Development and Assessment of a Novel Task Trainer and Targeting Tasks for Ultrasound-guided Invasive Procedures

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Rationale and Objectives: The American Institute of Ultrasound in Medicine (AIUM) recommends that all providers performing ultrasound-guided invasive procedures be competent in a core set of guidance skills common to all ultrasound-guided procedures, including in-plane and out-of-plane needle guidance and needle imaging optimization techniques such as probe translation, rotation, and heel-toe standoff. To allow for the practice and assessment of these core skills, we have created a novel task trainer and set of targeting tasks, and sought to obtain validity evidence in the content and response process domains for this training and assessment system according to the Standards for Educational and Psychological Testing.

Materials and Methods: We have constructed an ultrasound-guided invasive procedure training system and five targeting tasks that focused on the needle guidance skills outlined by the AIUM. All tasks were performed by obstetrics and gynecology or maternal-fetal medicine physicians with and without experience in ultrasound-guided invasive procedures during a series of simulation workshops. All participants completed a survey regarding the trainer's and the tasks' usefulness in the training of inexperienced physicians.

Results: The physicians who completed the tasks had favorable views of task trainer and curriculum. The targeting curriculum was felt to allow practice of all of the core guidance skills outlined by the AIUM. The average response provided for all of the tasks was 4.0 or greater, with half of the items having an average response of 4.5 or higher.

Conclusions: We have constructed a task trainer that incorporates all of the core skills outlined by the AIUM. All five tasks received very favorable reviews from both experienced and inexperienced providers. Taken together, our findings suggest they have strong content and response process validity evidence.

Key Words: Ultrasound guidance; simulation; task trainer; invasive procedures.

INTRODUCTION

With the dramatic improvements in ultrasound technology seen in recent years, many invasive procedures in a variety of medical fields that were performed blindly are now being performed with the aid of ultrasound guidance. Examples include paracentesis, central line placement, and amniocentesis, among numerous others. With the introduction of resident duty hour restrictions and the replacement of invasive procedures with noninvasive tests, it is now difficult for trainees to gain enough real-life experience during residency or fellowship to independently perform these procedures after graduation. The classic "see one, do one, teach one" training paradigm has become unsustainable.

As an example, in obstetrics and gynecology (OB/GYN), studies have demonstrated that between 50 and 100 procedures are required before a provider can become competent in amniocentesis (1,2). In chorionic villus sampling (CVS), a single study demonstrated that 100 procedures were required to obtain competence (3). These numbers of procedures are virtually impossible to obtain in a 4-year OB/GYN residency and remain difficult to achieve with an additional 3-year maternal-fetal medicine (MFM) fellowship. The same difficulties are encountered in interventional radiology. In 2013, the Society of Interventional Radiology outlined the minimum number of procedures required for graduation (4), including (1) 100 percutaneous vascular punctures, (2) 200 selective vascular catheterizations, (3) 50 vascular angioplasties, (4) 25 vascular stent placements, (5) 50 embolization procedures, and (6) 50 image-guided nonvascular procedures. These are very ambitious numbers for the combined 4 years of residency and 1 year of fellowship required for certification in interventional radiology.

In a move away from traditional minimum procedure number training requirements, the American Institute of Ultrasound in Medicine's (AIUM) Practice Statement on Selected

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Ultrasound Procedures outlined specific needle localization and guidance techniques necessary to safely perform these procedures (5). They recommend that all providers be proficient with both the in-plane guidance approach, where the needle path and ultrasound beam are within the same plane; and the out-of-plane guidance approach, where the needle path crosses the ultrasound beam at a single point. They also outline a variety of needle visualization optimization techniques that can be used during in-plane needle guidance. These techniques include probe translation, which involves moving the probe toward the needle along the plane of the needle path so as to center the needle in the ultrasound screen; rotation, which involves rotating the probe so that the ultrasound beam aligns with the plane of needle path; and the heel-toe oblique standoff technique, which involves pushing or rocking the transducer toward the needle tip so as to change the relationship of the long axis of the ultrasound beam and needle path from more parallel to more perpendicular. This focus on a set of core skills common to all ultrasound-guided procedures is a shift from the recommendations of many professional organizations that most often treat specific procedures as a separate entity from all others.

If invasive procedures are to continue to be performed safely with the steady decline in clinical training opportunities, alternative training methods will be essential. The use of simulation in a mastery learning training schema could replace many of the lost real-life training opportunities and allow trainees to gain skill in the core ultrasound guidance approaches and needle visualization optimization techniques outlined by the AIUM. The value of simulation has been demonstrated for several procedures, such as endoscopic surgery, central line placement, and intubation (6–9). Unfortunately, task trainers have not been widely incorporated into residency or fellowship training in medical specialties that perform invasive procedures. Although the available models can be helpful in instructing trainees, they are procedure-specific and expensive, placing them out of reach of many training programs. It would be more efficient and economical to initially train providers on the core hand-eye coordination skills common to all ultrasound-guided invasive procedures (such as those outlined by the AIUM) before moving to the skills unique to each invasive procedure.

Simulation can also address the difficulties encountered when attempting to objectively assess provider competency in complex invasive procedures. Currently, assessment is often subjective and lacks concrete end points. During training and credentialing, competence is typically based on the number of procedures a provider has performed. With today's focus on patient safety and healthcare quality, it will be increasingly important to abandon the practice of relying exclusively on procedure logs to determine competence and devise more objective methods of assessment. As simulation can be performed in a safe environment where providers can be allowed to make mistakes, it can be used to provide these needed objective assessments.

To address the issues mentioned earlier, we have created a novel task trainer and targeting curriculum for ultrasound-guided invasive procedures. Their validity must be vigorously studied to ensure that they deliver the outcomes for which they are designed. The assessment of validity has recently moved away from classical categories of face, content, construct, and criterion validity. Instead, the Standards for Educational and Psychological Testing has defined five main validity domains that provide different types of evidence supporting the claim that the test or training instrument is reaching the desired outcomes (10). These domains are the following:

1. *Content* describes the degree to which the instrument represents all aspects of the knowledge base or skill of interest.
2. *Internal structure* involves the reliability and reproducibility of the instrument, and includes the classic concepts of internal validity.
3. *Response process* describes how well the trainees and examiners feel the instrument actually assesses the skill or knowledge of interest, and is very similar to the classic concepts of content and face validity.
4. *Relations with other variables* define how well the instrument correlates with other measures of skill, such as level of training or performance on another instrument measuring the same knowledge base or level of skill.
5. *Consequences* of the instrument illustrate the positive and negative impacts that the use of the instrument will have on the examinee. This domain is typically reserved until sufficient validity evidence is obtained from the other domains to justify using the instrument in the first place.

The importance of the specific domains is expected to vary depending on the instrument being investigated, but one would hope to have some supporting evidence from each. Here we describe the details of the tasks trainer's construction and how to perform the targeting tasks. We also report the content and response process validity evidence for their use in inexperienced medical providers.

METHODS

Task Trainer Construction

Ballistic Gelatin Simulated Body Walls

A piece of solid Perma-Gel Ballistic Gelatin (MidwayUSA, Columbia, MO) is cut from the 20-pound block received from the manufacturer and placed into a metal container, which is in turn placed within a 22-quart turkey roasting oven (Fig 1a). The ballistic gelatin is heated to 350°C until liquefied over the course of 3–4 hours. Peach and brown acrylic paint is added to the liquid gelatin to opacify it and give it a flesh color. A 13-inch diameter cake pan (which serves as the mold for the gelatin) is coated with mold release spray (Alumilite Corporation, Kalamazoo, MI). The liquid gelatin is then poured into the cake pan to a depth of a ½ inch (Fig 1b). After fully cooling over a course of 3–4 hours, the ready-to-use gelatin is removed from the cake pan (Fig 1c). The simulated body walls can be used for an extended period of time, but will eventually develop