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Obstetric and gynecologic ultrasound curriculum and competency assessment in residency training programs: consensus report

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ABSTRACT

Ultrasound imaging has become integral to the practice of obstetrics and gynecology. With increasing educational demands and limited hours in residency programs, dedicated time for training and achieving competency in ultrasound has diminished substantially. The American Institute of Ultrasound in Medicine assembled a multi-Society Task Force to develop a consensus-based, standardized curriculum and competency assessment tools for obstetric and gynecologic ultrasound training in residency programs. The curriculum and competency-assessment tools were developed based on existing national and international guidelines for the performance of obstetric and gynecologic ultrasound examinations and thus are intended to represent the minimum requirement for such training. By expert consensus, the curriculum was developed for each year of training, criteria for each competency assessment image were generated, the pass score was established at or close to 75% for each, and obtaining a set of five ultrasound images with pass score in each was deemed necessary for attaining each competency. Given the current lack of substantial data on competency assessment in ultrasound training, the Task Force expects that the criteria set forth in this document will evolve with time. The Task Force also encourages use of ultrasound simulation in residency training and expects that simulation will play a significant part in the curriculum and the competency-assessment process. Incorporating this training curriculum and the competency-assessment tools may promote consistency in training and competency assessment, thus enhancing the performance and diagnostic accuracy of ultrasound examination in obstetrics and gynecology. Copyright © 2018 ISUOG. Published by John Wiley & Sons Ltd.

INTRODUCTION

Ultrasound imaging is integral to the practice of obstetrics and gynecology, as it allows comprehensive anatomic and physiologic evaluation of the fetus and detailed assessment of the maternal pelvic organs. Ultrasound imaging has significant advantages over other imaging modalities. The technology is portable, is relatively inexpensive and does not involve ionizing radiation. In the gynecologic patient, the real-time aspect of this modality allows the operator to use transducer pressure to palpate as the patient is imaged, thus localizing the anatomic source of pelvic pain, and to examine for the sliding of organs over each other and over the pelvic wall. Ultrasound imaging is also used widely in obstetrics, with current data suggesting that pregnant women in the USA receive on average about 4.5 ultrasound examinations per pregnancy[1].

To a much greater extent than computed tomography or magnetic resonance imaging, ultrasound imaging is operator-dependent. Adequate technical skills and a good understanding of anatomy are essential to performance

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of the ultrasound examination. The quality of ultrasound images is dependent on several factors, including the operator having a basic understanding of ultrasound physics and familiarity with the ultrasound machine control panel, as well as on their skills and competency in performing the examination. Obstetric ultrasound imaging is particularly challenging, given the small size of fetal organs and the variable fetal position in the uterus, which occasionally obscures target anatomic regions.

With the increasing educational demands and limited hours in residency training programs, dedicated time for training and achieving competency in ultrasound has diminished substantially. Data from the Accreditation Council for Graduate Medical Education on ultrasound performance in obstetric and gynecologic residency programs indicate that currently the number of ultrasound procedures performed as part of many training programs falls short of the minimum threshold required for physician qualification for the performance of obstetric and gynecologic ultrasound examinations, as defined by the American Institute of Ultrasound in Medicine (AIUM)[2,3].

Given the clinical importance and widespread use of ultrasound imaging in obstetrics and gynecology, the AIUM assembled a multi-Society Task Force to develop a standardized consensus-based curriculum and competency-assessment tools for the performance of the basic obstetric and gynecologic ultrasound examination, intended to be used in residency programs. Task Force participants included representatives from the AIUM, Society for Maternal-Fetal Medicine (SMFM), American Congress of Obstetricians and Gynecologists (ACOG), American College of Osteopathic Obstetricians and Gynecologists (ACOOG), American College of Radiology (ACR), International Society of Ultrasound in Obstetrics and Gynecology (ISUOG) and Society of Radiologists in Ultrasound (SRU).

PROCEDURE: CURRICULUM AND COMPETENCY DEVELOPMENT

The process of developing the document included multiple telephone conference calls and one face-to-face meeting between members of the Task Force. The curriculum was developed based on existing national and international guidelines for the performance of obstetric and gynecologic ultrasound examination[4–6] and is intended to provide fundamental ultrasound education in the first and second years, with more advanced ultrasound knowledge in the third and fourth years, of residency training. A competency-assessment process was developed for obtaining specific ultrasound images that are part of the basic obstetric and gynecologic ultrasound examinations. In addition, writing an ultrasound report, assessing ultrasound components of the biophysical profile and performing third-trimester amniocentesis were included. By expert consensus, the curriculum was developed for each year of training, criteria for each competency-assessment image were generated, the pass score was established at or close to 75% for each

(depending on number of criteria per competency), and obtaining a set of five ultrasound images with pass score in each was deemed necessary for attaining each competency. Some competencies, such as measurement of the uterus, require more than one image to be obtained and the pass score was established taking into account the criteria of all required images. The consensus decision to establish competency on the basis of five image submissions was supported by data (albeit limited) in the literature. In a study assessing performance measures and learning curves for use of an ultrasound simulator, novices reached the level of an expert with a median of five iterations[7]. In another prospective cohort study on the usability of simulation training in obstetric ultrasonography, measurements of crown–rump length, head circumference and femur diaphysis length were attained consistently with five or more iterations[8].

Given the current lack of substantial data on competency assessment in ultrasound training, the Task Force expects that the criteria set forth in this document will evolve with time. The Task Force encourages use of ultrasound simulation in residency training and expects that simulation will be a significant part of the curriculum and the competency-assessment process. In a recent study, the validity of an obstetric ultrasound simulator as a tool for evaluating trainees following structured training was compared to using standardized ultrasound planes obtained from volunteers[9]. Images obtained from the simulator and from the volunteer subjects were scored according to previously established quality criteria. Scores obtained from the obstetric ultrasound simulator were significantly higher than those obtained by volunteers. The study showed that an obstetric ultrasound simulator is as effective as volunteer-based examination for evaluating practical skills of trainees following structured training in obstetric ultrasound[9].

It is important to note that the competency-assessment aspect of this document requires the trainee to obtain personally the respective images for review and evaluation. For specialties and practices such as radiology practices, in which the primary mode of ultrasound training is based on interpretation of images acquired by sonographers, the competencies can be adapted to reflect this.

CURRICULUM

Objectives of the curriculum are organized around essential topics, including basic principles of medical ultrasound and characteristics of the equipment, aspects of the ultrasound examination, and ultrasound examination performance throughout the stages of pregnancy and in gynecology. The objectives are presented within a level-based framework that will allow trainees to progress along a continuum toward increasing competence.

Level 1 (Year 1)

Basic principles of medical ultrasound

- Basic principles of ultrasound physics.

- Ultrasound modes (B-mode, M-mode, Doppler, two-dimensional (2D) and three-dimensional (3D)).
- Bioeffects of ultrasound (mechanical and thermal effects: ALARA principle – As Low As Reasonably Achievable)[10].
- Ultrasound artifacts.
- Official statements from professional societies (AIUM, ACOG, ACOOG, ACR, ISUOG, SMFM and SRU).

Basic characteristics of ultrasound equipment (knobology)

- Ultrasound transducers: principles of sound generation; compare transducer characteristics and applications.
- Sound penetration and bioeffect with consideration related to acoustic power output.
- Effect of frequency on resolution and penetration.
- Effect of depth settings on field of view and image size.
- Gain settings for optimal image brightness with minimum power output.
- Focal zone depths to achieve best resolution of structures of interest.
- Image persistence settings to reduce background noise.
- Inputting patient information into ultrasound system before starting an ultrasound examination.

Aspects of the ultrasound examination

- Effective positioning of patients and application of coupling agents.
- Ergonomic practices that minimize repetitive stress injuries (positioning of operator and equipment).
- Correct transducer manipulation and image orientation.
- Ultrasound image labeling and storage.
- Appropriate communication of ultrasound findings to other health professionals.
- Protocol for transducer cleaning and disinfection.

Ultrasound in the first trimester

- Steps for performance of first-trimester transvaginal ultrasound examination.
- Indications for first-trimester ultrasound examination.
- Gestational sac evaluation (intrauterine location, discriminatory human chorionic gonadotropin levels and differentiation from endometrial fluid).
- Yolk sac.
- Amnion.
- Embryo/fetus (number).
- Embryo/fetus cardiac activity; document with M-mode or movie clip.
- Criteria for definitive diagnosis of embryonic/fetal death in first trimester.
- Components of sonographic dating in first trimester.
- Ultrasound evaluation of ampullary tubal ectopic pregnancy.
- Subchorionic hematoma.
- Sonographic features of molar pregnancy.

- Association between thickened nuchal translucency and fetal chromosomal anomalies.

Ultrasound in the second and third trimesters

- Components of basic second- and third-trimester ultrasound examinations.
- Components of fetal biometry in sonographic dating in second and third trimesters.
- Predisposing factors for fetal macrosomia and fetal growth restriction in third trimester.
- Imaging parameters for placental localization.
- Risks and indications for genetic amniocentesis.

Ultrasound evaluation of twin gestations

- Role of ultrasound in diagnosis of twins.
- Chorionicity and amnionicity in multifetal pregnancies.

Placental abnormalities

- Risk factors and sonographic diagnosis of placenta previa and low-lying placenta.
- Risk factors of placenta accreta.

Amniotic fluid assessment

- Methods for diagnosing oligohydramnios.
- Methods for diagnosing polyhydramnios.

Ultrasound examination of non-pregnant uterus

- Indications for pelvic sonography.
- Sonographic features of the normal uterus in relation to the menstrual cycle.

Ultrasound evaluation of adnexa

- Sonographic features of normal ovary in relation to menstrual cycle.
- Characteristics of a simple cyst.

Level 2 (Year 2)

Ultrasound in the first trimester

- Sonographic appearance of major fetal malformations in early gestation.
- Atypical locations of ectopic pregnancy, including interstitial, ovarian, cervical, abdominal and Cesarean scar implantations.
- Workup of pregnancy of unknown location.

Ultrasound evaluation of twin gestations

- Methods of determining twin placentation by ultrasound.
- Role of ultrasound in follow-up of twin gestations.
- Role of ultrasound in serial evaluation of discordant twins.
- Sonographic findings of monochorionic monoamniotic twins.

Placental abnormalities

- Risk factors and sonographic diagnosis of vasa previa.
- Risk factors and sonographic findings of placenta accreta.
- Role of ultrasound assessment of placental abruption.

Amniotic fluid assessment

- Ultrasound estimation of amniotic fluid volume in twin gestations.

Cervix

- Ultrasound measurement of cervical length in second and third trimesters of pregnancy.

Abnormalities of the non-pregnant uterus

- Ultrasound evaluation of anatomic locations of leiomyomas.
- Ultrasound evaluation of endometrial abnormalities.

Ultrasound evaluation of adnexa

- Sonographic characteristics of hemorrhagic cysts and their evolution (grayscale and color Doppler).
- Sonographic characteristics of endometriomas (grayscale and color Doppler).
- Sonographic characteristics of mature teratomas (grayscale and color Doppler).
- Sonographic characteristics of pedunculated leiomyomas and ovarian fibromas.
- Sonographic characteristics of hydrosalpinges.
- Sonographic characteristics of tubo-ovarian inflammatory process (tubo-ovarian complex/abscess).
- Sonographic characteristics of peritoneal inclusion fluid.
- Sonographic characteristics of polycystic ovaries.
- Sonographic characteristics of adnexal torsion.
- Sonographic characteristics of malignant adnexal masses.

Level 3 (Year 3)

Ultrasound in the second and third trimesters

- Normal fetal head anatomy and common malformations.
- Normal fetal facial anatomy and common malformations.
- Normal fetal thoracic anatomy and common malformations.
- Normal fetal heart anatomy and common malformations.
- Normal fetal abdominal anatomy and common malformations.
- Normal fetal pelvic anatomy and common malformations.
- Normal fetal skeletal anatomy and common malformations.

- Role of umbilical artery Doppler studies in evaluation of fetal growth restriction.
- Ultrasound diagnosis of hydrops.
- Writing the ultrasound report.

Ultrasound evaluation of twin gestations

- Role of ultrasound in diagnosis and management of twin–twin transfusion syndrome.
- Role of ultrasound in evaluation of twin anemia–polycythemia sequence and selective intrauterine growth restriction in monochorionic twins.
- Role of umbilical artery Doppler studies in the evaluation of fetal twin–twin transfusion syndrome.

Ultrasound examination of the non-pregnant uterus

- Sonographic features of adenomyosis.
- Classification of congenital uterine malformations (2D and 3D† ultrasound).
- Role of ultrasound in localization of intrauterine contraceptive devices (2D and 3D† ultrasound).

    †Note that this does not imply that the trainee needs to attain competency in 3D ultrasound, but rather explain the classification of uterine malformations and identify location of intrauterine contraceptive devices based upon 2D and 3D ultrasound.

Evaluation of the adnexa

- Role of color Doppler in evaluation of adnexal masses.
- Prediction models for ovarian cancer.
- International Ovarian Tumor Analysis (IOTA) simple rules for classification of adnexal masses[11].
- Sonographic features of endometriosis.

Level 4 (Year 4)

Ultrasound in the second and third trimesters

- Role of middle cerebral artery peak systolic velocity in screening for fetal anemia.

Ultrasound evaluation of twin gestations

- Sonographic features of conjoined twins.
- Role of ultrasound in diagnosis and evaluation of twin reversed arterial perfusion.

COMPETENCY ASSESSMENT

Competency is assessed by evaluation of still ultrasound images, movie clips, real-time scanning or a combination of methods, as determined by individual programs. The pass score for competency assessment was established at or close to 75%, and a set of five ultrasound images with pass score in each was deemed necessary for attaining each competency. Missing the specified criteria* fails the competency for a particular image (or movie clip when appropriate). The competencies are listed in Table 1.

Table 1 List of competencies assessed during Levels 1–4 (Years 1–4)

1. **Competency assessment: Level 1 (Year 1)**
   (Tables 1A–1K in Appendix S1)
   A. Mean sac diameter
   B. Crown–rump length
   C. Fetal presentation
   D. Fetal extremities
   E. Biparietal diameter
   F. Head circumference
   G. Abdominal circumference
   H. Femur diaphysis length
   I. Biophysical profile (ultrasound components)
   J. Amniotic fluid index
   K. Maximum vertical pocket
2. **Competency assessment: Level 2 (Year 2)**
   (Tables 2A–2G in Appendix S1)
   A. Cervical length (transvaginal ultrasound)
   B. Cervical length (transabdominal ultrasound)
   C. Endometrial thickness
   D. Uterine measurements
   E. Ovarian measurements
   F. Transvaginal pelvic examination: uterus
   G. Transvaginal pelvic examination: ovaries
3. **Competency assessment: Level 3 (Year 3)**
   (Tables 3A–3P in Appendix S1)
   A. Head: transventricular plane
   B. Head: transthalamic plane
   C. Head: transcerebellar plane
   D. Face: upper lip and philtrum
   E. Four-chamber view
   F. Left ventricular outflow tract
   G. Right ventricular outflow tract
   H. Abdomen: abdominal circumference level
   I. Abdomen: kidneys
   J. Abdomen: cord insertion
   K. Number of cord vessels
   L. Pelvis: bladder
   M. Spine: longitudinal
   N. Spine: axial
   O. Writing an ultrasound report: Obstetrics
   P. Writing an ultrasound report: Gynecology
4. **Competency assessment: Level 4 (Year 4)**
   (Tables 4A and 4B in Appendix S1)
   A. Face: facial profile
   B. Amniocentesis to assess fetal lung maturity
5. **Additional competencies**
   (Tables 5A–5E in Appendix S1)†
   A. Three vessels and trachea view
   B. Face: orbits
   C. Umbilical artery Doppler
   D. Nuchal translucency
   E. Saline contrast sonohysterography

†Not currently part of basic obstetric and gynecological ultrasound examination.

Details of each competency assessment and corresponding images are provided in Appendix S1.

CONCLUSION

This document, endorsed by the AIUM, SMFM, ACOOG, ISUOG and Society of Diagnostic Medical Sonography (SDMS), recognized by ACR and SRU, and supported by ACOG and the Council on Resident Education in Obstetrics and Gynecology (CREOG), presents a consensus-based curriculum and competency-assessment tools for performance of the basic obstetric and gynecologic ultrasound examination, and is intended to represent the minimum requirement for such training. Programs may choose to supplement this curriculum with additional material on normal and abnormal conditions as they see fit. It is understood that individual training programs may have different trajectories of curriculum and competency assessment as they fit into other components of the training and clinical practice requirements. Ultimately, the composite curriculum and competency assessment should be achieved by the time of completion of residency training.

This curriculum is also applicable to anyone who wants to learn how to perform obstetric and gynecologic ultrasound examinations, even if they have already completed their formal training.

In parallel to this Task Force, the AIUM has established another collaborative Task Force to develop narrated presentations by expert sonologists on ultrasound topics in obstetrics and gynecology, covering all aspects of the curriculum of this Task Force.

We recognize that residency program directors have the difficult task of balancing training requirements with limited flexibility in residency schedules. Ideally, a structured rotation in ultrasound during residency will facilitate ultrasound training and help in development of the technical skills required for the basic obstetric and gynecologic ultrasound examination. A 2003 survey on obstetric sonography by CREOG noted that 41% of residency programs had a required ultrasound rotation and 64% had didactic ultrasound training[12]. Although a structured ultrasound rotation is ideal, Task Force members believe that ultrasound training can also be performed during other residency rotations, given that ultrasound is embedded in obstetric and gynecologic clinical care. We hope that the curriculum and competency-assessment tools provided here will support residency program directors and will serve to facilitate ultrasound training in residency programs. The aforementioned accompanying narrated lecture series will be made available to program directors, among others, and the competency-assessment tools will serve to standardize training and track progress during the residency program.

We anticipate that simulation will evolve to provide educational and competency-assessment products to facilitate and accelerate residency training in ultrasound. Ultrasound simulators allow for flexibility in competency assessment, as the simulation can be performed remotely and does not require patient interaction. Standardized reports can be submitted electronically to program directors and the progress of ultrasound training and competency assessment can be tracked over time. Local institutions should evaluate the cost-effectiveness of ultrasound simulation, and how it would fit into their respective residency training. The Task Force believes that the cost of ultrasound simulation will drop substantially over time.

Incorporating this training curriculum and these competency-assessment tools should promote consistency in training and competency assessment, and thus enhance the performance and diagnostic accuracy of ultrasound examination in obstetrics and gynecology.

DISCLOSURES

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SUPPORTING INFORMATION ON THE INTERNET

The following supporting information may be found in the online version of this article:

Appendix S1 Details of competencies assessed during Levels 1–4 (Years 1–4), and additional competencies, with image examples.