Educational and clinical aspects of peripheral nerve blockade
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Citation for published version (APA):
Wegener, J. T. (2013). Educational and clinical aspects of peripheral nerve blockade

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Value of an electronic tutorial for image interpretation in ultrasound-guided regional anesthesia

Jessica T. Wegener, C. Thea van Doorn, Jan H. Eshuis, Markus W. Hollmann, Benedikt Preckel, Markus F. Stevens

Abstract

Background and Objectives
Use of ultrasound guided regional anesthesia (UGRA) requires considerable training. An embedded electronic tutorial as an element of an ultrasound machine may help to identify sono-anatomy for novices. Therefore, we investigated whether an electronic tutorial could improve accuracy or speed of performance in identifying anatomical structures.

Methods
35 novices in UGRA participated in a workshop on brachial plexus sono-anatomy. Following a lecture, training in handling of ultrasound machines and hand-eye-coordination, participants were randomized to group (S) using a standard ultrasound machine and group (T) using the same type of machine with an onboard electronic tutorial. Each participant had to identify 27 anatomical structures from the brachial plexus in a volunteer. A correct identified structure scored 1 point. An experienced observer noted scores and time required. Scores ± SD(%) and times ± SD(s) were compared between groups by analyses of independent samples T-test and ANOVA. Influence of anesthesia experience was determined by multivariate analyses.

Results
Group T scored significant higher (16.8 ± 3.6 (62%) vs. 13.4 ± 4.4 (50%), p=0.018), whereas time required was longer (1053 ± 244s vs. 740 ± 244s, p=0.001). Multivariate analysis revealed that experience had no influence on scores or time required. Examination of structures took more time in the beginning than at the end in group T.

Conclusions
An electronic tutorial can help novices in UGRA to identify anatomical structures. A significant increase in correct identifications was gained at the expense of significantly longer time required for this process. Increased time required may partly be related to unfamiliarity with the tutorial.
Value of an electronic tutorial for image interpretation in ultrasound-guided regional anesthesia

Introduction

Methods

Results

Discussion

Acknowledgments

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Introduction

Performance of UGRA requires specialized skills and an extensive training.\textsuperscript{1} Essential to a safe and effective practice of UGRA is a detailed knowledge of anatomy for reliable identification of anatomical structures on sonographic images.\textsuperscript{2} Training novices in UGRA generally starts with teaching device operations, scanning techniques and image optimization. In a second step, the identification of sono-anatomy is taught.\textsuperscript{3-10} Learning sono-anatomy is a challenging and demanding process that can deter many novices from starting UGRA in daily practice.\textsuperscript{11-12}

Also teaching sono-anatomy is time-consuming for trainers, because it requires a 1:1 teaching situation as well as a ‘volunteer model’. To support and facilitate this phase of learning, manufacturers have introduced embedded electronic tutorials as an element of ultrasound machines. The tutorial investigated here (MyLabOne, Esaote®, Genova, Italy) contains ‘how to do’ aids to speed the onset and improve the quality of peripheral nerve blocks. A photo displays the anatomical landmarks where the plexus/nerve should be approached. A second frame gives a schematic picture of the anatomy. A third window gives an example of the topographic sono-anatomy with description of the most relevant structures. Furthermore, instead of the text describing the sono-anatomy, a frame displaying the real-time anatomy of the actual patient (or volunteer) can be activated on the same screen. A typical screen shot of the ultrasound machine and tutorial is given in figure 1. Although this tutorial was written by a very experienced teacher in UGRA, the value of such a tutorial has never been validated or tested before. Moreover, it has to be determined whether the tutorial accelerates the learning curve. We hypothesized that an electronic tutorial increases the number of correctly identified anatomical structures of the brachial plexus by physicians inexperienced in the technique. Secondary aim was to determine the time required to identify anatomical structures with and without the tutorial.
Figure 1  Example of the electronic tutorial for the supraclavicular block on the display of the ultrasound machine. When the block/anatomical location of the brachial plexus is chosen (here supraclavicular plexus), the following pictures are displayed: 1. Lower left, a photograph of the landmarks and the location and orientation of the probe. 2. Upper left, a schematic anatomical picture of the brachial plexus supraclavicularly. 3. Lower right, a typical ultrasound picture of the region with a delineation of relevant anatomical structures. 4. The legend of the ultrasound picture and a short description on how to perform the block. This frame can be switched back and forth to the real-time picture of the brachial plexus.
Table of structures

<table>
<thead>
<tr>
<th>Structure</th>
<th>Start</th>
<th>End</th>
<th>Score</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td><strong>Interscalene plexus</strong></td>
<td>:</td>
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<td>:</td>
<td>7</td>
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<tr>
<td>Carotid artery</td>
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<td></td>
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<tr>
<td>Internal jugular vein</td>
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<td>:</td>
<td></td>
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<tr>
<td>Vagus nerve</td>
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<td>:</td>
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<td></td>
</tr>
<tr>
<td>Sternocephaloidial muscle</td>
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<tr>
<td>Anterior scalene muscle</td>
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<td></td>
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<tr>
<td>Middel scalene muscle</td>
<td>:</td>
<td>:</td>
<td>:</td>
<td></td>
</tr>
<tr>
<td>Nerve roots (C5, 6, 7, 8)</td>
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<td><strong>Supraclavicular plexus</strong></td>
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<td>5</td>
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<tr>
<td>Subclavian artery</td>
<td>:</td>
<td>:</td>
<td>:</td>
<td></td>
</tr>
<tr>
<td>First rib</td>
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<td></td>
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<tr>
<td>Pleura</td>
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<td></td>
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<tr>
<td>Plexus</td>
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<td></td>
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<tr>
<td>Dorsal scapular artery</td>
<td>:</td>
<td>:</td>
<td>:</td>
<td></td>
</tr>
<tr>
<td><strong>Infraclavicular plexus</strong></td>
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<td>7</td>
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<tr>
<td>Pectoral muscles</td>
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<tr>
<td>Subclavian artery</td>
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<td>:</td>
<td></td>
</tr>
<tr>
<td>Subclavian vein</td>
<td>:</td>
<td>:</td>
<td>:</td>
<td></td>
</tr>
<tr>
<td>Pleura</td>
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<td>Lateral cord</td>
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<tr>
<td>Posterior cord</td>
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<td><strong>Axillary plexus</strong></td>
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<tr>
<td>Axillary artery</td>
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<td>:</td>
<td></td>
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<tr>
<td>Coracobrachial muscle</td>
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<tr>
<td>Biceps muscle</td>
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<tr>
<td>Triceps muscle</td>
<td>:</td>
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<td></td>
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<tr>
<td>Musculocutaneous nerve</td>
<td>:</td>
<td>:</td>
<td>:</td>
<td></td>
</tr>
<tr>
<td>Median nerve</td>
<td>:</td>
<td>:</td>
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<td></td>
</tr>
<tr>
<td>Ulnar nerve</td>
<td>:</td>
<td>:</td>
<td>:</td>
<td></td>
</tr>
<tr>
<td>Radial nerve</td>
<td>:</td>
<td>:</td>
<td>:</td>
<td></td>
</tr>
<tr>
<td>Total score (max = 27)</td>
<td></td>
<td></td>
<td></td>
<td>27</td>
</tr>
</tbody>
</table>

Table 1  Table of structures associated with the interscalene, supraclavicular, infraclavicular and axillary sites of the brachial plexus for recording time and scores.
Methods

This randomized controlled study was conducted at the Academic Medical Center Amsterdam, Netherlands. The institutional Medical Ethics Committee gave a waiver for this investigation because the Medical Research Involving Human Subject Act (WMO) does not apply to the comparison of skill in ultrasound identification of predefined anatomical structures acquired with or without use of tutorial. Eligible participants were novices (residents and anesthesiologists) with little to no experience in UGRA. Participants signed up for an institutional free basic ultrasound course on UGRA of the upper limb. After enrolment for the course, written informed consent was obtained. Exclusion criteria for participation in the study were experience in UGRA (> 30 ultrasound-guided blocks in total), missing the introduction lecture or unwillingness to participate. Data of participants were collected on gender, years of general experience in anesthesia, estimated number of peripheral nerve blocks performed with a nerve stimulator and with ultrasound. The study took place during 4 institutional basic hands-on ultrasound courses for 8 to 9 participants from January to April 2011. We arranged eight volunteers (two for each session) to serve as sono-anatomy models. The course started with a 90 minutes lecture on physics of ultrasound, anatomy and sono-anatomy of the brachial plexus. The lecture was highly standardized and especially the anatomical structures later to be identified at four levels (interscalene, supraclavicular, infraclavicular, axillary) of the brachial plexus were explained in detail. After the lecture, participants were trained in handling of ultrasound machines (‘knobology’) and practiced hand-eye coordination on a phantom for 45 minutes.

The tutorial investigated here (MyLabOne, Esaote®, Genoa, Italy) contains ‘how to do’ aids for most frequently performed peripheral nerve blocks. A photo displays the anatomical landmarks where the plexus/nerve should be approached. A second frame gives a schematic picture of the anatomy. A third window gives an example of the topographic sono-anatomy with description of the most relevant structures. Furthermore, instead of the text describing the sono-anatomy, a frame displaying the real-time anatomy of the actual patient (or volunteer) can be activated on the same screen. A typical screen shot of the ultrasound machine and tutorial is given in Figure 1. Then participants were randomized by means of sealed opaque envelopes into group S using a standard ultrasound machine and group T using the same type of ultrasound machine with an onboard electronic tutorial (Fig. 1). Each participant had to identify 27 anatomical structures (see Table 1) at 4 predefined levels of the brachial plexus in a live volunteer model using the standard ultrasound machine (group S) or the same machine with a tutorial (group T). Scanning and identification was performed in a fixed sequence of levels: first interscalene, second
supraclavicular, third infraclavicular and finally axillary in both groups. An UGRA-experienced observer noted the correct identifications and time required after explaining the standard or tutorial ultrasound machine, respectively. Time allowed for identification of a given structure was limited to a maximum of 2 minutes. The observer helped with questions of the participants regarding the ultrasound machine. In order to avoid influences of differences in individual sono-anatomy between different models, we switched the models between group S and group T halfway during each course.

For each anatomical structure correctly identified, one point was given, resulting in a maximum score of 27 points (i.e. 100%) for each participant. Furthermore, time required for identification of each anatomical structure was noted, while time measured in group T included use of the tutorial. Groups were compared with regards to scores ± SD (%) and time ± SD (s) required at each anatomical structure, at each location and at the whole examination.

The primary aim of the study was to detect a difference in scores of correctly identified anatomical structures. Power analysis revealed that to detect a 10% difference in percentage of correctly identified structures with a power of 80% and an alpha of 0.05 a group size of n=17 was needed assuming a standard deviation of 10%. Values are expressed as mean ± SD. Scores and required time were compared between groups by using independent samples T-test and analysis of variance (ANOVA), respectively. Influence of experience in anesthesiology in general (years, staff, resident) and in regional anesthesia (numbers of patients) and gender on scores and required time was determined by multivariate analysis. P-values < 0.05 were considered statistically significant.

### Demographic data

<table>
<thead>
<tr>
<th>Group</th>
<th>S (n= 18)</th>
<th>T (n=17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M / F</td>
<td>8 / 9</td>
<td>8 / 10</td>
</tr>
<tr>
<td>Staff/Resident</td>
<td>8 / 9</td>
<td>8 / 10</td>
</tr>
<tr>
<td>Experience (yrs)</td>
<td>5.0 (0-20.0)</td>
<td>5.0 (1.0-17.0)</td>
</tr>
<tr>
<td>Neurostimulation (nrs)</td>
<td>50 (0-250)</td>
<td>35 (0-400)</td>
</tr>
<tr>
<td>Ultrasound (nrs)</td>
<td>2 (0-30)</td>
<td>3 (0-25)</td>
</tr>
</tbody>
</table>

Table 2  Variables of demographic data are presented as median (range) or as number (discrete variables).
Participants assessed for eligibility
(n = 35)

Excluded (n = 0)
- Not meeting inclusion criteria (n = 0)
- Declined to participate (n = 0)

Randomized
(n = 35)

Allocated to standard ultrasound (n=18)
- Received allocated intervention (n = 18)
Allocated to tutorial ultrasound (n = 17)
- Received allocated intervention (n = 17)

Follow up

Allocated to tutorial ultrasound (n = 17)
- Received allocated intervention (n = 17)

Analysis

Allocated to standard ultrasound (n=18)
- Received allocated intervention (n = 18)
Allocated to tutorial ultrasound (n = 17)
- Received allocated intervention (n = 17)

Analyzed (n = 18)
- Excluded from analysis (n = 0)
Analyzed (n = 17)
- Excluded from analysis (n = 0)
Correct identification of anatomical structures

![Figure 3](image3.png)

Subgroup analyzes of scores of correct identification of anatomical structures spread over four locations are delineated as percentages. Scores tended to be better in group T, but this was only significant at the axillary region at the end of the examination. Data are displayed as mean (SD) and were analyzed using independent samples T-test and ANOVA. * = p < 0.05

Required time for identification

![Figure 4](image4.png)

Times required for identification of anatomical structures of the brachial plexus at 4 sites are displayed. The scanning proceeded according to a fixed order, starting at the interscalene and ending at the axillary site. Significant differences in time were demonstrated between groups at the interscalene, supraclavicular, and infraclavicular sites, whereas no significant difference was found at the axillary region. Data are displayed as mean (SD) and were analyzed using independent-samples t test and ANOVA. *p < 0.05, **p < 0.01.
Results

A total of 35 volunteers with minimal experience in UGRA, but varying experience in anesthesia from first year residents to consultants with more than a decade experience in anesthesia, participated. A flow chart describing randomization and possible drop-out is displayed in figure 2. No participant was excluded after randomization, 18 participants were randomized to group S and 17 to group T. Characteristics of group S (n=18) and T (n=17) like gender ratio, staff to resident ratio, years of experience, number of performed blocks with nerve stimulation, and number of ultrasound guided blocks before study inclusion were comparable (table 2).

Group T scored higher in identifying anatomical structures (16.8 ±3.6 vs. 13.4 ± 4.4, p=0.018) compared to group S of totally 27 structures. Thus, with the aid of the tutorial the score increased from 50% to 62% of correct identifications. A subgroup analysis at the different sites of the brachial plexus (interscalene, supraclavicular, infraclavicular and axillary) revealed a significant improvement in identification only at the axillary site (fig. 3).

Mean time required for scanning and identifying of all anatomical structures linked to the brachial plexus was significantly longer in group T (1053±244s) compared to group S (740 ±244s), p=0.001). Identification took significant longer especially at the interscalene site in group T, but no significant difference was found at the axillary site (figure 3). Differences in time required for scanning and identification decreased gradually between group S and T during the progress of assessment of the brachial plexus.

Multivariate analyses revealed that experience in anesthesia generally or in regional anesthesia with nerve stimulation guided blocks specifically did not influence total scores (general experience p=0.50, nerve stimulation guided experience p=0.70) or time required (general experience p=0.51, nerve stimulation guided experience p=0.40. Even some minimal experience in UGRA did not influence total scores (p= 0.59) or time required to identify structures (p=0.93) compared to participants without any experience. Similarly, no difference was found between residents and staff or between men and women. Moreover, which live model was used for scanning and identification did not affect scores (p=0.47) or time (p=0.28).

However, availability of a tutorial on the ultrasound machine was the only influencing factor on total score (p=0.036) or time required (p=0.001) as determined by multivariate analysis.
Discussion

During scanning of the brachial plexus novices identified 62% of anatomical structures correctly with the aid of an electronic tutorial, while the control group scored only 50%. At the axillary site identification was even 21% better with the use of the tutorial. Subgroup analysis of the different anatomical structures revealed that the score improved over time with the electronic tutorial, while the time needed to identify structures with the tutorial decreased over time. No other factor (anatomy of the model, experience of the anesthesiologist, gender) influenced score or time. Interestingly, being resident or staff did not influence the scores or time, although electronic skills and chronological experience between residents and staff may vary widely.

After a 90-minute basic course of sono-anatomy of the brachial plexus, group S failed to identify half of the basic anatomical structures. In contrast, the electronic tutorial accelerated the learning curve of UGRA, although more than one third of the basic anatomical structures were still not recognized in group T. At the axillary site (the last scanned region of the exam) identification in group T was significant better then in groups S compared to the other scanned sites. It is unclear whether utilization of the tutorial increased by its extended use.

Settings of the ultrasound machine were optimized with help of an expert observer to exclude impaired identification due to poor handling of the ultrasound machine. The benefit of a basic training of 90 minutes to identify anatomical structures with ultrasound was disappointing, as is supported by previous publications showing slow learning curves for anesthesiologists in ultrasound assessment. In the present study the focus lied on the third skillset of image interpretation, thus the correct and

51 value of an electronic tutorial
timely identification of basic anatomical structures. The list of anatomical structures tested contained all the structures from the recommended skillset for image interpretation. Thus, the tested structures are agreed to be important for the practice of UGRA.

Recognition of anatomical structures on a sonogram starts with finding of specific patterns and landmarks, which should be consistent with corresponding cross-sectional anatomy. Application of simple sonographic anatomical patterns can provide a strategy to correctly locate nerves when performing ultrasound-guided cervical and brachial plexus anesthesia. This complex visual recognition process should be trained repeatedly by putting cross-section anatomy images, simplified drawings and defined ultrasound images together. Repetitive training sessions are essential to reinforce learning and acquire procedural skills, as part of a deliberate practice model. When expertise in pattern recognition progresses, small anatomical variations will not confuse the novices. We considered participants as inexperienced up to 30 UGRA procedures. It is still unknown how many procedures are needed to achieve any competence in UGRA. However we demonstrated that little experience of less than 30 UGRA procedures did not improve identification of structures or time required.

Eight different models took part in this investigation leading to a wide range of anatomical variations, finally allowing representative results. These models were equally distributed between groups avoiding a possible bias of different models for a given group. Furthermore, multivariate analysis reconfirmed that the differences in scores of correct identification between groups were not associated with different models. Interestingly, other variables like general or specific experiences in regional anesthesia of the participants did not influence the learning curve. This observation is in line with a recent study investigating the learning curves between novices in UGRA with no earlier RA experience and novices in UGRA with considerable experience in nerve stimulator guided RA. As in our study, there were no significant differences in learning curves found. However, results of the multivariate analysis must be interpreted with extreme caution due to small n-values.

The advantage of the tutorial became more obvious at the end of the observation period, showing that time requirement differences disappeared over time. Thus, it may be reasonable to assume that an introduction to the tutorial might have increased its advantages. However, that might have given the tutorial group some extra teaching which would have been difficult to control. In order to
avoid the bias of given the tutorial group extra training we did not give such an extra teaching session. Likely, the acceleration of learning in UGRA with the support of an electronic tutorial would have had been even greater if the novice should have known how to apply it.

In conclusion, an electronic tutorial improved correct identification of anatomical structures by 12% at the expense of a 42% increase in time required for the examination. This increased time requirement may be related to unfamiliarity with the tutorial. However, the just 12% absolute improvement in structure recognition and overall low scores demonstrate that UGRA cannot be learned in a few hours workshop.

Acknowledgements

The authors would like to express their gratitude to Prof. Dr. Thomas Grau for the preparation of the electronic tutorial.
References