REVIEW ARTICLE

Clinical Simulation in Modern Teaching and Training of Sonography in Obstetrics and Gynecology

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Abstract

Advances in computer technology, hardware and software have made ultrasound a diagnostic imaging technique of choice in certain areas of medicine or specialties such as obstetrics and gynecology. In teaching and training of obs/gyne ultrasonography, medical educators can utilize different forms of clinical simulators: traditional standardized patients and standard ultrasound diagnostic equipment, computer-based simulators, ultrasound simulators or ultrasound simulators with manikins. The popularity of a simulator is determined not only by its features, ease of use and cost, but also by its available learning modules and applications.

Technology in ultrasound and computers are rapidly advancing in enhancing the quality and miniaturizing ultrasound machines. Portable and handheld ultrasound equipments are quickly becoming indispensable diagnostic instruments in different health care settings especially the emergency rooms and physician offices. Concerns, however, remain related to the lack of competence of health care providers in using and interpreting results of ultrasound studies, and the needs to standardize the training in ultrasonography. It is important to have access to one or more ultrasound simulators; however, it is even more important to establish and integrate fundamental structure of training ultrasonography into the main training curriculum of undergraduate, graduate, and postgraduate medical education.

Keywords: Medical education, ultrasonography simulation, ultrasound training, comparison between ultrasound simulators.

INTRODUCTION

Advances in computer technology, hardware and software have made ultrasound a diagnostic imaging technique of choice in certain areas of medicine or specialties such as Obstetrics and Gynecology. Some medical schools in the United States have incorporated an ultrasound curriculum into basic science courses and clinical clerkships. In addition, the Residency Review Committees have required training programs such as Obstetrics and Gynecology and Emergency Medicine residency programs to provide residents with adequate competences in performing and interpreting ultrasound studies.

Decreasing costs, increasing resolution and convenient portability of the modern ultrasound devices make them more and more attractive in variety of clinical settings. Compared to other commonly used radiographic imaging techniques such as CT scan or MRI, ultrasound equipments are portable, affordable, and nonradioactive. Therefore, diagnostic ultrasound has been widely used not only in hospitals but also in physicians' offices, and other primary care settings.

CHALLENGES IN USING ULTRASOUND SIMULATION

While the uses of medical ultrasound are expanding, the teaching of sonography interpretation to medical students is not. The traditional curriculum in medical schools is far from emphasizing ultrasound diagnosis and curricula remain scattered, inconsistent and unverified. Nationally and internationally, the use of ultrasound remains fairly unregulated. Because of the popularity of ultrasound in health care settings in both developed and developing countries, the World Health Organization (WHO) has expressed concern about the quality control of the use of ultrasound.

The WHO issued a report outlining recommended training curricula for the general, advanced, and specialized use of ultrasound along with recommendations for standards in education and training of this technique.[1] The vast discrepancy in the educational criteria and performance expectations in sonography prompted such organizations as the American Institute of Ultrasound in Medicine and the European Federation of Societies for Ultrasound in Medicine and Biology to suggest minimum training recommendations, both theoretical and clinical, for the practice of medical ultrasound.[2-4] Furthermore, the 2000 report of the Institutes of Medicine suggested that medical education and training look into the capabilities of simulation in reducing medical errors.[5]

The American College of Obstetricians and Gynecologists (ACOG) has recommended the development of regional training centers with capabilities for high-fidelity simulation to focus on continuing professional education and skills training and retention.[6] The Society for Academic Emergency Medicine as well has recognized the need for emergent proficiency in ultrasound for bedside diagnostics and emergency procedures, and has recommended an ultrasound training curriculum including 150 ultrasound examinations, where simulation can be used for ultrasound image recognition and ultrasound-guided procedure performance.[7]

While there is a long history of simulation approaches, dating as far back as the Paleolithic period, the scientific knowledge and inquiry about simulation are yet in infancy.[8] Regulated contact hours for students and residents, coupled with decreased availability of opportunities for bedside teaching, call for creative thinking in organizing medical education in Ob and gyn and increased awareness about the potential of simulation in education.[8-10] Utilization of simulation in medical education is a key variable in changing trainees' learning curves and monitoring the number of exposures per learner.[8] Ob and gyn simulation has a huge potential for training and competency assessment, which might be utilized in board certification in the near future.[8,11] Somewhere in the midst of all possible teaching and assessment modalities, the ultrasound simulation option as a learning tool still waits to be fully unveiled.

MEASURABLE OUTCOMES OF ULTRASOUND SIMULATION TRAINING

Prototypes of ultrasound simulators with Ob and gyn application became available in 1995.[12] However, during the last 15 years, only few large-scale, multi-center studies on the use of ultrasound simulation in teaching and training Ob and gyn ultrasonography have been published. The available data show positive results of intervention, regardless of the form of simulation.[13,14] The optimum length of a simulation training session is currently considered to be between 75 and 90 minutes.[11]

More studies have focused on the effectiveness of a specific approach, or a specific skill acquisition. For example, one study showed that the utilization of a hybrid simulation scenario, involving both standardized patients and sonography simulation, increased the amniocentesis performance scores of Ob and gyn residents from 42% to 87%.[15] Another study reviewed the outcomes of a hybrid scenario that utilized endovaginal ultrasound task trainer and a high-fidelity ultrasound simulator, and reported improved trainee Ob and gyn educational experience.[16]

In teaching and/or training of Ob and gyn ultrasonography, the medical educators can utilize different forms of clinical simulators:

1. The traditional standardized patients (SP) and standard ultrasound diagnostic equipments.
2. The computer-based simulator—Fetal ultrasound simulator CD-ROM by Wesley-Lee, et al.[12]
3. The ultrasound simulator—SONOSim3-D, VirUS.[17,18]
4. The ultrasound simulator with manikin—UltraSim, SonoTrainer.[19]

Different characteristics of ultrasound simulators are reviewed by H. Maul[19] and summarized in Table 1.

The popularity of a simulator is determined not only by its features, ease of use and cost, but also by its available learning modules and applications (Table 2).

Among all Ob and gyn ultrasound simulators, the UltraSim is the most popular model. In 1995, its first ultrasound simulation model appeared on the market, based on real ultrasound patient data sets and accompanied by syllabus, instruction manuals and case presentations.[11] UltraSim (MedSim Ltd., Ft. Lauderdale, FL, USA) offers ultrasound simulation in both obstetrics and gynecology, including transvaginal techniques, as well as breast diagnostics. The cases vary by difficulty and complexity by pregnancy trimesters, including both normal and pathologic pregnancies. The color Doppler ultrasound module showcases the complete capabilities of modern ultrasound systems. UltraSim is one of the few simulators to offer instructional strategies and curriculum with lesson plans.

Table 1: Major characteristics of clinical simulators designed for teaching and training Ob and gyn ultrasonography (Adapted from reference 19)

Simulator	*Dummy*	*Realism*	*Interactive*	*Real-time*	*Image quality*	*Data acquisition*
UltraSim	+	+	+	+	Good	3-D scans
SonoTrainer	+	+	–	+	High	3-D scans
–SONOSim3-D*	–	–	+	+	Acceptable	3-D scans
VirUS*	–	–	+	–	Acceptable	Simulated

*Simulator system is not popular or widely reviewed, but is included for comparison.

Table 2: Ultrasound simulators and their Ob and gyn ultrasonography learning modules and/or applications (Adapted from reference 19)

Simulator	*Ob 1st trimester*	*Ob 2nd trimester*	*Ob anomalies*	*Prenatal NT*	*Fetal echocardio*	*Gyn abdominal and transvaginal*
UltraSim	+	+	+	+	–	+
SonoTrainer	+	+	+	+	+	+
*SONOSim3-D**	–	–	–	–	–	–
*VirUS**	–	–	–	+	–	–

*Simulator system is not popular or widely reviewed, but is included for comparison.

In general, ultrasound simulation should incorporate the basic simulation training principles, such as: (1) as reasonably realistic as objectively needed (ARRON), (2) deliberate practice of skills, (3) immediate feedback during procedure training, (4) practice with increasing levels of difficulty, (5) focus on proper technique and accuracy, and (6) clearly defined performance benchmarks and assessment objectives.[7,8]

TECHNICAL CHARACTERISTICS OF ULTRASOUND SIMULATORS

Not withstanding the use of different techniques and algorithms, all ultrasound simulators with or without manikins create "virtual reality" by applying the same principles: (1) data acquisition, (2) data processing, and (3) ultrasound imaging simulation.

Three-dimensional sensors provide virtual position data (data acquisition) to an image-processing computer. The computer computes and processes 3-D data associated with the position of the transducer and related slice-sections (data processing) to display 2-D ultrasound images on the monitor, i.e. imaging simulation[19] (Figs 1 and 2). The ultrasound images are constructed by scanning CT, MRI or ultrasound real patient images by a 3-D scanner, and stored in a database.

FUTURE OF ULTRASOUND SIMULATORS

Sonography simulation can be utilized for teaching and assessment purposes at different learner levels (i.e. students,

Fig. 1: The ultrasound simulator with manikin – UltraSim

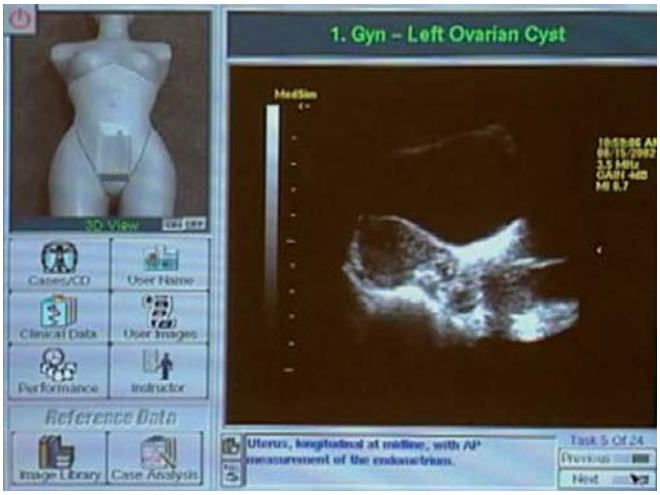

Fig. 2: Transabdominal ultrasound simulation on UltraSim demonstrating the uterus and left ovarian cyst

residents), and for different types of learners (i.e. medical students, nursing students, specialized training). Furthermore, sonography simulation could play a vital role in teaching evidence-based medicine, as well as in reducing medical errors. Examples include (1) diagnosis of adnexal torsion, ectopic pregnancy, premature labor and other acute conditions; (2) surface anatomy correlations with imaging aided by ultrasound; (3) ultrasound simulation for interventional Ob and gyn procedures, and (4) ultrasound simulation applications related to integrative clinical presentation—based medical curriculum.

Availability, portability, affordability and huge potential for scenario creating, could make ultrasound simulation a sought after teaching and learning modality, matching the integrative nature of modern medical curricula. Table 3 presents the opportunities for student learning in human reproduction utilizing Ob/Gyn sonography simulation in our curriculum.

Technology in ultrasound and computers are rapidly advancing in enhancing the quality and miniaturizing ultrasound machines. Portable and handheld ultrasound equipments are quickly becoming indispensable diagnostic

Table 3: Ultrasound skills related to human reproduction (compliments of Sanja P Kupesic, MD, PhD)

Clinical focus	*Ultrasound skills*
Normal and abnormal menstrual cycle	• Demonstrate ovarian and endometrial changes during ovulatory menstrual cycle • Diagnose outflow tract anatomic defects
Pregnancy	• Determine gestational age and viability • 1st trimester: nuchal translucency scanning • 2nd trimester: fetal anatomy survey • 3rd trimester: assessment of fetal weight • Ultrasound assessment of the cervix
Abnormal pregnancy/pregnancy loss	• Differentiate between intrauterine and ectopic pregnancy • Differentiate between threatened abortion, missed abortion, anembryonic pregnancy and gestational trophoblastic disease • Rule out uterine causes of pregnancy loss (uterine malformation, submucosal fibroid)
Infertility	Detect causes of infertility: • Ovarian (anovulation) • Tubal (adhesions, chronic PID) • Uterine (uterine anomalies, fibroids, synechiae)
Contraception	• Monitoring the position of an intrauterine contraceptive device (IUCD)
Menopause	• Assessment of endometrial thickness
Pelvic floor relaxation	• Ultrasound imaging of the pelvic floor muscles • Ultrasound assessment of residual urine volume
Female breast	• Ultrasound imaging of benign and malignant breast lesions • Ultrasound guided breast biopsy
Vaginal discharge sexually transmitted disease	• Ultrasound diagnosis of acute and chronic pelvic inflammatory disease • Ultrasound guided drainage of tubo-ovarian abscess
Abnormal genital tract bleeding	• Differentiate the causes of abnormal genital tract bleeding (dysfunctional uterine bleeding, pregnancy, uterine fibroid, atrophic endometrium, endometrial hyperplasia, polyps, and endometrial carcinoma)
Pelvic mass	Diagnose and differentiate: • Ovarian masses • Tubal masses • Uterine masses
Pelvic pain	• Differentiate between gynecologic and nongynecologic causes of pelvic pain • Ultrasound diagnosis of ectopic pregnancy • Ultrasound diagnosis of adnexal torsion • Ultrasound assessment of degenerative fibroids • Revisit ultrasound diagnosis of PID

instruments in different health care settings especially the emergency rooms and physician offices. Our concerns are similar to those raised by the WHO: the lack of competence of health care providers in using and interpreting results of ultrasound studies, and the needs to standardize the training of ultrasonography. It is important to have access to one or more ultrasound simulators; however, it is even more important to establish and integrate fundamental structure of training ultrasonography into the main training curriculum of undergraduate, graduate, and postgraduate medical education.

CONCLUSION

Based on our experiences and the review of literature, we would like to offer the following key points to medical educators aspiring to utilize clinical simulation in teaching and training of sonography in the area of obstetrics and gynecology:

1. The popularity of ultrasonography in medicine for diagnostic purposes rapidly increases. The miniaturization and portability of the handheld sonography machines makes them readily available at the point of care and maximizes their utilization.
2. There is a general consensus about the lack of preparation and adequate knowledge in interpretation of ultrasound imaging at the primary care office level. Therefore, we strongly recommend the implementation of ultrasonography in the curricula of undergraduate, graduate, postgraduate and continuous medical education.
3. There is a demand to increase the knowledge base and skills in sonography in order to enhance the diagnostic accuracy at the point-of-care, as well as to ensure patient safety and practice of evidence-based medical care. To accomplish that, we need to utilize broadly sonography simulation with and without manikins in medical skills training.

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