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Technical Notes

Is Digital Subtraction Flouroscopy a Useful Tool for the Interventional Pain Physician?

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Most interventional pain physicians are experts in the use of fluoroscopy and understand its importance in improving the safety, accuracy and efficacy of diagnostic and therapeutic procedures. The addition of digital subtraction may enhance the utility of radiography and improve the accuracy of our interpretations. This article illustrates the use of the technique in several patients. The utility of this enhanced technique in clinical versus research application remains to be determined.

Keywords: Interventional pain medicine, fluoroscopy, epidural steroids, epidurogram

Fluoroscopy has become the standard for administering diagnostic and therapeutic spinal injections. The strength of evidence for the efficacy of various modes of spinal injection supports this, as detailed by Manchikanti et al[1]. Typically, the use of fluoroscopy is coupled to the injection of some radiological contrast to document proper placement.

In the case of epidural steroid injections by all routes this should result in an epidurogram. The epidurogram confirms proper placement but may also be useful in outlining filling defects that may assist diagnostically.

Digital pictures can be enhanced with a variety of controls such as contrast and brightness. Also arithmetic summations, differences or subtractions may combine two or more images of the same region pre- and postcontrast injection to yield an improved analysis of contrast spread. This is most commonly applied in angiography as recently reviewed by Gates and Hartnell (2). There may be a further role to explore in terms of the use of carbon dioxide as a digital subtraction contrast for patients allergic to injectable contrast agents, as described by Barbey et al (3); perhaps this could be even more safely applied in the epidural space than via intravascular method. The problem of motion artifact is reviewed by Meijering et al (4).

The claimed benefit of caudal adhesiolysis technique is that areas of filling defect on the initial epidurogram are overcome by catheter placement, manipulation and hydrostatic forces and, possibly, chemo-adhesiolysis (5); though evidence for this last point is weak. Digital subtraction can highlight the distribution of an epidurogram clearly.

ILLUSTRATION OF DIGITAL SUBTRACTION

The images accompanying this article were obtained before and after contrast injection and were downloaded to floppy disk. Digital subtraction was achieved with imaging software on a computer. Some fluoroscopy units have optional digital subtraction packages that would likely perform these steps automatically and faster.

Digital subtraction may be utilized in multiple areas in interventional pain medicine. Potential applications are as follows:

- Epidural injections,
- Discography, and
- Adhesiolysis.

Three illustrations using digital substraction of caudal epidural steroid injections with the catheter tip in the anterior epidural space near the left L5 pedicle are shown in Fig. 1.

Subtraction of the preinjection image from the postinjection image eliminates the majority of bone shadows. The filling defect at left L5-S1 is far more apparent on the subtraction image than on the plain epidurogram. To achieve this, the patient and fluoroscopy tube must be immobile and the images obtained at the same respiratory stage. Movement degrades the utility of this technique.

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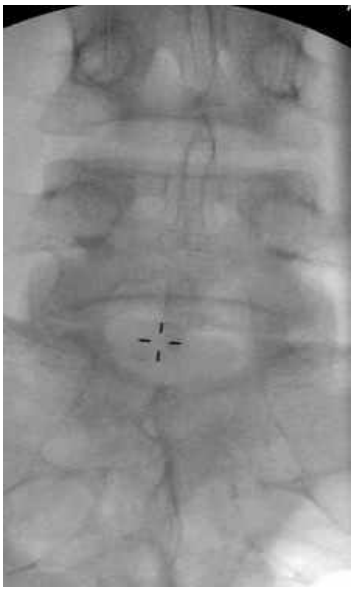

Fig. 1a. Preinjection image

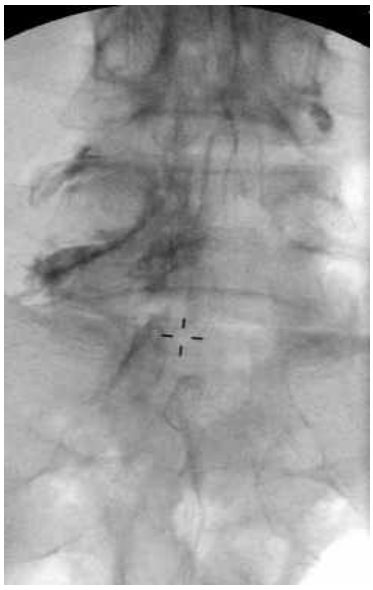

Fig. 1b. Post injection image

Fig. 1c. Subtraction image

Fig. 1. Comparison of caudal epidural steroid injection plain AP views and matching digital subtraction

Lateral subtraction views are also useful. The L5-S1 anterior epidural region is often difficult to see due to the traversing ilium and large articular processes. As seen in Fig. 2 the filling defect is clearly defined with subtraction. In this patient a large L5-S1 disc herniation is present on magnetic resonance imaging (MRI), (Fig. 2 a-b).

A filling defect such as this implies only a resistance to flow, with contrast following the path of least resistance. The contrast defect could be partially disc, partially ligament, induration, scar tissue or tumor.

Fig. 2a. MRI image

Fig. 2b. Subtraction Image

Fig. 2. Comparison of lateral views

Fig. 3 "a-d" shows plain anteroposterior views during the course of a caudal adhesiolysis, while "e-g" show digital subtractions. Fig. 3a is preinjection, and 3b follows 10 cc of caudal injected contrast before catheter placement. Fig. 3e is the subtraction of 3b-3a. Fig. 3c follows catheter introduction and injection of several cc of contrast into the filling defect and area of greatest symptoms at left L5. Fig. 3f is the subtraction of 3c-3a, revealing total contrast spread with the precatheter and postadhesiolysis injections. Fig. 3g is the result of subtraction of 3c-3b, demonstrating only the new areas filled following adhesiolysis. Fig. 3d follows 15 cc additional contrast and saline adhesiolysis. No release of the central L5-S1 adhesion occurred with this additional volume.

Cervical epidural steroid injections studied in this way are quite revealing. A typical AP epidural pattern perceived with conventional fluoroscopy for interlaminar epidural steroid injection with catheter typically reveals a "ladder"-like appearance and insignificant central or anterior spread. With subtraction far more diffuse spread is appreciated, and one better appreciates epineural sleeve filling. On regular lateral films, anterior spread is hard to appreciate, as the shoulders and head add a great deal of overlapping shadows. Subtraction reveals considerably greater central and epineural spread than would otherwise be appreciated (Fig. 4a-c).

Fig. 3a. Preinjection

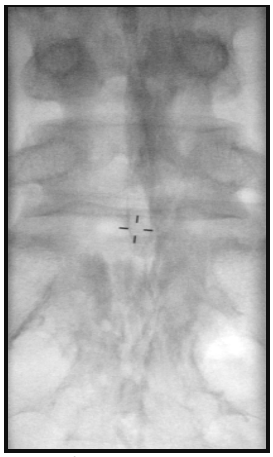

Fig. 3b. Following 10mL of contrast prior to catheter

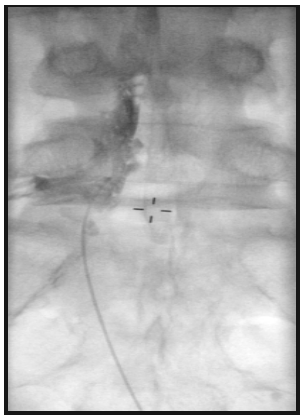

Fig. 3c. Following catheter introduction and injection of several mL of contrast into filling defect

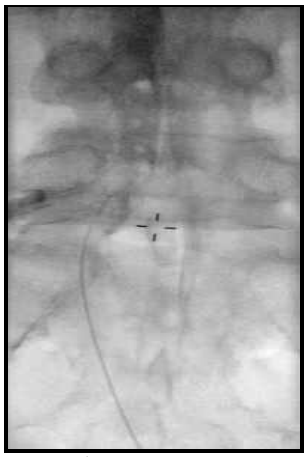

Fig. 3d. Following additional 15mL contrast and saline adhesiolysis

Fig. 3e. Subtraction of 3b-3a

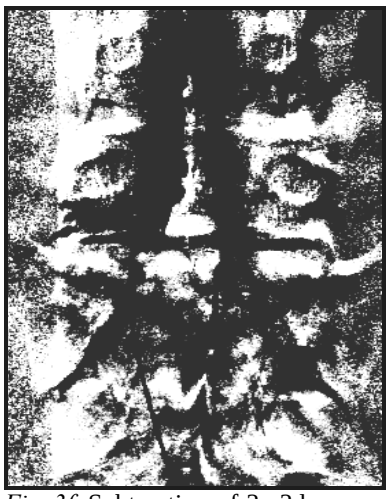

Fig. 3f. Subtraction of 3c-3d

Fig. 3g. Subtraction of 3c-3b

Fig. 3. Comparison of plain AP views during caudal adhesiolysis and matching digital subtractions

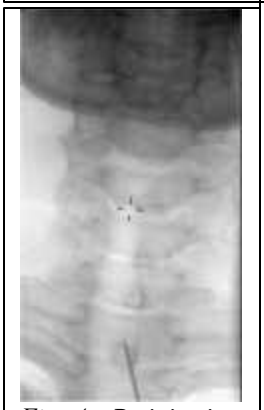

Fig. 4a. Preinjection

Fig. 4b. Post injection

Fig. 4c. Subtraction

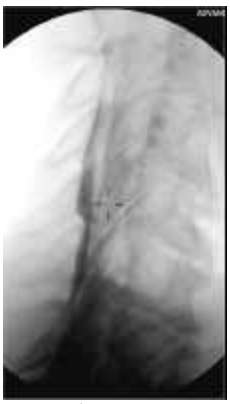

Fig. 4d. Regular lateral film

Fig. 4e. Subtraction

Fig. 4. Comparison of AP and lateral views during cervical epidural steroid injection and matching digital subtractions

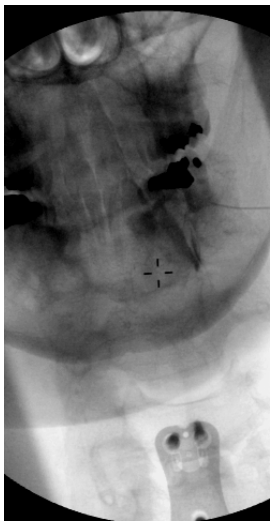

Fig. 5a. Transforaminal injection, regular film

Fig. 5b. Transforaminal injection, subtraction

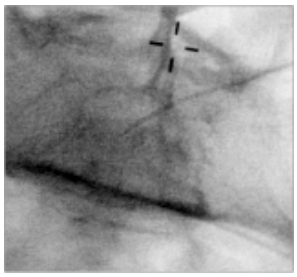

Fig 6a. Preinjection

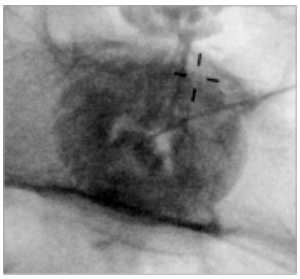

Fig 6b. Post injection

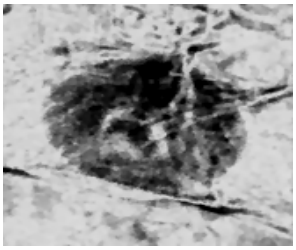

Fig 6c. Subtraction

Fig. 6. The pre and post injection images and a digital subtraction for one patient with demonstration of an annular tear already suspected by MRI

Subtraction is also helpful on a transforamenal injection, particularly at C3, as demonstrated in Fig. 5a – b.

Discography, a diagnostic and surgical planning tool, is primarily performed to demonstrate provocation of concordant pain via pressurization of the lumbar discs. It is considered a prerequisite test to fusion, annuloplasty or nucleoplasty. In addition to documenting the level of pain generation, it can demonstrate morphologic characteristics (6). This can be on plain films, or with the controversial and expensive addition of computerized tomography scanning postdiscography. Obtaining axial-like views pre- and postintradiscal contrast injection, one can subtract out the distracting elements and demonstrated pathology. With this technique the same requirement exists for maintaining the fluoroscopy and patient positions and respiratory cycle timing. Because some patients move when stimulated by provocative discography, this technique may have limitations.

Fig. 6 in left to right sequence are the pre- and postinjection images and a digital subtraction for one patient with demonstration of an annular tear already suspected from MRI.

CONCLUSION

Most interventional pain physicians are comfortable with fluoroscopy use and understand its importance in improving the safety, accuracy and efficacy of diagnostic and therapeutic procedures. The addition of digital subtraction may enhance the utility of radiography and the accuracy of our interpretations. There exists the possibility of using carbon dioxide as a contrast agent in patients sensitive to even nonionic contrast media, but this remains to be explored in interventional pain applications. Digital subtraction fluoroscopic interventional pain procedures could result in improved patient diagnosis, therapy assignment and therapeutic outcome. Further studies need to explore the actual clinical utility of digital subtraction for interventional pain procedures.

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