Original Article

The Investing Layer of the Deep Cervical Fascia: An Alternative Site for Ultrasound-guided Supraclavicular Nerve Block – A Cadaveric Anatomical Study

Sandeep Diwan[1], Shivaprakash S.[2], Rasika Timane[3], Pallavi Pai[4], Zenab Bohra[5], Abhijit Sukumaran Nair[6]*

[1]Department of Anesthesiology, Sancheti Hospital, Pune, Maharashtra, India, [2]Department of Anatomy, JSS Medical College, JSS Academy of Higher Education and Research, Mysore, Karnataka, India, [3]Department of Anesthesiology, Critizone Hospital, Nagpur, Maharashtra, India, [4]Department of Anesthesiology, Deenanth Mangeshkar Hospital, Pune, Maharashtra, India, [5]Department of Anesthesiology, Sai Samarth Hospital, Pune, Maharashtra, India, [6]Department of Anesthesiology, Ibra Hospital, Ibra, Oman

Abstract

Background: It is very well known that the supraclavicular nerve (SCN) which occupies the inferior part of the superficial cervical plexus basically originates from the ventral rami of C2–C4, then travels caudally into the investing layer of the deep cervical fascia (IL-DCF) alternatively termed the "prevertebral fascia." **Methods:** This cadaveric study (a total of 6 soft-embalmed cadavers and bilateral dissections, i.e. 12 specimens) intended to ascertain the location of SCN within the layers of the IL-DCF. We hypothesized that ultrasonography identification of SCN within the IL-DCF and needle tip positioned between the layers of IL-DCF provide an alternative site for the blockade of the SCN. **Results:** After dissection, we described a compact double-layered IL-DCF hosting the SCNs and a specific topographic arrangement at the C4 root with SCN lateral and C4 branches of the phrenic nerve medial to the C4. **Conclusion:** We recommend another alternative site for the SCN block at a site in the compact double layer of IL-DCF. We conclude that a caudal site at the exit of SCN from the IL-DCF would be appropriate to perform the intervention.

Keywords: Cadaver, deep cervical fascia, dissection, supraclavicular nerve, ultrasonography

Introduction

The supraclavicular nerve (SCN) occupies the inferior part of the superficial cervical plexus and originates from the ventral rami of C2–C4. Descending caudally, it runs a variable length of the course in the investing layer of the deep cervical fascia (IL-DCF) alternatively termed the "prevertebral fascia," and emerges from the posterior border of the sternocleidomastoid (SCM) muscle dividing into its terminal branches. The lateral branch of the SCN supplies the skin over the lateral aspect of the clavicle and innervates the acromioclavicular joint.[1-3]

To ascertain the location of SCN within the layers of the IL-DCF, we conducted a study in six soft-embalmed cadavers. At the level of the 6th cervical nerve root, the IL-DCF and the SCNs within were identified with an ultrasound (US) guided scan, and colored dye was injected. The diffusion of the dye was examined through a US probe. Later, anatomical dissections were executed on these specimens, and the spread and extent of diffusion of the dye were investigated from the level of C7–C2 cervical nerve roots.

Through this study, we found that injecting as little as 2 ml of dye within the layers of IL-DCF stained the SCN within all cadaver specimens. The dye did percolate cranial to soak the C4–5 cervical nerve roots in all the specimens but did not extend to stain C2–3 roots. The dye also did stain the phrenic nerve mild-moderately. The study also brings to light a unique topographic arrangement of nerves which is visualized at the

Address for correspondence: Dr. Abhijit Sukumaran Nair, Department of Anesthesiology, Ibra Hospital, Ibra 414, Oman.
E-mail: abhijitnair95@gmail.com

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level of the 4th cervical root, between the emergence of the SCN and the phrenic nerve.

We hypothesized that ultrasonography (USG) identification of SCN within the IL-DCF and needle tip positioned between the layers of IL-DCF provide an alternative site for the blockade of the SCN.

Materials and Methods

After the approval from the Institutional Ethics Committee, of JSS Medical College (approval number: JSSMC/IEC/240323/45NCT/2022-23) an observational study was conducted on six soft-embalmed cadavers, bilaterally (a total of 12 specimens). The cadavers were devoid of any anterior neck surgical procedures, infectious pathologies, and scoliotic deformations of the cervical spine. The informed consent was waived by the Institutional Ethics Committee.

Description of technique

The cadavers were placed in a supine position with the arms placed adducted and extended by the side of the body. The head was turned opposite to the side of the scan and later dissection.

Description of ultrasound scan

The US scan was performed by an operator experienced with US-guided blocks using a linear array US probe (M-Turbo SonoSite-Fuji 3–12 mHz, USA). The posterior triangle of the neck was scanned in a caudad-to-cephalad direction from the level immediately above the clavicle up to the level of the hyoid cartilage**.** After initial identification of the 7th cervical transverse process (TP) characterized as an absent anterior tubercle, the 6th cervical TP was identified. The hyperechoic structure just below the subcutaneous tissue, covering the middle scalenus muscle (MSM) and anterior scalenus muscle (ASM) in the interscalene groove was identified as the IL-DCF, and the hypoechoic structures were seen within as they coursed in the hyperechoic IL-DCF were presumed to be the SCN.

The 6th cervical TP was chosen as this is a common site for an interscalene brachial plexus block, where the needle tip penetrates the IL-DCF, and injections are performed in the vicinity of the 5th and 6th cervical roots.

A 22 G insulated blunt needle (B. Braun, USA) was inserted in line with the US probe in the lateral to medial direction, and the needle tip was positioned within the IL-DCF. Two ml of dilute methylene blue dye (MBD)–0.1 ml in 1.9 ml of 0.9% normal saline was then injected into the IL-DCF, and the diffusion within the two layers of IL-DCF was assessed in real time. Without any movement of the probe, a deeper spread of the injectate toward the cervical roots was inspected. US images were downloaded and saved for future use. This was carried out in all the six cadavers bilaterally. US-guided injection of dye on each side was followed by the dissection of that side.

Description of the dissection

Thirty minutes after the injection of dye, unaware of the block procedure, dissections were performed by a single anatomist in the posterior triangle of each side of the neck of all six cadavers (a total of 12 specimens). The skin, subcutaneous tissue, and platysma were reflected. The IL-DCF over the scalene muscles revealed dye diffusion. Subsequently, the IL-DCF was delicately peeled off from underlying structures. Furthermore, cephalad dissection was guided by tracing the spread of the dye. Pictures were clicked with Canon 1000D and stored in a separate folder. Structures soaked with MBD were examined and labeled as mild, moderate, and deeply stained.

Results

Ultrasonography findings

The IL-DCF was identified as a double layer of hyperechoic structure [Figure 1b] on both sides of the neck of all six cadavers. Hypoechoic shadows coursed through the IL-DCF as they emerged from the 4th cervical nerve root [Figure 1a]. The position of the needle tip was confirmed to lie within the IL-DCF [Figure 1c]. On injection of methylene blue, the dye injectate was discerned in the IL-DCF and was seen to have surrounded the hypoechoic shadows within the IL-DCF.

Dissection findings

The anatomical dissection demonstrated the bluish tinge of the subcutaneous tissue and soakage of the IL-DCF [Figure 2a and b]. On examination of the level of spread in the IL-DCF, it was found that in 5/12 specimens, the IL-DCF was deeply stained, and the spread extended from the level of the hyoid to the cricoid cartilage.

On gentle peeling of the IL-DCF, the SCN was observed to be stained deeply in all 12 specimens [Figures 2b, c and 3c]. Importantly, the phrenic nerve was seen to be moderately soaked with MBD in 7/12 specimens and mildly soaked in 5/12 specimens [Figures 2b, c and 3a, c]. A cephalad dissection revealed the mild staining of the respective C4 and C5 nerve root contributions of the phrenic nerve [Figures 2c-e and 3a-c]. Further cephalad and medial dissection revealed mild-to-moderate soakage of C4 and C5 cervical nerve roots in 5/12 specimens [Figures 2c, d and 3a].

Intricate dissection at the level of the C4 nerve root revealed a specific topographic arrangement of the SCN and the C4 contribution of the phrenic nerve [Figure 3b and c]. It was found that after the nerves emerged independently from the C4, the SCN coursed lateral, the C4 branch of the phrenic nerve (PN) coursed medial, and the C4 nerve root breached the IL-DCF; all lie in the same facial plane, enveloped by the IL-DCF. This specific arrangement was a consistent finding in all 12 specimens. On further cephalad dissection, the C2 and C3 [Figure 3b and c] were never stained in any of the specimens.

Summary of ultrasound and dissection findings

Specific topographic arrangement with SCNs emerging lateral and C4 branch of PN emanating medial to C4 was visualized in all specimens [100%]. Furthermore, the double-layer IL-DCF hosting the hypoechoic nodules was divulged in

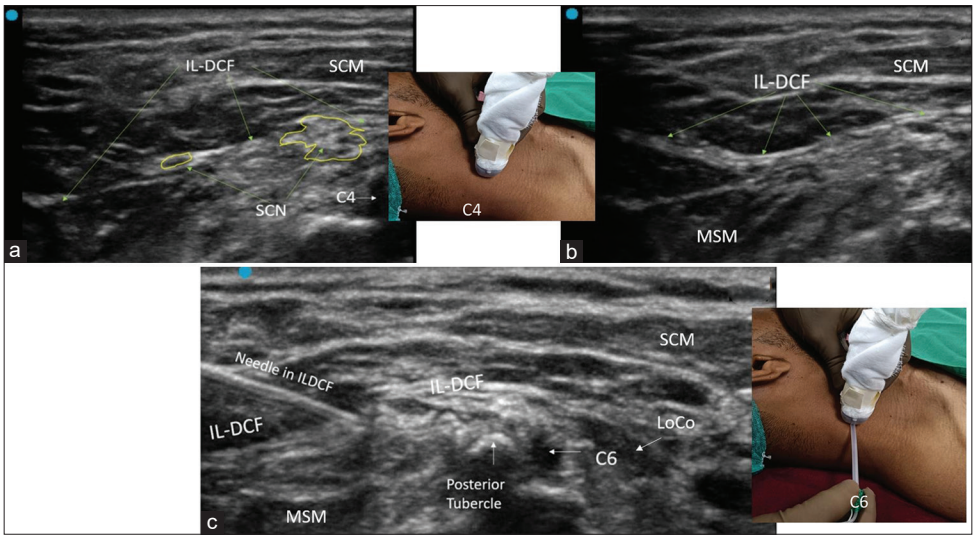

Figure 1: (a) Bunch of hypoechoic structures arising from the C4 nerve root and coursing through the investing layer of the deep cervical fascia (IL-DCF]/prevertebral fascia, (b) Double layer of IL-DCF, (c) Needle tip in between the IL-DCF

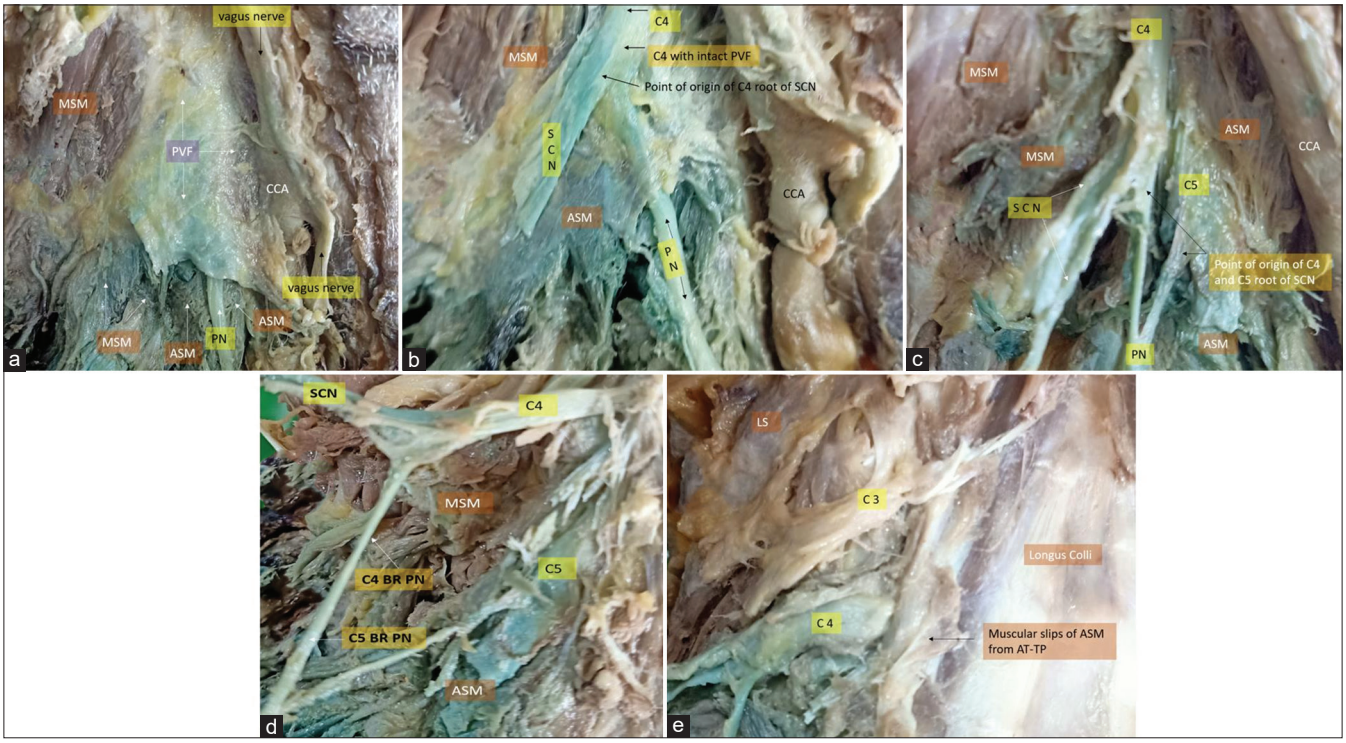

Figure 2: (a) The prevertebral fascia (PVF)/(mild stain) encompassing the phrenic nerve (PN) (moderately stained). The lower deep middle scalene muscle (MSM) is stained (light stain) and not the upper superficial MSM (b) The supraclavicular nerve (SCN) (heavy stain) and the PN (heavy stain) emerging from the C4 nerve root (light stain) and engulfed by the PVF. The lower deep MSM is stained (light) (c) The PN its roots from C4 and C5 (heavy stain), the SCN (moderate stain), the C5 (heavy stain), and the C4 (light stain) are illustrated. The upper medial part of MSM is lightly stained. (d) The C4br (light stain) and SCN (moderate stain) originating from the C4 nerve root (light stained), C5br of PN (light stain), and the C5 nerve root (heavy stain) are depicted. The lower anterior scalenus muscle and the MSM are moderately stained. (e) The C4 nerve root is represented with a light stain, while the C3 nerve root is not stained. PVF: Prevertebral fascia (aka investing layer of the deep cervical fascia), MSM: Middle scalene muscle, ASM: Anterior scalene muscle, CCA: Common carotid artery, PN: Phrenic nerve, SCN: Supraclavicular nerve, AT-TP: Anterior tubercle of the transverse process, VrC5: Ventral root of C5

all specimens [100%]. Needle tip and injectate spread were discerned in all specimens [100%]. However, the deeper diffusion could not be evaluated as the probe position was maintained to discourage movement-related spread [Table 1]. Targeting these nerves with the needle tip positioned in the IL-DCF, at the level of the 6th cervical TP, 2 ml MBD engulfed the SCN in all specimens (100%). However, dissection revealed soakage of IL-DCF (100%-heavy), SCNs (100%-heavy),

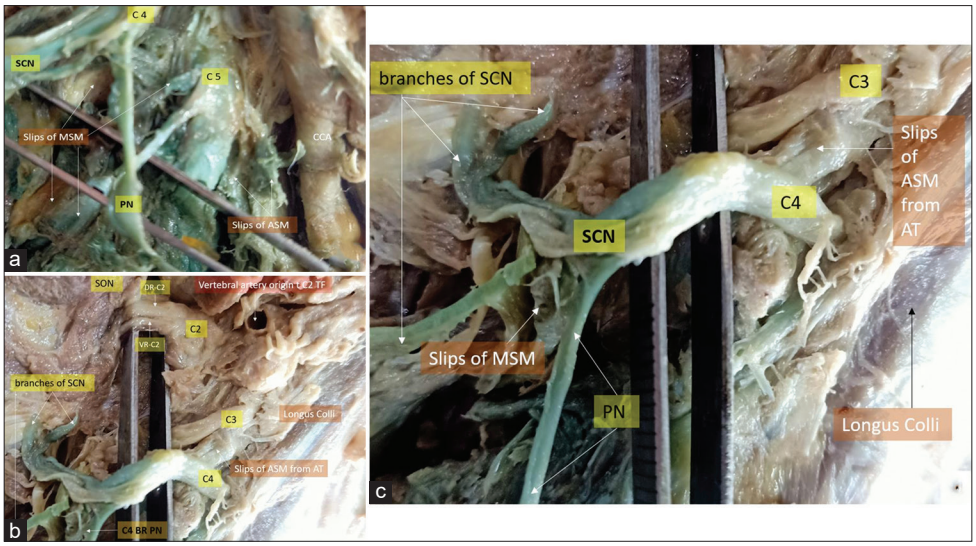

Figure 3: (a): The phrenic nerve (PN) and its roots from C4 and C5 are moderately stained, the supraclavicular nerve (SCN) is stained lightly, while the C4 and C5 are unstained (b) The distal SCN branches are moderately stained, the C4 is stained lightly, while the C4br of PN is moderately stained. The C3 is unstained. The unstained C2 with its dorsal and ventral root are envisaged. Muscular slips of anterior scalenus muscle are not stained. Origin of VA at the C2 FT is depicted. (c) The distal branches of SCN and PN are moderately stained. The main SCN, however, is lightly stained. The C4 is unstained. VA: Vertebral artery, FT: Foramen transversum, DR: Dorsal rami, VR: Ventral rami, AT: Anterior tubercle, Br of SCN: Branches of the supraclavicular nerve, C4rPN: Root from the 4th cervical nerve

Table 1: Spread and extent of methylene blue dye staining

Cadaver and specimens	IL-DCF	SCN	C4-5 Br of PN	PN	C7	C6	C5	C4	C3	C2
1 left										
1 right										
2 left										
2 right										
3 left										
3 right										
4 left										
4 right										
5 left										
5 right										
6 left										
6 right										

IL-DCF: Investing layer of the deep cervical fascia, SCN: Supraclavicular nerves, Br of PN: Branch of the phrenic nerve, C2–C7: 2nd–7th cervical roots Staining scale

Heavy | Moderate | Light | None

phrenic nerve soakage (7/12 [58.33%]-moderate; 5/12 [41.66%]-mild), and C4–5 branches of the phrenic nerve (9/12 [75%]-moderate; 3/12 [25%]-mild). The cervical roots, C6 (4/12–33%), C5 (12/12–100%), and C4 (12/12–100%), were mildly stained. In none of the specimens were the C3 and C2 roots highlighted.

Discussion

US-guided SCN block has been traditionally administered at the lateral edge of the SCM, in the connective tissue between the SCM and the middle scalene muscle.[4-8] Although other needle tip positions have been described as superficial, subcuticular, and subcutaneous,[9] the IL-DCF in our opinion has never been targeted as an alternative site for USG-guided SCN block. In six cadavers (12 specimens), under the USG scan, the SCNs were identified as hypoechoic structures within the hyperechoic IL-DCF. In the real-time US, they were visualized traveling in the IL-DCF.

Although earlier study reports the emergence of a hypoechoic edifice from the 4th cervical root and the presence of multiple hypoechoic structures resting in the connective tissue on the middle scalene muscle and beneath the SCM were suspected SCNs, the formation of the SCN and its course within the IL-DCF remained elusive/never been reported.[7,8]

Through our study, we describe a compact double-layered IL-DCF hosting the SCNs and a specific topographic arrangement at the C4 root with SCN lateral and C4 branch of PN medial to the C4, scanning caudal the two components depart lateral and medial to the C4 but still situated in the IL-DCF.

Our hypothesis that the compact double layer of IL-DCF allows an alternative site for a US-guided SCN block was complicated with anatomic dissection revealing dye diffusion cephalad to the PN and deeper to the C5 and C4 roots. Probably, due to the tight compliance of the IL-DCF, the dispersion of dye in the cephalad direction is imminent. However, the compliance could vary in living subjects between adults and elderly subjects.

Furthermore, from the IL-DCF, the injectate disperses into the deep cervical fascia through the pores and channels in the

IL-DCF.[10] These are present plausibly at the exit of the nerves as they appear from the deep to the superficial breaching the IL-DCF.[7] In our study, volume as low as 2 ml diffused toward the PN and its branches and the 4th and 5th cervical roots through the tunnels provided for the nerve pathway.

This study is important in many ways. First, IL-DCF is an attractive site wherein the SCN is easily identified and can be considered an alternative site for the SCN block. However, the low compliance will allow diffusion in the path of least resistance both cephalad and caudal involving the PN. Moreover, the communication from the superficial to deep cervical space exists, and the injectate may seep from the former to the latter compartment. Thinking otherwise, clinically, this could be considered to be a US-guided single-point injection "C5, 6 root block by proxy" for clavicle fractures in patients who can tolerate phrenic nerve paresis. Second, contrary to our study, SCN block performed with 2 ml at the level of C6 cervical TP, lower volumes would spare the PN. Third, it could be hypothesized that the SCN can be targeted at the exit point of the SCN from the IL-DCF. However, this could not be revealed conclusively in our study due to a more cephalad dissection. Fourth, we illustrated a specific topographical of SCN and PN arrangement in relation to the C4 root. This could have extended clinical implications. Finally, during an interscalene block, since the needle tip traverses the IL-DCF, we suggest that the SCN in the IL-DCF be identified to avoid probable impalement of these nerves.

There are many limitations of this study, including a small sample size. Although soft embalmed, extrapolation of findings in a cadaver to that in the living may not be plausible in all aspects. Moreover, the US scan and subsequent dissection to understand the distance the SCN traveled in the IL-DCF, and its exit from the fascia was not divulged by a more caudad dissection. Since most of the interest persisted in cephalad spread, the caudal dissection and affection of the C7 and C8 were unaccomplished. Moreover, the intensity of the anatomic stain pattern does not reflect a clinical effect.

We, through our study, very cautiously recommend another alternative site for the SCN block at a site in the compact double layer of IL-DCF. However, a more caudal site at the exit of SCN from the IL-DCF would be appropriate. The volume of injectate can be further reduced to less than 2 ml to accomplish anatomical block efficacy, which would be performed in future studies.

Conclusion

Based on our anatomic findings, we undauntedly indicate injections in IL-DCF as a C5 block by proxy. Moreover, any extrapolation of our findings in cadaver specimens to clinical scenarios warrants further clinical studies.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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