Title
Shoulder Dystocia Delivery by Emergency Medicine Residents: A High-fidelity versus a Novel Low-fidelity Simulation Model—A Pilot Study

Journal
AEM Education and Training, 1(4)

ISSN
2472-5390

Authors
Hart, Danielle
Nelson, Jessie
Moore, Johanna
et al.

Publication Date
2017-10-01

DOI
10.1002/aet2.10054

Peer reviewed

Shoulder Dystocia Delivery by Emergency Medicine Residents: A High-fidelity versus a Novel Low-fidelity Simulation Model—A Pilot Study

Danielle Hart, MD, MACM, Jessie Nelson, MD, Johanna Moore, MD, Eric Gross, MD, Adeleki Oni, MD, and James Miner, MD

ABSTRACT

Background: Shoulder dystocia (SD) requires emergent intervention to prevent maternal and fetal harm, and simulation models for training can be expensive. We developed a novel, cheap and easily transportable low-fidelity simulation (LFS) model to compare to a commercially available high-fidelity simulation (HFS) model.

Methods: Emergency medicine residents were randomized to training on the HFS or novel LFS model. Subjects completed a pretest and a 1-week and 6-month posttest including a self-assessment and a simulated SD delivery.

Results: Twenty-seven of the 43 residents completed the study (63%). The number of individuals performing dangerous maneuvers at baseline was similar, 1 week after training was five in HFS and 11 in LFS ($p = 0.08$) groups and at 6 months was again similar between groups. Mean checklist scores for appropriate actions increased 1 week after training but returned to baseline by 6 months and were similar between groups. The rate of successful delivery, median time to successful delivery, and maximum force applied improved at 1 week and was sustained at 6 months in both groups.

Conclusion: Within our limited study population, we did not find a large difference in the occurrence of dangerous actions during simulated SD delivery following HFS and LFS training. Our novel and easily transportable LFS trainer, assembled for less than US$10 each, may be a useful tool to train inexperienced providers on the steps of this procedure. However, this requires further study, as does whether HFS models with force monitoring capabilities may be helpful to train providers to minimize dangerous maneuvers such as the application of excessive force.

Shoulder dystocia (SD) complicates 0.6% to 1.4% vaginal deliveries and requires emergent intervention to prevent maternal and fetal harm.[1–3] Fetal risk of injury ranges from 4% to 40% in deliveries complicated by SD.[3] Improvement in management after simulation training has been associated with improved performance on SD drills, clinical performance, and patient outcomes.[2,4–6]

In this pilot study, we measured the frequency of dangerous maneuvers, appropriate maneuvers, and successful deliveries on a simulated SD model before and after emergency medicine (EM) residents were

From the Department of Emergency Medicine, Hennepin County Medical Center (DH, JM, EG, JM), and the University of Minnesota Medical School (DH, JN, JM, AO, JM); the Department of Emergency Medicine at Regions Hospital (JN). Dr. Gross is currently with the Department of Emergency Medicine, University of California at Davis. Dr. Oni is currently with the Department of Emergency Medicine, University of Maryland Medical Center.
Received February 28, 2017; revision received July 19, 2017; accepted August 1, 2017.
The authors have no relevant financial information or potential conflicts to disclose.
Supervising Editor: Jason Wagner, MD.
Address for correspondence and reprints: Danielle Hart, MD; e-mail: Hartd000@gmail.com
AEM EDUCATION AND TRAINING 2017;1:357–362.

doi: 10.1002/aet2.10054
ISSN 2472-5390

trained using a high-fidelity or novel low-fidelity model. We hypothesized for our primary outcome that training with high-fidelity simulation training with force monitoring would be associated with fewer dangerous maneuvers than the low-fidelity simulation training.

METHODS

Study Design

This institutional review board–approved, prospective randomized blinded study had two groups; investigators and assessors were blinded to which educational intervention subjects received. Prior to participation, all subjects gave written informed consent.

Study Setting and Population

This study was conducted at an urban county Level I trauma center with a convenience sample of 43 residents from EM and combined EM/internal medicine residencies.

Study Protocol

Participants self-assessed confidence on SD management and then managed a simulated SD as a pretest. This was followed by a 1-hour educational intervention beginning with 20 minutes of didactics jointly conducted by an EM and obstetric (OB) expert, reviewing the steps of SD management including a narrated demonstration. Subjects were then randomized to 40 minutes of hands-on training with a high-fidelity simulator (HFS; PROMPT birthing simulator, Laerdal Inc.), with force monitoring, or a novel low-fidelity simulation (LFS) model made from a miniature doll and an inflatable armband for less than US$10 each (Figure 1). Training in each group was facilitated by an expert in SD management (an EM or OB attending), allowing all participants to practice the maneuvers with real time feedback and observe each other. In the HFS arm, the participants also got real-time feedback on forces applied to the neonate's head and neck during delivery via force monitoring cables within the simulator. Since there was no ability to monitor the forces applied on the LFS model, instructors solely defined and discussed the dangers of "excessive force" (>100 Newtons [N]) in the LFS group. The SD was created on the LFS model by having the instructor (or a partner) hold the feet of the miniature doll and not allowing delivery until appropriate maneuvers were performed. Following the educational intervention, subjects again self-rated confidence (scale 1–5) and performed a simulated SD delivery at 1 week and 6 months on the HFS model.

Figure 1. Novel low-fidelity simulation delivery model.

Measurements

Emergency medicine and OB faculty reviewed the skill checklist detailing required steps of the procedure adapted from Daniels et al.[5] for content validity. Feasibility and reliability of our skills checklist was established with four blinded EM faculty observing three test subjects (one novice, one intermediate, one expert) manage a simulated SD, ensuring that there was at least 75% agreement on each checklist item in each case. This was calculated by simple percentage agreement with at least three of four raters agreeing on each item and was achieved on the first round of scoring for each of the three test subjects. The critical actions checklist included appropriate, neutral, and dangerous maneuvers, with each appropriate action given a value of one point (maximum one points).[2,7] We also recorded whether the delivery was successful (within 3 minutes), the time to delivery, and the maximum force applied (Data Supplement S1, available as supporting information in the online version of this paper, which is available at https://doi.org/onlinelibrary.wiley.com/doi/10.1002/aet2.10054/full).

The simulation was constructed such that after McRoberts, suprapubic pressure, delivery of the posterior arm, and a rotational maneuver were successfully performed, the baby would deliver. Delivery of the posterior arm prior to internal rotational maneuvers was included as checklist item under appropriate actions since that maneuver was associated with a higher rate of successful delivery than internal maneuvers.[1] The more extreme maneuvers such as intentional clavicle fracture, Zavanelli, and symphysotomy were listed as dangerous actions as they were not indicated in this scenario and it could be a source of morbidity to perform those interventions prior to performing the other appropriate maneuvers.[7] Fundal pressure has also been defined as a dangerous action, as it could further impact the shoulder in a dystocia and could even result in uterine rupture.[2,3,8] We classified force > 100 N as a dangerous action based on prior OB studies that have used this same definition, in part based on a study that examined forces in live deliveries and found a brachial plexus injury and clavicle fracture with a force of 99.8 N.[9–11] The accuracy of the force monitoring device is reported to have less than a ±10% deviation from the set value, which is the actual amount of weight used to measure the Newton force (B. Geldof, personal communication, 2017).

The acceptable time frame for delivery was defined as 3 minutes. This was based on knowing that 1) hypoxic-ischemic encephalopathy and death are feared complication of SD; 2) a study analyzing 56 SD deaths found that 47% of those SD deaths died in less than 5 minutes; 3) that same study found that in the 25 autopsies, hypoxic-ischemic organ damage was present in 96%; 4) the generally accepted period of time for anoxic brain injury in adults is 4 minutes; and 5) the resulting cerebral hypoxia-ischemia resulting from SD may have additional factors at play beyond the reduced cerebral arterial oxygenation such as cerebral venous obstruction and vagal stimulation with bradycardia due to neck compression.[3,12] Therefore, it seemed that a target of less than 4 minutes should be chosen, and 3 minutes for successful delivery therefore seemed like a reasonable target.

Two independent raters observed each simulated delivery. One rater was EM faculty from another EM residency, blinded to postgraduate year, overall prior performance, and program standing of subjects. The raters were instructed on the basic use of the assessment tool and had time to review the tool and ask questions, but formal rater training was not conducted since our preliminary data showed that four EM faculty were able to demonstrate at least 75% agreement on each checklist item during three consecutive ratings of variable performance without any additional rater training. Our primary outcome was the number of dangerous maneuvers performed during simulation testing. Secondary outcomes included number of appropriate maneuvers performed, delivery success, time to delivery, and maximum force applied.

Data Analysis

Residents unable to attend the educational intervention or any phase of data collection were excluded. Chi-square or Fisher's exact test when appropriate was used to compare the number of dangerous maneuvers between groups. Kappa value was used to calculate the inter-rater reliability between the two checklist assessors. Descriptive statistics were used as appropriate for resident self-assessment of confidence, successful delivery, checklist performance, time until delivery, and forces applied. Data were entered into an excel spreadsheet (Microsoft Corp.) and exported into STATA 10.0 (StataCorp) for analysis.

RESULTS

Of 43 potential subjects, five were unavailable for pretesting and were excluded. Clerical errors resulted in unclear randomization of two subjects, leaving 36 subjects; 18 were enrolled in each arm. Some subjects were unavailable for subsequent rounds of testing, leaving 14 in the HFS arm and 13 in the LFS arm (63% of potential subjects). Similar numbers of subjects from each postgraduate year of training were included in each group.

The baseline kappa value ± standard error between the two assessors was 0.54 ± 0.07, indicating moderate agreement. At 1 week and 6 months it was 0.70 ± 0.1 and 0.75 ± 0.1 respectively, indicating good agreement. The number of individuals performing dangerous maneuvers at baseline was similar ($p = 0.71$). One week after training, the number of individuals performing dangerous maneuvers was five in HFS and 11 in LFS ($p = 0.08$) and at 6 months was again similar ($p = 0.84$). Application of excessive force (>100 N) accounted for 83.6% (51/61) of all dangerous actions performed; at 1 week, the only dangerous actions performed were application of excessive force (>100 N). The mean checklist scores that assessed appropriate steps of the procedure increased 1 week after the training but returned to baseline by 6 months and were similar between groups. However, the rate of successful delivery, median time to successful delivery, and maximum force applied improved at 1 week and were sustained at 6 months in both groups (Table 1).

DISCUSSION

Shoulder dystocia must be managed expediently and carefully to avoid adverse fetal outcomes. After our brief training session, both groups had improved checklist scores and delivery success rate with decreased time to delivery. This does not correlate with a prior study, which reported lower successful delivery rates when LFS-trained providers were compared to HFS-trained providers.[8] We did not find a large difference between the inexpensive (<US$10) LFS model and the HFS model for teaching and reinforcing maneuvers required to successfully manage SD for providers without much prior experience performing this skill.

Prior studies found that "excessive force" was found in 40% to 67% of deliveries; we note similar findings prior to training.[9,11] This finding is important, since strong downward traction on the head during delivery is the most significant risk factor for neonatal injury. We found a trend toward a decrease in dangerous actions after HFS training when compared to LFS training at 1 week ($p = 0.08$), most predominantly due to the reduction in excessive force application. However, with the number of subjects enrolled, assuming a 0.8 power, we would only have been able to detect a difference of >50% between groups. Therefore, future larger studies are needed using excessive force application as the primary outcome.

While the HFS group maintained their lower number of dangerous actions at 1 week and 6 months, the LFS group continued to improve over the ensuing 6 months resulting in similar performance by the end of the study period. The reason for this is unclear; perhaps related to ongoing clinical experience and exposure or reading and practicing based on the knowledge of the study.

Our results also suggest an initial increase in subject's ability to perform the necessary maneuvers after training, but then a decrease in performance at 6 months in both groups, which differs from previous OB studies showing skill retention regarding performance of appropriate actions at 6 and 12 months.[13] EM providers perform this skill much less frequently than midwives and obstetricians, and the frequency of

Table 1
Outcomes of Shoulder Dystocia Testing for HFS and LFS Groups

Time	*n*	Subjects With Successful Delivery		Subjects Performing Dangerous Maneuvers			Subjects Applying Excessive Force		Checklist Score		Delivery Time (s)		Maximum Force (N)		Maximum Force (N)	
		HFS	LFS	HFS	LFS	P	HFS	LFS	HFS	LFS	HFS	LFS	HFS	LFS	HFS	LFS
Pretest	HFS 18, LFS 18	15 (83)	15 (83)	12 (67)	14 (78)	0.71	11 (61)	13 (72)	4.3 ± 1.8	4 ± 1.9	152 (69–260)	116 (42–180)	117.5 (50–250, 14)	150 (75–250, 15)	124 ± 66 (14)	165 ± 61 (15)
1 week posttest	HFS 15, LFS 17	15 (100)	17 (100)	5 (33)	11 (65)	0.08	5 (33)	11 (65)	5.6 ± 2.7	6.1 ± 1.9	82 (42–136)	68 (39–209)	80 (30–140, 13)	102.5 (30–250, 16)	88 ± 29 (13)	111 ± 50 (16)
6 month posttest	HFS 14, LFS 13	14 (100)	13 (100)	7 (50)	6 (46)	0.84	4 (29)	6 (46)	4.9 ± 3.0	4.2 ± 2.8	73.5 (29–174)	65 (40–104)	95 (50–150, 14)	95 (60–220, 13)	93 ± 28 (14)	115 ± 47 (13)

Data are reported as *n* (%), mean ± SD, median (range, *n*), or mean ± SD (*n*). Checklist score has a maximum of 8 points.
HFS = high-fidelity simulation; LFS = low-fidelity simulation; N = Newtons.

training may need to be greater than every 6 months for this group of providers, which requires further investigation. Further, if the lack of difference between groups are seen in future larger studies as well, this may indicate that HFS trainers may not be necessary for procedural skills training for inexperienced providers when concentrating on simply remembering the steps of this procedure. This could be a beneficial finding, since these novel LFS trainers are easily transportable and quite affordable and can easily be taken to remote environments for training. High-fidelity procedural trainers may be more beneficial for experienced providers working on refinement of techniques or when the high-fidelity trainer provides something specific and important that lower-fidelity models cannot, such as the ability to record and reveal forces applied.

LIMITATIONS

One limitation is that the size of this pilot study is sufficient to detect only large differences between groups. Another limitation is that subjects became aware of the topic during the consent process. This allowed subjects the opportunity to prepare in advance or during the study period. Those randomized to the HFS arm may have had an advantage in posttesting due to more familiarity with the HFS model. Some model limitations were also noted. Some subjects were able to overpower the model resulting in delivery despite not performing all correct maneuvers. Also, the force monitoring cable disconnected from the simulated umbilical cord during 10 of 95 total deliveries, resulting in missing data regarding the exact maximum force applied in 10.5% of subjects. Unfortunately, translational outcomes were unable to be studied due to the low frequency of SD management in EM practice.

CONCLUSION

Within our limited study population, we did not find a large difference in the occurrence of dangerous actions during simulated shoulder dystocia delivery following high-fidelity simulation and low-fidelity simulation training. Our novel and easily transportable low-fidelity simulation trainer, assembled for less than US $10 each, may be a useful tool to train inexperienced providers on the steps of this procedure, especially in environments with limited educational resources. However, this requires further study, as does whether high-fidelity simulation models with force monitoring capabilities may be helpful to train providers to minimize dangerous maneuvers such as the application of excessive force.

References

1. Hoffman MK, Bailit JL, Branch DW, et al. A comparison of obstetric maneuvers for the acute management of shoulder dystocia. Obstet Gynecol 2011;117:1272–8.
2. Draycott TJ, Crofts JF, Ash JP, et al. Improving neonatal outcome through practical shoulder dystocia training. Obstet Gynecol 2008;112:14–20.
3. Sokol RJ, Blackwell SC, American College of Obstetricians and Gynecologists. Committee on Practice Bulletins-Gynecology. ACOG practice bulletin: Shoulder dystocia. Number 40, November 2002. (Replaces practice pattern number 7, October 1997). Int J Gynaecol Obstet 2003;80:87–92.
4. Goffman D, Heo H, Pardanani S, Merkatz IR, Bernstein PS. Improving shoulder dystocia management among resident and attending physicians using simulations. Am J Obstet Gynecol 2008;199:294.e1–5.
5. Daniels K, Arafeh J, Clark A, Waller S, Druzin M, Chueh J. Prospective randomized trial of simulation versus didactic teaching for obstetrical emergencies. Simul Healthc 2010;5:40–5.
6. Fahey JO, Mighty HE. Shoulder dystocia: using simulation to train providers and teams. J Perinat Neonat Nurs 2008;22:114–22; quiz 23–4.
7. Roberts J, Hodges J. Clinical Procedures in Emergency Medicine. 4th ed. Philadelphia, PA: Saunders, 2004.
8. Crofts JF, Bartlett C, Ellis D, Hunt LP, Fox R, Draycott TJ. Training for shoulder dystocia: a trial of simulation using low-fidelity and high-fidelity mannequins. Obstet Gynecol 2006;108:1477–85.
9. Crofts JF, Ellis D, James M, Hunt LP, Fox R, Draycott TJ. Pattern and degree of forces applied during simulation of shoulder dystocia. Am J Obstet Gynecol 2007;197:156.e1–6.
10. Allen R, Sorab J, Gonik B. Risk factors for shoulder dystocia: an engineering study of clinician-applied forces. Obstet Gynecol 1991;77:352–5.
11. Deering SH, Weeks L, Benedetti T. Evaluation of force applied during deliveries complicated by shoulder dystocia using simulation. Am J Obstet Gynecol 2011;204:234.e1–5.
12. Hope P, Breslin S, Lamont L, et al. Fatal shoulder dystocia: a review of 56 cases reported to the confidential

enquiry into stillbirths and deaths in infancy. Br J Obstet Gynaecol 1998;105:1256–61.

13. Crofts JF, Bartlett C, Ellis D, Hunt LP, Fox R, Draycott TJ. Management of shoulder dystocia: skill retention 6 and 12 months after training. Obstet Gynecol 2007;110: 1069–74.

Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1002/aet2.10054/full

Data Supplement S1. Shoulder dystocia checklist.