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Ultrasound-guided Lumbar Facet Nerve Block

Accuracy of a New Technique Confirmed by Computed Tomography

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Background: **Lumbar facet nerve (medial branch) blocks are often used to diagnose facet joint-mediated pain. The authors recently described a new ultrasound-guided methodology. The current study determines its accuracy using computed tomography scan controls.**

Methods: **Fifty bilateral ultrasound-guided approaches to the lumbar facet nerves were performed in five embalmed cadavers. The target point was the groove at the cephalad margin of the transverse (or costal) process L1–L5 (medial branch T12–L4) adjacent to the superior articular process. Axial transverse computed tomography scans, with and without 1 ml contrast dye, followed to evaluate needle positions and spread of contrast medium.**

Results: **Forty-five of 50 needle tips were located at the exact target point. The remaining 5 were within 5 mm of the target. In 47 of 50 cases, the applied contrast dye reached the groove where the nerve is located, corresponding to a simulated block success rate of 94% (95% confidence interval, 84–98%). Seven of 50 cases showed paraforaminal spread, 5 of 50 showed epidural spread, and 2 of 50 showed intravascular spread. Despite the aberrant distribution, all of these approaches were successful, as indicated by contrast dye at the target point. Abnormal contrast spread was equally distributed among all lumbar levels. Contrast traces along the needle channels were frequently observed.**

Conclusions: **The computed tomography scans confirm that our ultrasound technique for lumbar facet nerve block is highly accurate for the target at all five lumbar transverse processes (medial branches T12–L4). Aberrant contrast medium spread is comparable to that of the classic fluoroscopy-guided method.**

STATE-OF-THE-ART lumbar facet nerve blocks ("medial branch blocks") to diagnose facet joint–mediated pain are performed under fluoroscopic guidance to ensure success and avoid complications.[1] Some physicians also use computed tomography (CT) scanning for guidance, when available. These techniques imply exposure to ionizing radiation for both the patient and the pain therapist and can only be performed in specially equipped pain clinics. These in turn are restricted by the availability of expensive and immobile imaging devices.

In an attempt to circumvent these difficulties, we developed an ultrasound-guided approach for lumbar facet nerve block and described its foundation in a sonoanatomical study.[2] Ultrasound proved to be a reliable and accurate instrument to visualize the lumbar paravertebral anatomy in cadavers, volunteers, and patients. The clinical feasibility of the new technique was demonstrated in a pilot case series with fluoroscopy control.

The success and validity of lumbar facet nerve blocks depends on an accurate technique because of the small volumes of local anesthetic that are applied to ensure specificity.[3] Inexact positioning of a needle may result in false-positive blocks because of inadvertent spread of local anesthetic[4] into the intervertebral foramen, the epidural space, or even the subarachnoid space, with possible complications such as spinal anesthesia.[5,6]

We tested the accuracy of our ultrasound-guided technique for lumbar facet nerve blocks with a CT imaging study in human cadavers with approaches at the transverse process of L1–L5, *i.e.*, to the medial branch of T12–L4.

Materials and Methods

The cadavers had been embalmed in a traditional manner and were in legal custody of the Institute of Anatomy, Histology and Embryology (Innsbruck, Austria). Institutional approval for the procedure was obtained. Seven days earlier, an independent examiner had selected five corpses (two male, three female; median age at death, 82 yr [range, 70.4–89.9 yr]; median height, 1.62 m [range, 1.55–1.72 m]). Three were of normal body type, and two were obese. We used a standard ultrasound device (Sonoline VersaPlus; Siemens Medical Solutions, Erlangen, Germany) with a 5-MHz curved array transducer (5C50+).

The cadavers were positioned prone without using pillows to compensate for lumbar lordosis, and the two examiners (M. G., L. K.), alternating sides, performed bilateral ultrasound-guided approaches to the medial branches T12–L4 at the transverse processes L1–L5, according to our previously described method[2] (fig. 1). An initial longitudinal paravertebral sonogram served to find the respective transverse processes and localize the lumbar levels. The sonographic image of the cephalad part of the sacrum was used as a landmark from which the lumbar transverse processes could be counted upward. Then the transducer was rotated into a transverse plane to delineate the transverse processes and the superior

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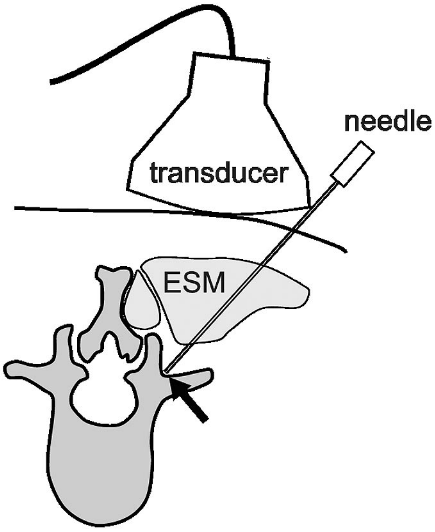

Fig. 1. Schematic drawing of the setting for ultrasound-guided lumbar facet nerve block: in-line technique with the needle guided in a transverse sonographic plane. ESM = erector spinae muscle.

articular processes of the adjacent facet joint. The bottom of the groove between the lateral surface of the superior articular process and the cephalad margin of the respective transverse process was defined as the target site. A needle (20 gauge, 0.9 × 70 mm; Terumo, Leuven, Belgium) was introduced with a freehand, in-line technique (fig. 2) using real-time ultrasound guidance and was directed to the described groove until bone contact was felt. The position of the needle tip in relation to the cephalad margin of the transverse process was verified on another longitudinal paravertebral sonogram and corrected if needed (fig. 3). The obtained sonograms were saved on the hard disk of the ultrasound device.

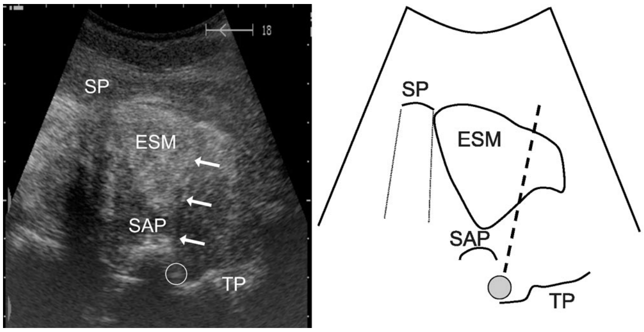

Fig. 2. (*Left*) Transverse paravertebral sonogram with a needle (*arrows*) placed at the target point on the transverse process L5 for an approach to the right-sided L4 medial branch. (*Right*) Corresponding schematic drawing showing the sonographic landmarks. *Circles* indicate targets. *Dotted line* indicates needle. ESM = erector spinae muscle; SAP = superior articular process; SP = spinous process; TP = transverse process.

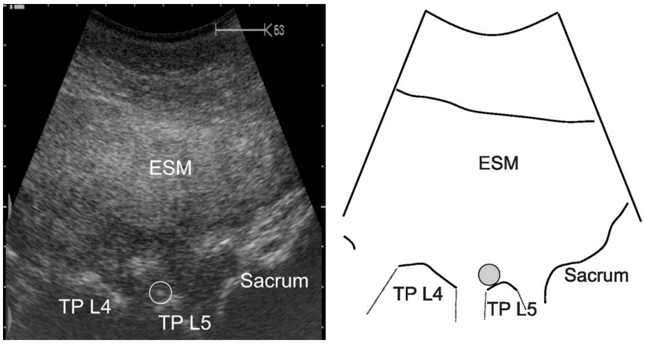

Fig. 3. (*Left*) Longitudinal paravertebral sonogram with the needle tip (*circle*) placed on the cranial end of the transverse process L5 for an approach to the right-sided L4 medial branch. (*Right*) Corresponding schematic drawing showing the sonographic landmarks. *Circles* indicate targets. ESM = erector spinae muscle; sacrum = curved echogenic reflex of the sacral bone; TP L4 = transverse process L4; TP L5 = transverse process L5.

After all needles had been positioned, 1-mm-slice axial transverse CT scans (Synergy; GE Medical Systems, Milwaukee, WI) were obtained to trace the inserted needles (fig. 4). Then, a 1-ml bolus of undiluted contrast dye (300 mg J/ml Jopamiro; Bracco, Milano, Italy) was injected slowly, over 3 s, through the needles at each level without controlling for the bevel orientation. CT scans were repeated immediately, *i.e.*, less than 1 min after the last injection (fig. 5). In one cadaver, we performed two sets of contrasted CT scans, one each after 0.5 and 1 ml dye per needle. A radiologist trained in image-guided interventions (P. K.) evaluated the CT scans. An approach was regarded as successful when the tip of the corresponding needle was placed at the defined target site. In case of a missed approach, the position and distance from the target site of each needle tip was recorded.

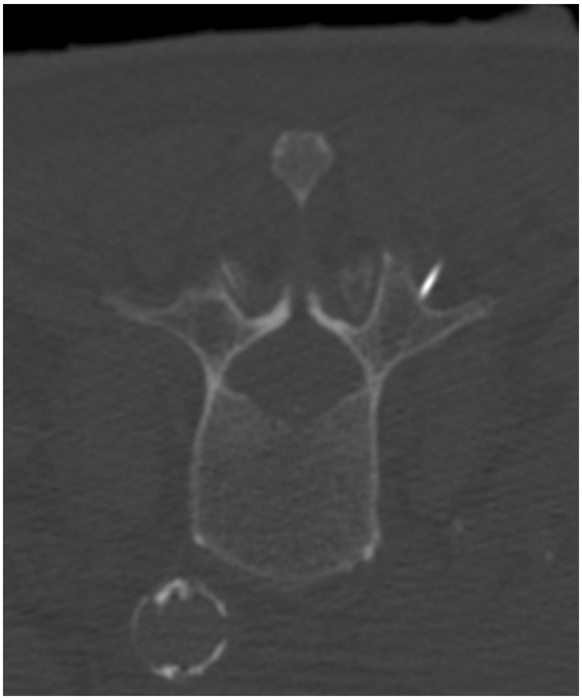

Fig. 4. Axial transverse computed tomography scan (1-mm slice) without contrast dye showing a needle tip at the target position for a right-sided L2 medial branch block.

Fig. 5. Axial transverse computed tomography scan (1-mm slice) with 1 ml contrast medium at both sides: typical localized spread reaching the location of the medial branch.

The distribution pattern and spread of the injected contrast dye was classified as (1) local distribution (distribution within the target site), (2) paraforaminal (spread of contrast dye around the intervertebral foramen, *i.e.*, any trace of contrast medium ventral to the transverse process), (3) epidural (spread of contrast dye into the epidural space, *i.e.*, any trace of contrast medium ventral to the ligamentum flavum), or (4) other pattern of spread.

Results

The examiners performed a total of 50 ultrasound-guided approaches to the medial branches T12–L4 at the transverse processes L1–L5 in five cadavers. For placement of every needle under ultrasound, not more than approximately 2–5 min was necessary.

The control scans revealed that in 45 of 50 approaches, the needle tips were successfully placed at the target site. In the remaining 5 cases, the needle tips were located on the lateral surface of the superior articular process four times (at L2, L3, L4) and once on the posterior surface of the transverse process (at L5). In these 5 cases, no needle tip was more than 5 mm away from the target site.

Forty-seven of 50 cases showed local distribution of contrast dye within the target site, which was considered indicative of a successful approach. Therefore, the simulated block success rate was 94% (95% confidence interval, 84–98%). In three cases, the contrast dye did not reach the target site because of an inaccurate needle position (at L2, L4, L5). Therefore, the simulated block failure rate was 6% (95% confidence interval, 2–16%). In the 47 cases with successful local distribution of contrast dye, additional paraforaminal spread was observed in 7 cases (at L1–L2, L2–L3, L3–L4, L4–L5), and epidural spread was observed in 5 cases (at L1, L2, L3, L4). In 4 of 5 cases of epidural spread, minute traces of contrast dye extended into the ventral space, whereas in the remaining case, distinct aberrant spread was limited to the dorsal epidural space. Three of 7 cases of paraforaminal spread and 1 of 5 cases of epidural spread occurred in the cadaver in which two 0.5-ml increments of contrast medium had been injected; they were seen only at a total volume of 1 ml and were absent at a volume of 0.5 ml.

In 2 of 50 approaches, we found intravascular contrast enhancement (ascending lumbar vein at L1, lumbar artery at L2). An intraarticular contrast enhancement within a facet joint was seen in one instance (at L4). In 2 of 50 cases, a deposit of contrast dye was found in the layer between the medial and lateral tracts of the erector spinae muscle. In addition, in 3 of 5 cadavers, distinct traces of contrast dye marked the needle channel, sometimes extending to the surface.

In all cases of paraforaminal, epidural, or other aberrant spread, contrast dye always in addition reached the target site. Abnormal contrast spread did not occur more frequently at any specific level. No differences in accuracy of needle placement or aberrant spread were observed in the three cadavers with normal body habitus *versus* the two that were obese.

Discussion

With this study, we successfully demonstrated that our ultrasound-guided methodology for lumbar facet nerve blocks can be performed with high accuracy, as verified by 1-mm-slice control CT scans. Assuming that contrast dye distribution around the medial branch is a valid surrogate marker for a successfully accomplished block, the simulated block success rate of our technique was 94%. Forty-five of 50 needle tips were situated exactly in the position currently recommended by the guidelines for the performance of lumbar medial branch blocks.[1] This corresponds to the spot "high on the eye of the Scotty dog," an artificial shape that can be distinguished on the oblique radiograph and which we likewise rendered visible in a three-dimensional reconstruction of our CT data. Using the conventional CT scans and the three-dimensional image, we were able to depict the needle tips in relation to the adjacent structures (fig. 6) and confirm the precision and efficacy of our ultrasound-guided freehand, in-line technique. The fact that this target point is a tiny one underscores the accuracy of our technique.

Fig. 6. Three-dimensionally rendered computed tomography scan reconstruction of the lumbar spine and the cephalad parts of the sacrum and the ilium, seen from an oblique, right-lateral view showing six needles (*dark colored*), placed with ultrasound guidance alone: upper five needles in correct position for a right-sided T12–L4 medial branch block at the transverse processes L1–L5; lowest needle in correct position for an L5 dorsal ramus block on the uppermost part of the dorsal surface of the sacrum. L1–L5 = spinous process of the respective lumbar vertebra; *white-lined shape* = "Scotty dog" image (looking to the right): ear = superior articular process; nose = transverse process; forefoot = inferior articular process; needle position = "high on the eye of the Scotty dog."

Lumbar facet nerve blocks are frequent interventions in pain management today.[7] The facet nerve is, more precisely, the medial branch of the dorsal ramus of the spinal nerve. As opposed to therapeutic regional anesthetic techniques, lumbar facet nerve blocks are necessary to confirm the diagnosis of facet joint–mediated pain[8] because physical or radiologic examination of patients with low back pain alone is insufficient.[9–12] Pain relief lasting several hours after the block procedure is considered highly indicative for facet joint–mediated pain,[3] although a block series sometimes including a saline injection as placebo control is advocated by many authors to increase specificity and decrease the rate of false-positive responses associated with single blocks.[7] According to the guidelines,[1] at least double blocks should precede denervating procedures such as radiofrequency neurotomy to ensure optimal outcome.[13]

This specificity can only be achieved with very small volumes of local anesthetics, typically 0.5–1 ml,[1,14] because uncontrolled spread of large volumes to adjacent structures can cause additional unwanted effects such as nerve root blocks. Recent studies and guidelines even suggest not to use more then 0.5 ml.[1] However, the smaller the volume of local anesthetic is, the more precisely the needle has to reach the target site. The current study used the method of CT scan imaging to determine whether our ultrasound-guided technique is capable of a similar level of precision.

For this purpose, we needed a precise definition of the target site. We knew from previous anatomical work that the lumbar dorsal ramus divides into medial, lateral, and intermediate branches approximately 5 mm from its point of origin.[15] The medial branch lies in a groove at the base of the superior articular process, where it crosses the transverse process in a posterior and inferior direction. In theory, the medial branch can be blocked anywhere on its way from the cephalad border of the transverse process to its caudad rim medial to the accessory process. We defined the target site as the bottom of the groove between the lateral surface of the superior articular process and the cephalad margin of the adjacent transverse process, because this is the most frequently used approach with a clear anatomical definition.[1] This point corresponds to the above-mentioned position "high on the eye of the Scotty dog" in a standard oblique lateral view in fluoroscopy.

However, Dreyfuss *et al.*[4] could show that this high position was correlated with more aberrant flow of contrast medium extending to the epidural space or intervertebral foramina compared with a slightly more caudal position on the transverse process. In his excellent CT study evaluating the face validity of fluoroscopy-guided lumbar medial branch and L5 dorsal ramus blocks *in vivo*, distal spread of contrast media into the posterior back muscles was recorded in all 120 cases. Aberrant spread toward neural structures other than the target nerve (foraminal, epidural) occurred in 16% but only with tiny fractions of the total volume and with no clinical relevance. Injection speed did not influence aberrant contrast medium distribution, but there was an apparent 8% rate of intravenous injections, entirely clearing the local anesthetic from the target area, which would presumably lead to false-negative results. As a consequence, application of contrast medium under fluoroscopy is advocated before the injection of local anesthetic to avoid this problem.

The contrast medium distribution pattern of our ultrasound-guided approaches were similar to those described above, despite being the results of a cadaver study. The somewhat higher rate of paraforaminal and epidural spread might be explained by the larger volume of contrast medium (1 ml *vs.* 0.5 ml in the study of Dreyfuss *et al.*[4]) and the different needle orientation (lateromedial *vs.* lateromedial and craniocaudal in the latter study[4]). This is supported by the fact that in the cadaver with 0.5 ml contrast dye, CT scans showed no evidence of aberrant spread, whereas after adding another 0.5 ml, the 10 approaches showed three paraforaminal traces and one epidural contrast trace. We used 1 ml here because, with this volume, we have performed our ultrasound-guided lumbar facet nerve blocks at the beginning to get a little "reserve" for visualizing the spread. Currently, we do not apply more than 0.5 ml for the block.

In the current study, four of five cases of epidural spread extended to the ventral epidural space. This is important to differentiate because ventral epidural spread is assumed to more likely result in false-positive blocks than dorsal epidural spread, especially with discopathies present. However, comparable with the data of Dreyfuss *et al.*,[4] only tiny fractions of the total volume reached the epidural space, so the clinical significance is questionable.

The consistency of cadaver tissue might also affect the dye patterns in this study because epidural spread occurred after bone perforation in one approach and traces of contrast media appeared in more than half of the needle channels. This suggests that the cadaver tissue is rather noncompliant and that more substantial tissue spread occurs in live subjects. To some extent, the altered tissue compliance also changes the feel of placing a needle. Moreover, the rate of intravascular injections (only 2 of 50) seems to be lower *post mortem* because of the lack of blood flow than it would be expected *in vivo*.[4] All of these limitations apply when comparing findings seen in embalmed cadavers to living patients.

However, the charted precision of our ultrasound-guided intervention validates the clinical relevance of this cadaver model all the more because of the fact that ultrasound image quality is worse in corpses than in vital tissue. Other successful ultrasound trials on cadaver models have recently been described: Paravertebral sonography for psoas compartment approach was confirmed by CT scan control,[16,17] and facet joint blocks in an animal study were validated by anatomical dissections.[18] Another study examined a robot-assisted fluoroscopy-guided needle driver for facet joint blocks in cadavers,[19] and our freehand technique was only marginally less precise.

Our data relate only to lumbar facet nerve blocks at the transverse processes L1–L5 (medial branch T12–L4), for which we uniformly used our validated ultrasound methodology.[2] We did not evaluate the accuracy of an ultrasound-guided L5 dorsal ramus block, although we successfully attempted several of these for training purposes in cadavers (fig. 6). The methodology for this approach differs from the above, is not yet validated, and seems to be more tricky because of ultrasound image artifacts caused by the iliac bone. Nonetheless, L5 dorsal ramus blocks are particularly relevant because the L5–S1 facet joint is frequently affected. It would therefore be important to show the same accuracy for ultrasound-guided L5 dorsal ramus blocks to broaden the spectrum of applications, which is currently confined to T12–L4 medial branch blocks.

Another possible limitation of the ultrasound technique is inadvertent vascular drainage of local anesthetic that may cause false-negative blocks as described with the conventional noncontrasted technique. Local spread of injected volume, however, even when such small quantities are used, is visible in real-time ultrasound. Moreover, Doppler ultrasound could be applied to identify blood flow and to avoid vascular puncture. Whether it would be possible to thus detect and avoid vascular drainage remains unclear.

The clinical advantages and disadvantages of ultrasound over the standard fluoroscopic technique may probably only be fully addressed in future studies that in addition evaluate patient and performer acceptance as well as outcomes of final treatment. Considering all these factors will help to choose the right guidance technique for the right patient. However, certain clear advantages of the ultrasound technique are evident now. Although exposure to ionizing radiation during properly performed fluoroscopy-guided lumbar facet nerve blocks may be low for a single case, it sums up when performed repetitively and can be completely avoided with our methodology. During pregnancy, fluoroscopy is contraindicated, whereas ultrasound can be used without a problem. Ultrasound is moderately priced and portable, and its application seems especially attractive for bedside use or for environments such as in underdeveloped countries.

In conclusion, this imaging study demonstrates that using a regular needle with ultrasound as a sole guide, lumbar facet nerve blocks can be simulated with a high degree of accuracy, as validated by CT scans. Ultrasound therefore allows the necessary accuracy and specificity for a valid diagnostic block and the avoidance of needle malpositioning, although *in vivo* confirmation of our data in a larger set of patients with facet joint mediated pain is lacking. However, the high precision of our new methodology indicates notable clinical relevance. Therefore, ultrasound could become an attractive alternative to fluoroscopy or CT scanning, helping to increase the practicability of lumbar facet nerve blocks while eliminating the exposure of both patients and therapists to ionizing radiation.

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