Received: 5 August 2024 | Revised: 24 November 2024 | Accepted: 4 January 2025 | Published online: 24 January 2025

DOI: 10.1002/ijgo.16164

CLINICAL ARTICLE

Obstetrics

Suction tube uterine tamponade versus uterine balloon tamponade for treatment of refractory postpartum hemorrhage: A randomized clinical feasibility trial

Mandisa Singata-Madliki[1] | Albaro J. Nieto-Calvache[2] | Luisa F. Rivera Torres[3] | Hazmath Abdul[4] | Joanne Batting[1] | Sylvia N. Cebekhulu[5] | Lawrence Chauke[6] | Priya Soma-Pillay[7] | Susan Fawcus[8] | Logie Govender[4] | Busiwe Majeke[9] | Xolani Mbongozi[10] | Katrin Middleton[11] | Poovangela Naidoo[12] | Sanele Ndaba[13] | Trevi Spence[14] | Gaynor M. Balie[6] | Angelica Monroy[2] | Monica Cantor[2] | G. Justus Hofmeyr[1,15]

[1]Effective Care Research Unit, University of the Witwatersrand and Walter Sisulu University, East London, South Africa

[2]Unidad De Alta Complejidad Obstetrica, Fundación Valle Del Lili, Cali, Colombia

[3]Centro De Investigaciones Clínicas, Fundación Valle Del Lili, Cali, Colombia

[4]Department of Obstetrics & Gynaecology, Queen Nandi Regional Hospital, Empangeni, University Of Kwazulu-Natal, KwaZulu-Natal, South Africa

[5]Department of Obstetrics and Gynaecology, Bongani Regional Hospital, University of the Free State, Department of Health, Bloemfontein, South Africa

[6]Department of Obstetrics and Gynaecology, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand, and Charlotte Maxeke Johannesburg Academic Hospital, Johannesburg, South Africa

[7]Department of Obstetrics and Gynaecology, Steve Biko Academic Hospital, University of Pretoria, UP/SAMRC Research Centre for Maternal, Fetal, Newborn and Child Healthcare Strategies, Pretoria, South Africa

[8]Department Obstetrics and Gynaecology, University of Cape Town, Cape Town, South Africa

Abstract

Objective: To compare low-cost "Suction Tube Uterine Tamponade" (STUT) treatment for refractory postpartum hemorrhage (PPH) with uterine balloon tamponade (UBT) using a randomized feasibility study.

Methods: After verbal assent, we allocated participants with refractory PPH by randomly ordered envelopes to STUT or routine UBT at 10 hospitals in South Africa and one tertiary referral center in Colombia between January 10, 2020, and May 3, 2024. In the STUT group, we inserted a 24 FG Levin stomach tube into the uterine cavity and applied suction. The control group received standard UBT, mainly the Elavi free-flow balloon or the Bakri fixed volume balloon. There were fundamental differences between the South African and the Colombian sites, so the pre-specified analysis combined data from the two countries by meta-analysis.

Results: We enrolled 59 participants. The rate of the primary outcome (blood loss >1000 mL or laparotomy or death) was 8/27 (30%) in the STUT group versus 14/27 (52%) in the UBT group (risk ratio [RR] 0.56, 95% confidence interval [CI] 0.30–1.05, $P=0.07$). Per protocol analysis was 7/26 (27%) versus 15/28 (54%) (RR 0.49, 95% CI 0.25–0.96, $P=0.04$). Reporting severe pain during the procedures was less frequent in the STUT group (RR 0.46, 95% CI 0.25–0.86, $P=0.01$). Most secondary outcomes favored the STUT group, with low certainty.

Conclusions: STUT was experienced as less painful than UBT. Results were consistent with reported observational findings and one other randomized trial evidence of greater effectiveness for suction than balloon tamponade.

M. Singata-Madliki and A. J. Nieto-Calvache are joint first authors.

[9]Department of Obstetrics and Gynaecology at Cecilia Makiwane Hospital, And Walter Sisulu University, East London, South Africa

[10]Department of Obstetrics and Gynaecology, Nelson Mandela Academic Hospital, Walter Sisulu University, Mthatha, South Africa

[11]Department of Obstetrics and Gynaecology, Frere Hospital and Walter Sisulu University, East London, South Africa

[12]Department of Obstetrics and Gynaecology, Chris Hani Baragwaneth Academic Hospital, University of the Witwatersrand, Johannesburg, South Africa

[13]Department of Obstetrics and Gynaecology, Kalafong Hospital, University of Pretoria, Pretoria, South Africa

[14]Department of Obstetrics and Gynaecology, New Somerset Hospital, Cape Town, South Africa

[15]University of Botswana, Gaborone, Botswana

Correspondence
G. Justus Hofmeyr, University of the Witwatersrand and Walter Sisulu University, Frere Maternity Hospital, Amalinda Drive, East London, South Africa.
Email: justhof@gmail.com

Funding information
New Venture Fund, Grant/Award Number: NVF-NGDF-UNIV1-Subgrant-011970-2021-01-01

KEYWORDS
feasibility, postpartum hemorrhage, randomized clinical trial, suction tube uterine tamponade, uterine balloon tamponade

1 | INTRODUCTION

Postpartum hemorrhage (PPH), is a major cause of maternal deaths globally.[1] Routine quantitative monitoring of blood loss after birth to trigger early use of a first-line treatment bundle (the MOTIVE bundle) is reported to reduce severe PPH by 60%.[1]

However, the effectiveness of treatments for refractory (unresponsive) PPH is less certain, because of the lack of robust research. A Cochrane systematic review concluded: "There is currently insufficient evidence from RCTs [randomized controlled trials] to determine the relative effectiveness and safety of mechanical and surgical interventions for treating primary PPH. High-quality randomized trials are urgently needed".[2]

WHO recommends uterine balloon tamponade (UBT) for the treatment of refractory PPH in the context of access to emergency care.[3] On the basis of compelling results from observational studies,[4] UBT has been promoted in low-resource settings by global agencies and is perceived as effective by providers.[5] It has been widely adopted in many countries, including South Africa and Colombia. However, both an individually randomized[6] and a cluster-randomized[7] trial found improvised condom UBT to be harmful. A systematic review found that the effectiveness of UBT is unclear,[8] and WHO has indicated the need for further research.[9]

As an alternative to conventional fixed-volume UBT systems, we have proposed a free-flow, gravity-fed balloon, to maintain a constant pressure but not prevent contraction and retraction of the uterus.[10] This innovation has been incorporated into the Ellavi UBT system (Sinapi Biomedical, South Africa), which was in routine use at most of the participating sites in South Africa during this trial.[11] In Colombia, the fixed-volume Bakri balloon was the standard of care.

An alternative to balloon tamponade is uterine vacuum tamponade (UVT). Negative intrauterine pressure is used to contract the uterus and so reduce bleeding. Several suction catheters have been designed or adapted for UVT. Observational studies[12–15] have reported a more than 90% association with arrest of PPH.

A disposable UVT device (Jada, Organon), has been approved by the US Food and Drug Administration, based on the results of an observational study in North America.[14] UVT using an improvised Bakri

catheter as a suction catheter has been in routine use in a Swiss obstetric unit since 2017.[16] Two observational studies have reported better outcomes with the Jada system than with the Bakri balloon.[17,18]

Cost may be a barrier to the use of these devices in low-resource settings. The single-use Jada device costs about US$ 1200.00.

We have identified a low-cost (US$ 0.50), widely available soft plastic catheter (the Levin stomach tube) and performed a preliminary assessment of the functionality of Suction Tube Uterine Tamponade (STUT), awarded the J.G. Sciarra prize by *IJGO* in 2019.[19] We reported three successful cases of the method used as a last resort in life-threatening PPH.[20]

Given physiologic plausibility, encouraging observational studies, and the potential for widespread use, randomized assessment of STUT will have meaningful global health implications.

WHO is conducting a large multicenter trial of treatments for refractory PPH (the RED Trial), including STUT.[21]

The objective of the current study was to conduct a limited size randomized feasibility study comparing the STUT device with current standard care (UBT), first to inform the larger WHO RED Trial with respect to the feasibility and acceptability of STUT. In addition, the trial was powered to detect a large difference in effectiveness. The hypothesis was that STUT would be more effective and comfortable than UBT. A randomized trial in India reported blood loss greater than 1000 mL in 4/16 participants (25%) with a simple stainless steel suction catheter versus 8/16 (50%) with condom balloon tamponade, and significantly less time to application of tamponade, time to hemorrhage control, and use of second-line instruments.[22]

2 | MATERIALS AND METHODS

We conducted an investigator-initiated, non-commercial, non-regulatory, open-label, randomized feasibility study with two parallel arms randomized in 1:1 ratio, at 10 secondary and tertiary hospitals in South Africa and one tertiary referral center in Colombia between January 10, 2020, and May 3, 2024. The trial was open label because the difference between the procedures does not allow for blinding.

We evaluated the effectiveness and acceptability of STUT for treatment of PPH, compared with current standard care (UBT). Because STUT is a relatively new procedure, our protocol included an internal pilot study to assess the functionality, acceptability, and safety of the STUT procedure among the first 24 participants enrolled, without unblinding of effectiveness outcomes, that has been reported previously.[23]

Patients with refractory PPH who met the inclusion criteria were approached to participate in the study and were enrolled upon providing verbal assent. The inclusion criteria included: age 18 or more years with refractory PPH (unresponsive to first-line treatment), thought to be arising from the uterine cavity, for whom a decision had been taken by the responsible clinician that uterine tamponade was necessary as the next treatment step according to local standard of care. Exclusion criteria were: condition imminently life-threatening or severe medical condition.

The intervention was STUT. The control group received the local standard of care (UBT). We followed the CONSORT extension for randomized pilot and feasibility trials.[24]

Initial routine treatment of PPH at the study sites included use of uterotonics and tranexamic acid, inspection for bleeding from genital tract tears, and exclusion of retained products of conception. In refractory cases, eligible participants were approached by the doctor for verbal assent, and if this was granted, the women were randomly allocated by the doctor by opening the next in a series of sequentially numbered, opaque, sealed envelopes in a computer-generated random sequence stratified by site to one of two groups. The envelopes were prepared by staff not involved in the trial and contained cards marked STUT or Control.

In the STUT group, a 24 FG Levin suction tube was inserted transvaginally into the uterine cavity. Suction was applied with an electric surgical suction unit or a manual vacuum aspiration syringe. If effective, the STUT suction was interrupted every 30–60 min and removed as soon as the bleeding was controlled without suction.

In the control group, management was continued according to local protocols, including UBT.

Participants were invited to complete a brief questionnaire on overall pain during the procedure and pain during the insertion of the device (no pain; mild pain; severe pain; unbearable pain; unsure), and general perception of the procedure (fine; uncomfortable but acceptable; unacceptable; unbearable; unsure). These questions were intended for evaluation of acceptability of the STUT procedure, but were also administered to participants in the UBT group.

The primary outcome was defined as measured blood loss using a "fracture" bedpan or drape within 60 min after enrolment of more than 1000 mL or operative procedures (e.g., laparotomy, hysterectomy) or death.

The trial was planned as a single-country trial in South Africa. Initial implementation of the trial was complicated by the COVID-19 pandemic. Subsequently, during 2022, recruitment slowed considerably. It appeared that staff at the participating hospitals experienced STUT as a more effective method and became reluctant to randomize potential participants. This impression was confirmed in an anonymous survey of staff, mainly at the participating hospitals, showing a clear preference for use of STUT rather than UBT.[25] To increase recruitment numbers, the trial was extended to a collaborating center in Colombia with a planned sample size of 20.

For this feasibility study we planned to be able to detect a 50% reduction in the primary outcome from 60% to 30% with 95% certainty and 80% power (sample size 84, Epi-Info [CDC] a public domain suite of software tools: https://www.cdc.gov/epiinfo/index.html).

The protocol was registered with the Pan African Clinical Trials Register PACTR on June 30, 2019, as PACTR201907769424884 (https://pactr.samrc.ac.za/TrialDisplay.aspx?TrialID=8223) and revised to include the Colombian collaboration on February 3, 2023, including a revision of the data analysis plan.

Baseline and outcome data were entered onto paper case record forms by the site investigators, double entered onto the study database (Excel, Microsoft) by the central research team, manually checked for errors, and imported to the EpiInfo package and Revman 5.4 for statistical analysis.

Because there were several fundamental differences between the research environments in Colombia and in South Africa, the revised analysis plan documented prospectively on the trial registration site specified that data from the South African and Colombian sites would be combined by meta-analysis provided that there was limited heterogeneity. In South Africa, birth took place on flat beds and blood was not routinely collected after birth. Blood loss was measured from enrollment until bleeding was controlled (minimum 60 min), using a low-profile plastic fracture bedpan or plastic disposable drape, plus blood collected in the suction reservoir. In Colombia, birth was conducted in lithotomy position and blood loss after birth was routinely collected using a disposable plastic drape. Blood loss was measured from the birth until bleeding was controlled (at least 60 min after enrollment), as well as blood collected in the suction reservoir. In South Africa, the study was conducted at 10 secondary and tertiary hospitals. Research procedures were carried out by routine staff without dedicated research staff. In Colombia the trial was conducted at a single tertiary research referral center with research staff to conduct trial procedures. In South Africa, the control group received various balloon devices, mainly the Elavi balloon. In Colombia the control group received Bakri balloons.

For continuous variables, the number of participants, means and standard deviations were reported. Means were compared by meta-analysis as mean differences with 95% confidence intervals (CI). For categorical variables, proportions and percentages were reported and compared by meta-analysis using the Mantel–Haenszel method and reported as risk ratios (RR) with 95% CI. A fixed effect model was used unless there was significant heterogeneity (I^2>60%), in which case a random effects model was used. EpiInfo and Revman 5.4 software packages were used. A *P* value less than 0.05 was regarded as statistically significant.

In view of the acute and unpredictable nature of PPH and the need for management without delay, the consent process approved by the research ethics committees followed the strategy used in recent studies of UBT in both low- and high-resource settings.[4,26] Verbal assent was requested at the time of enrollment, and deferred written consent was requested once the participant was clinically stable and able to undertake the formal informed consent process.

Care for all participants in the study was optimized in several ways. On-site training of staff in the prevention and management of PPH as well as for STUT procedures was conducted. Rapid interventions were facilitated by providing a PPH emergency trolley in the labor wards. The protocol specified that clinical care at all stages must be decided according to the responsible clinician's judgment of the participant's best interest, irrespective of study requirements. Serious adverse events were notified to the ethics committees promptly. Good Clinical Practice procedures were followed.

The study protocol was approved by the Human Research Ethics Committee (Medical), University of the Witwatersrand (Clearance certificate M190218, February 22, 2019), local ethics review boards of all the hospitals conducting the study, and the South African Health Products Regulatory Authority (SAHPRA Reference number MD20191003N, December 2, 2019). In Colombia the study protocol was approved by the local ethics committee with registration 576–2022 (protocol 1903/STUT).

3 | RESULTS

As indicated above, recruitment in South Africa failed to progress and the trial was closed without achieving the proposed sample size of 64 (+20 in Colombia). Participant flow is shown in Figure 1.

We recruited 59 participants (39 in South Africa and 20 in Colombia). Baseline data were similar between the two groups (Table 1), with somewhat more pregnancy complications in the STUT group and somewhat more previous and current cesarean births in the UBT group at the South African sites. These differences among multiple baseline measurements with small numbers are likely to reflect the play of chance.

There was one severe adverse event. A 32-year-old participant, parity 2 gravidity 3, with gestational diabetes was admitted at 38 weeks of pregnancy for labor induction with a Foley catheter balloon and three 2-h 25-μg doses of oral misoprostol solution. During labor she developed placental abruption and gave birth to a stillborn baby weighing 3050 g. She developed PPH that was unresponsive to medical management. She was enrolled in the trial and allocated to the control group. She received routine care including Elavi UBT. She subsequently suffered a cardiac arrest, was resuscitated and total abdominal hysterectomy was performed. She received 9 units of packed red blood cells, 6 units of fresh frozen plasma, 6 units of cryoprecipitate, and 1 megaunit of platelets. She suffered a second cardiac arrest and resuscitation efforts were unsuccessful. The death was considered unrelated to participation in the study as she received routine care according to hospital protocols throughout.

Insertion of the allocated device was unsuccessful in one participant allocated to the STUT group, who received an Elavi balloon, and one participant in the UBT group, in whom bleeding stopped without any device insertion (one of the five participants with no primary outcome recorded). In one participant, the STUT catheter was inserted successfully, but no suction apparatus was available. Suction was applied, initially successfully, using a manual vacuum aspiration syringe. Subsequently technical problems were encountered with blood clotting in the syringe and the STUT was replaced with an Elavi balloon. The outcomes are shown in Table 2.

There was no statistical heterogeneity between results for South Africa and Colombia, with the exception of the secondary outcome pulse rate, for which a random effects model was used. The primary analysis was by intention-to-treat (ITT). The rate of the

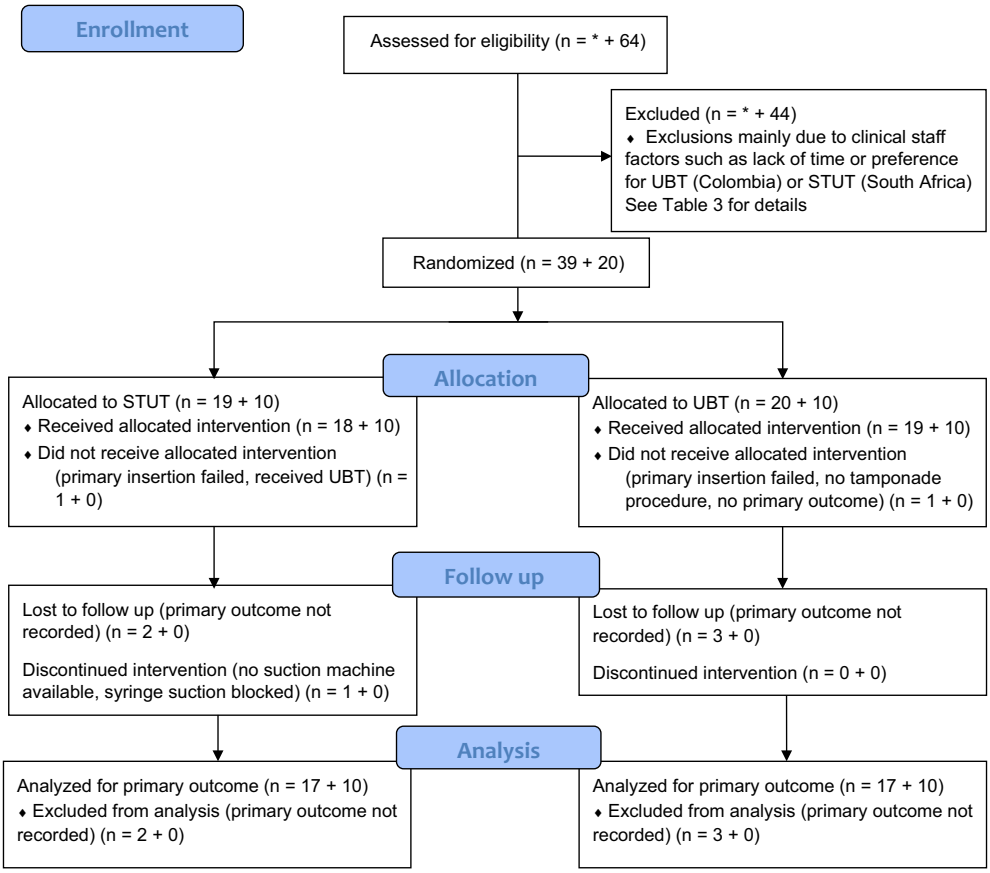

FIGURE 1 CONSORT flow diagram. Numbers are given for South Africa + Colombia respectively. STUT, suction tube uterine tamponade; UBT, uterine balloon tamponade. * In South Africa, potential participants who were not randomized were not recorded.

primary outcome (blood loss >1000 mL or laparotomy or death) was 8/27 (30%) in the STUT group versus 14/27 (52%) in the UBT group (RR 0.56, 95% CI 0.30–1.05, $P=0.07$), low certainty. On per protocol analysis according to the first device successfully inserted, the primary outcome rate was 7/26 (27%) in the STUT group versus 15/28 (54%) in the UBT group (RR 0.49, 95% CI 0.25–0.96, $P=0.04$).

Most secondary outcomes favored the STUT group but with low certainty. Mean diastolic blood pressure after initial treatment was 10.4 mm Hg higher in the STUT than the UBT group (95% CI 2.1–19, $P=0.01$) and reporting severe pain during the tamponade procedure was less frequent in the STUT group (RR 0.46, 95% CI 0.25–0.86, $P=0.01$). These findings should be interpreted with caution because of multiple secondary endpoint testing.

This feasibility study identified several barriers to randomized comparisons of treatments for refractory PPH; these are listed in Table 3.

4 | DISCUSSION

Previously reported comparisons of suction versus balloon uterine tamponade have been retrospective observational studies.[16,17] We chose a prospective random allocation trial design to optimize the comparability of the two groups. To our knowledge this is the second report of a randomized trial comparing suction with balloon tamponade.[22] This study highlights the difficulty of conducting randomized trials of interventions for refractory PPH, an uncommon clinical problem and one requiring urgent intervention. This may account for the dearth of robust evidence on the effectiveness of multiple mechanical and surgical interventions for refractory PPH referred to in the background above. An unanticipated barrier was increasing preference for the novel STUT procedure, contributing to the failure to achieve the planned sample size. In the ITT analysis, the 44% lower risk of the primary outcome in the STUT group was not statistically significant. In the per protocol analysis the risk reduction was 51% ($P=0.04$). Reporting of severe pain during the tamponade procedure was 54% lower with STUT ($P=0.01$). This difference is biologically plausible as STUT involves insertion of a simple smooth plastic tube and application of suction, whereas UBT involves insertion of a more complex and bulkier balloon, which is then inflated causing pressure inside the uterus.

The small numbers recruited in this feasibility study limited the power to detect differences with certainty. At the South African sites, implementation of the project by routine clinical staff without dedicated research staff support over a prolonged period of time resulted in suboptimal implementation of the trial procedures. Several allocation envelopes were opened out of sequence and several case record forms had missing data (as indicated by denominators in the

TABLE 1 Baseline data.[a]

	South Africa				Colombia				Totals			
	STUT		UBT		STUT		UBT		STUT		UBT	
Age, y	19	27.3 ± 4.6	20	29.3 ± 6.5	10	26.6 ± 7.0	10	28.8 ± 7.0	29	27.0 ± 5.4	30	29.1 ± 6.5
Primiparous	18	5 (28%)	20	7 (35%)	10	6 (60%)	10	2 (20%)	28	11 (39%)	30	9 (30%)
Previous cesarean birth(s)	18	2 (11%)	19	6 (32%)	10	0 (0%)	10	1 (10%)	28	2 (7.1%)	29	7 (24%)
Previous PPH	19	2 (11%)	20	1 (5.0%)	10	0 (0%)	10	0 (0%)	29	2 (6.9%)	30	1 (3.3%)
Weight, kg	18	82 ± 21	17	81 ± 32	10	81.3 ± 23	10	80.4 ± 8.7	28	82 ± 21	27	81 ± 25
Height, cm	18	159 ± 5.2	20	157 ± 11	10	160 ± 6.7	10	163 ± 5.5	28	159 ± 5.6	30	159 ± 9.7
Pregnancy complications	19	15 (79%)	19	7 (37%)	10	6 (60%)	10	5 (50%)	29	21 (72%)	29	12 (41%)
Multiple pregnancy	19	0 (0%)	20	2 (10%)	10	3 (30%)	10	1 (10%)	29	3 (10%)	30	3 (10%)
Assisted vaginal birth	19	2 (11%)	20	0 (0%)	10	1 (10%)	10	1 (10%)	29	3 (10%)	30	1 (3.3%)
Cesarean birth	19	2 (11%)	20	8 (40%)	10	2 (20%)	10	2 (20%)	29	4 (14%)	30	10 (33%)
Birth weight, g	19	3052 ± 639	20	3008 ± 559	10	2761 ± 461	10	3183 ± 999	29	2951 ± 530	29	3096 ± 722
Prophylactic oxytocin	19	18 (95%)	20	19 (95%)	10	10 (100%)	10	10 (100%)	29	28 (97%)	30	29 (97%)
Treatment oxytocin	19	18 (95%)	20	19 (95%)	10	10 (100%)	10	10 (100%)	29	28 (97%)	30	29 (97%)
Treatment ergo−/syntometrine	19	9 (47%)	20	12 (60%)	10	9 (90%)	10	9 (90%)	29	18 (62%)	30	21 (70%)
Treatment misoprostol	19	12 (63%)	20	16 (80%)	10	5 (50%)	10	8 (80%)	29	17 (59%)	30	24 (80%)
Tranexamic acid	19	15 (79%)	20	16 (80%)	10	10 (100%)	10	10 (100%)	25	26 (86%)	30	26 (87%)
Pre-delivery hemoglobin, g%	16	11.9 ± 2.0	18	11.4 ± 1.8	9	12.6 ± 1.7	9	12.4 ± 1.0	25	12.1 ± 1.9	27	11.7 ± 1.6

Abbreviations: PPH, postpartum hemorrhage; STUT, suction tube uterine tamponade; UBT, uterine balloon tamponade.

[a]Data are expressed as numbers, mean values ± standard deviation, or proportions (percentage). Differing denominators are due to missing data.

tables). It was reassuring that the findings at the South African sites were essentially similar to those at the Colombian site, where the investigation was conducted at a single referral center with dedicated research staff and where trial procedures were not compromised.

An inherent limitation of comparisons of suction versus balloon devices is that suction devices collect blood loss more efficiently than balloon devices, which may bias blood loss results in favor of the balloon devices.

To our knowledge, this is the second report of a randomized trial to compare low-cost suction tube uterine tamponade with balloon tamponade. The pragmatic trial design promotes generalizability to similar clinical settings. The observed recruitment difficulties constitute a useful outcome in a feasibility study to inform the design of future studies. The internal pilot results[21] were used to support approval of the WHO RED Trial.[20]

Feasibility: Randomized comparison of treatments for refractory PPH is feasible, but our study highlights several barriers that need addressing.

Effectiveness: Although the effectiveness data are low certainty (small sample size and statistical significance only in the per protocol analysis), the large point estimate for the primary outcome (>40% reduction) is consistent with substantially greater effectiveness and in line with the findings of large observational studies showing greater effectiveness of uterine suction devices over balloon tamponade.[16,17] When combined by meta-analysis with data from the only other randomized trial,[21] simple suction tube uterine tamponade compared with balloon tamponade significantly reduces the primary outcome of blood loss greater than 1000 mL (RR 0.56, 95% CI 0.33–0.97, Mantel-Heinzel method, fixed effects model, RevMan 5.4 software, Figure 2).

Acceptability: The more than 50% reduction in severe pain during the procedure is clinically plausible, given that STUT uses a narrow smooth plastic tube compared with a more bulky, irregular balloon, and does not involve distension of the uterine cavity.

In conclusion, in high-income settings, suction uterine tamponade with the Jada device is rapidly becoming standard of care for refractory PPH. In a post-marketing study at 16 centers in the USA involving 800 participants, treatment with the Jada device was reported to be effective in 93% following vaginal birth and 84% following cesarean birth.[27] In low-resource settings, improvised condom uterine balloons are widely promoted and used despite evidence of harm from two randomized trials.[6,7] The current study contributes to a growing body of evidence suggesting that, in the absence of purpose-designed suction tamponade devices, use of STUT rather than balloon tamponade is a reasonable clinical option. Given that STUT appears to be less painful for the patient, it would require robust evidence of greater effectiveness of balloon tamponade to justify the continued recommendation of balloon devices in preference to STUT.

AUTHOR CONTRIBUTIONS

GJH conceived the study and wrote the first draft of the protocol and report. AJN-C made substantial contributions to the interpretation and writing. All authors contributed to study design and/or conduct and approved the final manuscript.

TABLE 2 Outcomes.[a]

	South Africa				Colombia				Totals						
	STUT ($n=19$)		UBT ($n=20$)		STUT ($n=10$)		UBT ($n=10$)		STUT ($n=29$)		UBT ($n=30$)		RR/MD	95% CI	*P*
Blood loss >1000 mL or laparotomy or death (primary, ITT)	17	3 (18%)	17	6 (35%)	10	5 (50%)	10	8 (80%)	27	8 (30%)	27	14 (52%)	0.56 $I^2=0\%$	0.30 to 1.05	0.07
Blood loss >1000 mL or laparotomy or death per protocol analysis	16	2 (13%)	18	7 (39%)	10	5 (50%)	10	8 (80%)	26	7 (27%)	28	15 (54%)	0.49 $I^2=0\%$	0.25 to 0.96	0.04
Blood loss >1000 mL	17	3 (18%)	16	5 (31%)	10	5 (50%)	10	8 (80%)	27	8 30%)	26	13 (50%)	0.60 $I^2=0\%$	0.32–1.14	0.12
Blood loss >500 mL or transfusion	19	14 (74%)	18	15 (83%)	10	10 (100%)	10	10 (100%)	29	24 (83%)	28	25 (89%)	0.93 $I^2=0\%$	0.75 to 1.15	0.51
Blood transfusion	19	13 (68%)	18	13 (72%)	10	1 (10%)	10	2 (20%)	29	14 (48%)	28	15 (54%)	0.89 $I^2=0\%$	0.58 to 1.4	0.60
Blood loss, mL	17	564 ± 695	16	631 ± 627	10	974 ± 338	10	1156 ± 319	27	716 ± 614	26	833 ± 584	−149 $I^2=0\%$	−391 to 95	0.23
Laparotomy	19	1 (5.3%)	18	2 (11%)	10	0 (0%)	10	0 (0%)	29	1 (3.5%)	28	2 (7.1%)	0.47	0.05 to 4.8	0.53
Hysterectomy	19	1 (5.3%)	18	1 (5.6%)	10	0 (0%)	10	0 (0%)	29	1 (3.5%)	28	1 (3.6%)	0.95	0.06 to 14	0.97
Maternal death	18	0 (0%)	18	1 (5.6%)	10	0 (0%)	10	0 (0%)	29	0 (0%)	28	1 (3.6%)	0.32	0.01 to 7.3	0.47
ICU admission	19	1 (5.3%)	18	1 (5.6%)	10	0 (0%)	10	1 (10%)	29	1 (3.5%)	28	2 (7.1%)	0.58 $I^2=0\%$	0.08 to 4.2	0.59
Organ failure	19	1 (5.3%)	18	1 (5.6%)	10	0 (0%)	10	0 (0%)	29	1 (3.5%)	28	1 (3.6%)	0.95	0.06 to 14	0.97
Additional oxytocin	19	7 (35%)	19	4 (21%)	10	5 (50%)	10	6 (60%)	29	12 (41%)	29	10 (34%)	1.20 $I^2=0\%$	063 to 2.3	0.58
Additional ergometrine	19	2 (10%)	19	1 (5.3%)	10	5 (50%)	10	5 (50%)	29	7 (24%)	29	6 (21%)	1.17 $I^2=0\%$	0.50 to 2.7	0.72
Additional misoprostol	19	3 (16%)	19	0 (0%)	10	0 (0%)	9	0 (0%)	29	3 (10%)	28	0 (0%)	7.0	0.39 to 127	0.19
Additional tranexamic acid	19	2 (11%)	19	2 (11%)	10	5 (50%)	10	2 (20%)	29	7 (24%)	29	4 (14%)	1.75 $I^2=0\%$	0.59 to 5.2	0.31
Change in hemoglobin, g/dL	16	−3.31 ± 2.45	16	−2.42 ± 2.27	8	−1.48 ± 1.03	9	−2.01 ± 1.20	24	−2.70 ± 2.24	25	−2.27 ± 1.93	0.11 $I^2=51\%$	−0.78 to 1.00	0.85
Time from enrolment to insertion, min	18	9.3 ± 6.0	19	17 ± 20	10	6.6 ± 2.5	10	7.0 ± 3.5	28	8.4 ± 5.2	29	14.0 ± 17	−0.94 $I^2=53\%$	−3.5 to 1.6	0.47
Failed insertion	19	1[b] (5.3%)	20	1[c] (5.0%)	10	0 (0%)	10	0 (0%)	29	1 (3.5%)	30	1 (3.3%)	1.05	0.07 to 16	0.97
Insertion moderately difficult or difficult	17	3 (18%)	19	7 (37%)	10	1 (10%)	10	0 (0%)	27	4 (15%)	29	7 (24%)	0.63 $I^2=22\%$	0.22 to 1.8	0.38
Device facilitated examination	17	8 (47%)	14	4 (29%)	10	2 (20%)	10	0	27	10 (37%)	24	4 (17%)	1.99 $I^2=0\%$	0.79 to 5.0	0.14

TABLE 2 (Continued)

	South Africa				Colombia				Totals						
	STUT ($n=19$)		UBT ($n=20$)		STUT ($n=10$)		UBT ($n=10$)		STUT ($n=29$)		UBT ($n=30$)		RR/MD	95% CI	*P*
Device interfered with examination	17	0 (0%)	14	1 (7.1%)	10	0 (0%)	10	0 (0%)	27	0 (0%)	24	1 (4.2%)	0.28	0.01 to 6.3	0.42
Examination obscured by bleeding	19	2 (11%)	17	1 (5.9%)	10	0 (0%)	10	0 (0%)	29	2 (6.9%)	27	1 (3.7%)	1.79	0.18 to 18	0.62
10 min after enrolment:															
Pulse	18	102 ± 14	17	99 ± 20_	10	81 ± 18	10	103 ± 23	28	95 ± 18	27	100 ± 21	−8.6 $I^2=80\%$	−33 to 16	0.49 R
Systolic blood pressure	18	120 ± 16	17	111 ± 15	10	120 ± 14	10	113 ± 20	28	120 ± 15	27	111 ± 17	8.4 $I^2=0\%$	−0.13 to 17	0.05
Diastolic blood pressure	18	71 ± 20	17	64 ± 12	10	81 ± 14	10	66 ± 15	28	75 ± 19	27	65 ± 13	10.4 $I^2=0\%$	2.1 to 19	0.01
Pyrexia >37.5°C	18	0 (0%)	17	0 (0%)	10	3 (30%)	10	4 (40%)	28	3 (11%)	27	4 (15%)	0.75	0.22 to 2.5	0.64
Severe pain during initial care after enrolment	8	2 (25%)	9	8 (89%)	10	5 (50%)	10	8 (80%)	18	7 (39%)	19	16 (84%)	0.46 $I^2=28\%$	0.25 to 0.86	0.01
Severe pain on insertion of device	8	1 (13%)	3	1 (33%)	10	4 (40%)	10	7 (70%)	18	5 (28%)	13	8 (61%)	0.54 $I^2=0\%$	0.24 to 1.21	0.13
Experience of the tamponade procedure unacceptable	9	0 (0%)	3	0 (0%)	10	1 (10%)	10	5 (50%)	19	1 (5.3%)	13	5 (38%)	0.20	0.03 to 1.42	0.11

Abbreviations: MD, mean difference; RR, risk ratio; STUT, suction tube uterine tamponade; UBT, uterine balloon tamponade.

[a]Data are expressed as numbers, means ± standard deviation, or proportions (percentage) unless otherwise stated. Differing denominators are due to missing data. Comparisons by fixed effects meta-analysis except random effects for pulse due to heterogeneity ($I^2=82\%$).

[b]Ellavi balloon inserted instead.

[c]Bleeding controlled with uterotonics alone.

TABLE 3 Feasibility considerations identified during the implementation of the trial.

Identified difficulty	Description of the problem	Lessons learned in the current study
Selection of participants	Diagnosis of PPH differs in different settings.	We chose a pragmatic approach, with PPH diagnosed according to local clinical practice. In South Africa PPH was diagnosed clinically with visual estimation of blood loss. In Colombia a blood collection drape was used routinely after birth. In December 2023 WHO recommended routine blood loss measurement for all births. Future studies should employ routine blood loss measurement to standardize PPH diagnosis.
Measurement of blood loss as a study outcome	Strategies to quantify blood loss differed between South Africa and Colombia.	This was accommodated by meta-analysis of data from each country. In future studies, the method of blood loss measurement should be standardized.
Time taken for randomization	The time between diagnosis and emergency treatment is minimal. A complex randomization process is not feasible.	Considering that the included hospitals are in low- and middle-income countries where internet access for centralized randomization may be unreliable, we chose to randomize using opaque envelopes containing the sequence of intervention assignments. In Colombia the system was more efficient, where only the next sequential envelope was kept together with the "PPH kit" and was replaced with the next envelope in the sequence after enrolling a participant.
When to obtain informed consent from patients?	Obtaining informed consent from all patients antenatally means that large numbers of patients are exposed unnecessarily to time-consuming consent procedures which may cause anxiety and compromise the birth experience. Obtaining written consent after diagnosis might not provide patients with sufficient time to ask questions or adequately contemplate their response.	We chose to obtain verbal consent at the time of the diagnosis of refractory PPH, and confirm this with fully informed written consent after the event was managed, as has been done in previous similar published trials.
Barriers to introducing a new procedure such as STUT	In hospitals where UBT is routinely performed, it may be difficult to introduce STUT.	A discussion session was held with participating hospitals. We reviewed the available evidence supporting the use of UBT and STUT, emphasizing the lack of robust evidence. The potential positive impact on patient care if a benefit with STUT were proven, was discussed.
Lack of blinding	Impossible to mask during the execution of the obstetrical procedure.	Blinded observers should be used for evaluating outcomes.
Selection of hospitals to participate	Participating hospitals must have the capacity to correctly perform the surgical and research procedures.	Interventions to be compared must be clearly defined, and the participating hospitals must perform both procedures according to the study protocol. Quality control of the intervention is also essential. Although during this study we included all hospitals that expressed interest in participating, the results indicate that operational support through dedicated personnel to assist and supervise the study is fundamental. A significant educational effort is required not only for the leaders of each hospital but also for all medical and non-medical staff working in the obstetrics service, as they will be responsible for implementing the protocol.
Variability of resources available in different hospitals	Some PPH protocols require the use of expensive technology that is not available in all hospitals.	Use of PPH protocols based on procedures achievable in hospitals with limited resources. Inclusive and pragmatic or experience-based design. This protocol proposed the use of low-cost and easily obtainable supplies (Levin stomach tube).
Achieving recruitment of patients in participating hospitals	Structural, cultural, and psychological resistance exists to the use of randomization, especially during emergency situations. In Colombo, in the first 4 months of the study, it was difficult to get the primary responders to a hemorrhage event (who were not part of the investigative team) to consider something different from the Bakri balloon which they had used for several years.	After a lot of awareness work, in the second part of the study, the frequency of patient loss was lower. Almost all the included cases occurred during the day, when the local study coordinator was on duty and constantly reminded doctors, nurses, and trainees (interns) about the option to randomize treatment in case of bleeding. Only four patients were included at night, and that was in the last 2 months of the study by obstetricians who had previously included patients during the day, with the support of the study coordinator. General strategies include week-by-week support/contact with each participating hospital and clear authorship policy.

TABLE 3 (Continued)

Identified difficulty	Description of the problem	Lessons learned in the current study
Low recruitment and data validity	When using a new technique in managing a rare emergency situation, recruitment is likely to be low. Our study was affected by low recruitment, especially at the beginning of the study due to habituation to previous management, and towards the end of the recruitment period in some hospitals in South Africa when clinicians experienced (subjectively) better results with one of the two interventions.	There are several options to consider regarding the design and implementation of future studies: (1) Initial phase of familiarization: hospitals could initially execute either of the two interventions to be compared, allowing staff to become accustomed to the new intervention. However, this may not be ethically or practically feasible if one intervention has less evidence supporting its use than the other. (2) Differentiated analysis of study periods: another approach is to conduct a differentiated analysis of two study periods. The first period could involve a familiarization phase, during which groups accommodate to the new intervention. The second period assumes that all healthcare workers are familiar with the new procedure. This subgroup analysis would require a larger sample size and could increase the complexity of the study design. (3) Continuous educational and support activities: it is crucial to include ongoing educational and support activities at each hospital, which necessitates additional economic and operational investment. (4) Selective case inclusion based on staff availability: one option is to include only cases that occur when support personnel are present, excluding cases such as PPH during nights or weekends. This approach ensures consistent support and supervision but may limit the study's generalizability to situations without continuous support. There is no straightforward solution to this issue, which underscores the importance of considering these factors during the study design. Each option has its implications for feasibility, ethics, and the robustness of study findings, requiring careful evaluation based on the specific context and objectives of the research.
Inclusiveness in the study implementation activities in the participating hospitals	Presenting the study only to senior staff at each hospital is insufficient.	It is necessary to educate all the staff, not just the doctors and nursing professionals. Sometimes, the nursing assistants or trainees (interns) who knew the standard institutional protocol, in a case of failed medical management of PPH, would prepare a uterine tamponade balloon and influence the obstetrician (either by unwrapping the item that was ready in the PPH emergency kit or by asking the obstetrician to let them place the device). Most of the patients who missed randomization in Colombia were in the first 4 months of the study. This makes it clear that it is difficult to change entrenched practices within a workgroup and that any RCT in PPH requires substantial clinical, operational, and administrative support.
Financial constraints	Implementing studies with limited financial support is difficult.	This requires a culture of cooperation with each participating hospital contributing time and resources for the execution of the study.

Abbreviations: LMIC, low- to middle-income countries; PPH, postpartum hemorrhage; RCT, randomized controlled trial; STUT, suction tube uterine tamponade; UBT, uterine balloon tamponade.

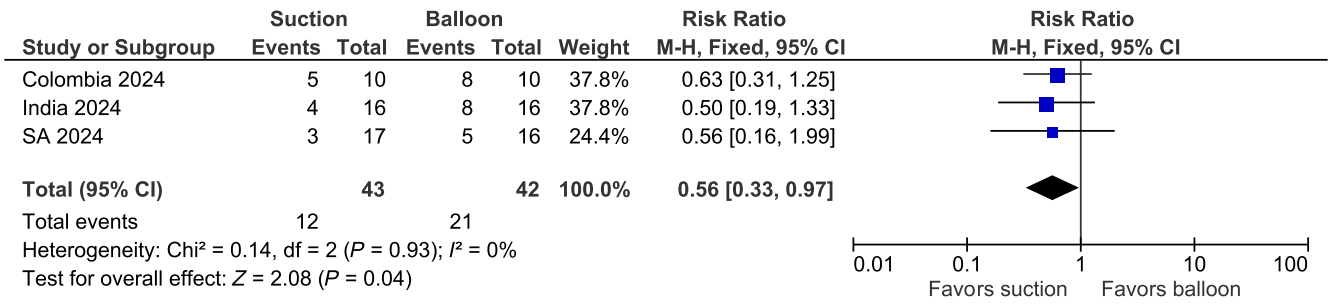

FIGURE 2 Forrest plot of meta-analysis of data from Colombia and South Africa (current study) and recent India trial[21] for the primary outcome blood loss greater than 1000 mL (Mantel-Heinzel method, fixed effects).

ACKNOWLEDGMENTS

The authors acknowledge and thank the trial participants, provincial departments of health, universities, hospitals' management, doctors, and midwives who contributed to this study.

FUNDING INFORMATION

The study received funding from the New Venture Fund, Washington DC, USA, www.newventurefund.org, grant no. NVF-NGDF-UNIV1-Subgrant-011970-2021-01-01. The research capacity development component of the study (research methods training of the site investigators) was funded by the WHO Human Reproduction Program. The funders did not participate directly in the study or preparation of the paper, which is the responsibility of the authors.

CONFLICT OF INTEREST STATEMENT

GJH has received consultancies as inventor of the Maternawell calibrated tray for blood loss monitoring after birth, which was not used in this study. The other authors have no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Mandisa Singata-Madliki https://orcid.org/0000-0003-4193-8786
Albaro J. Nieto-Calvache https://orcid.org/0000-0001-5639-9127
Luisa F. Rivera Torres https://orcid.org/0009-0000-7980-8595
Sylvia N. Cebekhulu https://orcid.org/0000-0001-6312-165X
Lawrence Chauke https://orcid.org/0000-0001-7051-6959
Logie Govender https://orcid.org/0000-0001-8157-7116
Xolani Mbongozi https://orcid.org/0000-0001-6113-3091
Poovangela Naidoo https://orcid.org/0000-0003-1879-7137
Sanele Ndaba https://orcid.org/0000-0001-9432-2198
Angelica Monroy https://orcid.org/0009-0006-7669-1807
G. Justus Hofmeyr https://orcid.org/0000-0002-3080-1007

REFERENCES

1. Gallos I, Devall A, Martin J, et al. Randomized trial of early detection and treatment of postpartum hemorrhage. *N Engl J Med*. 2023;389(1):11-21.
2. Kellie FJ, Wandabwa JN, Mousa HA, Weeks AD. Mechanical and surgical interventions for treating primary postpartum haemorrhage. *Cochrane Database Syst Rev*. 2020;1(7):CD013663. doi:10.1002/14651858.CD013663 PMID: 32609374.
3. https://apps.who.int/iris/bitstream/handle/10665/340796/9789240013841-eng.pdf.
4. Revert M, Cottenet J, Raynal P, Cibot E, Quantin C, Rozenberg P, Intrauterine balloon tamponade for management of severe postpartum haemorrhage in a perinatal network: a prospective cohort study, *BJOG* 2017;124(8):1255–1262
5. Finlayson K, Vogel JP, Althabe F, Widmer M, Oladapo OT. Healthcare providers experiences of using uterine balloon tamponade (UBT) devices for the treatment of post-partum haemorrhage: a meta-synthesis of qualitative studies. *PLoS One*. 2021;16(3):e0248656.
6. Dumont A, Bodin C, Hounkpatin B, et al. Uterine balloon tamponade as an adjunct to misoprostol for the treatment of uncontrolled postpartum haemorrhage: a randomised controlled trial in Benin and Mali. *BMJ Open*. 2017;7(9):e016590.
7. Anger HA, Dabash R, Durocher J, et al. The effectiveness and safety of introducing condom-catheter uterine balloon tamponade for postpartum haemorrhage at secondary level hospitals in Uganda, Egypt and Senegal: a stepped wedge, cluster-randomised trial. *BJOG*. 2019;126(13):1612-1621.
8. Pingray V, Widmer M, Ciapponi A, et al. Effectiveness of uterine tamponade devices for refractory postpartum haemorrhage after vaginal birth: a systematic review. *BJOG*. 2021;128(11):1732-1743.
9. Althabe F, Therrien MNS, Pingray V, et al. Postpartum hemorrhage care bundles to improve adherence to guidelines: a WHO technical consultation. *Int J Gynaecol Obstet*. 2020;148(3):290-299.
10. Fawcus S, Moodley J. *A Monograph of the Management of Postpartum haemorrhage*. South African National Department of Health. 2010:51-53 https://www.hst.org.za/publications/NonHST%20Publications/Monograph%20Postpartum%20Haemorrhage.pdf
11. Theron GB, Mpumlwana V. A case series of post-partum haemorrhage managed using Ellavi uterine balloon tamponade in a rural regional hospital. *S Afr Fam Pract*. 2004;63(1):1-4. doi:10.4102/safp.v63i1.5266
12. Ram H, Ram HS, Ram S, Panicker V. Vacuum retraction of uterus for the management of atonic postpartum hemorrhage. *IOSR-JDMS*. 2014;13(11):15-19.
13. Panicker TNV. Panicker's vacuum suction haemostatic device for treating post-partum haemorrhage. *J Obstet and Gynecol India*. 2017;67(2):150-151.
14. Purwosunu Y, Sarkoen W, Arulkumaran S, Segnitz J. Control of postpartum hemorrhage using vacuum-induced uterine tamponade. *Obstet Gynecol*. 2016;128(1):33-36.
15. D'Alton ME, Rood KM, Smid MC, et al. Intrauterine vacuum-induced hemorrhage-control device for rapid treatment of postpartum hemorrhage. *Obstet Gynecol*. 2020;136(5):882-891.
16. Haslinger C, Weber K, Zimmermann R. Vacuum-induced tamponade for treatment of postpartum hemorrhage. *Obstet Gynecol*. 2021;138(3):361-365.
17. Gulersen M, Gerber RP, Rochelson B, Nimaroff M, Jones MDF. Vacuum-induced hemorrhage control versus uterine balloon tamponade for postpartum hemorrhage. *JOGC/Journal of Obstetrics and Gynaecology Canada [Internet]*. 2023;45(4):267-272.
18. Trawick E, Watters A, Stetson BT. 723 intrauterine vacuum-induced tamponade versus intrauterine balloon-tamponade for postpartum haemorrhage management. *AJOG MFM Abstracts*. 2024;230:S386.
19. Hofmeyr GJ, Middleton K, Singata-Madliki M. Randomized feasibility study of suction-tube uterine tamponade for postpartum hemorrhage. *Int J Gynaecol Obstet*. 2019;146(3):339-343. doi:10.1002/ijgo.12889
20. Hofmeyr GJ, Singata-Madliki M. Novel suction tube uterine tamponade for treating intractable postpartum haemorrhage: description of technique and report of three cases. *BJOG*. 2020;127(10):1280-1283.
21. https://www.who.int/publications/m/item/pph-RED-TRIAL.
22. Shajahan A, Paily Paily V, Sudhamma A, et al. Postpartum haemorrhage management: a randomized controlled trial comparing transvaginal uterine artery clamp, vacuum-assisted uterine contraction and condom tamponade. *Eur J Obstet Gynecol Reprod Biol*. 2024;14(300):337-344.
23. Cebekhulu SN, Abdul H, Batting J, et al. "suction tube uterine tamponade" for treatment of refractory postpartum hemorrhage: internal feasibility and acceptability pilot of a randomized clinical trial. *Int J Gynaecol Obstet*. 2022;158(1):79-85.
24. Eldridge SM, Chan CL, Campbell MJ, et al. CONSORT 2010 statement: extension to randomised pilot and feasibility trials. *BMJ*. 2016:355.

25. Govender L, Naidoo P, Hofmeyr GJ. Preference for uterine tamponade devices as a barrier to research: a provider survey. *Am J Obstet Gynecol MFM*. 2023;5(7):100970.
26. Rozenberg P. Intrauterine Tamponade with a Belfort-Dildy Balloon in the Treatment of Immediate Postpartum Hemorrhage (TUB). https://clinicaltrials.gov/ct2/show/NCT02226731
27. Goffman D, Rood KM, Bianco A, et al. Real-world utilization of an intrauterine, vacuum-induced. *Hemorrhage-Control Device Obstet Gynecol*. 2023;142(5):1006-1016.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Singata-Madliki M, Nieto-Calvache AJ, Rivera Torres LF, et al. Suction tube uterine tamponade versus uterine balloon tamponade for treatment of refractory postpartum hemorrhage: A randomized clinical feasibility trial. *Int J Gynecol Obstet*. 2025;170:326-337. doi:10.1002/ijgo.16164