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PICTORIAL REVIEW

Assessment of the spine with CT and MRI prior to interspinous/interlaminar spinal procedures: a pictorial review

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ABSTRACT

Imaging of the spine is increasingly available, whether as dedicated spine examinations or as studies that include the spine in the images obtained (e.g. CT abdomen). This pictorial review discusses imaging of the spine with CT and MRI and how prior review of this imaging can be helpful with potentially difficult spinal procedures. Pathologies illustrated include osteoarthritis, scoliosis, inflammatory spondyloarthropathies and post-operative spines.

Many spinal procedures are performed using the interspinous (midline) or interlaminar (paramedian) approach with high success rates. These procedures include myelograms for diagnosis, epidural corticosteroid injections for pain relief, central neuraxial blocks in regional anaesthesia and lumbar punctures for cerebrospinal fluid (CSF) analysis. The causes for difficult spinal procedures are wide in range and include pathological/anatomical conditions of the spine. As with all

imaging as a whole, spinal imaging is increasingly more available with each individual patient [1], and review of such imaging can be helpful for difficult procedures.

This pictorial review will discuss imaging (CT, MRI) of spinal conditions that can contribute to difficult spinal procedures, in particular osteoarthritis, scoliosis and the inflammatory spondyloarthropathies. The illustrations will focus on the

interspinous/interlaminar approach for the thoracolumbar spine, but the principles provided can be used for other approaches.

IMAGING MODALITIES

CT is excellent at depicting osseous anatomy and pathology. In particular, three-dimensional (3D) volume-rendered reconstructions can be obtained from available CT data previously performed to assess extraspinal structures (*e.g.* CT chest, abdomen, pelvis). The data can be reconstructed to show the skeleton alone, the soft tissues alone or both. In addition, the reconstructions can be rotated in any plane to assess the capaciousness of the interspinous/interlaminar spaces.

MRI is best for assessing the soft tissues. The posterior epidural space is mainly composed of fat and is usually best seen on T_1 weighted images, where the bright fat contrasts with the dark CSF fluid.

OSTEOARTHRITIS

The degenerate spine has multiple presentations [2]. What is likely to be of most importance for the interspinous/interlaminar approach includes supraspinal ossification, interspinous osteoarthritis and facet joint osteoarthritis. Supraspinal ossification can be diffuse or focal (Figure 1). Interspinous osteoarthritis (Figure 2) can present as narrowing of the interspinous spaces or as interspinous calcification

Figure 1. Supraspinal ossification (arrows) of the lumbar spine. (a) Axial CT at the L1/L2 interspinous space. (b) Corresponding sagittal thick-slab CT. Incidental L1 vertebroplasty. (c) Corresponding three-dimensional (3D) CT viewed from the posterior left. (d) Sagittal CT with focal supraspinal ossification at L5/S1. (e) Corresponding 3D CT viewed from the posterior. A paramedian approach is preferable to midline at the L5/S1 level.

Figure 2. Interspinous osteoarthritis of the lumbar spine. (a) Sagittal CT with narrowing of the interspinous spaces (arrows). (b) Corresponding MRI (T_2 weighted with fat suppression) with high signal intensity oedema/fluid in the interspinous spaces (arrows). (c) Corresponding three-dimensional (3D) CT demonstrating narrowing of the interspinous spaces (arrows). A paramedian approach is preferable to midline. (d) Sagittal MRI (T_2 weighted with fat suppression) with a posterior epidural cyst (arrow). (e) Sagittal CT with L3/L4 interspinous calcification (arrow). (f) Corresponding 3D CT demonstrating L3/L4 calcification (arrow). A paramedian approach is preferable to midline.

without narrowing. Both supraspinal ossification and interspinous osteoarthritis hinder midline approaches. Posterior epidural cysts [3] not only impede needle access at the adjacent interspinous/interlaminar space but can also potentially disrupt flow mechanics in the posterior epidural space from epidural injections at nearby levels. Facet joint osteoarthritis (Figure 3) can impede paramedian needle access, either by osteophytosis or from an adjacent facet joint cyst.

SCOLIOSIS

Scoliosis (Figure 4) is a complicated deformity characterised by lateral curvature and vertebral rotation [4]. The distance from skin surface to epidural space can be measured on the CT image and is greater on the

concave side. 3D CT is better at demonstrating the interspinous/interlaminar spaces, and our personal observation is that the interlaminar space is more capacious at the convex side (this needs to be confirmed with dedicated studies). MRI studies of adolescent idiopathic scoliosis have also shown that the cord is deviated to the concave side with widening of the epidural space on the convex side [5]. These radiological findings would suggest that the convex side should be preferred to the concave for epidural injections. However, this hypothesis needs to be validated with clinical studies. For example, needle insertion on the concave side may be physically easier in some scoliotic patients owing to a “flatter” skin surface.

Figure 3. Facet joint osteoarthritis of the lumbar spine. (a) Axial CT with severe osteoarthritis (F) of the right L2/L3 facet joint. (b) Corresponding MRI (T_2 weighted) demonstrating right L2/L3 facet joint osteoarthritis (F) with resultant compression of the right thecal sac. (c) Corresponding three-dimensional (3D) CT viewed from the posterior right. The right L2/L3 interlaminar space is obstructed by the facet joint osteoarthritis (F) in comparison with the right L3/L4 interlaminar space (L3/L4 IS). (d) Axial MRI (T_2 weighted) demonstrating a facet joint cyst (arrow) potentially obstructing a left paramedian approach.

Figure 4. Scoliosis. (a) Axial CT demonstrating vertebral rotation (arrows). The vertebral body is directed towards the convex side and the spinous process is directed towards the concave side. The rib at the convex side is directed posteriorly while the rib at the concave side is directed anteriorly. (b) Three-dimensional CT of the lumbar spine viewed from the posterior.

Figure 5. Inflammatory spondyloarthropathy of the lumbar spine. (a) Three-dimensional CT of ankylosing spondylitis viewed from the posterior right. The L5/S1 interlaminar space (arrow) is patent but the cranial interspinous and interlaminar spaces are occluded by extensive bone bridging. (b) Corresponding axial CT confirming the patent L5/S1 interspinous/interlaminar space. (c) Corresponding axial CT with extensive bone bridging occluding the L3/L4 interspinous/interlaminar space. (d) Sagittal MRI (T_1 weighted with intravenous gadolinium) of psoriatic arthritis with intense enhancement (I) of the interspinous and supraspinal ligaments in keeping with the active inflammation.

INFLAMMATORY SPONDYLOARTHROPATHIES

These are chronic inflammatory rheumatic diseases that predominantly affect the axial skeleton and include ankylosing spondylitis, reactive arthritis and psoriatic arthritis (Figure 5). CT and MRI are more sensitive than plain radiographs for assessing involvement of the spine [6]. 3D CT is best for demonstrating the interspinous/interlaminar spaces, whereas MRI is best for demonstrating soft tissue inflammation.

OTHER CONDITIONS

The post-operative spine (particularly with posterior spinal instrumentation or heterotopic ossification) can provide obstruction to needle access (Figure 6). In general, 3D CT minimises metal-related artefacts associated with metal hardware [7].

Myositis ossificans (Figure 7a,b) is benign soft tissue ossification that occurs after trauma [8]. Needle access can be hindered when the ossification is extensive.

Epidural lipomatosis is an excess of epidural fat (Figure 7c,d) and has been linked to failure of analgesia [9]. This case report detailed a patient who had an elective small bowel resection with an L1/L2 epidural catheter for post-operative analgesia. The patient had persistent failure of analgesia above the T10 level, and a subsequent MRI demonstrated thoracic epidural lipomatosis.

DISCUSSION

More and more imaging is being performed as various medical subspecialties find clinical value in the high-quality images that can be obtained from modern

Figure 6. (a) Axial CT and (b) three-dimensional (3D) CT of the lumbar spine after laminectomy and posterior spinal instrumentation. Residual bone (Bn)/heterotopic ossification potentially obstructs needle access at some levels. (c) Axial CT of the lumbar spine after surgery for scoliosis. Posterior spinal metal rods and heterotopic ossification (arrow) are present. (d) Corresponding 3D CT viewed from the posterior right. The right L5/S1 interlaminar space (arrow) is patent, but the cranial interspinous and interlaminar spaces are occluded by metal instrumentation and heterotopic ossification.

Figure 7. (a) Axial CT demonstrating profuse myositis ossificans potentially obstructing a left paramedian approach. (b) Corresponding three-dimensional CT viewed from the posterior left. The left L5/S1 interlaminar space is potentially obstructed with a left paramedian approach. (c and d) Sagittal MRI (T_1 weighted) of the thoracic spine demonstrating the posterior epidural space. (c) Thoracic epidural lipomatosis. (d) Normal thoracic spine for comparison. MO, myositis ossificans; ES, epidural space.

imaging machines. Although this is a topic of debate regarding ionising radiation (with CT) and resource spending [1,10], this is also a growing source of information that can be drawn upon prior to performing spinal procedures.

In our opinion, 3D CT is the most ideal imaging modality to review prior to interspinous/interlaminar spinal procedures. The ability to rotate reconstructions in any plane allows optimal assessment of the interspinous/interlaminar spaces and potential osseous obstruction to needle access. MRI can also provide additional useful information, if available.

It should be noted that both CT and MRI are usually performed in the supine position, and as such, the images obtained may not be fully representative of the *in vivo* situation. This is one area where the role of ultrasound should be explored. Ultrasound can be performed in the *in vivo* situation [11] to confirm prior imaging findings, in addition to its known role in guiding needle access.

In conclusion, imaging is becoming increasingly available to each patient. Reviewing this imaging prior to performing spinal procedures can forewarn of potential difficulties and assist in selecting an appropriate site and approach.

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