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A New Solution to an Old Problem: Ultrasound-guided Cervical Retrolaminar Injection for Acute Cervical Radicular Pain

Prospective Clinical Pilot Study and Cadaveric Study

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Study Design. Prospective clinical pilot study and cadaveric study.

Objective. The aim of this study was to evaluate the spread of an ultrasound-guided interfascial plane blocks (UGIPBs) and its potential efficacy for cervical radiculopathy.

Summary of Background Data. Cervical radiculopathy is a common disorder, potentially leading to severe pain and disability. Conservative treatment with cervical epidural steroid injections (ESI) is limited by concerns regarding their safety. UGIPBs are used in cervical surgical procedures as part of the multimodal postoperative analgesia regimen however, were not described for cervical radiculopathy.

Methods. Twelve patients with acute cervical radicular pain who failed conservative treatment and were candidates for surgery were offered a cervical retrolaminar injection. A solution of 4 mL lidocaine 0.5% and 10 mg dexamethasone was injected, assisted by ultrasound guidance, at the posterior aspect of the cervical lamina corresponding to the compressed nerve root level. Additionally, a cadaver study was carried to evaluate the contrast spread and infiltration into near structures, both anatomically and radiographically.

Results. Twelve patients underwent the procedure, with a mean follow-up time of 14.5 weeks. Average numerical rating scale improved from 7.25 at baseline to 2.83 following the injection ($P < 0.001$). Three patients received 2 to 3 injections without significant improvement and were eventually operated. No adverse events were reported.

In the cadaver study, fluoroscopy demonstrated contrast spread between T1 and T3 caudally, C2 to C5 cranially and facet joints laterally. Anatomically, the dye spread was demonstrated up to C2 cranially, T1 caudally, the articular pillars of C4 to C7, and the neural foramen of C6 laterally.

Conclusion. A solution injected into the cervical retrolaminar plane can diffuse in the cranial-caudal axis to C2-T3 and laterally to the facet joints and the cervical neural foramen. Our pilot study confirmed the feasibility of our study protocol. Future studies are needed to support our early results.

Key words: local anesthesia, neck pain, nerve block, pain management, spinal injections.

Level of Evidence: 4

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Neck pain is the fourth leading cause of disability in the United States. The lifetime risk of developing cervicalgia approaches 50% in the general population.[1,2] Cervical radiculopathy usually results in neck pain, often accompanied by radiating upper extremity pain which affects approximately 1 in 1000 people per year.[3] The most common underlying pathologies are disc herniation and spinal foraminal stenosis that affect mainly the lower levels of the cervical spine, most commonly at C5-C7.[4–7]

Cervical epidural steroid injections (ESI) are among the most common interventional pain procedures performed for radicular pain, particularly in patients who are resistant to other conservative therapies.[8] However, the utility of these cervical ESI is limited by concerns regarding their safety.[9,10]

Presently, there is lack of consensus regarding the ideal technique for cervical ESI that balances safety and efficacy.[11,12]

Ultrasound-guided paraneuraxial nerve blocks have become very popular clinically, due to their clinical and anatomical characteristics.[13] These techniques are comparable to neuraxial nerve blocks in terms of success rate and analgesic efficacy and may confer many of advantages over neuraxial nerve blocks.[14] Retrolaminar blocks are among this family that are near but not within the neuraxis like spinals or epidurals.[15] Many ultrasound-guided interfascial plane blocks (UGIPBs) are currently used as part of the multimodal postoperative analgesia regimen in many cervical surgical procedures.[16,17]

Most reports and studies of retrolaminar blocks have been in the context of anesthesia for truncal surgery and truncal pain syndromes (thoracic and abdominal).[18,19] Postoperative and pain treatment cervical retrolaminar blocks studies are currently sparse.

We conducted a clinical pilot study in patients with cervical radicular pain treated with an UGIPB in the space posterior to the cervical lamina and a cadaver study aimed to evaluate the spread of this UGIPB.

METHODS

Pilot Study

Twelve adult patients (over 18) were enrolled. Each patient received a detailed explanation regarding the procedure and the study and was required to sign a consent form. All patients were neurologically intact, without myelopathy, and without a history of spine surgery. They had all failed conservative treatment for at least 3 months (*i.e.*, physical therapy and oral analgesics) and had been offered a cervical spine decompression surgery. The key measure tracked was the pain intensity, and we recorded age, sex, the side of the injection, numerical rating scale (NRS) —pre- and post-procedure, need for surgery post procedure, absolute NRS difference, and mean follow-up time.

The procedure was carried out with the patient lying in a prone position (Figure 1). Ultrasound and Doppler (Snerve, Sonosite Inc., Bothell, WA) were used to guide the needle insertion. A 22G needle (Stimuplex Ultra 360, 50 mm needle, Braun, Melsungen, Germany) was inserted in plane of the transducer. As this was a pilot study, fluoroscopy was used to provide an additional confirmation of the desired spinal level. As the needle reached its final position at the posterior aspect of the lamina (Figure 2), 1 mL of contrast (iodexol 270 mg/1 mL) was injected and again fluoroscopy was used (AP + lateral) to exclude inadvertent vascular or spinal spread and provide a description of the spread (Figure 3A–C). As a final step, 4 mL of Lidocaine 0.5% with 10 mg (1 mL) dexamethasone was injected.

Pain intensity was assessed using an 11-point numerical rating scale (NRS), with range from 0 (no pain) to 10 (worst possible pain). The patient assessments were carried out by our pain clinic nurses before the procedure, immediately following it, and at the follow-up appointments. The follow-up appointments were set at 1, 3, and 6-month post procedure. They were scheduled either by the visit of the patient to the clinic or a nurse contact. The final number of weeks of follow-up as included in the data corresponds to the number of weeks post procedure when the patient was either left with over the counter (OTC) analgesics or was refractory to conservative measures and then sent to surgery.

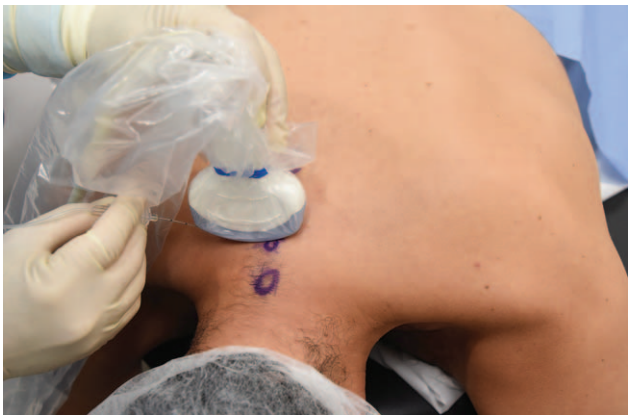

Figure 1. Procedure patient set up.

Statistical Analysis

The pilot study data was then analyzed using SPSS version 18.0.2 (SPSS Inc, Chicago, IL). A Shapiro-Wilk test ($P > 0.05$) and visual inspection of their histograms, normal Q-Q plots, and box were used to evaluate the normality of distribution of the pre- and post- NRS values. Mean value and standard deviations values were calculated using on sample t test. Pre-procedural to post-procedural NRS changes were analyzed with paired t tests. A P value <0.05 was considered statistically significant.

Cadaver Study

Six human Thiel embalmed cadavers[20] were used, five cadavers were employed for the image-guided study and

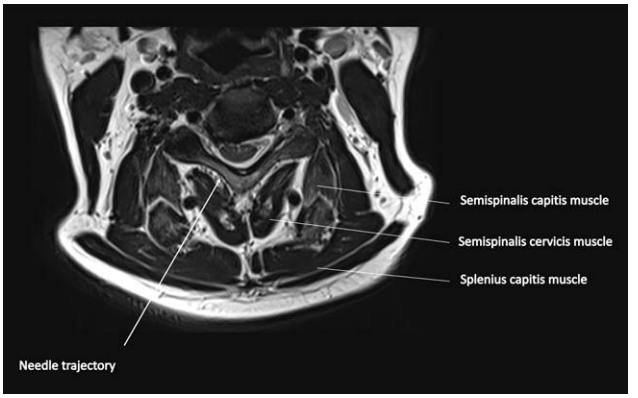

Figure 2. T2 magnetic resonance imaging axial view of cervical spine at the C6 level presenting the needle trajectory and relevant muscles.

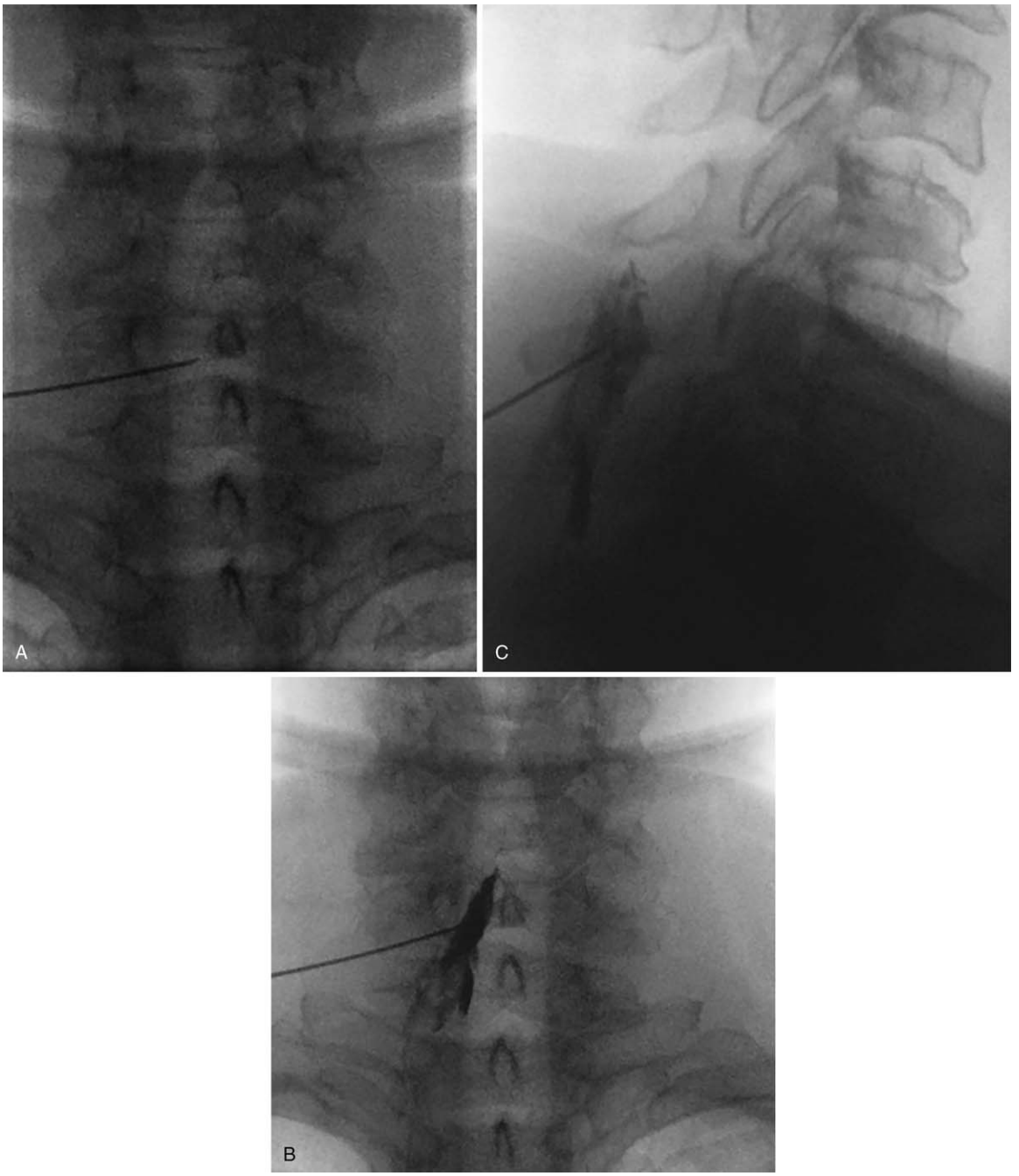

Figure 3. Fluoroscopy demonstrating contrast spread over the posterior aspect of the cervical lamina. (**A**) final needle position at an anterior-posterior (AP) view. (**B**) AP view post 1 mL contrast injection over the posterior aspect of the lamina at the height of cervical vertebrae C6. (**C**) Lateral view of contrast spread post injection.

one for the anatomical study. The study complied with the institutional and ethical standards of the School of Medicine where the study was performed. None of the cadavers had previous cervical surgery.

The procedure was performed with each cadaver in the prone position using ultrasound guidance (Snerve, Sonosite Inc., Bothell, WA) with a 6 to 13 MHz linear probe placed in an axial position at the C6 level, demonstrating the vertebra spinous process, lamina, transverse process along with the corresponding soft tissue (paraspinal muscles including erector spinae muscles). The C6 level was verified fluoroscopically, by counting both cranially from the first rib (T1) and caudally from C1. Under ultrasound guidance, an in-plane puncture was performed in a lateral to medial direction with the bevel up using a 22G needle (Stimuplex Ultra 360, 50 mm needle, Braun, Melsungen, Germany) with the needle advancing until it contacted the junction of the lamina and the spinous process, under the multifidi muscles. At this point, 5 mL of a radiocontrast dye mixture (2.5 mL of iodexol 270 mg/1 mL, and 2.5 mL saline solution) was injected while observing the separation of the cervical multifidus muscle, and AP and lateral X-ray images

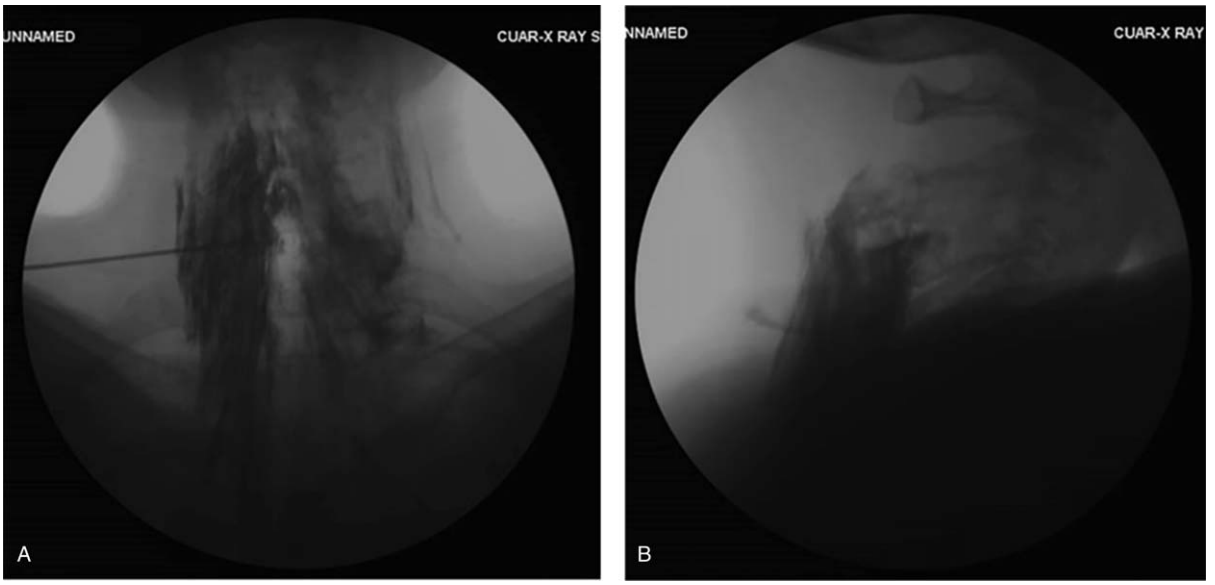

Figure 4. Cervical retrolaminar image-guided injection in the cadaver. (**A**) An AP x-ray image and (**B**) a lateral X ray image, obtained after an injection of 5 cc of the solution with contrast at the junction of the lamina and the spinous process. Both images correspond to injections number 1R and 1L. Cranial caudal spread results are described in Table 4.

were obtained (Figure 4A and B). All procedures were carried out by the same practitioner, an expert in US-guided procedures (U.H).

The assessment of the contrast spread was evaluated by two pain physicians (M.F. and J.S.). The same protocol was applied to the contralateral side. An overall of five specimens were injected a total of 10 injections.

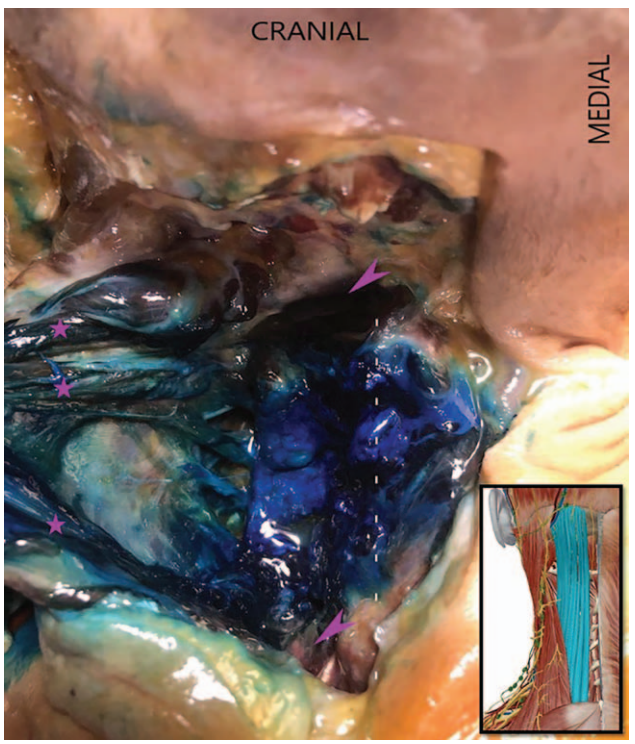

Figure 5. Posterior view of the cervical region. The splenius capitis and the semispinalis capitis lateral fascicle were reflected (purple stars). Purple arrowheads show the distribution of the contrast among the Erector Spinea (ES) muscles. Discontinued line shows the spinous processes line.

Anatomical Study

One specimen was injected unilaterally following the same protocol, except that the contrast solution was modified to include 1 mL of methylene blue (2.5 mL of iodexol 270 mg/mL, 1 mL methylene blue, and 1.5 mL saline solution). Immediately following the injection, the cervical region was dissected as follows: a skin incision was made along the left midline over the cervical spinous processes from C7 to the occipital protuberance. The skin was reflected laterally and the superficial muscles (trapezius, splenius capitis) were reflected.

The semispinalis cervicis, the semispinalis capitis medial fascicle and the multifidus muscles were identified and reflected as well (Figure 5).

To follow the lateral spread of the dye, the longissimus capitis and the semispinalis capitis lateral fascicle were removed (Figure 6). The caudocranial and lateral spread of the dye were explored and documented, shown in Table 4. The stages of dissection by layers are described in Figures 5 and 6.

RESULTS

Pilot Study

Demographic variables, procedural variables, NRS data, and follow-up time results are summarized in Table 1. Descriptive demographic and clinical variables are shown in Table 2. Descriptive VAS values and the need for surgery are presented in Table 3.

A Shapiro-Wilk test ($P > 0.05$) and visual inspection of their histograms, normal Q-Q plots, and box plot showed

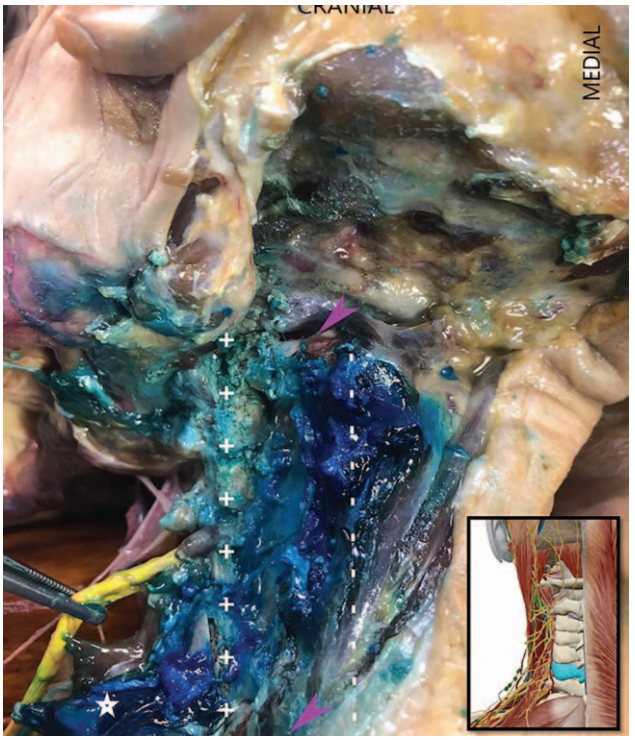

Figure 6. Removal of the left ES muscle. Purple arrowheads show the distribution of the contrast from C2 to C7, in the posterior portion of the cervical lamina, reaching medially to the spinous processes (discontinued line), laterally to the apophyseal joints (crosses line) and the C6 neural C6 neural foramen (the white star shows C6 radicular nerve stained with the contrast).

that the pre- and post-NRS values were approximately normally distributed. A skewness of 0.384 (standard error [SE] = 6.37) and kurtosis of −0.163 (SE = 1.232) was found for pre-procedure NRS. For post-procedure VAS, we found a skewness was 0.3846 (SE = 6.37) kurtosis of −0.159 (SE = 1.232).

The mean follow-up time was 14.5 weeks. The mean NRS value at pre-procedure was 7.25 and the mean values at post-procedure follow-up was 2.83 ($P < 0.01$). Two patients reported resolution of the arm pain but were left with cervical pain that was managed by over the counter (OTC) analgesics. Three patients received either two or three injection, in 4 weeks' intervals, and eventually underwent surgical decompression due to a lack of improvement. Patient #3 received two injections, following the first she improved substantially but a few weeks later deteriorated again, then receiving a second injection and was eventually operated. Patients #9 and #12 each received three injections. Patient #5 received two injections with an interval of 6 weeks between them, experiencing substantial pain relief and improved daily function following the second injection. Patients #5 and #7 both were left with mild cervical pain, without limb pain, treated by OTC pain analgesics. No adverse events were reported for any of the patients during the study.

TABLE 1. Demographic and Procedural Variables

Age	45.2 ± 18.1
Female/male ratio	1:1
Right/left ratio	1:1
NRS pre-procedure	7.25 ± 1.43
NRS post-procedure	2.83 ± 2.48
*P**	<0.01
Mean follow-up time, wk	14.5 ± 5.73

Values are presented as mean ± standard deviation.
NRS indicates to numerical rating scale.
**P value for paired t test comparing NRS pre- and post-procedure.*

Cadaver Study

A total of six cadavers were used, five of which were used to perform the contrast spread study and 1 was dissected to exemplify physically the spread. Contrast spread results are described in Table 4. Fluoroscopy studies demonstrated contrast spread between T1 and T3 caudally and between C2 and C5 cranially (Figure 4). Under dissection the dye spread out cranially to C2 level and caudally to T1. Laterally, the contrast extended to the articular pillars of C4 to C7, and C6 root (Figures 5 and 6). No epidural spread was observed in the image guided or in the anatomical study.

DISCUSSION

This study is the first step in evaluating the feasibility of a cervical retrolaminar injection as a means to provide pain relief for acute cervical radicular pain. This pilot study has demonstrated that the study protocol is feasible, and the cadaver study showed a wide spread along the cervical posterior region.

Common to all the patients enrolled in the pilot study is the prior failure of conservative treatments (physiotherapy, oral pain killers) and a recommendation for surgery given by a spine surgeon. Notably, at our institution we do not provide cervical ESI for over 7 years due to the potential complications associated with these injections.[21]

The mean reduction of NRS in our study was 4.42 points (61%). A successful, clinically meaningful procedure is defined when either the NRS score is reduced by two or more points,[22] or when the score is reduced by ≥50%. This strict definition was chosen over a typical 30% relief response to differentiate from potential placebo responders. Other trials have selected this same threshold,[23,24] and although the NRS improvement in our study exceeded the 50%, our results should be interpreted carefully due to the small sample size in this pilot study. Future studies should be carried out in order to further evaluate the efficacy and safety of this procedure.

This technique may be considered safer than ESI. The anatomical area of the posterior neck does not carry major blood vessels or nerves and hence, a needle inserted from the skin lateral to the midline to reach the cervical lamina is not risking direct touch to any major neurovascular structure. To reduce the likelihood of accidently entering the

TABLE 2. Descriptive Demographic and Clinical Data

Patient	Age	Sex	Side	Comorbidities	MRI Findings
1	34	Male	Right	None	C5-6 disc herniation-compression of C6 nerve root
2	51	Female	Right	None	C5-6 disc protrusion- with compression of right C6 nerve root
3	45	Female	Right	None	C5-6 disc protrusion- compression of C6 nerve root
4	30	Male	Left	None	C6-7 disc herniation- compression of C7 nerve root
5	48	Female	Right	None	C4-5 disc protrusion- compression of C5 nerve root
6	63	Male	Left	Ischemic heart disease, Hypertension	C6-7 disc protrusion- compression of C7 nerve root
7	20	Female	Left	None	C5-6 disc protrusion- compression of C6 nerve root
8	50	Male	Left	None	C4-6 moderate stenosis facet hypertrophy with foraminal stenosis and compression of C5,6 nerve roots
9	31	Male	Left	None	C6-7 disc herniation- compression of C7 nerve root
10	48	Female	Right	Benign mass of the lung	C5-6 disc protrusion- compression of C6 nerve root
11	65	Female	Left	None	C6-7 facet hypertrophy and forminal stenosis-compression of C7 nerve root
12	55	Male	Right	None	C6-7 disc herniation- compression of C7 nerve root

interlaminar space, we performed an in-plane ultrasound-guided insertion in the horizontal, axial plane. This angle reduces the risk of inadvertent interlaminar penetration of the needle, which typically requires 15° to 20° cephalad angulation of the needle.[25] Moreover, if such a procedure is carried by ultrasound, owing to its high-resolution identification of soft tissue and nerves, the risk of damage to such tissues is further reduced. Another advantage of an ultrasound-guided procedure is that it enables to view the spread of injected medications in real time. The use the fluoroscopy was intended to proof the final needle position and the spread of the injected solution and not as a guiding tool.

As C5-C6 and C6-C7 are the most common area of the degenerative changes that causes cervical radicular pain,[26] we chose C6 as the location of our cadaver study injection. The procedure target was chosen at the postero-medial aspect of the vertebral lamina, as it has been an effective choice in the thoracic area[19] and because the small size of the cervical transverses processes, and their proximity to the vertebral arteries make them a more challenging and less safe target.[18]

As the cervical transverse process is short and in close proximity to a neurovascular bundle we chose to aim the injection at the cervical lamina, easily distinctive bony structure slightly away from the neurovascular bundle of the cervical neuro-foramina. Similarly, as we aim toward the lamina and medially to the transverse process we get further from the deep cervical artery, theoretically reducing the likelihood of damaging it.

Our image-guided cadaver study results suggest that a contrast solution injected at the plane between the cervical multifidus muscles and the cervical lamina may reach a cranial C2 level and a caudal T3 level. Interestingly, no spread of the dye above C2 was noted in any of the injection Moreover, a ''roof phenomena'' was noted at C2 level, as

TABLE 3. Descriptive VAS Values and the Need for Surgery

Patient	NRS Baseline	NRS Post-procedure	Surgery Post-procedure	Follow-up time, wk
1	8	2	No	15
2	7	4	No	14
3	10	3	Yes	5
4	5	0	No	18
5	6	2	No	17
6	8	0	No	16
7	7	2	No	20
8	7	1	No	24
9	8	8	Yes	8
10	9	5	No	14
11	6	1	No	9
12	6	6	Yes	14
Mean	7.25 ± 1.43	2.83 ± 2.48		14.5 ± 5.73

P value for paired t test comparing NRS pre- and post-procedure <0.01. NRS indicates numerical rating scale.

TABLE 4. Image-guided Study, Contrast Spread Results

Cadaver No.	Cranial Spread	Caudal Spread	Lateral (Facet Joint) Spread
1R	C3	T3	Yes
1L	C2	T3	Yes
2R	C2	T1	Yes
2L	C4	T2	Yes
3R	C2	T3	Yes
3L	C2	T3	Yes
4R	C5	T3	Yes
4L	C3	T1	Yes
5R	C4	T1	Yes
5L	C3	T1	Yes

the spread abruptly stopped, while the caudal spread was T1-T4 (Figure 4). A possible explanation could be that the C2 level is the cranial insertion of the multifidi muscles. There was a lateral spread over the facets and the area between the facets. Along this area runs the medial branch nerve which supplies the innervation to the facet, which is a primary source of cervical pain. The anatomical study confirmed the posterior craniocaudal and lateral spread to the articular pillars of C4 to C7, but it also showed an extent to the neural foramina space of C6 which was not perceived in the fluoroscopy study.

No epidural spread was observed in the image guided or in the anatomical study. In theory, it could be possible, because the ligamentum flavum may not be completely continuous fused in the midline in the cervical region. Descriptions of anatomic variations of the cervical and high thoracic ligamentum flavum, showed that the incidence of midline gaps in the ligamentum flavum was 87% to 100% between C3 and T2 and that the location of the gap was more frequent in the caudal third of the ligamentum flavum.[27]

Cadaver studies are subjected to high level of bias. Postmortem changes, lack of muscle contraction, blood flow or respiratory changes affect the results of the spread that makes it difficult to extrapolate the results to the clinical setting. Despite this, Thiel embalmed cadavers as the one we used, maintain the fascial layers between structures, are known to provide the best physical and functional properties and are suitable for ultrasound-guided regional anesthesia of the cervical region.[28]

CONCLUSION

In conclusion, a solution injected into the cervical retrolaminar plane can diffuse extensively in the cranial-caudal axis to C2-T3 and could diffuse to reach clinically relevant targets such as the facet joints, or the cervical neural foramen. Our pilot study confirmed the feasibility of our study protocol. Future studies are needed to support our early results and confirm this procedure as an alternative to treat cervical radicular pain.

➢ Key Points

- ❑ Cervical radicular pain is a common medical problem. Epidural steroid injections are among the interventional procedures recommended, but their safety is unclear.
- ❑ Cervical retrolaminar steroid injection may serve as an alternative to treat cervical radicular pain.
- ❑ We report a clinical pilot study followed by a cadaver imaging and anatomical study.
- ❑ This is the first report suggesting that an ultrasound guided cervical retrolaminar injection could potentially serve as a tool to manage cervical radicular pain.

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