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Randomized Study Assessing the Accuracy of Cervical Facet Joint Nerve (Medial Branch) Blocks Using Different Injectate Volumes

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ABSTRACT

Background: Neck pain is a frequent cause of disability, with facet joint arthropathy accounting for a large percentage of cases. The diagnosis of cervical facet joint pain is usually made with diagnostic blocks of the nerves that innervate them. Yet, medial branch blocks are associated with a high false-positive rate. One hypothesized cause of inaccurate diagnostic blocks is inadvertent extravasation of injectate into adjacent pain-generating structures. The objective of this study was to evaluate the accuracy of medial branch blocks by using different injectate volumes.

Methods: Twenty-four patients received cervical medial branch blocks, using either 0.5 or 0.25 ml of bupivacaine mixed with contrast. One half of the patients in each group were suballocated to receive the blocks in the prone position and the other half through a lateral approach. Participants then underwent computed tomography of the cervical spine to evaluate accuracy and patterns of aberrant contrast spread.

Results: Sixteen instances of aberrant spread were observed in nine patients receiving blocks using 0.5 ml *versus* seven occurrences in six patients in the 0.25 ml group ($P = 0.07$). Aberrant spread was most commonly observed (57%) when an injection at C3 engulfed the third occipital nerve. Among the 86 nerve blocks, foraminal spread occurred in five instances using 0.5 ml and in two cases with 0.25 ml. The six "missed" nerves were equally divided between treatment groups. No significant difference in any outcome measure was observed between the prone and lateral positions.

Conclusions: Reducing the volume during cervical medial branch blocks may improve precision and accuracy.

What We Already Know about This Topic

- Cervical medial nerve branch block is used to identify patients for definitive therapy for neck pain but has a high false-positive rate

What This Article Tells Us That Is New

- Abberant spread, as measured by contrast dye and computed tomography, was common with this block but occurred half as often with 0.25 ml compared with 0.5 ml of injection volume
- Reducing medial nerve branch block volume to 0.25 ml may increase its diagnostic accuracy

NECK pain is a common cause of chronic pain and disability, with an annual prevalence rate ranging between 30 and 50%.[1] Among the various etiologies, facet arthropathy is estimated to account for between 36% and 60% of cases.[2–4] It is generally acknowledged that the only reliable method to diagnose a painful zygapophysial joint (z-joint) is through local anesthetic blocks of either the facet joints themselves, which are fraught with technical challenges, or the medial branch nerves that innervate them.[5,6] The basis for this assertion is that degenerative spondylosis is found on cervical spine imaging in a majority of patients irrespective of whether they suffer from neck pain or not.[7–10] However, no diagnostic spinal injection is infallible, and cervical medial branch blocks (MBB) are no exception.[11] Studies using either placebo-controlled or confirmatory blocks, wherein two different local anesthetics with dissimilar half-lives are used to screen out placebo responders, have found false-positive rates ranging between 27 and 63%.[12,13] This has led many experts to

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advocate the use of "double blocks" as the only reliable way to identify a z-joint as a putative pain generator.[2,4,6]

Nevertheless, this diagnostic paradigm is not devoid of drawbacks. Two separate theoretical computations conducted for lumbar MBB concluded that the double-block model is not cost effective.[14,15] More importantly, Lord *et al.*[16] found that designating concordant pain relief to lidocaine and bupivacaine confirmatory MBB as the standard for a positive response was associated with a significant false-negative rate. The implications of this are that requiring corresponding analgesia with double blocks before proceeding to radiofrequency denervation, the putative definitive procedure for cervical z-joint pain, will invariably lead to withholding a potentially beneficial, minimal risk procedure from a substantial number of neck pain sufferers.

The placebo effect not withstanding, myriad other factors have been deemed responsible for the inaccuracies of diagnostic MBB.[11,17] Perhaps, foremost among these is injectate volume. Using excessive volumes can render a diagnostic block nonspecific by virtue of extravasation of the injectate to secondary pain-generating structures such as muscles, ligaments, and spinal nerves. In a computed tomography (CT) study by Dreyfuss *et al.*,[18] 16% of lumbar MBB performed with 0.5 ml of contrast spread into either the epidural space or intervertebral foramina, potentially mitigating the predictive value. To overcome this impediment, many authors have recommended reduction in the injection volume.[17–21] Yet, excessive volume reduction can have the unintended consequence of missing the target nerve altogether. No investigation to date has compared success rates by using different volumes for MBB, but clinical studies evaluating radiofrequency and therapeutic block outcomes have varied widely with regard to screening blocks, with volumes ranging from 0.25 to 2.0 ml.[22–27] The primary objective of this randomized study was to determine whether reducing the volume for cervical MBB can enhance the specificity.

Materials and Methods

Permission to conduct this randomized, double-blinded study was granted by the Department of Clinical Investigation at Walter Reed Army Medical Center, Washington, DC, and all subjects gave written informed consent. Inclusion criteria for participation included a predominance of axial (neck > arm) cervical pain for more than 3 months, failure to respond to conservative therapy, and asymmetry in laterality. Exclusion criteria were pregnancy, untreated coagulopathy, allergy to iodinated contrast, ongoing litigation, presence of focal neurologic signs or symptoms, suspected C2–C3 pathology (*i.e.*, a need to block the third occipital nerve), and any uncontrolled medical or psychiatric condition that might preclude an optimal response to treatment. Before commencement, a one-tailed power analysis determined that 20 patients would have an 80% chance of detecting a difference between the two groups with respect to the spread of injectate to unintended pain-generating structures. The power analysis was based on the following assumptions: nearly all the injections would bathe the target nerve; each patient would receive an average of 3.5 nerve blocks; the injectate would spread to an aberrant structure for 5% of blocks done with 0.25 ml and for 25% of the blocks done with 0.5 ml; each block was considered an independent entity; and because anteroposterior and lateral imaging would be used to guide needle placement for both prone and lateral approaches, both techniques would have equivalent accuracy rates.

Randomization

Randomization was done in groups of four by a research assistant using presealed envelopes. Including four patients done as a feasibility pilot project using the same methodology as the ensuing participants, a total of 24 subjects were allocated in a 1:1 ratio to receive cervical MBB using either 0.25 or 0.5 ml of injectate. Within each main treatment group of 12 patients, one half of the participants underwent blocks in the lateral position, whereas the other half were suballocated by presealed envelopes to the prone position. Patients and the reviewing radiologist were blinded to treatment group.

Injections

All blocks were performed in an outpatient center using judicious superficial anesthesia. The targeted facet joints were determined based on palpation done under fluoroscopy as per previous findings,[27] and referral patterns determined from studies conducted in patients and asymptomatic volunteers.[28–30] For blocks done in the prone position, an anteroposterior fluoroscopic view was used to delineate the lateral border of the cervical vertebral columns. Needle insertion sites were marked at the waist of the targeted spinal level, and 22-gauge spinal needles were inserted using a coaxial view parallel to the lateral edge of the bony margin. Lateral fluoroscopic imaging was used to assess and confirm depth. In the anteroposterior view, the needle tip was maintained at the junction of the bony soft-tissue interface.

For blocks done in the lateral position, the paired articular pillars at the targeted levels were aligned to remove parallax, and a lateral fluoroscopic view was used to mark the center. Twenty-two gauge needles were then inserted into the middle of each targeted rhomboid for C3–C6 blocks. For C7 MBB, which vary considerably because of the capricious course of the nerve, the final position for blocks done in both positions was situated at the center of the articular process, which is one of the several commonly used sites for neural blockade.[20,31] Similar to prone blocks, a cross-table anteroposterior image was used to confirm correct needle placement at the waist of the bony soft-tissue interface.

The injectate composition for all blocks was a 50:50 mixture of bupivacaine (0.75%) and Isovue 300 (61%) (Bracco Diagnostics, Princeton, NJ), yielding a final bupivacaine concentration of 0.375%. Once final needle position was deemed adequate at all levels, aliquots of the injectate were dripped into the hub of all needles, after which the allotted injectate volume was administered through pre-prepared

1-ml syringes. In the case of intravascular injection, the needle was repositioned as soon as vascular uptake was observed, and the original amount of injectate was administered.

Radiologic Grading

All cervical spine CT scans were done within 20 min of injections. Helically acquired 2.5-mm axial CT images were obtained from the base of the skull to the upper thoracic region. Multiplanar reconstruction was done at 1.25-mm intervals, at which time sagittal and coronal reformations were performed. CT scans were windowed in both bone and soft-tissue algorithms.

All CT scans were read by a board-certified radiologist who was blinded to treatment allocation. The following criteria were predesignated to categorize the various outcome measures. A targeted medial branch was deemed to be missed when no contrast was visualized at the waist of the targeted articular pillar. For the C7 medial branch, which can vary considerably in its course, the block was considered to be errant when the bony target area was devoid of contrast (*i.e.*, the nerve was considered to "hug" the bone at the designated target point). An injection was designated as inappropriately blocking the spinal nerve if contrast extended into the middle of the foramen in the horizontal plane, and to such a degree in the vertical dimension as to envelop the exiting nerve. If contrast was noted proximal to the base of the foramen, the block was subcategorized to be epidural. An inadvertent intra-articular injection was annotated when contrast filled the facet joint at a nontargeted spinal level (*i.e.*, the facet joint just below or above one of the two terminal nerve blocks). The variable "contiguous spread to an adjacent medial branch" was recorded only for the two terminal nerve blocks because continuous spread to a different targeted nerve is impossible to ascertain and irrelevant. For the C3–C6 medial branches, this was considered to occur when contrast was observed at the waist of the articular pillar just below or above the targeted medial branch. In the case of C7, it was recorded as positive when contrast was seen at the designated C7 target point. Contiguous spread to the nearby third occipital nerve was deemed to have occurred when contrast was noted along the course of the nerve adjacent to the C2–C3 z-joint.

Data Collection and Pain Assessment

In addition to the baseline demographic data and radiologically assessed accuracy measures, the clinical variables recorded for analysis were as follows: duration of pain, active duty status, baseline pain score, Neck Disability Index score (a validated instrument used to assess disability secondary to neck pain),[32] obesity, and opioid usage.

Analgesic response to injection was assessed using an 8-h pain diary based on a 0–10 numeric rating scale in which a score of 0 represented "no pain" and a score of 10 signified "the worst pain imaginable." A successful outcome was predefined as at least 50% pain relief lasting a minimum of 3 h.

Statistical Analysis

The statistical significance of differences observed between groups by volume and position were assessed with two-tailed tests using Stata 10.1 (StataCorp. 2007; Stata Statistical Software: Release 10; StataCorp LP, College Station, TX). Histograms were constructed to examine the distribution of variables on a continuous scale by volume and position groups. Because these variables were not normally distributed, a nonparametric test of the equality of the medians was performed. For categorical data, chi-square and Fisher exact tests were used. Continuous data are presented as medians and interquartile ranges (IQR), whereas categorical data are presented as the point estimate and percentages. To evaluate differences in proportions, a two-sample proportion test was used. For each analysis, a P value less than 0.05 was considered statistically significant. In addition, we estimated the standardized effect size of the volume injected on instances of aberrant spread per person.

Univariate and multivariate regression models were constructed to estimate the relation of instances of aberrant spread to clinical and demographic characteristics. In the multivariate model, all variables were included at the same time. In addition, because there is some potential for differences at the individual level to confound block level variability, generalized estimating equations were used to account for clustering by individual.

Results

Patient demographics broken down by volume group are shown in table 1. The differences observed between groups were small and none were statistically significant, indicating successful randomization. Median age of study participants was in the mid-40s, and most participants were men. Individuals randomized to receive a 0.25-ml injection reported a median duration of pain of 2.5 (IQR 1.5–5.0) years, whereas persons in the 0.5 ml group had experienced pain for a median of 4.3 (IQR 2.0–8.0) years. Median baseline pain intensity was moderately severe, 5.8 of 10 (IQR 5.0–7.0) in the 0.25 ml group and 5.5 of 10 (IQR 4.0–7.0) in the 0.5 ml group. Six persons in the 0.25 ml group and three in the 0.5 ml group reported having at least 50% pain relief.

Among the 86 nerve blocks performed, intravascular contrast uptake was noted in six cases, all of which were remedied on the first attempt by slightly repositioning the needle. Detailed radiologic examination of these injections revealed that in three blocks, an increased volume of contrast was noted whereby it was not possible to discern the initial injectate from the subsequent correction. In one case, no aberrant spread was noted but the increased volume of contrast still missed the target nerve. In the other two cases, no aberrant contrast spread was noted at any level despite the increased volume. However, one could not definitively rule out that the target nerve was engulfed because of the increased injectate volume. Hence, the statistical analysis was adjusted accordingly in these two cases.

Table 1. Baseline Demographic and Clinical Characteristics of Study Patients

	Medial Branch Blocks with 0.25 ml (n = 12)	Medial Branch Blocks with 0.5 ml (n = 12)	*P* Value
Age, median (IQR)	45.5 (43.0–50.0)	44.0 (42.0–49.0)	0.53
Sex, n (%)			1.00
Male	8 (66.7)	8 (66.7)	
Female	4 (33.3)	4 (33.3)	
Duration of pain, yr, median (IQR)	2.5 (1.5–5.0)	4.3 (2.0–8.0)	0.68
Levels blocked, median (IQR)	4.0 (3.0–4.0)	3.5 (3.0–4.0)	1.00
Active duty, n (%)	7 (58.3)	7 (58.3)	1.00
Obese, n (%)	1 (8.3)	2 (16.7)	1.00
No. patients on opioid therapy, n (%)	4 (33)	2 (16.7)	0.64
Baseline NRS pain score, median (IQR)	5.5 (5.0–7.0)	5.5 (4.0–7.0)	0.68
Baseline NDI score, median (IQR)	46.0 (14.0)	38.0 (18.0)	0.68
Postblock NRS pain score, median (IQR)	3.0 (3.0–4.0, n = 11)	3.3 (3.0–4.0, n = 12)	0.87
≥50% pain relief (%)*	6 (54.5)	3 (25)	0.21

A nonparametric test of the equality of medians was used for continuous data; chi-squared and Fisher exact tests were used for categorical data.

* One patient in the 0.25 group did not return pain diary (n = 11).

IQR = interquartile range (75th value–25% value); NDI = Neck Disability Index; NRS = numerical rating pain scale.

The number and types of aberrant injectate spread stratified by volume are illustrated in table 2. The standardized effect size was estimated to be 0.37, suggesting a moderate to large effect of volume injected on aberrant spread. In the 0.5 ml group, 50% more individuals (9 *vs.* 6) were noted to have at least one instance of aberrant spread, with these patients also experiencing more cumulative occurrences (16 *vs.* 7; $P = 0.07$). Most occurrences involved spread to a nontargeted contiguous medial branch. In the 0.25 ml group, all five cases (56%) involved spread from C3 to the supra-adjacent third occipital nerve. In the 0.5 ml group, two thirds of the nine cases involved spread to another medial branch. Among the 19 terminal nerve blocks done with 0.5 ml that did not involve C3, contrast was observed at a nontargeted adjacent facet joint nerve 31.5% of the time, whereas all 15 non-C3 terminal nerve blocks done with 0.25 ml were target specific (fig. 1).

The differences observed between the two injectate volumes for spread to contiguous nerves were similar for other

Table 2. Instances of Aberrant Spread and Missed Nerve Blocks Stratified by Injectate Volume

	0.25 ml (n = 12, 44 blocks)	0.50 ml (n = 12, 42 blocks)	*P* Value
Persons with aberrant spread	6 (50.0%)	9 (75.0%)	0.32
Total instances of aberrant spread	7 (15.9%)	16 (38.1%)	0.07
Instances of spread to contiguous medial branch*	5 (20.8%, n = 24 blocks)	9 (37.5%, n = 24 blocks)	0.18
Instances of spread to third occipital nerve	5 (55.6%, n = 9 blocks)	3 (60.0%, n = 5 blocks)	0.40
Instances of spread to other medial branch	0 (0%, n = 15 blocks)	6 (31.5%, n = 19 blocks)	0.006
Instances of foraminal spread	2 (4.5%, n = 44 blocks)	5 (11.9%, n = 42 blocks)	0.19
Instances of epidural spread	0 (0%)	0 (0%)	NA
Instances of terminal facet joint spread†	0 (0%, n = 24 blocks)	2 (8.3%, n = 24 blocks)	0.15
No. missed nerves‡	3 (7.0%, n = 43 blocks)	3 (7.3%, n = 41 blocks)	1.00

"N" in columns represents the total number of opportunities for the variable to occur (*e.g.*, in the 0.25 ml group, there were 9 instances where the C3 medial branch was targeted, and therefore 9 chances for spread to the third occipital nerve; for instances of spread to contiguous medial branch, there were 24 chances for contiguous nerve spread to be detected). Differences in instances were assessed by Wilcoxon rank-sum test for nonparametric analog to independent samples and *t* test interpreted as assessing the differences in the average number of aberrant spread instances per person between groups.

* Refers to spread to adjacent medial branch only for the highest or lowest nerve blocks. † Refers to spread into the facet joint only at the highest or lowest nerve blocks because only half of these facet joints are anesthetized by medial branch blocks; hence, only spread into these joints can be a source of false-positive cases. ‡ Based on 43 and 41 nerve blocks for the 0.25 and 0.5 ml groups, respectively, because for one block in each group, intravascular uptake occurred in which it was not possible to reliably discern whether the nerve was anesthetized because of the increased volume observed after repositioning and reinjecting the needle.

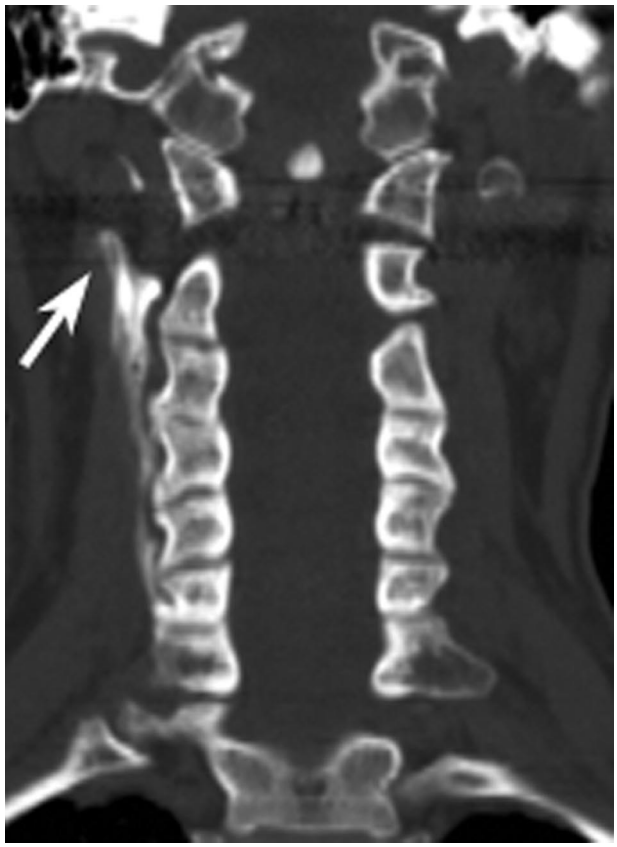

Fig. 1. Coronal reconstructed computed tomographic image demonstrating a right-sided C3–C6 medial branch block with contiguous spread to the third occipital nerve.

outcome measures as well. Contrast spread into the center of an intervertebral foramen was noted during two blocks (4.5%) in the 0.25 ml group *versus* five times (11.9%) in the 0.5 ml group ($P = 0.19$). Only two instances of intra-articular z-joint spread were observed, both of which occurred during the lowest nerve block in the 0.5 ml group. No epidural spread was noted in any of the blocks (figs. 2 and 3).

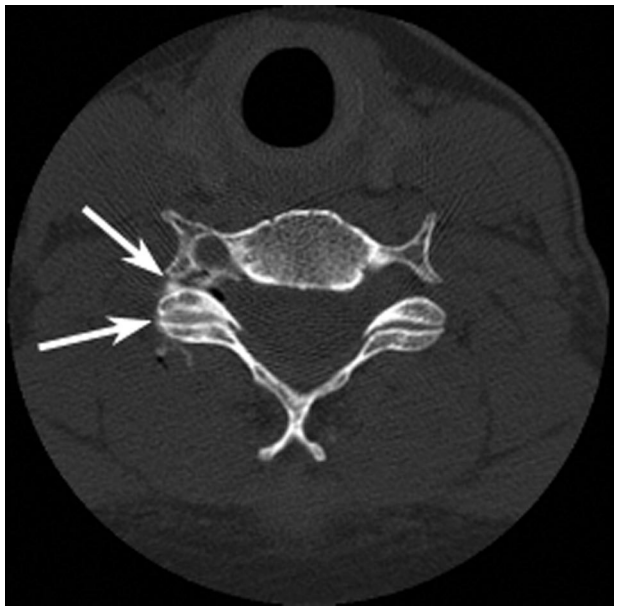

Fig. 2. Axial computed tomographic image showing spread into the right C6–C7 zygapophysial joint and foramen.

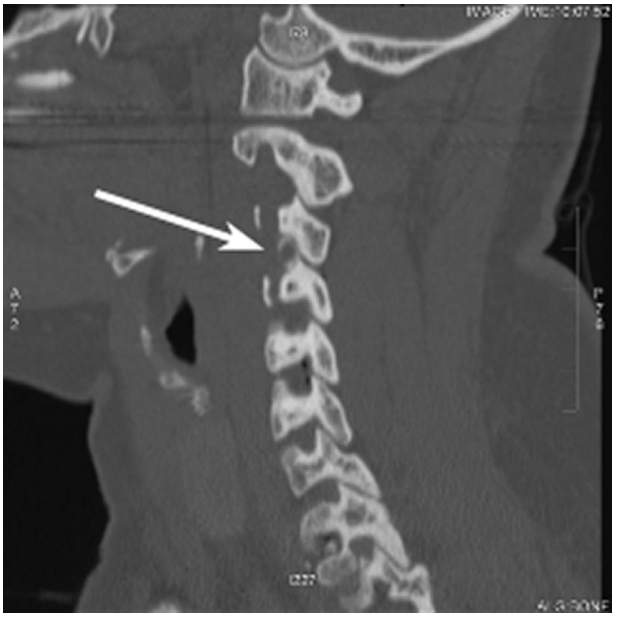

Fig. 3. Sagittal reconstructed computed tomographic image showing left C3–C4 foraminal spread.

Three nerves were missed in each treatment group, indicating a 93% accuracy rate. In three of these cases, air was present adjacent to the articular waist, suggesting that needle placement was accurate but the contrast still spread laterally (fig. 4). In the 12 patients who underwent blocks with 0.25 ml, the postinjection pain scores decreased by 50% to 2.9

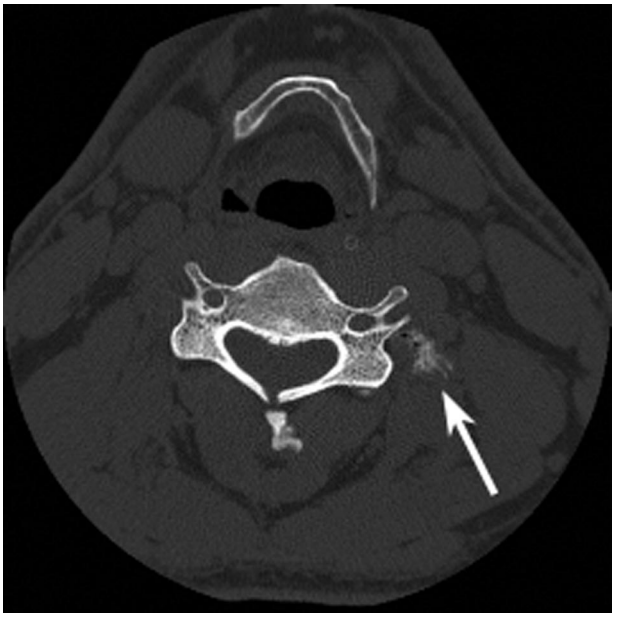

Fig. 4. Axial computed tomographic image demonstrating missed left C4 medial branch block. The air bubble adjacent to bone suggests that although the needle was appropriately positioned, the lateral spread of contrast and local anesthetic resulted in an inadequate block.

Table 3. Instances of Aberrant Spread and Missed Nerve Blocks Stratified by Position

	Prone (n = 12, 42 blocks)	Lateral (n = 12, 42 blocks)	*P* Value
Persons with aberrant spread	8 (66.7%)	7 (58.3%)	0.51
Total instances of aberrant spread	11	12	0.93
Instances of spread to contiguous medial branch*	8 (33.3%, n = 24 blocks)	6 (25.0%, n = 24 blocks)	0.56
Instances of spread to third occipital nerve	4 (66.7%, n = 6 blocks)	4 (50.0%, n = 8 blocks)	1.00
Instances of spread to other medial branch	4 (22.2%, n = 18 blocks)	2 (12.5%, n = 16 blocks)	0.36
Instances of foraminal spread	3 (7.0%, n = 43 blocks)	4 (9.3%, n = 43 blocks)	0.66
Instances of epidural spread	0 (0.0%)	0 (0.0%)	NA
Instances of facet joint spread†	0 (0.0%, n = 24 blocks)	2 (8.3%, n = 24 blocks)	0.15
Number of nerves missed‡	4 (9.5%, n = 42 blocks)	2 (4.8%, n = 42 blocks)	0.68

"N" in columns represents the total number of opportunities for the variable to occur (*e.g.*, in the prone group, there were 6 instances where the C3 medial branch was targeted, and therefore 6 chances for spread to the third occipital nerve; for instances of spread to contiguous medial branch, there were 24 chances for contiguous nerve spread to be detected). Differences in instances were assessed by Wilcoxon rank-sum test for nonparametric analog to independent samples and *t* test interpreted as assessing the differences in the average number of aberrant spread instances per person between groups.

* Refers to spread to adjacent medial branch only for the highest or lowest nerve blocked. † Refers to spread into the facet joint only at the highest or lowest nerve blocks because only half of these facet joints are anesthetized by medial branch blocks; hence, only spread into these joints can be a source of false-positive cases. ‡ Based on 42 nerve blocks, because for one block in each group, intravascular uptake occurred in which it was not possible to reliably discern whether the nerve was anesthetized because of the increased volume observed.

(SD 1.4). The reduction in postblock pain scores was more modest in the 0.5 ml group, declining by 31% to 3.8 (SD 1.9). Six patients in the 0.25-ml treatment group experienced ≥50% pain relief after their blocks, compared with three in the 0.5 ml group.

When examined by patient position (table 3), all differences in the numbers and locations of aberrant contrast spread were small and statistically nonsignificant. Although one more patient in the prone positioned group was observed to have aberrant contrast spread (8 *vs.* 7), overall there was one less instance of aberrant spread in the lateral group (11 *vs.* 12). In subjects treated in the prone position, there were slightly more instances of spread to a contiguous medial branch and missed nerve blocks. In contrast, episodes of foraminal and intra-articular spread were slightly more common in persons treated in the lateral position.

When examined by position, the changes in median pain intensity were the same, decreasing from 5.5 of 10 (IQR 5–7) to 3.0 of 10 (IQR 3–4) in the prone group, and from 5.5 (IQR 4–7) to 3.0 (IQR 3–4) in the lateral group. One third of the people in the prone group and 45.4% of persons in the lateral group obtained ≥50% pain relief after their blocks ($P = 0.55$).

The accuracy of blocks stratified by the targeted nerve is shown in table 4. Accuracy was higher for blocks done at C4, C5, C6, and C7 than C3 (78 *vs.* 36%, $P = 0.002$). Results of the uni- and multivariate regression models are shown in table 5. The set of independent covariates accounted for 21.0% of the variability in the outcome. None of the odds ratios (OR) observed was statistically significant; however, several of the multivariate estimates bear noting. Specifically, the OR for aberrant spread increased by 4.3 for persons who received a 0.5-ml injection, when all other variables were held constant. Being on active duty (OR 4.23, 95% confidence interval 0.15–122.62) and being obese (OR 2.65, 95% confidence interval 0.14–50.54) were also associated with an increased likelihood of aberrant spread, whereas opioid use was associated with a decreased likelihood (OR 0.33, 95% confidence interval 0.03–3.28).

Discussion

The key finding in this study is that cutting the injectate volume for cervical MBB from 0.5 to 0.25 ml seems to improve specificity. Spread to adjacent, nontargeted, potential

Table 4. Accuracy of Nerve Blocks Stratified by Injection Level

	Accurate Block*	Inaccurate Block†
C3 medial branch (n = 14)‡	5 (35.7%)	9 (64.3%)
C4 medial branch (n = 22)	16 (72.7%)	6 (27.3%)
C5 medial branch (n = 24)	21 (87.5%)	3 (12.5%)
C6 medial branch (n = 19)	15 (79.0%)	4 (21.1%)
C7 medial branch (n = 7)	4 (57.1%)	3 (42.9%)

Duplicate "inaccuracies" at each level counted only once. A two-sample proportion test was used to test the null hypothesis of no difference between the proportions of accurate blocks. All persons had a C5 block; therefore, the *P* value was not calculable. Data were analyzed with chi-squared and Fisher exact tests.

* An "accurate" block refers to a block in which the target nerve was anesthetized and no aberrant contrast spread was noted. † Inaccurate block includes instances of "missed" nerves and aberrant contrast spread. ‡ $P = 0.0015$ for difference between accuracy of C3 blocks and all other blocks.

Table 5. Association of Demographic and Clinical Characteristics with Aberrant Spread, Clustered by Individual (n = 24, r^2 = 0.2102)

	Univariate Model			Multivariate Model		
	Unadjusted Odds Ratio	95% CI	*P* Value	Adjusted Odds Ratio	95% CI	*P* Value
Age (centered at the mean age)	1.01	0.96–1.08	0.63	3.92	0.08–190.64	0.49
Female gender	2.33	0.34–15.93	0.39	4.75	0.57–39.66	0.15
Lateral patient position	0.70	0.13–3.82	0.68	0.53	0.05–6.27	0.62
0.5 ml volume injected	3.00	0.51–17.54	0.22	4.30	0.51–36.57	0.18
Duration of pain	1.02	0.89–1.18	0.75	1.10	0.84–1.42	0.49
No. levels affected	1.20	0.22–6.62	0.83	1.97	0.13–29.2	0.62
Right side	0.57	0.10–3.30	0.53	0.61	0.04–8.86	0.72
Preprocedure NRS pain intensity	1.07	0.61–1.91	0.80	1.19	0.45–3.16	0.73
Neck Disability Index score	0.99	0.93–1.05	0.70	0.96	0.86–1.07	0.46
Active duty	1.20	0.22–6.62	0.83	4.23	0.15–122.62	0.40
Obese	1.23	0.09–16.77	0.88	2.65	0.14–50.54	0.52
Opioid use	0.19	0.03–1.46	0.11	0.33	0.03–3.28	0.34

The baseline set of covariates was for a male person, newly diagnosed with pain, treated with a 0.25-ml injection in the prone position, without preprocedure pain or disability on the Neck Disability Index, 44 yr of age, three levels affected, treated on the left side, not on active military duty, not obese, and not using opioids.

NRS = numerical rating scale.

pain-generating structures occurred in 16 cases, compared with only seven blocks done with 0.25 ml of injectate. This incidence was more than two times higher than that reported by Dreyfuss *et al.*[18] for lumbar MBB. This discrepancy is likely attributable to several factors, including dissimilarities in scale between the lumbar and cervical spine, anatomical differences among relationships between various structures in the two regions, and the larger number of variables examined in this study.

With the exception of intra-articular spread which, although uncommon (2%), occurred exclusively in blocks done with 0.5 ml in the lateral position, patient position during needle insertion seemed to have little impact on either sensitivity or specificity. In fact, half of the missed target nerves occurred in the 0.5-ml treatment group, which suggests that needle position may be a more important determinant of specificity than volume. Other factors that could potentially affect accuracy include needle plane (*i.e.*, parallel or perpendicular to the target nerve), bevel orientation, speed of injection, and variations in tissue impedances.[33] Intrafacetal spread may occur more frequently with the lateral approach because this needle trajectory renders the joint space more exposed and accessible. Whether the lateral and posteroanterior approaches would still be equivalent in accuracy had needle position not be confirmed using anteroposterior and lateral fluoroscopy remains unknown, but several reasons make this practice desirable/ideal. These include optimizing needle placement (*i.e.*, articular pillars are often obscured in a lateral view at lower levels and spinal levels can best be discerned from this perspective), enhancing safety, and evaluating contrast dispersion patterns.

Perhaps the most striking finding was that in 57% of C3 MBB, the injected contrast mixture also engulfed the third occipital nerve. This may have occurred because of the close proximity between C3 and the supra-adjacent nerve and is relevant for two reasons. First, the C3 medial branch carries little, if any, sensory information from the C2 to C3 z-joint that lies superior to it.[34] The second reason is that this joint is most frequently implicated in chronic neck pain and cervicogenic headaches.[2,35] Because a properly placed, controlled C3 radiofrequency lesion will never extend to the third occipital nerve,[36,37] the extraneous injectate flow may be an important contributor to the high false-positive rate reported for uncontrolled cervical MBB. In contrast, contiguous injectate spread was relatively infrequent (18%) at other target sites and never occurred with 0.25 ml. In addition to the aberrant flow of local anesthetic, other causes of false-positive diagnostic blocks include the placebo effect, excessive administration of superficial anesthetic, and the inappropriate use of sedation.[11,17] Missed nerve blocks occurred with equal frequency using both volumes, which suggests that needle positioning and not volume of contrast is the principal cause of false negatives.

It is interesting to note that the higher incidence of inadvertent spread to untargeted nervous tissue did not translate into reduced pain scores in the 0.5 ml group. The reasons for false-positive blocks are manifold and include not just inadvertent spread to adjacent pain-generating structures, but also anxiolysis, the placebo effect, and the overzealous use of superficial anesthesia.[11,17,38] Because z-joint pain accounts for a relatively high proportion of patients with chronic neck pain, under ideal circumstances the incidence of false-positive blocks would be expected to be low. Because this study was not powered or intended to detect differences in postprocedure pain scores, between-group disparities in the true

prevalence of cervical facet joint pain or any of the other variables could account for the findings.

The results of this study may potentially serve to increase the specificity of diagnostic MBB, enhance their diagnostic utility, and possibly improve their prognostic value for radiofrequency denervation. First, because halving the injected volume increased specificity without a concomitant increase in the number of missed nerves, practitioners should strongly consider cutting the volume of local anesthetic injected from 0.5 to 0.25 ml. Whether further reducing the volume might result in even better accuracy rates is an area ripe for investigation. Second, the third occipital nerve was inadvertently anesthetized, thereby rendering the z-joint insensate in more than half of the C3 MBB done, irrespective of volume or position. The potential negative ramifications of this lack of specificity can be addressed in several ways, including investigating the effect of further decreasing the injected volume for C3 MBB, performing all C3 blocks in conjunction with either diagnostic third occipital nerve blocks or third occipital nerve radiofrequency lesioning, and performing all C3 blocks under CT guidance to ensure the absence of aberrant contrast extravasation. Finally, targeted nerves were missed in 7% of blocks, which sometimes occurred despite radiologic attestation of correct needle placement. This, in conjunction with previous studies demonstrating no difference in radiofrequency outcomes, when 50% pain relief was designated as the threshold for a positive block compared with more than 80% relief,[27,39] augurs favorably for using the lower cutoff value as the criterion for proceeding to radiofrequency denervation.

There are several limitations that should be addressed to place these results in context. First, although CT scans have previously been used as the definitive standard for evaluating the accuracy of fluoroscopically guided nerve blocks,[18,40] they are limited by their inability to visualize nervous tissue. Despite potential variability in nerve location,[33,41] this was deemed acceptable because the target sites are almost always the same for fluoroscopically guided MBB,[2–4,17,27] which are subject to the same limitations. Second, our power analysis was conducted under the assumption that because the final needle position for all blocks was confirmed in both anteroposterior and lateral fluoroscopic views, the lateral and posteroanterior approaches would be equally accurate. However, dispersing liquid at the exact same point from two different planes does not guarantee a similar dispersion pattern, just as spraying water at a dirty car from a hose situated at different angles would be expected to wet different parts of the car. For example, one might anticipate that nerve blocks done through a lateral approach would tend to have a greater likelihood of foraminal spread than those performed in a true prone position, because with the latter technique, a needle cannot be positioned too anteriorly without also veering laterally, which naturally protects against transforaminal extension. Finally, the sample size was calculated based on the total projected instances of aberrant flow for each group. For subcategories of aberrant flow, these numbers were not reached. This makes it difficult to distinguish whether negative subcategorical findings were a reflection of the lack of power, lack of an effect, or a combination of the two.

In conclusion, the results of this study demonstrate that reducing the volume for cervical MBB from 0.5 to 0.25 ml may enhance specificity. Because blocks performed in the prone and lateral positions were comparable in accuracy irrespective of treatment group, the reduced volume can be administered using either patient position.

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