

OBSTETRICS

Evaluation of force applied during deliveries complicated by shoulder dystocia using simulation

Shad H. Deering, MD; Leslie Weeks, MD; Thomas Benedetti, MD

OBJECTIVE: We sought to objectively evaluate the amount of force applied during deliveries complicated by shoulder dystocia among different providers.

STUDY DESIGN: Providers who do deliveries at our institution were approached for participation. The simulation exercise used a childbirth mannequin that measures the amount of force the provider applies to the fetal head during delivery. The amount of force applied and information regarding the provider's level of experience, height, weight, and gender was recorded. This study was approved by the hospital institutional review board.

RESULTS: A total of 47 providers participated. The mean force applied during each situation was not associated with the provider's experience, height, weight, or gender.

CONCLUSION: Provider experience, gender, and body habitus were not associated with the amount of force applied during delivery. We found differences between family medicine and obstetrics/gynecology providers. In addition, a significant number of all providers (19/47, 40%) pulled >100 N.

Key words: force, shoulder dystocia, simulation

Cite this article as: 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.

Shoulder dystocia occurs when the anterior fetal shoulder becomes impacted behind the pubic symphysis. This complication occurs in up to 2% of all vaginal deliveries and may be associated with significant long-term complications to include brachial plexus injuries, clavicular fracture, hypoxic brain injury,

neonatal death, and significant maternal lacerations.¹⁻³

There are several studies that have begun to explore the forces applied to the fetal head and neck during different delivery scenarios, both simulated and real, in an effort to better understand and manage the emergency of shoulder dystocia. Albeit a rather arbitrary cutoff, 100 N has generally been accepted as the maximum force that should be applied during a delivery. This number comes from a study done by Allen et al⁴ that demonstrated that 99.89 N of force resulted in a brachial plexus injury and clavicular fracture in 1 delivery complicated by shoulder dystocia. A recent United Kingdom study by Crofts et al⁵ used a mannequin to evaluate forces applied by midwives and physicians during a simulated shoulder dystocia scenario. Delivery, which in their study required delivery of the posterior arm, was achieved in only 42.5% of the simulations prior to training. Forces that exceeded 100 N were used in two-thirds of the simulations. This study would suggest that specific training in management of shoulder dystocia might enable providers to use maneuvers rather than resorting to increased forces to resolve a shoulder dystocia.

Because of the significant differences between obstetric practice and providers in the United States vs the United Kingdom, most notably the greater prevalence of midwives for routine deliveries, we undertook this study to evaluate the forces applied during spontaneous vaginal delivery and those complicated by shoulder dystocia in our provider population. Our study was also designed to take into account additional variables that could potentially influence the amount of force applied to include a provider's specialty, level of training, personal experience with this emergency, gender, and body habitus.

MATERIALS AND METHODS

This protocol was approved by the hospital institutional review board. Providers at Madigan Army Medical Center who regularly perform deliveries, to include obstetrics and gynecology staff, obstetrics and gynecology residents, certified nurse midwives, family medicine staff, and family medicine residents, were recruited for the study either during normal departmental morning report or scheduled academic time. Informed consent was obtained prior to enrollment.

A commercially available childbirth simulator (PROMPT birthing trainer;

From Madigan Army Medical Center, Andersen Simulation Center, Tacoma, WA (Drs Deering and Weeks), and Department of Obstetrics and Gynecology (Dr Benedetti), University of Washington School of Medicine, Seattle, WA.

Presented at the Annual American College of Obstetricians and Gynecologists Armed Forces District Meeting, Louisville, KY, Oct. 28-31, 2007.

Received July 27, 2010; revised Sept. 16, 2010; accepted Oct. 13, 2010.

Reprints: Shad H. Deering, MD, Department of Obstetrics and Gynecology, Madigan Army Medical Center, Tacoma, WA 98431. deering95@hotmail.com.

The opinions expressed herein are those of the author and do not reflect the official policy or position of the Department of the Navy, the Department of the Army, the Department of the Air Force, the Department of Defense, or the United States Government.

0002-9378/\$36.00

Published by Mosby, Inc.

doi: 10.1016/j.ajog.2010.10.904

FIGURE 1

Force feedback model in use



Deering. Force applied during simulated shoulder dystocia deliveries. *Am J Obstet Gynecol* 2011.

Limbs and Things Ltd, Bristol, United Kingdom) was used, which measures the force in newtons applied to the infant's head during delivery. This simulator and the internal force measurement mechanism have been described in detail in a previous publication.⁵ The mannequin was positioned on an examination table either in clinic or on labor and delivery. Prior to beginning the simulation, investigators recorded information about the following for each participant: gender, height, weight, body mass index (BMI), number of deliveries performed, number of shoulder dystocias managed, practice specialty, and level of training.

Participants were allowed to sit or stand as they usually do during a delivery; they were also allowed to adjust the examination table to their preferred height. The infant head was always placed in the left occiput anterior position (Figure 1). Participants were advised not to expect descent of the fetus or resolution of the dystocia, as the purpose of the study was not to achieve delivery but to determine how hard they believed they normally pulled on the fetal head during the situations presented. Parti-

cipants were instructed to pull as hard as they usually do: (1) during a normal vaginal delivery, (2) to diagnose a shoulder dystocia, (3) with application of McRoberts position and suprapubic pressure to resolve a shoulder dystocia, and (4) prior to abandoning attempts at vaginal birth and performing the Zavanelli maneuver. The peak force for each of these pulls was then added together to calculate the total peak force applied, which was included to determine if there was any summative difference that might not be seen between the individual pulls. These 4 scenarios were explained to participants before starting the simulations. After simulation was completed, feedback was given to the participants regarding how hard they pulled in each situation. An example of the feedback output recorded by the software can be seen in Figure 2.

Statistical analysis was then performed using software (SPSS; SPSS Inc, Chicago, IL) to evaluate how the above-mentioned personal identifiers affected force applied during the 4 scenarios and included both regression analysis as well as the Student *t* test as appropriate.

A *P* value of $\leq .05$ was considered significant.

RESULTS

We enrolled a total of 47 providers including 15 obstetric staff (including 3 certified nurse midwives), 14 obstetric residents, 8 family medicine staff, and 10 family medicine residents. See Table 1 for additional demographics to include gender, height, weight, and BMI. Of 47 participants, 32 (68%) had performed >100 vaginal deliveries, and experience with shoulder dystocia is represented in Figure 3 divided by specialty.

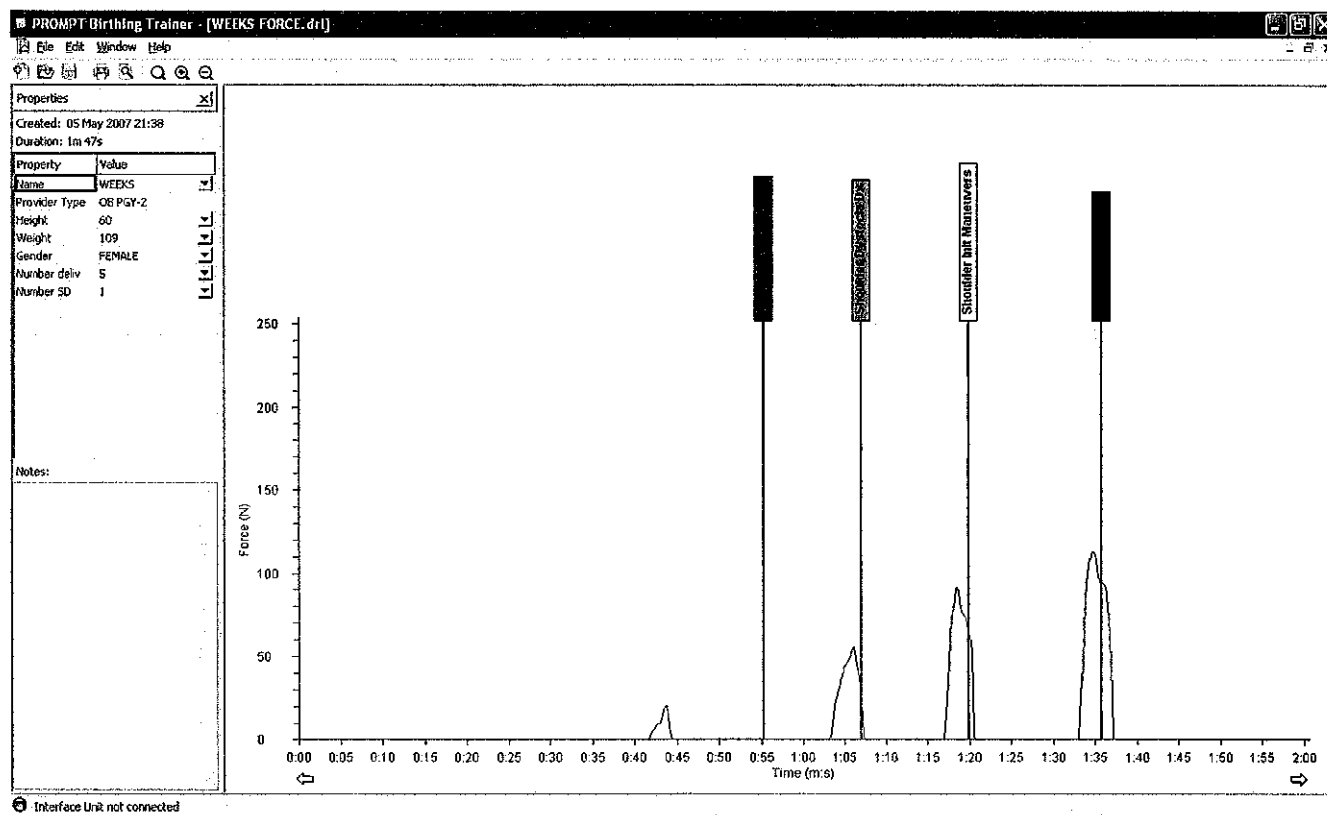
When regression analysis was performed, gender, height, weight, BMI, number of deliveries managed, and number of dystocias managed were not significantly associated with the amount of force applied during any of the 4 simulated delivery scenarios or the total force applied. A post hoc power analysis found that the current study had an observed power between 0.85–0.88 to detect a difference for the 4 different delivery scenarios and total force applied.

When the providers were divided by practice specialty (family medicine vs obstetrics) there were significant differences noted in the amount of force applied to the fetal head during a normal delivery (38.4 vs 22.76 N, respectively; $P = .05$) and for the diagnosis of shoulder dystocia as well (60.2 vs 38.3 N, respectively; $P = .05$). There were no significant differences noted in the amount of force applied after initial maneuvers, the maximum amount of force applied, or the sum of the total peak forces applied during the simulation (Table 2).

With regard to the maximum amount of force providers were willing to apply, 40% of providers (19/47) pulled at least 100 N at some point during the simulated deliveries and nearly 15% (7/47) pulled >150 N. When we looked at these results by specialty there was not a significant difference (family medicine providers 44% [8/18] vs obstetric providers 38% [11/29]; $P = .65$) who were willing to pull >100 N during the simulation.

Table 3 summarizes the amount of force applied by all providers.

FIGURE 2
Force feedback graph example



Deering. Force applied during simulated shoulder dystocia deliveries. *Am J Obstet Gynecol* 2011.

COMMENT

Based on our study, gender, body habitus, and provider experience were not predictive of how much force a provider applies on the fetal head during a simulated vaginal delivery or shoulder dystocia. Our study demonstrated that on average, family medicine providers pulled slightly harder on the fetal head during normal deliveries and to diagnose a

shoulder dystocia than obstetrics and gynecology providers, but well below the 100 N cutoff for these situations. Additionally, we found that a significant number of providers pulled >100 N during the simulation, which is consis-

tent with previously published data from the United Kingdom.⁵

Because one cannot accurately predict when a shoulder dystocia will occur, it is critical for delivering providers to be proficient in managing this emergency

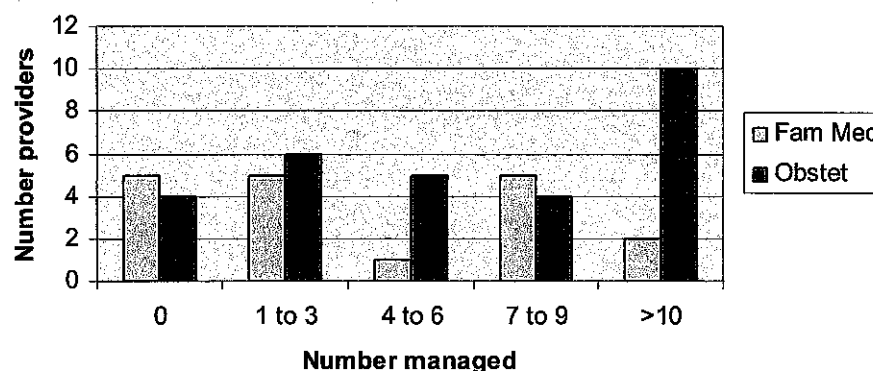
TABLE 1
Provider demographics

| Demographic | n |
|-----------------------------|------|
| Male | 22 |
| Female | 25 |
| Mean height, in | 67.8 |
| Mean weight, lb | 161 |
| Mean BMI, kg/m ² | 24 |

BMI, body mass index.

Deering. Force applied during simulated shoulder dystocia deliveries. *Am J Obstet Gynecol* 2011.

FIGURE 3
Number of shoulder dystocias managed by type of provider



Fam Med, family medicine provider; Obstet, obstetric provider.

Deering. Force applied during simulated shoulder dystocia deliveries. *Am J Obstet Gynecol* 2011.

TABLE 2

Comparison of family medicine and obstetric providers

| Variable | Normal delivery | Diagnose dystocia | Initial maneuvers | Maximum for dystocia | Total force |
|------------------------------------|-----------------|-------------------|-------------------|----------------------|---------------|
| Family medicine providers (n = 18) | 38.4 ± 31 N | 60.2 ± 38 N | 76.0 ± 41 N | 98.0 ± 59 N | 272.8 ± 156 N |
| Obstetric providers (n = 29) | 22.7 ± 22 N | 38.3 ± 39 N | 62.0 ± 50 N | 89.1 ± 52 N | 212.2 ± 148 N |
| P value | .05 | .05 | .32 | .59 | .19 |

Deering. Force applied during simulated shoulder dystocia deliveries. *Am J Obstet Gynecol* 2011.

to minimize tragic outcomes for mother and baby. There is evidence in the literature that training for this complication can not only improve resident performance, but actually decrease the incidence of brachial plexus injuries.⁶⁻⁸ With access to new birthing simulators that can measure force, current simulation training may be augmented and feedback given. While traditional teaching has largely been to attribute brachial plexus injury to physician-applied force, recent experimental and clinical data bring this assertion into question.

There has been a significant amount of controversy regarding what the maximum amount of force that can be applied safely during delivery should be. The cutoff of 100 N comes from the peak force recorded by Allen et al⁴ during an actual shoulder dystocia that resulted in a transient neonatal brachial plexus injury. It is probably an unreasonable assumption that this single reported value should be used as a standard to measure when "excessive" force is applied during delivery. While the amount of force used may be related to the incidence of brachial plexus injury, more study in this area is warranted given the fact that a significant number of providers in the studies done to date pulled >100 N. If both our simulation and those reported by Crofts et al⁵ reflect actual clinical practice, then when a shoulder dystocia occurs the

majority of infants (>60%) may be exposed to >100 N of force while few have recognizable injuries at birth and even fewer have permanent impairment. Additionally, at least 3 recent reports have been published where both transient and permanent brachial plexus injuries have resulted from documented unassisted deliveries and cesarean section.⁹⁻¹¹

Given these findings it is necessary to consider additional variables when attempting to determine what factors may result in some babies having permanent injuries while others do not. While the potential for physician-applied force to play a part in stretching the brachial plexus cannot be ignored, other factors such as prolonged exposure to labor, fetal shoulder size, mechanical issues, and even biologic variability in the propensity for brachial plexus injury must be considered. Another suggested possibility involves the rate at which force is applied rather than the amount of force used.⁵ When all of these factors are taken into consideration, a simple cutoff for how much force is used, such as the arbitrary level of 100 N, is probably not useful.

When considering why family medicine physicians pulled harder for both a spontaneous vaginal delivery and to diagnose a shoulder dystocia, it is possible that this is because performing a cesar-

ean section is not within their scope of practice. The lack of another option to achieve delivery in a timely manner may result in these providers applying more force than an obstetrician who has the additional ability to perform a Zavanelli maneuver, which replaces the fetal head back into the uterus and is then followed by an urgent cesarean section to allow delivery. Another potential reason may be simply that this is how our staff train their residents to perform deliveries at our institution. Regardless of the reason, it is very important to note that even though family medicine providers pulled harder than obstetricians for a spontaneous vaginal delivery and to diagnose a shoulder dystocia, there was not a significant difference in either the maximum or total peak amount of force that they applied, and no difference in the percentage who pulled >100 N. In other words, the mean force applied during this simulated emergency situation was still within the same range as the obstetricians with regard to peak forces used.

While we acknowledge that there are limitations to this study, including the fact that we only sampled providers from a single institution, we believe that the number of providers and their levels of experience are representative of general practice patterns within the United States. In addition, we recognize that the

TABLE 3

Summary of forces applied (n = 47)

| Variable | Normal delivery | Diagnose dystocia | Initial maneuvers | Maximum for dystocia | Total force |
|------------------------------------|-----------------|-------------------|-------------------|----------------------|---------------|
| Mean force, all providers | 28.7 ± 27 N | 47.6 ± 38 N | 67.4 ± 47 N | 92.5 ± 55 N | 235.4 ± 153 N |
| No. of providers who pulled >100 N | 1 | 4 | 11 | 19 | N/A |
| No. of providers who pulled >150 N | 0 | 1 | 2 | 7 | N/A |

N/A, nonapplicable.

Deering. Force applied during simulated shoulder dystocia deliveries. *Am J Obstet Gynecol* 2011.

simulator and methods we used cannot completely simulate or measure either the actual forces applied to the fetal brachial plexus or the stress encountered during an actual shoulder dystocia. However, because lateral flexion of the head of the birthing fetus simulator does increase the travel of the central internal cable that measures forces, both lateral and axial forces were measured by the strain gauge. The force levels that we observed were also comparable to those seen in studies done with actual deliveries.¹² Strengths of our study include that it was conducted in a prospective manner and that the same investigators ran all of the simulations in a standardized fashion.

Although our study was conducted somewhat differently than the study by Crofts et al,⁵ the equipment used was the same and there are enough similarities to make it reasonable to compare at least some of the results of the 2 studies. In reviewing their findings we noted some potentially significant similarities and differences in comparing the amount of force applied by our providers to that in their study. For example, the mean maximum force applied before shoulder dystocia maneuvers were used was 47 N in their study vs 46.7 N in our population. However, the percentage of providers who pulled >100 N during their simulated shoulder dystocia was 66% (75/113), which was higher than the 40% (19/47) in our study. The difference may be due to the fact that their study in-

involved a simulated drill complete with evoked stress and adrenaline while ours involved 4 distinct pulls in a more controlled environment.

At our institution, it does not appear that height, weight, BMI, or provider experience are related to how much force providers exert during vaginal delivery or during a delivery complicated by shoulder dystocia. These findings are also consistent with findings in a previous study by Allen et al¹³ that used a different type of simulator in a laboratory and found that the amount of force applied was not associated with clinician gender or experience. While a large number of providers pulled >100 N, there is controversy as to the significance and validity of this cutoff with regard to causing fetal injury. Further research in this area is needed to better determine what factors other than just the maximum physician-applied force may be related to brachial plexus injuries and if there is a more reasonable cutoff that is associated with fetal injury so that this model may be used to better train physicians in the management of shoulder dystocia.

REFERENCES

1. Rodis JF. Shoulder dystocia. Up To Date, version 11.2, April 2003.
2. Poggi SH, Ghidini A, Allen RH, Pezzullo JC, Rosenbaum TC, Spong CY. Effect of operative vaginal delivery on the outcome of permanent brachial plexus injury. *J Reprod Med* 2003; 48:692-6.
3. Gherman RB, Ouzounian JG, Goodwin TM. Obstetric maneuvers for shoulder dystocia and associated fetal morbidity. *Am J Obstet Gynecol* 1998;178:1126-30.
4. Allen R, Sorab J, Gonik B. Risk factors for shoulder dystocia: an engineering study of clinician-applied forces. *Obstet Gynecol* 1991;77: 352-5.
5. Crofts J, Ellis D, James M, Hunt L, Fox R, Draycott T. Pattern and degree of forces applied during simulation of shoulder dystocia. *Am J Obstet Gynecol* 2007;197:156.e1-6.
6. Deering SH, Poggi S, Macedonia C, Gherman RB, Satin AJ. Resident competency in the management of shoulder dystocia improves with simulation training. *Obstet Gynecol* 2004; 103:1224-8.
7. Wilson L, Ash J, Crofts J, Sibanda T, Draycott T. Does training reduce the incidence of fetal injury in cases of shoulder dystocia? *Simul Healthc* 2006;1:185.
8. Draycott TJ, Crofts JF, Ash JP, et al. Improving neonatal outcome through practical shoulder dystocia training. *Obstet Gynecol* 2008; 112:14-20.
9. Allen RH, Gurewitsch ED. Temporary Erb-Duchenne palsy without shoulder dystocia or traction to the fetal head. *Obstet Gynecol* 2005;105:1210-2.
10. Molina O. Brachial plexus palsy after cesarean delivery: an intrauterine phenomenon. *Obstet Gynecol* 2006;4S:35S.
11. Lerner HM, Salamon E. Permanent brachial plexus injury following vaginal delivery without physician traction or shoulder dystocia. *Am J Obstet Gynecol* 2008;198:e7-8.
12. Poggi SH, Allen RH, Patel C, et al. Effect of epidural anesthesia on clinician-applied force during vaginal delivery. *Am J Obstet Gynecol* 2004;191:903-6.
13. Allen RH, Bankoski BR, Butzin CA, Nagey DA. Comparing clinician-applied loads for routine, difficult, and shoulder dystocia deliveries. *Am J Obstet Gynecol* 1994;171:1621-7.