Digital Subtraction Imaging for Transforaminal Injections

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Myth: Digital subtraction imaging (DSI) reliably prevents inadvertent intravascular injection during transforaminal epidural steroid injections.

Fact: While DSI improves the rate of detection of intravascular injection, use of this technology does not guarantee the prevention of this occurrence or the associated potential consequences.

Complications specific to a transforaminal approach to epidural steroid injection are well described. Cerebral or spinal cord infarction is possible if particulate steroid is inadvertently injected into an artery that nourishes neural structures, such as the vertebral artery or a radiculomedullary artery [1,2]. Distinct from effects of particulate steroid, a small volume of local anesthetic inadvertently injected into the vertebral artery can provoke seizure [3-5]. While unintentional injection into venous structures does not create the possibility of cerebral or spinal cord infarction, deposit of injectate into the vascular system will decrease or eliminate the diagnostic and/or therapeutic effect of the intended injection. These considerations have resulted in the development of techniques and recommendations to reduce the possibility of intravascular injection during transforaminal epidural steroid injection (TFESI) [1,6]. Because of the poor sensitivity of techniques like aspiration and intermittent fluoroscopy, live fluoroscopy during contrast injection is considered the minimum standard for imaging during TFESI [1,7,8]. Furthermore, it has been suggested that the additional use of digital subtraction imaging (DSI) should be considered, though at the discretion of the provider [1].

DSI became commercially available in the 1970s and has been adopted as a common technique in the spinal intervention field [9]. During DSI a baseline image of the target region is obtained (the “mask image”) and then these pixels are subtracted from subsequent images obtained during a live run of fluoroscopy that is captured during the injection of contrast medium. This principle of pixel subtraction results in the ability to view radiopaque structures or substances that move during live fluoroscopy. As such, during a technically adequate DSI study, the flow of contrast medium is distinct from static spinal structures, and the ability to detect vascular flow is enhanced.

Multiple studies have demonstrated the ability of DSI to increase the detection rate of inadvertent vascular injection, which allows for needle repositioning prior to final deposition of the therapeutic injectate. In the majority of the published literature related to TFESIs, DSI increases the rate of detection of intra-vascular needle position compared to live fluoroscopy alone, though with significant variability. McLean et al. performed a retrospective analysis of cervical TFESIs, which demonstrated the rate of detection of vascular uptake of contrast medium nearly doubled with the use of DSI compared with only live fluoroscopy (33% vs. 18%, respectively; P=0.047) [12]. In a prospective study, Lee et al. also found that DSI compared with live fluoroscopy, blood flash, and aspiration combined substantially increased the rate of detection of vascular uptake of contrast medium (23% vs. 6%, respectively; p=0.039) [10]. Another prospective study demonstrated a small increase in the rate of detection of intravascular needle position with the use of DSI compared with live fluoroscopy, blood flash, and aspiration combined during cervical, lumbar, and sacral TFESIs, though this was not statistically significant (23% vs. 21%, respectively) [11]. One study reported no difference in the rate of detection of intravascular needle position when using DSI compared with live fluoroscopy alone [13].

This wide range of reported variation in detection of vascular flow likely relates to the ability of the operator to obtain an appropriate DSI study and to interpret the images [14]. Patient movement creating a poor mask...
image, lack of adequate contrast injection, and the lack of a wide anterior-posterior fluoroscopic view are variables that may reduce the quality of DSI studies and the ability of the operator to effectively assess the presence of vascular contrast flow [14]. Indeed, DSI is not an infallible technique to prevent intravascular injection, and further, the sensitivity for detection of arterial contrast flow, specifically, is unknown. A case of spinal cord infarction has been reported despite the use of DSI during a lumbar TFESI [15]. In this particular case, the images published demonstrate patient movement and an inadequate volume of contrast medium injected during the DSI study. While a case of cerebral or spinal cord infarction has never been reported in association with a technically adequate DSI study, the possibility of inadvertent intravascular injection remains.

In summary, the published evidence demonstrates superior sensitivity of DSI compared with live fluoroscopy alone in detecting inadvertent vascular injection. The degree of sensitivity of DSI for the detection of vascular flow is operator dependent. Importantly, use of this technology does not intrinsically guarantee detection of inadvertent intravascular injection.

Table 1: Elements of adequate DSI acquisition (adapted from cervical spine recommendations [14])

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<tr>
<th>Patient/fluoroscope positioning before initiation of DSI</th>
<th>Mask image</th>
<th>Volume of contrast medium injected during DSI</th>
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<td>• Obtain a true anteroposterior (AP) view of the spine.</td>
<td>• The mask image should ideally appear completely “washed-out” or “blank” and remain so during the DSI sequence.</td>
<td>• Sufficient contrast medium should be delivered in order to delineate the exiting nerve root and the ipsilateral epidural space.</td>
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<td>• Visualization of two spinal segmental levels above and below the site of injection OR visualization of the tip of the dens if the injection is performed at the C2-C3 neuroforamen should be obtained.</td>
<td>• If bony prominences are visualized but without a signal density significant enough to be confused with or obscure the observation of a vascular contrast pattern, this may be acceptable at the discretion of the operator, but is less ideal.</td>
<td>• At minimum, contrast medium should be delivered until spread to the medial aspect of the neuroforamen is observed. OR if contrast medium does not reach the medial border of the neuroforamen, extraradicular spill is visualized (ie, the foramen is too stenotic to allow passage of contrast medium).</td>
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<td>• The patient is appropriately prepared to remain motionless, suspend respiration, and refrain from swallowing.</td>
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<td>• If vascular contrast flow is visualized or suspected, the needle tip position must then either be adjusted or the procedure should be discontinued.</td>
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References


