CONTINUING EDUCATION PROGRAM: FOCUS...

CT-guided transforaminal cervical and lumbar epidural injections

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Abstract Transformaminal injections are widely used. Serious complications including strokes and paraplegia have been reported after transforaminal injections of corticosteroids, and the Afssaps (2011) has issued a warning about their use\textsuperscript{[1]}. The needle must be positioned in the posterior aspect of foramen, and its correct placement validated by an injection of contrast product. It is preferable to choose cortivazol (Altim\textsuperscript{®}) as the corticoid for injection. This procedure is simple, reproducible, and durably effective in 60 to 70% of cases. Complications and adverse effects are rare but potentially serious: allergies, blood pressure surge, vasovagal syncope, transient exacerbation of pain, infection, stroke, and paraplegia. The aim of this course is to stress the need for rigor — in the indication, the technical performance of the procedure, and the overall management of the patient.

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Technique

In 2010, five radiologists (DC, SS, LA, ME, and VAB) performed 1529 CT-guided cervical and lumbar transforaminal injections in our establishment with two CT scanners (one GE Brightspeed Elite Advantage 16 - 2008 and one Brilliance 40 Philips - 2006). The injection was cervical in 24.4% of the cases, lumbar in 75.6%.

The physicians referring these patients were rheumatologists in 51% of the cases, general practitioners in 40%, neurosurgeons and orthopedic surgeons in 8%, and, more rarely, neurologists. Systematically, all patients who were referred for a cervical or lumbar injection procedure of any type, received with their appointment a letter (Appendix I) explaining the procedure, the contraindications, and incompatibility with some drugs.

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in particular anti-coagulants and platelet aggregation inhibitors. They also received an informed consent form (Appendix II). When appointments were made directly by the patients, as they often were, our trained secretaries also provided this information by telephone.

The day of the procedure: the patient brings his or her file with him; if not, the procedure is postponed.

The radiologist:
• sees the patient, questions him about his clinical symptoms, the different treatments already undertaken — manipulations, medications, physical therapy, injections, surgery, etc.;
• verifies that the patient's current condition presents no contraindications to the procedure:
  ◦ platelet aggregation inhibitor or anti-coagulant treatment that was not stopped either at all or for a long enough period,
  ◦ is the pain still present? It is not unusual for patients, while awaiting this appointment, to find their pain relieved by rest, sick leave, medical treatment, etc. In this case, we do not perform the injection,
  ◦ does he have an intercurrent infectious condition — general, bronchial, cutaneous, urinary or other? If so, the procedure is postponed to a later date to avoid any infectious complications,
  ◦ does he have any drug or other known allergies?
  ◦ does he have diabetes? If so, he is instructed to monitor his blood glucose very strictly for the week to come, and this is mentioned on the report to the general practitioner;
• examines the radiology file, which must include:
  ◦ standard radiographs to screen for a potential transitional abnormality, subluxation in standing position, etc.,
  ◦ a CT scan,
  ◦ or MRI, with injection of contrast product if necessary in patients with a history of surgery,
  ◦ any laboratory results with examination of hemostatic variables if the patient is under long-term treatment with platelet aggregation inhibitors,
  ◦ if no slice imaging was previously performed, we do so before the procedure, and we obviously discuss the indications for the procedure.

One or more skilled radiology technicians place the patient on the apparatus and explain the procedure to him to help him relax. The radiologist chooses the segment for the injection and informs the technician.

At what segment should the injection be performed?

In the cervical spine, the injection should go into the segment involved. For example, cervicobrachial neuralgia (CBN) involving the right side of C6 is injected at the right C5-C6 foramen. In the lumbar region, it depends on the site of the impingement; if it is foraminal or extraforaminal, the foramen is targeted; on the other hand if it is a postero-lateral discoradicular impingement, the foramen below is injected, to facilitate contact with the spinal ganglion of the corresponding root: injection for left L5 sciatica from a left L4-L5 posterolateral herniated disc is through the left L5-S1 foramen. In the cervical region, contrast product is injected intravenously to locate the vascular structures; this precaution is not necessary for the lumbar region. Helical acquisition is then centered on the involved segment, and four slices are positioned.

For the transforaminal cervical routes, the approach is anterolateral and the patient in the dorsal decubitus position; for transforaminal lumbar routes, the approach is posterolateral and the patient position ventral decubitus. Once the injection path has been identified, it is labeled on the skin. The technician then cleans the skin a first time with an antiseptic solution. The technician prepares a sterile table with all the necessary equipment. We use a Chiba short bevel needle — 22G. It should not be any thinner because that would increase the theoretical risk of catheterization or vascular trauma [2–4]. The skin is cleaned a second time, this time by the radiologist, who coats a sterile field. Then the patient is told that the puncture is beginning, and the needle is positioned in the posterior and external part of the foramen, immediately behind the spinal ganglion (Fig. 1). We aspirate for 8 to 10 seconds to verify the absence of blood reflux, although this absence does not guarantee that there is no vascular invasion [5–7]. Contrast product (Iodixanol, Visipaque 270) is injected (0.3 to 0.5 cc) slowly under clinical and CT-guidance (Fig. 2). If vascular opacification or a "washout" effect is observed, that is, if no opacification of the foramen is seen, the opacification is very probably arterial; the needle must then be repositioned, contrast product injected again, and the opacification verified.

Foraminal diffusion can appear lump-like. Leakage into the epidural space is often observed.

In no case do we force catheterization of the foramen: the injection is periangionic and not preganglionic. To optimize radioprotection, we minimize the irradiation constants, but can still follow the trajectory of the needle and the opacification of the foramen. The mean irradiation for patients is 61 cGy cm² in the cervical spine and 74 cGy cm² in the lumbar spine.

One to 2 cc of lidocaine hydrochlorate (Xylocaine® 10 mg/mL without preservatives) is injected very slowly into the lumbar region. We do not inject Xylocaine® into the cervical spine because of the proximity of the vertebral artery. No procedures are performed under sedation so that we

![Figure 1. Placement of the needle at the foramen entrance. 1: needle; 2: aorta; 3: radicular medullary artery; 4: spinal ganglion; 5: dural sac.](image-url)
can examine the patient, communicate with him and detect any complications or adverse effects as rapidly as possible. Then, 2 or 3 minutes after the lidocaine, very slowly, to avoid producing excessive pressure on the needle and potentially forcing it into a vascular vessel, we inject an ampoule of cortivazol (Altim®); we do not use acetate of prednisolone (Hydrocortancyl®) because its presentation is substantially larger (5 cc versus 1.5 cc), and it is known to form macroaggregates that can cause distal vascular emboli [8–11]. The puncture needle is then withdrawn and a local bandage placed, which the patient removes the following morning.

The pain is often reactivated in the lumbar region (two thirds of cases), whether the cause of the root compression is osteoarthritic or discal. Pain reactivation is rarer in the cervical region, probably because we do not use lidocaine there. Patients remain under observation in the CT preparation room for 30 to 60 minutes, in armchairs after cervical procedures and on stretchers after lumbar injections. We recommend that someone come with them and especially that they not drive themselves home. We also advise them to rest for 24 to 48 hours and to see the physician who prescribed the procedure within 2 to 4 weeks. As part of the continuity of care, we are of course at their disposition to see them in case of any problem, and can be contacted by a telephone hotline. All percutaneous procedures are performed on an outpatient basis, but in a healthcare facility with anesthetists/critical-care specialists, cardiologists, etc., available onsite. The CT room contains resuscitation equipment that is checked regularly.

What are the indications for CT-guided transforaminal injections?

Radicular pain, related to disc impingement or osteoarthritic stenosis of the foramen or the lateral recess, is the indication for this type of injection. It must not be a first-line treatment; it should only be performed after appropriate medical treatment, including rest and oral medication for 3 to 4 weeks. In 21% of cases, a second procedure was performed soon after the first (4 to 6 weeks later). In 19% of cases, the patient had already had spinal surgery, on the same or an adjacent segment.

What is the mechanism of action of these local anti-inflammatory agents? [12,13]

Radicular pain is related to several factors:
• mechanical, of course, by compression linked to a herniated disc or osteoarthritic stenosis;
• this compression engenders a molecular reaction with the release of disc decay products (prostaglandin and phospholipase A2);
• inflammatory reaction (response to the decay products);
vascular reaction to venous congestion in the foramen and edematous reaction through the increase in vascular permeability.

Anti-inflammatories can act locally, directly on the inflammation factors.

Complications recorded in our series

• three blood pressure surges (0.2%): all three cases involved patients under treatment for hypertension (two lumbar injections and one cervical). This surge occurred immediately after the procedure in one case and 15 minutes afterwards in the other two. It was accompanied by a sensation of malaise, with headache; blood pressure soared above 210/160. Venous access was placed for the lumbar procedures and kept for the cervical one; pulse, blood pressure, and ECG monitoring began in the preparation room, and the on-call cardiologist was called immediately for management in the intensive care unit. One patient was hospitalized for 24 hours; the other two were allowed to return home after several hours of observation and were advised to see their general practitioner and/or their cardiologist to verify their blood pressure later;

• thirty-five vasovagal synapses (2.3%), all spontaneously resolved after leg elevation. In three cases, it occurred before the procedure, during the establishment of brachial venous access, before the percutaneous cervical procedure;

• five cases of allergic reactions (0.3%) occurred, with dyspnea and facial erythema; all resolved rapidly after an IV injection of 200 mg of hydrocortisone hemisuccinate. Patients with a history of allergies were premedicated according to standard procedures before we began. In cases of known allergies to iodinated contrast product, we do not inject it before the steroid injection. In these cases, the aspiration maneuvers are longer and the procedure must be performed with CT and not fluoroscopy;

• reproduction of the pain during the procedure must not be considered a complication: it is very frequent (65%) in the lumbar region, sometimes accompanied by the onset of paresthesia secondary to the injection procedure; this resolves in a period between several minutes and a half-hour. We routinely keep the patients lying down on a stretcher. Should these very frequent episodes of paresthesia lead us to omit the Xylocaine® injection that precedes the Altim® injection, as we do in the cervical spine? This injection can be recommended as a test-dose before that of the corticosteroid to observe a potential neurological complication that would be only transient after lidocaine [14];

• an increase in radicular pain in the days following the injection is fairly frequent, reported in 37.4% of the cases in Huston’s series [15], especially in the cervical injections. We have made similar observations.

Should interlaminar injections be performed more often?

In the cervical region, interlaminar procedures are more difficult for patients, and complications including subdural hematomas or direct puncture of the spinal cord have been described [16,17]. They are sometimes performed under sedation [18]; the risk of missing an acute complication is then much greater. At the lumbar level, the procedure is simple; it is often less painful than a transformaminal procedure because it does not cause transient exacerbation of the radicular pain. Nonetheless, in cases of postoperative pain, the placement of the needle can also be dangerous because of post-laminectomy remodeling, with a risk of epidural hyperemia and therefore of increased vascular passage of the corticoid [19]. The complications may be delayed because of the puncture site (epidural hematoma). When radicular impingement is the cause of the pain, the foraminal site of the injection procedure is logical: corticosteroids are injected at the very seat of the radicular impingement. On the other hand, when the patient complains of lumbar, sciatica or alternating sciatica, a posterior epidural injection is probably more logical. The technique must also be extremely rigorous.

Should the transformaminal injections be performed under videofluoroscopy with digital subtraction angiography?

Arterial passage of contrast product is probably best identified by fluoroscopy or during an angiographic series, but only for expert eyes, experienced in angiography. These arteriographies have been almost totally replaced by CT-angiography or MRI-angiography, however, and this change makes it more difficult to train young radiologists. Moreover, the simplicity of needle placement under CT-guidance is such that it is probably fairly easy to learn to perform this technique rigorously to avoid the error of vascular and especially arterial introduction of the product.

What other complications have been observed and reported in the literature?

Wybier has collected several cases of dramatic complications, recently observed and reported in the literature. These led to the Afsaps warning issued in March 2011 [1,8–11,14,16].

Twelve dramatic complications with strokes or para- or tetraplegia have been reported, none with Altim®. These complications are probably linked to arterial embolus, due in turn to particulate injections. The size of the particles depends on the corticoid injected [20], soluble in aqueous media (Altim®) or non-soluble, in a microcrystalline suspension with a tendency to clump (Hydrocortancyl®).

The molecules that transport glucocorticosteroids can also be toxic (benzyl alcohol, polyethylene glycol) [21]. A direct breach of a branch of the radiculomedullary artery by the needle in the foramen can lead to a spasm or cause an embolism and an infarction.

These arterial complications are linked to the anatomy of the foramen and the vascularization of the spinal cord by the anterior spinal axis (ASA), which is fed by the anterior radiculomedullary arteries. The largest of these is the Adamkiewicz artery, which vascularizes the thoracic spinal cord and the terminal cone. It arises most often on the left, from an intercostal branch but it can also develop on the
right or from a lumbar or even sacral branch. Another large arterial branch begins in C5 or C6 and provides blood to the cervical enlargement. The arterial branches penetrate the foramen and the dura mater along the entire path where the nerves emerge; these arteries then divide into dural branches. There are also posterior spinal arteries, which are very variable, less systematized, and much thinner.

There is thus a great anatomical variability in the source of the arteries feeding the spinal cord. Normally, radicular arteries enter the anterior part of the foramen, medial to the spinal ganglion. Nonetheless, a recent study by Huntoon of dissections of the cervical spine [22] shows that the branches of the deep and ascending cervical arteries could enter the foramen in its posterior aspect, which is the target for the injection. These branches can participate in spinal cord vascularization. Moreover, in the case of osteoarthritic or postoperative remodeling, these anatomical relations may change. Both these facts demonstrate the complexity and variability of arterial positions in the intervertebral foramen.

Venous structures are also present, more or less dilated, located outside the spinal ganglion. Their distribution has previously been studied by lumbar phlebography, which showed epidural lumbosacral venous plexuses, pushed back by hernias or dilated upstream of a stenosis [5]. The epidural veins are also complex and connected with spinal cord veins [23]. According to Candido, the use of specific needles, with curved tips or a lateral orifice, does not seem to prevent the intravascular passage of products effectively [4]. On the other hand, Scanlon et al. recommends using these specific needles [24].

What needles should be utilized? Not thinner than 22G, that is, approximately 400 μ in diameter.

Aspiration by the needle before any injection of corticoids or Xylocaine® does not suffice to avoid intravascular injection [5–7]. Other complications have been documented:

- one case of epidural hematoma has been described after transforaminal injections [16]. The hematoma may be linked to venous bleeding; the clinical symptoms appeared several days after the procedure. The authors reported that injection of contrast into the epidural venous plexus is probably more difficult to authenticate than intra-arterial passage, thus pointing out the importance of good image quality. This complication occurs more commonly after interlaminar epidural injections;
- headaches were described; they are very rare in transforaminal injections and more frequent in epidural procedures. In this case, they are a sign of an unnoticed meningeal breach. They most often resolve spontaneously in several days. When they persist, a blood patch must be placed;
- infectious complications are always a threat. They have been described in transforaminal, epidural, and interfacet injections. Nonetheless, no published series exists. Spondylodiscitis, meningitis, and epidural abscesses have been reported. These complications are extremely rare [25,26]. In a review of complications of injections by rheumatologists published by Barden in 2002, the rate of infectious complications was determined to be 1/77,300 cases [27];
- metabolic disorders, especially, blood glucose. Strict monitoring of blood glucose should be recommended to patients with diabetes.

Discussion

Complications are very rare in both transforaminal and interlaminar injections and are essentially the same in both groups [19]. The technique must be meticulous, rigorous, and reproducible. The files must be examined and the clinical appropriateness of the planned procedure verified. The needle must be placed very precisely, under either CT or fluoroscopic guidance, with contrast product injected to assess the diffusion space. Only then should the corticoid, which must be cortivazol, be slowly injected. Compliance with all of these requirements should limit the complications.

This procedure involves teamwork with radiology technicians, who must be trained very specifically and in detail, as for all interventional procedures. Always bear in mind the great variability in foraminal, dural, epidural and medullary vascularization and the possibility of postoperative changes or venous engorgement in stenotic foramina. Nonetheless, zero risk does not exist. Schaufele [19] estimated that the risk of a dramatic complication following a transforaminal corticoid injection ranges from 1/100,000 to 1/1,000,000. But these are only statistics.

The alternative of interlaminar injections also carries additional risks, including epidural hematomas or direct trauma to the spinal cord. Moreover, it may be equally inappropriate to recommend this interlaminar approach to patients with previous spinal surgery, given that postoperative ligament and epidural remodeling can promote the onset of complications [11]. Nor is the interlaminar injection as effective for radicular pain as the transforaminal procedure [28]. Some authors recommend posterior articular approaches for the cervical spine and epidural for lumbar and only for spines which have had no surgery [29]. This is therefore very reductive, especially since these are often young or working patients who have already had several treatments that did not help (oral and injectable medication, physical, physical therapy, etc.). Efficacy has been demonstrated at both the cervical and lumbar levels: 65 to 70% of patients report durable pain relief (mean duration 15 months) with improvement at the end of 13 days, on average [13,30]. Several simple rules should be borne in mind to minimize the risks [14]:

- never perform these procedures under sedation;
- place the tip of the needle in the posterior aspect of the foramen;
- inject contrast product;
- for lumbar procedures, inject a test dose of lidocaine and wait 2 or 3 minutes before injecting cortivazol.

Conclusion

The use of these types of injections must continue, but it is essential to stress both the need for rigor in the performance of this procedure and the importance of the training of interventional radiologists specializing in the spine to standardize practices and minimize risks. Both the physicians prescribing
these procedures and those performing them must be perfectly aware of all of these risks. The patient must also be informed about the technique, the risks involved and the estimated success rate of 65 to 70%, as well as of the need to rest for 24 to 48 hours after the procedure [13,30].

**TAKE-HOME MESSAGES**
- Rigor in the examination of the patient and the file and in performing the procedure.
- Performance of the procedure in a healthcare facility.
- Important role of the radiology technician in patient placement and in pinpointing locations.
- Standardized training in interventional radiology.
- Know all the potential risks.

**Disclosure of interest**

The authors declare that they have no conflicts of interest concerning this article.

**Appendix I.**

Madam, Sir:
You are expected on the ............... for a radiology examination.

So that it can take place in the best possible conditions, we ask you to follow the instructions below:

**For the examination,**
- Bring with you all documents concerning examination, images from radiography, CT, MRI…
- Plan to have someone accompany you if you know how to drive (possible pain).
- If you are or think you might be pregnant, please let us know.

**The Secretariat of Radiology**

**Appendix II. Informational letter before spinal corticoid injection under CT or fluoroscopic guidance**

Madam, Sir:

Your physician has prescribed a spinal injection to treat cervicobrachial neuralgia or sciatica due to impingement in the vertebral column or low back pain.

This injection is often effective in relieving this pain. Nonetheless it may involve some complications that you must be informed about:
- Bleeding complications (hematoma); thus the examination cannot be performed if you are taking an anti-coagulant treatment or platelet aggregation inhibitor (ASPIRIN, PLAVIX). These treatments (except for posterior articular and sacroiliac injections) must be stopped several days before the procedure, possibly replaced temporarily by injections of low-molecular-weight heparin, depending on the case (to see with your general practitioner);
- Infectious complications (abscesses);
- Allergy to iodine, because as a general rule we inject an iodinated contrast product before the main injection to verify that the corticosteroid is not being injected in a blood vessel.

Most often, this would be a simple urticaria (hives), but more serious allergic accidents (asthma, giant urticaria, and anaphylactic shock) have been observed, fortunately very rarely.

Please tell us if you have a history of allergy to iodine or of severe allergies to other substances; anti-allergic premedication for three days might be necessary, depending on the situation:
- Complication associated with the metabolic activity of injectable corticosteroids and, in particular, loss of diabetes control;
- You must also be informed of the very rare risk of a neurological accident after transforaminal injections:
  - Tetraplegia (paralysis of four limbs) after cervical injection,
  - Paraplegia (two lower limbs) after lumbar injection,
  - Cerebrovascular accident (stroke).

These accidents are extremely unusual (several cases described in the literature, and not with the corticoid that we use).

**After the injection:**

You are advised to rest for 24–48 h.

It is possible to perceive unusual pain in the back, arm or in leg in the days after the injection; it is probably caused by the injected corticoid, a suspension that contains small crystals that can trigger an inflammatory attack. In this case,
the pain will disappear progressively over several days; it should be controlled by an ice bag and minor analgesics (DOLIPRAN).

On the other hand, please contact us if this pain persists for more than a week without diminishing, if it increases progressively after a week, or if you have a fever: we will arrange to see you to look for a rare infection associated with the puncture. Attention, do not confuse this unusual pain caused by the corticoid with the pain for which we are performing the injection! That can persist longer than one week without being abnormal. Sometimes it may take 2 to 3 weeks before observing improvement in the pain after injection.

We are at your disposition for any additional information. I ____________

consent to the performance of a spinal injection.

Date:
Signature:

Please bring this sheet, signed, with you to your appointment, together with your radiology files and your physician’s prescription.

References


