Implementation of Low-Cost Obstetric Hemorrhage Simulation Training Models for Resident Education

Abigail M. Ramseyer, DO, FACOG*; CDR. Monica A. Lutgendorf, MC, USN†

ABSTRACT
Introduction: Simulation is beneficial training for low frequency high acuity events such as management of obstetric hemorrhage. Our objective was to evaluate perceived competency in management of obstetric and pelvic hemorrhage following training with low fidelity task trainers using inexpensive and common medical supplies. Materials and Methods: This was a prospective observational study of training residents for management of obstetric and pelvic hemorrhage using a brief didactic instruction and low-cost task trainers with inexpensive common medical supplies. Participants practiced placement of a uterine tamponade balloon, uterine packing with gauze, pelvic parachute packing and temporary abdominal closure. Following training, participants completed a self-report survey regarding perceived competency with each technique. The Wilcoxon Signed-Rank Test was used to compare results before and after training. Results: Eighteen of 23 residents completed the training and completed the survey on perceived competencies. There was a statistically significant improvement in perceived competency for all participants before and after training, with scores improving by 1.5 points for Bakri placement, from 1.94 to 3.44 ($p < 0.001$), improving by 1.67 points for uterine packing, from 1.78 to 3.44 ($p < 0.001$), improving by 1.95 for pelvic parachute packing, from 1.16 to 3.11 ($p < 0.001$), and improving by 1.89 for temporary abdominal closure, from 1.22 to 3.11 ($p < 0.001$).

Conclusions: Low-cost supplies and task trainers can be utilized to simulate postpartum hemorrhage and improve perceived competency in managing obstetric and pelvic hemorrhage. Similar training programs can be used in small community programs with limited resources.

INTRODUCTION
Maternal morbidity and mortality are increasing in the United States. Obstetric emergencies such as postpartum hemorrhage are significant contributors, and current national recommendations reinforce the importance of simulation training as part of effective systems readiness and response. Team performance, communication, critical thinking and leadership during emergencies are critical elements to improve patient outcomes. Evaluations of suboptimal outcomes in emergencies demonstrate common errors including confusion in roles and responsibilities, lack of cross-monitoring, failure to prioritize and perform tasks in a structured, coordinated manner, communication deficits and lack of organization. Simulation training can be useful in developing effective multidisciplinary teams and provide a safe opportunity to develop and maintain skills. Multidisciplinary teams that are taught how to manage obstetrics emergencies using simulation are more likely to report improvements in confidence levels, knowledge and clinical skills than teams taught with didactic lectures alone. Research on simulation training demonstrates the effectiveness of this intervention as a complement to didactic education in residency training programs. Several studies have shown that simulation increases long-term retention of management skills while also improving confidence and minimizing anxiety. When medical simulation is conducted in a high stress environment, it allows participants to practice management skills and performance under stressful conditions that then leads to improved coordination and communication skills outside of the patient care setting. Hands on simulation and task trainers provides time for trainees to practice algorithms used in patient care, learn equipment and maintain skills, and practice communication prior to encountering an actual emergency in clinical practice.

Simulation also reinforces the six general competencies that govern graduate medical education programs as outlined by the Accreditation Council for Graduate Medical Education including patient care, medical knowledge, practice-based learning and improvement, interpersonal and communication skills, professionalism, and systems-based practice. Residents are expected to have a solid medical knowledge base, be able to communicate effectively, to accurately gather critical information,
to make appropriate informed decisions, and to design and complete patient management plans. Simulation training and task trainers to practice skills provide a vehicle for residents to gain knowledge and hone skills in preparation for future clinical practice and provides a safe opportunity to improve patient care. Prior studies have demonstrated the utility of skills and teamwork training using obstetric simulators in improving resident confidence and competence in managing obstetric emergencies.

In remote or community settings with limited resources appropriate training and use of available supplies can provide life-saving care and allow stabilization and safe transfer to a higher level of care. Prior studies of simulation training in low resource settings have demonstrated an improvement in self-reported technical and management skills. Given the unique challenges in low resource settings, increased familiarity with temporizing measures such as pelvic packing is important prior to transport. Low-cost task trainers can be an integral part of training and skills maintenance, especially for high acuity low frequency events such as obstetric hemorrhage. The objective of our study was to evaluate the effects of skills training with low-cost task trainers and common medical supplies on perceived competency with management of obstetric and pelvic hemorrhage.

METHODS
This investigation was approved by the Chief, Navy Bureau of Medicine and Surgery, Washington, D.C. Research data were derived from an approved Naval Medical Center, Portsmouth, VA IRB protocol [NMCP.2010.0056]. This was a prospective observational study of a convenience sample of residents from a single institution. Obstetrics and gynecology residents at Naval Medical Center Portsmouth (a large military treatment facility in southeastern Virginia) attended a lecture followed by a series of task trainer exercises using simulators and common medical supplies. After completion of the training and the task trainer sessions, all participants completed a self-report survey using a four-point Likert scale noting independent competency with each technique before and after the exercise. Choices included: Not at all competent (1), Minimally competent (2), Somewhat competent (3) and Definitely competent (5). Data were analyzed using the Wilcoxon Signed-Rank test due to the small sample size.

Training Intervention
The residents attended a 1-hour lecture on postpartum hemorrhage and pelvic hemorrhage as well as techniques for clinical management such as uterine packing and uterine balloon tamponade. The lecture included instruction on emergency parachute packing of the pelvis and temporary abdominal closure, techniques used by the military in combat trauma evacuations, and potentially useful in remote or isolated military treatment facilities and community hospitals to treat refractory pelvic hemorrhage.

FIGURE 1. Cantaloupe uterine model. (A) Cut top edge off and remove seeds; (B) finished model with hollow oblong cavity; (C) Bakri balloon in uterine model; (D) Assessing uterine tamponade.
After attending the lecture, the obstetrics and gynecology residents completed three task trainer exercises to practice management of postpartum hemorrhage and uncontrolled pelvic hemorrhage using common medical supplies. Residents were divided into training teams containing one resident from each year-group. These teams completed a series of rotations through three stations: uterine packing and uterine tamponade balloon, pelvic parachute packing, and temporary abdominal closure. Each station was staffed with an attending physician to provide hands on guidance as participants completed guided practice on the skills demonstrated with each task trainer. Residents completed a series of rotations, spending approximately 45 minutes at each station. With staff guidance, residents were allowed to practice skills until they felt comfortable with the techniques and principles.

**Task Trainer Models**

For the postpartum hemorrhage task trainer basic mannequin and a hollowed-out cantaloupe melon were used to simulate the atonic postpartum uterus. The melon model was constructed by orienting the cantaloupe vertically and cutting the top edge off, then removing the seeds leaving a vertically oriented oblong cavity. (Fig. 1) Intravenous catheter tubing was threaded through a hole in the top of the melon with red colored solution instilled to provide “active hemorrhage” for the simulation. Alternate options include similarly sized hollow fruits such as honeydew melons or papayas. During the postpartum hemorrhage exercise, the residents practiced uterine packing using standard gauze, as well as a commercial uterine balloon tamponade system, the Bakri Postpartum Balloon (Cook Medical, Bloomington, IN).

Participants practiced placing a uterine tamponade balloon into the simulated uterus (melon) per manufacturer instructions to achieve tamponade of the simulated atonic postpartum uterus. (Fig. 1) Residents were able to feel the pressure/tamponade effect of the balloon against the simulated uterus. (Fig. 1D) The standard uterine packing technique involved placing a non-adherent barrier inside the simulated atonic uterus (melon). A sterile Mayo stand cover was used, with one corner cut and the closed end inserted into the simulated uterine cavity. Rolled radiopaque gauze were then tied together and ring forceps were used to pack the gauze beginning high in the fundus of the uterus and continuing to the lower uterine segment until tamponade was achieved.

For the pelvic hemorrhage task trainer, an abdominal pelvic mannequin was used to simulate pelvic parachute packing and temporary abdominal closure. For emergency pelvic parachute packing, sterile x-ray covers were used to create a non-adherent barrier, rolled radiopaque gauze packing was tied into a continuous strip and placed in the sterile x-ray cover. The lower edge was gathered into a neck with a gauze tail. The pack was placed in the pelvic model with the neck passed through the vagina and weighted with a liter bag of fluid tied to the neck with IV tubing as shown in Fig. 2.

For the temporary abdominal closure task trainer, an abdominopelvic mannequin was used, and residents were taught to secure the pelvic/abdominal packing with a temporary using moist sterile towels, Jackson-Pratt drains and suction with and a large adhesive dressing as would be done prior to transport to a higher level of care (Fig. 3).

**RESULTS**

Of the 23 obstetrics and gynecology residents in all year-groups, 18 (78%) attended the lecture, simulations and completed the survey. Participant level of training was fairly...
evenly distributed across all year groups, with 34% (n = 6) in post-graduate year (PGY) 1, and 22% (n = 4) in PGY-2, PGY-3 and PGY-4.

There was a statistically significant improvement in perceived competencies after the training. A Wilcoxon Signed-Ranks Test indicated that post-training scores (median 3.5) were significantly higher than pre-training scores (median 1) for perceived competency with Bakri placement, \( z = 3.6, p < 0.001 \), with mean scores improving by 1.5 points, from 1.94 to 3.44 post-training. Post-training scores (median 3) were also significantly higher than post-training scores (median 1.5) for perceived competency with uterine packing, \( z = 3.8, p < 0.001 \), with mean scores improving by 1.67 points, from 1.78 to 3.44 post-training. For pelvic parachute packing, post-training scores (median 3) were significantly higher than pre-training scores (median 1) for perceived competency, \( z = 3.8, p < 0.001 \), with mean scores improving by 1.95 points, from 1.16 to 3.11 post-training. Similarly, post-training scores (median 3) were significantly higher than pre-training scores (median 1) for perceived competency, \( z = 3.8, p < 0.001 \), with mean scores improving by 1.89, from 1.22 to 3.11 post-training. (Fig. 4)

**DISCUSSION**

Use of a didactic educational program and low-cost task trainer sessions improved resident perceived competency of their management of obstetric and pelvic hemorrhage for all skill including uterine tamponade balloon, uterine packing, pelvic parachute packing and temporary abdominal closure. Although we did not evaluate individual experiences, as residents progress throughout training, they continue to gain knowledge and clinical experiences that shape their practice, and ongoing training and experiences may further impact participant competencies and comfort.

High fidelity birthing mannequins can be used to simulate obstetric emergencies and enhance multidisciplinary team training and patient care. However, this resource is not available at all hospitals, and the cost of these mannequins can range from $10,000–15,000. Additionally, not all models offer the option to utilize equipment and practice skills such as uterine balloon tamponade placement and uterine packing. The models we used in our simulation allowed participants to practice skills for managing postpartum hemorrhage at a low cost and in a safe, low-stress environment. The approximate cost of the simulation without the pelvic/abdominal models is estimated to be $300, which incorporates the cost of the common supplies and the balloon tamponade system. Though uterine tamponade balloons are commonly used in the United States, low cost alternatives have been reported using a condom fastened to a 24-French Foley catheter with cotton string. The opportunity to focus on procedural skills is another benefit, that is particularly useful for low frequency high acuity events such as management of postpartum and pelvic hemorrhage.

This prospective observational study sought to evaluate a simulation technique using common medical supplies that can potentially be adopted in smaller hospitals with limited resources. The supplies used for this training are available at all levels of care, including hospitals in the community setting and more remote or rural areas. Practice and use of these techniques may allow for stabilization and transfer to a higher level of care and could also improve care and outcomes for women in the community and in lower resource settings. Consistent training of the entire care team is important, as simulation training is educationally beneficial in residency training programs and improves outcomes when a multidisciplinary approach is used. Decreasing the cost of such equipment while maintaining a realistic simulation experience enhances team training and may allow more widespread use and benefits in lower resource settings.

The limitations of this study are the small number of participants and the fact that it was limited to a single institution in a large military treatment facility. Additionally, the measure of success of our simulation program was judged by participant self-reported perception of competency following the training. Objective assessment of resident skills and ability to perform in actual clinical scenarios was not conducted.

**FIGURE 3.** Temporary abdominal packing.

**Supplies:**
- Mayo stand cover
- 4 blue surgical towels
- 2 Jackson-Pratt drains
- 1 antimicrobial adhesive drape
  (e.g., loban incise drape)
- 1 portable wound vacuum or low continuous wall suction

**Assembly:**
- Cut an approximately 18 x 24 inch piece from a sterile Mayo stand cover
- Cut fenestrations in the drape piece
- Place evenly in the abdomen/pelvis over bowel and under abdominal fascia
- Place 2 folded blue towels over the abdominal incision
- Place 2 flat Jackson-Pratt drains above the towels
- Place 2 more folded blue towels over the JP drains
- Cover everything with antimicrobial adhesive drape
- Connect to wound vacuum or low continuous suction
Additionally, the training intervention included both a lecture and a task trainer component. We are unable to tell specifically which portion of the intervention provided the most benefit. However, the ability to practice and apply knowledge in hands-on activities has been shown to be beneficial in prior studies.³

CONCLUSION

Overall, the standardized educational program and simulation scenarios improved resident perceived competency of the management of obstetric and pelvic hemorrhage. These simulation techniques are relatively inexpensive, and can be used in smaller hospitals and locations with limited resources. Simulation of these rare events provide invaluable hands-on experiences for residents and can also be used in a labor and delivery setting to practice teamwork strategies and improve patient care. Future simulations could also incorporate faculty evaluation of resident competency and performance, and could be used to follow skills longitudinally to determine optimum frequency of training. The training models described above are simple and cost-effective, and could be integrated into ongoing unit training and simulations to improve provider skills in managing obstetric emergencies in community and remote settings.

REFERENCES

1. Creanga AA, Berg C, Syverson C, Seed K, Bruce FC, Callaghan WM.: Pregnancy-related mortality in the United States, 2006–2012. Obstet Gynecol 2015; 125: 5–12.
2. Main EK, Goffman D, Scavone BM, et al: National partnership for maternal safety consensus bundle on obstetric hemorrhage. Obstet Gynecol 2015; 126: 155–162.
3. Pliego JF, Wehbe-Janek H, Rajab M, Browning JL, Fothergill RE: Ob/Gyn boot camp using high-fidelity human simulators: enhancing residents’ perceived competency, confidence in taking a leadership role, and stress hardiness. Simulation Healthcare 2008; 3(2): 82–89.
4. Sissakos D, Crofts JF, Winter C, Weiner CP, Draycott TJ.: The active components of effective training in obstetric emergencies. Br J Obstet Gynecol 2009; 116: 1028–1032.
5. Issenberg SB, McGaghie WC, Petrusa ER, Gordon E, Scalese RJ.: Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. Med Teacher 2005; 27(1): 10–28.
6. Srinivasan M, Hwang JC, West D, Yellowless PM.: Assessment of clinical skills using simulator technologies. Acad Psychiatry 2006; 30: 505–515.
7. Jude DC, Gilbert GG, Margrane D: Simulation training in obstetrics and gynecology clerkships. Am J Obst Gynecol 2006; 195: 1489–1492.
8. Crofts JF, Bartlett C, Ellis D, Hunt LP, Fox R, Draycott TJ.: Training for should dystocia: a trial of simulation using low-fidelity and high-fidelity mannequins. Obstet Gynecol 2006; 108: 1477–1485.
9. Deering S, Hoder J, Wylen M, Poggi S, Nielsen P, Satin A.: Additional training with an obstetric simulator improves medical student comfort with basic procedures. Simulation Healthcare 2006; 1: 32–34.
10. Pliego J, Rajab H.: Residency education: impact of clinical simulation training on anxiety and self-confidence. Simul Healthcare 2006; 1: 49–55.
11. Dressang LT, Gonzalez MMA, Beasley J, et al: The impact of Advanced Life Support in Obstetrics (ALSO) training in low-resource countries. Int J Gynecol Obstet 2015; 131: 209–215.
12. Dildy GA.: An effective pressure pack for severe pelvic hemorrhage. Obstet Gynecol 2006; 108(5): 1222–6.
13. Makin J, Suarez-Reblin DJ, Shivkumar PV, Tarimo V, Burke TF.: Innovative uses of condom uterine balloon tamponade for postpartum hemorrhage in India and Tanzania. Case Rep Obstet Gynecol 2018; 4952048. doi:10.1155/2018/4952048.
14. Ramanathan A, Eckardt MJ, Nelson BD, et al: Safety of a condom uterine balloon tamponade (ESM-UBT) device for uncontrolled primary postpartum hemorrhage among facilities in Kenya and Sierra Leone. BMC Pregnancy Childbirth 2018; 18: 168.