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Original Article

Determination of Spread of Injectate After Ultrasound-guided Interscalene and Supraclavicular Brachial Plexus Block: A Fresh Cadaveric Study

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Abstract

Objective: The aim of this anatomical study was to establish the likely spread of local anesthetics *in vivo* and the segmental nerve involvement resulting from ultrasound-guided interscalene brachial plexus blocks and supraclavicular brachial plexus blocks.
Materials and Methods: We performed ultrasound-guided injections of different alinine dyes into the right brachial plexus at the interscalene and supraclavicular levels in seven fresh human cadavers. We then dissected the cadavers to determine the extent of dye spread and the nerve that was dyed.
Results: The cadavers provided excellent sonographic images during nerve blocks. After excluding one pilot specimen, six right brachial plexus blocks were successfully performed and dissected. The extent of dye spread and nerve involvement were different in the interscalene brachial plexus blocks and supraclavicular brachial plexus blocks. The phrenic nerve with dye was identified in the interscalene brachial plexus block.
Conclusion: This study showed that the extent of dye spread and nerve involvement differs in interscalene and supraclavicular brachial plexus blocks. Phrenic nerve involvement in the interscalene block was confirmed through dissection. Fresh human cadavers, by providing excellent sonographic images, are potential learning and practice models in ultrasound-guided brachial plexus blocks. [*Tzu Chi Med J* 2010;22(4):184–188]

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1. Introduction

For decades, brachial plexus blocks, by providing sufficient surgical anesthesia and postoperative analgesia, have been widely used in shoulder and upper limb surgery [1]. The nerves of the plexus may be localized by traditional landmarks and blind methods where the needle and target nerves are not visualized, such as needle paresthesia, palpitation of the accompanying artery or electrical nerve stimulation. However, in the last decade, the popularity of regional techniques has increased with the use of ultrasound for precise needle placement. Interest in performing brachial plexus blocks with ultrasound guidance has surged among anesthesiologists because of improved safety and quality [2,3].

The aim of this anatomical study was to use dye injections into the brachial plexus with ultrasound guidance and subsequent cadaver dissections to establish the likely spread of local anesthetics *in vivo* and the segmental nerve involvement resulting from ultrasound-guided interscalene brachial plexus blocks and supraclavicular brachial plexus blocks.

2. Materials and methods

This study was approved by the ethics committee with permission from involved families for postmortem donation of corpses for scientific purposes. It was conducted in a university anatomical laboratory (School of Medicine, Tzu Chi University).

We studied seven thawed unembalmed fresh human cadavers. These cadavers were frozen to –30°C within 8 hours after death, and were kept frozen until experimental use. They were thawed at 4°C for 72 hours before use.

A 13–16 MHz, 38 mm broadband linear array ultrasound probe and Sonosite Micromaxx ultrasound machine (SonoSite Titan; SonoSite Inc, Bothell, WA, USA) were used to facilitate needle placement in this study. A stimuplex needle 50 mm 20 G (B. Braun Melsungen AG, Melsungen, Germany) was connected to a 5 mL syringe which contained 1 mL alinine dye. We used blue alinine dye for interscalene brachial plexus block and green alinine dye for supraclavicular brachial plexus block.

All blocks were performed in the right brachial plexus of the cadavers by the same anesthesiologist who is well experienced in both techniques.

2.1. *Interscalene block (ISB)*

In the transverse ultrasonographic view (short axis), the roots were identified as multiple round or oval hypoechoic areas between the anterior and median scalene muscles (Fig. 1A). The needle was inserted lateral to the ultrasound probe using the "in-plane" technique, between two scalene muscles and advanced under direct visualization into the interscalene space close to the roots. Blue alinine dye 1 mL was injected around the roots under continuous ultrasound visualization. Fig. 1B shows the C5–C7 roots infiltrated by the dye.

2.2. *Supraclavicular block (SCB)*

In the transverse ultrasonographic view (short axis), the trunks or divisions were identified. Nerves in the supraclavicular region appeared hypoechoic and were round or oval (honeycomb structure). The brachial plexus was located lateral and posterior to the pulsatile subclavian artery and superior to the first rib (Fig. 2A). The needle was inserted lateral to the ultrasound probe using the "in-plane" technique, and advanced under direct visualization close to the nerves. Green alinine dye 1 mL was injected around the roots under continuous ultrasound visualization. Fig. 2B shows the nerves infiltrated by the dye.

After performing ISB and SCB, the cadavers were dissected to determine the extent of dye spread and nerve involvement in each block technique. Adjacent

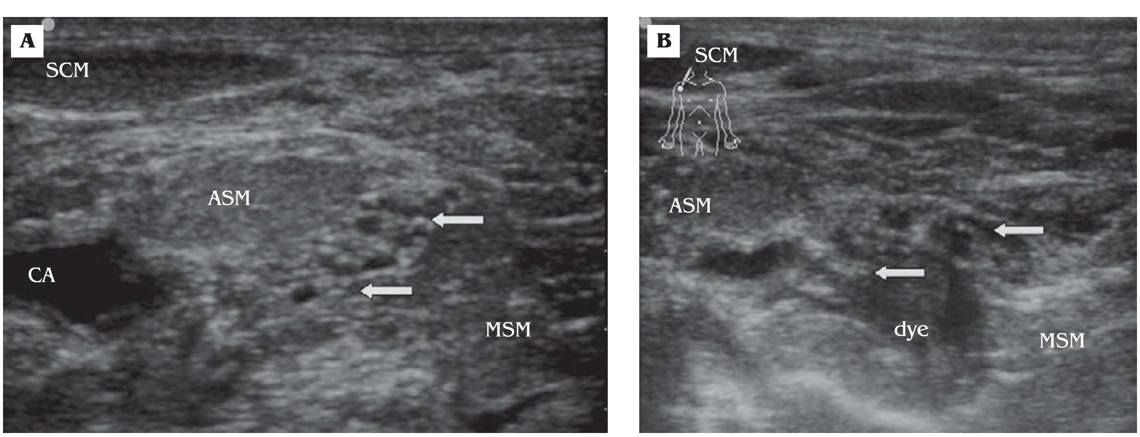

Fig. 1 — Transverse ultrasound section through the superficial part of the interscalene space. (A) The arrows point to the roots of C5 to C7, which are visualized as round or oval hypoechoic areas. (B) The nerve roots after injection of the dye. ASM=anterior scalene muscle; CA=carotid artery; MSM=middle scalene muscle; SCM=sternocleidomastoid muscle.

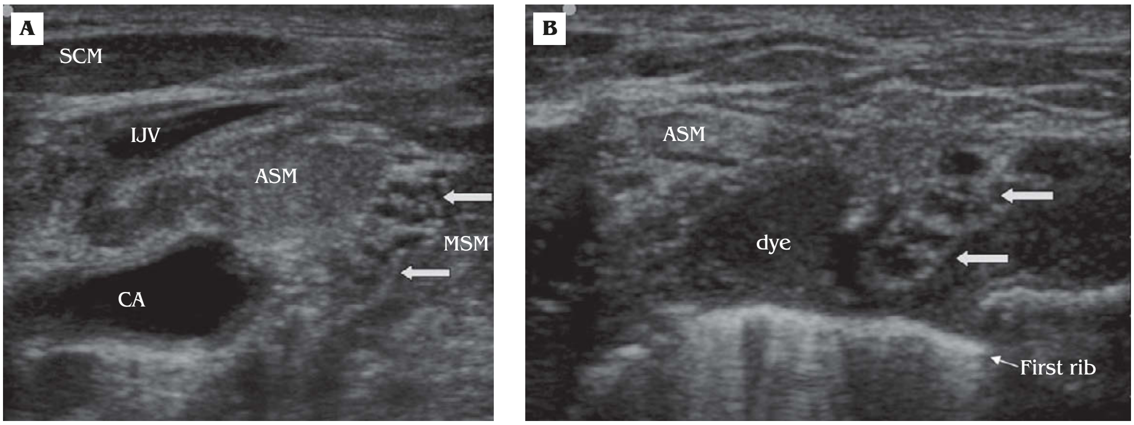

Fig. 2 — Transverse ultrasound section through the superficial part of the supraclavicular space. (A) The arrows point to the brachial plexus, which is visualized as a honeycombed hypoechoic area. (B) The brachial plexus after injection of the dye. ASM=anterior scalene muscle; CA=carotid artery; IJV=internal jugular vein; MSM=middle scalene muscle; SCM=sternocleidomastoid muscle.

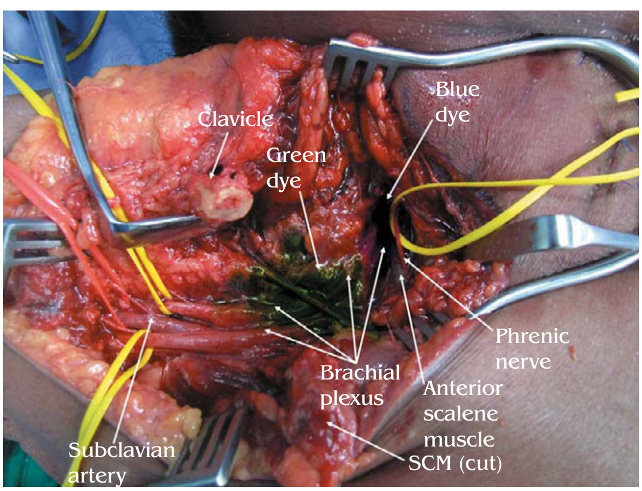

Fig. 3 — The blue dye is spread around the nerve roots at the interscalene level. The green dye is spread around the brachial plexus at the supraclavicular level. The phrenic nerve is seen over the anterior scalene muscle and is dyed blue. SCM=sternocleidomastoid muscle.

structures were preserved and the target nerves and surrounding dye were identified.

3. Results

We excluded one fresh human cadaver for a pilot specimen. We successfully performed right ISB and SCB on six cadavers under ultrasound guidance. We then dissected the brachial plexus region to examine the spread of the dye, and the segmental nerve involved in different blocks.

Fig. 3 shows that the dye had spread well and close to the nerves in different segments. In the ultrasound-guided ISB, the blue dye was injected around the C5–C7 nerve roots in the interscalene space, with the phrenic nerve dyed. In the ultrasound-guided SCB, the green dye was injected around the brachial plexus trunks or divisions, and no phrenic nerve dye was noted. The dissection confirmed the ultrasound results with different dyes at different segments of the brachial plexus in different blocks. The dissection also confirmed the accuracy of the injected dye around the desired nerves with ultrasound use, even with a small volume of dye. Also, it showed anatomically the involvement of the phrenic nerve in ISB, whereas the phrenic nerve was spared in SCB.

4. Discussion

Ultrasound-guided nerve block has gained popularity in regional techniques in recent years. Compared with the traditional landmark technique, ultrasound-guided nerve block provides direct visualization of nerves, adjacent structures and needle placement. Potential benefits of the ultrasound-guided technique include an improved success rate, shortened performance of the block, faster onset, increased intensity and duration of sensory and motor block, reduced block-related complications and increased patient satisfaction [2,4–7].

Studies of ultrasound-guided brachial plexus nerve blocks in fresh human cadavers are scarce in the literature. In this study, we found that fresh cadavers provided excellent ultrasonographic images of soft tissues, compatible with those of clinical patients. Previous studies also showed similar results [8–11]. Direct visualization of the nerves and adjacent structures, such as vascular areas, pleura and bone, as well as needle placement, can be obtained real-time throughout the procedure.

In the past, medical students and residents usually learned new technical skills and invasive procedures directly on clinical patients under the guidance of supervisors. This is especially common in ultrasonographic practice or ultrasound-guided nerve blocks because manikins cannot provide sonographic images that exactly simulate structures in the human body. Complications, sometimes fatal, can occur in patients as a result of errors by learners. With the clear sonographic images available, fresh cadavers can act as excellent learning models for clinical practitioners. Clinical practitioners can obtain experience learning ultrasound-guided nerve blocks on cadavers without being concerned about harming patients, as in traditional clinical practice. More preparation of skills can be provided for clinical practitioners with promotion of safety and satisfaction for clinical patients.

ISB and SCB are two approaches of brachial plexus block often seen in shoulder and upper limb surgery. Both provide sufficient surgical anesthetic and postoperative analgesic effects. However, block-related complications often raise concerns about this approach. One common complication of interscalene brachial plexus block is phrenic nerve blockade. It can lead to diaphragmatic paralysis and further result in compromise of respiratory function. Therefore, it is usually contraindicated for patients with poor pulmonary compliance [12,13].

In this study, we observed dyeing of the brachial plexus nerve roots and phrenic nerve in ISB, thus confirming the anatomic involvement of these nerves. This gross observation on a dissected cadaver clearly explains clinical findings of diaphragmatic paralysis owing to phrenic nerve blockade. Even with a small volume of injected dye, we still found dyed phrenic nerves in our dissected cadavers. Because the nerve roots are close to the interscalene space, phrenic nerve involvement in ISB seems to be inevitable [14].

In SCB, we could easily identify the first rib and pleura with the use of ultrasound. This prevents accidental puncture of the pleura during traditional blind methods. We found the dye spread well around the brachial plexus trunks and divisions. The phrenic nerve was spared through gross observation of the supraclavicular level a few centimeters from the interscalene level. However, if the volume of the injectate is large (i.e., 20–30 mL), as it is in clinical practice, there is a high possibility that the injectate at the supraclavicular level may infiltrate the phrenic nerve nearby. This could explain the clinical finding that up to 30–50% of cases have phrenic nerve blockade in SCB.

There were several limitations in this study. First, although the cadavers provided clear and excellent ultrasonographic images comparable to those of human bodies, there might still be some differences in the resolution of images after the cadavers have been frozen and thawed. Second, the dye that we used in the study was different from local anesthetics, especially the viscosity and small volume, which may have an impact on its spread in nerve blocks. Third, we only studied and dissected ultrasound-guided nerve blocks in the right brachial plexus, leaving the left side unexplored. Further studies may focus on similarities and differences between left and right brachial plexus blocks.

In this anatomical study, we found that the extent of dye spread and nerve involvement differs in interscalene and supraclavicular brachial plexus blocks. By dissection and direct observation, we confirmed that phrenic nerve blockade is almost inevitable in ISB, which is compatible with clinical findings. The excellent ultrasonographic images from fresh human cadavers also provide a good learning model for clinical practitioners in ultrasound-guided brachial plexus blocks.

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