Original Article

C5 ventral ramus block for clavicle surgery: How low concerning the volume can we go?

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Abstract

Background and Aims: Clinical case reports mention 3-5 ml of local anesthetic (LA) at the cervical root 5 (C5) for surgical anesthesia essential for clavicle surgeries with reasonable success. A volume of 5 ml LA has been shown to cause hemidiaphragmatic paresis.
Material and Methods: We implement the 3–5 ml LA for awake clavicle surgeries along with a supraclavicular nerve (SCN) block with another 2 ml. To understand the spread of injectate, we conducted anatomic macroscopic dissection on Theil based cadavers. Post ultrasound injection of 3 ml of blue latex in one cadaver and green latex in the other, we dissected one cadaver and the other cadaver underwent a cross-section.
Results: Dissection confirmed a vertical spread of dye more caudad than cephalad. There was no neuraxial spread visualized in the cross-section. The phrenic nerve (PN) was not stained in both cadavers, but a possibility exists depending on its course.
Conclusion: Based on this limited study we recommend a volume of LA of 3 ml at the level of C5 and another 2 ml at the level SCN of LA for clavicle surgeries.

Keywords: Cadaver, cervical root, clavicle, phrenic nerve, regional anesthesia, supraclavicular nerve, ultrasonography

Introduction

Local anesthetic (LA) injection of 3–5 ml at the level of C5 is used for clavicle surgeries and in the management of C5 radiculopathy.[1-3] The phrenic nerve is in close association at the level of C5.[4] Block at this level could lead to hemidiaphragmatic paresis. Cadaveric study with 5 ml dye at the level of C5 root demonstrated an epidural spread and soakage of the phrenic nerve.[5] Since an undesirable spread is expected with 5 ml of injection, we hypothesized whether another reduction in volumes is possible without an epidural and more distal spread.

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We aimed to determine the spread of 3 ml latex (the volume of LA we inject in clinical practice for clavicle surgeries) after injecting at the level of C5 under US guidance, positioning the needle tip close to the epineurium of the ventral ramus. Cadaveric dissection was to identify if the spread is to the nerves innervating the clavicle (nerve to subclavius, supraclavicular nerves, suprascapular nerve, and lateral pectoral nerve) and cadaveric cross-section was to understand the spread at level of the vertebral body of C5.[6]

Material and Methods

Two investigated bodies donated to science (BDTS) fall under the strict rules of the donation program of the Department of

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Macroscopic and Clinical Anatomy of the Medical University of Graz and the Styrian burial law. The BDTS were embalmed with Thiel´s method which provides very lifelike conditions for investigations with regional anesthetic backgrounds.[7,8] Bilateral C5 blocks were performed using latex. In the first cadaver, 3 ml blue latex was injected posterior and lateral to C5. In the second cadaver, 3 ml green latex was injected posterior and lateral to C5 and during withdrawal of the needle, 1 ml was injected below sternocleidomastoid (SCM) muscle i.e., supraclavicular nerve (SCN) block. One cadaver underwent bilateral dissection and the second cadaver was frozen for two weeks and underwent cross-sections for analysis. The C5 ventral ramus was chosen as target for injection at level of the C5 vertebral body and intervertebral foramen C4/C5. The transducer was placed in transverse oblique plane and the needle advanced lateral to medial. The final needle tip target was planned posterior and lateral to the C5 ventral ramus directly underneath the prevertebral fascia. A 50 mm blunt insulated needle (Pajunk 50 mm, Pajunk, Geisingen, Germany) was inserted in plane and guided under real-time US towards the hypoechoic oval structure. The needle tip was stabilized posterior (ventral) and lateral to the hypoechoic structure – the ventral ramus of 5th cervical root -arising between the anterior and posterior tubercles along the sulcus of transverse process. The needle tip did not penetrate the hyperechoic lining surrounding the hypoechoic nerve structure. Cadaver 1 to be dissected was injected with 3 ml of blue latex. Cadaver 2 was injected with 3 ml green latex. Injections were made with low pressures, unmonitored, in small boluses of 0.2 ml until 3 ml was injected. A continuous visualization of the spread was monitored and recorded. Injecting small boluses confirmed the posterior (ventral) and lateral spread. With each injection, the ventral ramus of C5 was elevated and settled as the injectate dispersed. With the needle tip lateral and with no swelling of the ramus, none of the injections were underneath the epineural sheath. Two days after injection, ensuring that the latex had hardened, the posterior triangle of the cadaver 1 (BDTS) was dissected carefully by elevating all layers until the prevertebral fascia was reached. The fascia was elevated and the ventral ramus of C5 segment was dissected carefully. The medial to lateral and cranial to caudal spread with a special focus on the phrenic nerve as well as the intervertebral foramen concerning the epidural spread was visualized. This BDTS was stabilized at minus 40 degrees Celsius temperature for 2 days and underwent horizontal sections. The medial spread and discoloration of the phrenic nerve were visualized.

Results

The dissected BDTS showed that the identified supraclavicular nerves were not stained superficial to the prevertebral fascia. The transverse cervical artery was observed traversing superficially to the brachial plexus and the prevertebral fascia. A bluish stain was seen through the prevertebral fascia covering the brachial plexus elements. On elevating the prevertebral fascia, the blue latex was seen sandwiched between the superior trunk and middle trunk [Figure 1]. Vertical spread was documented from the lateral point of the intervertebral foramen to the level of the omohyoid muscle traversing the posterior triangle. Since the latex did not spread into the intervertebral foramina, dissection into the intervertebral foramina was avoided. The unstained suprascapular nerve was visualized emerging on the superior and lateral aspect of the superior trunk. The phrenic nerve turned medially directly after emerging from the intervertebral foramen and reached the ventral surface of the anterior scalene muscle and was not stained in its entire course.

The cadaver 2 was sectioned after freezing for 2 weeks at –40 degrees Celsius. At the level of C5 the latex spread was visualized on its dorsal aspect. There was no spread in the intervertebral foramina and in the neuraxial space. Without an intervertebral foramen spread the latex, was seen, along to the lateral flank in the underdeveloped prevertebral muscles underneath the prevertebral fascia. The anterior scalene muscle was very thin in this cadaver and no spread occurred on the its ventral surface. One ml latex injected separately was identified below SCM.

Discussion

The investigation clearly documented by direct dissection or cross-section proves that even a small volume of 3 ml injected to the ventral ramus of C5 can result in a huge vertical spread but sparing the phrenic nerve.

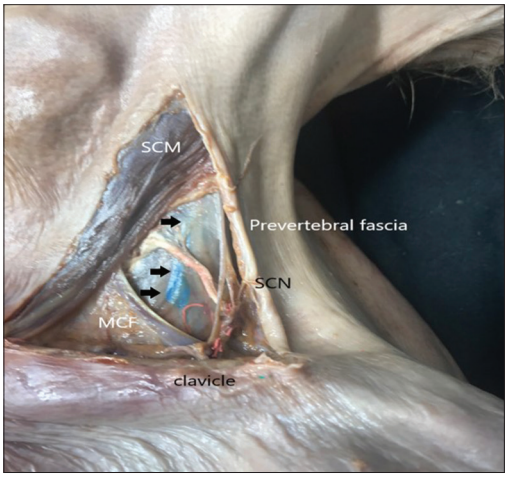

Figure 1: Left neck dissection demonstrating the bluish discolouration below the prevertebral fascia. (SCM -sternocleidomastoid; SCN -supraclavicular nerve; MCF-middle cervical fascia; Black arrows – Bluish stain below prevertebral fascia)

US-guided selective C5 ventral ramus blocks have been described in several case reports as a safe and effective means to anesthetize the distal clavicle while maintaining innervation of the upper extremity and preserving diaphragmatic function. We thought of implementing this in cadaver to understand the flow dynamics both proximal towards the neuraxial space and distal along the brachial plexus elements. We chose 3 ml as this is the volume being injected in clinical practice for fracture clavicle.[1] In the absence of a pressure monitoring device we chose to inject manually with our clinical experience. Low injection pressures were maintained for each bolus of 0.2 ml until 3 ml was injected. This volume was placed posterior (ventral) and lateral to the ventral ramus of C5.

Our study depicts no neuraxial spread in dissected specimen in cadaver 1 [Figures 2 and 3] and in cross-section in cadaver 2 [Figure 4]. Choosing dissection and cross-section technique, the spread can be documented more precisely. Dissections can show the spread into spaces and structures surrounded by latex, which can be easily identified. Concerning the spread into deeper regions away from the target, cross-sections can give a much better result. As a consequence, we could show spread into intervertebral areas or intramuscular spread or deep to the muscle but not into the intervertebral foramen. In the cervical region neuraxial spread can be assessed with cross-sections. This does mean that a low volume, low-pressure injections with ultra-low volume boluses probably does not produce a neuraxial spread. In cadaver 1, dissection revealed no stain of the phrenic nerve all along its course. In cadaver 2, the cross-section depicted no spread on the anterior scalene muscle, meaning no involvement of the phrenic nerve. We thus conclude that a 3 ml latex spread would not have affected the structures in the neuraxial space or the phrenic nerve. Concerning the phrenic nerve affection an important information can be seen by the latex spread which has to be taken into consideration. As the latex shows no spread ventromedially on the anterior scalene muscle, the documented vertical spread in direction along the ventral branch of C5 still could reach the phrenic nerve in its cranial course. The phrenic nerves in the investigated BDTS curls around the anterior scalene muscle immediately and is therefore in a safe distance from the C5 segment at injection level. However, in the case of a more lateral convex course of the phrenic nerve, the nerve gets in close relation to the C5 segment before turning medially to reach the ventral surface of the anterior scalene muscle. In such cases, the C5 injection would affect the phrenic nerve for sure, even with a volume of 3 ml or smaller. To avoid a phrenic nerve palsy, the identification of the phrenic nerve topography and course is recommended.

As opposed to our findings, another study demonstrated an epidural and a spread to the brain stem 1 in 4 cadavers after 5 ml of 0.5% methylene blue dye was injected under US at C5.[5] Another publication reported an epidural spread after an injection with pressure monitoring in 1 of 8 cadaver with 5 ml of combination of ropivacaine and methylene blue dye. In both studies, the dissections were immediately performed after injection of a non-viscous solution.

Regarding the spread of the injected latex, it is notable that we still documented a surprising extensive vertical spread. The 3 ml injected got spread vertically to level of the omohyoid muscle, which indicates that the prevertebral fascia is a guiding structure as well as a barrier. As 3 ml represents a

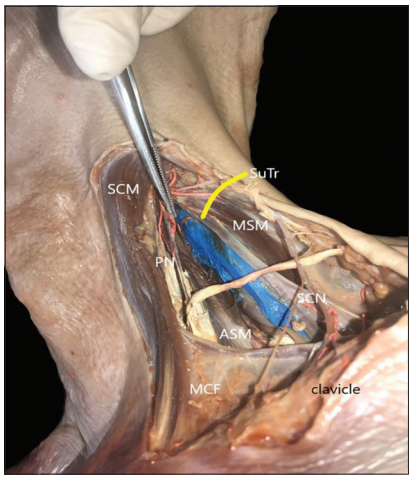

Figure 2: The left side of the neck shows the blue latex spreading in the interscalene gap, along the superior trunk. The phrenic nerve is not coloured. (SCM -sternocleidomastoid; SuTr- Superior Trunk; MSM – middle scalene muscle; ASM -anterior scalene muscle; PN-phrenic nerve; MCF-middle cervical fascia; SCN-supraclavicular nerve)

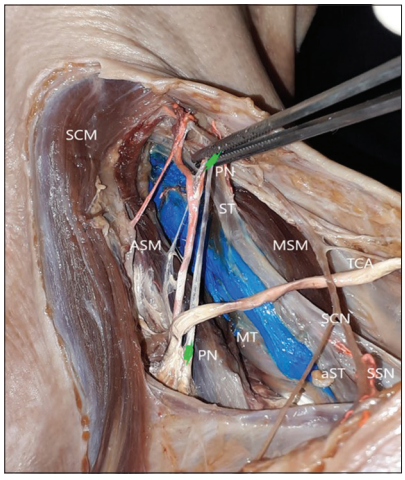

Figure 3: The latex reaches the area of the intervertebral foramen. The phrenic nerve is not stained by the latex although the close relationship. (SCM -sternocleidomastoid; ST- Superior Trunk; MSM – middle scalene muscle; ASM -anterior scalene muscle; PN-phrenic nerve (green arrows) SCN-supraclavicular nerve; MT-middle trunk; aST – anterior division superior trunk; suprascapular nerve; TCA- transverse cervical artery)

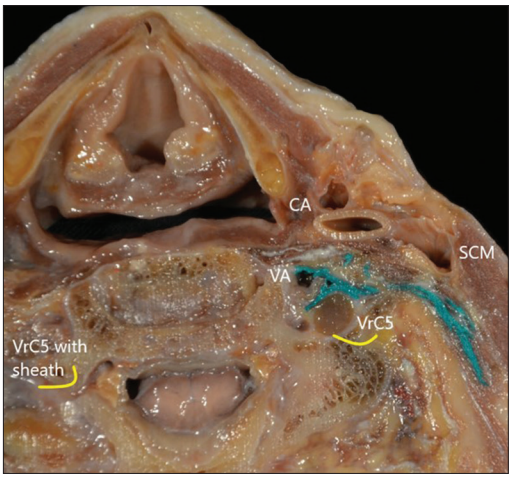

Figure 4: Latex visualized on the superior aspect of the C5 ventral branch. A small spread in the front of the vertebral artery. The superficial cervical plexus is below the sternocleidomastoid and posterior. (VrC5-Ventral ramus C5; SC -spinal cord; VA- vertebral artery; CA- carotid artery; SCM- sternocleidomastoid)

very small volume, one has to imagine a spread with volumes higher than 5 ml or 10 ml which results in unpredictable and explain unwelcome affections. Though the needle position and the spread around the C5 with 3 ml may be ideal on US, cranial spread and its affection on the phrenic nerve may not be assessed.

In conclusion, a low volume of 3 ml with low injections pressures in small boluses of 0.2 ml at the posterior and lateral corner of C5 provides an adequate spread along the ventral branch of C5 or superior trunk in both cranial and caudal directions. We translate this particular study in clinical practise where a low volume C5 and SCNB provides adequate anesthesia and analgesia for prolonged duration. Injections respecting the special topography of the phrenic nerve might result in efficient blocks. As the US-guided technique creates a clear visible and easy identifiable structure such as the C5 ventral ramus and combined with a precise needle guidance by US it can be assumed that even smaller volumes than 3 ml might be enough for an efficient block and to decrease unwelcome spread to other areas or nerve structures. We certainly are aware that the number of investigated BDTS are very low and cannot provide an absolute statement concerning the volume, but it should be seen as a starting point of discussing the role of volumes injected into well-bordered spaces and well visible targets under an US-guided regional anesthetic blocks.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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