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SHORT COMMUNICATION

Differences in tip visibility and nerve block parameters between two echogenic needles during a simulation study with inexperienced anesthesia trainees

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Abstract Needle tip visualization during ultrasound-guided regional anesthesia (UGRA) is necessary for safety and efficacy. However, disruption of the image of the needle tip driven toward the target is a general problem, especially for beginners. The purpose of this study was to compare performance parameters between using the Sonoplex and Stimuplex D-Plus echogenic needles in a simulated ultrasound-guided interventional task by inexperienced anaesthesia residents. After a standardized training session, 28 anesthesiology residents performed simulated nerve blocks in a beef phantom with each needle. All ultrasound images were digitally stored for analysis. The absolute time the needle tip was in view, total procedure time, and angle of needle insertion were subsequently measured objectively by two single investigators. The procedures that used the Sonoplex echogenic needle had significantly better tip visibility and shorter total procedure time at insertion angles between 42° and 64° relative to the phantom surface. We have demonstrated that inexperienced users who used the Sonoplex echogenic needle were able to complete the procedure more quickly. Needles with improved visibility would be a very useful addition to UGRA for inexperienced users.

Keywords Regional anesthesia · Ultrasound · Needle visualisation

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Needle tip visualization during ultrasound-guided regional anesthesia (UGRA) is requisite for safety and efficacy. However, disruption of the image of the needle tip driven toward the target is a general problem, especially for beginners [1]. Therefore, new needle tips, termed "echogenic," were produced to increase needle visualization during ultrasonography by the use of different technologies and designs [2]. It has been shown that echogenic technology improves identification of the needle tip by both experienced and inexperienced operators. In addition, echogenic needle identification is independent of experience level [2, 3]. In previous studies, the Sonoplex echogenic needle showed higher visibility scores than the Stimuplex D-Plus echogenic needle [4, 5]. However, information about their use in interventional procedures is limited. The purpose of this study was to compare the performance parameters between the Sonoplex and Stimuplex D-Plus echogenic needles used in a simulated ultrasound-guided interventional task by inexperienced anesthesia residents.

After receiving approval from the institutional review board, 28 anesthesia residents were recruited for this study. They had no prior experience with ultrasound-guided procedures. The needles used in the study are the 22-gauge 50-mm SonoPlex Stim cannula (Pajunk Medizintechnologie, Geisingen, Germany) and the 22-gauge 50-mm Stimuplex D-Plus needle (B. Braun Melsungen AG, Germany).

All applications were performed using the same ultrasound machine (Esaote My Lab 30, US Machine, Florence, Italy) with a 10–18 MHz linear high-frequency transducer. A 15 × 10 × 10 cm (length × width × height) piece of beef meat was deodorized in alcohol for 30 min. A 4-mm-diameter metal rod, selected for imitation of the target, was placed about 3 cm deep in the meat longitudinally recumbent. Residents were asked to advance the needle to

the metal rod with the in-plane approach. Precise needle–target contact was verified by dynamic ultrasound images and tactile sensing.

Before starting the trial, a 120-min standard education was provided for all the residents by one instructor. The instruction started with holding the probe on the phantom, visualization of metal rod (hyperechoic target), and needle visualization using the in-plane technique. Subsequently, the residents were allowed to practice with the needle technique for 15 min.

After completing the training session, the residents were separated into two groups according to the types of needle that they used first. A randomized-crossover schedule predetermined the order in which the needles were placed into the phantom. Each resident used the other needle in the second period after performing the insertion with one needle. To avoid any learning effects, the residents were not allowed to observe each other during the procedure. All procedures were performed on the same day and the same phantom. Gain, depth focus, and all other machine settings were identical. Residents and investigators analyzing the data were blinded up until the point of needle insertion.

The ultrasound imaging from each procedure was recorded on the ultrasound machine's hard disk and the records transferred to the computer for later analysis. Recording was started at the puncture of the needle into the phantom tissue and ended when successful needle–target contact was visualized in ultrasound (total procedure time). The number of puncture attempts was recorded for each needle. After having performed the procedures, the residents were asked to subjectively score the tip visibility of each needle on a scale from 1 (not seen) to 5 (very good). The method defined by Hebard and Hocking [6] was used to evaluate dynamic images objectively. All recorded ultrasound images were reviewed with Media Player Classic Home Cinema (http://mpc-hc.sourceforge.net/) by two independent blinded researchers. Ultrasound images were displayed at low speed (1/4, 1/2), pausing where necessary to precisely fix the presence or absence of the needle tip. Thus, researchers measured the absolute time the needle tip was in view during each procedure (time in view) and calculated percentage tip visibility for each procedure (time in view/total procedure time $\times$ 100), which we defined as "objective needle tip visibility." Needle insertion angle relative to the phantom surface was measured with the use of a protractor when the image of the needle was frozen at the moment of contact with the target. The mean values of measurements obtained by two researchers were used for statistical analyses. The primary outcome measure was percentage needle tip visibility. Study power was based on data from the objective needle tip visibility study by Hebard and Hocking [6] (the mean percentage tip visibility of Sonoplex was 55 %). We calculated that 28 participants would provide 80 % power and 95 % confidence level to detect a 10 % difference in mean percentage tip visibility of two needles.

Analysis of the numerical data for objective tip visibility, total procedure times, and insertion angles, and the ordinal data for subjective tip visibility did not indicate a normal distribution when the Shapiro–Wilk test was used. Therefore, the Mann–Whitney U test was used for comparison of these data. Categorical variables (the number of puncture attempts) were compared using Fisher's exact test. p values <0.05 were considered statistically significant. Numerical data are presented as median and interquartile range with 95 % confidence intervals or mean $\pm$ standard deviation. Statistical analyses were performed with SPSS 16.0 (SPSS, Chicago, IL, USA).

A total of 56 simulated interventional tasks were analyzed (28 for each needle). At insertion angles between 42° and 64°, the objective tip visibility of Sonoplex was significantly higher [79.7 % (95 % CI, 73.2–82.3 %) vs. 55.5 % (95 % CI, 50.5–66.1 %); $p = 0.001$]. Data of subjective needle tip visibility are shown in Fig. 1. The subjective tip visibility of Sonoplex was significantly higher also [4 (4–4.75) vs. 3 (3–4); $p = 0.001$]. The total procedure time was shorter in the Sonoplex group [13 (10–16) vs. 20 (14–29) s; $p = 0.002$]. The needle insertion angles were not significantly different between the two needles (49.7° $\pm$ 5.5° vs. 47.6° $\pm$ 2.6°, respectively; $p = 0.4$). On ten occasions (three with the Sonoplex and seven with the Stimuplex D-Plus), two puncture attempts were needed. Number of puncture attempts was not significantly different between the two needles ($p = 0.1$).

Improved visibility might result from the difference between the needles in terms of design and surface technology. The Sonoplex echogenic needle uses texturing of the needle surface with "cornerstone" reflectors [7]. The

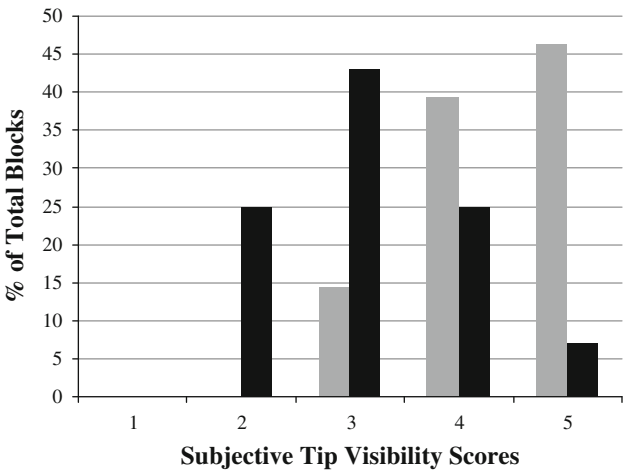

Fig. 1 Subjective tip visibility estimates for Sonoplex (*gray bars*) and Stimuplex D-Plus (*black bars*)

surface area has been increased in these indented regions, in which the waves are reflected. These angled indentations between the smooth surfaces cause intense waves reflecting at different angles to bounce back to the probe by changing the reflection angles of the waves coming from the transducer [2]. Similarly, the 2-cm tip of Stimplex D-Plus has laser-based markings; however, this section is insulated with a white coating [7]. Another potential reason could be that the depths and angles of these indentations vary among individual needles.

The few studies conducted with the needles used in the current study were designed to evaluate static views by experienced operators. In the study by Hebard et al. [4], the participants identified needle tip position on the static images taken from unembalmed human cadavers. The Sonoplex showed significantly higher confidence and visibility scores than Stimuplex D-Plus in their study. In the study by Guo et al. [5], the visibility of both echogenic needles was assessed by two independent, blinded observers using a 5-point Likert ordinal scale in a Thiel cadaver model. It was reported in their study that the Sonoplex had better visibility. The present study attempted to objectively quantify tip visibility of the needles on dynamic clinical imaging and therefore provide new information. Although both studies were conducted using static images, the results of our study support their findings.

Although speed is not a priority, it is one of the surrogate measures that reflect the applicability of the procedure. A reduced number of needle insertions may indicate the applicability of the procedure and potential decrease in complication rates. Poor needle visibility is one of the major factors preventing the wide use of ultrasound in regional anesthesia [2]. On the other hand, echogenic needles do not solve all the problems associated with needle visibility and UGRA [2]. Other factors might affect the block performance, including tissue echogenicity and other needle characteristics such as sharpness and smoothness.

According to the findings of the current study, the Sonoplex echogenic needle had better visibility than the Stimuplex D-Plus echogenic needle during the in-plane ultrasound-guided procedures. Additionally, inexperienced users who used the Sonoplex were able to complete the procedure more quickly. The limitations of this study are its in vitro nature and examination of (being geared toward) only inexperienced participants. There is a need for clinical studies conducted with real patients that utilize a wide range of parameters on safety and efficacy to determine the effects of needle visibility in training novice users and in block performances.

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Conflict of interest None.

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