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Research Article

Surgical Interventions in Management of Atonic Pph - A Prospective Study

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AIBSTRACT
Background: Postpartum haemorrhage (PPH) remains a leading direct cause of maternal mortality worldwide, with atonic PPH contributing the largest share despite evidence-based medical protocols. When uterotonics fail, timely surgical interventions are critical, particularly in low- and middle-income settings where interventional radiology is limited.
Methods: This prospective observational study was conducted in the Department of Obstetrics and Gynaecology, Karnataka Institute of Medical Sciences, Hubballi, from June 2023 to May 2024. All women with atonic PPH within 24 hours of delivery, in whom standard medical management (high-dose oxytocin, misoprostol, carboprost, uterine massage, tranexamic acid) failed and surgical intervention was required, were included (n=83). Women with secondary PPH (>24 hours) were excluded. Data on demographics, obstetric risk factors, type and sequence of surgical procedures, intra- and postoperative course, near-miss events (WHO criteria), and maternal deaths were recorded. Statistical analysis was performed using SPSS v26; $p<0.05$ was considered significant.
Results: Most women were young (mean age 25.2±4.3 years); 54.2% were unbooked and 75.9% delivered by caesarean section. Severe preeclampsia/gestational hypertension (51.8%) was the most frequent risk factor. Uterine artery ligation was performed in 62.7% and bilateral internal iliac artery ligation (BIIAL) in 48.2%; compression sutures (B-Lynch/Hayman) were used in 34.9%. Hysterectomy was required in 22/83 (26.5%) women, predominantly after failure of BIIAL. Uterine artery ligation alone controlled haemorrhage in 48.1% of cases, whereas hysterectomy was strongly associated with maternal mortality (71.4% of deaths; $p=0.002$) and near-miss status (36.7%; $p<0.001$). Overall maternal mortality was 8.4% and maternal near-miss occurred in 36.1%.
Conclusion: In this high-risk cohort, a stepwise devascularisation strategy—uterine artery ligation, BIIAL and uterine compression sutures—allowed uterine preservation in nearly three-quarters of women with refractory atonic PPH. However, a substantial proportion still required hysterectomy, which was strongly associated with severe morbidity and mortality, underscoring the need for earlier referral, protocolised escalation, and optimisation of perioperative critical care.

Keywords: Atonic Postpartum Haemorrhage; Uterine Artery Ligation; Internal Iliac Artery Ligation; B-Lynch Suture; Hysterectomy; Maternal Near-Miss; Surgical Management.

INTRODUCTION

Postpartum haemorrhage (PPH) is one of the leading direct causes of maternal mortality worldwide, particularly in low- and middle-income countries where access to timely, high-quality obstetric care is often limited [1–3]. Haemorrhage consistently accounts for a substantial proportion of maternal deaths in global analyses, despite the availability of effective preventive and therapeutic interventions [2,3]. Recognising this, the World Health Organization (WHO) has issued detailed recommendations and, more recently, consolidated guidelines for the prevention, diagnosis and treatment of PPH, emphasising early recognition, bundled care and health-system readiness [1,4,11].

Primary PPH complicates approximately 3–5% of deliveries, and uterine atony remains the commonest underlying cause [4,8,12]. In many settings, especially referral public hospitals, the burden of severe PPH is amplified by high-risk case-mix, suboptimal antenatal care, delays in referral and rising caesarean section rates [2,3,12]. First-line management of atonic PPH centres on active management of the third stage of labour, timely uterine massage, uterotonics and tranexamic acid, supported by rapid resuscitation and blood component therapy [1,4,8,11]. When bleeding persists despite maximal medical therapy, guidelines recommend prompt escalation to conservative surgical interventions and, if these fail, life-saving hysterectomy [1,4,5].

A range of uterus-sparing surgical options has been developed to avoid hysterectomy where possible. These include uterine compression sutures (such as the B-Lynch and its modifications), stepwise uterine and utero-ovarian artery ligation, and pelvic devascularisation with bilateral internal iliac artery ligation (BIIAL) [5–8]. Systematic reviews suggest that these techniques can achieve haemostasis in many women and preserve fertility, but most data come from heterogeneous observational studies, with limited information from high-volume public sector facilities in low-resource settings [5,6,8]. In parallel, the WHO near-miss approach has shifted attention beyond mortality alone, highlighting severe maternal morbidity and "near-miss" events as key indicators of the quality of emergency obstetric care [9,10]. Applying standardised near-miss criteria to women with severe PPH allows a more nuanced assessment of health-system performance and of the impact of surgical interventions [9,10].

Against this backdrop, the present prospective observational study from a tertiary referral centre in South India aimed to evaluate patterns of surgical management of atonic PPH unresponsive to medical therapy, focusing on the use and effectiveness of uterine compression sutures, uterine artery ligation, BIIAL and hysterectomy, and their relationship with maternal near-miss and mortality outcomes.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective observational study conducted in the Department of Obstetrics and Gynaecology, Karnataka Institute of Medical Sciences (KIMS), Hubballi, a tertiary referral centre catering to urban and rural populations of North Karnataka. Data were collected over 12 months (June 2023–May 2024), with subsequent analysis and dissertation completion by January 2025.

Participants

All women diagnosed with atonic PPH within 24 hours of vaginal or caesarean delivery and requiring surgical intervention after failed medical management were eligible. Atonic PPH was defined according to institutional protocol (estimated blood loss ≥500 mL after vaginal birth or ≥1000 mL after caesarean, or any blood loss associated with haemodynamic instability) in the presence of a soft, poorly contracted uterus.

Inclusion Criteria

1. Women with primary atonic PPH within 24 hours of delivery.
2. Failure of standard medical management, defined as having received at least:
   - Oxytocin 10 IU intramuscularly, plus
   - Oxytocin 20 IU infusion at 40–60 drops/min,
   - Misoprostol 800 µg (per rectum or sublingual as per protocol), and
   - Four doses of carboprost 250 µg intramuscularly at 15-minute intervals, with ongoing bleeding and/or haemodynamic deterioration.

Exclusion Criteria

1. PPH diagnosed more than 24 hours after delivery (secondary PPH).
2. PPH primarily due to trauma, retained placenta, or coagulation disorders without a significant atonic component.

Sample Size

The sample size was calculated for estimation of the prevalence of atonic PPH among PPH cases, assuming a prevalence of 88% based on previous studies, with 95% confidence and 7% absolute error. Using the formula $n = Z^2pq / l^2$ (Z=1.96; p=0.88; q=0.12; l=0.07), a minimum of 83 cases was required; all consecutive eligible women (n=83) were included.

Data Collection

After obtaining informed consent from the woman or, when necessary, a responsible relative, a structured proforma was used to record: sociodemographic details, booking status, obstetric history, antenatal risk factors, mode and place of delivery, intrapartum complications, and initial PPH management at referring facilities. On admission, all women underwent detailed physical examination; vital signs and shock index were monitored serially. Baseline investigations included haemoglobin, haematocrit, coagulation profile, renal and liver function tests, and blood grouping and cross-matching; these were repeated as clinically indicated.

Surgical Management

All women first received intensive medical management according to unit protocol, including uterine massage, oxytocin infusion, methylergometrine (unless contraindicated), carboprost, misoprostol, and tranexamic acid. Surgical intervention was undertaken when bleeding persisted or when there was evidence of ongoing haemodynamic compromise, falling

haemoglobin, or rising shock index despite maximal medical therapy.

The choice and sequence of surgical procedures were determined by parity and desire for future fertility, haemodynamic status, site and severity of bleeding, and surgeon expertise. Procedures included:

- **Uterine Compression Sutures** (B-Lynch, Hayman or global compression sutures) during caesarean section or laparotomy.
- **Uterine Artery Ligation** (bilateral) with or without additional utero-ovarian ligation.
- **Bilateral Internal Iliac Artery Ligation (BIIAL)** in cases with persistent haemorrhage despite more proximal devascularisation.
- **Subtotal or Total Hysterectomy** as a life-saving measure when conservative surgery failed or when the patient was moribund with no fertility desire.

Detailed intraoperative documentation included procedure type, estimated blood loss, transfusion requirements, operative time, intraoperative complications and need for additional procedures or relaparotomy.

Postoperative Care and Outcomes

Women were monitored in the intensive care unit (ICU) or high-dependency unit as indicated. Parameters recorded included haemodynamic status, urine output, ventilatory support, duration of ICU and hospital stay, and postoperative complications (acute kidney injury, disseminated intravascular coagulation, sepsis, need for dialysis, secondary PPH, wound infection).

Maternal near-miss was defined using WHO near-miss criteria (clinical, laboratory and management-based indicators of life-threatening conditions) Maternal deaths and their causes were documented.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee of KIMS, Hubballi. Confidentiality was maintained and participation did not alter standard care.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarised as mean±standard deviation (SD) or median (interquartile range) as appropriate; categorical variables were expressed as frequencies and percentages. Group comparisons for continuous variables were performed using independent *t*-test or Mann–Whitney U test. Associations between categorical variables (e.g. surgical procedure vs maternal outcome) were assessed using chi-square test or Fisher's exact test. A p-value <0.05 was considered statistically significant. Exploratory multivariable logistic regression was planned to identify factors associated with maternal mortality and near-miss; given the sample size and number of events, these analyses were interpreted cautiously.

RESULTS

Maternal Characteristics and Clinical Profile

Eighty-three women with atonic PPH unresponsive to medical therapy underwent surgical intervention during the study period. The mean age was 25.2±4.3 years (range 18–35); nearly half (48.2%) were aged 21–25 years, and 28.9% were 26–30 years. Most women (49.4%) were primiparous, while 50.6% were multiparous (gravida ≥2). More than half (54.2%) were unbooked or inadequately booked at the study hospital.

The majority of deliveries (60.2%) occurred at term (≥37 to <42 weeks), with 31.3% late preterm and 8.4% early preterm. Caesarean section was the predominant mode of delivery (75.9%; emergency 68.6%, elective 7.2%), reflecting the high-risk nature of referrals; only 24.1% delivered vaginally. Severe preeclampsia/gestational hypertension was the single most common risk factor (51.8%), followed by multiparity (21.7%), placenta previa/antepartum haemorrhage (8.4%), previous caesarean section (9.6%), anaemia/thrombocytopenia (8.4%), and multiple pregnancy or prolonged labour (each 2.4%). Notably, 14.5% had no identifiable risk factor.

Most women experienced moderate to severe haemorrhage: 60.2% had estimated blood loss 500–1000 mL, 24.1% 1000–1500 mL, and 9.6% 1500–2000 mL; only 6.0% had <500 mL but were haemodynamically unstable due to underlying anaemia and comorbidities. Intraoperative vital signs remained stable in 89.2% of women, although 10.8% exhibited hypotension or instability.

Table 1. Maternal Demographic and Obstetric Characteristics (N=83)

Variable	Category	n (%) or Mean±SD

Age (years)	18–20 / 21–25 / 26–30 / 31–35	8 (9.6) / 40 (48.2) / 24 (28.9) / 11 (13.3); mean 25.2±4.3
Booking status	Booked / Unbooked	38 (45.8) / 45 (54.2)
Parity	Primipara / Gravida 2 / Gravida ≥3	41 (49.4) / 21 (25.3) / 21 (25.3)
Gestational age	29–32 / 32–<37 / ≥37–<42 weeks	7 (8.4) / 26 (31.3) / 50 (60.2)
Mode of delivery	Vaginal / Caesarean	20 (24.1) / 63 (75.9)

Table 1 shows that women requiring surgical management for atonic PPH were predominantly young, primiparous and term pregnancies, with a high proportion of unbooked status and emergency caesarean deliveries. This profile reflects the referral nature of the tertiary centre and the contribution of inadequate antenatal care to severe maternal morbidity. The clustering of cases among term and late-preterm gestations underscores that atonic PPH remains a major threat even outside traditional "high-risk" preterm scenarios.

Surgical Interventions Performed

Uterine artery ligation was the most common devascularisation procedure, performed in 52/83 (62.7%) women. Among these, haemorrhage was controlled with uterine artery ligation alone in 25 (48.1%), whereas 27 (51.9%) required additional procedures, including BIIAL or hysterectomy. BIIAL was undertaken in 41 (48.2%) women overall. Uterine compression sutures were used in 29 (34.9%) women—B-Lynch in 15 (18.1%), Hayman in 13 (15.7%), and global compression suture in 1 (1.0%).

Hysterectomy (subtotal or total) was required in 22/83 (26.5%) cases. In 17 (77.3%) women, it followed failure of BIIAL, whereas 5 (22.7%) underwent primary hysterectomy due to profound haemodynamic instability or extensive uterine damage. Laparotomy (separate from caesarean) was required in 25 (30.1%) women, mainly after vaginal delivery (80% of laparotomies). Only one woman (1.2%) required relaparotomy, culminating in hysterectomy.

Table 2. Surgical Interventions for Atonic PPH (N=83)

Procedure	**n (%) among total**
Uterine compression sutures (any)	29 (34.9)
– B-Lynch	15 (18.1)
– Hayman / global	14 (16.8)
Uterine artery ligation	52 (62.7)
BIIAL	41 (48.2)
Hysterectomy (any)	22 (26.5)
Laparotomy after vaginal delivery	20 (24.1)
Relaparotomy	1 (1.2)

Table 2 illustrates a predominantly stepwise, uterus-sparing approach in which uterine artery ligation and BIIAL were frequently employed, often in combination with compression sutures. Nevertheless, over one-quarter of women ultimately required hysterectomy, highlighting the severity of haemorrhage and limitations of conservative procedures in this high-risk cohort. The low relaparotomy rate suggests that once the definitive surgical step was chosen, haemostasis was usually durable, but at the cost of fertility in a substantial minority.

Mode of Delivery and Choice of Procedure

There was a statistically significant association between mode of delivery and type of surgical intervention (p=0.002). Following vaginal delivery (n=20), BIIAL alone (45.0%) and hysterectomy (35.0%) were more common, whereas uterine artery ligation alone (23.8%), compression sutures (19.0%) and combined procedures (27.0%) predominated in caesarean deliveries (n=63). This likely reflects greater opportunity to perform compression sutures and stepwise devascularisation when the abdomen is already open during caesarean section.

Table 3. Distribution of surgical interventions by mode of delivery (n=83)

Surgical intervention	Vaginal (n=20) n (%)	Caesarean (n=63) n (%)	p-value
BIIAL alone	9 (45.0)	12 (19.0)	
Uterine artery ligation alone	0 (0.0)	15 (23.8)	
Compression sutures alone	1 (5.0)	12 (19.0)	
Hysterectomy	7 (35.0)	7 (11.1)	
Combined procedures	3 (15.0)	17 (27.0)	*0.002

Table 3 demonstrates that women with atonic PPH after vaginal delivery were more likely to undergo major pelvic devascularisation or hysterectomy, whereas those bleeding during caesarean section benefitted from earlier uterine artery ligation and compression sutures. The significant association suggests that surgical access at caesarean facilitates timely conservative procedures, potentially reducing the need for hysterectomy. These findings support recommendations for rapid escalation to uterus-sparing surgery when severe atony is encountered with the abdomen already open.

Maternal Outcomes: Mortality, Near-Miss and Morbidity

Overall, 46 (55.4%) women required ICU admission; mean ICU stay was 2.6±3.9 days. The mean total hospital stay was 7.1±5.8 days. Major postoperative morbidities included need for mechanical ventilation (10.8%), disseminated intravascular coagulation (8.4%), hypovolemic shock (8.4%), acute kidney injury (3.6%; all requiring dialysis), and sepsis (3.6%). Prolonged hospital stay (>7 days) occurred in 25.3% of women.

Maternal mortality occurred in 7/83 (8.4%) women; all were referred cases, and all underwent peripartum hysterectomy. Thirty women (36.1%) fulfilled WHO maternal near-miss criteria.

There was a strong association between specific surgical procedures and adverse outcomes. Among the seven deaths, five (71.4%) occurred in women who underwent hysterectomy, one (14.3%) in a woman with BIIAL plus other procedures, and one (14.3%) in a woman with BIIAL alone; no deaths occurred in women managed with uterine artery ligation alone or compression sutures alone (p=0.002). Similarly, hysterectomy was far more frequent in near-miss cases than non-near-miss cases (36.7% vs 5.7%; p<0.001).

Table 4. Surgical Interventions by Maternal Outcome (N = 83)

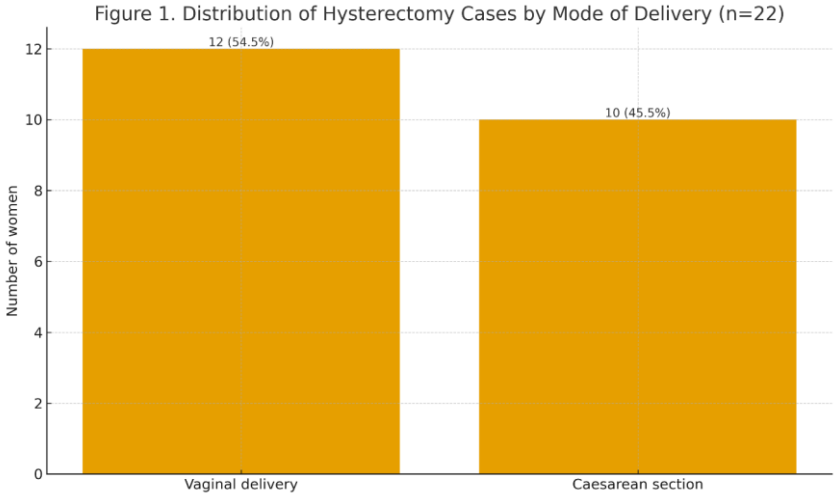
Surgical intervention	Mortality (n = 7) n (%)	Survival (n = 76) n (%)	Near-miss (n = 30) n (%)	No near-miss (n = 53) n (%)	p-value†
BIIAL alone	1 (14.3)	20 (26.3)	8 (26.7)	13 (24.5)	
Uterine artery ligation alone	0 (0.0)	15 (19.7)	1 (3.3)	14 (26.4)	
Compression sutures alone	0 (0.0)	13 (17.1)	2 (6.7)	11 (20.8)	
Hysterectomy	5 (71.4)	9 (11.8)	11 (36.7)	3 (5.7)	
Combined procedures	1 (14.3)	19 (25.0)	8 (26.7)	12 (22.6)	
Overall association (χ^2)	–	–	–	–	Mortality: 0.002; Near-miss: <0.001

Table 4 underscores that women requiring hysterectomy represent the most severely ill subset, with a disproportionate share of deaths and near-miss events concentrated in this group. In contrast, no deaths occurred among those treated successfully with uterine artery ligation or compression sutures alone, suggesting that when instituted promptly in appropriate candidates, conservative surgery may be associated with more favourable outcomes. However, the need for hysterectomy likely reflects underlying haemorrhage severity

and delay, rather than the procedure itself causing excess risk.

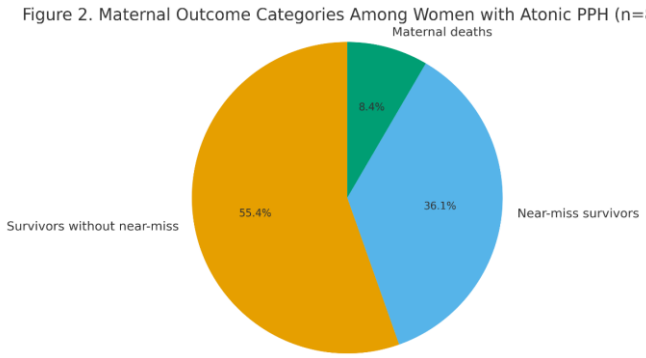
FIGURES

Figure 1. Distribution of Hysterectomy Cases by Mode of Delivery (N=22)



Hysterectomy followed vaginal delivery in 12 (54.5%) women and was performed during or after caesarean section in 10 (45.5%). Although caesarean births predominated overall, vaginal deliveries contributed disproportionately to hysterectomy cases, suggesting that women delivering vaginally may reach the threshold for surgery later, often after delayed recognition or referral. This pattern highlights the need for vigilant quantification of blood loss and early transfer of high-risk labouring women to centres capable of providing definitive surgical care.

Figure 2. Maternal Outcome Categories among Women with Atonic Pph (N=83)



Overall, 76 women (91.6%) survived, of whom 30 (36.1% of the cohort) were classified as maternal near-miss and 46 (55.4%) required ICU admission, while 7 women (8.4%) died. Displaying these data in a three-sector bar or pie chart emphasises that, beyond mortality, a substantial proportion endured life-threatening complications requiring intensive support. The high near-miss burden reinforces the value of near-miss surveillance as a sensitive metric of emergency obstetric care quality within PPH audit cycles.

DISCUSSION

This prospective study from a tertiary referral centre provides real-world data on surgical interventions for atonic PPH that persisted despite standard medical therapy. The cohort predominantly comprised young women, many of whom were unbooked and had hypertensive disorders of pregnancy, mirroring the risk profile described in global and national reports of severe PPH [2,3,8,12]. Despite aggressive management, maternal mortality (8.4%) and near-miss rates (36.1%) remained high, underscoring the life-threatening nature of

refractory atonic PPH in low-resource, high-volume settings [2,3,9,10].

Our findings are consistent with WHO and professional guidelines that emphasise a stepwise escalation of care—medical management followed by uterine-sparing surgery and, only when necessary, hysterectomy [1,4,5,11]. Uterine artery ligation was the most frequently used devascularisation procedure in this series and achieved haemostasis without further surgery in almost half of the women. Although this success rate is somewhat lower than that reported in some institutional series where ligation is performed very early during caesarean section [5,8], it likely reflects the referred, more severely compromised population and delays inherent in the referral pathway [2,3,12].

BIIAL was employed in nearly half of the cohort, typically as an escalation after failure of more conservative measures. Previous work has shown that pelvic devascularisation can control haemorrhage in a substantial proportion of women while avoiding hysterectomy, but that its success is strongly influenced by timing, coagulopathy and surgical expertise [5,6,8]. The fact that most hysterectomies in our study followed BIIAL failure suggests that BIIAL is reserved for the most severe cases, often with established shock, massive transfusion and evolving disseminated intravascular coagulation, in whom any surgical technique may have limited efficacy [5,8].

Compression sutures were used in about one-third of women, predominantly during caesarean delivery. Since they were first described, B-Lynch and related sutures have been widely adopted and shown in observational studies and systematic reviews to provide rapid haemostasis, high uterine salvage rates and acceptable subsequent fertility, with relatively few serious complications [5–8]. The absence of maternal deaths among women whose bleeding was controlled with uterine artery ligation or compression sutures alone in our series aligns with these data and reinforces the importance of early deployment of uterus-sparing techniques when technically feasible [5–8,11].

Importantly, the strong association between hysterectomy and both maternal mortality and near-miss status in this study should be interpreted as a marker of disease severity rather than as evidence that hysterectomy itself is inherently unsafe. As in other reports, peripartum hysterectomy tends to be performed in women with the most profound haemorrhage, delayed presentation, and established organ dysfunction [3,8,12]. Nonetheless, the high proportion of women losing their uterus in their mid-twenties has major psychosocial and reproductive implications and highlights the need to strengthen upstream components of care—antenatal risk identification, timely referral, early use of bundles and rapid escalation to conservative surgery before haemorrhage becomes overwhelming [1,2,4,9,11].

The observation that hysterectomy and BIIAL were more frequent following vaginal delivery than caesarean section, despite the higher absolute number of caesareans, likely reflects both logistics and clinical context. After vaginal birth, there is often a delay before the decision for laparotomy is made and theatre access is secured, allowing haemorrhage to progress. By contrast, when atony occurs during caesarean section the abdomen is already open, enabling immediate application of compression sutures and uterine artery ligation [4,5,8,11]. These findings support current recommendations for vigilant postpartum surveillance, objective quantification of blood loss and early laparotomy when bleeding persists after vaginal delivery [1,4,11].

Near-miss analysis adds depth to outcome assessment beyond crude mortality. The near-miss rate in this study is comparable with other reports that have applied WHO criteria in similar settings [9,10]. Concentration of near-miss events in the hysterectomy and combined-procedure groups underlines that these women experienced the most extreme physiological derangements and should be the focus of detailed case review to identify avoidable delays and system failures [9,10].

Strengths and limitations include the prospective design, use of standard WHO near-miss criteria and detailed recording of surgical sequences. However, this single-centre study with a modest sample size may not be generalisable to all settings, and the observational design precludes definitive comparison of procedures. Long-term reproductive outcomes after uterus-sparing surgery, which are increasingly recognised as important endpoints, were not assessed [5–8]. Interventional radiological techniques such as uterine artery embolisation and routine use of balloon tamponade, now recommended in updated WHO guidance and contemporary reviews [6,8,11], were not widely available during the study period, limiting comparison

with centres where such modalities are integrated into PPH bundles.

CONCLUSION

In this prospective series of 83 women with atonic PPH refractory to medical therapy, a structured surgical strategy incorporating uterine compression sutures, uterine artery ligation and BIIAL enabled uterine preservation in nearly three-quarters of cases. Nonetheless, more than one quarter required peripartum hysterectomy, and overall maternal mortality and near-miss rates remained high, particularly among referred women. These findings emphasise the importance of early recognition of haemorrhage, timely referral, and ready access to skilled pelvic devascularisation in tertiary centres. Future research should prioritise multicentre evaluation of stepwise PPH algorithms, integration of interventional radiology where feasible, and long-term reproductive outcomes after uterine-sparing surgery.

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