Toward Improving the Safety of Transforaminal Injection

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Transforaminal injection of steroids has emerged as a common technique for the treatment of acute radicular pain associated with intervertebral disk herniation.[1] In contrast to placing steroid in the epidural space using a standard, midline approach between adjacent laminae (the "interlaminar" approach), the transforaminal technique uses a needle that approaches the posterolateral aspect of the intervertebral foramen and places the steroid directly adjacent to the affected spinal nerve at the site of inflammation. The concept is to inject the steroid solution directly at the target site in high concentration. There are limited data suggesting that the efficacy of steroid placed via a transforaminal approach is superior to that of the same steroid placed via an interlaminar approach.[2,3] In recent years, catastrophic neurologic complications have been reported after transforaminal injection of steroids. After cervical transforaminal injection: spinal cord infarction resulting in quadriplegia,[4,5] cortical blindness, and fatal strokes in the territory of the posterior cerebral circulation;[6,7] after lumbar transforaminal injection: paraplegia resulting from infarction of the conus medullaris.[8] The clinical suspicion has been that the mechanism of injury is ischemia caused by end-arteriolar occlusion after the inadvertent intraarterial injection of particulate steroid,[9] which has been recently confirmed in a convincing study performed in large animals.[10] It follows that the only safe manner to perform transforaminal injection using the common particulate formulations of steroid that have been used for this application is to devise a means to detect intravascular needle position before particulate steroid is injected, allowing the needle position to be adjusted to avoid intraarterial injection of even a portion of the injected steroid. Experts have recommended the use of radiographic contrast injected under continuous or "live" fluoroscopy with or without digital subtraction to detect intravascular needle position.[9] In this issue, Kim et al.[11] prospectively examined the frequency of intravascular injection using radiographic contrast injected under continuous fluoroscopy.

What is most striking is that the incidence of intravascular injection that Kim et al.[11] report is frighteningly high: 56 of 182 injections (30.8%) overall, 45 of 71 (63%) cervical, 11 of 110 (10%) lumbar with no blood flashback through the 21-gauge needle in 45 of 56 (80%) these cases. The incidence is markedly higher during cervical injections when compared with lumbar injections. Static fluoroscopic injections performed during and immediately after injection do not reliably detect intravascular injection in more than half of the cases. Simultaneous perineural spread and intravascular uptake frequently occurred (23 of 45 [52%] in cervical and 1 of 11 [9%] in lumbar injections), whereas pure vascular uptake occurred in 11.3% of cervical and 0.9% of lumbar injections, underscoring the need for a continuous fluoroscopy.

However, something is curious: the authors tell us that they cannot distinguish between IV (benign) and arterial (potentially catastrophic) uptake. A previous report also did not discern between IV and intraarterial injection, finding a somewhat lower incidence of intravascular injection during cervical transforaminal injection (19.4% of 504 injections)[12] and a similar rate during lumbar transforaminal injection (11.2% in a series of 761 injections).[13] Clinical practice and a few sporadic observations suggest that

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Accepted for publication March 9, 2009.

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DOI: 10.1213/ane.0b013e3181a81ee1

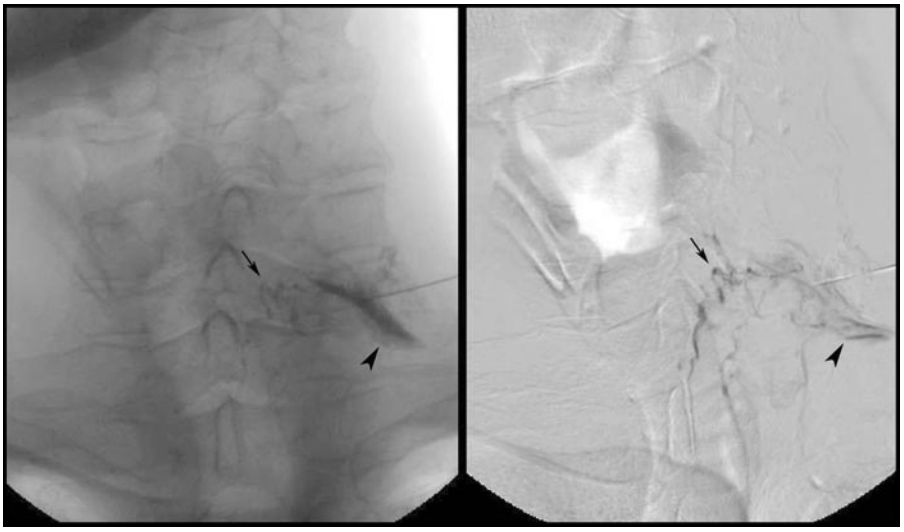

Figure 1. Anterior-posterior view of the cervical spine during cervical transforaminal injection demonstrating intraarterial contrast injection. Left panel, image as seen on fluoroscopy. Right panel, image as seen with use of digital subtraction. The needle tip lies in the left C7/T1 intervertebral foramen. Contrast outlines the spinal nerve within and lateral to the foramen (arrowhead) and digital subtraction clearly reveals that contrast extends medially toward the center of the spinal canal via a spinal medullary artery (small arrow) to the anterior spinal artery. (Reproduced from Ref. 9, with permission.)

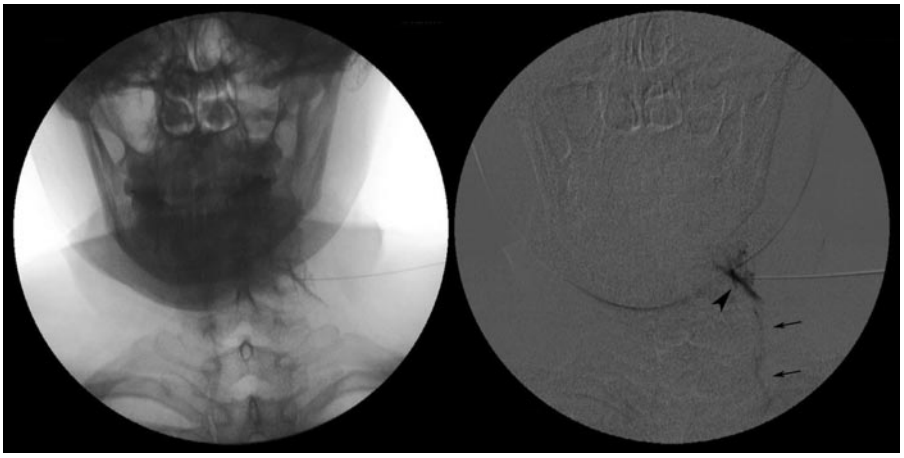

Figure 2. Anterior-posterior view of the cervical spine during cervical transforaminal injection demonstrating IV contrast injection. Left panel, image as seen on fluoroscopy. Right panel, image as seen with use of digital subtraction. The needle tip lies in the left C5/6 intervertebral foramen. Contrast outlines the spinal nerve within and lateral to the foramen (arrowhead) and digital subtraction clearly reveals that contrast extends laterally and inferiorly away from the spinal canal toward the central venous circulation (small arrow).

IV injection is common and intraarterial injection is rare, and that the two can be distinguished with imaging.

The first hint is discussed by Kim et al.[11] in this study: flow toward the midline. They tell us, "Eleven cases out of 71 cervical transforaminal epidural injections (TEI) (15%) showed vascular flow pattern on anterior-posterior view running to the vertebral column. However, there was a significantly different result in lumbar TEI; one case of intravascular uptake (0.9%) running toward the midline of vertebral column." Flow toward the spinal canal is consistent with arterial or venous flow, suggesting that 15% of cervical transforaminal injections in this series were potentially intraarterial before the needle was repositioned and this is alarming.

Are there better means to differentiate IV from intraarterial injection? The use of digital subtraction technology has been suggested.[9] There is little doubt that digital subtraction technology can enhance the visualization of small vascular structures by "subtracting" the digital image that exists before contrast injection from subsequent images, leaving the practitioner to see only the pattern of contrast flow without distracting overlying shadows. Most modern imaging equipment stores the digital subtraction runs as a series of individual frames and allows immediate playback of the images as a motion picture loop. In this way, the practitioner can reexamine the sequence of injection looking for subtle patterns of contrast flow. When continuous fluoroscopy is used without the capability of storing and reviewing a series of consecutive images, the practitioner must repeat the injection using additional x-ray exposure and contrast media. Most modern portable c-arms now have the capability to allow for routine use of digital subtraction. The difficulties described by Kim et al.[11] in distinguishing IV from intraarterial injection may have been reduced or eliminated by the addition of digital subtraction. Indeed, the brisk arterial flow toward the spinal canal and the clear delineation of the arterial supply to the spinal cord itself (Fig. 1) would seem difficult to confuse with the sluggish venous flow away from the spinal canal and toward the central venous circulation, also well delineated with digital subtraction (Fig. 2).

So, what have we learned from this study? The authors have confirmed that return of blood from the

needle during transforaminal injection, either passively or with aspiration, is not a reliable means to detect intravascular needle placement. They also confirm that intravascular injection is common and may be more common during cervical than lumbar transforaminal injection, appearing in as many as one third of these procedures. They clearly demonstrate that still radiographs, no matter when they are obtained during the course of the injection, cannot reliably detect intravascular needle placement. However, the current findings do not help us to understand how best to distinguish IV injection, which is unlikely to lead to serious sequelae, from intraarterial injection. Moreover, although no adverse events are reported in this small series, it is unclear what practitioners should do once they detect intravascular needle placement. Is it really safe to proceed with injection of particulate steroid after simply adjusting the position of the needle? It seems feasible that a portion of the steroid could be forced into the arterial system once the artery has been penetrated, even if the tip of the needle no longer resides within the arterial lumen. Finally, digital subtraction technology seems to offer some promise of improving the safety of transforaminal injection, but is in need of further study. Other critical questions also remain, foremost among them: should we move to the routine use of nonparticulate steroid or abandon the transforaminal technique altogether? For now, this new study reinforces the critical need for real-time imaging in detecting intravascular injection during transforaminal injection.

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