Original Article

The Paraneural Sciatic Sheaths in Longitudinal Axis at the Level of Greater Trochanter: An Ultrasound Cadaveric and Clinical Correlation Study

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Abstract

Background: Paraneural sheath engulfing the sciatic nerve (SN) between the ischial tuberosity and the greater trochanter is well known. **Methods:** In order to explore the anatomical planes separating the paraneurium from the epineurium in SN, we conducted a cadaveric study (two patients and four specimens), followed by a clinical study in 10 patients. **Results:** We demonstrated an elevation of 5–7 layers of paraneural tissues after an in-plane injection in the longitudinal axis of the proximal SN, which was possibly the last of the paraneural sheath. In the clinical study, the block provided low pain scores with no rescue analgesia postoperatively and no neurological deficit at the time of discharge. **Conclusion:** This is probably the first series which has described the elevation of several layers of paraneural tissues after an in-plane injection in the longitudinal axis of the proximal SN.

Keywords: Acute pain, cadaver, regional anesthesia, sciatic nerve, ultrasonography

Introduction

Paraneural sheath engulfing the sciatic nerve (SN) between the ischial tuberosity and the greater trochanter is an established entity both in cadaver and clinical ultrasound (US) studies.[1,2] US in the axial plane does not differentiate between the epineurium and the paraneurium.[3] In a bid to understand the anatomical plane that would probably separate the paraneurium from the epineurium, we initially conducted an open cadaveric dissection after injecting latex, which revealed multiple sheaths of the paraneural tissue until the epineural tissue, followed by a clinical study. Upon injection, US images illustrated an elevated paraneural sheath that separated from the epineural tissue of the SN. This was possibly the last of the paraneural sheath (LOPS).

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Methods

Cadaveric study

Cadaveric details

Two investigated bodies donated to science (BDTS) fall under the strict rules of the donation program of the Department of 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 lifelike conditions for investigations with regional anesthesia backgrounds.[4] The cadavers were aged 84 years (C1) and 88 years (C2), without medical disorders at the time of death.

Interventions in the cadavers

Bilateral US-guided SN blocks (left and right in both C1 and C2: four interventions) were performed in the prone

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position [Figure 1a]. Following the identification of SN in the axial plane between the greater trochanter and the ischial tuberosity, the curvilinear probe (SonoSite M-Turbo 5–12 MHz) was oriented in the longitudinal axis along the SN. In all four interventions, a blunt needle (21 G Pajunk, 100 mm, Germany) was inserted from caudal to cephalad in the longitudinal axis of the SN. With 3 ml 0.9% saline injection, the needle tip was confirmed within the paraneural tissue. Subsequently, 20 ml of blue latex was injected. The Spread of the latex in the paraneural tissues and the relation of the latex spread to the SN were observed in real time initially in the longitudinal axis and confirmed in the axial plane at the end of injection.

Clinical study

This clinical study was approved by the Institutional Ethics Committee, Sancheti Hospital for Orthopedics and Rehabilitation, Pune India (approval number: SIEC/17-12-2021; approval date: 17/12/2021). Ten patients (seven males and three females), aged between 24 and 46 years and with a mean body mass index of 23 kg/m^2 who underwent a calcaneum surgery under spinal anesthesia, were recruited in the clinical study. All surgical procedures were performed in the lateral position. All patient informed consent was obtained.

Interventions in the patients

Postoperatively, all patients received an US-guided and neurostimulation-aided posterior SN block for postoperative pain relief with 20 ml of 0.2% ropivacaine in 30 µg clonidine. In all 10 patients, under aseptic precautions, a curved array transducer (2–4 mHz SonoSite M-Turbo) was deployed between the greater trochanter and the ischial tuberosity in the axial plane [Figure 2a]. The SN was identified in the axial plane, and the probe was rotated in the longitudinal axis. A 21 G 100 mm stimulating needle (Pajunk 21G, Germany) was inserted beneath the probe from caudal to cephalad, and upon either a dorsiflexion or plantar flexion at 0.6 mA, the needle–nerve contact was established, and a 3 ml test dose of 1% lidocaine led to disappearance of evoked muscle responses. An initial 10 ml of LA (0.2% ropivacaine) was injected in the longitudinal axis, and a spread pattern was observed in the paraneural tissue [Figure 2b]. Subsequently, another 10 ml LA was injected, and a diffusion pattern was evaluated. After 20 ml LA injection, the paraneural layers, the LA spread, and the relation between the outer layer of the SN (epineural tissue) and the elevated layer of paraneural tissue were evaluated in the longitudinal plane. The final spread around the SN was confirmed in the axial plane [Figure 2c]. Intramuscular diclofenac 75 mg was injected on request and noted as the time to first analgesia and was administered every 12 h thereafter. Intravenous tramadol 50 mg was prescribed as a rescue analgesic (when the pain score was 4 or more). An increase in the vertical and horizontal diameters of the SN in the longitudinal and axial planes was also evaluated for intraneural injections.

Results

Dissection details in the cadavers

The dissection revealed unstained paraneural tissue layers beneath the retracted gluteus maximus. Deep to the paraneural tissue, a linear bluish structure was observed covered by a fascial layer that coursed from cephalad to caudal. The paraneural layers were peeled of gently from each other. Almost 5–7 layers of the paraneural tissue were evident [Figure 1b]. With gentle dissection of probably the LOPS tissue, the blue latex surrounding the SN was evident, encircled by a flimsy fascia which was easily peeled off [Figure 1c – white arrows]. The posterior cutaneous nerve of the thigh remained unstained in all specimens and was coursing in a separate paraneural tissue. The inferior gluteal artery was envisaged medial to

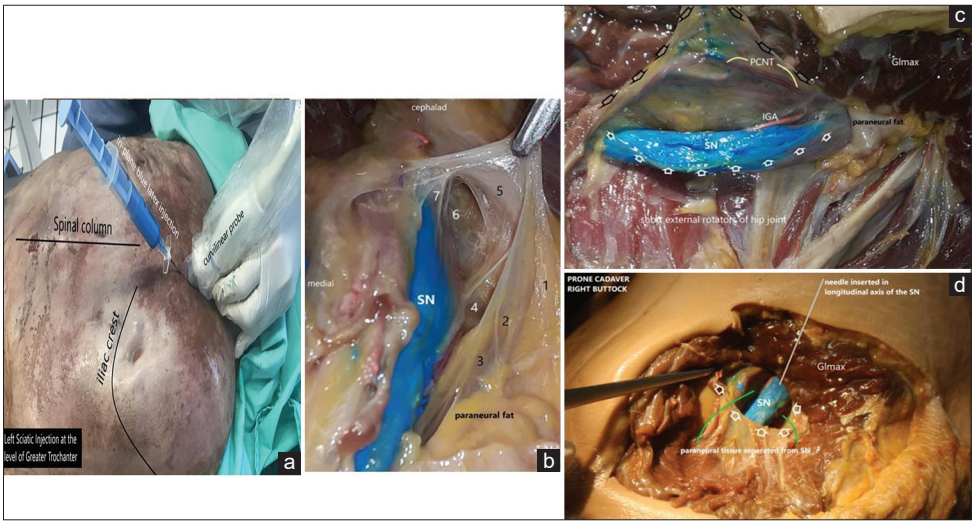

Figure 1: (a) The left sciatic nerve injection at the level of the greater trochanter in the cadaver, (b) Gentle dissection depicted the multiple layers of the paraneural tissue (5–6), unstained and surrounding the sciatic nerve engulfed with blue latex, (c) The posterior cutaneous nerve of the thigh is depicted in a separate paraneural sheath, unstained (the blue stain appears during dissection). White hollow arrows depict the last of paraneural sheath engulfing the latex-laden sciatic nerve. The inferior gluteal artery is medial to the sciatic nerve, (d) Needle is simulated from caudal to cephalad (gray line). The hollow white arrow is the last of the paraneural tissue

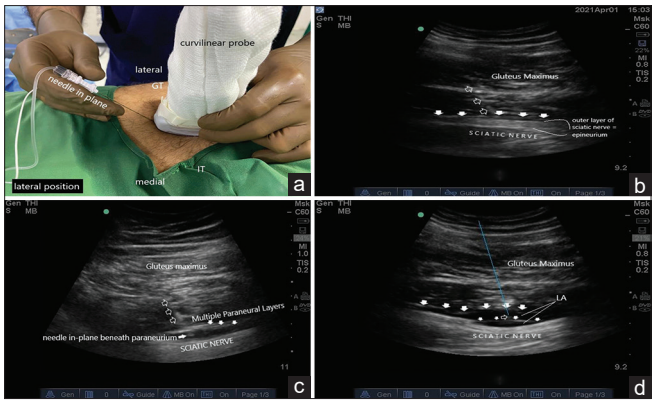

Figure 2: Longitudinal axis and in-plane SN block. (a) Probe placement and direction of needle entry (GT, IT), (b) Needle tip (hollow bold arrows) in the paraneural tissue (bold white arrows) of SN. The outer layer of sciatic nerve = epineurium (thick white covering = depicted by white lines) is visualized, (c) Through the needle (white hollow arrows), 10 ml LA injection within the paraneural tissue had elevated several layers of paraneural tissue (white bold arrows). Few layers of the paraneural tissue are visualized in close approximation of the epineurium of the sciatic nerve (d) A further 10 ml LA is injected in small boluses, through the needle (simulated as thin blue line), as the needle tip (hollow white arrow) pierces, possibly the last layer paraneural tissue (small white bold arrows). The LA occupies the space between the last of paraneural tissue and in approximation with the epineurium of the sciatic nerve. SN: Sciatic nerve, GT: Greater trochanter, IT: Ischial tuberosity, LA: Local anesthetic

the SN [Figure 1c]. Figure 1d depicts the needle simulation penetrating the skin, subcutaneous tissue, the gluteus maximus, and finally, the sheath encompassing the SN (blue latex – white arrows). The paraneural space was separated from the flimsy covering that encompassed the SN.

Assessment of injections using ultrasonography in cadaveric study

In real time, US identified the needle tip in all four injections: the initial 10 ml spread of the latex as a hyperechoic linear flow along the paraneural tissues of the SN in the longitudinal axis. Upon further injection of 10 ml, the latex cleaved between the paraneural tissues and elevated possibly the last layer of paraneural tissue exposing from the external covering of the SN (epineurium). A cephalad scan revealed the latex distribution in the parasacral area. Rotating the probe in the axial plane confirmed the latex encircled the 3/4th of SN, on its anterior, medial, and lateral areas.

Assessment of the injection spread using ultrasonography in clinical study

Needle tip was identified in all US images close to the hyperechoic SN. A 3 ml injection identified that the spread was in the paraneural tissue. An initial 10 ml injection distinctly elevated the various layers of the paraneural tissues. LA had diffused and collected in this space between the multiple layers of the paraneural tissues. The needle tip was advanced carefully in the hypoechoic pocket of LA in the paraneural tissue. The final 10 ml was injected, which cleaved the paraneural tissue until no further separation of the paraneural tissue layer was separated from the SN. The elevated LOPS was a continuous layer in the longitudinal plane and exposed the epineurium of the SN. The separation was envisaged in real time after penetration of the elevated paraneural layer [Video 1]. There was no increase in the vertical and horizontal diameters of the nerve, suggesting no intraneural injections.

Finally, the probe was rotated from longitudinal to axial. The LA distribution was seen in the paraneural tissue which got separated in several layers [Figure 2d]. The plausible LOPS was distinctly seen as an elevated layer beneath which and superficial to the outer layer of the SN which was collection of LA. The LA encircled the anterior, lateral, and medial aspects, but not the posterior. The LOPS appeared to be discontinuous in the axial plane [Figure 2c].

Analgesic efficacy of the interventions in the clinical study

The block was adequate in all patients with time to first analgesia, a mean of 14.5 h, and no rescue analgesics were required in the form of intravenous tramadol. The mean pain scores at 0, 6, 12, 18, 24, 36, and 48 h were 0, 2, 1.8, 2.2, 2, 1.5, and 1.6, respectively. At the time of hospital discharge, no patients complained of neurological deficit in the operated limb.

Discussion

US-guided, specifically targeted acute and chronic pain interventions are not only safe as they are performed in real time by visualizing the vital structures such as blood vessels and the nerves *per se*, they are also more efficacious.[3,4] US-guided subparaneural popliteal SN injections in the axial plane have resulted in faster onset, high success, and prolonged duration.[1,2] Touted to be the future destination for SN blocks, the deposition of LA in this narrow extraneural space is associated with transient paresthesia (20%–29.4%), inadvertent intraneural injections (2.6%–9%), and prolonged neurological deficit (3%).[5-7] Axial US imaging of the SN identifies two potential compartments after LA injection, and these are subepimyseal (between the epimysium and paraneural sheath) and subparaneural (potential fat-filled region separating the paraneurium from the epineural). Further, a circumferential and proximal to distal spread has been associated with improved block efficacy with SPC blocks.[1] Elevation of several layers of paraneural tissues after an in-plane injection in the longitudinal axis of the proximal SN has neither been explored nor established in the literature. In our cadaver study, at least 5–7 layers of the paraneural tissue were identified.

A limited cadaveric study is the major obstacle in this series. A microscopic and histological evaluation would have established the difference between the paraneurium and the epineurium, which was not performed. The limited case series, block administered after a spinal anesthetic, no demonstrations of the sensory delineation, and no long-term follow-up for chronic pain would be some of the major limitations. Although no intraneural injection was detected, injection pressure monitoring should have been executed.

However, the strengths of the study lie in correlating a single approach (longitudinal plane) in evaluating the spread of solutions in the cadaver and clinical scenarios and attempting to delineate space between the paraneurium and the epineural tissue.

We perceive that the posterior in-plane longitudinal approach to SN provides adequate visualization of needle to the paraneural tissue with injection to be performed in the longitudinal plane which would enhance safety for posterior approaches. However, a comparative study is warranted between the axial and longitudinal approaches.

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Conflicts of interest

There are no conflicts of interest.

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