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Case Report

Dural Puncture and Subdural Injection: A Complication of Lumbar Transforaminal Epidural Injections

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Case Report: Two cases are presented in which the complication of dural puncture is documented in the context of a lumbar transforaminal epidural steroid injection. The hazard of dural puncture during transforaminal epidural injections, the anatomy of the dural and thecal sac, the potential for subdural injections, and relevant literature are reviewed.

Design: Report of two cases.

Background: Lumbar transforaminal epidural steroid injections are a commonly employed procedure for the treatment of lumbar radiculopathy. The optimal target point lies at the "6 o' clock" position of the pedicle. Contrast is injected to confirm proper placement of the needle and correct flow of the medication through the epidural space. Despite apparent proper placement of the needle, a potential complication exists of puncturing the dura while performing this procedure. Spinal injectionists should recognize the subsequent contrast patterns associated with this complication.

Conclusion: Subdural and intrathecal spread of contrast is rarely seen with transforaminal injections and thus can be easily overlooked. Becoming familiar with the images presented in these cases may help alert the interventionalist of a dural puncture, and thus avoid injection of medications into the intrathecal and subdural spaces.

Key words: Back pain, epidural steroid injection, subdural, intrathecal

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Lumbar transforaminal epidural steroid injections have been utilized and shown to be effective in the treatment of lumbar radiculopathy (1-3). These fluoroscopically guided injections are commonly employed to selectively deliver medication to the epidural space near the exiting spinal nerves. The goal of the transforaminal approach is to enter the intervertebral foramen, while avoiding dural puncture, vascular injection, and segmental nerve trauma.

The anatomy of the lumbar intervertebral foramen is complex. Structures that form the boundaries

of the foramen, as described by Gilchrist et al (4), include the superior and inferior vertebra and respective pedicles, the intervertebral disc, the posterior longitudinal ligament, the anterior longitudinal venous sinus, the pars interarticularis, the ligamentum flavum, and the superior and inferior articular process of the adjacent facet joint. The lateral border is formed by fascia and psoas muscle, while the medial border contains the dural sleeve. Contents within the canal include the nerve root enclosed within the dural sleeve, epidural fat, radicular vessels that run with the nerve root, and the intraforaminal ligaments (4,5). A pair of spinal nerve roots leaves and penetrates the dural sac in an inferolateral direction, taking with them an extension of dura and arachnoid mater referred to as the dural sleeve. This sleeve encloses the nerve roots until the dura mater merges with, or becomes, the epineurium of the spinal nerve. Just within the dural sleeve lies the subdural space, a potential cavity containing a small volume of serous fluid between the dura and arachnoid mater (6). The nerve roots are further sheathed by arachnoid or pia mater, and are bathed in cerebral spinal fluid (CSF) as far as the spinal nerve (5). The subdural potential space is widest around the dorsal nerve roots, as this is where the attachments of the dura and subarachnoid mater separate. The arachnoid is fixed more proximal to the ganglion, with the dura relatively more distal (7). Based on electron microscopy studies, it is hypothesized that the origin of the subdural space lies within the dura-arachnoid interface when the neurothelial cells break up within this space (8). The subdural space has also been described to extend from the S2 vertebrae superiorly to the cranium (6,7).

The optimal target point for transforaminal epidural steroid injections lies on the posterior surface of the vertebral body, adjacent to the caudal border of the pedicle above the target nerve, opposite the sagittal bisector of the pedicle. When viewed under fluoroscopy, this point has also been described as the 6 o'clock position below the respective pedicle. This 6 o'clock position lies in the upper margin of the traditionally described "safe triangle" (9,10). The safe triangle is formed by a transverse line tangential to the lower margin of the pedicle, a sagittal line tangential to the lateral margin of the pedicle, and a hypotenuse passing obliquely inferiorly and laterally from the inferior medial corner of the pedicle, tangential to the curvature of the pedicle at that corner. A needle may be introduced into the upper and lateral reaches of the triangle and adjusted to the target point, if necessary, with less risk of puncturing the dural sleeve of the target nerve. The 6 o'clock position is used because the dural sleeve typically ends medial to this position. Of note, this description is based upon normal anatomy, which may not exist with advanced spondylosis, foraminal disc intrusion, or severe disc height loss. Thus, the safe triangle is a term relative to normal anatomy. In the stenotic foramen, there is a competition for the space by all of the foraminal contents. This often leaves a pinned down segmental nerve with its closely applied dura. During the transforaminal epidural steroid injection, contrast is injected in order to confirm and document the appropriate spread of the medication into the epidural space and around the ipsilateral spinal nerve. Botwin et al have documented epidurography/contrast flow patterns with this procedure (11).

Two cases of transforaminal epidural steroid injections are presented in which the dura was punctured despite apparent proper technique. The literature regarding this presumably rare complication during transforaminal epidural steroid is sparse, with the incidence being unknown. One survey reviewing 322 transforaminal injections did not report any dural punctures (12). Potential complications of dural puncture and subsequent injection into the subdural and subarachnoid spaces include cauda equina and conus medularis syndromes, persistent parathesias, arachnodiditis, meningitis, temporary respiratory depression, ascending weakness/sensory loss, apnea, and unconsciousness (6,13-18).

Recognition of abnormal contrast flow during transforaminal epidural injections, particularly subdural injection, should help reduce the risk of these complications. These cases demonstrate appropriately placed needles, yet upon injection of contrast, subdural disbursement of contrast ensued. The purpose of these cases is to demonstrate contrast patterns that occur after dural puncture, which can occur despite apparent proper needle placement and lack of cerebral spinal fluid (CSF) flashback.

Case Descriptions

Case 1

A 61-year-old female presented with 3 weeks of acute low back and left leg (anterior thigh) pain. MRI imaging revealed severe left neural foraminal stenosis at L3-4.

The patient underwent a left L3 transforaminal epidural steroid injection, as well as a therapeutic L3-

4 intradiscal steroid injection. The rationale for the therapeutic intradiscal steroid injection is controversial, at best anecdotal, and is beyond the scope of this discussion (19,20).

First, the L3-4 disc was cannulated using a 22-gauge spinal needle via the right oblique approach. Next, using a left oblique approach, another 22-gauge spinal needle was placed just caudal to the left L3 pedicle at the 6-o'clock position. Placement was checked on anteroposterior (AP) and lateral fluoroscopic visualization (Figs. 1A and B). Contrast was injected beneath the left L3 pedicle, but the flow pattern was suggestive of possible subdural (extra-arachnoid) spread on lateral imaging (Fig. 1C). AP imaging seemed to confirm the presence of contrast in the subdural spaces (Fig. 1D). Subdural spread was suspected because contrast seemed to be outlining the thecal sac on lateral imaging (Fig. 1C). This was further confirmed on AP imaging in which the contrast pattern crossed the midline when compared to the AP scout image (Figs. 1A and D). Furthermore, the contrast pattern within the central canal had a glass-like appearance as opposed to a more honeycomb presentation typically seen with an epidurogram. The contrast spread also appeared delineated within the dural sleeve, which is consistent with subdural spread (Figs. 1A and D). The needle was

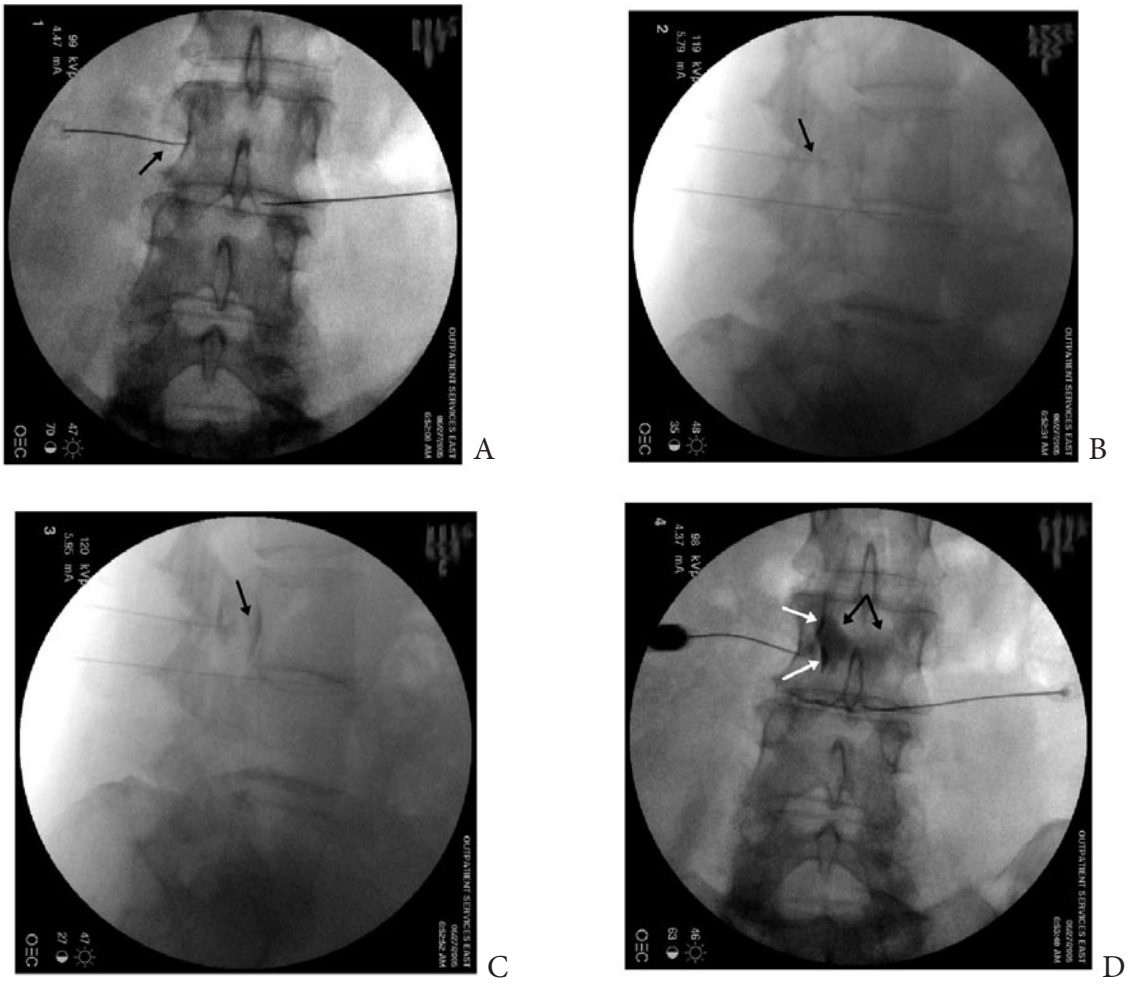

Fig. 1. *A. Spot AP image of needles under the left L3 pedicle and in the L3-4 disc. B. Lateral image depicting depth of needles underneath the L3 pedicle and in the L3-4 disc. C: Lateral post-contrast image suggesting subdural spread (black arrow pointing to "convex anterior bulging" consistent with subdural spread patterns). D: AP post-contrast image suggesting subdural injection with contra-lateral (black arrows) and lateral (white arrows) spread of contrast within the dural sleeve.*

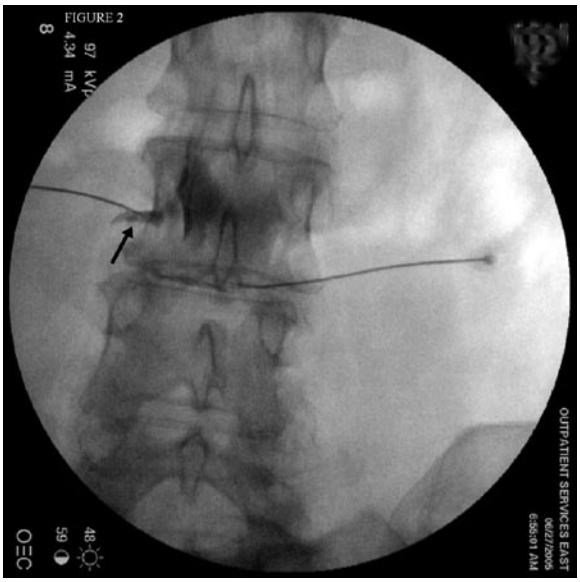

Fig. 2. *Needle was withdrawn slightly and contrast re-injected with more appropriate epidural flow along the left L3 nerve root (black arrow).*

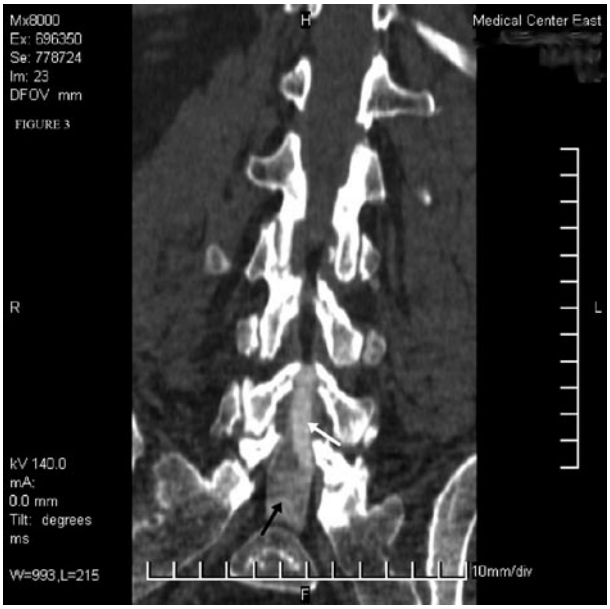

Fig. 3. *Coronal CT reconstruction delineating intrathecal (black arrow) and left subdural flow (white arrow).*

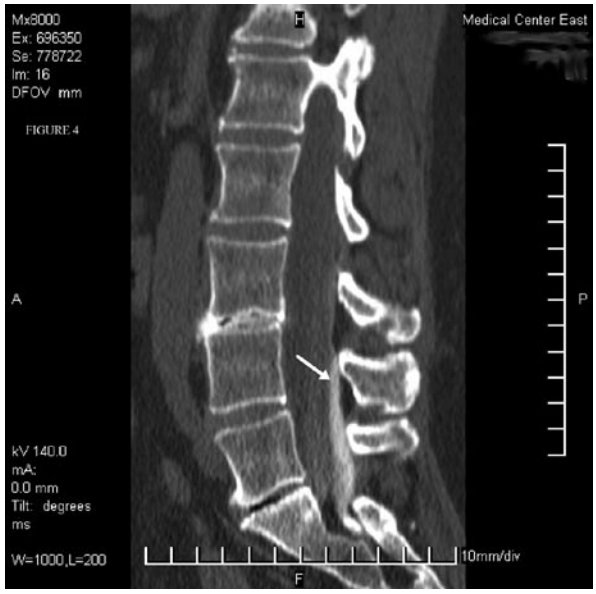

Fig. 4. *CT sagittal reconstruction demonstrating a left subdural spread (white arrow)*

thus withdrawn slightly and redirected more laterally. Contrast was then re-injected until a dominant left L3 transforaminal selective spinal nerve injection ensued (Fig. 2). A solution containing 1 mL of triamcinolone acetonide (40mg/mL) and 4 mL of bupivacaine (0.25%) was slowly injected.

In order to confirm the subdural spread of the contrast, the patient underwent a computed tomography (CT) scan of the lumbar spine immediately following the procedure. The CT images, which were reviewed by a neuroradiologist, revealed contrast within the subdural spaces (Figs. 3-6). In addition, there was contrast present in the subarachnoid space (Fig. 7). It is conceivable that the contrast diffused from the subdural space to the subarachnoid space, where it can be seen pooling at the lower levels of the thecal sac.

Two weeks later the patient was seen in the clinic. She had no apparent complications, and was doing significantly better with regard to her back and left leg pain. In addition, she denied

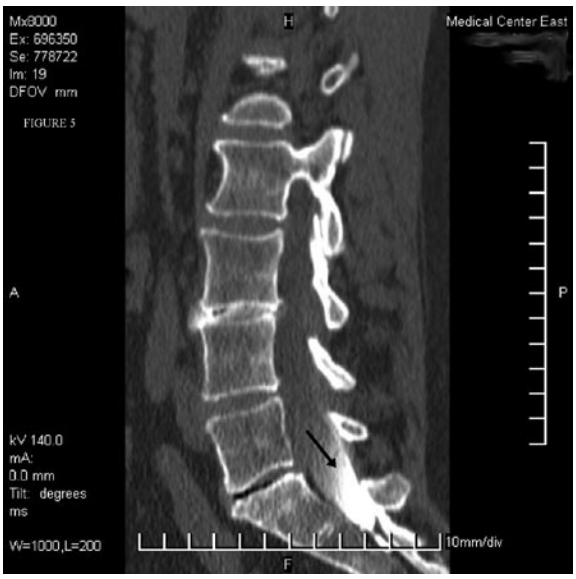

Fig. 5. *CT sagittal reconstruction demonstrating intrathecal spread (black arrow).*

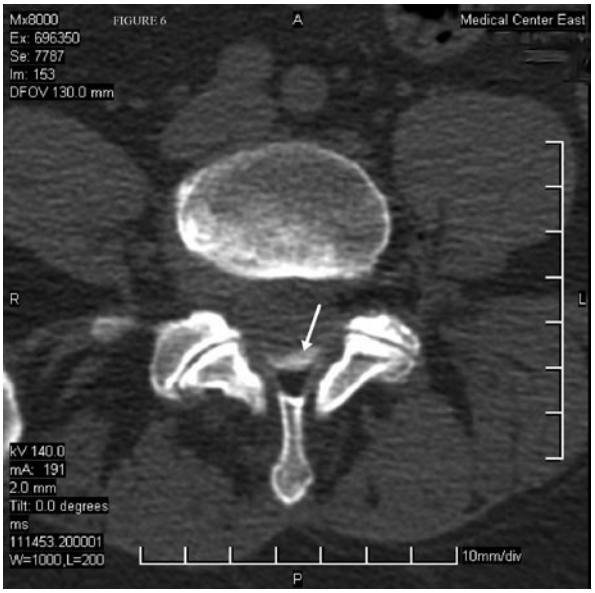

Fig. 6. *Axial CT demonstrating subdural spread within the posterior central spinal canal (white arrow).*

any significant headaches following the procedure. The patient was discharged from the clinic with follow-up as needed.

Case 2.

A 64-year-old female with a history of rheumatoid arthritis presented with a 3-year history of progressive low back and right greater than left leg pain. MRI imaging revealed severe, multilevel DDD L2-3 through L5-S1. Upon review of this patient's history, physical exam, and advanced imaging, right L3, L4, and L5 transforaminal epidural steroid injections were performed. This was felt to be a superior choice to an interlaminar epidural steroid injection considering the patient's more dominant right leg pain, the diminished posterior epidural space seen on MRI, and previous poor response in the past to interlaminar epidurals (albeit non-x-ray guided).

Twenty-two-gauge needles were advanced just caudal to the L3, L4, and L5 pedicles at the

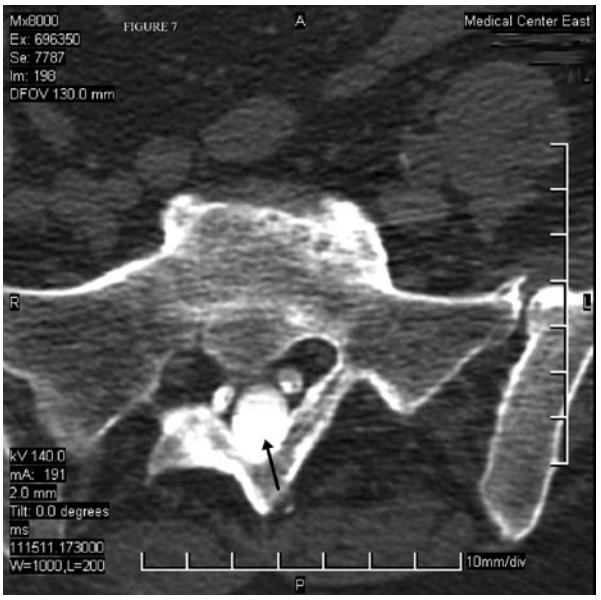

Fig. 7. *Axial CT demonstrating intrathecal spread (black arrow).*

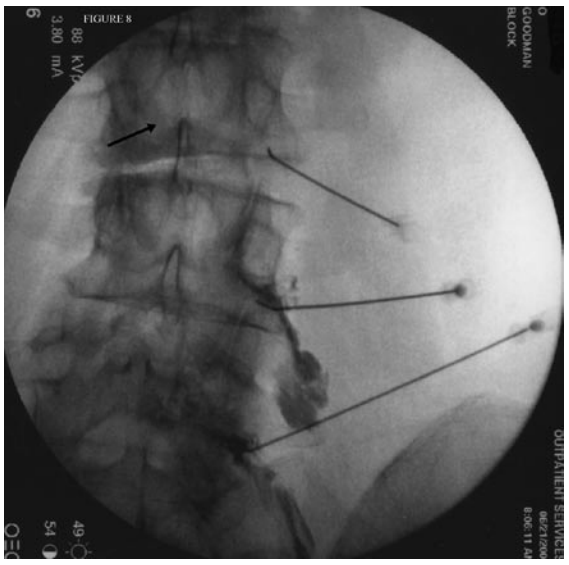

Fig. 8: AP image with needles under right L3, 4, 5 pedicles at the 6 o'clock position. Transforaminal epidural spread at L4 and L5. Pre-contrast injection image at L3 (note absence of contrast at arrow).

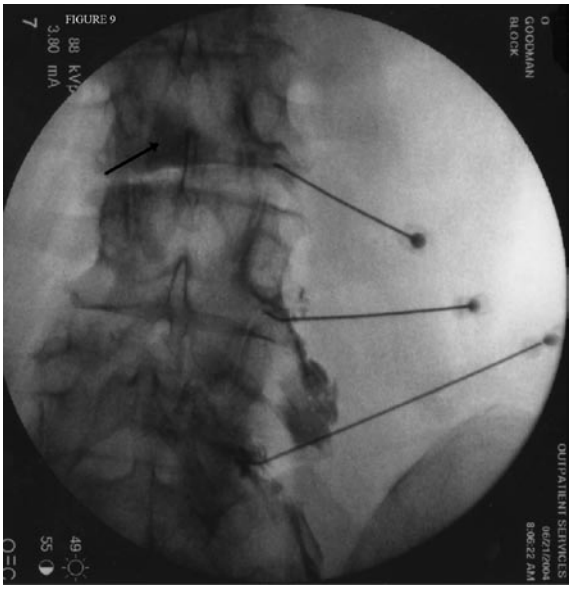

Fig. 9: AP imaging depicting post-contrast subdural spread (black arrow) at L3, and transforaminal epidural spread of contrast for L4 and L5.

"6-o'clock" position using a right oblique approach. The needle position was confirmed using AP and lateral fluoroscopic imaging. Contrast was injected and selective epidural spread with outline of the right L4 and L5 nerve roots was appreciated (Fig. 8). With the injection at L3, however, there appeared to be subdural spread with contrast filling the inner L3 dural sleeve (Fig. 9). Once again the contrast, when carefully referenced to the scout image, appears to fill the subdural (extra-arachnoid) space along the central spinal canal and cross the midline to fill the contra-lateral side at the L3 level. The L4 and L5 levels, in comparison, demonstrate a typical transforaminal epidural pattern. The needle at L3 was withdrawn slightly and contrast was injected, at which point the outline of the selective L3 spinal nerve, as well as epidural flow was appreciated. A solution containing 2 mL of triamcinolone acetonide (40mg/mL) and 7 mL of bupivacaine (0.25%) was then evenly divided among the 3 levels.

The patient was seen 2 weeks after the above procedure for follow up. Her pain was significantly less, especially in the right leg. She denied any fevers or spinal headaches, and was discharged from the clinic with follow-up as needed.

Discussion

The lumbar transforaminal epidural injection technique since being introduced has been routinely utilized in the treatment of radicular pain syndromes (21). The proposed benefit of the transforaminal epidural technique is to place higher concentrations of corticosteroid and anesthetic preparations close to the spinal nerve/disc interface utilizing epidurography. While performing this procedure, it is important to recognize subsequent contrast patterns that occur after a dural puncture in order to avoid instillation of local anesthetic and corticosteroids into the lumbar subdural and intrathecal spaces.

Potential complications of unrecognized intrathecal anesthetic/steroid injections include cauda equina syndrome from volume compression of neural elements, neural toxicity, or local anesthetic effect. Symptoms from cauda equina blockade, though temporary, may include loss of sensation and motor weakness in the lower extremities, bowel and bladder disturbances, loss of sexual functioning, and saddle sensation loss. Other complications reported in the literature with subarachnoid or intrathecal injections

include worsening of radicular pains, persistent parasthesias, aseptic meningitis, conus medularis syndrome, and even paraplegia (13-17). Inadvertent dural puncture may also lead to spinal headache (22), though no headaches were reported in these cases. Finally, intrathecal administration of corticosteroid has been implicated in arachnoiditis, although subsequent studies seem to refute this (23-25).

A particularly concerning complication of a dural puncture involves the instillation of anesthetic into the subdural space. With the injection of anesthetic into the subdural space, a subdural neural blockade may occur. Prior reports have suggested an incidence of 0.82% for subdural injections during interlaminar epidural injections (7). Symptoms of a subdural block include a delayed onset of motor and sensory loss with onset varying from 5 to 30 or more minutes (7,26). Neurologic blockade may be of a patchy or uneven pattern, and symptoms typically are out of proportion to the amount of anesthetic injected. Detailed anatomic studies performed by Reina et al of the subdural space and the dura-arachnoid interfaces seem to explain the variance of symptoms reported with subdural blocks (8). The posterior nerve roots are also more likely to be affected than the anterior nerve roots, thus sensory losses are more typically seen (6,7,27). Blockage of anterior nerve root fibers, however, can occur with subsequent blockade of sympathetic and motor fibers. Transient motor weakness and hypotension from sympathetic blockade have also been reported in the literature (6,7). Cephalad or ascending blockade has been described in previous case reports (6,18), possibly secondary to capillary effects and lower resistance in the superior subdural spaces (7). A "massive block" may thus occur if a large volume of anesthetic is used, resulting in serious cardiovascular and respiratory effects such as temporary respiratory depression (7). Further spread of anesthetic to subdural spaces within the cranium may also account for previous reports of cranial nerve symptoms and even unconsciousness and apnea from brainstem anesthetic block (18).

With careful scrutiny of the images presented in these cases, one could argue that the needle tip positions are less than ideal. In case 1, the needle positioning as demonstrated in Fig. 1-A appears to be beyond or medial to the inter-pedicular bisector. Fig. 2, on the other hand, demonstrates a better needle tip position just outside the inter-pedicular bisector. In case 2, as demonstrated in Fig. 9, the needle tip may have been positioned closer to the pedicle (i.e. more superior) and thus more within the safe triangle. In both of these cases, the dural puncture occurred at the L3 level, which may be related to anatomic variation of the exiting nerve roots. The upper lumbar nerve roots exit the dural sac at more of a right angle, while the lower lumbar nerve roots exit at a steeper, more oblique angle from the lateral dural margin (5). The angle of the exiting upper lumbar nerve roots makes the intraspinal portions of the nerve roots very short, while bringing the dural sleeve up against the medial pedicle walls (4). One may need to proceed with extra caution when performing transforaminal injections at upper lumbar levels such as L3, when compared to the typical L4, L5, and S1 injections. It is the lead author's practice now to utilize a retroneural approach rather than place the needle deep into the neuroforamen (subpedicular approach). The retroneural approach may help avoid the complication of dural puncture. In retrospect, given the proximity of the dural puncture in these cases, it may have been appropriate to decrease or eliminate the use of local anesthetic in the subsequent transforaminal epidural steroid injections. Furthermore, the authors no longer utilize particulate corticosteroids for transforaminal epidural steroid injections.

In order to recognize a potential dural puncture, interventionalists need to be able to distinguish intrathecal, subdural, and epidural contrast flow patterns. The characteristic of intrathecal spread on AP imaging is a flat, glasslike appearance of the contrast within the central canal as opposed to a patchy, honeycomb appearance ipsilateral to the side of the injection consistent with epidural spread. A transforaminal epidural also shows contrast along the medial wall of the pedicle and out the selective spinal nerve distal to where the dural sleeve ends. Distinguishing subdural or extra-arachnoid spread from intrathecal can be more challenging, especially as relatively smaller amounts of contrast are used during fluoroscopy when compared to a myelogram. Subdural spread can mimic intrathecal spread, with a central mass of contrast that lacks lateral nerve root filling (18). Subdural contrast, however, can appear more opaque and persist longer than intrathecal contrast, given the lack of CSF dilution and runoff in the subdural space (27). A higher concentration of contrast can also be seen in the posterior-lateral aspects of the subdural space, as seen in Figs. 1D and 9, where contrast appears to hug lateral dural sleeves near the point of entry. Lateral imaging perhaps offers more

insight when characterizing subdural patterns. Subdural contrast is more often confined to the dorsal spinal canal with a flat dorsal margin against the dura mater and an irregular shaped ventral margin that follows the circumference of the arachnoid mater (27). The subdural contrast can also be described as "bulging" anteriorly into the vertebral canal, giving a convex shape when seen on lateral imaging (18). Close examination of Fig. 1C demonstrates a flat dorsal margin along with anterior bulging of contrast into the vertebral canal. The CT images in Figs. 4 and 6 further demonstrate subdural contrast within the dorsal spinal canal. Prior case reports have also described extensive subdural spread of contrast along thin lateral columns (18), though this phenomenon was not observed in the above cases.

These 2 cases demonstrate the complication of dural puncture when performing lumbar transforaminal epidural steroid injections. Case 1 displays fluoroscopy and CT images that confirm the subdural and intrathecal spread of contrast. Case 2 provides fluoroscopic images that allow us to compare subdural versus epidural spread patterns at different spinal levels. In each case, the subdural spread of contrast was recognized under fluoroscopy, after which the needle was redirected such that appropriate epidural spread ensued. In the lead author's experience, CSF flashback, which might alert the operator of a dural puncture, is rarely seen in the needle hub during transforaminal epidural steroid injections. The subdural space is perhaps widest around the dorsal nerve roots (6,7,27), making this potential space particularly accessible in the transforaminal space. Therefore, with transforaminal injections, subdural injection maybe a relatively common sequalae following a dural puncture, though the research to confirm this suspicion is lacking.

Conclusion

When performing transformational epidural injections, the dura may be punctured despite appropriate needle placement. Subdural and intrathecal spread of contrast is rarely seen with transforaminal injections and thus can be easily overlooked. The authors believe that the complication of dural puncture during transforaminal epidural steroid injections, especially subdural injection, is probably under-reported by practitioners. Factors that contribute to the failure recognize this complication include a lack of CSF flashback, unfamiliarity with subdural contrast patterns, and low clinical suspicion.

The purpose of these cases is to demonstrate this contrast pattern in the setting of a spinal injection. The authors advocate the routine use of contrast medium with direct AP and lateral fluoroscopic visualization when performing transforaminal epidural steroid injections. The authors also advocate the use of scout images without contrast to help delineate subdural, intrathecal, and epidural spread once the contrast is injected. Contrast injection should also be performed under live fluoroscopy to best discern flow patterns including intrathecal runoff and vascular injection. Spinal interventional physicians must be familiar with myelograms and their images to assist with the recognition of intrathecal and subdural spread patterns. Finally, given the delayed onset of potentially serious neurologic sequalae associated with subdural injections, the authors advocate careful post procedural monitoring of the patient when performing spinal interventions. Becoming familiar with the images presented in these cases may help spinal interventionalists recognize a dural puncture and subdural spread, and thus avoid subsequent potential complications.

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