The effect of simulation-based training on initial performance of ultrasound-guided axillary brachial plexus blockade in a clinical setting – a pilot study

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Abstract

Background

We hypothesized that virtual reality simulation-based training offers an additional learning benefit over standard training in preparing novice anesthesiologists to perform their first ultrasound-guided axillary brachial plexus blockade in the clinical setting. We carried out pilot testing of this hypothesis using a prospective, single blind, randomized controlled trial.

Methods

We planned to recruit 20 anesthetists who had no experience of performing ultrasound-guided regional anesthesia. Initial standardized training, reflecting current best available practice was provided to all participating trainees. Trainees were randomized into one of two groups; to undertake additional simulation-based training or no further training. On completion of their assigned training, trainees attempted their first ultrasound-guided axillary brachial plexus blockade. Two experts, blinded to the trainees’ group allocation, assessed the performance of trainees using validated tools.

Results

This study was discontinued following a planned interim analysis, having recruited 10 trainees, because functionality of the available simulator was insufficient to meet our training requirements. There were no statistically significant difference in clinical performance, as assessed using the sum of a Global Rating Score and a checklist
score, between simulation-based training [mean 32.9 (standard deviation 11.1)] and
control trainees [31.5 (4.2)] (p = 0.885).

Conclusions

We have described a methodology for assessing the effectiveness of a simulator,
during its development, by means of a randomized controlled trial. We believe that
the learning acquired will be useful if performing future trials on learning efficacy
associated with simulation based training in procedural skills.

Keywords

Ultrasound-guided regional anesthesia, Simulation, Validation, Virtual reality,
Procedural training, Technology-enhanced learning.

Background

The learning environment in which resident anesthesiologists acquire procedural skills has
fundamentally changed. Training programmes are shorter and afford fewer training
opportunities than heretofore. Patient, institutional and regulatory expectations limit
acceptance of trainees acquiring de novo skills on patients. In the context of ultrasound-
guided axillary brachial plexus blockade (USgABPB), we have demonstrated that
anesthesiologists in Ireland perceive a lack of learning opportunity as being the most
important impediment to procedural skill development [1].

It is indisputable that simulation will play in an increasingly important part in the training and
assessment of procedural skills [2]. Simulation offers trainees an opportunity to attain skills in
a risk-free environment. Training bodies are attempting to move from traditional time-based
training programmes to competency-based training [3]. Since January 2010, the American
Board of Anesthesiology (ABA) has included simulation-based training as a mandatory
component of Maintenance of Certification in Anesthesiology (MOCA) [4]. A recent meta-analysis demonstrated that technology-enhanced simulation-based training is associated with large positive effects on knowledge, skills, and behaviors, and moderate effects on patient-based outcomes [5]. Grottke et al [6] have previously described the development of a virtual reality (VR) simulator for regional anesthesia guided by peripheral nerve stimulation.

Previous work at our institution described the development of a similar device simulating spinal anesthesia [7].

To date, simulation in ultrasound-guided regional anesthesia (UGRA) has largely been limited to tissue (e.g. turkey breasts or cadavers) and non-tissue (e.g. gelatin or tofu) phantoms [8,9]. Computer-based VR simulation has been utilized effectively for training in a number of procedural domains, e.g. laparoscopic surgery [10] and colonoscopy [11]. VR simulation offers a number of advantages over the alternatives; (i) variety of predefined standardized scenarios, (ii) multiple anatomical variations, (iii) models do not degrade with repeated needle insertion, (iv) realistic representations of anatomy acquired via MRI, CT or ultrasound derived data, (v) normal variation of a single anatomical site can be represented, and (vi) multiple anatomical sites (thus different types of blocks) can be represented in a single simulator [12]. We have participated in developing a VR visuo-haptic simulator to train USgABPB, as part of a collaborative project with the National Digital Research Centre (www.ndrc.ie). The simulator attempts to render the haptic (related to tactile and proprioceptive) sensations normally felt during manipulation of both needle and ultrasound probe. We set out to assess the effect of training USgABPB utilizing a novel prototype simulator, during its development, on skill transfer.

We hypothesized that VR-based training offers an additional learning benefit over standard training (using cadaveric dissection and human volunteers) in preparing novice anesthesiologists to perform their first USgABPB in the clinical setting. We carried out pilot testing of this hypothesis using a prospective, single blind, randomized control trial.
Methods

This prospective, randomized controlled trial was conducted at Cork University Hospital and St Mary’s Orthopaedic Hospital (Cork, Ireland). The Clinical Research Ethics Committee of the Cork Teaching Hospitals approved the study and the study was registered with ClinicalTrials.gov (NCT01965314). All subjects, patients and anesthesiologists, provided written informed consent. We planned to recruit 20 College of Anaesthetists of Ireland affiliated trainees who had no experience of performing ultrasound guided regional anesthesia. The sample size was arbitrarily based on previous studies indicating the effectiveness of VR simulation-based teaching procedural skills to novices [10]. Subjects provided baseline personal data, experience in practice of anesthesia (years in training) and handedness. Each subject was asked to categorize his/her (i) previous experience of peripheral nerve blockade with peripheral nerve stimulation [0=0 blocks, 1=1-5 blocks, 2=5-10 blocks, 3=10-50 blocks, 4=50-100 blocks, 5≥100 blocks] (ii) previous experience of ultrasound-guided vascular access [0=0 procedures, 1=1-5 procedures, 2=5-10 procedures, 3=10-50 procedures, 4=50-100 procedures, 5≥100 procedures] (iii) previous attendance at a peripheral nerve blockade course (incorporating ultrasound-guided techniques) [0=never, 1=≤half day course, 2=full day course, 3=≥2 day course, 4=multiple courses]. Baseline visuo-spatial ability was assessed using the card rotation, shape memory, and snowy picture tests (Educational Testing Service) [13]. Psychomotor ability was assessed using a grooved pegboard (Lafayette Instruments, Lafayette, IN). Subjects were randomly allocated (non-stratified) into 1 of 2 groups, (i) the control group (CG) or (ii) the simulator trained group (SG) using random number tables.

Common Training

All participating anesthesiologists received standardized training. These educational sessions took place in the Department of Anatomy, University College Cork. The educational sessions
were attended by 4-6 trainees. A single anesthesiologist (BOD) with expertise in both
teaching and performing the procedure delivered all sessions and supervised the trainees
during the hands-on sessions. Each session involved a number of components, namely; (i) a
didactic session, (ii) a hands on session with appropriately prepared cadaveric specimens, (iii)
ultrasound scanning of a volunteer, and (iv) a needling skills session with tissue phantoms.
Subjects were taught to perform USgABPB using a technique as described in Appendix IV
and V of ‘The American Society of Regional Anesthesia and Pain Medicine and the European
Society of Regional Anaesthesia and Pain Therapy Joint Committee Recommendations for
Education and Training in Ultrasound-Guided Regional Anesthesia’ [14]. All ultrasound
examinations performed on volunteers or on patients entailed the use of a Sonosite M Turbo
(Sonosite, Bothell, WA, USA) (or similar device) with a 7-12 MHz 38mm linear probe.
Following the educational intervention, all subjects were asked to give written feedback, by
means of a standard form, on the content and delivery of the session. On completion of the
common training those in the CG received no further training and those in the SG went on to
complete a proficiency-based training period using a prototype simulator.

Simulator training

The simulator was comprised of two PHANTOM Desktop devices (www.sensible.com,
Wilmington, MA, USA), a desktop computer (Hewlett-Packard, www.hp.com), a liquid
crystal display (LCD) monitor (Samsung Sync master 2233) capable of rendering 120 frames
per second synchronized with a pair of 3D stereoscopic glasses (www.nvidia.co.uk), and the
H3D API (www.sensegraphics.se). The SG subjects were asked to scan and perform
procedure specific tasks on a virtual arm. The model of the arm was informed using 1.5 Tesla
MRI DICOM datasets which generated skin and bone surfaces. A number of computer
generated structures were added to this model based on typical anatomical positioning (The
Science Picture Company, www.sciencepicturecompany.com, Dublin, Ireland). These were
the axillary artery and three nerves (representing median, ulnar and radial nerves). The
resultant image was thus a computer generated “animation”.

Before subjects began simulation-based training, 3 experts (each of whom had undertaken
structured higher subspecialty training in regional anesthesia and maintained proficiency by
performing at least 100 UGRA procedures during the previous year) performed each task
under similar conditions on three consecutive occasions. The mean values of their
performances set a proficiency level against which subsequent trainee performance was
benchmarked.

Following initial familiarization with the simulator, lasting 50 – 60 minutes (length partially
due to the prototypal nature of the device), SG subjects were asked to complete 4 procedure
specific tasks to a predefined proficiency level, 2 relating to ultrasound scanning (utilizing a
single haptic device) and 2 relating to needle advancement under ultrasound guidance
(concurrently controlling two haptic devices – see Figure 1). Computer generated feedback
was given to the subject after each attempted performance of each task. Participants were
required to meet proficiency levels on two consecutive attempts before passing each task. In
order to complete simulation training the SG participants had to pass all 4 tasks. The tasks
were specifically chosen to cover the pre-procedural scout scan and the needling component
of USgABPB, while also permitting capture of behaviors likely to lead to significant clinical
errors [15]. Table 1 outlines each task, the feedback given and the proficiency level which
had to be met. There was no specified time limit to meet these requirements. Subjects were
free to control the frequency and duration of use of the simulator. Following initial
orientation, training on the simulator in this study was largely unsupervised. An investigator
was immediately available to address any technical issues which may have arisen.

**Assessment**

We aimed to assess the performance of the subjects first USgABPB within two weeks of
completing the educational interventions. Patients recruited required anesthesia for
forearm/wrist/hand surgery where USgABPB would ordinarily be offered as standard care.

Informed patient consent was obtained. Study participant performance of USgABPB was closely supervised by a trained regional anesthesiologist. Intravenous sedation was administered as clinically indicated, and subsequent care of the patient may have included general anesthesia. Subjects were asked to perform USgABPB using an in-plane approach and short-axis view. The procedure was video recorded using a handheld video recording device (Flip Ultra, www.theflip.com) in a manner aimed to conceal both the identity of the patient and the identity of the anesthesiologists performing the block. Two experts in UGRA later evaluated the video data.

Patient inclusion and exclusion criteria were:

**Inclusion criteria:** ASA grades I and II, age 18-80 years, capacity to consent, already consented for USgABPB, Body Mass index 20 – 26 kg/m^2

**Exclusion criteria:** Parameters outside inclusion criteria, contraindication to regional anesthesia, language barrier, psychiatric history, pregnancy.

**Outcome Measures**

The subject’s performances were assessed retrospectively based on a task specific, dichotomous, checklist and a behaviorally anchored 5-point global rating scale previously validated for this procedure (See Appendices) [16]. Two experts, experienced with this form of evaluation, carried out these assessments. The experts were blinded to group allocation.

The primary outcome measure was the average value of the sum of (i) global rating scale (GRS) scores and (ii) total number of procedural checklist items as assessed by the two blinded experts. Secondary outcome measures were (i) GRS scores, (ii) checklist scores, (iii) procedural times (iv) number of needle passes, (v) block success (as defined by sensory and motor blockade in the distribution of all four relevant nerves demonstrated within 15 minutes of USgABPB), (vi) block failure (as defined by an unanticipated need for an additional peripheral nerve block or an unplanned conversion to general anesthesia), (vii) participating
anesthesiologist confidence levels (measured on a ten point verbal rating scale, on completion of assessment of the block – “How confident were you in performing the block?”) following performance of the USgABPB, and (viii) patient satisfaction measure (measured on a ten point verbal rating scale, on discharge from recovery “How satisfied were you with the block?”).

SPSS version 17.0.2 software (SPSS, Inc., Chicago, IL, USA) was used for data analysis. Data were analyzed using Mann–Whitney’s U-test for continuous variables. A p value of <0.05 was considered significant. Inter-rater levels of agreement were estimated using Cohen’s Kappa and percentage inter-rater reliability, defined as agreements / (agreements + disagreements) times 100 [10].

**Results**

Having originally planned to recruit 20 trainees, this study was discontinued following a planned interim analysis. Ten trainee anesthesiologists were recruited from a university affiliated teaching hospital (Cork University Hospital) in July 2010, 4 to the Simulation group and 6 to the Control group Recruitment was discontinued because, it became clear that the functionality of the available simulator was insufficient to meet our training requirements. Baseline participant data are summarized in Table 2. The results of visuo-spatial testing using Snowy Picture, Shape Memory and Card Rotation Tests and psychomotor assessment using the Perdue Pegboard are summarized in Table 3. Trainees in the SG did score significantly better in the Shape Memory Test than those in the CG, a measure of visual memory (23.3 (4.6) vs. 12.3 (4.6), p = 0.010). The differences in other visuo-spatial and psychomotor tests were not statistically significant. Video data corruption occurred during the recording of two participants’ ultrasound-guided axillary brachial plexus blockade, rendering assessment impossible (both in CG). A comparison of primary and secondary outcome measures is shown in Table 4. There was no
A statistically significant difference in clinical performance between the groups, as assessed using the sum of the GRS and CHECKLIST scores. There was also no difference in the secondary outcomes measured. No participant completed the performance of the block independently. Data relating to procedural times, number of needle passes and block success/failure were therefore not available. All candidates in both groups were adjudged by expert consensus to have “failed” in their performance of the block.

Participant assessment of content and delivery of the traditional training portion is shown in Table 5. Trainees in the SG rated elements of traditional training higher than CG participants. However, the magnitude of the differences tended to be low.

There was a trend towards a greater interval from commencement of training (traditional training session) to block performance in the Simulation group compared to that in the Control group; however this was not statistically significant [SG 24.5 (16.1) [mean (std dev)], CG 6.5 (6.0) respectively, \( p=0.054 \)].

The inter-rater reliability of the assessment of trainee performance by review of video was 89.3% (Range 83.7-93.9%) for checklist scores and 27.8% (Range 0-66.7%) for GRS scores. The Kappa for checklist scores was 0.749 (p<0.01) indicating a good level of agreement [17], while the Kappa for GRS scores was not statistically significant (Kappa=0.037, \( p=0.628 \)), indicating poor inter-rater reliability [17]. Table 4 compares i) sum of global rating scale plus checklist scores, ii) global rating scale scores, and iii) checklist scores between the two groups. Participant confidence did not differ statistically between the group 2 (2.45), and 2.83 (2.64) [mean (std dev)] in the Simulation and Control Groups respectively (\( p=0.587 \)).

**Discussion**

We have described a methodology for assessing the effectiveness of simulator based training in improving novice trainee’s performance in the clinical setting, by means of a randomized control trial. Our pilot study found no difference in trainee performance between those who underwent standard training and those who received supplemental simulation-based training.
This may have been due to a Type 2 error or to limitations of the prototype simulator (which led to early discontinuation of the trial). We recruited half our a priori defined group of 20 trainees, at one time point (the recruitment of trainee anesthetists in our region occurring biannually). Having trained this cohort, a planned natural point of interim analysis arose. Simulated sono-anatomy was subject to a number of limitations (e.g. clinically relevant muscles/tendons/fat were not modeled), resulting in relevant structures being presented against a relevantly homogenous background. There are two main reasons for this; 1. The technical requirements to generate simulated structures, such as biceps or coracobrachialis muscles/tendons, would be significant and were beyond the resources of our team, and 2. The computational requirements to render these secondary structures accurately in real-time, as the user scanned the virtual arm, would be beyond the capacity of the available computer processing units. As a result, it is likely that the simulator allowed for identification of structures in an unrealistic fashion (i.e. lacked fidelity). Indeed, one participant in the SG commented that she would have preferred to attempt to perform the block at an interval closer to the traditional training session, where she had practiced scanning a real human volunteer. It is likely the simulator had a negative impact in teaching trainees sono-anatomy relevant to USgABPB. It is possible that this diminished any potential improvement in ultrasound-guided needle advancement. Following our interim analysis, we elected to suspend further recruitment as further use of our prototype simulator could have resulted in negative learning which could have negatively impacted on the care of real patients.

The recent Association for Medical Education in Europe (AMEE) Best Evidence in Medical Education (BEME) guide [18], highlighted outcome measures of education as one of the key areas requiring further research. This is the first study to look at the transfer of skills from VR simulation-based training to clinical practice, for an UGRA procedure. In their analysis of VR-based training for laparoscopic surgery, Sinitsky et al [19] acknowledged that the science of setting proficiency levels is still ill-defined, describing it as “the most pressing issue.” We chose to set proficiency levels based on a limited number of attempts by our group of experts
(mean of first three attempts following initial familiarization). Sinitsky et al [19] also recommended that laparoscopic procedural skills are best learnt through distributed not massed practice. A one day intensive hands-on course on UGRA is an example of massed practice, whereas distributed practice is spread over a greater period of time (shorter practice sessions with long intervals between sessions). In more general studies of the effectiveness of technology-enhanced learning on medical education, Cook [5,20] also suggests distributed practice is more effective than massed practice. The same authors also found an association between individualized learning and better non-time based skills outcomes [20]. Following the initial familiarization session, trainee’s use of the simulator in this study was self-regulated. As a result, participants could train at a rate which best suited them and was distributed across a number of sessions over a number of days. Inter-rater reliability between experts was poor for GRS scores. This is likely due to the relatively subjective nature of GRS assessment. This may have been improved by enhanced training on using the assessment tools. While inter-rater reliability was good for checklist scores, such tools are subject to a number of limitations. It is possible that an assessment tool which specifically captures clinically relevant errors would be more useful in assessing procedural skills. Such a tool would be particularly useful in providing formative feedback. In the absence of such a validated tool, we chose our primary outcome measure as a combination of GRS and checklist scores.

Our study is subject to a number of limitations. Firstly the prototype simulator used was insufficient to meet the training requirements for teaching anesthesiologists, novice in UGRA. Our study sample was small and technical issues with video-recording decreased the size of the dataset acquired further. The poor inter-rater reliability of the GRS component raises questions over the validity of our results. There was a difference in training time between the two groups. This difference related to the additional time it took participants in the simulation group to complete simulation training to the predefined proficiency level. It is possible that an improvement in performance in the SG could have been partially attributed to the increased
training time, had this occurred. It is also possible that, in this novice population, elements of
the traditional training were more important than those enhanced by the simulator training. In
particular, when compared to the simulator-generated images, novices appeared overwhelmed
by the amount of information they had to interpret in reality. The trend towards an increased
interval from the traditional training to block performance in the SG may have had a negative
impact on their performance. A number of elements of the traditional training session were
rated lower by CG participants than by SG participants. This study does not look at cost of
training as the simulator was under development and has no defined monetary value [21]. The
simulator described utilizes haptic devices which are costly. Comparisons of haptic and non-
haptic based in VR simulation has questioned the need for such devices when training
laparoscopic surgical skills [22]. Future studies will need to address this question in training
UGRA. Such analysis would have to include both the costs of the devices themselves and also
the potential savings (e.g. those associated with faster training, more self-directed learning
with lesser requirement for 1:1 teaching with trainers, lesser need for dedicated UGRA
courses). The results of this study have informed the iterative development of the simulator.
Ultrasound imagery in future prototypes will likely be based on real acquired ultrasound data
[23] from which the simulator will be capable of rendering a real-time image. Rosenberg et al
have described mannequin-based simulators for ultrasound-guided regional anesthesia [24].
Based on our experience in this study, we have cautioned these authors that the ultrasound
imagery generated not be clinically relevant and could result in negative learning [25].
For the purpose of this study simulation-based training and traditional training were separated
into two discrete components with no overlap (to control for possible confounding effects). In
reality a more blended approach would be potentially more beneficial. This would likely
lessen the negative impact of deficiencies of, for example, an inadequate training
tool/simulator.
With increasing computational capacity and reduced cost, it is likely that simulation will
move to a more personal environment where supervision is no longer a necessary component
to the experience [26]. This may facilitate an individual gaining expertise through self-
regulated deliberate practice. However establishing validity of such devices would be
essential. The potential for a trainee to learn incorrect or dangerous techniques in an
unsupervised environment, could have catastrophic results if transferred into the clinical
domain [26]. To date, publications of simulation-based training in UGRA have largely been
limited to descriptive pieces with few addressing transfer of skills into a clinical setting. Here,
we attempted to partially address this deficit.

Conclusions

We believe that the information acquired during this pilot study will be useful in performing
future trials on learning efficacy associated with simulation-based training in procedural
skills. In particular, confirmation of a degree of fidelity in the challenges rendered by a
simulator is a pre-requisite to carrying out such a study. We believe that failure to do so,
could result in spurious results due to factors other than the training or educational value of
the simulation-based programme.

Authors' contributions

All authors contributed to the conception and design of the study, acquisition and
interpretation of the data and the initial drafting and final revision of the manuscript
for important intellectual content. All authors read and approved the final manuscript.

Abbreviations

ABA: American Board of Anesthesiology, AMEE: Association for Medical Education in
Europe, ASA: American Society of Anesthesiologists, BEME: Best Evidence in Medical
Education, CG: control group, GRS: global rating scale, LCD: liquid crystal display, MOCA:
Maintenance of Certification in Anesthesiology, SG: simulator trained group, UGRA:
ultrasound-guided regional anesthesia, USgABPB: ultrasound-guided axillary brachial plexus
blockade, VR: virtual reality.
Competing interests

All authors declare that they have no competing interests.

Acknowledgements

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Figures

Figure 1 - Configuration of simulator similar to that during trial
Figure 2 - Study flowchart
Figure 3 - Sample instruction material
Figure 4 - Sample End of Session Debrief
Figure 5 - Automated Login Process

Tables

Table 1. Task, the feedback given and the proficiency level to be met.

<table>
<thead>
<tr>
<th>Task</th>
<th>Feedback</th>
<th>Proficiency Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Identify the 4 relevant structures represented at a point in the axilla</td>
<td>Number of structures correctly identified</td>
<td>All four structures identified</td>
</tr>
<tr>
<td>2 Follow the course of two of these structures (median and ulnar nerves) from axilla towards the elbow, while keeping the structures in the centre of the virtual ultrasound screen</td>
<td>The amount (%) of the structure represented in the middle of the virtual ultrasound as a proportion of the total length of the structure (from axilla to elbow) (out of 100%)</td>
<td>Mean expert performance</td>
</tr>
<tr>
<td>3 Advance a virtual needle towards a specified target (median nerve) keeping the needle in plane during advancement</td>
<td>The proportion (%) of needle advancement which occurred “in plane” as a proportion of the total distance the needle tip advanced in the virtual arm</td>
<td>Mean expert performance</td>
</tr>
<tr>
<td>4 Trigger a virtual injectate at an appropriate distance from the target.</td>
<td>The distance from the needle tip to the target structure when injection triggered</td>
<td>Injection at a distance not less than the mean expert minimum distance and not more than the mean expert maximum distance. Needle tip must also be visualized at the time of triggering.</td>
</tr>
</tbody>
</table>
Table 2. Baseline participant data.

<table>
<thead>
<tr>
<th></th>
<th>Simulation Group (n=4)</th>
<th>Control Group (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male : Female</td>
<td>2 : 2</td>
<td>5 : 1</td>
</tr>
<tr>
<td>Years Experience in practice of anesthesia [Median Range]</td>
<td>5 (0-12) 4.5 (0-22)</td>
<td></td>
</tr>
<tr>
<td>Previous Experience of Peripheral Nerve blockade with peripheral nerve stimulation</td>
<td>0.5 (0-4) 1.5 (0-3)</td>
<td></td>
</tr>
<tr>
<td>Previous Experience of Ultrasound-Guided Vascular Access</td>
<td>2 (0-4) 1 (0-5)</td>
<td></td>
</tr>
<tr>
<td>Previous Attendance at a Peripheral Nerve Blockade course (incorporating Ultrasound-Guided techniques)</td>
<td>0.5 (0-2) 0 (0-3)</td>
<td></td>
</tr>
<tr>
<td>Handedness</td>
<td>3 Right + 1 Am bidextrous</td>
<td>6 Right</td>
</tr>
</tbody>
</table>

Table 3. Visuo-spatial and psychomotor testing.

<table>
<thead>
<tr>
<th></th>
<th>Simulation Group (n=4)</th>
<th>Control Group (n=6)</th>
<th>Mann–Whitney’s U-tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snowy Pictures [mean(std dev)]</td>
<td>13.3 (5.6)</td>
<td>10 (4.8)</td>
<td>p = 0.285</td>
</tr>
<tr>
<td>Shape Memory Test</td>
<td>23.3 (4.6)</td>
<td>12.3 (4.6)</td>
<td>p = 0.010*</td>
</tr>
<tr>
<td>Card Rotation Test</td>
<td>21 (15.3)</td>
<td>6.67 (10.7)</td>
<td>p = 0.165</td>
</tr>
<tr>
<td>Pegboard - Sum Averages Right + Left + Both Hands</td>
<td>45.1 (8.0)</td>
<td>43.1 (5.3)</td>
<td>p = 0.522</td>
</tr>
<tr>
<td>Pegboard – Assembly</td>
<td>35.6 (7.8)</td>
<td>32.3 (5.7)</td>
<td>p=0.240</td>
</tr>
</tbody>
</table>

Legend: Visuo-spatial testing using Snowy Picture, Shape Memory and Card Rotation Tests (Educational Testing Service) and psychomotor assessment using the Grooved Pegboard (Lafayette Instruments)
Table 4. Primary and secondary outcome measures.

<table>
<thead>
<tr>
<th></th>
<th>Simulation Group (n=4)</th>
<th>Control Group (n=4)</th>
<th>Mann–Whitney’s U-tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRS+CHECKLIST</td>
<td>32.9 (11.1)</td>
<td>31.5 (4.2)</td>
<td>p = 0.885</td>
</tr>
<tr>
<td></td>
<td>[mean (std dev)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRS</td>
<td>18.4 (5.8)</td>
<td>15.8 (1.7)</td>
<td>p = 0.561</td>
</tr>
<tr>
<td>CHECKLIST</td>
<td>14.5 (5.4)</td>
<td>15.8 (4.6)</td>
<td>p = 0.564</td>
</tr>
</tbody>
</table>

Table 5. Participant assessment of content and delivery of the traditional training.

<table>
<thead>
<tr>
<th></th>
<th>Simulation Group (n=4)</th>
<th>Control Group (n=6)</th>
<th>Mann–Whitney’s U-tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>Quality of Speaker</td>
<td>10 (10-10)</td>
<td>10 (8-10)</td>
</tr>
<tr>
<td></td>
<td>[median(range)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quality of Slides</td>
<td>10 (10-10)</td>
<td>8 (8-9)</td>
</tr>
<tr>
<td></td>
<td>Potential to Learn</td>
<td>10 (10-10)</td>
<td>8 (8-9)</td>
</tr>
<tr>
<td>Cadaveric Anatomy</td>
<td>Delivery of Information</td>
<td>10 (9-10)</td>
<td>8 (8-10)</td>
</tr>
<tr>
<td></td>
<td>Hands on Experience</td>
<td>8 (7-10)</td>
<td>8 (6-10)</td>
</tr>
<tr>
<td>US Scanning of Volunteer</td>
<td>Delivery of Information</td>
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<td>10 (9-10)</td>
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<td>Hands on Experience</td>
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<td>9 (5-10)</td>
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<td>Hands on Experience</td>
<td>10 (10-10)</td>
<td>9.5 (3-10)</td>
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Appendix 1 - Task Specific Checklist for Ultrasound Guided Axillary Brachial Plexus Block

CLEARLY IDENTIFIED OBSERVABLE BEHAVIOR
i.e. can be identified if seen by assessor on videotape

Yes/No

Positioning
Exposure of the axilla
☐ ☐

The subjects dignity should be maintained
The arm should be out of the sleeve
Axilla and shoulder should be completely exposed

Positioning of arm
☐ ☐

Abduction - 90° at the shoulder
Flexion – flexion of arm at the elbow
External rotation – external rotation of arm

Patient comfort following positioning
☐ ☐

Positioning of Equipment
Ultrasound Screen
☐ ☐

Ultrasound machine screen should be in the same field of vision as the ultrasound probe

Sterile Trolley
☐ ☐

Sterile trolley should be within in arms distance and within the same field of vision as the ultrasound machine screen and the ultrasound probe

Preparation
Preparation of needle
22G gauge, 50mm Stimuplex needle (Standardized)
Needle flushed
☐ ☐

Preparation of Ultrasound Probe
Protection of probe
☐ ☐

Probe should be covered with either a sheath or a protective covering
Application of gel
☐ ☐

Gel can be applied to either axilla or ultrasound probe

Block
Preparation of Axilla
Antiseptic solution should be applied in the axilla

Application of Ultrasound Probe

Orientation of probe

Probe placed perpendicular to the arm in upper axilla

Stabilizes transducer hand by resting gently on the patient

Identification of Anatomical Structures

The participant will at this stage point at the ultrasound screen and identify the individual anatomical structures

Axillary Artery

Axillary Vein/s

The Axillary artery and vein should be identified via color flow analysis

Coracobrachialis muscle

Musculocutaneous Nerve

Median Nerve

Ulnar Nerve

Radial Nerve

If using long axis approach maintain the needle in plane keeping whole needle in view at all times

Deposition of Local Anesthetic

• For each nerve (v) further dose injection – the spread of Injectate should be visible on ultrasound screen

Nerve 1

i. Needle tip is identified

ii. Aspiration

iii. Test Dose (spread of injectate identified)

iv. Patient comfort on injection

v. Further dose injection

Nerve 2

i. Needle tip is identified
24

ii. Aspiration □ □

iii. Test Dose (spread of injectate identified) □ □

iv. Patient comfort on injection □ □

v. Further dose injection a □ □

Nerve 3 __________

i. Needle tip is identified □ □

ii. Aspiration □ □

iii. Test Dose (spread of injectate identified) □ □

iv. Patient comfort on injection □ □

v. Further dose injection b □ □

Nerve 4 __________

i. Needle tip is identified □ □

ii. Aspiration □ □

iii. Test dose (spread of injectate identified) □ □

iv. Patient comfort on injection □ □

v. Further dose injection b □ □

18 **Assessment**

19 Wound stabilization device removed □ □

20 Dressing/ cast should be removed before assessment

21 Patient should be asked about pain before removing
device

23 Musculocutaneous Nerve

24 Sensory b □ □

25 Lateral aspect of forearm should be checked for cold

26 sensation

27 Motor □ □

28 Forearm Flexion

29 Radial Nerve

30 Sensory b □ □

31 Posterior forearm, dorsum of hand, thumb, index and

32 middle finger should be checked for cold sensation

33 Motor □ □
Wrist and finger Extension

Median Nerve

Sensory

Anterior and medial aspect of forearm, thumb, index, middle and half of ring finger should be checked for cold sensation

Motor

Flexion of lateral two fingers

Ulnar Nerve

Sensory

Medial aspect of hand on the hypo-thenar eminence, little, ring and middle finger should be checked for cold sensation

Motor

Thumb opposition or finger abduction

NOTES:

a. For each nerve (v) **further dose injection** – the spread of Injectate should be visible on ultrasound screen.

b. Regarding 13a-16a (sensory assessment) Assessment at one of listed sites is sufficient
Appendix 2 - Generic Technical Skills Global Rating Scale
<table>
<thead>
<tr>
<th></th>
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<th>2</th>
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<tr>
<td><strong>Respect for Tissue</strong></td>
<td>Frequently used unnecessary force on tissue or caused damage</td>
<td>Careful handling of tissue but occasionally caused inadvertent damage</td>
<td>Consistently handled tissue appropriately with minimal damage</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Time and Motion</strong></td>
<td>Many unnecessary moves</td>
<td>Efficient time/motion but some unnecessary moves</td>
<td>Clear economy of movement and maximum efficiency</td>
<td></td>
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<tr>
<td><strong>Instrument Handling</strong></td>
<td>Repeatedly makes tentative or awkward moves with instruments by inappropriate use of instruments</td>
<td>Competent use of instruments but occasionally appeared stiff or awkward</td>
<td>Fluid moves with instruments and no awkwardness</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Knowledge of Instrument</strong></td>
<td>Frequently asked for wrong instruments or used inappropriate instrument</td>
<td>Knew names of most instruments and used appropriate instruments</td>
<td>Obviously familiar with the instruments and their names</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Flow of Procedure</strong></td>
<td>Frequently stopped procedure and seemed unsure of next move</td>
<td>Demonstrated some forward planning with reasonable progression of procedure</td>
<td>Obviously planned course of procedure with effortless flow from one move to the next</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Use of Assistants</strong></td>
<td>Consistently placed assistants poorly or failed to use</td>
<td>Appropriate use of assistants most of the times</td>
<td>Strategically used assistants to the best advantage at all times</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Knowledge of Procedure</strong></td>
<td>Deficient knowledge</td>
<td>Knew all important steps of operation</td>
<td>Demonstrated familiarity with all aspects of operation/procedure</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overall Performance</strong></td>
<td>Very poor</td>
<td>Competent</td>
<td>Clearly superior</td>
<td></td>
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</table>
1 Overall in this task, should the candidate ☐ Pass ☐ Fail?

2

3

4
**SCOUT SCAN**

You will now be presented with a 3D representation of a right arm. You will have up to 5 minutes to familiarise yourself with the sytem and the anatomy. You will then be asked to perform a number of tasks.

1) Select an appropriate view where you feel all relevant features are within the ultrasound view.

2) Identify all the main features in the view.

3) Track the specified nerve along the extent of the arm (start at the optimal point in the axilla, move down towards the most distal end of the arm and then finish at the most proximal part of the arm).

---

**PROBE ALIGNMENT**

Position the probe on the skin, placing the probe in a vertical position along the short axis of the arm. Placing the probe in a horizontal position along the long axis of the arm generates a distorted image.

---

**PROBE TRACKING**

Position the probe in the axilla, track the features along the arm up to the most distal end and then track the features back along the arm until you reach the most proximal end.

---

**PERFORM BLOCK**

At this point, you would have completed the scout scan and identified a potential insertion point. You will now be asked to perform a number of tasks.

1) Identify the specified feature in the axilla.

2) Insert the needle and advance towards the specified feature using an in-plane approach.

3) Aspirate and inject when you are satisfied with the needle tip position.

---

**NEEDLE INSERTION**

When you have chosen an optimal position where all features can be clearly identified in the ultrasound screen, select your insertion point as close as possible adjacent to the probe.
Completed Training Scenario

1. Distance From Target Nerve To US Centre
The percentage of time the target nerve was in the required section of the ultrasound screen while tracking proximally and distally (combined)

2. Probe Tracking Length
The path length of the probe while tracking as a proportion of the optimal path length (linear distance between the optimal position, distal region and back to the proximal region)

10%

Graphical Feedback

Grade History

Distance From Target Nerve To US Centre

Previous Scores

Percentage

Previous Attempts

0 1 2 3 4 5

0 10 20 30 40 50 60 70 80 90 100

Percentage

Previous Scores

Attempt Number

0 1 2 3 4 5

0 10 20 30 40 50 60 70 80 90 100

Percentage

Previous Scores

Attempt Number

0 1 2 3 4 5

0 10 20 30 40 50 60 70 80 90 100

Percentage

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Previous Scores

Attempt Number

0 1 2 3 4 5

0 10 20 30 40 50 60 70 80 90 100

Percentage

Previous Scores

Attempt Number

0 1 2 3 4 5

0 10 20 30 40 50 60 70 80 90 100

Please choose with section you would like to start

- Scout Scan
- Perform block
- Practice

Start
Login GUIs

- **Login Details**
  - Password:
  - Register:
  - If this is your first time using the simulator, please register.

- **Registration Details**
  - Name:
  - Password:
  - Device Setup:
    - Right Handed
    - Left Handed
  - Register:

- **Section Choice**
  - Please choose with section you would like to start:
    - Scout Scan
    - Perform Block
    - Practice
  - Start:

Database

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