arteriovenous malformations (AVMs) or instrumental induced pseudoaneurysms requiring embolization with non-resorbable material, and those with non-vascularized or minimally vascularized RPOC (Gutenberg types 0–1), were excluded.

Highly vascularized RPOC was defined by Doppler US as: RI < 0.5 and PSV ≥ 0.7 m/s (Gutenberg types 2–3). (3–5) The decision to perform UAE was made at a multidisciplinary meeting involving gynaecologists,

diagnostic radiologists, and interventional radiologists. All patients underwent transabdominal and transvaginal Doppler US (Aplio a450; Canon, Otawara, Japan) to confirm hvRPOC, assess RPOC size and vascularization, and identify transmyometrial vessels. Only a few patients also underwent a preoperative pelvic MRI with 4D dynamic imaging following contrast injection.

## Angiography and UAE Technique

All procedures were performed in an outpatient setting by an interventional radiologist using a dedicated angiography suite (Artis Zeego; Siemens). A 4-F femoral catheter (Terumo Cobra Glide 4F) was used to access the anterior division of each internal iliac artery. Bilateral proximal uterine artery angiography was systematically performed. When needed, a microcatheter (Terumo Progreat 2.7F) was used to navigate around spasm or unfavourable anatomy, or to achieve selective embolization of distal branches.

Based on angiographic findings, a 4-stage classification was defined:

- • **Stage 0**: Normal uterine arteriography, without blush or vascular anomaly.
- • **Stage 1**: Localized arterial blush only, without uterine or transmyometrial vessel hypertrophy.
- • **Stage 2**: Arterial blush associated with hypertrophy of transmyometrial vessels and/or hypertrophic uterine artery.
- • **Stage 3**: Stage 2 features with early venous return, indicating arteriovenous fistula.

Unilateral or bilateral proximal UAE was performed depending on the vascular supply of the RPOC, using GS torpedoes (CuraSpon; CuraMedical, The Netherlands). Technical success was defined as complete occlusion of the supplying uterine artery or arteries on final angiography. Patients were discharged after clinical evaluation.

## Follow-up

Clinical follow-up and Doppler US were scheduled at 4–6 weeks (W4–W6) after UAE, allowing for at least one complete menstrual cycle to facilitate spontaneous RPOC expulsion. Follow-up ultrasound findings were classified as: (1) complete disappearance of RPOC, (2) persistence of an avascular RPOC, or (3) persistence of a vascular RPOC. If both bleeding and RPOC had fully resolved, follow-up was discontinued. In cases of persistent RPOC (avascular or vascular), a second US was scheduled at 12 weeks (W12), provided bleeding had ceased. In cases of persistent vascular RPOC with residual or recurrent bleeding, a second UAE was performed under the same conditions. Persistent avascular RPOC at W12 was managed by D&C.

## Study Endpoints

**Primary endpoint**

Clinical success, defined as cessation of vaginal bleeding between UAE and the first follow-up at W4–W6.

**Secondary endpoints**

(i) Description of the distribution of the four angiographic stages ; (ii) Imaging success, defined as complete disappearance of RPOC on Doppler US at W4–W6 (persistence of a vascular or an avascular RPOC was considered imaging failure); (iii) safety of UAE for hvRPOC, assessed using the CIRSE classification of adverse events; (17) (iv) post-embolization curettage rate; (v) agreement between angiographic staging and MRI-based staging as a potential non-invasive stratification tool and (vi) predictive factors of clinical and imaging failure, including etiology, angiographic stage, presence of transmyometrial vessels, baseline RPOC size, and Doppler parameters (PSV, RI).

# Statistical Analysis

Continuous variables are reported as medians and interquartile ranges (IQRs); categorical variables as counts and percentages. Fisher's exact test was used for categorical variables (etiology, angiographic stage, transmyometrial vessels), and Wilcoxon rank-sum test for continuous variables (RPOC size, PSV, RI). A p-value < 0.05 was considered statistically significant. A weighted kappa coefficient was calculated to assess agreement between angiographic and MRI-based staging. Analyses were performed using R software.

## Results

# Patient Characteristics

Between November 2017 and September 2024, 226 women were evaluated for RPOC at CHUGA. Of these, 115 patients (50.8%) presented with non-vascularized or minimally vascularized RPOC and were excluded (managed conservatively), and 5 patients (2.2%) had authentic AVMs requiring permanent embolization. A total of 106 consecutive women with hvRPOC underwent proximal UAE and were included in this analysis (Figure [flowchart]).

The median age was 32 years [IQR: 27–37]. The main etiology was abortion in 74 patients (70%), miscarriage in 28 patients (26%), and postpartum in 4 patients (4%). The median time from the end of pregnancy to UAE was 46 days [IQR: 33–60]. All 106 patients (100%) presented with vaginal bleeding; 2 patients (2%) also reported pelvic pain. Baseline clinical and US data are summarized in Table 1.

Table 1
Clinical and ultrasound data (n = 106)

| **Characteristic** | **n = 106** |
|---|---|
| Age (years), median [IQR] | 32 [27–37] |
| **Gynecological history** | |
| Gravidity, median [IQR] | 2 [1–3] |
| Parity, median [IQR] | 2 [1–2] |
| **Etiology, n (%)** | |
| Abortion | 74 (70%) |
| Spontaneous miscarriage | 28 (26%) |
| Postpartum | 4 (4%) |
| History of curettage, n (%) | 2 (2%) |
| Vaginal bleeding, n (%) | 106 (100%) |
| Pelvic pain, n (%) | 2 (2%) |
| Management interval (days), median [IQR] | 46 [33–60] |
| **Doppler US data** | |
| RPOC size (mm), median [IQR] | 26 [21–33] |
| RPOC arterial vascularization, n (%)[1] | 104 (99%) |
| Enhanced myometrial vascularity (EMV), n (%)[2] | 68 (92%) |
| PSV (m/s), median [IQR][3] | 1.1 [0.8–1.4] |
| RI, median [IQR][4] | 0.39 [0.33–0.40] |
| Transmyometrial vessels, n (%)[2] | 68 (92%) |

*IQR interquartile range; PSV peak systolic velocity; RI resistance index; RPOC retained products of conception; EMV enhanced myometrial vascularity. [1]n = 104; [2]n = 74; [3]n = 98; [4]n = 97.*

All patients underwent Doppler US with a median RPOC size of 26 mm [IQR: 21–33]. The median PSV was 1.1 m/s [IQR: 0.8–1.4] and the median RI was 0.39 [IQR: 0.33–0.40]. Transmyometrial vessels were identified in 68 of 74 patients with available data (92%). Additional MRI was performed in 23 patients (21.7%). IRM data missed for 2 patients.

## Angiographic Findings and Staging

Angiographic staging revealed Stage 0 (normal arteriography) in 14 patients (13.2%), Stage 1 in 33 patients (31.1%), Stage 2 in 33 patients (31.1%), and Stage 3 in 26 patients (24.5%) (Table 2 and Fig. 1).

Of note, the 14 patients with Stage 0 angiography despite fulfilling Doppler US inclusion criteria (RI < 0.5 and PSV ≥ 0.7 m/s) likely represent patients whose RPOC had spontaneously devascularized in the interval between Doppler assessment and angiography.

Table 2
Angiographic data (n = 106)

| Variable | n = 106 |
|---|---|
| **Angiographic stage, n (%)** | |
| Stage 0 – Normal arteriography | 14 (13%) |
| Stage 1 – Localized arterial blush | 33 (31%) |
| Stage 2 – Blush + hypertrophic vessels | 33 (31%) |
| Stage 3 – Stage 2 + early venous return | 26 (25%) |
| **Utero-ovarian anastomoses, n (%)** | |
| Right-sided | 23 (22%) |
| Left-sided | 29 (27%) |
| Bilateral | 20 (19%) |
| **Embolization, n (%)** | |
| Unilateral | 5 (5%) |
| Bilateral | 101 (95%) |
| Microcatheter use, n (%) | 10 (9.4%) |
| Procedure time (min), median [IQR] | 35 [25–47] |
| Radiation dose (Gy·cm²), median [IQR]* | 20.2 [12.4–31.9] |
| **n = 98.* | |

Bilateral UAE was performed in 101 patients (95.3%), and a microcatheter was required in 10 patients (9.4%). The median procedure duration was 35 minutes [IQR: 25–47] and the median radiation dose was 20.2 Gy·cm² [IQR: 12.4–31.9]. Technical success was achieved in all 106 patients (100%).

# Clinical and Imaging Outcomes

Clinical success at W4–W6 was achieved in 95 patients (89.6%). At 3 months, clinical success was observed in 96 of 100 patients with available data (91%) (Table 3). Ten patients (9.4%) required a second UAE for persistent vascular RPOC with persistent or recurrent bleeding. Seven patients (6.6%) ultimately underwent surgical curettage, after one or two embolizations.

Table 3
Follow-up outcomes (n = 106)

| **Outcome** | **n = 106** |
|---|---|
| Technical success, n (%) | 106 (100%) |
| Clinical success at W4–W6, n (%) | 95 (89.6%) |
| Clinical success at 3 months, n (%)* | 96 (91%) |
| **Imaging follow-up at W4–W6, n (%)**** | |
| Complete RPOC disappearance | 55 (53%) |
| Avascular RPOC persistence | 25 (24%) |
| Vascular RPOC persistence (imaging failure) | 23 (22%) |
| **Imaging success (disappearance of RPOC at W4/W6)** | **55 (53%)** |
| Second UAE, n (%) | 10 (9.4%) |
| Surgical curettage, n (%) | 7 (6.6%) |
| **Complications, n (%)** | |
| Major/moderate (CIRSE Grades 2–6) | 0 (0%) |
| Minor – Post-embolization syndrome (CIRSE Grade 1) | 25 (23.5%) |
| Minor – Groin hematoma (CIRSE Grade 1) | 15 (14.2%) |
| **n = 100; **n = 103.* | |

Imaging follow-up was available in 103 patients at W4–W6. Imaging success (disappearance of RPOC at W4-W6) was achieved in 55 patients (53%). At W4-W6, an avascular RPOC persisted in 25 patients (24%) and vascular RPOC persisted in 23 patients (22%). At 3 months, imaging follow up was available in 95 patients and a disappearance of RPOC was observed in 78 patients (82%).

# Safety

Moderate complication (CIRSE Grades 2) was recorded in one patient (endometritis). Minor complications (CIRSE Grade 1) occurred in 40 patients (37.5%): post-embolization syndrome in 25 patients (23.5%) and groin hematoma in 15 patients (14.2%). All resolved spontaneously without requiring medical intervention or hospitalization.

# Predictive Factors

No clinical or Doppler variables—including etiology, RPOC size, PSV, RI, or presence of transmyometrial vessels—were significantly associated with clinical failure (Table 4). Angiographic stage was also not associated with clinical success (p = 0.30).

Table 4
Predictive factors for clinical and imaging outcomes

| Variable | p (clinical success) | p (imaging success) |
|---|---|---|
| Etiology | 0.35 | n.a. |
| Angiographic stage | 0.30 | 0.06* |
| Angiographic stage (complete disappearance†) | — | **0.004** |
| RPOC size (US) | 0.66 | n.a. |
| PSV | 0.42 | n.a. |
| RI | 0.38 | n.a. |
| Transmyometrial vessels on US | 0.59 | n.a. |

*Bold indicates p < 0.05. *Non-significant trend. †Imaging success defined as complete RPOC disappearance (stricter definition). n.a. = not analyzed.*

*Body text word count: ~3,200 words • References: 31 • Tables: 4 • Figures: 5 (+ 1 supplementary)*

For imaging outcomes, angiographic stage showed a significant trend toward association with imaging success (disappearance of RPOC on US doppler at W4/W6) (p = 0.004) (Fig. 5).

# MRI vs. Angiographic Staging

Among 21 patients with both MRI and angiographic data available, staging agreement was observed in 16 cases (76.2%). Discordant cases (5/21, 23.8%) consistently showed MRI underestimating the angiographic stage by one stage in 4 cases and by two stages in 1 case, suggesting that MRI is less sensitive to transmyometrial vessel hypertrophy than angiography. Overall inter-modality agreement was good (quadratic-weighted κ = 0.77).

## Discussion

This large single-center series confirms that proximal UAE with GS torpedoes is a safe and effective first-line treatment for hemorrhagic hvRPOC, achieving clinical success in 89.6% of patients at W4–W6 and 91% at 3 months. These results are consistent with those of our previous monocentric (100%, n = 24) (15) and multicenter studies (94.2%, n = 224) (16) and support the growing evidence base for UAE s a first line treatment in this indication. Importantly, the current series is the largest using exclusively GS torpedoes as the embolic agent, and is the first to propose a standardized angiographic classification system.

A key finding of this study is the significant correlation between angiographic stage and complete RPOC disappearance at one month (p = 0.004). This suggests that higher angiographic stages, characterized by more complex vascular anomalies (arteriovenous shunting, vessel hypertrophy), are associated with

slower or incomplete imaging response after a single embolization. This finding is consistent with the observation by our previous multicenter study (16) that hypertrophic uterine artery on angiography was associated with greater risk of persistent vascular RPOC on imaging control, extending this finding to a broader 4-grade classification. In clinical practice, patients with Stage 3 disease may benefit from a planned combined approach (UAE followed by D&C) or pre-emptive counselling about the higher probability of requiring a second procedure.

The absence of association between angiographic stage and clinical success (i.e., cessation of bleeding) is consistent with previous reports (16) and may be explained by the mechanism of action of GS torpedoes: proximal occlusion reduces arterial inflow sufficiently to control bleeding regardless of the distal vascular architecture, but may not achieve complete devascularization in complex lesions. The divergence between clinical and imaging outcomes underscores the importance of distinguishing these two endpoints in future studies.

The observation that 14 patients (13.2%) had Stage 0 angiography despite meeting Doppler US inclusion criteria (RI < 0.5 and PSV ≥ 0.7 m/s) is noteworthy. It suggests that a proportion of hvRPOC may spontaneously devascularize between the time of Doppler assessment and angiography, potentially rendering embolization unnecessary. While this has limited practical implications—since angiography is performed as part of the embolization procedure rather than for diagnostic purposes alone—it raises the question of whether MRI staging, when available, could identify Stage 0 patients preoperatively and allow more conservative management.

In this context, the good agreement between MRI-based and angiographic staging (κ = 0.77) is a clinically important finding. MRI systematically underestimated the angiographic stage in discordant cases, likely because transmyometrial vessel hypertrophy—the key feature distinguishing Stage 2 from Stage 1—is more reliably detected on angiography than on MRI. Despite this limitation, MRI-based staging may represent a practical tool to identify patients with low-grade disease (MRI stages 0–1) who could be managed conservatively with US surveillance, thereby avoiding an invasive procedure.

The minor complication rate of 37.5% in this series is higher than those reported in previous publications using GS torpedoes (15, 16) but may partly reflect a more systematic retrospective data collection at follow-up consultations, with heightened sensitivity to minor events such as groin hematoma. Importantly, no events required hospitalization or specific treatment, and no major complications (uterine necrosis, endometritis requiring hospitalization, ischemic complications) were recorded. This safety profile compares favourably with D&C, which carries risks of acute haemorrhage, intrauterine adhesions, and Asherman's syndrome, particularly in young women with fertility intentions. (6–9)

Authentic AVMs were excluded from this study, as they typically require permanent embolic agents and multiple sessions. (10, 11) It is worth noting that AV fistula may represent an advanced stage in the natural history of untreated or surgically disrupted hvRPOC. The hypothesis that early UAE of hvRPOC may prevent progression to AVM is supported by case observations, including one case of uterine AVF at our institution that developed after sequential D&C and conservative management for RPOC

(Supplementary Fig. 6). Early UAE could therefore be considered not only curative for hvRPOC but also potentially preventive for its most severe vascular complications.

This study has several limitations. Its retrospective and single-center design limits generalizability. The high success rate and relatively few failures may have reduced the statistical power to detect clinical predictors. Angiographic staging was performed without a standardized, previously validated classification, introducing potential inter-observer variability; however, all angiograms were reviewed by a single operator, minimizing this bias. The MRI staging analysis was limited to 21 patients, and the moderate sample size precludes definitive conclusions. Finally, long-term fertility outcomes were not assessed.

## Conclusion

Proximal uterine artery embolization with gelatine sponge torpedoes is a safe and effective treatment for haemorrhagic highly vascularized retained products of conception. The proposed 4-stage angiographic classification provides clinically relevant prognostic information: higher angiographic stages are associated with a lower probability of complete RPOC disappearance at one month. MRI-based staging demonstrates good agreement with angiographic findings and may support non-invasive pre-procedural patient stratification, helping to identify candidates for conservative management or combined approaches. Prospective multicenter validation of this classification is warranted to standardize treatment protocols and refine management strategies for post-abortion and postpartum intrauterine retention.

## Abbreviations

hvRPOC highly vascularized retained products of conception; UAE uterine artery embolization; GS gelatine sponge; US ultrasound; PSV peak systolic velocity; RI resistance index; CIRSE Cardiovascular and Interventional Radiological Society of Europe; AVM arteriovenous malformation; IQR interquartile range; D&C dilation and curettage; EMV enhanced myometrial vascularity; LVJ lymphovenous junction

## Declarations

# Compliance with Ethical Standards

This study was approved by the national institutional review board (CERIM). Informed consent was waived given the retrospective nature of the study.

**Conflict of Interest:**

The authors declare no conflicts of interest.

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# Figures

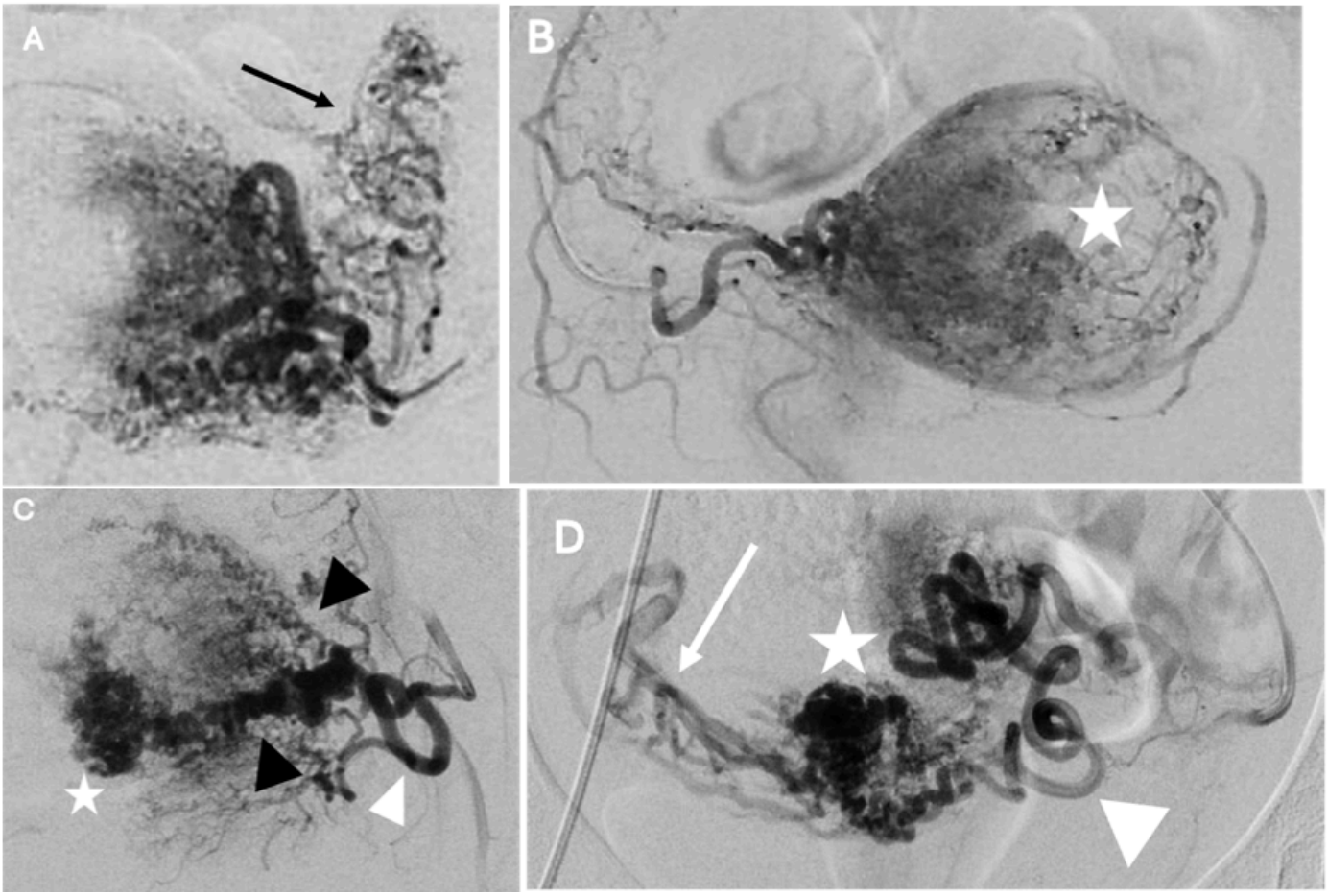



**Figure 1**

*Angiographic stages of hvRPOC.*

*(A) Stage 0: normal uterine angiography. Note the presence of a left utero-ovarian anastomosis (black arrow).*
*(B) Stage 1: localized arterial blush (white star).*
*(C) Stage 2: arterial blush (white star) with hypertrophy of transmyometrial vessels (black arrowhead) and of the uterine artery (white arrowhead).*
*(D) Stage 3: arterial blush (white star) with hypertrophic uterine artery (white arrowhead) and early venous return (white arrow).*

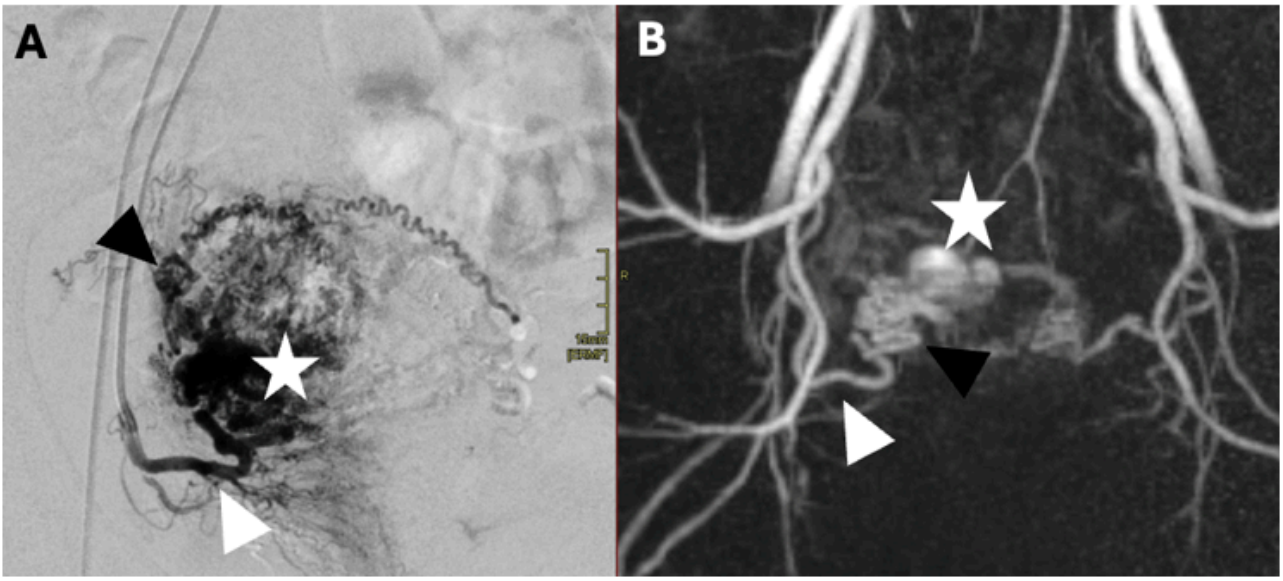
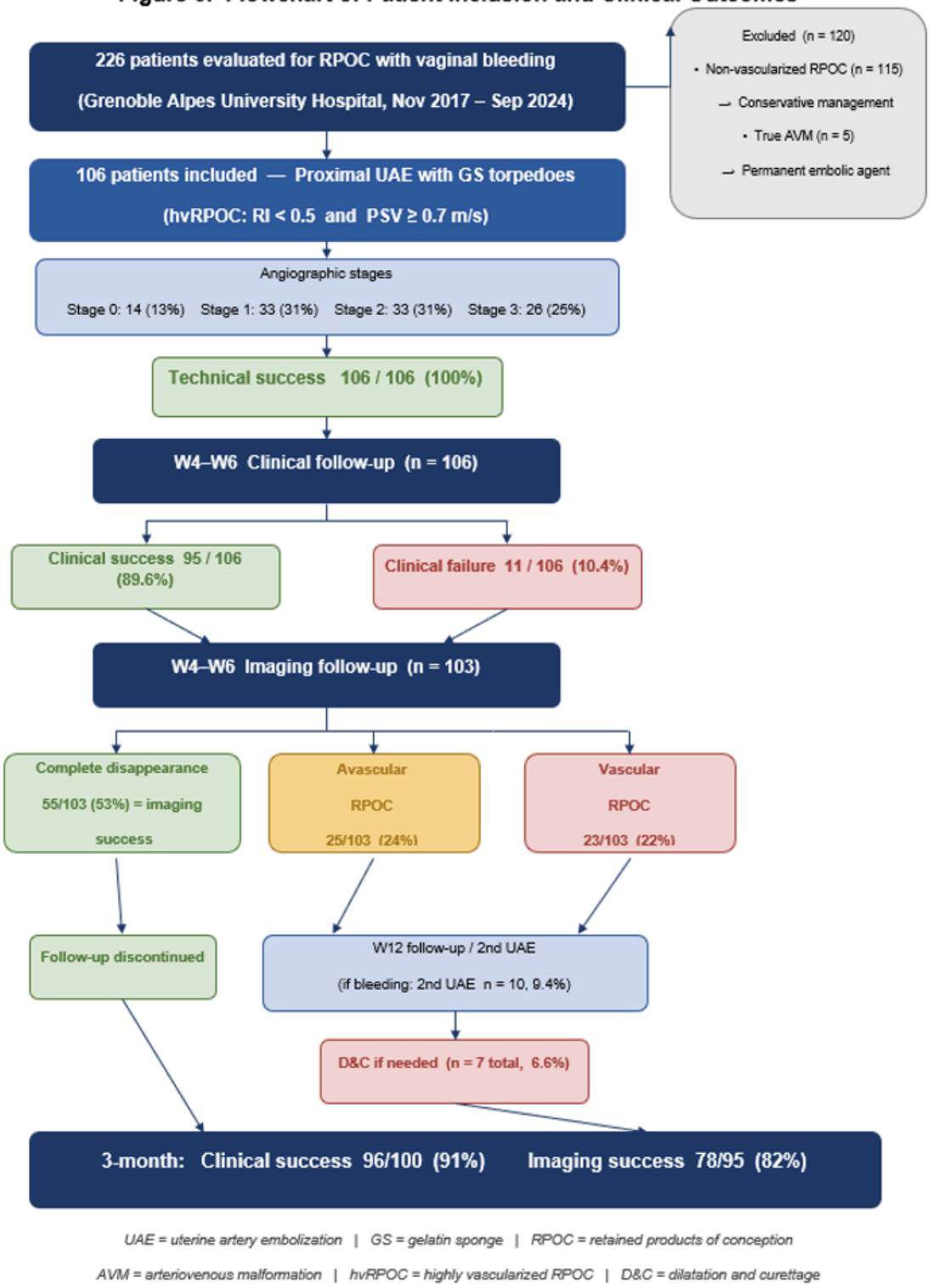



**Figure 2**

*Example of angiographic (A) and MRI (B) stage 2 findings in the same patient with an arterial blush (white star), hypertrophic transmyometrials (black arrowhead) and hypertrophic uterine artery (white arrowhead).*

**Figure 3. Flowchart of Patient Inclusion and Clinical Outcomes**




## Figure 3

See image above for figure legend.

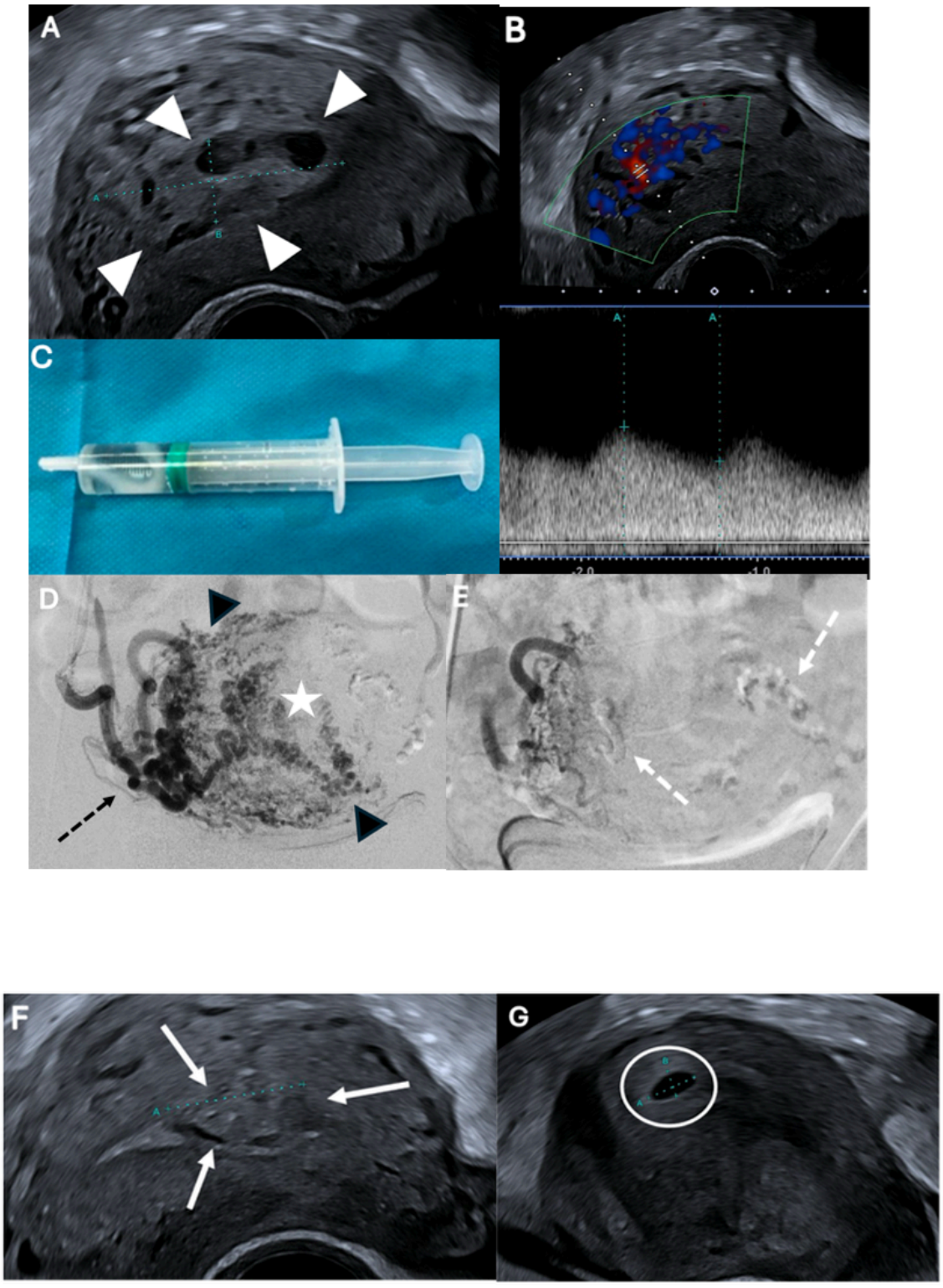



**Figure 4**

*Example of follow-up in a 24-year-old woman referred for vaginal bleeding 4 weeks after medical abortion.*

*(A, B) Endovaginal Doppler US confirming an endometrial RPOC (white arrowhead) with hypervascularization and increased myometrial vascularity (RI: 0.30; PSV: 1.3 m/s).*

*(C) Gelatin sponge torpedoes prepared in a syringe before embolization.*

*(D) Angiography showing stage 2 findings: arterial blush (white star), hypertrophy of transmyometrial vessels (black arrowhead), and hypertrophy of the uterine artery (black dashed arrow).*

*(E) Bilateral embolization with gelatin sponge torpedoes achieved technical success. Final control demonstrated bilateral proximal occlusion of the uterine arteries (black star) with complete interruption of flow.*

*(F) Doppler US one month after UAE showing persistence of an avascular RPOC (white arrow) with decreased size.*

*(G) Follow-up at 3 months showing complete disappearance of the RPOC and an intrauterine gestational sac (white circle). The patient reported a positive serum β-hCG result 4 weeks before presentation.*

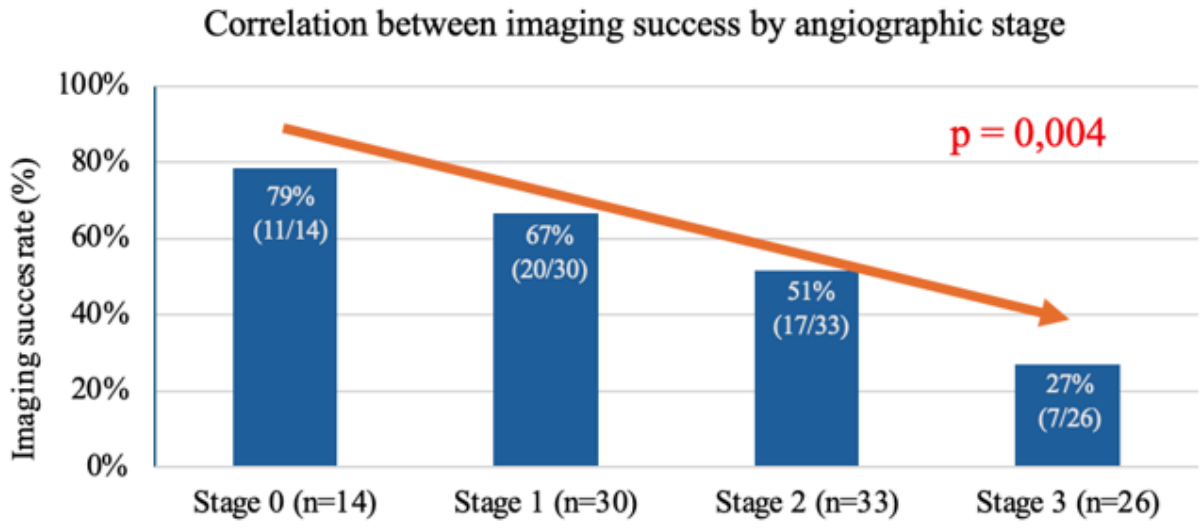



**Figure 5**

Correlation between imaging success and angiographic stages

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SUPPLEMENTARYMATERIAL.docx