Research Article

Different Learning Curves for Axillary Brachial Plexus Block: Ultrasound Guidance versus Nerve Stimulation

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Little is known about the learning of the skills needed to perform ultrasound- or nerve stimulator-guided peripheral nerve blocks. The aim of this study was to compare the learning curves of residents trained in ultrasound guidance versus residents trained in nerve stimulation for axillary brachial plexus block. Ten residents with no previous experience with using ultrasound received ultrasound training and another ten residents with no previous experience with using nerve stimulation received nerve stimulation training. The novices’ learning curves were generated by retrospective data analysis out of our electronic anaesthesia database. Individual success rates were pooled, and the institutional learning curve was calculated using a bootstrapping technique in combination with a Monte Carlo simulation procedure. The skills required to perform successful ultrasound-guided axillary brachial plexus block can be learnt faster and lead to a higher final success rate compared to nerve stimulator-guided axillary brachial plexus block.

1. Introduction

Ultrasound-guided regional anaesthesia, requires the mastering of different skills: knowledge of physics, use of the ultrasound machine, improved manual dexterity, and extensive knowledge of sonographic anatomy are all needed. On the other hand, the use of a nerve stimulator to detect vicinity of the needle to a nerve also requires knowledge of physics as well as knowledge of physiology and pathophysiology. The correct use of a nerve stimulator also deserves an adequate teaching. The acquisition of all these different skills can be especially challenging for the novice.

Learning curves comparing different manual anesthesia techniques provide figures that demonstrate the minimum number of cases required for each procedure to achieve a high success rate and define the competence level [1–4]. Little is known about the process of learning the skills required to perform ultrasound-guided blocks, for example, the number of blocks needed to acquire proficiency. Till now, no study has compared the success rates of ultrasound-guided nerve blocks with nerve stimulation during the learning process.

The aim of this study was to generate novices’ learning curves for nerve stimulator-guided axillary brachial plexus block by retrospective data analysis of the resident’s anaesthesia records before the ultrasound was introduced and to compare them with the generated learning curves for real-time ultrasound-guided axillary brachial plexus block after introducing the ultrasound technique at our department. The goal of this study was primarily to demonstrate a possible difference between the learning curves for each technique and to compare any specific side effects or complications (vascular puncture). The null hypothesis stated learning curves for either technique will not differ from one another significantly after the first 20 attempts.

2. Methods

The study was performed at the Department of Anesthesiology and Pain Therapy at the Bern University Hospital after general approval of the ethics committee for retrospective data analysis.

Before June 2006, the multistimulation technique was standard practice for axillary brachial plexus block in our department. We applied the multistimulation technique as described by Sia et al. [5, 6] starting with the median,
followed by radial or ulnar nerve and finally musculocuta-
neous nerve, eliciting a distal motor response for each nerve. 
To achieve sufficient needle-nerve proximity, the motor 
response had to be present at a decreasing current intensity 
between 0.3 to 0.5 mA with preset pulse duration of 100 ms
and a frequency of 2 Hz. Instruction of the nerve stimulation 
technique was performed individually and included technical 
instruction on the use of the nerve stimulator, anatomy 
teaching using a regional anaesthesia manual (Meier and 
Büttnar [7]), and demonstration on one patient. The first 
ten blocks were performed under direct supervision by 
the staff anesthesiologist, thereafter the residents continued 
indeedently but with a staff anesthesiologist present in the 
operating room and on call for help at anytime.

From September 2006, a few months training in ultra-
sound-guided regional anaesthesia for the staff was provided 
before ultrasound was broadly introduced and taught in 
the clinical practice. Training for the staff consisted of a 2-
day workshop in a specialized clinic in Vienna as well as 
training under supervision by an in-house expert in ultra-
sound-guided procedures. After this period, the same staffs 
were responsible for instruction of the ultrasound technique 
to the residents. Two lectures including basic principles 
of ultrasound, the use of the ultrasound device and the 
specific ultrasound anatomy were given to all residents. Two 
afternoons of practical workshops training in scanning and 
in needling techniques using both phantoms and models 
were performed prior to patient contact. Moreover, there 
was open access to phantoms/chicken drumsticks for all res-
idents. After one demonstration in the operating room each 
resident performed 10 blocks under the direct supervision 
of a staff anesthesiologist, therafter, the residents performed 
indeedently with a staff anesthesiologist present in the 
operating room on call for help at anytime. For real-
time ultrasound-guided technique we used a high-definition 
ultrasound device (MicroMaxx, SonoSite Inc, Bothell, WA 
98021-3904) with a 5–10 MHz linear array transducer 
(L38e, 10–5 MHz, 38-mm broadband linear array, SonoSite 
Inc, Bothell, WA 98021-3904). Ultrasound-guided axillary 
branchial plexus block was routinely performed with a 
22 G insulated needle (Polymedic UPC 50, TeMenA SAS, 
F-Charrières-sur-Seine) connected to a nerve stimulator 
(Stimuplex HNS 11 B, Braun Medical, D-Melsungen) with 
a fixed stimulation output of 0.3 mA (0.1 ms impulse width).
The target nerves were identified by ultrasound and the 
noodle tip was advanced under direct visualization close to 
the nerve. Needle guidance was performed using an out-
of-plane technique. The local anesthetic was then injected 
under direct visualization around the targeted nerves. The 
nerve stimulator was used for two purposes: (1) in case 
the needle tip was lost on the ultrasound screen a motor 
response would indicate nerve contact. In such a case, 
the injection of local anesthetics was omitted in order to avoid 
an intraneuronal injection. (2) To confirm nerve identity when 
a motor response was present.

Although the introduction to the ultrasound technique 
requires more information to be given, that is, about the 
ultrasound device itself or how to perform an ultrasound 
exam, and so forth. practical training in the operating room 
was comparable. The same three staff anesthesiologists were 
responsible for instruction of the residents before and after 
introduction of the ultrasound technique.

All data were collected by retrospective analysis of the 
anesthesia electronic database after obtaining institutional 
ethics review board approval as well as written informed 
consent from the residents. The electronic database was 
created in 2000. Each handwritten intraoperative anaesthesia 
record, as well as the preoperative and postoperative records 
were scanned into the electronic database. Beside all drugs 
given during anesthesia, details of the block procedures were 
recorded. The occurrence of paresthesias, inadvertent vascu-
lar puncture, and local anesthetics given by the surgeon in 
case of a required block supplementation were meticulously 
documented. Because the effect of the block was not recorded 
in a standardized way, block success was defined according 
to clinical efficacy (see below). Other outcome measures like 
onset, intensity, or extent of the block were not recorded.

Anesthesia records from residents who started the 
training in one of these two methods at our department 
between 2000 and 2008 were analyzed. All residents in 
the nerve stimulation group had no previous experience 
in performing peripheral nerve blocks at all. Only four 
residents starting ultrasound-guided peripheral nerve block 
were already familiar with the nerve stimulation technique 
(having performed more than 20 nerve stimulator-guided 
axillary brachial plexus blocks). No residents in the ultra-
sound group had any previous experiences in performing 
ultrasound-guided peripheral nerve blocks. Their learning 
curves were analysed separately (the mixed group). All 
axillary brachial plexus block records were sorted chrono-
logically. The records of the nerve stimulation group dated 
from February 2000 to December 2004, the records of the 
ultrasound group dated from September 2006 to March 
2008. The time between 2005 and 2006 was excluded from 
analysis in order to avoid any bias due to the growing 
knowledge of ultrasound-guided regional techniques and 
any subsequent contamination of teaching.

From the records retrieved from the database, a chrono-
logically binary table of successful or failed axillary brachial 
plexus blocks for each resident was created. A failure was 
defined as block supplementation by the surgeon, need for 
deep sedation with propofol, ketamine, or conversion to 
general anesthesia. Furthermore, the following notes on the 
anesthesia records were accounted as block failure: if a part 
of the block was performed by the staff member, if the staff 
manually intervened to complete the block, or performed a 
rescue block before surgery.

The number of inadvertent vascular punctures, the time 
to perform the block, and the type and amount of local 
anesthetics documented by the present anesthesia nurse 
were all recorded as secondary endpoints.

2.1. Data Analysis and Statistics. No sample size calculation 
was performed due to a lack of analysis methods for 
comparing learning curves. The first 10 residents who were 
trained in ultrasound-guided puncture were systematically 
analysed. For the time between 2000 and 2004, we randomly
picked out ten residents who were known to be novices for nerve stimulator-guided peripheral nerve block.

From the binary data, individual success rates were computed, pooled among all participants, and compared between the groups of residents. The institutional learning curve was calculated by applying a fitting model with a Monte Carlo procedure, a random number simulation technique to mimic a statistical population [1, 4]. To calculate the 95% confidence intervals, the data were bootstrapped [8]. The confidence intervals were used to create the institutional learning curves [4]. We defined the highest point of the success rate during the learning phase as “leveling-off.” This point gives an approximation of the number of procedures required to achieve the final success rate—or in other words, the “number needed to learn.” The differences in success rates of the nonextrapolated data were compared using a chi-square test with Bonferroni adjustment, therefore a *P*-value smaller than .01 was considered statistically significant. Comparison of the preoperative patient’s characteristics and the axillary brachial plexus block characteristics were made either by using Student’s *t*-test or Mann Whitney rank sum test. Proportions were analysed with chi-square test. A probability of less than .05 was considered significant. All calculations were performed by using SigmaStat for Windows Version 3.5.

3. Results

A total of 602 anesthesia records of ten residents in the nerve stimulation group and ten residents in the ultrasound group were reviewed. In the ultrasound group, there were four residents already familiar with the nerve stimulation method so this group was further divided in a mixed subgroup for constructing the learning curves. The nerve stimulation group counted 343 anesthesia records compared to 259 anesthesia records for the ultrasound groups (127 records for mixed). The groups were similar with regards to preoperative patient characteristics and surgical procedures (Table 1).

Overall success rates for ultrasound-guided blocks (both groups) after 40 blocks was 89% (95% CI 85–93) which is significantly higher than the success rate of 80% (95% CI 75–84) in the nerve stimulation group after 40 blocks (*P* = .002). The difference was also significant after the first 10, 20, or 30 blocks (Table 3 shows results from the unextrapolated raw data). When comparing the learning curves (extrapolated data), for ultrasound, the number needed to learn was between 10 and 15 whereas for nerve stimulation it was between 25 and 30 attempts (Figure 1). The learning success for ultrasound-guided axillary brachial plexus block of residents already familiar with the nerve stimulator (mixed group) was slightly lower. The learning curve of this group was found to lay between the nerve stimulation and ultrasound groups without significant difference between them (Figures 2 and 3). For ultrasound-guided blocks, residents used a smaller volume of local anesthetics compared to the volume of local anesthetics used for nerve stimulator-guided blocks (38 ± 6.3 mL versus 46 ± 6.8 mL; *P* < .001). The type of local anesthetics used was also slightly different. In the nerve stimulation group, there were more combinations of long-acting (Bupivacaine 0.5%) with short-acting local anesthetics (Mepivacaine 1%), whereas in the ultrasound group more blocks were performed using solely long-acting...
Table 1: Preoperative patient characteristics. Data are numbers or mean (±SD).

|                      | Ultrasound | Nerve stimulator | P-values |
|----------------------|------------|------------------|----------|
| Number of records    | 259        | 343              |          |
| Age mean (SD)        | 47 (±19.65)| 46 (±18.16)      | .866     |
| Gender (f : m)       | 99 : 163   | 127 : 201        | .816     |
| Missing Data or not defined | —   | 15               |          |
| BMI                  | 26 (±5.34) | 25 (±4.68)       | .631     |
| Surgical characteristics |          |                  |          |
| Bones hand           | 66 (25.5)  | 74 (22.2)        |          |
| Hand soft tissues    | 155 (61.0) | 187 (56.2)       |          |
| Bones forearm        | 26 (10.0)  | 37 (16.9)        | .058     |
| Forearm soft tissues | 12 (4.6)   | 35 (5.1)         |          |
| Missing data or not defined | —   | 10               |          |
| ASA physical status  |            |                  |          |
| I                    | 94 (36.3)  | 139 (41.9)       |          |
| II                   | 122 (47.0) | 147 (44.3)       | .344     |
| III                  | 43 (16.6)  | 46 (13.3)        |          |
| Missing Data or unclear |        | 11               |          |

![Diagram](image)

**Figure 3:** Institutional learning curve of the mixed group compared to the nerve stimulation group. Note: the different endpoints of the curves reflect that more blocks beyond 40 attempts were evaluated in the nerve stimulation groups.

The popularity of real-time ultrasound guidance for nerve blockade has increased dramatically over the last 10 years. A few studies have shown that the use of ultrasound improves the success rate of axillary brachial plexus block when compared with nerve stimulation [9, 10] or with the transarterial technique [10, 11]. An alternative study by Casati et al. [12] however, could not demonstrate this improved success rate. Benefits of the use of ultrasound are the reduced need for nerve stimulation with improved patient comfort [10, 11], reduced volume of local anesthetics used [13–16], and shortened onset time [10, 17]. In this retrospective study focussing on learning of the skills, we found that ultrasound-guided axillary brachial plexus block when performed by junior residents is learned faster and with a higher success rate compared to nerve stimulator-guided axillary brachial plexus blocks. Furthermore, there were significantly less vascular punctures when using ultrasound.

The learning curves for ultrasound-guided axillary brachial plexus blocks showed a stronger upsurge compared to nerve stimulator-guided axillary brachial plexus blocks and the levelling of the curve reached 10–15 attempts earlier. This means that the ultrasound technique, is easier to learn than the nerve stimulation technique although the ultrasound technique is thought to require more highly developed motor and visual skills [18–20]. In our eyes the main reason for this difference is the fact that the staff anaesthesiologist is able to follow the needle track and...
Table 2: Axillary brachial plexus block characteristics. Data are numbers or mean (±SD).

|                          | Ultrasound | Nerve stimulator | P-values |
|--------------------------|------------|------------------|----------|
| Number of records        | 259        | 343              | —        |
| Block-performing time in minutes | 22.1 (±8.4) | 34.7 (±12.7)     | <.001    |
| Incidence of vessel puncture | 32 (12.4)  | 173 (50.4)       | <.001    |
| Volume of local anaesthetics in millilitres | 38.5 (±6.3) | 46.7 (±6.9)      | <.001    |
| Type of local anaesthetics |            |                  |          |
| Mepivacaine 1%           | 182 (73.4) | 187 (58.3)       |          |
| Ropivacaine 0.75%        | 49 (19.8)  | 1 (0.3)          |          |
| Combination of mepivacaine and bupivacaine | 17 (7.9)    | 133 (41.3)       | <.001    |
| Not recorded             | 11         | 22               |          |

Table 3: Different success rates for both ultrasound and nerve stimulation groups for the cumulated first 10, 20, 30, and 40 attempts with the according confidence intervals. Chi-square test with Bonferroni correction, P < .01.

| Attempts | Number of residents | N | Ultrasound (SR%) (CI ± 95%) | N | Stimulator (SR%) (CI ± 95%) | P-value |
|----------|---------------------|---|-----------------------------|---|-----------------------------|---------|
| 10       | 20                  | 100 | (86) (78–92)                | 100 | (68) (58–76)                | .002    |
| 20       | 16                  | 179 | (88) (82–92)                | 199 | (76) (70–82)                | .004    |
| 30       | 13                  | 235 | (89) (85–93)                | 289 | (79) (74–83)                | .001    |
| 40       | 4                   | 259 | (89) (85–92)                | 343 | (80) (75.0–84)              | .002    |

All needle manipulations of the resident on the screen. Malpositioning and false direction of the needle is better recognized and can be corrected immediately. Integrating visual and tactile information with anatomical knowledge and instructor comments appear to accelerate resident learning.

The flat part of the learning curve (Figures 1–3) is descriptive for the maximal reached success rate once the skills have been learned (final success rate). The same success rate has been shown in randomised controlled trials comparing ultrasound with nerve stimulator guidance for interscalene [21], infraclavicular [22], and distal sciatic nerve block [23]. For the axillary brachial plexus block our success rate with ultrasound and nerve stimulation is similar to the data of Lo et al. [10]. Nevertheless, the final success rate of 89% after learning ultrasound-guided axillary brachial plexus block is lower than those reported by Chan et al. [9] and Casati et al. [12]. There are three possible explanations for this difference. First of all, in contrast to other studies, we describe the initial learning phase of junior residents acquiring the method for the first time and not terminal success rates or the level at proficiency of experts. Secondly, ultrasound had recently been introduced in our institution prior to the first resident instruction. That means that the teachers learned it only a few months prior to the first resident. Their individual learning curves to perform a block and even more to teach the technique were possibly not at the highest level. This could represent an institutional learning curve bias. However, this is a common situation when a new technique is introduced into clinical practice. Thirdly, the supervision was less rigorous after the first 10 blocks. For the first blocks, the teacher was actively present. After these initial blocks, the staff was on call in the operation theatre. Our generated learning curves show a levelling-off after approximately 15 blocks. Since the knowledge of these results, we recommend a close supervision for at least the first 15 blocks performed by residents.

The most frequent error experienced by novices is to lose visibility of the needle tip as described by Sites et al. [18]. This may contribute to the still high incidence of inadvertent vascular puncture (12.4%) in the axillary region in spite of vessel visualization during ultrasound-guided blocks. Nevertheless, ultrasound guidance dramatically reduced the number of vascular punctures compared to the nerve stimulation technique, as supported by Orebaugh et al. [24]. In other regions, to lose visibility of the needle tip can lead to more severe complications (e.g., pneumothorax with the supraclavicular approach; spinal injection, or damage/injection into the vertebral artery with the interscalene approach). Therefore, we start ultrasound-guided block training with the axillary brachial plexus block first and proceed to other locations only after residents are able to reproducibly and continuously manage to localize and follow the needle tip as supported by Marhofer et al. and Hargett et al. [20, 25].

Another advantage of using ultrasound is to improve the patient’s comfort by omitting nerve stimulation [12]. Nevertheless, we opted to maintain the nerve stimulator connected, but at a reduced current (0.3–0.5 mA), to help...
with recognition and avoidance of intraneural needle placement, in cases where the needle tip was poorly visualised. Curiously, Sites et al. [18] and Lo et al. [10] suggest that the use of a nerve stimulator may reduce success rates when used in combination with ultrasound as trainees may prefer the more familiar motor response as an endpoint rather than the ultrasound-visualized perineural spread of local anesthetic. We made the same observation when analyzing our mixed group, residents already familiar with the nerve stimulator showed a smaller upsurge in the learning curve, reaching the same endpoint, but needing more time.

Previous studies have demonstrated that with ultrasound use, the required volume of local anesthetic can be significantly reduced, and this study supports that finding showing a reduction in local anesthetic volume occurring as early as after the first few nerve blocks [13–16].

**Limitation.** An obvious limitation of this study is the retrospective analysis of anesthesia records. We cannot exclude that every block supplementation by the surgeon was properly recorded. A prospective study would have been of greater significance but is not feasible anymore. It is probable that a staff experienced in ultrasound-guided axillary brachial plexus block would have a better anatomical knowledge and this would bias his teaching of the stimulator technique.

The Monte-Carlo simulation, as a resampling technique was chosen to mimic a statistical population to generate confidence intervals for the curves. Although the Monte-Carlo simulation is a well-accepted method, it is an extrapolation and has, therefore, some limitations as described elsewhere [3].

We evaluated the success rates of novices only for the first 20 to 40 blocks. Improvement of this technique may have continued beyond the first 40 blocks due to the constant technique refinement which may have improved the final success rate of experts to a level much higher than our reported 80% for the nerve stimulator and 89% for ultrasound guidance. Even in our institution, the success rates with the nerve stimulator and ultrasound guidance of our advanced learners or expert anesthesiologists is higher and comparable to the success rates reported in the literature.

Obviously learning curves vary between different institutions and learning environments. For example, our learning curves for nerve stimulator-guided blocks are different from learning curves described by Konrad et al. [4]. It was, therefore, important to compare the learning curves for the two different techniques for axillary brachial plexus block under near constant conditions within the same institution, using the same resources, the same teaching staff, and a similar population of residents.

In conclusion, this retrospective analysis of residents trained by two different needle guidance methods suggests that ultrasound permits higher success rates after fewer blocks, especially for residents with no previous training in nerve stimulation. Inadvertent vascular punctures are markedly reduced when using ultrasound guidance, thus, when they do occur they indicate a further need for needle guidance training.

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**References**

[1] G. K. Schüpfner, C. Konrad, and J. I. Poelaert, “Manual skills in anaesthesiology,” *Anaesth.,* vol. 52, no. 6, pp. 527–534, 2003.

[2] G. Schuepfer and M. Jörh, “Psoas compartment block (PCB) in children—part II—generation of an institutional learning curve with a new technique,” *Paediatric Anaesthesia,* vol. 15, no. 6, pp. 465–469, 2005.

[3] G. Schuepfer and M. Jörh, “Generating a learning curve for penile block in neonates, infants and children: an empirical evaluation of technical skills in novice and experienced anaesthetists,” *Paediatric Anaesthesia,* vol. 14, no. 7, pp. 574–578, 2004.

[4] C. Konrad, G. Schüpfner, M. Wietlisbach, and H. Gerber, “Learning manual skills in anaesthesiology: is there a recommended number of cases for anesthetic procedures?” *Anaesthesia and Analgesia,* vol. 86, no. 3, pp. 635–639, 1998.

[5] S. Sia, M. Bartoli, A. Lepri, O. Marchini, and P. Ponzecci, “Multiple-injection axillary brachial plexus block: a comparison of two methods of nerve localization-nerve stimulation versus paresthesia,” *Anaesthesia and Analgesia,* vol. 91, no. 3, pp. 647–651, 2000.

[6] S. Sia, A. Lepri, and P. Ponzecci, “Axillary brachial plexus block using peripheral nerve stimulator: a comparison between double- and triple-injection techniques,” *Regional Anesthesia and Pain Medicine,* vol. 26, no. 6, pp. 499–503, 2001.

[7] G. Meier and J. Buettner, *Peripheral Regional Anesthesia. An Atlas of Anatomy and Techniques,* Thieme, Stuttgart, Germany, 2nd edition, 2006.

[8] R. T. Bradley Efron, *An Introduction to the Bootstrap,* Chapman & Hall, Boca Raton, Fla, USA, 1993.

[9] V. W. S. Chan, A. Perlas, C. J. L. McCartney, R. Brull, D. Xu, and S. Abbas, “Ultrasound guidance improves success rate of axillary brachial plexus block,” *Canadian Journal of Anesthesia,* vol. 54, no. 3, pp. 176–182, 2007.

[10] N. Lo, R. Brull, A. Perlas et al., “Evolution of ultrasound guided axillary brachial plexus blockade: retrospective analysis of 662 blocks,” *Canadian Journal of Anesthesia,* vol. 55, no. 7, pp. 408–413, 2008.

[11] B. D. Sites, M. L. Beach, B. C. Spence et al., “Ultrasound guidance improves the success rate of a perivascular axillary plexus block,” *Acta Anaesthesiologica Scandinavica,* vol. 50, no. 6, pp. 678–684, 2006.

[12] A. Casati, G. Danelli, M. Baciarello et al., “A prospective, randomized comparison between ultrasound and nerve stimulation guidance for multiple injection axillary brachial plexus block,” *Anesthesiology,* vol. 106, no. 5, pp. 992–996, 2007.

[13] P. Marhofer, K. Schrögendorfer, T. Wallner, H. Koinig, N. Mayer, and S. Kapral, “Ultrasonographic guidance reduces
the amount of local anesthetic for 3-in-1 blocks,” *Regional Anesthesia and Pain Medicine*, vol. 23, no. 6, pp. 584–588, 1998.

[14] H. Willschke, P. Marhofer, A. Bösenberg et al., “Ultrasoundography for ilioinguinal/iliohypogastric nerve blocks in children,” *British Journal of Anaesthesia*, vol. 95, no. 2, pp. 226–230, 2005.

[15] N. S. Sandhu, B. Maharlouei, B. Patel, E. Erkulwater, and P. Medabalmi, “Simultaneous bilateral infraclavicular brachial plexus blocks with low-dose lidocaine using ultrasound guidance,” *Anesthesiology*, vol. 104, no. 1, pp. 199–201, 2006.

[16] U. Eichenberger, S. Stoeckli, P. Marhofer et al., “Minimal local anesthetic volume for peripheral nerve block: a new ultrasound-guided, nerve dimension-based method,” *Regional Anesthesia and Pain Medicine*, vol. 34, no. 3, pp. 242–246, 2009.

[17] U. Schwemmer, C. K. Markus, C. A. Greim, J. Brederlau, and N. Roewer, “Ultrasound-guided anaesthesia of the axillary brachial plexus: efficacy of multiple injection approach,” *Ultraschall in der Medizin*, vol. 26, no. 2, pp. 114–119, 2005.

[18] B. D. Sites, B. C. Spence, J. D. Gallagher, C. W. Wiley, M. L. Bertrand, and G. T. Blike, “Characterizing novice behavior associated with learning ultrasound-guided peripheral regional anesthesia,” *Regional Anesthesia and Pain Medicine*, vol. 32, no. 2, pp. 107–115, 2007.

[19] G. A. Chapman, D. Johnson, and A. R. Bodenham, “Visualization of needle position using ultrasonography,” *Anaesthesia*, vol. 61, no. 2, pp. 148–158, 2006.

[20] P. Marhofer and V. W. S. Chan, “Ultrasound-guided regional anesthesia: current concepts and future trends,” *Anesthesia and Analgesia*, vol. 104, no. 5, pp. 1265–1269, 2007.

[21] S. Kapral, M. Greher, G. Huber et al., “Ultrasoundographic guidance improves the success rate of interscalene brachial plexus blockade,” *Regional Anesthesia and Pain Medicine*, vol. 33, no. 3, pp. 253–258, 2008.

[22] P. Marhofer, C. Sitzwohl, M. Greher, and S. Kapral, “Ultrasound guidance for infraclavicular brachial plexus anaesthesia in children,” *Anaesthesia*, vol. 59, no. 7, pp. 642–646, 2004.

[23] A. Perlas, R. Brull, V. W. S. Chan, C. J. L. McCartney, A. Nuica, and S. Abbas, “Ultrasound guidance improves the success of sciatic nerve block at the popliteal fossa,” *Regional Anesthesia and Pain Medicine*, vol. 33, no. 3, pp. 259–265, 2008.

[24] S. L. Orebaugh, B. A. Williams, and M. L. Kentor, “Ultrasound guidance with nerve stimulation reduces the time necessary for resident peripheral nerve blockade,” *Regional Anesthesia and Pain Medicine*, vol. 32, no. 5, pp. 448–454, 2007.

[25] M. J. Hargett, J. D. Beckman, G. A. Liguori, and J. M. Neal, “Guidelines for regional anesthesia fellowship training,” *Regional Anesthesia and Pain Medicine*, vol. 30, no. 3, pp. 218–225, 2005.
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