Sonographically Guided Lumbar Spine Procedures

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Recently, there has been considerable interest in the use of sonography for lumbosacral regional anesthesia and chronic pain management procedures. For regional anesthesia procedures involving the lumbosacral spine, landmarked-based techniques have predominantly been used. In chronic pain management, traditional visualization techniques for spine procedures include fluoroscopy and computed tomography (CT). With fluoroscopically guided procedures, the initial extrapolation of the position of soft tissues (ie, muscles, blood vessels, and nerves) is based on their anatomic relationship to viewed bony structures. The interest in the use of sonography for chronic pain management procedures has grown from certain visualization advantages, including the ability to see bone, muscle layers, nerves, and blood vessels (Table 1). Sonography allows for the elimination or reduction of radiation exposure for the patient, fetus, and physician. In addition, real-time needle advancement can be visualized with sonography. Limitations to current sonographic technology exist when using it as a visualization technique for axial spine procedures, including narrow image windows, procedural targets at greater depths, and acoustic shadow artifacts, which result in the inability to view structures or detect intravascular injections deep to bony obstruction.

This article will first provide an overview of the lumbosacral spine sonoanatomy. A detailed understanding of anatomy is critical for interpretation of sonograms and procedural performance. Next, the applicability of this lumbosacral spine sonoanatomy will be described for specific regional anesthesia and chronic pain management procedures. The discussion will be focused on the role of sonography for preprocedural scanning for entering the spinal canal (intrathecal and epidural space) and lumbar facet joint interventions.

Lumbosacral Spine Sonoanatomy

A low-frequency curved array transducer (2–6 MHz) is used to visualize the lumbosacral spine. The depth of the neuraxial structures in the adult lumbar spine is in the range of 5 to 7 cm. The use of a linear transducer is not recommended because of its limited field of view and inadequate depth of penetration. Bony structures that
can be visualized with sonography include the spinous processes, transverse processes, laminae, articular processes, facet joints, and posterior border of the vertebral body. Soft tissue structures that can be visualized include the lumbar nerve roots, paraspinal muscles, ligamentum flavum, and posterior dura. In certain cases, it is not always possible to distinguish the ligamentum flavum from the posterior dura (eg, ligamentum flavum/posterior dura complex).

We propose 7 basic sonographic views (Table 2) to visualize the lumbar spine. First the parasagittal views of the lumbar spine are obtained. When obtaining the parasagittal views, the probe can either start at the anatomic midline and be moved laterally (Video 1) or start laterally at the position of the transverse processes and be moved medially toward the spinous processes. Below, the views will be explained as the ultrasound probe starts laterally at the level of the transverse processes and moves medially until reaching the level of the spinous processes.

For the parasagittal transverse process view (Figures 1 and 2), the probe is placed approximately 3 to 4 cm lateral to the midline lumbar spinous processes and slightly cephalad to the sacrum. The transverse processes are visible as hyperechoic curvilinear structures. The erector spinae muscle group is superficial to the transverse processes, and the psoas muscle is deep and in between the transverse processes. The sonographic view of the transverse processes has been described as the “trident sign.” When the probe is moved medially in the parasagittal plane, the next view obtained is the parasagittal interlaminar view (Figure 3). Three main transverse views (Video 2) are used to identify the lumbar spine sonoanatomy. For all of these views, the probe is rotated 90° into a transverse orientation, which is centered on the neuraxial midline. In the parasagittal view, the erector spinae muscle is seen superficial to the continuous hyperechoic line. The final parasagittal view is the parasagittal oblique view (Figure 4). This view is obtained when the probe is tilted to angle the beam in a medial direction toward the median sagittal plane. A “sawtooth” hyperechoic line is visualized, which represents the laminae. The dimensions of the spinal canal are visible. In this view, the ligamentum flavum and posterior dura may be seen as separate hyperechoic structures or as a ligamentum flavum/posterior dura complex. It has been suggested that the posterior dura may be easier to visualize.7

As the probe is moved toward the anatomic midline, the midline sagittal spinous process view is obtained (Figure 5). Three main transverse views (Video 2) are used to identify the lumbar spine sonoanatomy. For all of these views, the probe is rotated 90° into a transverse orientation, which is centered on the neuraxial midline. In the
transverse spinous process view (Figure 6), the spinous process and laminae are visible. Structures beneath the spinous process and laminae are obstructed by an acoustic shadow artifact generated by the bony structures. Once the transverse spinous process view is obtained the probe is moved in either the cephalad or caudad direction to obtain a transverse interlaminar view (Figure 7). Because the acoustic shadow artifact does not occur at this level from the spinous process, one is able to see the contents of the vertebral canal.

When observing the transverse process views, the junctions between the spinous process, the superior articular process, and the transverse process can be seen (Figure 8). The transverse views are used for the in-plane lumbar medial branch block approach. In addition, the entry site into the lumbar facet joint is often visible (Figure 9). A third transverse view (Figure 10), the transverse oblique foraminal view, is helpful in viewing the neuroforamen and lumbar paraspinal sonoanatomy. To obtain the transverse oblique foraminal view, the probe is moved in a transverse plane.

Figure 2. Parasagittal transverse process view. The transverse processes have the appearance of a “trident sign.” The white dots mark the cranial portion of the transverse processes. ESM indicates erector spinae muscle; P, psoas muscle; and T, transverse process.

Figure 3. Parasagittal articular process view. AP indicates articular process; and ESM, erector spinae muscle.

Figure 4. Parasagittal oblique view. L indicates lamina; LF/PD, ligamentum flavum/posterior dura; S, sacrum; and VB/PLL, vertebral body/posterior longitudinal ligament.

Figure 5. Midline sagittal spinous process view. L3 indicates spinous process of the L3 vertebral body; L4, spinous process of the L4 vertebral body; L5, spinous process of the L5 vertebral body; and S, sacrum.

Figure 6. Transverse spinous process view. L indicates lamina; and S, spinous process.
off the midline to the paraspinal space at the level of the neuroforamen. Then the transducer is tilted medially, with gentle pressure added, toward the vertebral body.

**Sonographically Guided Lumbar Spine Interventional Techniques**

**Sonographically Assisted Lumbar Spine Procedures for Entering the Spinal Canal**

Although real-time sonographically guided neuraxial procedures for entering the spinal canal (epidural and intrathecal placement) have been described,7–12 most of the literature focuses on non–real-time sonographically assisted neuraxial procedures. The most advantageous technique for real-time sonographically guided neuraxial procedures is still being optimized and developed.4 To date, most clinical studies on the use of sonography for neuraxial blocks in regional anesthesia describe the use of sonography for preprocedural establishment of important landmarks.3,4 Preprocedural sonography is used to identify and mark the target interspace and anatomic midline. In addition, sonography allows for estimation of both the depth to the epidural and intrathecal spaces and the angle of needle insertion, which enhance the performance of spinal and epidural needle insertion. The use of sonography for preprocedural scanning before performing lumbar central neuraxial blocks in the lumbar spine has been shown to improve technical and clinical outcomes.3,9,13–15 Table 3 lists the clinical advantages of using preprocedural sonography in comparison to the palpation-guided technique for entering the epidural and intrathecal spaces for anesthesia and analgesia. Although advantages have been documented for the use of sonography in neuraxial procedures, its rate of incorporation into clinical practice has been slow.23

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**Figure 7.** Transverse interlaminar view of the lumbar spine at the L4–L5 level. AP indicates articular pillar; LF/PD, ligamentum flavum/posterior dura complex; S, shadow of the spinous process; SC, spinal canal; and V, vertebral body.

**Figure 8.** Needle (arrowheads) being placed at the target point for a lumbar medial branch block. S indicates spinous process; SA, superior articular process; and T, transverse process.

**Figure 9.** Lumbar facet joint. The arrow indicates the entry zone (hyperechoic space) into the lumbar facet joint between the medial aspect of the inferior articular process and the lateral aspect of the superior articular process. This space does not represent the entire joint but rather the posterior entrance point into the joint. S indicates spinous process; SAP, superior articular process; and T, transverse process.

**Figure 10.** Transverse oblique foraminal view. ESM indicates erector spinae muscle; N, lumbar nerve root; PS, psoas muscle; and Q, quadratus lumborum.
In addition to the field of anesthesiology, sonography has also been used in other medical fields such as emergency medicine to assist in identifying pertinent landmarks for lumbar puncture. Ferre and Sweeney showed that emergency department physicians were able to obtain high-quality lumbar spine sonograms in 88% of 76 scanned patients with a mean body mass index (BMI) ± SD of 31.4 ± 9.8 kg/m² after the completion of a brief training session consisting of a review of previously published lumbar spine images and 10 practice scans.

Once the basic sonoanatomy of the lumbosacral spine is identified as described in the “Lumbosacral Spine Sonoanatomy” section above, the respective levels can be labeled on the basis of the parasagittal oblique view starting at the sacrum (Figure 4). After labeling of the levels in the parasagittal oblique view, confirmation can occur with the transverse spinous process view. In the transverse spinous process view, the transducer is centered on the neuraxial midline with the probe initially in a caudad position over the sacrum. The transducer is slowly moved cephalad to identify the S1 median crest (Figure 11). Once the S1 median crest of the sacrum is identified, the probe is then moved in the cephalad direction, and the lumbar spinous processes are counted. The lumbar levels identified in the parasagittal views should correspond to the lumbar levels identified in the transverse spinous process views. In addition to identification of the appropriate interlaminar level, the optimal target site, normal sonoanatomy, abnormal sonoanatomy, and depth of the epidural and intrathecal spaces can be identified. The ultrasound machine’s built-in calipers are used to measure the distances to the epidural and intrathecal spaces.

### Limitations of Interventional Epidural and Intrathecal Pain Management Procedures

Although sonographically assisted neuraxial blocks are more advantageous than the traditional blind surface landmark approach that is used in regional and obstetric anesthesia, at this time, the sole use of sonography to guide these blocks for interventional chronic pain management cannot be recommended. The inability to detect intravascular injection and the spread of the injectate because of bony artifacts substantially limits the use of sonography for neuraxial procedures (interlaminar epidural and intrathecal blocks) in chronic pain management.

### Sonographically Guided Lumbar Medial Branch Blocks and Intra-articular Facet Joint Injections

#### Background

Zygapophysial (facet) joint–mediated pain has been identified as a source of chronic low back pain. The lumbar facet joints are the cause of low back pain in 15% to 45% of cases depending on the age of the studied population. Lumbar medial branch blocks and facet joint injections are used for both diagnostic and therapeutic purposes. Sonographically guided approaches have been developed for lumbar medial branch blocks and intra-articular facet joint injections. To visualize the appropriate structures for lumbar medial branch blocks and intra-articular facet joint injections, it is important to have an understanding of the lumbar spine sonoanatomy presented above.

Multiple cadaver and clinical studies have evaluated sonographically guided lumbar medial branch blocks (Table 4). In the 3 studies with clinical series, needles were appropriately placed at the targeted level in 62% to 95% of cases. The study by Rauch et al examining sonographically guided lumbar medial branch blocks in obese
patients (BMI > 30 kg/m²) was, as expected, associated with the lowest accuracy rate of 62%.

On the other hand, only a few studies have evaluated sonographically guided intra-articular facet injections. First, Galiano et al.³¹ compared sonographically guided to CT-guided intra-articular lumbar facet joint injections in a cadaver model and later in a prospective randomized clinical trial.³² A total of 40 patients were enrolled in the randomized clinical trial. Sixteen of the 20 patients randomized to the sonography group were deemed to have clearly visualized sonoanatomic landmarks. In these 16 patients, the accuracy of needle placement was 100%. Two of the 20 patients randomized to the sonography group were not deemed candidates for the sonographically guided technique secondary to the inability to clearly visualize the lumbar facet joints. These 2 individuals had BMIs of 28.3 and 32.9 kg/m². The procedure was faster with sonography and occurred with less radiation in comparison to CT-guided injections.³²

The sonographically guided intra-articular facet injection approach was also compared to the most commonly used fluoroscopically guided approach in a retrospective study.³³ In both groups, the intra-articular injections improved pain control, and there were no significant differences in the incidence of complications between the two guidance methods. Furthermore, in both groups, the procedure times were comparable between the fluoroscopy (4 minutes 7 seconds) and sonography (4 minutes 25 seconds) groups.

Limitations also exist for sonographically guided lumbar medial branch blocks and intra-articular facet joint injections when compared to fluoroscopically based techniques. These limitations include the following: (1) the inability to correctly visualize the target in obese individuals; (2) challenges in detecting intravascular injections at such a depth; (3) the possible need for a larger-gauge needle to improve visibility; and (4) the inability to confirm intra-articular placement with radiographic contrast.

### Technique for Lumbar Medial Branch Blocks and Intra-articular Facet Joint Injections

The patient is placed in the prone position with a pillow under the abdomen to reduce lumbar lordosis. A systematic approach using the lumbar sonographic views described above is used to identify key anatomic structures. The sacrum is identified, and then each respective lumbar level is labeled in both the parasagittal and transverse views. Once the appropriate level of the lumbar spine is identified in the parasagittal views, the level to be anesthetized is centered. The probe is then rotated 90° to the transverse (cross-axis) view. In the transverse view, the step-off between the superior articular process and the transverse process is visualized. Under real-time sonographic guidance with an in-plane approach, a 22-gauge spinal needle is inserted from lateral to medial (Figure 8 and Video 3). The insertion angle is approximately 45° to 60° to the skin. The needle is directed down to the junction between the superior articular process and the superior border of the transverse process. Once bony contact is reached, the transducer is rotated back to the parasagittal transverse process view to confirm that the needle tip is at the cranial edge of the transverse process (Figure 2 and Video 4). The location of the needle tip in the parasagittal transverse process view may not be possible in all cases, especially in

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**Table 4. Summary of Cadaver and Clinical Studies Evaluating Sonographically Guided Lumbar Medial Branch Blocks**

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<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Results</th>
<th>Comments</th>
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<tr>
<td>Greher et al²⁷</td>
<td>3-part study of lumbar medial branch blocks: cadaver, volunteer, clinical case series</td>
<td>Clinical case series: 25/28 needles placed correctly (89% accuracy rate)</td>
<td>L2-L4 medial branches targeted; L5 dorsal ramus block not evaluated; median BMI 23 kg/m²</td>
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<tr>
<td>Rauch et al²⁸</td>
<td>Clinical series of lumbar medial branch blocks in 20 obese patients</td>
<td>52/84 needles placed correctly (62% accuracy rate)</td>
<td>L3 and L4 medial branches and L5 dorsal ramus targeted; BMI &gt; 30 kg/m²; L5 dorsal ramus success rate only 44%</td>
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<tr>
<td>Shim et al²⁹</td>
<td>Clinical series of lumbar medial branch blocks in 20 patients</td>
<td>96/100 needles placed correctly (95% accuracy rate)</td>
<td>T12-L4 medial branches targeted; L5 dorsal ramus block not evaluated; median BMI 22.8 ± 3.1 kg/m²</td>
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<tr>
<td>Greher et al³⁰</td>
<td>Lumbar medial branch blocks in cadavers: needle placement confirmed with postprocedure CT, 1 mL of radiographic contrast agent injected to follow dye spread</td>
<td>45/50 needles placed correctly (90% accuracy rate); 14% of cases had pararotundal spread</td>
<td>T12-L4 medial branches targeted; L5 dorsal ramus block not evaluated</td>
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obese patients. In those cases in which the needle tip cannot be verified in the parasagittal transverse process view, appropriate cephalad placement can be confirmed by walking the needle up and down the transverse process on the transverse in-plane view. A local anesthetic is then injected to anesthetize the targeted medial branch.

When performing a sonographically guided lumbar intra-articular facet joint injection, the above scanning technique is used to identify the target level. Once the target level is identified, adjustments are made with the transducer alignment to identify the entrance to the facet joint between the inferior and superior articular processes (Figure 9). The target point is the middle portion of the joint. A 22-gauge needle is advanced from lateral to medial with an in-plane technique. In patients with substantial degenerative changes, accessing the joint can be challenging.

Conclusions

Sonographic guidance for lumbosacral regional anesthesia and chronic pain management procedures is rapidly evolving. An in-depth understanding of anatomy is important to enable correct identification of sonographically visualized structures. When compared to palpation-guided techniques, sonographically assisted procedures have been shown to improve clinical outcomes. When used for chronic pain management lumbar spine procedures, sonography has certain visualization advantages and limitations compared to fluoroscopy. Great strides have been made in the advancement of sonography as a primary visualization technique for specific lumbosacral spine procedures. Further advancements in sonographically guided scanning techniques and equipment development are needed to overcome some of the current sonographic visualization limitations for lumbosacral procedures. In addition, future studies are needed to evaluate the safety and efficacy of sonographically guided techniques for lumbosacral procedures.

References


