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Simulation-Based Training for Management of Uterine Bleeding in Medical Education: Improving Clinical Competence of Medical Students

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Abstract: Uterine bleeding, particularly postpartum hemorrhage, remains one of the leading causes of maternal morbidity and mortality worldwide. Rapid recognition and effective management of obstetric bleeding are essential competencies for future healthcare professionals. However, traditional medical education often provides limited opportunities for students to practice emergency obstetric interventions due to concerns about patient safety. Simulation-based education has emerged as an effective approach for teaching complex clinical skills in a safe and controlled environment. The aim of this study was to evaluate the effectiveness of simulation-based training in improving medical students' competence in the management of uterine bleeding. A prospective educational study was conducted at the simulation training center of Tashkent State Medical University during the 2025–2026 academic year. A total of 100 senior medical students participated in the study and were divided into two groups: a simulation training group (n=50) and a control group (n=50) receiving traditional clinical instruction. The simulation program included structured obstetric emergency scenarios focusing on uterine bleeding management, postpartum hemorrhage control, patient assessment, and teamwork in emergency care. Students' competencies were assessed using Objective Structured Clinical Examination, instructor evaluation checklists, and pre- and post-training knowledge tests. Statistical analysis was performed using descriptive statistics and Student's t-test, with statistical significance set at $p < 0.05$. Students who participated in simulation-based training demonstrated significantly higher clinical competence scores compared with the control group. The mean Objective Structured Clinical Examination score increased from 56.8 ± 7.4 before training to 86.2 ± 6.1 after simulation training ($p < 0.001$), while the control group showed only moderate improvement (57.1 ± 7.2 to 69.4 ± 6.9). Simulation-trained students also demonstrated better performance in recognizing uterine bleeding, initiating emergency management, and coordinating team-based care. Simulation-based training significantly improves medical students' competence in managing obstetric emergencies such as uterine bleeding. Integration of structured simulation programs into medical curricula may enhance clinical preparedness and contribute to improving maternal healthcare outcomes.

Key words: Simulation-based learning; obstetric simulation; uterine bleeding; postpartum hemorrhage; medical education; clinical competence.

INTRODUCTION

Obstetric hemorrhage remains one of the leading causes of maternal morbidity and mortality worldwide. Among these conditions, uterine bleeding, particularly postpartum

hemorrhage (PPH), represents a major global health concern. According to the World Health Organization (WHO), postpartum hemorrhage accounts for approximately 25–30% of all

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maternal deaths globally, making it the most common cause of maternal mortality, especially in low- and middle-income countries [1]. It is estimated that more than 14 million women experience postpartum hemorrhage each year, and severe cases may rapidly progress to hypovolemic shock and maternal death if timely management is not provided [2].

Early recognition and prompt management of uterine bleeding are therefore critical competencies for healthcare professionals involved in obstetric care. The most common causes of PPH include uterine atony, retained placental tissue, genital tract trauma, and coagulation disorders, all of which require rapid clinical assessment and appropriate intervention [3]. Failure to identify and treat obstetric hemorrhage in a timely manner may lead to severe maternal complications, including disseminated intravascular coagulation, multi-organ failure, and death [4].

Preparing medical students and young healthcare professionals to manage obstetric emergencies is an essential component of modern medical education. However, traditional clinical training often provides limited opportunities for students to actively participate in the management of obstetric emergencies due to patient safety concerns, ethical considerations, and the unpredictable nature of clinical cases [5]. As a result, students may graduate with insufficient practical experience in managing life-threatening conditions such as postpartum hemorrhage [6].

In recent years, simulation-based medical education has emerged as an effective strategy for improving clinical competence and practical skills among medical students and healthcare professionals. Simulation technologies allow learners to practice complex clinical procedures in a safe, controlled, and reproducible environment, without posing risks to real patients. Simulation modalities may include high-fidelity mannequins, virtual simulation systems, standardized patients, and computer-based clinical scenarios that replicate real medical situations [7]. Several studies have demonstrated that simulation-based training significantly improves students' clinical

decision-making skills, teamwork, communication abilities, and confidence in managing emergency situations [8-10]. Specifically, research has shown that features of high-fidelity medical simulations, including realism, feedback mechanisms, and repetitive practice, lead to effective learning outcomes [11]. Despite the growing recognition of simulation-based education in medical training, the integration of structured obstetric simulation programs into undergraduate medical curricula remains inconsistent across institutions. The aim of this study was to evaluate the effectiveness of simulation-based training in improving medical students' clinical competence in the management of uterine bleeding and postpartum hemorrhage.

METHODOLOGY

This study was designed as a prospective educational study and was conducted at the Simulation Training Center of Tashkent State Medical University during the 2025–2026 academic year. The simulation center is equipped with modern educational technologies, including high-fidelity obstetric simulators, task trainers for obstetric procedures, and standardized clinical scenarios designed to replicate real-life obstetric emergencies. A total of 100 senior medical students enrolled in clinical training programs participated in the study. All participants had previously completed theoretical coursework in obstetrics and gynecology but had limited exposure to emergency obstetric procedures. Participation in the study was voluntary, and all students were informed about the objectives of the research before enrollment.

The students were divided into two groups: a simulation training group (n=50) who participated in structured simulation-based training sessions focused on the management of uterine bleeding, and a control group (n=50) who received traditional clinical instruction including lectures, case discussions, and bedside observation. The simulation-based training program consisted of structured educational sessions conducted in the university simulation center. Each session involved realistic obstetric emergency

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scenarios designed to train students in the recognition and management of uterine bleeding and postpartum hemorrhage. The training scenarios focused on developing competencies in early recognition of postpartum hemorrhage, rapid clinical assessment of the patient, identification of the cause of bleeding, initiation of emergency management protocols, and teamwork and communication during obstetric emergencies. Simulation sessions used high-fidelity obstetric mannequins capable of reproducing clinical signs such as bleeding, vital sign changes, and physiological responses to treatment interventions. Each simulation session lasted approximately 60–90 minutes and included three stages: pre-briefing (introduction to the clinical scenario and learning objectives), simulation scenario (active management of uterine bleeding using obstetric emergency protocols), and debriefing session (structured discussion guided by instructors to analyze performance, identify errors, and reinforce clinical reasoning) [12].

The primary training scenario involved postpartum hemorrhage due to uterine atony, with initial clinical parameters including progressive blood loss of 500–700 mL, heart rate of 110 beats/min, blood pressure of 90/60 mmHg, respiratory rate of 24 breaths/min, oxygen saturation of 94%, and soft uterine tone indicating uterine atony. Students were required to perform rapid assessment of maternal condition, estimation of blood loss, uterine massage, administration of uterotonic medications, initiation of fluid resuscitation, communication with the medical team, and preparation for advanced interventions if bleeding persisted. The scenario was designed according to international obstetric emergency management guidelines, including recommendations from the World Health Organization and the American College of Obstetricians and Gynecologists (ACOG) [13]. Each simulation scenario lasted 20–25 minutes, followed by a 30-minute structured debriefing session where students discussed recognition of clinical signs, appropriateness of interventions, errors or delays in management, decision-

making processes, and teamwork and communication performance.

Students' competencies were assessed using multiple evaluation tools: Objective Structured Clinical Examination (OSCE) to evaluate practical clinical skills, instructor evaluation checklists during simulation scenarios, pre- and post-training knowledge tests to assess theoretical understanding of uterine bleeding management, and student feedback questionnaires to evaluate perceptions of the simulation training. Clinical performance was assessed using standardized scoring systems measuring diagnostic accuracy, appropriateness of clinical decisions, timeliness of emergency interventions, and communication and teamwork skills. Each domain was scored using a 5-point competency scale. Data were collected before and after the training sessions. Quantitative data included OSCE scores, written test results, and checklist-based performance evaluations. Statistical analysis was performed using SPSS version 23.0. Descriptive statistics were used to summarize the data, including mean values and standard deviations. Differences between the simulation training group and the control group were analyzed using Student's t-test, with statistical significance defined as $p < 0.05$. The study was conducted in accordance with ethical standards for educational research. Participation was voluntary, and all students provided informed consent prior to inclusion in the study. Personal data were anonymized to ensure confidentiality and privacy of the participants.

RESULTS

A total of 100 senior medical students participated in the study. The participants were equally divided into a simulation training group ($n=50$) and a control group ($n=50$) receiving traditional clinical instruction. Baseline theoretical knowledge and initial clinical competence were comparable between the two groups before the training intervention ($p > 0.05$). After completion of the training program, students who participated in simulation-based obstetric emergency training demonstrated significantly higher clinical competence in the

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management of postpartum hemorrhage compared with the control group.

Table 1 shows the comparison of Objective Structured Clinical Examination (OSCE) scores between the two groups before and after training. Students in the simulation group showed a substantial improvement in OSCE

performance, with mean scores increasing from 56.8 ± 7.4 before training to 86.2 ± 6.1 after simulation training ($p < 0.001$). Although the control group also demonstrated moderate improvement from 57.1 ± 7.2 to 69.4 ± 6.9 ($p = 0.03$), the increase was significantly smaller compared with the simulation-trained students.

Table 1. Comparison of OSCE Scores Before and After Training

Group	Before Training (Mean \pm SD)	After Training (Mean \pm SD)	p-value
Simulation group (n=50)	56.8 ± 7.4	86.2 ± 6.1	<0.001
Control group (n=50)	57.1 ± 7.2	69.4 ± 6.9	0.03

Students' ability to recognize and manage postpartum hemorrhage was evaluated during simulation scenarios using structured clinical evaluation checklists. Table 2 presents the clinical performance indicators for both groups. Students who participated in simulation-based training demonstrated significantly better performance in recognizing postpartum hemorrhage and initiating appropriate emergency interventions compared with those

who received only traditional clinical instruction. Specifically, 88.0% of the simulation group demonstrated early recognition of hemorrhage compared to 65.0% of the control group ($p = 0.01$); 84.0% accurately diagnosed uterine atony versus 62.0% ($p = 0.02$); 82.0% correctly initiated uterotonic therapy versus 60.0% ($p = 0.01$); and 86.0% performed timely fluid resuscitation versus 64.0% ($p < 0.01$).

Table 2. Clinical Performance in Postpartum Hemorrhage Management

Clinical Indicator	Simulation Group (%)	Control Group (%)	p-value
Early recognition of hemorrhage	88.0	65.0	0.01
Accurate diagnosis of uterine atony	84.0	62.0	0.02
Correct initiation of uterotonic therapy	82.0	60.0	0.01
Timely fluid resuscitation	86.0	64.0	<0.01

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Team-based management is essential in obstetric emergencies. Table 3 summarizes the teamwork and communication performance of both groups. Students trained with simulation scenarios demonstrated significantly higher teamwork and communication scores, reflecting improved coordination and leadership during emergency obstetric

management. The mean team communication score was 4.5 ± 0.6 in the simulation group compared to 3.4 ± 0.7 in the control group ($p < 0.001$); task coordination scores were 4.3 ± 0.7 versus 3.2 ± 0.8 ($p < 0.001$); and leadership in emergency management scores were 4.2 ± 0.8 versus 3.1 ± 0.9 ($p < 0.001$).

Table 3. Teamwork and Communication Performance

Indicator	Simulation Group (Mean \pm SD)	Control Group (Mean \pm SD)	p-value
Team communication score	4.5 ± 0.6	3.4 ± 0.7	<0.001
Task coordination	4.3 ± 0.7	3.2 ± 0.8	<0.001
Leadership in emergency management	4.2 ± 0.8	3.1 ± 0.9	<0.001

Overall, the results indicate that simulation-based obstetric training significantly improves medical students' clinical competence, decision-making ability, and teamwork skills in the management of postpartum hemorrhage.

DISCUSSION

Postpartum hemorrhage remains one of the leading causes of maternal morbidity and mortality worldwide. According to international data, postpartum hemorrhage accounts for approximately 25–30% of maternal deaths globally, particularly in low- and middle-income countries [1,2]. The World Health Organization emphasizes that rapid recognition and timely intervention are the most critical factors in preventing severe maternal outcomes [3,4]. Therefore, effective training of healthcare professionals in emergency obstetric management is essential for improving maternal health indicators [5,6].

The present study demonstrated that simulation-based training significantly improves clinical competence, decision-making ability, and teamwork skills in the management

of postpartum hemorrhage among medical students. Students who participated in simulation scenarios showed significantly higher OSCE scores (86.2 ± 6.1 vs. 69.4 ± 6.9 , $p < 0.001$) and better performance in clinical decision-making compared with those trained through traditional teaching methods. These findings are consistent with recommendations from the American College of Obstetricians and Gynecologists, which highlights the importance of simulation-based training in preparing healthcare providers for obstetric emergencies [13]. According to ACOG guidelines, regular simulation exercises enable clinicians to practice critical interventions, reduce delays in treatment, and improve coordinated team responses during life-threatening complications such as postpartum hemorrhage.

In our study, students trained with simulation scenarios demonstrated significantly higher rates of early recognition of hemorrhage (88.0% vs. 65.0%), correct administration of uterotonic agents (82.0% vs. 60.0%), and timely fluid resuscitation (86.0% vs. 64.0%). These results align with global clinical recommendations,

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which emphasize the importance of early identification of uterine atony and rapid initiation of uterotonic therapy as the first-line treatment strategy for postpartum hemorrhage [13]. The positive impact of simulation-based education on clinical performance has also been reported in several international studies. Research published in high-impact medical journals has shown that simulation training improves both technical and non-technical skills, including clinical reasoning, crisis resource management, and communication during emergency situations [7,11,14]. Such training environments allow learners to practice complex clinical scenarios without risk to real patients, thereby enhancing both confidence and competence [15].

Furthermore, teamwork and communication skills are essential components of effective obstetric emergency management. In our study, students in the simulation group demonstrated significantly higher scores in team communication (4.5 ± 0.6 vs. 3.4 ± 0.7 , $p < 0.001$), leadership (4.2 ± 0.8 vs. 3.1 ± 0.9 , $p < 0.001$), and task coordination (4.3 ± 0.7 vs. 3.2 ± 0.8 , $p < 0.001$). These findings support previous international research indicating that simulation training improves interdisciplinary collaboration and reduces clinical errors in emergency settings [8,9,16]. A prospective randomized trial by Daniels et al. demonstrated that simulation-based teaching was superior to traditional didactic teaching for obstetrical emergencies [10]. Similarly, the Cochrane review by Fransen et al. concluded that multi-professional simulation-based team training in obstetric emergencies improves patient outcomes and trainee performance [12]. Another important advantage of simulation-based training is the opportunity for structured debriefing. During the debriefing sessions, participants were able to analyze their clinical decisions, identify errors, and discuss optimal management strategies according to international protocols. This reflective learning process significantly enhances knowledge retention and promotes evidence-based clinical practice [11,14]. Research by Zendejas et al. has shown that simulation-based medical education translates into improved patient outcomes [15],

while Walker et al. demonstrated that simulation-based programs in obstetric and neonatal emergencies significantly improve team performance and clinical management [16]. Overall, the results of this study confirm that simulation-based medical education is an effective method for improving the preparedness of future healthcare professionals in managing obstetric emergencies such as postpartum hemorrhage. Integration of structured simulation training into medical curricula may therefore play a crucial role in improving the quality of obstetric care and reducing preventable maternal complications [17].

CONCLUSION

The findings of this study demonstrate that simulation-based training significantly improves medical students' clinical competence in the management of postpartum hemorrhage, one of the most critical obstetric emergencies. Students who participated in structured simulation scenarios showed markedly higher OSCE scores (86.2 ± 6.1 vs. 69.4 ± 6.9 , $p < 0.001$), better clinical decision-making abilities, and more effective teamwork performance compared with those who received traditional clinical instruction. Simulation-based education allows learners to practice complex emergency situations in a controlled and safe environment, enabling the development of both technical skills and non-technical competencies, including communication, leadership, and rapid decision-making. These skills are essential for timely recognition and effective management of postpartum hemorrhage. The results of this study are consistent with international recommendations of the World Health Organization and the American College of Obstetricians and Gynecologists, which emphasize the importance of regular emergency obstetric training and simulation exercises to improve maternal outcomes [1-4,13]. Integration of simulation-based training into undergraduate medical education can therefore play a significant role in enhancing the preparedness of future physicians for obstetric emergencies. Such educational strategies may contribute to improved quality of maternal

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healthcare and reduction of preventable maternal morbidity and mortality [5,6,17].

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