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ORIGINAL ARTICLE

The safety and efficiency of performing cervical transforaminal epidural steroid injections under fluoroscopic control on an ambulatory/outpatient basis

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Abstract

Purpose Cervical transforaminal epidural steroid injections (CTFESIs) have become an increasingly utilised means of treating radicular pain over recent decades, although a number of reports have brought their safety into question. Much of this has been attributed to the use of particulate steroids and the theoretical risk of embolic complications with inadvertent intra-arterial injection. This study documents the complications encountered at our centre when performing CTFESI over a more than 10-year study period with predominant use of particulate steroid. Our procedural technique is also described. This study aims to highlight the importance of operator technique first and foremost and how, with safe and reproducible technique that confidently avoids intra-arterial injection, CTFESI can be performed safely irrespective of the choice of steroid.

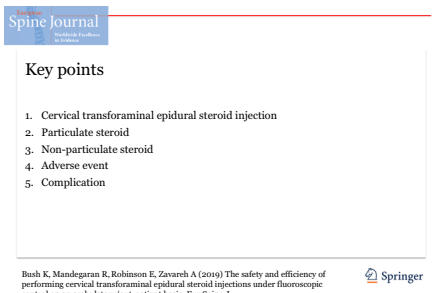
Methods All patients undergoing CTFESI between January 2008 and August 2018 at our centre were prospectively recruited to the study, documenting total number of injections/procedures per patient, presence of/description of complications and severity and type of steroid administered.

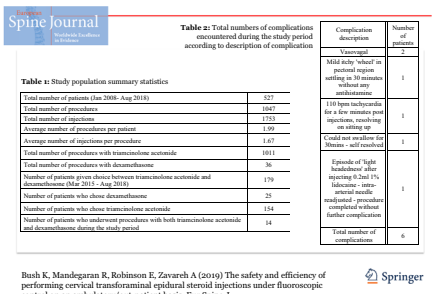
Results Five hundred and twenty-seven patients underwent 1047 procedures (1753 individual cervical levels injected) over the study period: 1011 procedures performed with particulate steroid (triamcinolone acetonide) and 36 performed with non-particulate (dexamethasone). Only six complications were encountered, all spontaneously self-resolving without intervention and considered minor (grade 1).

Conclusions With fastidious safe technique, CTFESI can be safe, efficacious and cost-effectively administered on an outpatient basis. Predominant use of particulate steroids did not lead to any significant complications.

Graphic abstract

These slides can be retrieved under Electronic Supplementary Material.





Keywords Cervical transforaminal epidural steroid injection · Particulate steroid · Non-particulate steroid · Adverse event · Complication

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Introduction

The therapeutic and diagnostic value of cervical transforaminal epidural steroid injections (CTFESI) in the management of radicular pain is well documented [1–8]. The goal of the procedure is simple: localised perineural delivery of steroid in combination with local anaesthetic close to the site of neural impingement. To this aim, various techniques and imaging modalities have been advocated by practitioners including fluoroscopy, CT and even ultrasound, with much debate as to which is superior [1, 2, 6–9]. Even more contentious is the choice of injectate, with a move away from particulate towards non-particulate steroids in recent years given the theoretical risk of embolic complications attributed to the former [2, 4, 5].

Given the close proximity of the exiting cervical nerve root to the adjacent vertebral and radicular arteries, concerns regarding procedure safety are justifiable. Whilst complications are infrequent, growing numbers of reports have described severe neurological complications following CTFESI including spinal cord, brainstem and cerebellar infarcts, and even death [10–13]. Whilst the theoretical risk associated with inadvertent arterial cannulation and intra-arterial steroid injection is certainly greater with particulate steroids, much of the literature evidencing the potential complications of CTFESI has focused on the choice of steroid as the cause rather than addressed the question of operator technique [3–5, 14–16].

Our practice has been performing CTFESI for 35 years using the same fluoroscopic technique, predominantly using particulate steroid and performed by an experienced practitioner (KB). We undertook a 10-year prospective study to examine the adverse outcomes and complication rates in our practice. The purpose of this study was to highlight that with safe and reproducible technique first and foremost, CTFESI is a safe procedure largely irrespective of choice of steroid. We begin by describing our technique, highlighting the key safety steps taken to avoid inadvertent intra-arterial injection, followed by the study outcomes.

CTFESI protocol

Patient selection

Patients with clinical features of radiculopathy and correlating findings of nerve root impingement on MRI are considered for CTFESI. Patients are fully counselled regarding procedure risks (including vascular injury, stroke, permanent neurological deficit) during the consenting process. From March 2015, patients have been additionally counselled regarding the theoretical increased risk associated with particulate steroids as well as the debatable efficacy of non-particulate and have been offered the choice of triamcinolone acetonide (particulate steroid) versus dexamethasone (non-particulate). This was following the US Food and Drug Administration's warning in 2014 that 'injection of corticosteroids into the epidural space of the spine may result in rare but serious adverse events, including loss of vision, stroke, paralysis, and death' [17]. Prior to March 2015, all patients underwent CTFESI with triamcinolone acetonide.

Facilities

- Angiography suite with a high-resolution Philips C-arm equipped with monitoring/resuscitation facilities.
- Recovering bays adjacent to the angiography suite.

Protocol and technique

Patients arrive at the fluoroscopy/X-ray department 30 min prior to the procedure. Following clerking by a nurse (including general health assessment, medications, allergies, pregnancy status), they change into a gown and consent is confirmed.

Thirty minutes is allocated to the procedure. Fully conscious patients are positioned supine, monitored with pulse oximetry, and skin cleaned with chlorhexidine in spirit. A lateral view is taken, and using non-touch technique, a butterfly needle is positioned as a marker opposite to the anterior–superior angle of the lower vertebral body (Fig. 1a). A 22-G 3½-inch spinal needle is then introduced and directed towards the posteroinferior angle of the vertebral body above (Fig. 1b)—needle direction is therefore along the axis of the nerve root foramen. It is slowly introduced whilst intermittently screening for direction until osseous contact with the inferior facet is made.

With a 30° oblique view to show the foramen, the needle is rotated 180° (bevel posterior) and then withdrawn slightly before stepping it over the inferior facet to just enter the foramen (Fig. 1c). Finally, under fully magnified AP view angled caudad-to-cephalad (to avoid overlying mandible), the needle is again rotated 180° (bevel anterior) before advancing half way along the foramen, tracking along its posterior border, i.e. adjacent to the anterior surface of the inferior facet (Fig. 1d).

The stylet is then withdrawn. Providing no blood is aspirated/seen to flow back; then, Omnipaque 300 is introduced in 0.1 ml increments with minimal needle tip adjustment (no more than 1 mm) until satisfactory spread of contrast is depicted up the foramen into the epidural space (Fig. 1e).

A test dose of 0.5 ml 1% lidocaine is then introduced, and the contrast should be seen to partially wash away.

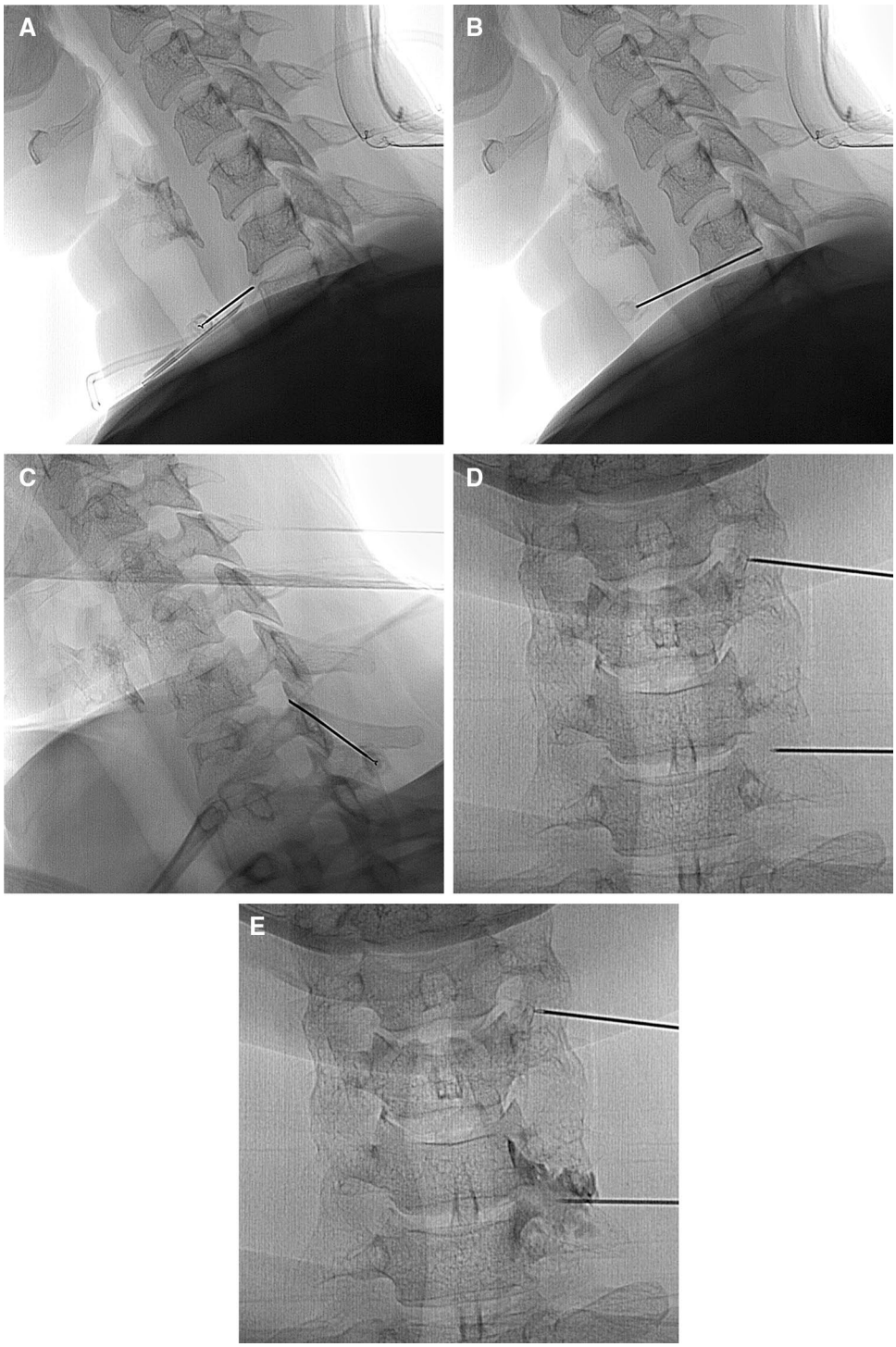

Fig. 1 A series of fluoroscopic images illustrating the key positions when performing a C6/7 transforaminal epidural injection. **a** Lateral image with a butterfly needle as a marker, illustrating the point of skin entry opposite the anterior superior angle of the C7 vertebral body. **b** Lateral image illustrating the needle making bony contact with the lateral mass of the inferior facet at the level of the posterior inferior angle of the C6 vertebral body. **c** 30° oblique image illustrating the needle stepping over the lateral border of the inferior facet in the posterior inferior region of the foramen. **d** Magnified AP image illustrating needle placement halfway up the root canal. **e** Magnified AP image illustrating distribution of contrast throughout the C7 root canal and into the epidural space above and below the foramen

After 1 min, the patient is asked to wiggle their fingers and toes. If well, 1 ml injectate [0.5 ml 1% lidocaine with 0.5 ml triamcinolone acetonide (TA) (20 mg) or 1 ml dexamethasone (3.3 mg)] is introduced in small increments with intermittent screening to confirm that the contrast is gradually washed away. The needle(s) is then withdrawn and spot plaster/s placed over the injection site/s.

Pulse oximetry is monitored for the next few minutes. If stable, the patient sits up and, after a short discussion, returns to their changing cubicle. The procedure, films and expectations are discussed with the patient during 30 min of further observation before they leave the department.

Materials and methods

All patients undergoing CTFESI at our centre between January 2008 and August 2018 were prospectively recruited. Data collected for each patient comprised the following:

- Total number of injections performed per procedure
- Number of procedures performed per patient during the study period
- Presence/absence of post-procedure complications
- Description of post-operative complication and grading of complication severity (graded 1–5 as per Dindo et al. [18]: 1 = minimal severity defined as any deviation from the normal post-operative course without need for pharmacological treatment or surgical, endoscopic or radiological interventions; 5 = maximal severity–patient death)
- Steroid administered: either TA or dexamethasone (all patients prior to March 2015 received TA)
- Patient's choice of steroid (from March 2015, all patients were offered the choice of triamcinolone acetonide or dexamethasone and counselled regarding potential risks versus benefits of both, as outlined in the procedure protocol)
- Patient's choice of subsequent steroid if returning for a further procedure (i.e. for patients that underwent more than one procedure between March 2015 and August 2018).

Table 1 Study population summary statistics

Total number of patients (January 2008–August 2018)	527
Total number of procedures	1047
Total number of injections	1753
Average number of procedures per patient	1.99
Average number of injections per procedure	1.67
Total number of procedures with triamcinolone acetonide	1011
Total number of procedures with dexamethasone	36
Number of patients given choice between triamcinolone acetonide and dexamethasone (March 2015–August 2018)	179
Number of patients who chose dexamethasone	25
Number of patients who chose triamcinolone acetonide	154
Number of patients who underwent procedures with both triamcinolone acetonide and dexamethasone during the study period	14

Table 2 Total numbers of complications encountered during the study period according to description of complication

Complication description	Number of patients
Vasovagal	2
Mild itchy 'wheel' in pectoral region settling in 30 min without any antihistamine	1
110 bpm tachycardia for a few minutes post-injections, resolving on sitting up	1
Could not swallow for 30 min—self-resolved	1
Episode of 'light headedness' after injecting 0.2 ml 1% lidocaine—intra-arterial needle readjusted—procedure completed without further complication	1
Total number of complications	6

Results

A total of 527 patients underwent 1047 CTFESI procedures (317 males and 210 females; mean age 51 years, range 21–84 years); summary statistics are shown in Table 1. The total number of individual injections performed was 1753 (mean average of 1.67 cervical levels injected per procedure). Each patient underwent an average of two procedures (3.84 individual injections) during the study period.

All patients prior to March 2015 underwent CTFESI with TA. From March 2015, all patients were counselled and given the choice of steroid, with a total of 179 patients undergoing CTFESI between March 2015 and August 2018. Of these, 25 chose dexamethasone, of which six had received TA prior to March 2015 and eight subsequently opted for TA because of lack of response to dexamethasone.

In total, six patients experienced complications throughout the study period (1.14% of all patients, or 0.34% of all individual injections), all of which occurred during or immediately following the procedure. All six complications were considered minor (grade 1), i.e. spontaneously resolving without need for medication/intervention, and are described in Table 2.

Discussion

CTFESI is increasingly utilised to treat cervical radicular pain, with over 250% increase in number of injections performed annually in the USA between 2000 and 2014 [19]. Over the past four decades, CTFESI techniques have evolved to take advantage of developments in imaging technology, with further variation introduced by other factors including choice of injectate, needle approach, needle size, use of local anaesthetic versus sedation to name a few [1, 2, 6–9]. Whilst there is much literature advocating use of a given approach, choice of imaging modality and technique is typically dictated by injectionist preference and resources available.

Although significant adverse reactions/complications are uncommon, there is a body of evidence limited to individual case reports describing an array of severe neurological

complications following CTFESI. The review by Benny et al. identified 27 published cases of brain infarction/TIA, 15 cases of spinal cord infarction, four cases of combined brain/spinal cord infarction, two cases of cortical blindness and 15 cases of death [10]. Our literature search identified one further more recent case of death following CTFESI [11]. Furthermore, a survey of 1340 pain specialists with 287 responders reported 30 cases of infarction of the brain and/or spine and 13 cases of death in their cumulative experience of performing CTFESI [12]. Whilst a minority of the published complications have been attributed to direct intra-medullary injection, vertebral artery dissection and high spinal anaesthesia, many of the complications have been attributed to intra-arterial injection [10–13].

Particulate steroids such as methylprednisolone and TA have been extensively used since their advent in the 1960s, and their efficacy in CTFESI has been well published [1, 3, 6–8]. Whilst it remains the subject of debate, particulate steroids have traditionally been preferred to non-particulates such as dexamethasone owing to their lower solubility coefficient, preventing the steroid from being washed away, therefore exerting a positive effect on the target tissues over a longer time period [20, 21]. The spine literature remains conflicting on this issue: as recently as 2018, a large study by Bensler et al. demonstrated significantly lower pain scores at 1 week and 1 month post-injection with particulate steroids compared to non-particulate amongst 594 patients following lumbar epidural steroid injections [22]. Conversely, two systematic reviews from 2015 failed to identify a significant difference amongst the studies within their selection criteria [14, 15]. Leaving the efficacy debate to one side, it is perhaps not surprising that the majority of reports documenting severe complications post-CTFESI have occurred in the context of the particulate steroids, given that they have traditionally been the injectate of choice.

In the inadvertent event that injection is performed with an intra-arterial needle position, the potential embolic effects of particulate steroid are theoretically greater than non-particulate. However, whilst much of the literature addressing safety issues of CTFESI has focused on the potential causative role of the particulate versus non-particulate steroid debate, relatively little attention has been paid to what constitutes 'safe procedural technique' as a means of minimising risk of adverse events.

In our experience, we have yet to encounter any serious complications, whilst the current study comprising 1753 injections resulted in only six minor self-resolving adverse effects and no serious complications despite predominant use of particulate steroid. In our opinion, performing CTFESI requires a sound understanding of the regional anatomy and should be performed (or in a training scenario, closely supervised) by a safe and experienced practitioner. With this in mind, there can be little excuse for intra-medullary needle placement, particularly with a transforaminal technique and use of three fluoroscopic planes or use of CT cross-sectional imaging. Likewise, intra-arterial needle placement directly into the vertebral artery should easily be avoided, given that up to the level of the C1 vertebra, the vertebral artery ascends anterior to the acceptable target of CTFESI.

More challenging is avoidance of radicular arteries given their small calibre and passage adjacent to the target nerve roots. We take several steps to ensure the needle tip is located within the neural foramen, whilst ensuring intravascular injection is avoided:

1. Needle size: Various techniques are described using needle calibres ranging from 21 to 26G. However, there has been almost no mention of needle size and safety in the literature. A recent cadaveric study has shown cervical radicular artery calibre to range from 0.75 to 1.02 mm and a case report has shown that these arteries can be inadvertently cannulated with small calibre 25G needles [23, 24]. We prefer a larger calibre 22G needle, hypothesising that the larger needle is less likely to inadvertently cannulate small calibre radicular arteries than smaller 25G/26G needles.
2. Observing for flow back of blood when the needle stylet is withdrawn and attempting to aspirate blood
3. Incrementally injecting small volume Omnipaque 300 and ensuring satisfactory perineural/epidural spread of contrast: if this is not seen, or contrast is seen to wash away promptly, it suggests intra-vascular needle tip position (foraminal venous sinuses or radicular artery).
4. Administering a test dose of local anaesthetic prior to injecting the final injectate: we have adopted this practice since it was postulated that if the needle tip is inadvertently placed within an artery, introducing 0.5 ml of lidocaine 1% would result in a fairly immediate untoward reaction [25]. As yet, we have never encountered any adverse reaction. This immediate patient feedback is possible since we avoid any sedation, giving the added safety benefit of allowing patients to communicate an adverse reaction as it happens. Furthermore, the added reassurance of the contrast partially washing away following lidocaine injection also confirms that the needle tip is not intra-vascular.

Whilst the general trend amongst most practitioners has been a move away from particulate steroids, the use of particulate steroids in epidural spinal injections throughout the

spine has proved both safe and efficacious in our hands [1]. It may be that we only have dexamethasone concentrations of 3.3 mg per ml available to us in the UK, whereas a concentration of 10 mg per ml is available in the USA. However, with a 35-year experience base and a tertiary referral practice attracting patients who have failed to respond to non-particulate CTFESI, we remain to be convinced that non-particulate steroids efficacy matches that of particulate steroid. We continue to review the literature on this issue and keep our patients fully informed.

Ultimately, this study emphasises the importance of employing safe methodology first and foremost in preventing significant complications arising from CTFESI. During the more than 10-year study period and following 1753 injections, all 527 patients walked out of the fluoroscopy/radiology department within 1½ h of walking in, with only six minor self-resolving complications encountered despite the predominate use of particulate steroid. We believe documenting our experience and technique will contribute to improving awareness of the potential pitfalls that should be avoided and highlight the importance of fastidious safe technique in improving the safety, efficacy and the cost-effectiveness of CTFESI.

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Compliance with ethical standards

Conflict of interest All authors confirm no conflicts of interest.

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