Abstract- Integrated tutor facilitating curriculum training with a mixed reality simulator for thoracic epidural and thoracic paravertebral blocks

Background/Introduction/Purpose

Discovery learning is not as effective as an organized curriculum when trying to master complicated procedures such as Thoracic Paravertebral (TPVB) and Thoracic Epidural (TE) placement. This study assesses the efficacy of an integrated tutor in a mixed reality anatomically realistic simulation in the independent learning (self-study) of trainees. The mixed reality simulator, equipped with an integrated tutor (IT), deconstructs complicated procedures into basic components and helps learners fine-tune their technique, step-by-step. In addition, the integrated tutor provides instruction by using multimedia, and also provides feedback to learners. Use of the integrated tutor allows learners to study at their own pace and master complex techniques while reducing or possibly eliminating the time and cost needed from experts or instructors.

Hypothesis: The learner's accuracy and precision in needle placement and ultrasound (US) imaging are expected to increase when the integrated tutor curriculum is added as a self-study tool to learn, perform, receive feedback and master these complicated procedures. A curriculum with the Intelligent Tutor will be superior to discovery learning (i.e., without specific objectives or feedback on skill mastery).

Methods

The bony structures of the T2–9 spine and ribs were 3D printed and encased in ballistic gel. We then fused this physical phantom of the upper back with an anatomically correct 3-D virtual image of the bony anatomy, manually adding virtual structures of interest such as lungs, ligaments, spinal cord, and dural sac.

The mixed reality simulator allows trainees to experience realistic tactile feel such as hitting bone when a physical needle lands on the transverse process, or loss of resistance when the needle "engages" in a ligament.

More anatomic structures like the internal intercostal membrane and intercostal muscles were added to study more lateral approaches to the TPVB. Two levels of difficulty were incorporated by decreasing the dimensions of the epidural and paravertebral spaces, and adding a false LOR when the epidural needle exits the interspinous ligament.

All trainees viewed lectures and then had access to the simulator for up to 5 hours (with a minimum of 40 blocks required) spread over multiple sessions.

The subjects are divided into three groups, each group having a different education platform available to them:

- Group A has access only to traditional lecture materials and the simulator without visualization of the 3D virtual anatomy and without the immediate feedback on the quality of performed blocks (discovery learning).
- Group B has access to visualization of the 3D anatomy, cognitive aids, and immediate feedback but still uses discovery learning without the assistance of the integrated tutor (IT).
- Group C has access to all the same features as group B but with the addition of the IT.

Four techniques were chosen for this study:

- ultrasound-assisted TPVB
- ultrasound-guided TPVB – prone in plane while the US probe is axial
- ultrasound-assisted epidural
- landmark-based epidural

All subjects, regardless of group designation, learn TPVB and TE placement without the assistance of an expert in regional anesthesia. The integrated tutor is composed of individual steps, each based on a recording of a clinical instructor's use of the simulator. The recording was a mix of the following: a screen capture of the simulation session, video clips recorded by an external video camera, and replay files of 3D

visualization generated by the simulator. In many cases the specific clinical actions were created first, then replayed in the simulator, allowing the instructor clinician to pause, point out, and articulate individual teaching points while using cognitive aids and tools in the simulation as needed. The instructors' voice was recorded by the video camera; this served as a base script to create formal versions of all recorded assets using iMovie. In this way, the instructor's content creation time was minimized.

A curriculum editor was created to allow clinicians and assistants to edit the integrated tutor without programming skills. These edits include: adding, deleting, ordering integrated tutor steps, adding annotations, graphics, videos, and optional links to custom parts of the simulation.

Results

Preliminary results indicate that, while ultrasound imaging was a harder skill to acquire, its mastery helped complete complicated tasks more successfully. We learned that even in advanced practitioners, it takes at least 1–2 hours of practice on the simulator to enhance the ability to efficiently manipulate the needle and to effectively use US as a tool to improve RA success and safety. Enrollment and involvement in our Institutional Review Board approved study has begun and is on-going.

Conclusions

While we embarked on a journey to instruct trainees in the acquisition of the complex skills of TPVB and TE placement, we as educators and researchers have gathered new insight into WHAT we teach and HOW we teach it.

We believe that self-study with our integrated tutor curriculum and mixed reality simulator is efficacious in learning thoracic RA techniques. We expect results to show that using the complete curriculum: self-study, advanced mixed-reality simulation with visual augmentation (3D visualization), and integrated tutor will result in increased accuracy and precision of needle placement and US imaging, as well as higher performance scores on the post-training practical exam.

We plan to use the data collected in this study to further test the clinical transferability of the knowledge and skills obtained through this curriculum by asking subjects who had independently trained with our simulator (even novices without previous training in RA) to perform blocks on cadavers and compare their competency with those individuals trained on cadavers by experts in TPVB and TE block performance.