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Cervical Transforaminal Injection of Steroids

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CERVICAL radicular pain is pain perceived in the upper limb caused by irritation of a cervical spinal nerve. It affects approximately 1 person per 1,000 population per year¹ and is most often caused by a disc herniation or foraminal stenosis. Its natural history can be favorable,² but not all patients recover naturally. Many remain severely disabled and require treatment.

Surgery is the mainstay of treatment.^{3,4} For relieving cervical radicular pain, surgery has a good reputation, but scientifically, it is based only on multiple observational or descriptive studies.² However, surgery is not without risks and constitutes a major undertaking for patients.

Conservative therapy, typically including graduated exercise and oral analgesics, is supported only by observational studies, which have not controlled for natural history or nonspecific effects of treatment. Some have reported complete resolution of pain and neurologic dysfunction in as many as 80% of cases,^{5,6} but others have attested to resolution of radiculopathy in less than 40%.^{7,8} The controlled studies that have been conducted have shown no significant benefit for traction⁹⁻¹¹ or exercises.¹⁰

The failure of conventional, conservative treatments to provide a cure for cervical radicular pain fostered the development of alternatives. Prominent among these has become transforaminal injection of steroids.

Rationale

The rationale for injecting steroids is that they suppress inflammation of the nerve, which, in many instances, is believed to be the basis for radicular pain.^{12,13} The rationale for using a transforaminal route of injection

rather than an interlaminar route is that the injectate is delivered directly onto the target nerve. This ensures that the medication reaches the site of the suspected pathology in maximum concentration.

Anatomy

At typical cervical levels, the ventral and dorsal roots of the spinal nerves descend in the vertebral canal to form the spinal nerve in their intervertebral foramen. The foramen faces obliquely forward and laterally. Its roof and floor are formed by the pedicles of consecutive vertebrae. Its posterolateral wall is formed largely by the superior articular process of the lower vertebra and in part by the inferior articular process of the upper vertebra and the capsule of the zygapophysial joint formed between the two articular processes. The anteromedial wall is formed by the lower end of the upper vertebral body, the uncinat process of the lower vertebra, and the posterolateral corner of the intervertebral disc. Immediately lateral to the external opening of the foramen, the vertebral artery rises closely in front of the articular pillars of the zygapophysial joint (fig. 1).

The spinal nerve, in its dural sleeve, lies in the lower half of the foramen. The upper half is occupied by epidural veins. The ventral ramus of the spinal nerve arises just lateral to the intervertebral foramen and passes forward and laterally onto the transverse process. Radicular arteries arise from the vertebral artery and the ascending cervical artery and accompany the spinal nerve and its roots to the spinal cord.

Technique

Cervical transforaminal injections can be performed with the patient lying in a supine, an oblique, or a lateral decubitus position, depending on operator preference and patient comfort. The position must allow adequate visualization of the cervical intervertebral foramina in anteroposterior, lateral, and oblique planes.

The critical first step is to obtain a correct oblique view of the target foramen. In this view, the foramen is maximally wide transversely, and the anterior wall of the superior articular process projects onto the silhouette of the lamina. Through a puncture point overlying the posterior half of the target foramen, a needle is passed into the neck. Its tip should always lie over the anterior

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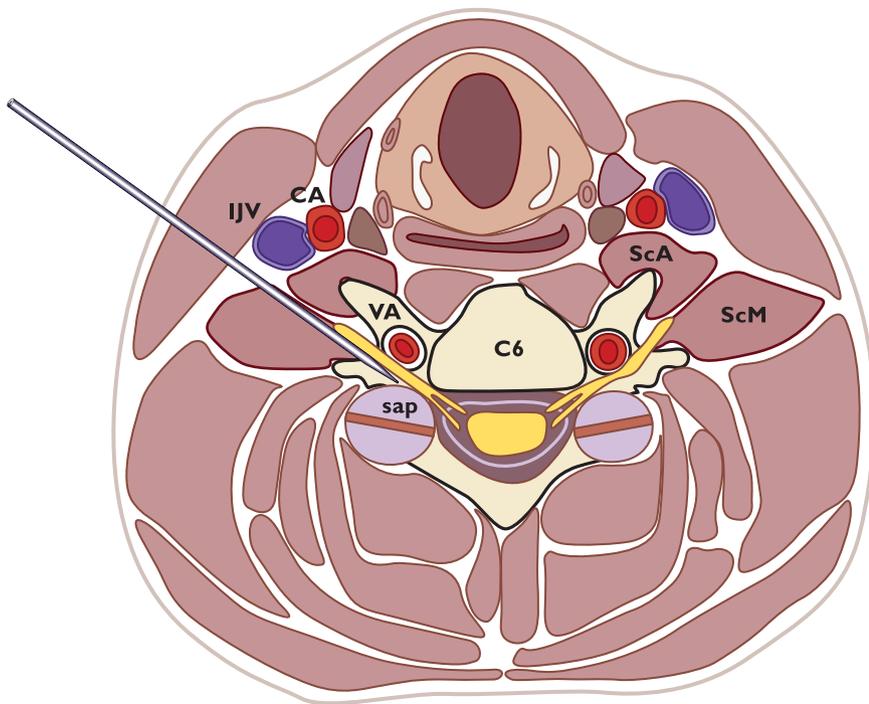


Fig. 1. Illustration of an axial view of the cervical intervertebral foramen and adjacent structures at the level of C6 with a needle inserted parallel to the axis of the foramen along its posterior wall. Note the proximity of adjacent structures: C6 = vertebral body of C6; CA = common carotid artery; IJV = internal jugular vein; sap = superior articular process of C5–C6 zygapophysial joint; ScA = anterior scalene muscle; ScM = middle scalene muscle; VA = vertebral artery.

half of the superior articular process, lest it be inserted prematurely and too far into the foramen. When the needle has reached the superior articular process, the needle is then readjusted to enter the foramen tangential to its posterior wall, opposite the equator of the foramen (fig. 2A). Above this level, the needle may encounter veins; below it, the needle may encounter the spinal nerve and its arteries.

Using an anteroposterior view, the tip of the needle

should finally be adjusted to lie opposite the sagittal midline the articular pillars. Insertion beyond this depth risks puncturing the dural sleeve or thecal sac. The final position should be checked and recorded on an oblique view (fig. 2A), which documents placement against the posterior wall of the foramen, and on an anteroposterior view (fig. 2B), which documents depth of insertion.

Under direct, real-time fluoroscopy in the anteroposterior view, a small volume of nonionic contrast medium

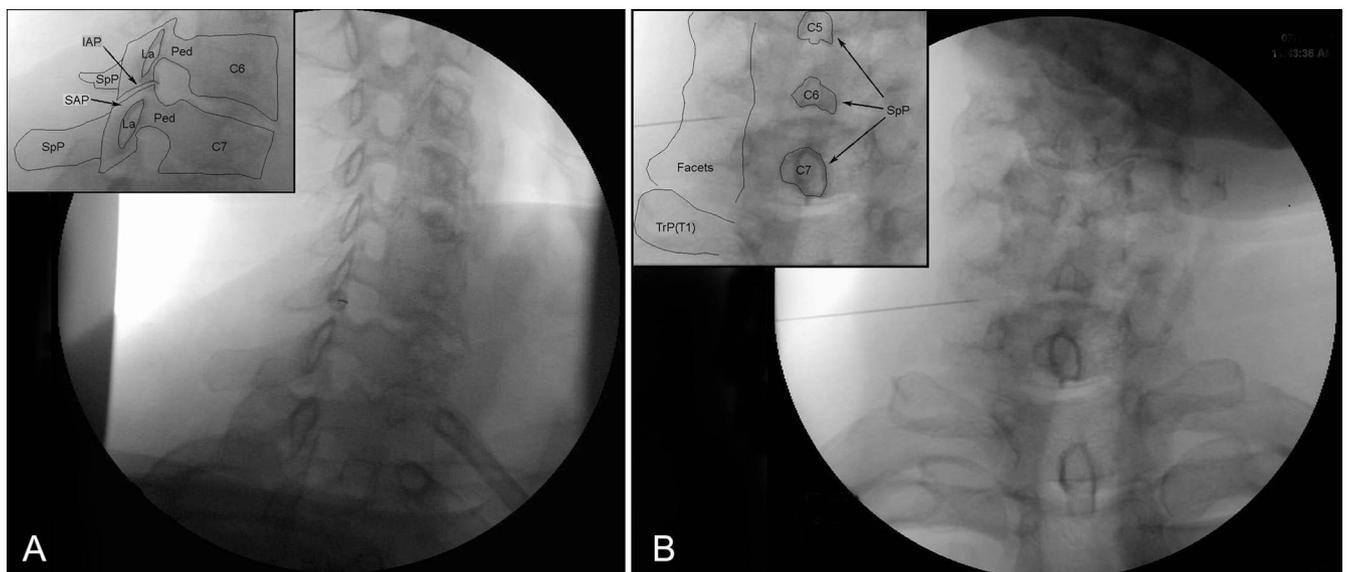


Fig. 2. (A) Right anterior oblique radiograph demonstrating a needle in position along the posterior aspect of the right C6–C7 intervertebral foramen. *Inset* of midportion of image with bony structures labeled: C6 = C6 vertebral body; C7 = C7 vertebral body; IAP = inferior articular process; LA = lamina; Ped = pedicle; SAP = superior articular process; SpP = spinous process. (B) Anteroposterior radiograph demonstrating needle in final position within the right C6–C7 intervertebral foramen. The needle lies halfway between the medial and lateral borders of the articular pillars. *Inset* of midportion of image with bony structures labeled: Facets = medial and lateral aspect of the facet column; SpP = spinous processes of C5, C6, and C7; TrP (T1) = transverse process of T1.

Fig. 3. Anteroposterior radiograph demonstrating needle in final position within the right C6–C7 intervertebral foramen after injection of 1 ml radiographic contrast medium (180 mg/ml iohexol). Contrast outlines the exiting nerve root (*arrowheads*) and extends along the lateral aspect of the epidural space below the foramen (*small arrows*).



(1.0 ml or less) is injected. The solution should outline the proximal end of the exiting nerve root and spread centrally toward the epidural space (fig. 3). Real-time fluoroscopy is essential to check for inadvertent intraarterial injection, which may occur even if the needle is correctly placed (fig. 4). Intraarterial injection is manifest

by rapid clearance of the injected contrast. Contrast medium may also fill epidural veins, which are recognized by the slow clearance of the contrast, characteristic of venous flow.

Only a small volume of contrast medium (1.0 ml or less) is required to outline the dural sleeve of the spinal

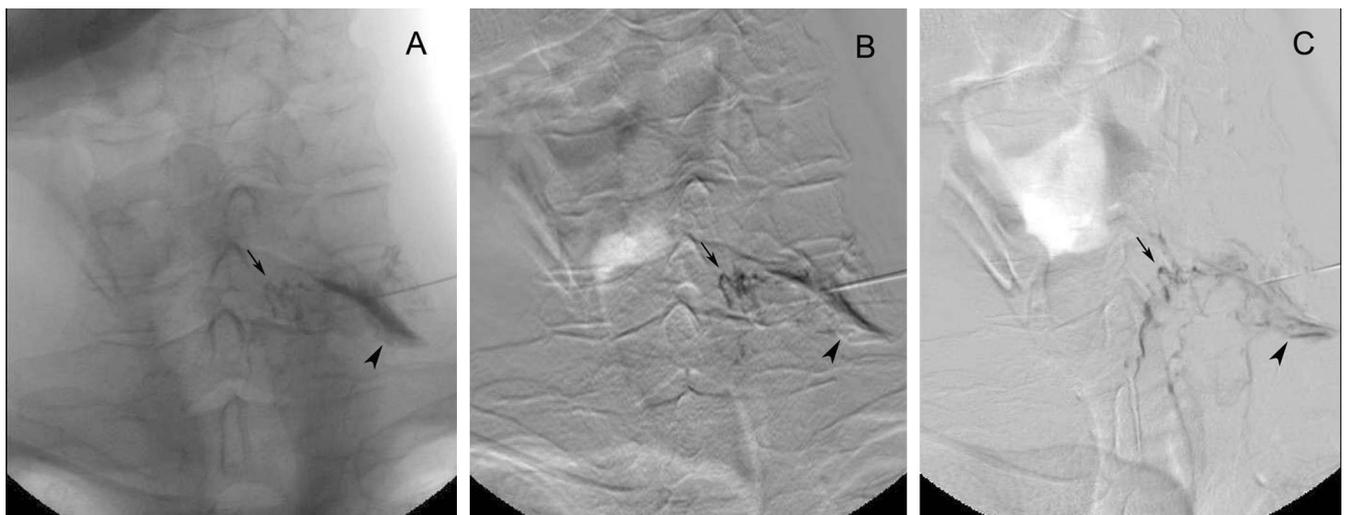


Fig. 4. An anteroposterior view of an angiogram obtained after injection of contrast medium, before planned transforaminal injection of corticosteroids. (A) Image as seen on fluoroscopy. The needle lies in the left C7–T1 intervertebral foramen no further medially than its mediolateral point. Contrast medium outlines the exiting nerve root (*arrowhead*). The radicular artery appears as a thin thread passing medially from the site of injection (*small arrow*). (B) Digital subtraction angiogram reveals the radicular artery extending medially more clearly (*small arrow*). (C) Digital subtraction angiogram after pixel-shift reregistration reveals that the radicular artery (*small arrow*) extends to the midline to join the anterior spinal artery.

nerve. As it spreads onto the thecal sac, the contrast medium assumes a linear configuration (fig. 3). Rapid dilution of the contrast medium implies subarachnoid spread, which may occur if the needle has punctured the thecal sac or a lateral dilatation of the dural root sleeve into the intervertebral foramen. When the target nerve has been correctly outlined, a small volume of a short-acting local anesthetic and corticosteroid are injected.

Indications

The indication for cervical transforaminal injection of steroids is for the treatment of cervical radicular pain with or without radiculopathy. The difficulties in making this diagnosis have been reviewed elsewhere.¹⁴ The only constant feature of cervical radicular pain is pain in a dermatomal distribution (the distribution of referred symptoms caused by cervical root irritation), which may resemble the distribution of classic dermatomal maps for cervical nerve roots but not infrequently is provoked outside of the distribution of these classic dermatomal maps.¹⁵ Confidence in the diagnosis is enhanced if the patient also has radiculopathy, but this may not always be the case. Paresthesias, segmental numbness, weakness, and loss of reflexes are reliable and valid signs of radiculopathy that allow the diagnosis to be made clinically, without recourse to investigations. Disc protrusion and foraminal stenosis are the most common causes, but diagnostic imaging is required to exclude tumors and other infrequent causes such as infection, trauma, or inflammatory arthritides.¹⁶

Efficacy

In a prospective cohort study, Bush and Hillier¹⁷ treated 68 patients with cervical radiculopathy using a sequence of procedures in which patients who failed to respond to an injection of corticosteroids into the scalene region were treated with a transforaminal injection; those who failed to respond to transforaminal injection were, in turn, treated with an interlaminar injection of steroids. They reported that 76% of patients achieved complete relief of arm pain, but it is not possible from their report to derive what proportion responded explicitly to transforaminal injections.

Slipman *et al.*¹⁸ reported a retrospective analysis of transforaminal injection of steroids in 20 patients with cervical radicular pain due to cervical spondylosis and clinical, radiographic, and electrodiagnostic findings consistent with nerve root involvement due to foraminal stenosis. Outcomes were measured using a functional outcome categorization that combined measures of pain, work status, medication use, and patient satisfaction. The investigators reported pain reduction, return to full-time work status, reduction or elimination in analgesic

use, and satisfaction with treatment in 60% of patients at 12–45 months' follow-up (average, 21.7 months) after treatment with an average of 2.2 injections.

Using a prospective cohort design, Vallee *et al.*¹⁹ performed transforaminal injection of steroids in 30 patients with cervical radicular pain of more than 2 months' duration and foraminal stenosis observed on computed tomography or magnetic resonance imaging. They observed greater than 75% diminution or complete resolution of pain in 53% of patients at 6 months after an average of 1.3 injections. At 3 months, 29% of patients had complete resolution of pain. This proportion persisted at 6 months but diminished to 20% at 12 months. At 3 months, an additional 29% of patients reported at least 50% diminution of their pain. This proportion persisted at 6 months but decreased to 18% at 12 months.

Together, the studies of Slipman *et al.*¹⁸ and Vallee *et al.*¹⁹ suggest possible efficacy of cervical transforaminal injections of corticosteroids. They suggest that some 30% of patients can obtain partial but lasting relief of their pain, and a further 30% can obtain complete relief. However, these studies were observational studies without any comparison treatment. Their outcomes may be due to the natural history of cervical radicular pain syndromes or nonspecific treatment effects.

Cervical epidural steroids placed by the interlaminar route have also been advocated for the treatment of radicular pain.^{20–22} The reported studies have been retrospective, often with short or unstated periods of follow-up. They attest to variable efficacy, with 0–29% of patients obtaining complete relief of pain and between 0 and 40% of patients achieving at least 75% relief after 6 months.^{20–25} There have been no studies published to date comparing translaminar *versus* transforaminal approaches to epidural steroid injection.

Complications

Some investigators have reported no complications resulting from the use of cervical transforaminal injection of steroids.²⁶ This has not been the case in other situations. The literature reports one case of fatal spinal cord infarction attributed to a transforaminal injection of corticosteroids.²⁷ As well, the current authors are aware of three other cases in Australia, another in Europe, and 11 in the United States, in which patients have experienced severe neurologic sequelae, including spinal cord or brainstem infarction. These cases have not been published in the literature either because they are still *sub judice* or because lawyers and patients have declined to have their case records released into the medical literature.

In some of the unpublished cases, it seems that steroids have been injected into the vertebral artery. Correct needle placement should ensure that the needle is not in the vertebral artery, and due attention to the flow of a test dose of contrast medium would reveal if it is.

In the published case, and in most of the unpublished cases, no radiographic records are available to establish exactly where the needle was placed. In these cases, the basis for neurologic complications remains unclear. The leading conjecture has been that, somehow, a radicular artery was compromised.

Baker *et al.*²⁸ reported a case in which a transforaminal injection was initiated at the C6–C7 level. Digital subtraction, real-time fluoroscopic imaging revealed contrast medium filling a tiny vessel that ran transversely, directly to the spinal cord: clearly a radicular artery. On seeing this image, the operator promptly abandoned the procedure. The patient experienced no ill effects.

These cases provide circumstantial evidence of the mechanism of spinal cord injury after cervical transforaminal injection of steroids. Material can be injected inadvertently into radicular arteries. It seems feasible that particulate matter in depot preparations of corticosteroids might act as an embolus, and if it enters an artery that happens to be a critical reinforcing supply to the anterior spinal artery, the spinal cord would be infarcted. Large caliber vessels that reinforce the anterior spinal artery are variable in incidence and in location and can occur anywhere from C3 to C8.²⁸

Longitudinal spread of intraneuronally injected local anesthetic can lead to unexpected spinal anesthesia.²⁹ It is also feasible that intraneuronal injection of steroid solution with longitudinal spread to the spinal cord could result in spinal cord injury.

Discussion

A compelling evidence base for conservative treatment of cervical radicular pain is lacking, and patients with severe pain may not benefit from conservative therapy. The choice then lies between surgery and transforaminal injection of steroids.

There have been no controlled studies of cervical transforaminal injection of steroids. Consequently, their efficacy has not been established. Nevertheless, the results of observational studies render transforaminal injection of steroids an option.

Similarly, the efficacy of surgery has not been demonstrated by a prospective, randomized, controlled trial. The one controlled trial, conducted in Scandinavia, found surgery to be no more effective than conservative therapy,³⁰ but the outcomes from surgery in that study were considerably worse than those reported in observational studies conducted in the United States and Australia.² Those observational studies variously attest to good or excellent outcomes in anywhere from 53% to more than 90% of cases. No studies, however, have reported exactly what proportions of patients are rendered completely pain free or for how long.

The singular disadvantage of cervical transforaminal

injection of steroids is the risk of serious complications. Were it not for the risk of spinal cord injury, cervical transforaminal injection of steroids would probably find a place in the management of cervical radicular pain, even in the absence of controlled studies.

The incidence of serious complications from cervical surgery is not known. If these are similar in nature and similar in incidence to those of cervical transforaminal injections, some proponents of injections would argue that the risk of complications is not grounds for denying patients the option of treatment with injections.

There is clearly a need for better data on the efficacy of cervical transforaminal injection of steroids as well as surgery for radicular pain. To this end, a comparison of surgery and cervical transforaminal injection of steroids in a prospective clinical trial is warranted. There is also a need for accurate data on the incidence of complications from either treatment.

It is disappointing that lawyers, the practitioners involved, and their patients have not released the available material regarding complications. That information could shed light on how the complications occurred. Intraarterial injection might prove not to be the mechanism of injury. Nevertheless, practitioners who elect to continue using this procedure should be conscious of the hazards and ensure that their technique is optimal.

Critical to the safety of cervical transforaminal injection of steroids is an understanding of the anatomy of the cervical intervertebral foramina and their contents, coupled with disciplined and accurate imaging. Under correct, oblique views, the needle must always remain in contact with the posterior wall of the foramen. This avoids contact with the spinal nerve, its roots, and their accompanying vessels (fig. 2A). Aspiration before injection is an unreliable means of detecting intravascular needle placement, perhaps because of the small caliber of the vessels in this region. Injection of a test dose of contrast medium is important to the safe execution of the procedure. Previously, this was used to indicate correct location of the injection and to exclude intrathecal injection, whereas it now also serves to identify inadvertent intraarterial injection. This must be done under real-time imaging because spot films taken after the injection may not show contrast medium that has been rapidly cleared.

Summary

Because of the encouraging results of uncontrolled reports, cervical transforaminal injection of steroids is being used to treat patients with cervical radicular pain who do not have improvement with conservative therapy. There is a need for better data on both efficacy and safety because this treatment carries a risk of serious complications, including spinal cord injury. Critical to

the safety of this technique is an understanding of the anatomy coupled with disciplined and accurate use of imaging.

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