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Research Article

Interventional Radiology in Postpartum Hemorrhage: Effectiveness and Safety of Uterine Artery Embolization

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Abstract: ***Introduction:*** **Objective:** To evaluate the effectiveness, safety, failure predictors and reproductive consequences of uterine artery embolization for postpartum hemorrhage. **Study design:** Systematic review of comparative studies, cohorts, systematic reviews and interventional-radiology series. **Place and duration of the study:** Global evidence indexed to 30 April 2026 was reviewed between 1 January and 30 April 2026. **Methodology:** MEDLINE/PubMed was searched for postpartum hemorrhage combined with uterine or pelvic artery embolization and interventional radiology. Studies reporting technical success, clinical hemostasis, hysterectomy, complications, transfusion, mortality or subsequent pregnancy were included. Published estimates were synthesized without recalculation. **Results:** The search identified 459 records and 35 focused publications informed the review. A comparative meta-analysis included 833 patients, 583 (70%) treated with embolization. Embolization reduced red-cell use (MD -7.39 units, 95% CI -14.73 to -0.04; p=0.05) and hospitalization (MD -3.22 days, 95% CI -5.42 to -1.02; p=0.004). Procedural complications were 16.45% versus 28.8% after hysterectomy. In a 56-patient series technical and clinical success were 100% and 92.85%. A 227-patient cohort reported 96.9% technical and 93.8% clinical success. Subsequent pregnancy requires high-risk surveillance because recurrent hemorrhage and abnormal placentation were increased in registry data.**Conclusion:** Uterine artery embolization is an effective uterus-preserving treatment for refractory postpartum hemorrhage when the patient can be stabilized and interventional expertise is immediately available. Failure, rebleeding, ischemic complications and later placental disorders require structured monitoring and timely surgical rescue.

Keywords: postpartum hemorrhage; uterine artery embolization; interventional radiology; maternal morbidity; fertility preservation; placenta accreta spectrum

INTRODUCTION

Postpartum hemorrhage remains a leading preventable cause of maternal death and severe morbidity. Initial management requires rapid recognition, uterotonics when indicated, tranexamic acid, resuscitation and correction of the bleeding source. Mechanical tamponade, surgical devascularization, compression sutures and hysterectomy may be necessary when first-line measures fail [1]. Interventional radiology adds targeted vascular control without immediate uterine removal and can be used therapeutically after delivery or prophylactically in selected abnormal placentation pathways [2].

Uterine artery embolization is performed through arterial access followed by pelvic angiography, selective catheterization and delivery of temporary or permanent embolic material. Its principal advantage is rapid hemostasis with preservation of the uterus. It may also identify extrauterine collateral bleeding that is difficult to localize surgically. Uterus-sparing procedures are clinically important because emergency hysterectomy carries operative injury, transfusion and permanent fertility consequences [3]. Effectiveness is influenced by shock, coagulopathy, placenta accreta spectrum, arterial spasm, collateral supply and the time required to mobilize a trained team [4].

Reported technical success is generally high but clinical success is the outcome that matters. Angiographic stasis does not guarantee durable hemostasis when disseminated intravascular coagulation, retained placenta or diffuse venous bleeding persists. Contemporary cohorts report clinical success above 80% although selection and definitions vary [5]. Fertility preservation also cannot be equated with normal reproductive prognosis. Subsequent pregnancy may involve recurrent hemorrhage, placenta previa or placenta accreta spectrum and rare ischemic complications may damage the endometrium or myometrium [6].

Pakistan and other resource-constrained settings face a systems gap. Interventional radiology is concentrated in tertiary centres and obstetric transfer may occur after profound shock. Local randomized evidence is sparse

and national embolization registries are absent. International outcomes must therefore be interpreted alongside availability, transport, blood products and surgical rescue. This review assessed technical and clinical success, comparative outcomes, complications, failure predictors and future fertility after uterine artery embolization for postpartum hemorrhage [7-13].

MATERIALS AND METHODS

A systematic review was conducted using PRISMA 2020 principles. The population comprised women with primary or secondary postpartum hemorrhage after vaginal or cesarean birth. The intervention was uterine or pelvic arterial embolization used for active bleeding, recurrent hemorrhage or planned control in placenta accreta spectrum. Comparators included hysterectomy, surgical management, no embolization or internal comparisons between successful and failed embolization. Primary outcomes were technical success and clinical hemostasis without additional major intervention. Secondary outcomes were hysterectomy, re-embolization, transfusion, hospital stay, complications, mortality, menstruation and subsequent pregnancy.

MEDLINE/PubMed was searched from inception to 30 April 2026. Terms combined postpartum hemorrhage, postpartum haemorrhage, obstetric hemorrhage, uterine artery embolization, pelvic artery embolization, transcatheter arterial embolization and interventional radiology. Related terms for placenta accreta spectrum, pseudoaneurysm, clinical failure, fertility and subsequent pregnancy were used during focused screening. The reproducible query identified 459 indexed records. Reference lists of recent reviews and large cohorts were checked. This count represents indexed retrieval and not 459 full-text assessments.

Comparative studies, systematic reviews, observational cohorts and consecutive clinical series were eligible when embolization outcomes were separable. Case reports were used only for uncommon safety signals and were not included in success-rate summaries. Studies limited to fibroid embolization, non-obstetric bleeding, abortion without postpartum data or prophylactic balloon occlusion without embolization were excluded from the principal therapeutic synthesis. Overlapping cohorts were retained only when they reported distinct outcomes or follow-up.

Data were extracted into a standardized form covering country, setting, sample size, hemorrhage cause, delivery route, hemodynamic status, embolized arteries, embolic material, technical success, clinical success, rebleeding, repeat embolization, hysterectomy, complications, death and reproductive follow-up. Technical success was accepted as completion of intended embolization or angiographic control. Clinical success was accepted as sustained hemostasis without unplanned repeat embolization, surgery or hysterectomy according to each study. Published n (%), means, medians, IQRs, ORs, RRs, mean differences and p-values were retained.

Risk of bias was assessed according to design. Comparative cohorts were evaluated for treatment-selection bias, hemorrhage severity, time-dependent confounding and adjustment. Single-centre series were evaluated for consecutive inclusion, outcome definitions and completeness of follow-up. Fertility studies were evaluated for desire for pregnancy, denominator choice and live-birth ascertainment. Results were not re-pooled because recent meta-analyses overlapped and clinical indications differed. Ethical approval was not required for published aggregate data and confidentiality was not applicable. Statistical significance was accepted at $p<0.05$ when specified by the original study [14].

RESULTS

The database search identified 459 records. Focused assessment retained 35 publications addressing therapeutic embolization, comparative effectiveness, placenta accreta spectrum, complications, rebleeding or subsequent pregnancy. The evidence was dominated by retrospective cohorts and case series. One recent meta-analysis compared embolization with hysterectomy. Figure 1 summarizes selection and the outcome domains.

Comparative evidence included 833 patients from four cohorts, of whom 583 (70%) underwent uterine artery embolization. Compared with hysterectomy, embolization was associated with fewer red blood cell units (MD -7.39, 95% CI -14.73 to -0.04; p=0.05) and a shorter hospital stay (MD -3.22 days, 95% CI -5.42 to -1.02; p=0.004). Procedural complications occurred in 16.45% after embolization and 28.8% after hysterectomy. Ureteric injury was lower (OR 0.05, 95% CI 0.01-0.38; p=0.004) and bladder injury was lower (OR 0.02, 95% CI 0.00-0.15; p<0.001). Thirty-five (6%) required conversion to hysterectomy and 27 (4.6%) underwent re-embolization with 100% bleeding control. Mortality did not differ significantly.

Individual cohorts showed high immediate effectiveness. In 56 patients technical success was 100% and clinical success was 92.85%. Hysterectomy after failed embolization occurred in 7.14%. Periprocedural and late complication rates were

each 3.56% and no technique-related mortality occurred. A separate 57-patient series reported 100% technical and 84.2% clinical success. Severe complications were sepsis in one patient and uterine empyema in one patient.
A cohort of 227 women included 46 with placenta accreta spectrum and 181 without it. Overall technical and clinical success were 96.9% and 93.8%. Technical success was 95.7% with placenta accreta spectrum and 98.3% without it (P=0.267). Clinical success was 91.3% and 95.6% (P=0.269). Twenty-four immediate complications comprised pelvic pain in 20, urticaria in 3 and puncture-site hematoma in 1. No major complication was reported.

A 112-patient placenta accreta spectrum cohort achieved successful embolization without major complications in 90 (80.4%). Rebleeding occurred in 22 and required surgery in 11 or repeat embolization in 11. Mean time to rebleeding was 52.1 hours (range 1-648 hours; IQR 4.0-11.25 hours). Overt disseminated intravascular coagulation ($p<0.001$), remnant placenta ($p<0.001$), angiographic extravasation ($p=0.005$) and transfused packed red cells ($p=0.005$) were independent failure factors.

Additional predictors were reported in a 47-patient study. Clinical success was 87.2% (41/47). Six patients rebled, four underwent hysterectomy and two underwent repeat embolization. A narrow uterine artery on angiography was independently associated with clinical failure (OR 18.5, 95% CI 2.5-134.8; P=0.004). In severe postpartum hemorrhage assessed by dynamic computed tomography, arterial extravasation was found in 58 patients. Embolization was required in 50/58 (86.2%) with extravasation and 35/122 (28.7%) without it. Extravasation was associated with embolization need (OR 27.74, 95% CI 10.52-83.14).

Reproductive follow-up was mixed. In the 57-patient series 16 pregnancies occurred in 12 women who desired fertility: 3 miscarriages and 13 live births. One uterine rupture and one placenta accreta occurred. A meta-analysis of 15 studies found a lower postoperative pregnancy rate after embolization (RR 0.721, 95% CI 0.531-0.979) and increased subsequent postpartum hemorrhage (RR 3.182, 95% CI 1.319-7.675). A Korean registry matched 1,119 women with prior embolization to 11,184 without it. Subsequent placenta accreta spectrum (OR 38.91, 95% CI 18.61-81.34), placenta previa (OR 6.98, 95% CI 5.57-8.75), preterm birth (OR 2.23, 95% CI 1.71-2.90) and recurrent postpartum hemorrhage (OR 8.94, 95% CI 7.19-11.12) were increased. Tables 1-3 summarize effectiveness, safety and post-treatment factors.

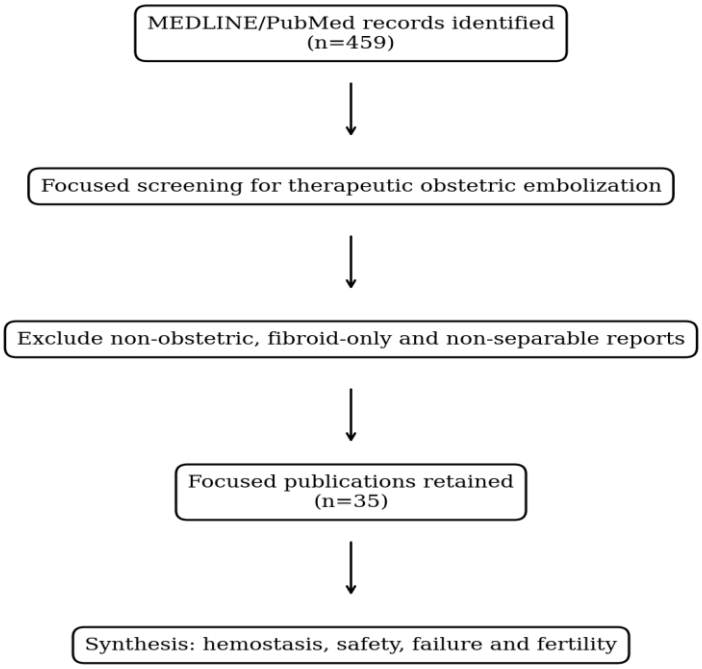

Figure 1. Study selection and evidence-synthesis flow

Table 1. Baseline characteristics of principal evidence

Study/evidence	Sample	Clinical context	Comparator
Comparative meta-analysis	833; UAE 583 (70%)	Refractory PPH	Peripartum hysterectomy
Single-centre effectiveness series	56	PPH after failed initial care	None
PAS cohort	227; PAS 46	Intractable PPH	PAS vs no PAS
PAS rebleeding cohort	112	PPH with PAS	Success vs rebleeding
Korean registry	1,119 prior UAE; 11,184 matched controls	Second delivery	No prior UAE

Table 2. Main effectiveness and safety outcomes

Outcome	Result	Precision/p-value	Interpretation
Red-cell use	MD -7.39 units	95% CI -14.73 to -0.04; p=0.05	Lower with UAE
Hospital stay	MD -3.22 days	95% CI -5.42 to -1.02; p=0.004	Shorter with UAE
Procedural complications	16.45% vs 28.8%	Comparative pooled values	Lower with UAE
Clinical success	92.85% in 56-patient series	Hysterectomy 7.14%	High immediate control
Clinical success by PAS	91.3% vs 95.6%	P=0.269	No significant difference

Table 3. Failure, complications and subsequent pregnancy

Factor/outcome	Reported association	Value
Narrow uterine artery	Clinical failure	OR 18.5 (95% CI 2.5-134.8); P=0.004
CT arterial extravasation	Need for UAE	OR 27.74 (95% CI 10.52-83.14)
Subsequent PAS	Prior UAE vs no UAE	OR 38.91 (95% CI 18.61-81.34)
Recurrent PPH	Prior UAE vs no UAE	OR 8.94 (95% CI 7.19-11.12)
Pregnancy after UAE	15-study synthesis	RR 0.721 (95% CI 0.531-0.979)

DISCUSSION

This review found that uterine artery embolization provides effective uterus-preserving hemorrhage control in appropriately selected patients. Technical success was consistently high and clinical success commonly exceeded 80%-90%. Comparative evidence suggested less transfusion, shorter hospitalization and fewer urinary-tract injuries than hysterectomy without a demonstrated mortality difference [15]. These findings support embolization as an escalation option rather than a substitute for resuscitation or timely surgery.

The distinction between technical and clinical success is essential. Angiographic completion was 100% in several series although clinical success ranged from 84.2% to 99.1% [16]. Continued coagulopathy, retained placenta, extrauterine collaterals or arterial spasm can permit rebleeding after apparent stasis. A treatment pathway must therefore specify post-procedure observation, serial hemodynamic assessment and criteria for repeat angiography or surgery.

Comparative national data from the United States showed that embolization was used less often than hysterectomy despite similar mortality and shorter adjusted hospital stay [17]. This may reflect availability and treatment selection rather than inferiority. Hysterectomy remains necessary for uterine rupture, uncontrolled diffuse bleeding, sepsis, nonviable uterus or failure of conservative measures. Embolization is most

valuable when it can be mobilized without delaying definitive control.

Placenta accreta spectrum does not uniformly predict failure. A 227-patient cohort found no significant difference in technical or clinical success by placenta accreta status [18]. A later 112-patient cohort had 80.4% success but identified disseminated intravascular coagulation, remnant placenta, transfusion burden and contrast extravasation as rebleeding factors [19]. Disease severity and residual placental vascularity are therefore more informative than the diagnostic label alone.

Angiographic anatomy also matters. A narrow uterine artery increased failure odds and likely represented vasospasm or limited access to the true bleeding territory [20]. Repeat procedures demonstrate that collateral vessels and prior arterial obliteration can alter pelvic supply [21]. Multicentre data found placental abnormalities and collateral formation more often during repeat embolization [22]. Operators should evaluate internal iliac, ovarian and round-ligament supply when uterine arteries do not explain continued hemorrhage.

Imaging must be used selectively. Dynamic computed tomography identified arterial extravasation strongly associated with embolization requirement [23]. A stable transferred patient with treatment-resistant bleeding may benefit from rapid computed tomography that maps the source. Unstable patients should not undergo a diagnostic delay when immediate angiography or surgery is available. Bedside shock index, laboratory coagulation and response to resuscitation remain central. The safety profile was generally favourable but rare ischemic injury is serious. Uterine necrosis has been described after postpartum embolization and may present with fever, pain, sepsis or delayed tissue breakdown [24]. Further reports show that conservative treatment is occasionally possible [25] although hysterectomy may be required. Risk may increase with small permanent particles, extensive bilateral embolization, repeated embolization, shock and collateral compromise. Embolic choice should match the vascular lesion and anticipated recanalization.

Fertility preservation should be discussed accurately. Menstruation and successful pregnancy commonly occur after embolization yet this does not establish normal risk. Cohorts describe Asherman syndrome, uterine injury and abnormal placentation [26]. A report of pregnancy after uterine necrosis highlights the need for specialist follow-up [27]. Counseling should separate uterine preservation at the emergency event from later fecundity and pregnancy safety.

Subsequent pregnancy data were concerning. The nationwide Korean study reported markedly increased placenta accreta spectrum, placenta previa, preterm birth and recurrent hemorrhage [28]. Residual confounding is probable because the original hemorrhage and placental pathology may themselves predict recurrence. A smaller cohort also found higher blood loss and numerical increases in placenta previa and accreta after prior pelvic embolization [29]. Women with prior embolization should receive early placental localization and delivery planning in a high-risk unit.

Secondary postpartum hemorrhage and pseudoaneurysm are particularly suitable for targeted embolization. Imaging can identify a focal arterial lesion after cesarean delivery [30] and selective treatment can avoid blind curettage or major surgery [31]. Clinical deterioration, infection and retained products still require multidisciplinary assessment. Embolization controls arterial flow but does not remove infected or retained tissue.

In Pakistan the principal barrier is timely access. No recent Pakistan-specific therapeutic embolization cohort was identified in the focused evidence. Experience from Tanzania illustrates that establishing uterine artery embolization can have major public-health value in settings where hysterectomy and transfer carry high costs [32]. Regionalization should include a 24-hour referral number, blood-bank readiness, trained obstetric anesthesia, defined transport criteria and immediate surgical backup.

Prophylactic interventional strategies in placenta accreta spectrum require separate interpretation. Multidisciplinary reviews support selective use [33]. A network meta-analysis suggests that some endovascular procedures may reduce blood loss but study designs and device strategies are heterogeneous [34]. Prophylactic embolization should be restricted to experienced centres with radiation governance and prospective audit rather than generalized from emergency therapeutic success.

Early detection remains the best opportunity to preserve options. Contemporary work emphasizes recognition of hemorrhage that will become refractory before profound shock develops [35]. Activation criteria should combine blood loss trajectory, hemodynamics, transfusion need, cause and response to uterotonics or tamponade. A single call should mobilize obstetrics, anesthesia, interventional radiology, hematology and surgery. Embolization must occur within a parallel damage-control pathway.

Patient selection should be dynamic rather than based on one blood-loss threshold. A woman with continuing arterial bleeding can deteriorate despite initially normal blood pressure. Conversely diffuse atony may respond quickly to uterotonics and tamponade. The embolization decision should integrate cause, rate of loss, shock index, fibrinogen, transfusion trajectory and proximity to angiography. Repeated reassessment is especially important during transfer because the treatment window can close before arrival.

Resuscitation and embolization are simultaneous processes. Large-bore access, balanced blood components, temperature control, calcium replacement and correction of fibrinogen must continue in the

angiography suite. The obstetric team should remain involved because uterine tone, retained placenta and genital-tract trauma can require parallel treatment. A technically successful arterial procedure cannot correct every component of mixed postpartum hemorrhage.

Temporary gelatin sponge is commonly used when diffuse postpartum bleeding is expected to resolve and future recanalization is desirable. Coils or liquid agents may be required for focal pseudoaneurysm, arterial rupture or persistent collateral supply. Evidence does not identify one universal embolic material. Selection should account for vessel calibre, coagulopathy, desired permanence and operator experience. Procedure reports should document both uterine arteries, collaterals, endpoint and radiation metrics.

Radiation should be minimized without compromising maternal survival. Fluoroscopy time, collimation, pulsed imaging and selective acquisitions can reduce exposure. After delivery fetal exposure is no longer relevant although maternal ovarian and skin dose still matter. Prophylactic antepartum procedures require additional fetal-radiation planning. These differences should be explicit when emergency postpartum success is used to support planned placenta accreta pathways.

Access route may affect workflow. Femoral access is familiar and provides direct pelvic catheterization while radial access can allow mobilization and may be preferable in selected stable patients. Emergency evidence is insufficient to declare superiority. The fastest safe route in local hands is appropriate. Closure strategy must consider coagulopathy and the possibility that recurrent bleeding will require repeat access.

A post-embolization observation protocol should include vital signs, bleeding, uterine findings, hemoglobin, coagulation and symptoms of pelvic ischemia or infection. Rebleeding can occur hours after apparent control and the reported range extended to 648 hours in placenta accreta spectrum. Persistent pain, fever, foul discharge or inflammatory deterioration should prompt imaging and senior review. Early discharge based only on angiographic success is unsafe.

Quality assurance should measure more than technical success. Useful indicators include time from escalation to interventional-radiology activation, time to arterial access, blood products before hemostasis, clinical success, repeat intervention, hysterectomy, complications and maternal survival. Fertility desire and later pregnancy should be captured prospectively. Audit should compare outcomes by hemorrhage cause because a single overall success percentage can conceal poor performance in a high-risk subgroup.

Service planning must include failure. An operating theatre, obstetric surgeon and massive-transfusion capability should remain available during embolization. Transfer agreements should specify when the referring hospital should proceed to surgery rather than wait. In hospitals without round-the-clock interventional radiology, simulation can clarify decision points and communication. A uterus-preserving intention should never override immediate maternal survival.

Consent during hemorrhage is constrained by urgency. When the patient is conscious, the team should explain the purpose of embolization, the possibility of repeat treatment or hysterectomy and uncommon ischemic complications in direct language. Emergency treatment may proceed under applicable consent principles when delay threatens life. After recovery, debriefing should describe what was done and why. This information is important for psychological recovery and future pregnancy planning.

Antibiotic practice varies. Arterial embolization is a clean percutaneous procedure but postpartum uterine tissue, retained placenta, prolonged labour or prior instrumentation may increase infection risk. Local protocols should define prophylaxis and criteria for therapeutic antibiotics. Fever after embolization can represent post-embolization inflammation, endometritis or uterine necrosis. Persistent systemic illness should not be attributed automatically to an expected post-procedure syndrome.

Long-term follow-up should include return of menstruation, pelvic symptoms, fertility intention and pregnancy outcomes. Women who do not attempt conception should not be counted as infertile and women lost to follow-up should remain visible in denominators. Subsequent pregnancy plans should document prior embolic material and arterial anatomy when known. Early referral to maternal-fetal medicine is reasonable because placental implantation and recurrent hemorrhage risks may be increased.

Cost-effectiveness is context dependent. Embolization requires equipment and trained staff but can avoid intensive surgery organ injury and prolonged admission. A service that is rarely available after hours will not reproduce published benefits. Economic evaluation should include transport, standby staffing, blood use, hysterectomy avoided and later reproductive care. Hub-and-spoke models may be more realistic than attempting to place full interventional capability in every maternity unit.

Secondary prevention after a severe hemorrhage includes accurate documentation. The discharge summary should state the bleeding cause, arteries embolized, material used, complications and whether hysterectomy was avoided after failed initial care. A copy should be available to the patient. Future clinicians otherwise may not recognize altered pelvic vasculature or the need for placental surveillance.

Research comparisons should use clinically meaningful rescue definitions. Counting repeat embolization as

success in one study and failure in another prevents valid comparison. A minimum dataset should distinguish angiographic completion, bleeding control after one procedure, control after repeat embolization, hysterectomy and death. Time to hemostasis and blood products are also important because delayed control can produce morbidity despite eventual uterine preservation. The maternal-survival endpoint should remain visible even in fertility-focused reports. Uterine preservation is valuable only after durable control of hemorrhage and restoration of physiology. Studies should report intensive-care admission organ dysfunction, thrombosis, infection and readmission as well as hysterectomy. Patient-reported recovery and psychological consequences are rarely measured but can influence future pregnancy decisions and quality of life.

Training should include recognition of embolization candidates by obstetric staff and obstetric emergencies by radiology staff. Joint simulation can test activation, transfer to the angiography suite, blood-product delivery and conversion to surgery. Competence depends on the whole pathway rather than catheter skill alone. Debriefing after every major case can identify delays and improve the next response.

This review had limitations. Most evidence was retrospective and treatment selection strongly favoured embolization in women stable enough for transfer. Technical and clinical success definitions varied. Comparative studies could not fully adjust for hemorrhage cause or severity. Fertility denominators frequently excluded women not attempting conception and subsequent pregnancy analyses were vulnerable to confounding by the original placental disorder. Rare complications were derived partly from case reports. Evidence from Pakistan and other low-resource settings was sparse and no new meta-analysis was performed.

CONCLUSION

Uterine artery embolization is an effective uterus-preserving intervention for refractory postpartum hemorrhage with high technical and clinical success in experienced centres. It may reduce transfusion, hospital stay and urinary-tract injury compared with hysterectomy but it must not delay surgery in uncontrolled shock. Coagulopathy, retained placenta, contrast extravasation, vasospasm and collateral bleeding increase failure or rebleeding risk. Survivors require counseling and high-risk surveillance in subsequent pregnancy. Regional registries and coordinated referral pathways are priorities for Pakistan.

Declarations

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