To the Point: The expanding role of simulation in obstetrics and gynecology medical student education

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This article, from the "To the Point" series prepared by the Association of Professors of Gynecology and Obstetrics (APGO) Undergraduate Medical Education Committee (UMEC), provides educators with an overview of the use of simulation in undergraduate medical education in the field of obstetrics and gynecology. Simulation plays an important role in the education of medical students. Students are increasingly serving as clinical observers and providing less direct patient care. Simulation can help standardize education and ensure quality and comparability across an enlarging educational environment. This article summarizes the expanding role of simulation in undergraduate medical education in obstetrics and gynecology and its effect on important learner outcomes such as confidence, knowledge, skills, workplace behaviors, and translation to patient care.

Key words: clerkship, gynecology, medical education, medical students, obstetrics, simulation

In this article in the ongoing "To the Point" series produced by the Association of Professors of Gynecology and Obstetrics, Undergraduate Medical Education Committee, we review the expanding role of simulation in undergraduate medical education in obstetrics and gynecology.

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Received July 24, 2018; revised Oct. 12, 2018; accepted Oct. 17, 2018.

The authors report no conflicts of interest.

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0002-9378/$36.00

https://doi.org/10.1016/j.ajog.2018.10.029

Definition of Simulation

In medical education, the term "simulation" refers to instruction in which learners interact with facsimiles of a clinical task, a clinical context, or an environment to learn clinical skills that can then be applied directly to actual patient care. The use of simulation-based methods provides medical students the opportunity to acquire the confidence, knowledge, skills, and workplace behaviors required to provide quality patient care in a safe learning environment.[1]

The interplay of numerous forces such as patient autonomy and preference, quality measures, changing health care systems, and trainee work environment modifications has led to the expansion of simulation in medical education. Physicians care for an increasingly well-informed patient population that expects appropriate experience and training and that questions the ethics of having a learner practice on real patients.[2] In the United States, where medical error is one of the leading causes of death, simulation allows trainees to bypass the early error-prone period, reduces the length of the learning curve, and improves patient safety.[3] In our ever-changing health care systems, physicians are required to see more patients, minimize risk, and maximize revenue. This transformation has resulted in students more often acting as clinical observers rather than active participants in direct patient care. Work-hour restrictions and decreasing exposure to cases have all contributed to fewer opportunities for medical students to learn clinical skills on the obstetrics and gynecology clerkship.[4]

Simulation in the clerkship, as an adjunct method of instruction, is one potential solution. Simulation training should be complementary to, not a replacement of, the traditional

apprenticeship model of medical education that places the student in direct contact with the patient. Simulation training has become integral to present medical education.[5] There are numerous advantages to simulation-based training (SBT), including millennial learner preference, a nonthreatening controlled learning environment, the ability to structure learning and control the clinical variables, immediate feedback, and more objective performance assessment. Skills can be practiced until mastery is achieved without risking harm to patients.[1] SBT helps medical students to acquire and refine both the cognitive and the technical skills necessary to perform complex patient care activities. It can be used to teach students complex decision making, to practice infrequent or acute clinical scenarios, and to learn and practice skilled tasks.[6]

Fidelity is the degree to which the simulator or simulation replicates reality. Simulators are labeled either low- or high-fidelity depending on how closely they mimic real clinical experiences. The most common type of simulation modalities in order of increasing fidelity are task trainers, screen-based computer simulators, virtual reality platforms, haptic systems that combine real world and virtual reality, standardized patients, and full scale mannequins that can be programmed to respond with realistic physiological responses.[7]

Educators should consider 4 criteria when designing, implementing, and evaluating, a simulation:

1. Simulations should allow for sustained, deliberate practice. Deliberate practice is defined as engaging learners in focused, effortful skill repetition in progressive exercises with informative feedback.[8]
2. Simulations should provide access to expert tutors.
3. Simulations should map to real-life clinical experiences.
4. SBT should provide a supportive, motivational, and learner-centered environment that is conducive to skill development.[6]

Funding, institutional buy-in, curricular design, faculty development, and research are crucial for a sustainable, effective program to achieve its learner outcomes and to have a positive impact on patient care.[3]

This Expert Review will examine the expanding role of simulation in undergraduate medical education in obstetrics and gynecology, and will highlight educational simulation research that has an effect on important learner outcomes such as confidence, knowledge, skills, workplace behaviors, and translation to patient care. With the assistance of a research librarian, 3 databases were searched from 1990 to 2018 using multiple search terms, and more than 100 articles were identified. Articles were eliminated for either duplication, non-English language, involving resident learners instead of student learners, or for being focused on knowledge, skills, or workplace behaviors not relevant to the field of obstetrics and gynecology. The articles were then reviewed, and three broad themes were identified including the following: 1) discrete procedures and examination skills specific to obstetrics and gynecology (breast examination, pelvic examination, vagina/cervical examination, vaginal delivery, surgical skills), 2) broader clinical skills (communication, interprofessionalism), and 3) the role of feedback, assessment, and validation in successful simulation education. These themes align with the Association of American Medical Colleges (AAMC) Entrustable Professional Activities, the Accreditation Council for Graduate Medical Education (ACGME) Milestone One objectives for obstetrics and gynecology, and the APGO Basic Clinical Skills. These themes form the structure for the article.

Task or Skill Simulation

Pelvic examination

Traditionally, the skills of breast, pelvic, and obstetric vaginal or cervical examination have been taught using textbooks, lectures, audio-visual aids, pelvic manikins, or the apprenticeship model whereby students learn and practice on real patients. Inanimate models may not be realistic enough, and practicing on real patients can be anxiety provoking for both patients and students. These barriers have been overcome by using trained simulated or standardized patients (SPs) also known as gynecologic teaching associates or GTAs.[9] Of the obstetrics and gynecology clerkships in US medical schools, 72% use GTAs to teach pelvic examinations.[10] The advantages of GTAs include a safe-learning environment, real-time feedback, and the ability to practice until competency is achieved.

However, maintaining a SP program is expensive. To have a quality SP program requires an SP Educator, whose salary ranges from $35,000 to $60,000, depending on geographic location, and a cohort of SPs with salaries ranging from $15 to $25 per hour to $75 to $125 per hour for breast and pelvic examinations. The annual cost of an SP program is dependent on how many learning opportunities include SPs and how many students are participating in the curriculum. At the primary author's institution, where an SP program has been in place for more than 20 years and the simulation and SP curriculum across the institution is very robust, the annual cost is $315,000. For obstetrics and gynecology—specific curricula, the annual cost at the primary author's institution is approximately $12,000.[11,12]

Several studies have evaluated the effectiveness of GTAs on student confidence, examination skill competence, and communication. In 2015, Smith et al published a systematic review and meta-analysis of the data comparing GTA teaching of the pelvic examination to more traditional methods. Table 1 from their publication is reprinted with permission and summarizes the results of 5 randomized controlled trials (RCTs) and 6 observational studies (Table 1).[9] GTA training improved learner competence with the pelvic examination and patient-centered communication skills during the pelvic examination compared with traditional teaching methods, and this improvement was maintained even when the pooled analysis was restricted to RCTs. No effect on student confidence was observed.[9] In 2016, Duffy et al did a multi center randomized

TABLE 1

Details of study methodology and population for the assessment of gynecology teaching associates against other interventions for teaching pelvic examination

First author name (year)	Study design	Country	Population (number)	Intervention (duration)	Comparison	Time of outcome measurement (completeness)	Competence			Confidence			Communication		
							Assessor	Outcome assessment	Results	Assessor	Outcome assessment	Results	Assessor	Outcome assessment	Results
Herbers (2003)	RCT	USA	Junior doctors (I = 39; C = 33)	GTA training (9 hours) + clinical orientation	Instructional brochure + clinical orientation	14 weeks (97%)	Blinded, GTA assessor	A comparison of means from a composite score of dichotomous items with a maximum score of 29; scores were normalized to a 100-point scale with a maximum of 1.0	I = 0.79 vs C = 0.57; $P < .001$	NR	NR	NR	NR	NR	NR
Livingstone (1978, 1980[a])	RCT	Canada	Medical students (I = 50; C = 50)	GTA training (2.5 hours)	Clinical orientation	4 days (100%); 1 year (69%)	Blinded, GTA assessor	A comparison of mean scores from a composite score of items on 3-point scales with a maximum score of 37; scores were transformed into a percentage	I = 75 % vs C = 54%, $P < .001$ at 4 days; I = 76% vs C = 61%, $P < .001$ at 1 year	Participant questionnaire	A comparison of percentage of students saying yes to being confident	I = 93% vs C = 34% at 4 days, no *P* value	Blinded, physician and GTA assessor	A comparison of mean scores from a composite score of items on 3-point scales with a maximum score of 32. Scores were transformed into a percentage	I = 64.8% vs C = 50.0%, $P < .01$ at 4 days; I = 48% vs 47%, P = not significant at 1 year
Nelson (1978)	RCT	USA	Medical students (I = 15; C = 15)	GTA training (NR)	Pelvic model	5 days (100%)	Blinded, GTA assessor	Comparison of number of students palpating the uterus and adnexa	I = 11/15 vs C = 1/15 correctly palpated ovaries, $P < .001$; I = 15/15 vs C = 14/15 correctly palpated uterus, P = not significant	NR	NR	NR	NR	NR	NR
Pickard (2003)	RCT	UK	Medical students (I = 44; C = 48)	GTA training (2 hours) + clinical orientation	Clinical orientation	3 weeks (79%), 12 weeks (76%)	Blinded, doctor, nurse, and GTA assessors	A comparison of means from a composite score of items on 2- or 3-point scales with a maximum score of 192	I = 155.51 (SD, 17.97) vs C = 104.66 (SD, 24.93), $P < .001$ at 3 weeks; I = 148.06 (SD, 22.94) vs C = 114.51 (SD, 28.81), $P < .001$ at 12 weeks	NR	NR	NR	Blinded, doctor, nurse, and GTA assessors	A comparison of means on an amalgamated score on 10-point scales with a maximum score of 30	I = 25.67 (SD, 2.68) vs C = 18.13 (SD, 3.92), $P < .001$ at 3 weeks; I = 24.16 (SD, 3.64) vs C = 19.13 (SD, 5.32), $P < .001$ at 12 weeks

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TABLE 1

Details of study methodology and population for the assessment of gynecology teaching associates against other interventions for teaching pelvic examination *(continued)*

First author name (year)	Study design	Country	Population (number)	Intervention (duration)	Comparison	Time of outcome measurement (completeness)	Competence			Confidence			Communication		
							Assessor	Outcome assessment	Results	Assessor	Outcome assessment	Results	Assessor	Outcome assessment	Results
Pradhan (2010)	RCT	USA	Medical students (I = 53; C = 53)	GTA training (NR)	Faculty trainer + standardized patient	6 weeks (100%)	Blinded, faculty assessors	A comparison of means from a composite score of dichotomous items with a maximum score of 11	I = 10.0 (SD, 0.8) vs C = 9.9 (SD, 1.0); $P = .8$	Participant questionnaire	A comparison of means from a 10-point scale with a maximum score of 10	I = 7.3 (SD 1.6) vs C = 7.2 (SD 1.3)	NR	NR	NR
Guenther (1983)	COS	USA	Medical students (I = NR; C = NR)	GTA training (1 afternoon)	Faculty trainer + clinic patients	NR (100%)	Blinded, GTA assessor	A comparison of means from a 10-point scale	$P < .001$ favoring the GTA model	NR	NR	NR	Blinded, GTA assessor	A comparison of means using a composite of 12 items	$P < 0.0001$ favoring the GTA model
Holzman (1977)	COS	USA	Medical students (I = 28 (14 + 14); C = 10)	Group 1 = GTA training (1 hour) + pelvic model (1 hour) + videotape + instructional brochure Group 2 = as above without pelvic model (1 hour)	Pelvic model + videotape + instructional brochure	6 weeks (100%)	Blinded, GTA assessors	A comparison of means from a composite score of dichotomous items with a maximum score of 12	Group 1 = 9.9 vs C = 6.3, $P < .05$; Group 2 = 8.5 vs C = 6.3 (not significant)	NR	NR	NR	Blinded, GTA assessors	A comparison of means from a composite score of dichotomous items with a maximum score of 12	Group 1 = 9.2 vs C = 5.8; $P < .05$; Group 2 = 8.5 vs C = 5.8, $P < .05$
Kleinman (1996)	COS	USA	Medical students (I = 48; C = 33)	Third-year medical students: GTA training (3 hours) + videotape + lecture	Second-year medical students: faculty and patient (3 hours) + videotape + lecture	3 months (100%); 6 months (75%)	Unblinded, physician and GTA assessors	A comparison of means from a composite score of dichotomous items with a maximum score of 18	I = 12.54 vs C = 12.11, P = not significant	NR	NR	NR	Unblinded, physician, and GTA assessors	A comparison of means on a composite score of dichotomous items with a maximum score of 17	I = 15.81 vs C = 12.89, $P = .01$
Shain (1982)	COS	USA	Medical students (I = 104; C = 104)	GTA training (NR)	Pelvic model	NR (100%)	Blinded, physician, staff, nurse, and GTA assessors	A comparison of mean scores on a 5-point scale with a maximum score of 5	I = 3.79 vs C = 3.50, $P = .016$	NR	NR	NR	Blinded, physician, staff, nurse, and GTA assessors	A comparison of mean scores on a 5-point scale with a maximum score of 5	I = 3.76 vs C = 3.49, $P = .035$
Theroux (2006)	COS	USA	Nurse practitioner students (I = 19; C = 23)	GTA training (NR) + videotape	Voluntary peer training + faculty + videotape	Immediately (64%); after 2 semesters (67%)	NR	NR	NR	Participant questionnaire	A comparison of percentage of students saying yes to being confident	I = 92% vs C = 71% immediately; I = 73% vs C = 54% at 2 semesters; no P values	NR	NR	NR

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TABLE 1
Details of study methodology and population for the assessment of gynecology teaching associates against other interventions for teaching pelvic examination *(continued)*

First author name (year)	Study design	Country	Population (number)	Intervention (duration)	Comparison	Time of outcome measurement (completeness)	Competence			Confidence			Communication		
							Assessor	Outcome assessment	Results	Assessor	Outcome assessment	Results	Assessor	Outcome assessment	Results
Wanggren (2010)	COS	Sweden	Medical students (I = 53; C = 34)	GTA (2 hours) + lecture + video + clinical orientation	Pelvic model (2 hours) + clinical patient under gynecologist supervision (1 hour) + clinical orientation	NR (100%)	Unblinded, faculty assessor	A comparison of medians on a 5-point Likert scale with a maximum score of 5	I = 5 vs C = 4, $P = .02$	NR	NR	NR	Unblinded, faculty assessor	A comparison of medians on a 5-point Likert scale with a maximum score of 5	I = 5 vs C = 5, $P = 0.83$

C, comparator; *COS*, comparative observational study; *GTA*, gynecology teaching associate; *I*, intervention; *NR*, not recorded; *RCT*, randomized controlled study; *SD*, standard deviation; *SP*, standardized patient.

[a] Livingstone (1980) provided 1-year follow up on the students presented in Livingstone (1978).

Reprinted with permission from Smith PP, Choudhury S, Clark TJ. The effectiveness of gynaecological teaching associates in teaching pelvic examination: a systematic review and meta-analysis. Med Educ 2015;49:1197-1206.

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control trial that concluded the addition of GTA training to a low-fidelity pelvic exam simulation model improved medical student knowledge comfort and confidence.[13] Based on this review, educators can confidently use GTAs to supplement or replace traditional methods of teaching the pelvic examination. Another cost-effective way to teach the pelvic examination and Papanicolaou smear collection is using a hybrid model with an inanimate pelvic model for the examination, which is less expensive than paying GTAs for intimate examinations, but then using the GTA for the patient interaction and history-taking portion of the clinical encounter. This has been shown to be authentic, acceptable, and feasible from both the student and faculty perspective.[14]

Breast examination

Similarly to the pelvic examination, GTAs are increasingly being used to teach or simulate the breast examination in 65% of obstetrics and gynecology clerkships.[9] GTAs incorporated into the clerkship standardize learning, improve students' breast examination skills, increase Objective Structured Clinical Examination (OSCE) scores, and improve performance in the clinical setting.[15,16] Nassif et al compared a breast lecture plus a tabletop examination with a breast model to a breast lecture with a GTA simulated breast examination. Students were assessed during the OSCE with a GTA who was blinded to the student's training assignment. Those in the hybrid group with the GTA had better lesion identification with no increase in false-positive results, less fear of missing a lesion, and increased satisfaction with the teaching method.[17]

Labor cervical examination

Another physical examination skill in the field of obstetrics and gynecology that lends itself to simulation is the obstetric vaginal examination or the labor cervical examination (LCE). Teaching this skill during medical training can present some ethical, medico-legal, and patient safety issues, and may be anxiety provoking for the learner while exposing the patient to

multiple cervical examinations.[18] The ability to perform an accurate LCE is an essential skill for the successful management of labor, and thus competency in this skill is needed and can be accomplished through simulation.[19] Students trained using a cervical examination simulator were more accurate in assessing dilation and effacement than students in a control group.[18,19] In addition simulation training improved the accuracy of LCEs performed by students in the clinical setting, even for features such as fetal position and cervical consistency that were not practiced on the simulator. Thus, students should receive LCE training on a simulator before examining pregnant patients in labor.[19]

Vaginal delivery

Obstetric simulation has been compared to traditional lecture[5,20–23] to case-based learning[25] and to bedside teaching.[20,25] High-fidelity obstetric simulators, such as Noelle S550 from Gaumard (Miami, Florida), which costs $4295, are expensive, and medical schools and medical educators are looking for less expensive options. Numerous studies have been performed comparing high-fidelity obstetric simulators to low-fidelity obstetric simulators[26] and to hybrid models using a standardized patient.[27] Outcomes assessed in studies using vaginal birth simulation include students' perceptions, satisfaction, preparedness, confidence, and comfort in delivery skills and knowledge. The results of these comparative studies are summarized in Table 2. In summary, curricular evaluations of obstetric simulation demonstrate increased clerkship satisfaction[22] and high-quality[25,26] and high-relevance ratings of the simulated curriculum.[26] Students in the obstetric simulation group had better communication,[27] increased confidence,[5,21,22] and higher written,[22] oral,[22] and clinical[23,24] examination scores (Table 2). Early studies focused on survey data of students and perceptions of students following vaginal delivery simulation. Current data are more objective and quantitative, and measure student knowledge and skills using checklists. Nitsche et al[28] created a validated vaginal delivery checklist, and determined minimum cutoff scores for minimal competence and mastery. They also evaluated the number of simulations necessary to achieve minimal competency and mastery, and reported a dose response whereby each session of simulation training results in an increasing effect on performance.[28]

Teaching and the Practice, Retention, and Transferability of Surgical Skills

Surgical training is becoming increasingly complex, with an increasing number of surgical techniques and approaches. However, the length of medical school and residency training programs has not increased, and the actual time spent in the clinical setting has decreased with the implementation of duty hours. Thus, medical students and trainees are being asked to learn more volume and more complex surgical skills in less time, which can negatively affect learner competency and confidence. A potential solution to this issue is to move the practice of surgical skills out of the clinical realm to the simulated environment.[29]

Much of surgical education focuses on teaching specific surgical skills, and most of the literature focuses on faculty, fellows, and residents. Very few studies use students as the primary learner.[30] The authors believe that this is appropriate, as medical students do not need to be learning complex surgical skills such as laparoscopy during medical school. In most articles describing surgical simulation, medical students are being used as surgically naive learners to try to establish learning curves, to identify the most high-yield simulator exercises, the ideal number of repetitions, and the recommended intervals between training sessions, so as to optimize surgical technical skill, reach a predetermined level of competency, and contribute to our understanding of how trainees learn surgical skills.[31]

If one uses the AAMC Entrustable Professional Activities, the ACGME Milestones for obstetrics and gynecology, and the APGO Basic Clinical Skills to inform what surgical skills medical students should be learning, the list will include the following: universal precautions, sterile technique, knot tying, suturing, surgical positioning, urinary catheter placement, informed consent, and surgical instruments. These skills are most commonly taught using simulation in resident readiness or transition courses to prepare fourth-year medical students to transition from students to interns. Students who participate demonstrate increased knowledge and skills.[30,32]

Communication skills simulation

Traditionally physicians have learned to communicate information to patients through an apprenticeship model of observation and modeling. Teaching communication skills transfers across content areas and is an excellent application for simulation.[33] These communication skills can be practiced in a simulated environment using standardized patients and assessed by objective observers.[34]

Standardized patients (SPs) can simulate emotion and increase the realism of the simulated clinical scenario.[35] Role-play gives the learner the opportunity to experience, reflect on, and receive constructive feedback about integrated aspects of clinical care including professionalism, interpersonal and communication skills, clinical reasoning, management, and patient education.[36] Simulation can be introduced in a variety of innovative clinical scenarios, such as student willingness to speak up when witnessing a surgical error,[37] student empathy,[38] communication with a talkative patient,[39] communication of pregnancy options,[34] preconception counseling,[40] and student professional attitudes and values clarification in sensitive areas in which providers need to be aware of their personal beliefs that could lead to biased care.[36] Another area of communication that is difficult for physicians and can be taught in a simulated environment in medical school is conveying bad news. Communicating bad news well can improve patients' trust and mitigate fear, anger, and blame. Traditionally, most medical schools have not formally trained medical students to

TABLE 2
Comparison of outcome assessments and results for medical students exposed to vaginal delivery simulation

First author Name (year)	Study design	Population (n)	Intervention (duration)	Comparison	Outcome assessment	Results
Dayal (2009)[23]	RCT	Medical students (I = 18; C = 15)	Lecture with pelvic skeleton demonstration + simulation demonstration on Noelle Obstetrics Simulator (60 minutes) + teaching /practice session with simulator (1−2 hours)	Lecture with pelvic skeleton demonstration	1) Obstetric simulator delivery skill score assessed by researcher; 2) number of live births assisted in during clerkship; 3) confidence levels with vaginal delivery based on self-assessment survey	1) Students in simulator group had higher overall delivery score; 2) students in simulator group participated in more live vaginal deliveries during clerkship; 3) no difference in original confidence surveys, but students in simulator group reported more confidence with some parameters at the end of the clerkship
DeStephano (2015)[26]	RCT	Medical students (I = 45; C = 44)	Vaginal delivery simulation training using low-fidelity birth simulator, MamaNatalie (45 minutes)	Vaginal delivery simulation training using high-fidelity birth stimulator, Noelle (45 minutes)	1) Performance during first SVD rated by both preceptors and self-reported assessment of performance; 2) confidence with steps of vaginal delivery based on self-assessment questionnaires at 3 different time points	1) No difference between preceptor ratings and self-report ratings for first SVD; 2) Similar self-reported confidence levels between the groups, with the MamaNatalie group reporting significantly more confidence on 2 vaginal delivery steps at the postintervention time point and 1 step at the end of the clerkship time point
Holstrom (2011)[22]	RCT	Medical students (I = 57; C = 56)	Formal lecture + vaginal delivery simulation training with Noelle Obstetrics Simulator (60 minutes)	Formal lecture	1) Confidence with vaginal deliveries based on self-assessment questionnaires at 5 different time points; 2) written and oral examination scores; 3) final evaluation from resident / attending physician; 4) number of vaginal deliveries participated in	1) Simulation group reported more confidence with most stages of vaginal delivery post-intervention, no difference between groups at the end of clerkship; 2) simulation group had higher written and oral exam scores; 3) no significant difference in evaluations between the groups; 4) no difference in the number of vaginal deliveries participated in
Siassakos (2010)[27]	RCT	Medical students (I = 11; C = 9)	Simulated shoulder dystocia (SD) delivery + simulation session on SD management + SIM session with patient actor (NR)	Simulation shoulder dystocia (SD) delivery + simulation session on SD management + small group tutorial	1) Communication skills rated by patient actor; 2) ability to deliver infant appropriately; 3) reaction to training through survey	1) Students assigned to patient actor had significantly higher median communication scores; 2) both groups able to deliver infant appropriately; 3) strong positive reaction to simulation

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(continued)

TABLE 2
Comparison of outcome assessments and results for medical students exposed to vaginal delivery simulation *(continued)*

First author Name (year)	Study design	Population (n)	Intervention (duration)	Comparison	Outcome assessment	Results
Deering (2006)[5]	COS	Medical students (I = 18; C = 60)	Standard training with didactic lectures + simulation training with Noelle obstetrics simulator (90 minutes)	Standard training with didactic lectures	1) Comfort with basic obstetric procedures following obstetrics and gynecology rotation based on self-assessment surveys	1) Students who were trained with simulator reported increased confidence in certain obstetric procedures
Jude (2006)[21]	COS	Medical students (I = 17; C = 16)	Formal lecture with mannequin demonstration + vaginal delivery simulation training with Noelle obstetrics simulator (NR)	Formal lecture with mannequin demonstration	1) Confidence with vaginal delivery based on postintervention self-assessment surveys	1) Students who were trained with simulator had increased self-report confidence levels with most of the parameters measured
Nackman (2003)[24]	COS	Medical students (I = 54; C = 27)	Human patient simulator session focusing on shock (60−75 minutes)	Case-based lecture focusing on patient in shock	1) Objective structured clinical evaluation (OSCE), which included an "R" score based on radiograph study interpretation and a "C" score based on ICU clinical interpretation and management	1) Students who participated in the simulation session demonstrated higher OSCE scores at the end of clerkship
Nitsche (2016)[28]	COS	Medical students (I = 98; C = 80)	Vaginal delivery simulation training with Noelle Obstetrics Simulator (90 minutes)	No vaginal delivery simulation training	1) Perceived preparedness to perform a vaginal delivery based on self-assessment questionnaire; 2) attitudes toward training; 3) number of deliveries performed	1) Students trained with simulator had higher self-reported perceived preparedness; 2) simulation group had a more positive reaction to training; 3) no difference between groups for number of deliveries performed
Posner (2010)[25]	Cross-sectional	Medical students (I = 110)	Vaginal delivery simulation training with high-fidelity obstetric manikin (NR)	None	1) Assessment of pre- and posttest scores on definitions, risk factors, and management decisions related to labor and delivery; 2) student ratings on the appropriateness and quality of the session	1) Significant increase in posttest scores compared to pretest following simulation session; 2) mean scores for quality and appropriateness were 8.7/10 and 9.1/10, respectively

C, comparator; *COS*, comparative observational study; *GTA*, gynecology teaching associate; *I*, intervention; *ICU*, intensive care unit; *NR*, not recorded; *RCT*, randomized controlled trial; *SD*, standard deviation; *SP*, standardized patient; *SVD*, Simulated Vaginal Delivery.

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communicate bad news to patients. However, newer data show that students formally trained in giving bad news performed better, even when confronted with unfamiliar, unpracticed clinical scenarios.[33] Student performance improved after simulated communication training.[34,38,40] Communication skills can be taught using role-play with student peers,[41] volunteer patients,[42] trained standardized patients,[35] and virtual simulated patients[43] depending on the objectives of the curriculum and the available resources. Jabeen demonstrated no difference in history taking or patient counseling when students' communication skills were assessed with simulated patients or with real patients, and students favored practicing using simulation.[44] Taylor et al found no difference in communication ratings of students randomized to the SP group versus the role-play group.[41] However additional, randomized controlled trials are needed to identify best practices.

Interprofessional education simulation

Interprofessional education (IPE) refers to scenarios in which students from two or more professions in health care learn together during all or part of their professional training with the objective of cultivating collaborative practice and transdisciplinary teamwork. In the United States, 22,000 reported adverse events occur in obstetrics in hospitals each year, and approximately 70% of these are attributed to a failure of communication and collaboration between the women's health members.[45] Even though health care professionals share common knowledge, skills, and values, current health care education occurs in silos, fosters hierarchy, and favors individual decision making. In response to patient safety concerns, the Joint Commission in 2010 advised implementing interprofessional simulation teamwork training in medical education to promote a collaborative team approach, joint responsibility for care, clear delineation of roles, and improved communication and collaboration to improve patient outcomes and satisfaction and to reduce medical errors.[45] In 2012, Posmontier et al published their IPE simulation experience. Their intent was to shift students from individual reactive behaviors during adverse obstetrics and gynecology clinical scenarios to a team mindset in which members listen to each other and act in concert. The authors wanted to minimize the hierarchical inequity. Their specific aim was to assess whether an IPE simulation experience would improve collaborative attitudes among a diverse group of women's health students. The program evaluation used a pretest−posttest comparative design to measure changes in collaborative attitudes among 35 multidisciplinary women's health students before and after a transdisciplinary simulation experience. Their results showed significant increases in attitudes for mutual support and communication.[46] IPE health care teams have become the mainstay of medical practice. Simulation provides a unique opportunity for students to learn the skills critical in working within health care teams. Interprofessional teamwork simulation may be a key strategy for reducing medical errors, for promoting collaboration, teamwork, and effective communication, and for identifying clear roles and joint responsibility. This ultimately improves patient outcomes, patient satisfaction, and team collaboration while decreasing medical errors.[46−49]

Role of feedback in simulation

In 2015, Hunter et al wrote an excellent summary on feedback and debriefing. Feedback is essential for learning and a cornerstone of effective clinical teaching. Traditionally, in the clinical setting, feedback occurs between a clinical preceptor and a medical student after an observed clinical interaction. The goal of feedback is to improve the student's clinical performance. However, several challenges to effective feedback in the clinical setting exist, and include a lack of privacy, high clinical acuity, unclear expectations, unidirectional and hierarchical communication, and time. In the simulated setting, these challenges to feedback can be overcome.[50] Before medical educators knew how to develop simulation curricula, medical students and trainees were often sent to the simulation on their own to "practice" or "play" with the tools. As the research evolved, it became clear that for complex tasks or technical skills, guided instruction and feedback from a teacher could enhance learning, decrease training time, and improve performance in simulation. Feedback results in shorter learning curves and fewer errors, and learners report improved self-confidence, self-efficacy, and competency in performing the technical skill.[51,52] The presence of an expert, observing the learner and providing concurrent, expert verbal feedback through the learning phase of a complex technical skill leads to better acquisition and retention of skills.[53,54] Thus, when designing a simulation curriculum for a technical skill, one must consider who, what, where, when, and how to give feedback.

After a simulation experience, debriefing is the gold standard for feedback. It can overcome traditional barriers to feedback in the clinical environment by creating a culture in which learners are held in high regard; feedback is not perceived as positive or negative but, rather, as a normal consistent component of the learning experience; and feedback is grounded in the direct observation of the student's experience. In this setting, there is a greater opportunity for self-reflection, intrinsic motivation to improve, collaboration, and teamwork.[50]

Debriefing is a reflective feedback strategy used in simulation to promote meaningful learning. Debriefing is conducted by a trained facilitator and occurs immediately after a simulation experience. There are several frameworks for debriefing described in the literature, but all of them include guided reflection and facilitated group discussion. Rudolph et al[55] designed a debriefing model specifically for simulation-based medical education. The model has 3 stages: the reaction phase, the understanding phase, and the summary phase. In stage 1, learners are allowed to react to the simulation experience and are encouraged to

summarize what happened and what was observed by all the participants, to create a shared mental model of the experience. Stage 2 is the key component of the debriefing session, and it requires inquiry and analysis. The facilitator and the participants unpack assumptions and actions and try to understand why participants felt a certain way and answered or reacted in a certain way. Finally, stage 3 is a summary of lessons learned and takeaway points on how to do better in the future.[55] To be successful, debriefing must occur in a safe space where learners feel supported and safe to make mistakes. It should be confidential for all learners, and, since it often uncovers performance errors, gaps in knowledge, and system failures, the focus should always be on the process and not on individual performance.[50]

As medical educators, we are often asked to perform a debriefing session with little or no training. Practicing debriefing skills is critical to the success of the simulation experience for the learner. An effective debriefer must be able to guide the discussion to meet the learning objectives and to engage the learners in meaningful reflection. A debriefer must be comfortable defusing stressful situations and managing difficult conversations, and must be nonjudgmental.[50] There are several debriefing scripts in the literature, but a simple and recent one named Promoting Excellence and Reflective Learning in Simulation (PEARLS) was specifically designed for new debriefers and to be easily adaptable to multiple simulation activities. This script has 4 domains—reaction, description, analysis, and application—and consists of the following 6 questions:

1) How is everyone feeling? (Reaction)
2) Can someone summarize the case? (Description)
3) Can someone describe what the main issues of the case are? (Description)
4) What aspects of the case were managed well? (Analysis)
5) What aspects of the case were challenging? (Analysis)
6) What is one takeaway that will help you in the future? (Application)[51]

The growing body of research on debriefing in health care provides educators with a wealth of resources on effective feedback strategies. Incorporation of these methodologies into clinical teaching fosters the mastery of higher-level cognitive skills and critical thinking.[50]

Role of assessment in simulation

Assessment is critical to medical education. Simplified, assessment in medical education is either formative or summative. Formative assessment is the day-to-day appreciation and coaching feedback that we provide to medical students on a daily basis. Summative feedback is the evaluation feedback that we provide at set intervals throughout the 4 years of medical school.[50] Medical educators make judgements about learners based on several types of assessment, including examinations, checklists, rating scales, and clinical gestalt.[56]

Medical student assessment in simulation is primarily focused in 2 areas: Observed Structured Clinical Exams (OSCEs), and Objective Structured Assessment of Technical Skills (OSATS) with checklists. The OSCE was first described in 1975 and was introduced as a method to assess the clinical competence of medical students. OSCEs improve feedback to both students and faculty. Unlike written examinations that can measure only medical knowledge, OSCEs can measure other related clinical skills such as professionalism, communication, critical thinking, and technical skills. The use of the OSCE has increased dramatically in medical education in recent years. OSCEs have been compared to written board examinations and determined to be reasonable assessment tools.[57]

Objective Structured Assessment of Technical Skills (OSATS) were introduced in 1997.[7] Virtual simulators and OSATS are both reliable and valid methods for task-specific skill assessment. OSATS use checklists specific to the task, as well as a global rating scale. OSATS are generally paired with low-technology simulators. They are inexpensive, but require significant faculty time and training. In contrast, virtual reality (VR) simulators are expensive, but require no faculty oversight. Numerous studies have shown that these simulators are reliable and valid for teaching and assessing psychomotor skills for various laparoscopic procedures.[6]

The combined use of OSATS, performance assessment from VR simulators, and global rating scales from direct faculty observation of a trainee during live surgery can all be used congruently to formulate a more robust assessment of trainee surgical skills.[9] Kumar et al[58] took a unique look at assessment to evaluate whether the act of assessment drove learning. They implemented an IPE program that consisted of pre-reading, a lecture, a video, and a simulation session with 3 stations. A total of 405 medical students and 104 midwifery students went through the program over a 2-year period. They found that the medical students had lower pretest scores than the midwifery students, likely due to less clinical exposure at the time of the pretest. Both groups improved on the post-test and there were no differences in the medical students or midwifery students' post-test scores. They discovered that the pre-test helped students to identify the objectives of the course and to direct the students' learning. The presence of the assessment kept students engaged, and helped teachers to stay focused and to cover objectives during the teaching sessions. The posttest helped learners to recognize what they had learned, along with their gaps, and was an opportunity to review content and to reinforce learning.[58] Thus, assessment can be used to drive learning; it can be a formative or summative type of feedback; and there are numerous assessment tools that can be used individually or in combination to measure a student's knowledge, skills, and workplace behaviors. No single assessment tool is perfect, and, to make sound judgements about a student's competency, medical educators must understand the strengths and limitations

of the decision-making process and of each assessment tool. In the era of competency-based medical education, with increased reliance on assessments of mastery, entrustable professional activities or clinical tasks, and milestones, how we make decisions about a learner's competency is becoming increasingly important. Assessments are intended to result in a defensible decision about the person being assessed. Validation is the process of collecting and interpreting evidence to support that decision.[56]

Role of validation in simulation

In 2015, Cook et al[56] published a contemporary approach to validity arguments using Kane's framework. Traditionally, each tool of simulation, whether it was a virtual reality simulator, a manikin, a standardized patient, or a hybrid model, was studied for its validity and reliability. "Validity" refers to the ability of a test to measure what it is designed to measure. "Reliability" refers to the ability of a test to generate the same results repeatedly.[6] Validity is no longer considered an endpoint but, rather, a process. Validation has evolved over the last 100 years and is defined currently by Messick[59] and Kane[60] as a process of collecting and interpreting evidence to support the decision made using the assessment.[59,60] A rigorous validation process involves articulating the claims and assumptions of the decision (the interpretation and use argument), testing these assumptions, and organizing the evidence into a coherent validity argument. Kane identifies 4 inferences in the validating argument: scoring, generalization, extrapolation, and implications. Scoring is translating the observation into one or more scores. An example would be observing a student taking an obstetric history on a standardized patient and giving the student a numerical score of 3 on a 5-point Likert scale. Generalization is using the score as a reflection of performance in a test setting. To use our analogy, above, we would make an assumption that a score of 3 could be generalized to a similar score on the end of clerkship OSCE. Extrapolation is using the score as a reflection of real-world performance. We would assume that the score of 3 could be extrapolated to stating that the learner would perform similarly in the clinical setting with a real patient. Implication is applying the score to inform a decision or action. Finally, we would use this score to decide whether or not the student was competent at taking an obstetric history, or whether that student could be entrusted to perform a history without supervision or that he or she met the standards of Milestone One. Evidence should be collected to support each of these 4 inferences. Evidence should focus on the most questionable assumptions in the chain of inference. Key assumptions and needed evidence are variably weighted, depending on the intended use of the decision. For high-stakes decisions, stronger evidence is warranted, and vice versa for low-stakes decisions. Kane's framework is more flexible than the more traditional definition of validity, and can be applied to quantitative and qualitative assessments and to individual and programmatic assessment.[60]

As the role of simulation grows and the stakes of assessment rise, the science of validation will become increasingly important. It is this area of science that will allow us to choose the best simulator for a specific task, for a specific environment, and for a specific learner, and to be confident that the learner assessment of competency is accurate.[61–69] Thus, when choosing an assessment tool, medical educators should search the medical literature for existing tools that have undergone a robust validation process; or, when developing an assessment tool, educators should validate the tool and publish their work, as this is an expanding field of scholarly work.

Conclusion

Multiple forces in health care delivery and medical education have been identified that contribute to the decreased volume of clinical opportunities for medical students in obtaining obstetrics and gynecology skills. As such, simulation plays an increasingly important role in the education of medical students. In this article, we have delineated the expanding roles of simulation in undergraduate medical education in the field of obstetrics and gynecology and its effect on important learner outcomes, including confidence, knowledge, skills, workplace behaviors, and translation to patient care. Multiple challenges to the application of simulation in obstetrics and gynecology remain, including cost, variability of resources across institutions, and the distribution of learners and teachers across multiple clinical sites. Nonetheless, simulation in the education of obstetrics and gynecology medical students is a valuable learning platform, and provides solutions for educators who must ensure a comprehensive and standardized training experience for all learners. ■

ACKNOWLEDGMENTS

The authors acknowledge Elizabeth Sievers at the Department of Obstetrics, Gynecology, and Reproductive Sciences, University of Vermont Medical Center, for administrative assistance; and Ellen Cook, medical student at Drexel University College of Medicine, for creating Table 2 for this article.

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