Technical White Paper

Smart Nerve

Automatic Nerve Recognition

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Background

A nerve block is an injection of local anesthetic around a nerve trunk, plexus, or ganglion to prevent conduction of nerve impulse, so that the region controlled by the nerves is anesthetized. Brachial plexus blocks are the major means of anesthesia used in upper limb and shoulder surgeries. The excellent analgesic effect of brachial plexus blocks helps to reduce greatly the amount of opioid analgesics used, so that patients can undergo surgical operations without intubation general anesthesia that may affect their cardiopulmonary function and hemodynamics. This is particularly significant for critically ill patients[1]. Since the 1990s, ultrasound technology has been widely used to guide peripheral nerve blocks[2, 3]. As ultrasound visualizes nerves of patients, the ultrasound-guided method significantly reduces the complications incurred by nerve blocks compared with the traditional blind puncture method based on body surface location. Therefore, nerve blocks become much safer[4]. As mentioned in the *Expert Consensus About Ultrasound-guided Regional Anesthesia/Analgesia (2014)*[5], it has been proven that the use of ultrasound guidance can significantly reduce the difficulty of neuraxial blocks for adults, children and parturient women.

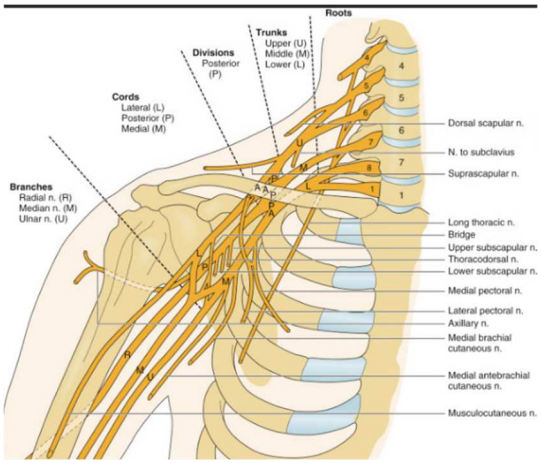


Figure 1: Brachial plexus

As the intermuscular sulcus and supraclavicular brachial plexus is located at the superficial layer, ultrasound-guided brachial plexus blocks are usually performed using 6–13 MHz high-frequency linear array probes.

To perform an ultrasound-guided interscalene brachial plexus block, the operator needs to place the ultrasound probe horizontally on the cricoid cartilage at the center of the patient's neck, and then move the probe outward.

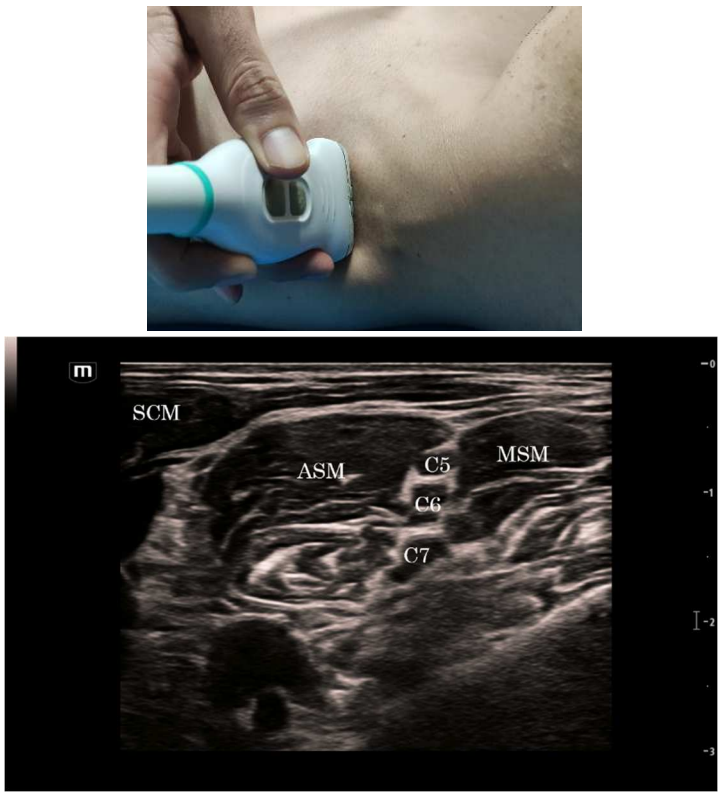


Figure 2: Placement of the ultrasound probe to view the interscalene brachial plexus and the anatomical image displayed

To perform an ultrasound-guided supraclavicular brachial plexus block, the operator needs to place the ultrasound probe on the clavicular midpoint and make its long axis parallel with the clavicle.

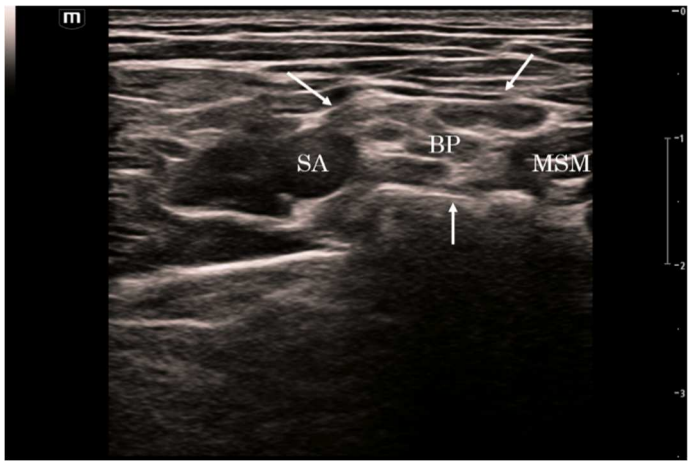


Figure 3: Placement of the ultrasound probe to view the supraclavicular brachial plexus and the anatomical image displayed

Clinical Significance

Ultrasound images of nerves vary depending on acoustic echoes of surrounding tissues and nerves and angles between acoustic beams and nerves. It is difficult to distinguish nerves from blood vessels and lymph glands in ultrasound images. Once the ultrasound probe is moved, the typical image will disappear, in which case the operator has to repeat the above-mentioned complex procedure to relocate the nerves[6]. In addition, the brachial plexus is difficult to locate because it does not have distinguishing features, and underdeveloped muscles and thick subcutaneous fat of patients can reduce the clarity of nerve images. When performing a brachial plexus block, the anesthetist needs to hold the ultrasound probe with one hand and the puncture needle with the other hand, while observing the image on the screen. This operation requires skillful cooperation between hands and eyes, which is difficult for beginners. Therefore, beginners often fail to complete the operation, spend a long time, puncture the skin of the patient multiple times, or even damage the patient's nerves because they do not see the puncture path clearly. Such nerve damage will cause severe negative effects to the patients in their life and work, and heavy financial burdens to their families[7].

Automatic recognition of intermuscular sulcus and supraclavicular brachial plexus makes it easier for anesthetists to identify the brachial plexus, thus significantly reducing the difficulty and duration of brachial plexus blocks. This feature can be used to teach beginners, helping them master ultrasound scanning of the brachial plexus quickly.

Technology Description

The Smart Nerve identifies the intermuscular sulcus and supraclavicular brachial plexus region based on pattern recognition based traditional image processing method. In Nerve Enhancement mode, the system enhances images of the brachial plexus region using image processing methods such as anisotropic convolution and high-frequency filtering, so that the doctor can see the brachial plexus more clearly in a shorter time. Smart Nerve supports real-time and offline recognition of the brachial plexus region.

UI Interaction Design

Smart Nerve provides two operation modes, as shown in the following figure.

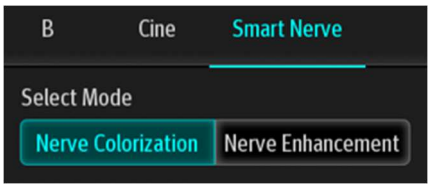


Figure 4: Selecting a mode

1. **Nerve Colorization (default mode):** The brachial plexus region is highlighted in yellow.

Figure 5: Nerve Colorization mode

The highlight transparency can be adjusted in the range of 0%–100% by dragging the

transparency bar. The default value is 25%.

Figure 6: Highlight transparency bar

In Nerve Colorization mode, **Dual Screen Comparison** can be turned on to compare the images.

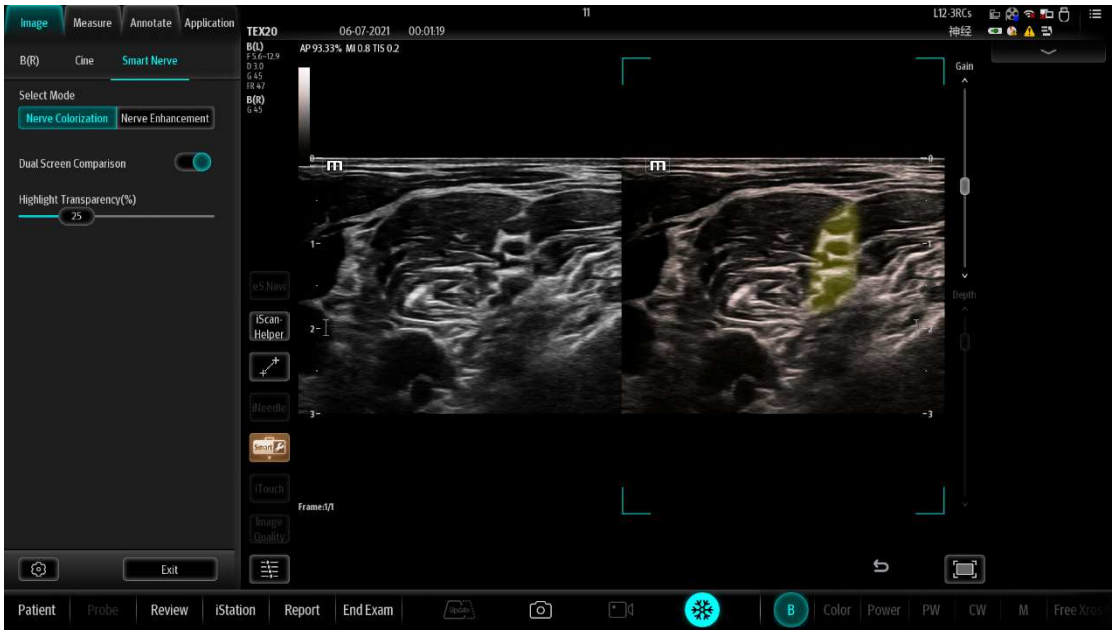
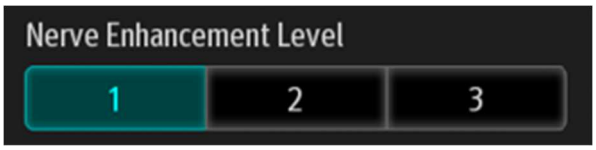


Figure 7: Switch of Dual Screen Comparison and display after the switch is turned on

2. **Nerve Enhancement:** The image of the brachial plexus region is enhanced. This mode provides three enhancement levels. Level 1 provides the lowest enhancement to the original image. Level 3 provides the highest enhancement to present most details of nerve texture. Level 2 (default) provides medium enhancement.



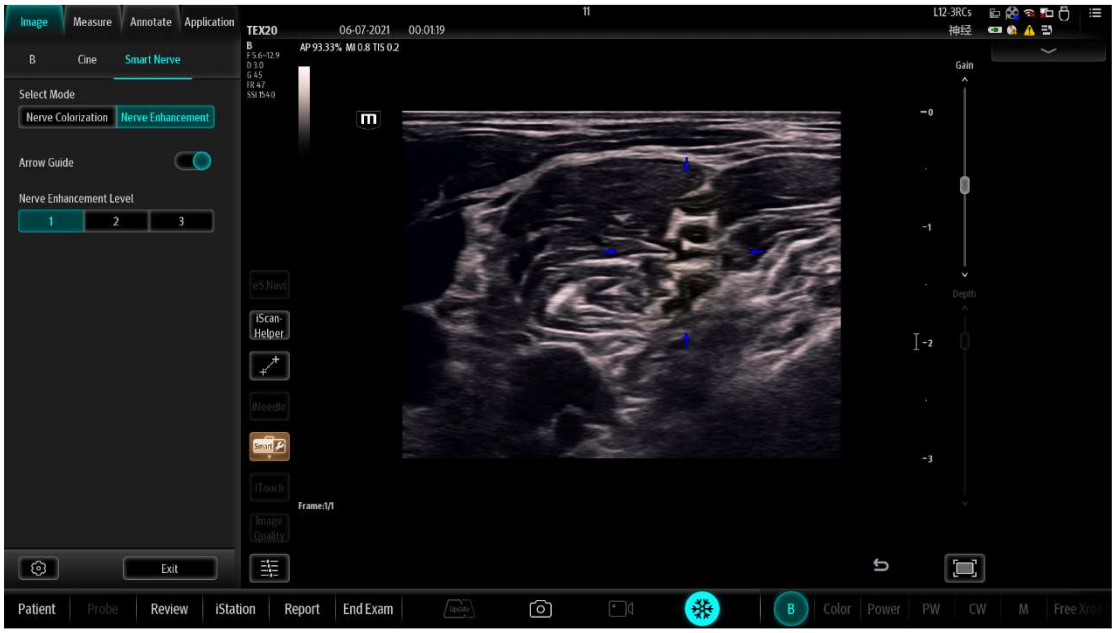

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Figure 8: Nerve enhancement levels and effects of these levels

Clinical Cases

When new anesthetists are learning to scan the intermuscular sulcus and supraclavicular brachial plexus, they often need to watch the ultrasonic screen and handbook simultaneously, which is not a good experience. During the learning, they often mistake some similar structures for brachial plexus. Moreover, the brachial plexus structures of patients waiting for anesthesia are usually different from the standard structure shown in the handbook, making it difficult for new anesthetists to accurately locate the brachial plexus of the patients. Smart Nerve addresses these problems. It highlights the brachial plexus region directly in ultrasound images to remove the need of new anesthetists to check the handbook and prevent them from mistaking similar structures (as shown in the green circle in Figure 9) for the brachial plexus. In addition, it identifies the brachial plexus in different forms (as shown in Figure 10) to help improve the efficiency of learning and shorten the time used.

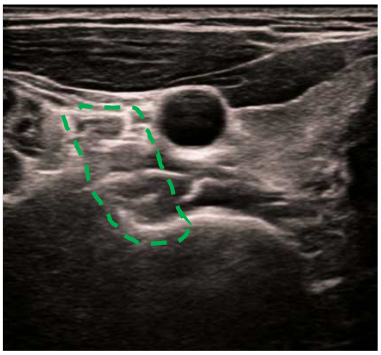

Figure 9: Similar structure not mistaken for the brachial plexus

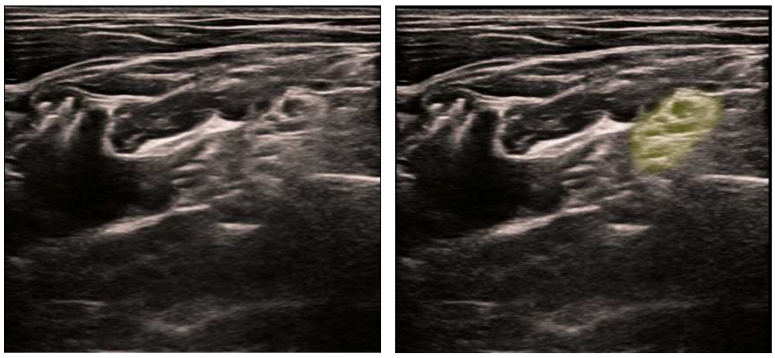

Figure 10: Recognition of the brachial plexus in a nonstandard form. Left: original image; right: brachial plexus highlighted

Conclusion

The capability of Smart Nerve to recognize the brachial plexus helps new anesthetists learn to locate the brachial plexus quickly. This feature provides Nerve Colorization and Nerve Enhancement modes to highlight the brachial plexus structure in ultrasound images, so that new anesthetists can observe the brachial plexus directly without checking the handbook. In addition, Smart Nerve can accurately recognize different brachial plexus structures based on a large amount of brachial plexus data, so that beginners can learn various brachial plexus samples easily and gain a deep understanding of brachial plexus quickly.

References

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