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ORIGINAL ARTICLE

Simulation Training on Uterine Compression Sutures Placement

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ABSTRACT

Background: Postpartum haemorrhage remains the leading cause of maternal morbidity and mortality worldwide. In PPH, uterine compression sutures (UCS) are effective in managing atony and related conditions. The techniques were seldom applied at Muhimbili National Hospital (MNH) despite uterine atony being the second most common cause of peripartum hysterectomy. Simulation training was done on the UCS techniques.

Objective: To determine the immediate and long-term outcomes of simulation training on UCS placement in the management of PPH.

Methods: Simulation training with uterine mattress models was conducted for the B-Lynch Suture (BLS), Hayman Suture (HS), and Cho-Squire sutures (CSS). In the pre- and post-training phases, participants reported their self-perceived knowledge and attitudes toward applying UCS via Likert-scale questions. The Wilcoxon matched-pairs signed-rank test was used to compare the median score before and after training. A P value of <.05 was considered statistically significant. A follow-up was conducted over the course of one year to assess the application of the techniques, and another year to follow up on the patients.

Results: Sixty-nine doctors participated in the training, with the majority being residents (71.1%). In the pre-training survey, 48.7% of participants reported confidence in surgically managing uterine atony via hysterectomy, 20.3% via UCS, and 26.1% reported being unable to apply any surgical method. The median (range) scores increased from 3 (1-5) to 5 (3-5) (P<.01) from pre- to post-training. B-Lynch and Hayman's sutures were used in 15 patients over a one-year period. These techniques were effective in 14 (93.3%) patients.

Conclusion: Simulation training in UCS techniques using low-cost uterine models showed significant improvements in self-perceived knowledge, positive attitude, and skills in applying BLS and HS for PPH management (P<.001). It resulted in an abrupt increase in cases of PPH managed by BLS and HS.

BACKGROUND

Postpartum haemorrhage (PPH) is recently defined as a cumulative blood loss equal to or more than 1L or any blood loss after giving birth with signs of hypovolemia, regardless of the mode of delivery.[1–3] Postpartum haemorrhage causes about 25% of maternal deaths worldwide, with uterine atony being the leading cause (75-90%) of the cases.[4] In Sub-Saharan Africa, the prevalence of PPH is estimated to be more than 33%,[5] while in Tanzania, it is 25%.[6]

Although the incidence of peripartum hysterectomy (EPH) has declined in developed countries due to atony, it has been increasing in most sub-Saharan African countries. Conversely, the complications resulting from EPH are growing. A study at a tertiary hospital in Madagascar reports an EPH prevalence of 0.44%, with atony as the leading cause, accounting for 48.7%.[7] In a University Hospital in Nigeria, a study showed an increase in EPH incidence from 3.49/1000 deliveries to 5.71/1000 deliveries between 1993 and 2003, and 2004 and 2013, respectively. In this study, uterine atony was the second most common cause.[8] In a low-resource facility in Burkina Faso, the frequency of EPH was 0.4%, of which 60% was attributed to uterine atony.[9] In a recent study at Muhimbili National Hospital (MNH), the hysterectomy rate increased from 5.8% in 2014 to 24.7% in 2020. In this review, uterine atony accounted for 25.6% of EPH cases.[10] Among the complications of EPH are an increased rate of transfusion,[8,10] ureteric injuries, and vesicovaginal fistula.[8 9] Furthermore, the loss of a uterus has psychological and social impacts on some women due to loss of fertility and a feeling of loss of womanhood.[11,12]

Uterine compression sutures (UCS) are Sutures applied in various patterns to compress the non-contracting uterus mechanically during severe postpartum haemorrhage. It is usually done when the medical method fails. The techniques are less invasive,

easy to learn, simple, safe, quick to apply, and preserve life and fertility.[5,13,14] Across the world, the use of UCS varies, with more cases reported in Europe, North America, and the Middle East.[13,15] One of the factors limiting the application of UCSs is the lack of practical or simulation-based training.[16–18] The effectiveness of UCS ranges from 76 - 100%.[13,14,18–22] Since the first publication of UCS by Christopher B-Lynch in 1997, various techniques have been developed, all aimed at controlling PPH. Among UCS techniques, the B-Lynch suture (BLS),[14] Hayman suture (HS),[21] and Cho square suture (CSS)[22] are the earliest and most reported. While BLS and HS are generally suitable for uterine atony, CSS is more effective in PPH due to a morbidly adherent placenta and bleeding from placenta praevia.[13] Technically, HS is considered the most uncomplicated method compared to BLS or CSS.[13]

Simulation training on UCS has been reported to improve self-understanding,[17,23] long-term knowledge retention,[24] confidence to apply the techniques,[25] and technical skills.[17,26]

UCS techniques were seldom applied at MNH. We found that there has been no hands-on UCS training in the department. For this reason, department doctors received simulation training on UCSs.

We prepared uterine models as simulation tools to train BLS, HS, and CSS techniques. The study aimed to impart knowledge, skills, and positive attitudes regarding UCS applications and, ultimately, to make UCS techniques an additional option for managing PPH at MNH.

METHODS

Study Design and Area

The study design was an interventional, pre-post training study. The study took place at MNH, the largest tertiary hospital in Tanzania, from 2021 to 2023. The hospital serves patients from home and primarily refers patients from hospitals in Dar es Salaam city and throughout the country. It also serves as a teaching hospital for Muhimbili University of Health and Allied Sciences and St. Joseph University of Tanzania. Approximately 60% of patients admitted to MNH for obstetric care are referrals, and 75% of Cesarean sections (CS) performed are emergencies. It is estimated to conduct 9,000 deliveries per year, with a CS rate of approximately 59%.[27] Residents perform most emergency CS procedures, except for hysterectomies, which are typically performed by Obstetricians or residents under their supervision. In PPH management, the departmental protocol recommends using medical methods first (oxytocin 10 IU bolus, then maintenance infusion at 20 IU/minute, misoprostol 1000 mcg rectally, and Tranexamic acid 1g) when uterine atony is the cause. When the medical method fails, in cases of CS, the next step is surgical interventions, which include either UCS application, bilateral uterine artery ligation, or hysterectomy. Among surgical methods, EPH was commonly used. Uterine balloon tamponade was used in cases of vaginal delivery.

Study Population

The study involved Registrars, Residents, and Obstetricians in the Department of Obstetrics and Gynaecology. Participation in the study was voluntary. In total, the department comprised 104 doctors, including obstetricians, residents, registrars and intern doctors.

Sample Size

The expected number of participating doctors was 72, based on eligibility and availability. It was the anticipated number of eligible participants and was not derived from a formal statistical calculation. Of the total number of doctors in the department, interns were excluded from the study because they were not responsible for decisions regarding the surgical management of postpartum haemorrhage. Moreover, some eligible doctors were expected to miss the training due to holidays, emergencies, outreach visits, and external rotations for residents. The training was therefore offered to doctors who met the eligibility criteria and were available and willing to participate on the day of the training.

For Patients: No prior sample size was calculated because this was a patient follow-up cohort; patients were recruited by default from the time any participating doctor performed UCS as an incidental intervention for atonic PPH during the one-year study period (2021–2022).

Sampling Technique

Convenience sampling was used because the simulation training was implemented as a departmental educational intervention, and participation depended on the availability and willingness of doctors responsible for the surgical management of PPH during the training period. The training was therefore offered to all eligible doctors in the department rather than selecting participants through a probability-based sampling procedure.

For the patients: all patients who underwent UCS during the study period, as documented by the participating doctors. They were told that at the end of the follow-up, their information and outcomes would be shared with other medical professionals.

Inclusion Criteria

For Doctors: all doctors in the department who were responsible for making decisions for the surgical management of PPH.

For patients: All patients who underwent UCS placement (BLS, HS, or CSS) for the surgical management of PPH during the one-year study period.

Exclusion Criteria

For Doctors: those who declined to participate in the study and those who were absent during the training.

For Patients: those for whom the surgeon or surgery records did not clearly state the type of UCS applied to control PPH.

The Uterine Model Preparation

The materials for preparing the uterine model included pieces of a 2-centimetre-thick mattress; a fine, slightly elastic, pale-pink fabric to mimic the natural colour of the uterine serosa; a pair of scissors; a tape measure; a sewing needle and thread; and a clipboard. All the materials were available in the street shops.

The mattress and a piece of cloth were cut to make the middle part 20 cm wide, with bilateral extensions, each 10 cm long (to serve as fallopian tubes), at the same level. In comparison, the ends were progressively tapered

from the broader middle section to a width of 12 cm. Two additional extensions, each 5 cm long, were made, extending from the middle toward one of the tapered ends (to serve as an ovarian ligament). The length from one tapered end to the other was 44 cm. On either side of the mid extensions at the proximal part, triangular cut sections were excised (4*5 cm inward and laterally, respectively). This was important for the model's later sloping appearance at the fundus (Figure 1a).

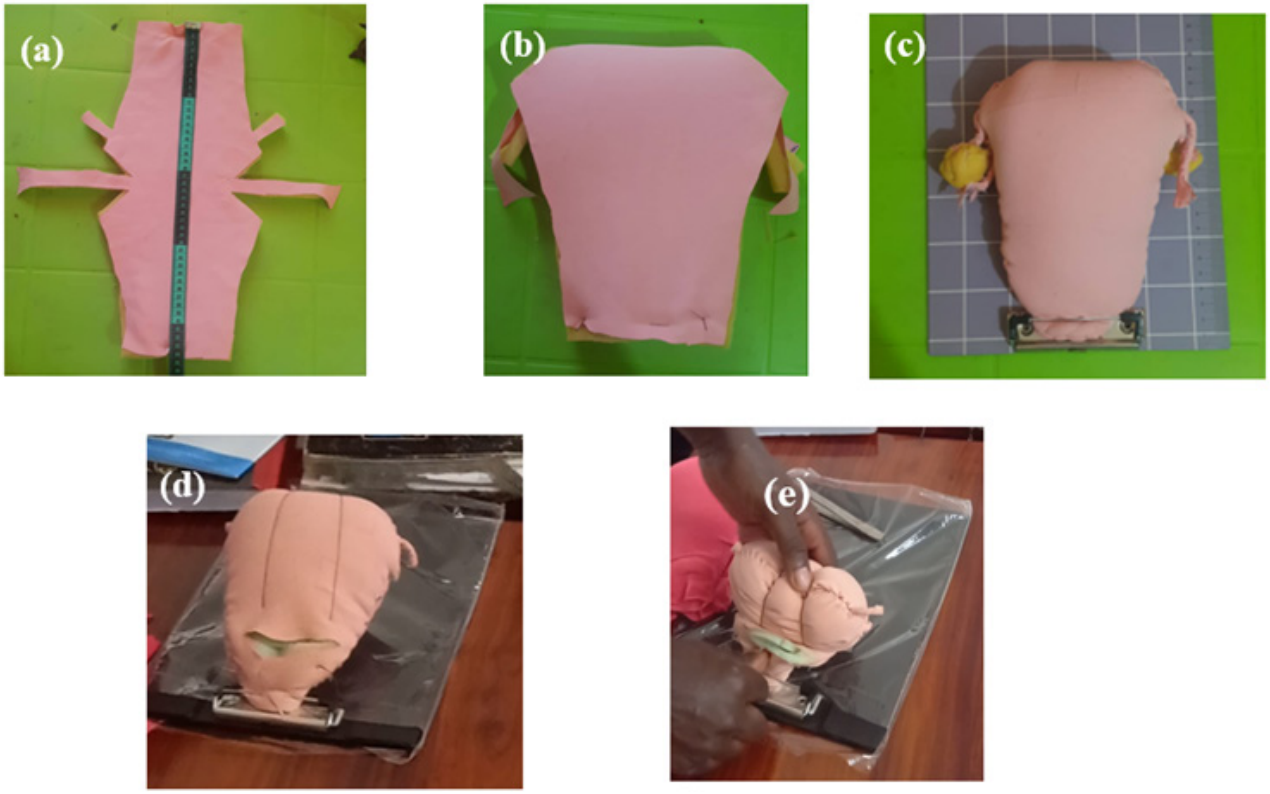
The cut pieces of mattress and fabric were adhered with staples and folded, with the fabric facing outward (Figure 1b). Using Cornelius's suture technique, the lateral free edges and the extensions were sutured using a hand-sewing needle and thread. Several small pieces of mattress were placed inside the model fundus to improve its appearance. The mattress served as the myometrium, while the piece of cloth on top represented the peritoneal layer of the uterus (serosa). The tapered ends formed the lower segment of the uterus, while the middle part, with its extensions, formed the uterine fundus, fallopian tubes, and ovarian ligament. The model was placed on a spring-loaded clipboard, which, together with the board, acted as a posterior abdominal wall anchoring the uterus in the pelvic cavity (Figure 1c to Figure 1e). It was compressible, mimicking the boggy atonic uterus. The estimated time to construct one model was 1 hour, and the estimated cost per model was approximately $5.00.

(a) a cut section of pieces of Mattress and fabric, (b) folding the cut pieces of the mattress and fabric, ready for suturing the edges, (c) the uterine model on the clipboard, (d) the lower segment is open with the suture in situ, (e) the B-Lynch suture has been tied, compressing the model

The Training and Study Tools Validation
Study Tools Validation

The principal researcher prepared the pre- and post-training questionnaires. They were pretested for validity before use, with a pilot simulation of the techniques and a review of the questionnaire first. It involved two obstetricians, five residents, and three registrars from another hospital in Dar es Salaam. Before and after the simulation, they completed the pre-and post-training questionnaire, respectively. The questionnaire clarity, length, and ease of completion were evaluated. The questionnaire consisted of "Yes"/ "No" and 5-point Likert-scale questions (1 = very low/strongly disagree, 5

FIGURE 1: Description of the Uterine Model



(a) Cut section of pieces of a mattress and fabric, (b) folding the cut pieces of the mattress and fabric, ready for suturing the edges, (c) the uterine model on the clipboard, (d) the lower segment is open with the suture in situ,(e) The B-Lynch suture has been tied, compressing the model

= very high/strongly agree) on levels of knowledge and attitude. All data collection tools were in English because all doctors were familiar with it.

The Training

The training was done in a doctor's morning report meeting room. Two weeks before the training date, the doctors were informed through posters, verbal announcements during morning report meetings, and doctors' WhatsApp groups.

The PowerPoint presentation first provided an overview of PPH, followed by descriptions of BLS, HS, and CSS, including their effectiveness, complications, possible causes, and ways to minimise complications. Then, the participants practised applying the sutures to the model in pairs. First, each procedure was demonstrated, and then the participants did it. Five pre-trained instructors from MUHAS supervised the simulation.

The Follow-up After Training

After the simulation, a data collection sheet was prepared and placed in the obstetric theatre and in the post-operative wards. The doctors were informed that if a patient with PPH was managed with UCS, it should be recorded. Every morning, the principal researcher followed up on it. The sheet comprises demographic data, the indication for caesarean section, intraoperative findings and management, the type of UCS placed, and follow-up notes. This was done for one year (2021-22), when the principal researcher moved away from the study centre. Then, after 2022-23, only the patients were followed up by phone.

On discharge, the patient's phone number was obtained, and she was given the principal researcher's phone number to be contacted in case of any problems. Importantly, she was asked to report if she saw her menses or conceived.

Data Collection and Analysis

Each participant was assigned a unique number to serve as their identity for both questionnaires. The pre-training questionnaire was filled out before UCS training. Immediately after training, participants completed the post-test questionnaire. We used IBM SPSS Statistics for Windows version 23 (IBM Corp, Armonk, NY, USA) to code, store, and analyse the data. The mean and standard deviation (SD) of age were calculated. For the "Yes/No" questions, data were analysed using frequencies and percentages. In contrast, the Wilcoxon signed-rank test was used to compare scores on levels of knowledge and attitude before and after training, with medians (ranges) reported. A P value of <.05 was considered statistically significant. The long-term outcome was defined as the actual application of UCS in the management of PPH. On the other hand, the one-year patient follow-up aimed at identifying any adverse effects of the UCS technique.

The Follow-up After Training

After the simulation, a data collection sheet was prepared and placed in the obstetric theatre and in the post-operative wards. The doctors were informed that if a patient with PPH was managed with UCS, it was recorded. Every morning, the principal researcher followed up on it. The sheet comprises demographic data, the indication for caesarean section, intraoperative findings and management, the type of UCS placed, and follow-up notes. This was done for one year (2021-22), when the principal researcher moved away from the study centre. Then, after 2022-23, only the patients were followed up by phone.

On discharge, the patient's phone number was obtained. She was also given the principal researcher's phone number to contact if any problems arose. Importantly, she was asked to report if she had her menses or conceived.

Ethical Approval and Consent to Participate

Ethical clearance and permission to conduct the study were granted by the MUHAS Senate Research and Publication Committee (ref.). No. DA.282/298/01.C/. The study participant doctors provided informed consent prior to their inclusion in the study. There were no signed consent forms for patient follow-up; instead, as is usually done before a surgical procedure, patients signed the informed consent form for CS or PPH intervention. After the procedure, those to whom UCS was applied were informed of the procedure and that a follow-up about their condition was necessary, as it was not routinely performed at the hospital. They were told that at the end of the follow-up, their information and outcomes would be shared with other medical professionals. The disclosure of patient identity was carefully done.

RESULTS

The Demographic Characteristics of the Participants

Sixty-nine participants completed the training and the pre- and post-training surveys. The mean and standard deviation (SD) of participants' ages were 37 (7.8) years. The majority of the 72 doctors were residents, comprising 49 (71.0%) (Table 1).

TABLE 1: Demographic Characteristics of Participant Doctors

Characteristics	Frequency	Percentage
Age (years)		
≤ 29	9	13.0
30 to 39	39	56.5
≥ 40	21	30.5
Mean age (±SD)	37 (± 7.8)	
Sex		
Male	42	60.9
Female	27	39.1
Qualifications of doctors		
Registrars	5	7.3
Residents	49	71.0
Obstetricians	15	21.7

Participating Doctors' Clinical Characteristics Regarding PPH Management

Among the participants, 51 (73.9%) reported being confident in managing PPH using surgical methods. The most frequently reported surgical method was hysterectomy, used in 33 cases (47.8%). The B-Lynch suture technique was the most well-known among participants (91.3%) (Table 2).

Comparison of Participants' Pre- and Post-Training Scores

Statistically, there was a significant improvement in self-perceived knowledge and attitudes toward the application of UCSs after training in the B-Lynch, Hayman, and Cho sutures. The median (range) scores rose from 3 (1-5) before training to 5 (3-5) after training (P<.001) (Table 3). Sixty-eight participants (98.6%) agreed that the simulation training was valuable.

The Outcomes After One Year

Uterine compression sutures were applied to 15 patients. The mean age (±SD) was 30.7 (±6.1) years. More than half (53%) were primiparous. All patients were delivered through CS, the indications being previous uterine scars and abruptio placenta each 33.3%, obstructed labour 20%, fetal distress, and old (38 years) age pregnancy each 6.7%. Two techniques were used: classic BLS for 8 patients and HS for 7 patients. A combination of BLS and one loop of HS was applied to one patient. This patient had a vast, boggy uterus such that the BLS alone could not control the bleeding. All patients had uterine atony, and for five mothers, it was associated with abruptio placentae.

The success rate of the techniques was 93.3% (14/15). The mean (±SD) blood loss was 1426 (±910) mls, while the mean surgery duration (IQR) was 60 (60-90) minutes. Six patients received transfusions due to significant blood loss; five of them had abruptio placentae, and one had uterine atony associated with placental accreta. One patient ended with a subtotal hysterectomy after the Hayman suture application failed. Examination of the removed uterus showed there was an incomplete uterine rupture on the left side, lower uterine segment, with hematoma formation at the site.

One patient conceived after 5 months and delivered at 39 weeks by CS a 3480 g baby. The uterus was normal structurally. Three were lost to follow-up, while 10 resumed menstruations within 2 to 4 months.

TABLE 2: Participant Doctors' Clinical Characteristics

Characteristics	Frequency	Percentage
Confidence in the management of atonic PPH by the surgical method		
Yes	51	73.9
No	18	26.1
Which surgical method do you apply confidently?		
Hysterectomy	33	47.8
Uterine artery ligation	4	8.8
Uterine compression sutures	14	20.3
Not able to apply any surgical method	18	26.1
Have you ever attended practical training on UCSs?		
Yes	9	13.0
No	60	87.0
Knowledge of B-Lynch suture		
Yes	63	91.3
No	6	8.7
Knowledge of Hayman's suture		
Yes	30	43.5
No	39	56.5
Knowledge of Cho's suture		
Yes	9	13.0
No	60	87.0

Key to abbreviations: PPH, Postpartum haemorrhage

TABLE 3: Participants' Pre- and Post-Training Scores on Knowledge and Attitude on UCS

Variable	Score Before Training		Score After Training		*P Value*
	Median	Range	Median	Range	
UCS Technique Knowledge					
B-Lynch	3.0	1-5	5.0	3-5	<.001
Hayman	2.0	1-5	5.0	3-5	<.001

Continue

TABLE 3: Continued

Variable	Score Before Training Median	Range	Score After Training Median	Range	*P Value*
Cho	1.0	1-5	5.0	3-5	<.001
Attitude*					
B-Lynch	4.0	1-5	5.0	3-5	<.001
Hayman	3.0	1-5	5.0	3-5	<.001
Cho	2.0	1-5	5.0	3-5	<.001

*Attitude was evaluated on the component "feeling": whether the participants felt they could apply UCS techniques and get PPH control
Key to abbreviations: UCS, uterine compression sutures.

DISCUSSION

Our pre-training survey of participants showed that the most common method used to control PPH due to uterine atony was an emergency hysterectomy. A quarter of participants were not confident in the management of the atonic uterus by any of the surgical methods. A few doctors reported that they had already attended UCS training with practical components. We found that simulation training improved self-perceived knowledge, attitude, and skills in UCSs. Most participants agreed that the training was valuable. In one year, there was an abrupt increase in the number of cases managed by UCSs.

Simulation training is one of the key factors in learning surgical procedures. In our survey, the number of participants who had attended UCS training previously was low. A study in the UK reported similar findings.[18] However, two other studies reported a slightly higher proportion.[16,28] The higher proportion in the latter two studies was due to their multicenter design. Teaching by simulation is now considered a bridge between theory and practice, especially for rare conditions, and it helps doctors acquire skills and confidence.[17,18,20,23,25,29] It is essential because the number of students has increased, outpacing the number of instructors and the available space in the theatre for learning surgical procedures. In our study, most participants agreed that the simulation was helpful. The same response was observed among participants in the simulation training for PPH management in Nigeria and France. In these countries, the curriculum of teaching by simulation has already been proposed.[17,25,29,30]

Following simulation training, there was a marked improvement in self-perceived knowledge and attitude to applying UCS in the management of PPH, and objectively, the techniques were applied thereafter. Before the study, a 10-year review of theatre records showed that 3 cases were managed with BLS. In the one-year post-training period, the number of cases managed with UCS was five times higher. The results show the importance of simulation training for UCS techniques. Other studies have shown the same results.[23–25]

Our results indicate that the classic BLS technique is the most widely known, most widely trained in, and most widely practised among UCS techniques. Most participants were familiar with BLS, whereas CSS was the least well-known technique. This has been demonstrated in other studies.[13,21,31] This calls for further simulation training of other UCS techniques to complement situations where the classic BLS is challenging or not applicable. For instance, when there is no opening in the lower segment of the uterus or focal bleeding at the placental bed, HS and CSS can be applied, respectively.

Study Strength

In this study, we have developed a low-cost uterine model that supports simulation training not only for UCS placement but also for uterine artery ligation and caesarean section. Most participants (residents) were from different Regions of Tanzania and from outside the country. This may later help spread knowledge and skills more easily to other health workers across various locations.

Study Limitations

Our study had some limitations: Participants completed self-assessments; hence, the information provided may be biased. The uterine model was non-biological, and there was no actual demonstration of the procedure(s) to patients. The study results cannot be generalised because the training was conducted in only one hospital.

CONCLUSION

Simulation training in UCS techniques using low-cost uterine models shows significant improvements in self-perceived knowledge, positive attitude, and skills in applying BLS and HS for PPH management (P<.001). It resulted in an abrupt increase in cases of PPH managed by BLS and HS. Through the study, a low-cost uterine model using locally available materials has been developed, and the desired outcome has been achieved. This is especially feasible in low-resource health teaching institutes and hospitals, where industrial models may be expensive.

However, further studies are still needed to harmonise the heterogeneity of UCSs, as there are no clear guidelines, for example, on when to apply the suture after PPH has occurred or on the type of suture material to use.

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