

The Sheath of the Brachial Plexus

Fact or Fiction?

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Background: The concept of the axillary “sheath” has been a central tenet of brachial plexus regional anesthesia for many years. Recent investigations have cast doubt on its nature and existence. This study further examines the issue.

Methods: Computerized axial tomographic dye studies were performed using continuous catheter systems for the sciatic nerve and the brachial plexus. The resultant images were compared and contrasted.

Results: The images of the two catheter systems were the same, with the exception that one was of the upper extremity and the other was of the lower extremity.

Conclusions: The sciatic nerve is not surrounded or enveloped by a “sheath”—it lies in the tissue plane between rigid anatomical structures. Similarly, the brachial plexus lies in the tissue plane between the rigid anatomy of the chest wall, scapula, humerus, and pectoral fascia. This finding is inconsistent with the concept of the axillary sheath.

THE axillary or brachial plexus “sheath” has been a fundamental tenet of regional anesthesia applied anatomy for many years.¹⁻⁴ More recently, however, some doubt has been cast on the precise nature and existence of the sheath.⁵⁻⁸ In the context of this controversy, we sought to find an alternative way to try to further the debate.

Using computerized axial tomography dye studies (CTDSs), we compared and contrasted the images of two peripheral nerve catheter systems: brachial plexus and sciatic nerve.

Materials and Methods

With the approval of the Nelson-Marlborough Ethics Committee (Nelson, New Zealand) and written informed consent, three patients with functioning brachial plexus catheters and two patients with functioning sciatic nerve catheters were enrolled in the study.

The three patients with brachial plexus catheters had these inserted using the “bent needle” technique of supraclavicular block,⁹ and all had undergone major wrist, elbow, or forearm surgery during regional anesthesia, followed by regional analgesia using their catheters. The catheters were inserted to a depth of 10–11 cm from skin to catheter tip. The CTDS was performed on the second postoperative day. For the purposes of the

study, a functioning brachial plexus catheter block was defined as absence of cold sensation in the territories of the ulnar, median, radial, medial and lateral antebrachial cutaneous, and axillary nerves 1 h before CTDS.

The two patients with sciatic nerve catheters had these inserted in similar fashion to the technique described by Sutherland.¹⁰ Both had undergone major ankle surgery using combined general anesthesia and regional nerve blocks. Postoperative analgesia was provided *via* their sciatic nerve catheters. The catheters were inserted to a depth of 12–15 cm from skin to catheter tip. The CTDS was performed on the second postoperative day. For the purposes of the study, a functioning sciatic nerve catheter was defined as absence of cold sensation in the territories of the common peroneal and tibial nerves 1 h before CTDS.

The position of the catheter tips was determined by a radiologist (C.L.) by injecting 1 ml of 50% diluted 300 mg/ml Omnipaque (iohexol; Amersham Health Limited, Auckland, New Zealand) dye down the respective catheters and then performing a preliminary computerized tomography scan. Then, 20 ml of 50% diluted Omnipaque dye was injected down each catheter, and the patients were rescanned at a slice thickness of 3 mm and a pitch of 2. The brachial catheter CTDS was performed from the top of the clavicle to 30 mm below the glenoid fossa, and the sciatic catheter CTDS was performed from the top of the sacroiliac joints to 20 mm below the lesser trochanter.

The images were then visually compared for similarities and differences. Particular attention was paid to the direction of distribution of the dye from the catheter tip, the contours of the dye-enhanced neural tissues, and the nature of the anatomical structures immediately adjacent to the nerves. Distortion or displacement of the tissues surrounding the nerves was noted.

Results

The brachial plexus catheter tips lay just inferolateral to the coracoid process of the scapula, whereas the sciatic nerve catheter tips lay between the tip of the ischial tuberosity and the femur.

The following observations relate to figures 1–4. Both systems showed substantial anterograde and retrograde flow from the catheter tip, with clear limits of outward spread determined by solid anatomical structures, and clear lines demarcating the limits of spread (figs. 1–4). The pattern of distribution of dye within the neural tissues was similar between the two systems, both in the region of the catheter tip and at the extremes of dye

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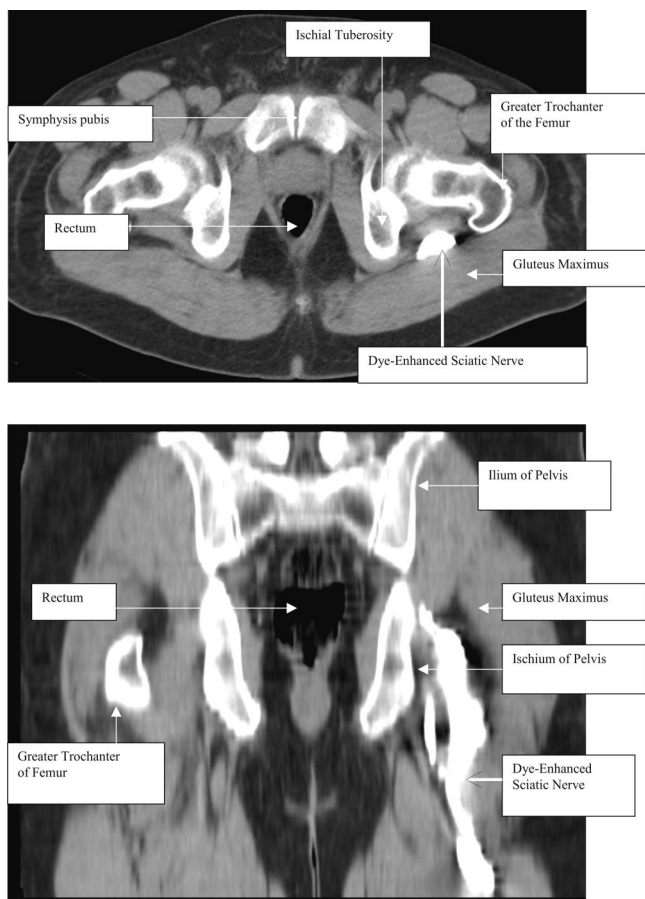


Fig. 1. (A) Axial section of sciatic nerve catheter. (B) Coronal section of sciatic nerve catheter.

distribution. There was neither distortion nor displacement of the anatomical structures surrounding the nerves (figs. 1B, 2B, 3, and 4). Indeed, frequently the line of dye conformed to the shape of the surrounding anatomy (figs. 2B, 3, and 4). The major difference between the two systems lay beyond the limits of spread of the dye, where the anatomy was clearly different, *i.e.*, upper extremity *versus* lower extremity (figs. 1-4).

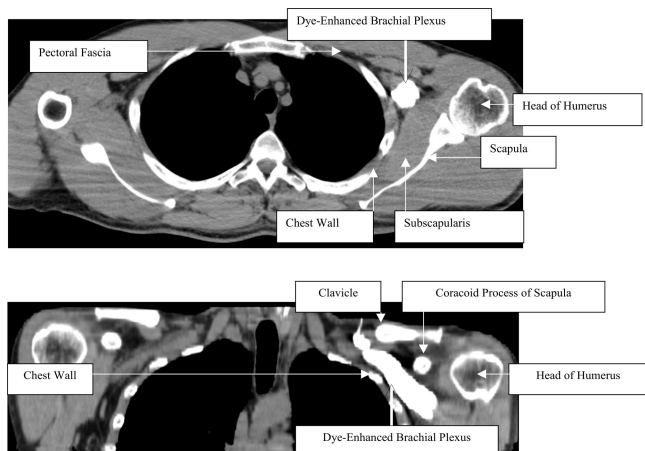


Fig. 2. (A) Axial section of brachial plexus catheter. (B) Coronal section of brachial plexus catheter.

Discussion

We believe that the similarities between the two different sets of CTDSs are not coincidental and that there are sound anatomical reasons to explain this.

It is generally agreed that there is no “sheath” surrounding or containing the sciatic nerve.¹¹ Rather, the sciatic nerve lies in a “tissue plane” closely surrounded by the gluteal muscles, the ischium of the pelvis, and the femur. A tissue plane is a potential space of embryologic origin that separates muscular and/or visceral compartments and that provides space for transmission of arteries, veins, lymphatics, and nerves between these compartments. Tissue planes are fundamental to surgical dissection technique,¹² but perhaps they are not sufficiently emphasized in anesthetic practice, given the number of publications in the literature that describe them.^{5,6,13-16}

Similar to the sciatic nerve then, the brachial plexus lies in a tissue plane closely surrounded by the clavicle, scapula, chest wall, and humerus.

There are several reasons why the tissue plane is important anatomy to understand. First, there may be minimal space for soft tissue expansion at any one point,¹⁷ and therefore, flow must occur along the tissue plane, according to resistances encountered along the way.¹⁸ As observed in the images from this study, one of the paths of lesser resistance within the tissue plane is along the line of the nerve, and in both directions from the point of injection. The dynamics of spread have the potential to be quite different¹⁸ from those one might expect from a simple tubular structure such as a sheath. A series of plain x-ray film dye studies^{3,19,20} have shown containment of solution, but plain x-ray films do not adequately define nonbony structures, and they lack the three-dimensional perspective of computerized tomography scanning. Accordingly, it is possible to misinterpret the images from these studies. Second, compartmentalization may occur because the layers of connective tissue within the tissue plane are not homogeneous, do not necessarily interconnect, and may hinder or prevent diffusion.⁸ Therefore, injection at one point does not guarantee spread elsewhere. Third, it is said that “supraclavicular” techniques are more effective than “axillary” techniques because the nerves are closer together. This is a less than convincing argument because the nerves are not far apart at either level. At the supraclavicular level, however, the elements of the plexus—trunks, divisions, and cords—interlace and interlink, and hence the connective tissues containing these nerves interconnect, a feature observed when they are dissected.⁸ This interconnection would allow for a more even spread of injected solution, a phenomenon that is observed clinically.²¹ This is distinctly different at the axillary level, where the terminal nerves do not interconnect and the connective tissues surrounding them create distinct compartments for each.¹⁶ Fourth, side effect profiles may be explained by the interconnection, *via* tissue planes, of the anatomical compartments across which the nerves travel. Hence, an injected

Fig. 3. Coronal and corresponding axial section for 2 subjects. The *white arrows* indicate the dye-enhanced nerves in both coronal and axial sections. The *horizontal black line* in the coronal section indicates an axial section that is then displayed as directed by the *solid black arrow*. Note how the dye conforms to the shape of the surrounding rigid anatomy—chest wall, coracoid process, and subscapularis. *Dark areas* adjacent to the nerves are adipose tissue.

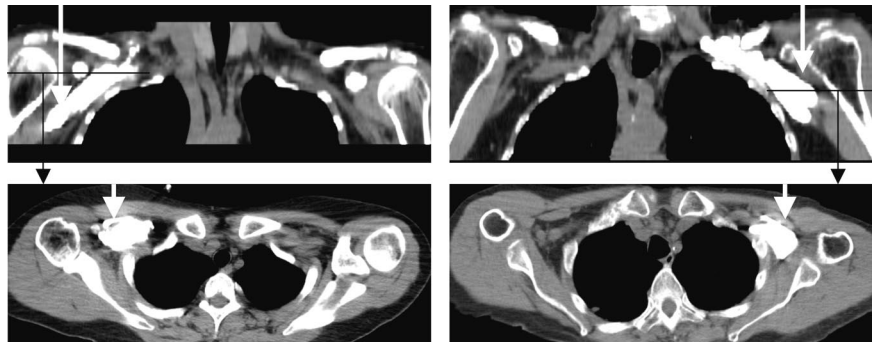
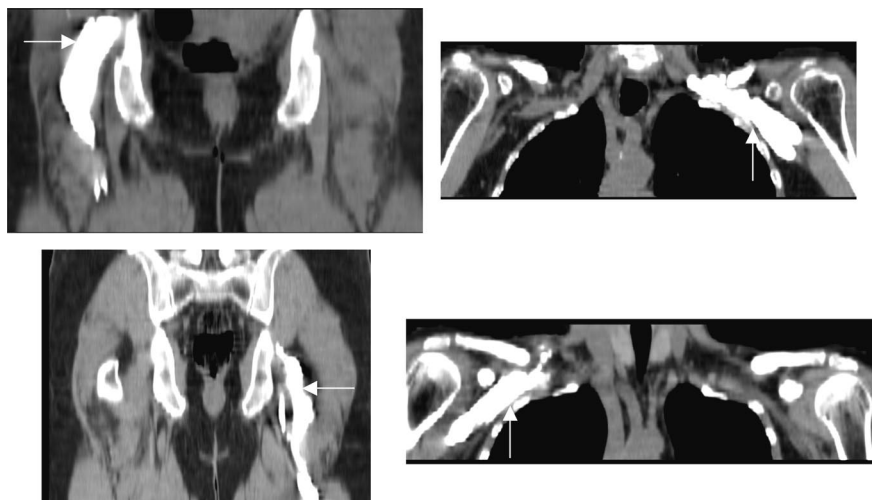


Fig. 4. Coronal images for different subjects. The *solid white arrows* indicate the dye-enhanced nerves.



solution can spread to unwanted places with unwanted effects, *e.g.*, phrenic nerve block and interscalene²² or subclavian perivascular block.²³

In conclusion, this study suggests that there may not be an enveloping and encasing soft tissue structure, or “sheath,” around the brachial plexus. The brachial plexus instead lies in the tissue plane between the rigid anatomical structures that form the boundaries of the anatomical axilla.¹⁷ This rigid anatomy and the tissue plane within its borders combine to contain and direct the flow of an injected solution. The concept of the brachial plexus “sheath” seems to describe the anatomy inaccurately.

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