Unexpected contrast filling during fluoroscopy guided epidural steroid injection; What should we do?

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Learning objectives

1. To be familiar with various epidurographic findings that can be observed during fluoroscopy-guided epidural steroid injection (ESI).

2. To recognize inappropriate abnormal contrast spread patterns that occur during fluoroscopy-guided ESI and provide a method to deal with these situations.
Background

Epidural steroid injection (ESI) has been widely used for axial and radiating pain since Robecci and Capra first reported it in 1952 (1). The purpose of ESI is to deliver medication to the epidural space. The medication can be delivered by caudal, interlaminar, and transforaminal routes with CT or fluoroscopy guidance (2). Contrast medium is injected to confirm proper needle placement and correct flow of the medication through the epidural space. However, the spread of the contrast in the epidural space can vary depending on the amount of contrast medium, anatomic variation, degree of spinal stenosis, injection technique, and location of the needle tip (3-9). Therefore, becoming familiar with various epidural contrast spread pattern is important for spine interventionalists for accurate delivery of the medication.

Through the use of fluoroscopy and epidurography, the location of the needle tip can be identified immediately so that serious complications can be markedly reduced (10). However, potential complications can develop, if abnormal contrast flow is not recognized while performing ESI (11-15). Therefore, recognizing the contrast pattern during the procedure is crucial to avoid complications, and to maximize the effect of the medication (11). Inadvertent contrast or medication injection into unexpected space during ESI is rarely reported and is probably under-reported by the practitioners (11), due to unfamiliarity with abnormal contrast spread patterns seen with a small amount contrast medium and the transient nature of fluoroscopy.

In this article, we reviewed the various inappropriate contrast spread patterns, that can occur during fluoroscopy-guided ESI and require repositioning of the needle or abandoning the procedure on the basis of our 14-year experience with spine intervention and a review of the literature. We also provide common situations in which inappropriate contrast spread patterns may occur and a method to deal with these situations.
Findings and procedure details

- Normal epidurographic findings

1. Caudal approach

For caudal approach to epidural space, the needle is introduced into the sacral canal through the sacral hiatus after puncturing the sacroccocygeal ligament. Although the injectate delivery close to the lumbar level where the pathology is present is ideal, the needle tip should not be above the S2 or S3 because of the risk of dural puncture (16).

In the AP view, the contrast dispersal can be seen in the sacral epidural space and exiting nerve roots, and creates the characteristic appearance of "Christmas tree" (Fig. 1). The contrast dispersal in the epidural space is not symmetric and can be either unilateral or bilateral in the AP view (Fig. 1).

In the lateral view contrast extends along both the ventral and dorsal epidural space which can be seen like "railroad track" or "double line" (17) (Fig. 2).

Rarely, linear band like filling defect in the midline can be observed in epidurography during caudal or interlaminar ESI. This is believed as plica mediana dorsalis (18, 19). (Fig. 3)

2. Interlaminar approach

Hogan classified the epidural space as posterior, lateral, and anterior compartments (20). Posterior epidural space is a triangular space between the ligamentum flavum and the dura. It is filled by a fat pad which apart from a few attachments to the dura and the midline of the ligamentum flavum. Lateral epidural space is just medial to each intervertebral foramen and the spinal nerves, vessels, and fat fill the lateral compartment. Anterior epidural space is almost filled by a rich internal venous plexus. As the posterior epidural space is widest in the midline underneath the junction of the lamina and narrows laterally beneath the facet joints, cervical and lumbar interlaminar ESI usually performed in the mid line (7).

In the lateral view, the contrast filling may be seen as either of a linear band or a semilunar shaped contrast collection with convex margin toward the dural sac. And then, it spreads out vertically and circumferentially along the dorsolateral epidural space. As the volume of the injectate is increased, the contrast disperses to the anterior epidural space and the "railroad track" or "double line" appears (Fig. 4).

In AP view, firstly injected small amount of the contrast medium appears in the midline first and spreads out in the central spinal canal. A further contrast medium injection reveals a central contrast column, denser in the lateral than in the central zone (21). A continuation
of the contrast medium along the spinal nerves can be observed passing through the intervertebral foramen (Fig. 4).

3. Transforaminal approach

Commonly used for unilateral radicular pain for cervical and lumbar spines because of its advantage of target specific injection (2, 4).

Well-known approaches: classic subpedicular technique, retroneural technique, retrodiscal technique (Fig. 5)

Classic subpedicular technique approaches the safe triangle below the underside of the pedicle (4). When this is properly performed, ventral and lateral contrast spread along the segmental nerve root is well observed (4, 22) (Fig. 6). The common pattern of the contrast filling is that the contrast disperses along the spinal nerve root first and then the ventral epidural dispersal is identified.

Retroneural transforaminal injection is performed through the posterior lateral epidural space (23, 24). In cases of the retroneural approach, the posterior or lateral epidural contrast spread may be firstly and commonly seen than the anterior epidural contrast spread (Fig. 7).

Retrodiscal transforaminal injection approaches from the lateral aspect of the superior articular process of the lower vertebra into the anterior medial neural foramen (24, 25).

However the contrast spread pattern for transforaminal ESI may vary depending on the epidural anatomy and degree of spinal stenosis or nerve root compression, as well as the approaching technique (25).

• Inappropriate contrast dispersal into unexpected space

1. Intrathecal injection

Unrecognized intrathecal anesthetics or steroid injections may cause complications including cauda equina syndrome, neural toxicity, worsening of radicular pains, persistent paraesthesias, aseptic meningitis, spinal headache, and arachnoiditis. (11). Therefore, prompt recognition of the dural puncture is essential for the spine interventionalists.

The characteristic intrathecal contrast filling pattern

• AP view - flat glass -like appearance of the contrast within the central canal as opposed to a patchy honeycomb appearance in the epidural space
• Lateral view - fluid-fluid level (contrast medium-CSF) in the ventral side of the dural sac in prone position because the contrast medium has a higher specific gravity. (Fig. 8)
Precautions are necessary when performing caudal injection in patients with dural sac tip located in the lower sacrum or with a sacral meningocele or perineural cysts at the sacral level. (26) (Fig. 9)

When intrathecal contrast filling is identified, the needle needs to be withdrawn and the procedure should be abandoned. The patient should be observed after the procedure as a precaution for spinal headache. If a headache does occur, treatment may consist of bed rest, hydration, analgesics, and caffeine. In rare cases, an epidural blood patch may be performed (27).

2. Subdural injection

The spinal subdural space is not a true space, but is believed to be a cellular interface between the laminar arachnoid and internal layer of the dura mater (28).

Incidence: 0.8% with lumbar epidural injection (11, 15).

Rare but potentially life threatening if anesthetic is injected in the subdural space.

The characteristic subdural contrast spread pattern

- An extensive circumferential contrast spread around the subdural space and cephalocaudal extension over multiple vertebral segments (29). On AP and lateral views, extensive narrow lateral contrast columns extend high into the thoracic spine with a characteristic “railroad track” appearance (Fig. 10). However contrast spread along the exiting nerve root is not seen unlike epidural contrast filling.
- A sausage-shaped mass of contrast in the posterior subdural space (30). Subdural contrast can appear more opaque and persist longer than intradural contrast because it is not diluted by CSF and does not run off in the subdural space (Fig. 11). Subdural contrast filling is often confined to the dorsal spinal canal with a flat dorsal margin against the dura mater and an irregularly shaped ventral margin that follow the circumference of the arachnoid mater (11). On a lateral view, this subdual contrast may bulge anteriorly into the vertebral canal with a convex shape.

A possible explanation for the differences in subdural contrast filling is that the subdural space is not a single entity, but may exist in two or more separate planes within the many layers of the dura-arachnoid interface, and each plane may have its own distinct radiographic characteristics (28, 30). Whether a dense central contrast collection bulging into the anterior vertebral canal is called a subdural space or intradural space remains controversial (28, 30, 31).

When subdural contrast filling is identified, the needle needs to be withdrawn and repositioned. Once an appropriate epidurogram is achieved after repositioning the needle, the drug can be injected. If contrast medium persistently enters into the
subdural space, the procedure should be abandoned. Local anesthetic injection is not recommended because of the possible high level of anesthesia. The patients should be monitored after the procedure, for a possible delayed onset of potentially serious neurologic sequelae associated with subdural injection (11).

3. Intravascular injection

Incidence: quite common, Furman et al. reported an overall rate of 11.2% of intravascular injection for lumbosacral transforaminal ESI (32) and 19.4% of it for cervical transforaminal ESI (33). Sullivan et al. reported 10.9% of intravascular contrast injection for caudal ESI (34).

Intravenous drug injection may not result in the complications or adverse effects in most of the cases (32, 34). However, intravenous drug injection can diminish the efficacy of epidural ESI (32) and the patients may experience temporary adverse reactions from systemic uptake of local anesthetics.

Intraarterial penetration and subsequent injection of particulate steroids can lead to a catastrophic result (35, 36). The penetrating artery during ESI shows smaller and high flow as opposed to relatively larger and slow flow of the vein (Fig. 12, 13). Arterial contrast filling is so fast and it is rapidly washed out in the fluoroscopy due to arterial influx. Therefore, digital subtraction angiography (DSA) may be recommended for detection of the intraarterial flow (37, 38) (Fig. 14).

If intravascular flow is obtained, the needle is withdrawn back and redirected in to a different region of the foramen or the epidural space. In the case of cervical transforaminal ESI, the needle should be kept in the posterior half of the foramen, away from the vertebral artery (39). In the case of lumbar transforaminal ESI, the approach to the posterior aspect of the foramen (retroneural technique) can be tried because the segmental artery is located in the anterosuperior aspect of the spinal nerve (the target zone in classic lumbar transforaminal ESI) (36). It may be helpful to inject small amount short acting local anesthetics first, and see if any neurologic symptom is developed after a few minutes. Non-particulate steroid injection should be recommended.

4. Intradiscal injection

Incidence: 0.17 ~ 2.3% during lumbar transforaminal ESI (40, 41).

Mechanism: The negative pressure of intradiscal space related with a severely degenerated vacuum disc with disrupted annulus, which may pull the contrast dye from the epidural space into the disc caused by the pressure gradient (42).

The characteristic intradiscal filling pattern
• The contrast is found in the intervertebral disc space, and spreads into the central portion of the disc, like discography (Fig. 15).

The potential complication of the intradiscal penetration is discitis (40, 41).

When intradiscal contrast spread is identified, the needle should be repositioned. Cohen et al. recommended placing the needle tip in the anterosuperior aspect of a foramen where is less likely to result in inadvertent annular penetration (42). When the appropriate epidurogram is achieved after repositioning of the needle, the drug can be injected. Cohen et al. also recommended parenteral antibiotics after the procedure to avoid the risk of discitis (42). Administration of intradiscal antibiotics was also mentioned in their study.

5. Intraarticular and intraligamentous injection

Incidence: 1.2% during lumbar interlaminar ESI (43).

The characteristic intradiscal filling pattern

• In lumbar spine lateral view, it is a crescentic or semilunar appearance that spreads superiority and inferiorly throughout the injection, and has a diagonal curvilinear configuration (43). In AP view, it is occasionally sinusoidal or S shaped (43, 44). In AP view, the contrast filling pattern may look like "butterfly" or rhomboid shape, projecting over the facet joint, in cases with bilateral contrast filling of ligamentum flavum and the facet joints (44).

• In cervical spine, the facet joint contrast filling is easily identified in lateral view. In lateral view, the contrast filling in the facet joint is seen as an oblique line or band with 35-45 degree posterior slope (Fig. 16). In AP view, the contrast filling in the facet joint is seen in oblique transverse plane, overlapped with lateral mass.

• When intraarticular or intraligamentous contrast filling is identified without sufficient epidural contrast filling, the needle should be repositioned for effective delivery of the drug into epidural space. For needle repositioning during interlaminar ESI, midline approach is preferred than paramedian route, since the midline is less contact with ligamentum flavum and has widest dorsal epidural space. The injected contrast in the ligamentum flavum or interspinous bursa may interfere with the visualization of the needle tip during the procedure (Fig. 17). Loss of resistance technique, attempt in other level, or other approaching technique (transforaminal or caudal approach) can be considered.

6. Intraneural injection

Direct trauma of the nerve root or dorsal root ganglion can occur by inadvertent needle placement, especially during transforaminal ESI (45).
Intraepineural contrast spread, the nerve root has several thin linear contrast fillings inside the nerve root as a feathery appearance (46, 47) (Fig. 18). In cases of intraepineural injection, the patients may have severe radiating pain during the procedure, and it may cause mechanical neuritis or nerve injury inside the nerve root.

When this type of contrast spread pattern is identified and the patient presents severe pain during the procedure, the needle should be slightly withdrawn and reassessment of the needle position is recommended (45). The patient should not be over sedated before the procedure so that the patient's reaction is not masked. Retroneural or retrodiscal approach may help avoid nerve trauma (45).

7. Retroperitoneal or intra-psoas muscle injection

During lumbar transforaminal ESI, the needle tip may be located in the anterolateral aspect of the foramen, and contrast can be injected into the retroperitoneal space or in the psoas muscle.

The retroperitoneal contrast spread appears patchy and can be dispersed into the cranial portion along the inner margin of the psoas muscle (Fig. 19). A lateral view should be taken to identify the exact location of the needle tip.

The contrast dispersal in the psoas muscle shows fascicular patterns along the fascicles of the attachments. It is linear and oblique in direction, and can mimic a nerve root filling in the AP view (Fig. 20).

When this type of contrast spread pattern is identified without sufficient nerve root or epidural contrast spread, the needle should be withdrawn and repositioned to avoid additional advancement into the ventral aspect of the intervertebral foramen. When the needle tip is identified in the lateral aspect of the pedicle in the AP view, the needle is withdrawn a little and repositioned in the posterior and medial direction. Cranial or caudal angulation may be helpful to obtain the right oblique angle in patients with high location iliac crests. The needle tip is identified in the lateral aspect of the pedicle in the AP view, the needle is withdrawn a little and repositioned in the posterior and medial direction. Cranial or caudal angulation may be helpful to obtain the right oblique angle in patients with high location iliac crests.
**Fig. 1:** AP epidurograms showing various contrast spread pattern. A, B. Unilateral contrast spread (A) and bilateral spread (B). The contrast filling pattern resembles "Christmas tree".

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**Fig. 2:** Lateral epidurograms for caudal epidural injection. A. Dorsal filling pattern of the contrast (arrows). Note the clear interphase with the dorsal margin of the dural sac. The contrast spreads out to the dorsolateral aspect of the dural sac (arrow heads). B. Ventral filling pattern of the contrast. The contrast disperses in the ventral epidural space.
with fuzzy margin (arrow heads) except clear interface with the dura (black arrow). The contrast spreads along the ventral sacral nerve roots (white arrow). C. Circumferential filling pattern surrounding the dural sac (arrows). Contrast extends along both the ventral and dorsal aspects of the epidural space producing a "double line" or "railroad track" appearance.

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**Fig. 3:** Plica mediana dorsalis. AP epidurogram shows linear band like filling defect in the midline. Contrast is seen both sides of the plica mediana dorsalis (arrows).
Fig. 4: Lateral epidurograms for lumbar interlaminar epidural steroid injection (ESI) (A-C) and AP epidurogram for cervical interlaminar ESI (D). A. Initial lateral view after 0.5 ml contrast medium injection. The contrast is collected in the posterior epidural space with convex margin toward the dural sac (arrows). B. Lateral view after 1 cc contrast medium injection shows dense dorsal contrast band and lighter contrast spread pattern into the dorsolateral epidural space (arrows). C. Lateral view after additional 5 cc drug mixture injection, typical "railroad track" or "double line" appears with contrast spread in the ventral epidural space. D. AP epidurogram for cervical interlaminar ESI shows
"railroad track" appearance (black arrow) with contrast filling in the exiting nerve roots (white arrows).

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**Fig. 5:** Various techniques for lumbar transforaminal epidural injection. A, B. AP (A) and lateral (B) lumbar radiographs show the relationship between the spinal nerve (yellow bold arrow) and the final needle locations of each technique. Classic subpedicular technique (blue arrow) approaches through the safe triangle bordered by the pedicle superiority, the spinal nerve medially, and the vertebral body anteriorly. Retroneural technique (black arrow) approaches from the more posterior in the neural foramen compared to classic subpedicular technique. Retrodiscal technique (red arrow) places the needle past the lateral aspect of the superior articular process of the lower vertebra into the neural foramen and the needle tip is finally located in the medial aspect of the spinal nerve in the anterior epidural space (retrodiscal area).

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Fig. 6: Contrast spread pattern of the classic subpedicular lumbar transforaminal epidural steroid injection (TFESI). Left L5 TFESI was performed for management of lumbar disc herniation of L4-5 level. A. AP epidurogram with 0.5 ml contrast medium injection shows contrast filling along the L5 nerve root and small amount epidural reflux (arrow). B. lateral epidurogram after additional 2.5 cc drug mixture injection reveals ventral epidural contrast spread into the pathologic level of L4-5 intervertebral disc (arrow).
Fig. 7: Contrast spread pattern of the retroneural lumbar transforaminal epidural steroid injection. A. Lateral epidurogram with 0.5 ml contrast medium injection shows contrast filling along the posterior epidural space (arrows). B. AP epidurogram after 1 ml contrast medium injection reveals diffuse epidural contrast spread pattern and small amount of the nerve root filling (arrow).

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Fig. 8: Intrathecal contrast injection for cervical interlaminar injection. Lateral view after injecting 0.5 ml contrast medium shows linearly sunk contrast in ventral aspect of the spinal canal (arrows). Note the small amount of dorsal contrast filling even if the needle tip is located in the dorsal aspect of the spinal canal (arrow head). CSF pulsation and movement was visualized due to intrathecal contrast in real time fluoroscopy.

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Fig. 9: Intrathecal contrast injection via perineural cyst. A. Lateral view of the caudal injection shows the punctured perineural cyst (arrows) and subsequent intrathecal contrast filling. The fluid-fluid level is seen at S1 level (arrow heads). B. AP view shows glass-like contrast filling in central spinal canal (arrows). The tract between the punctured perineural cyst and the tip of the dural sac is clear (arrow heads). The procedure was abandoned and caudal epidural steroid injection was performed successfully 1 week later.

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Fig. 10: Subdural contrast injection for lumbar interlaminar epidural steroid injection. A. AP view shows linear contrast filling outlining the lateral side of the dural sac. It looks like a "railroad track" (arrows). However, contrast did not fill along the exiting nerve root unlike an epidural "railroad track". B. Lateral view shows a pipe-like linear opacity along the dural sac margin. It rapidly extended to a high level of the upper lumbar spine. By courtesy of professor Ja-Young Choi (Seoul national university).

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Fig. 11: Subdural contrast injection during caudal epidural steroid injection (ESI). A. The AP view after 2 ml contrast medium injection shows central radio-opaque contrast filling (arrows) differentiated with patchy Christmas tree appearance of the contrast in the epidural space (arrow heads). B. The abnormal contrast collection was not recognized during the procedure, and additional 7 ml drug mixture was injected. AP view shows remaining contrast collection in the central spinal canal (arrows) while most of the contrast is diluted by the drug injectate and disperses into the epidural space. C. CT was taken for evaluation of the location of the contrast collection. Axial CT scan reveals contrast collection in the posterior and left lateral subdural space. The patient was observed for one hour in the recovery room and no symptom was developed.

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**Fig. 12:** Intravenous contrast injection for cervical trasnforaminal injection (A) and caudal injection (B). A. AP view shows the contrast in the penetrated vein is drained into the external venous plexus (arrows). B. AP view in different patients show contrast filling in the lateral sacral vein (arrow) via the segmental vein.

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**Fig. 13:** Intraarterial contrast injection during transforaminal epidural steroid injection. Tortuous small vascular contrast filling is noted in right S1 neural foramen (arrows). It was washed out very quickly, because of the arterial influx.

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Fig. 14: Intravascular contrast filling during cervical transforaminal epidural injection (ESI). A. AP radiograph shows linear intravascular contrast filling from the approaching neural foramen to lower cervical spine (arrows). It was regarded as a venous structure due to the caudal direction of the flow. B. Digital subtraction angiography (DSA) image was obtained after repositioning of the needle tip. No intraarterial flow is detected in the spinal canal and the neural foramen. C. AP view after needle tip repositioning shows appropriate contrast filling along the nerve root with epidural reflux. No vascular contrast filling is found. ESI was performed successfully.

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**Fig. 15**: Intradiscal contrast filling during lumbar transforaminal epidural steroid injection (TFESI). A, B. AP (A) and lateral (B) views after injecting 0.5 ml of contrast shows intradiscal contrast filling in the L4-5 intervertebral disc (arrows). The contrast was assumed to disperse from the needle tip location at the infrapedicular level of L4 (arrow head). The needle tip was relatively low and deep in the posterior spinal canal. C,D. The T2-weighted sagittal (D) and axial (E) MR images show a disc extrusion in left subarticular to foraminal zone of L4-5 with superior migration to infrapedicular level of L4 (arrow).

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**Fig. 16:** Intra-articular contrast filling during cervical interlaminar epidural steroid injection (ILESI). A. Lateral view after injecting 1 ml of contrast shows contrast filing in the facet joint (arrow) and dorsal epidural space (arrow heads). B. AP view shows facet joint contrast filling, overlapped with lateral mass (arrows). C. Even though intraarticular contrast filling was identified in the facet joint, the drug was injected without needle repositioning since the contrast spread in the epidural space was sufficient. AP view after additional drug injection shows circumferential contrast spread around the dural sac and along the nerve root (arrows).

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**Fig. 17:** Intraligamentous contrast filling during cervical interlaminar epidural steroid injection (ESI). A, B. AP (A) and lateral (B) views after injecting 0.5 ml of contrast show bilateral lambdoid-shaped contrast filling along the posterolateral margin of the spinal canal (arrows). Neither intra-facet joint contrast filling nor appropriate contrast filling in
the epidural space was identified. The needle was advanced to ensure the location of the needle tip due to the contrast opacity in the ligamentum flavum (arrows). C. PA view for transforaminal ESI. The needle was finally withdrawn and transforaminal ESI was successfully performed.

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Fig. 18: Intraneural contrast injection. AP view after injecting 0.5 ml of contrast shows linear thin contrast strips inside the nerve root with a feathery appearance.
**Fig. 19:** Retroperitoneal contrast injection. During transforaminal approach, the needle was misplaced ventral and lateral aspect of the neural foramen. AP (A) and lateral (B) view after injecting 1 ml of contrast show patch contrast filling in lateral aspect of the vertebral body (arrows) and contrast filling along the inner margin of the psoas muscle (arrow heads). The needle tip was located at the lateral margin of the pedicle level (bold arrow in A) and the far anterior aspect of the neural foramen (bold arrow in B). No epidural contrast spread pattern was identified. C. AP view after repositioning of the needle tip shows proper contrast filling along the L5 nerve root (arrows).
Fig. 20: Intra-psoas muscle contrast injection. A. AP view shows linear contrast bundles with a fascicular pattern in right psoas muscle (arrows). B. Oblique view shows the contrast is located in the anterolateral aspect of the foramen (arrows).

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Conclusion

The complications of ESI are rare, but can potentially be serious. Careful review of MRI or CT before the procedure, with regard to the needle path, may help to decrease the risk of abnormal needle placement. However, inadvertent contrast filling in unexpected spaces can occur even when the needle is properly placed. The spine interventionalist should be familiar with various normal epidurographic findings and inappropriate contrast spread patterns during fluoroscopy-guided ESI, to effectively deliver the drug and prevent potential complications.
References


