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The Prevalence of Chronic Cervical Zygapophysial Joint Pain After Whiplash

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Study Design. A survey of the prevalence of cervical zygapophysial joint pain was conducted.

Objectives. To determine the prevalence of cervical zygapophysial joint pain in patients with chronic neck pain after whiplash.

Summary of Background Data. In a significant proportion of patients with whiplash, chronic, refractory neck pain develops. Provisional data suggest many of these patients have zygapophysial joint pain, but the diagnosis has been established by single, uncontrolled diagnostic blocks.

Methods. Fifty consecutive, referred patients with chronic neck pain after whiplash injury were studied using double-blind, controlled, diagnostic blocks of the cervical zygapophysial joints. On separate occasions, the joint was blocked with either lignocaine or bupivacaine in random order.

Results. A positive diagnosis was made only if both blocks relieved the patient's pain and bupivacaine provided longer relief. Painful joints were identified in 54% of the patients (95% confidence interval, 40% to 68%).

Conclusion. In this population, cervical zygapophysial joint pain was the most common source of chronic neck pain after whiplash. [Key words: neck pain, prevalence, whiplash, zygapophysial joint] **Spine 1995;20: 20–26**

Few topics in medicine polarize views more than whiplash injury. On the one hand, it is argued that chronic pain after whiplash injuries is maintained by psychological factors, either as a deliberate lever for financial gain or as a consequence of pre-existing psychological disturbance. On the other hand, many authorities have advocated that much of the chronic morbidity after whiplash injury can be explained by legitimate, organic lesions.

Careful review of the studies purporting to show that whiplash patients are malingering has revealed little if any evidence to support such a proposition.[24,25] Furthermore, a recent prospective study provided strong evidence to refute the hypothesis that chronic symptoms after whiplash injury arise from pre-existing psychological problems.[27]

In contrast, the data supporting an organic basis for chronic pain after whiplash is compelling and has been derived from a number of sources, including experimental studies on animals[22,33,34] and cadavers,[1,15] and descriptive studies of postmortem and clinical findings.[2,21] These different approaches have been surprisingly consistent in their findings, revealing a number of pathologic lesions capable of producing chronic pain after a flexion-extension (whiplash) injury to the neck. These have included injuries to the discs, ligaments, and the cervical zygapophysial joints.

The cervical zygapophysial joints are particularly relevant. Clinical and experimental studies of whiplash injuries in humans and animals have revealed tears of the joint capsules, hemarthroses, and fractures of the articular cartilage and subchondral bone.[2,14,33–35] Detecting these injuries *in vivo* is difficult. It has been clearly demonstrated that injuries to the cervical zygapophysial joints frequently are undetectable on conventional x-ray examination,[10,21,35] and there are no known clinical features that permit their identification. Consequently, the contribution of painful cervical zygapophysial joints to the problem of chronic neck pain after whiplash injury is not known.

The only known way to reliably diagnose painful cervical zygapophysial joints is through local anesthetic blocks of the joints themselves or the nerves that supply them. If these procedures relieve pain, it can be legitimately inferred that the target joint is the source of pain.[3,5,13] Provisional, descriptive studies using these techniques have revealed that painful cervical zygapophysial joints may account for more than 60% of chronic, post-traumatic neck pain, as seen in referral-based practice.[3,13] However, these studies were limited in that the patients studied were heterogenous with respect to the etiology of their neck pain, and the diagnoses were based on single, uncontrolled diagnostic blocks that have been shown to carry a 27% false-positive rate.[6]

The present study was designed to determine the prevalence of cervical zygapophysial joint pain in patients with chronic neck pain after whiplash injury. To eliminate any risk of false positive responses, a stringent

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protocol of double-blind, controlled blocks using contrasting anesthetic agents was used to rule in the diagnosis. If cervical zygapophysial joint pain were shown to be uncommon or rare, further research into this condition could be abandoned or at least reduced. On the other hand, if it were shown unequivocally to be common, major revisions of attitudes and clinical approaches to patients with chronic whiplash pain would be required.

To prepare for the present study, we explored and established the face validity of medial branch blocks for the diagnosis of cervical zygapophysial joint pain.[5] These blocks do not anesthetize any other structure that legitimately might be an alternative source of pain.[5] Subsequently, we established the construct validity of double-blind, comparative local anesthetic blocks.[7] Comparative blocks reliably allow true-positive responders to be identified.[7] Having established the validity of these diagnostic techniques, we were able to apply them to pursue the prevalence of chronic zygapophysial joint pain.

Methods

The subjects for this study were the first 50 consecutive patients referred to the Cervical Spine Research Unit, a tertiary referral unit. Patients were referred by medical practitioners who believed that the patient had chronic neck pain that had defied conventional management. Upon referral, the referring doctors were provided with written details of the eligibility criteria and copies of an application form. The criteria for inclusion were neck pain of more than 3 months duration following, and attributed to, a motor vehicle accident; previous assessment of the neck pain by a consultant or specialist; and age greater than 18 years. By definition, patients with neck pain before their accident and patients who ascribed their neck pain to causes other than a motor vehicle accident were not included. Pregnant women were excluded to avoid the risks associated with x-ray exposure. Eligible patients were seen in the order their completed application forms were received.

The unit is located in an industrial city, with a population of 250,000, and has received referrals from a large nearby city (Sydney) and rural areas as well as from local medical practitioners. Ethics approval for the study was granted by the University and Area Health Service ethics committees.

All patients initially were assessed by a rheumatologist. Informed, written consent was obtained, and a full medical history and examination were recorded. Visual analog scales of pain severity were completed by all patients, and McGill pain questionnaires were administered to all English-speaking patients. Patients then were seen by a psychologist who administered the SCL-90-R psychological symptom checklist.[16] Three non-English-speaking patients did not complete the McGill pain questionnaire, but all completed the SCL-90-R with the aid of an interpreter. A cervical zygapophysial joint was selected for initial investigation based on the location of the patient's pain and by comparing it with the distribution of pain from cervical zygapophysial joints in studies of normal volunteers.[4,17] (Figure 1).

The model adopted was that if a patient had pain emanating from a cervical zygapophysial joint, the pain should be fully relieved if that joint were anesthetized. In addition, if, on different occasions, two local anesthetics with different durations of action were used, patients should obtain longer-lasting relief from the long-acting local anesthetic. Except in the case of the third occipital nerve, cervical medial branch blocks do not reliably produce cutaneous anesthesia. Consequently, there are no external cues regarding which agent may have been used. Only a genuine patient with genuine pain could determine whether a local anesthetic had been injected and whether it was a short-acting or long-acting agent. This investigative strategy has been validated elsewhere and is reliable in ruling-in true-positive responses.[7]

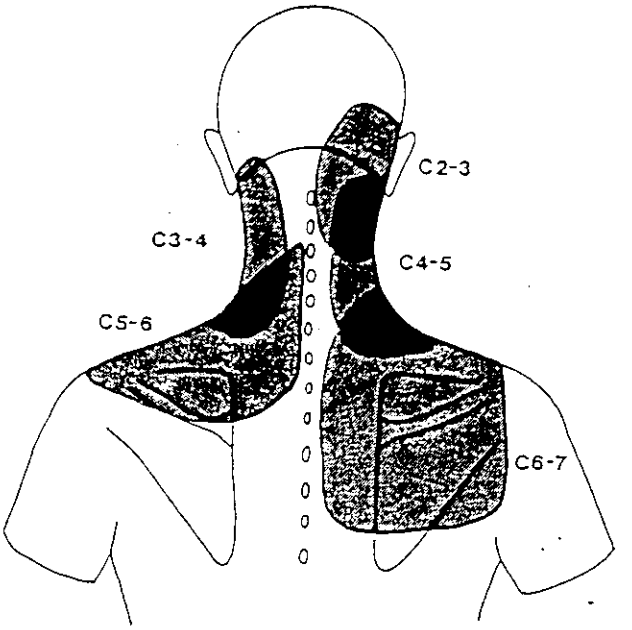

Figure 1. The referred pain map used to determine which joint should be initially investigated in a patient with suspected cervical zygapophysial joint pain. From Dwyer et al.[17]

Each patient was randomly assigned to receive lignocaine 2% or bupivacaine 0.5% as the initial local anesthetic. All patients and the assessing physician remained blind as to which anesthetic was being used.

The target joint was anesthetized by blocking the medial branches of the cervical dorsal rami innervating the joint. For the C3–C4 to C6–C7 zygapophysial joints, the two medial branches bracketing the joint were anesthetized, whereas for the C2–C3 joint, the third occipital nerve alone was anesthetized.[3–5,12,13,17] Under fluoroscopic control, each nerve was blocked using a 10-cm, 22-gauge or 25-gauge spinal needle inserted along a lateral approach. The target point for the third to seventh medial branches was the centroid of the projection of the articular pillar as seen on the lateral radiograph (Figure 2A). For the third occipital nerve, three target points were used to ensure adequate saturation of this relatively larger nerve (Figure 2B). At each of the three sites over the third occipital nerve, 0.5 ml of local anesthetic was injected. For the lower joints, the medial branches of the dorsal rami above and below the target joint were infiltrated with 0.5 ml of local anesthetic. These blocks have been validated in previous studies and have been shown to be specific for diagnosing cervical zygapophysial joint pain.[5]

After the procedure, each patient was observed for at least 20 minutes and then was requested to record a pain diary to determine the length of any pain relief. The next day they were contacted by an investigator who was blind to the anesthetic used. The degree and duration of any pain relief was recorded. The degree of pain relief was graded as "none" if there was no change in the pain, or "partial" if there was some relief of pain, but not more than might be ascribed to natural fluctuations. Pain relief was graded as "definite" if there was an unexpected loss of pain in one area or a complete loss of pain in a substantial part of the area in which pain was typically experienced. Relief was graded as "complete" if there was a complete loss of the patient's usual neck pain.

A joint was considered positive only if either definite or complete relief of pain was achieved. In such cases, the time at which the pain returned was noted, and the duration of pain relief was calculated. If a joint was positive, a second control) block was performed at that level with the complementary local anesthetic after a minimum of 2 weeks.

If a joint was negative, another, usually adjacent, joint was studied. This process was repeated until a symptomatic joint was identified, or until negative responses had been obtained at all potentially painful joints. Injections were performed at intervals of no less than 2 weeks.

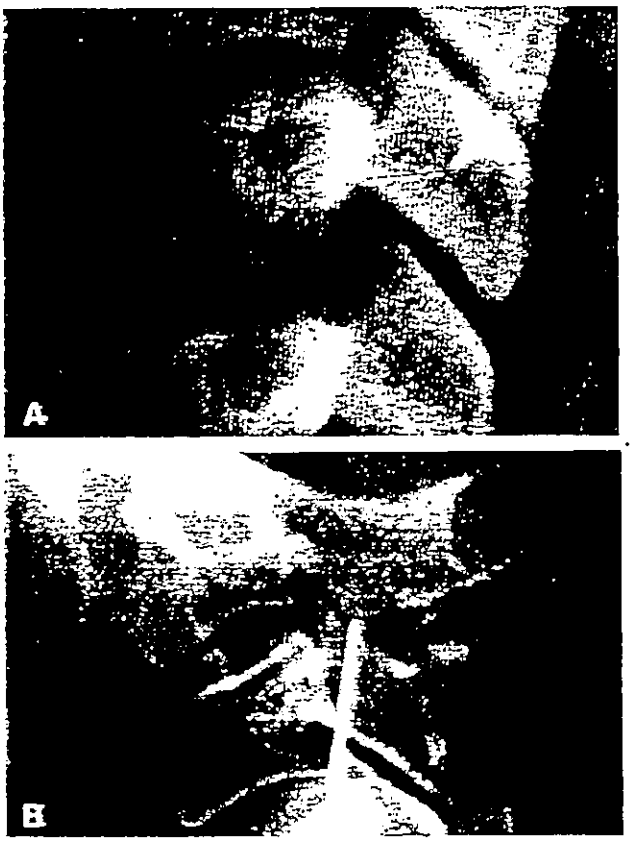

Figure 2. Radiographs showing needles in position on the target points for medial branch blocks. (A) C6 medial branch block. The needle is located at the target point—the centroid of the articular pillar—which lies at the intersection of the diagonals (dotted lines). (B) Third occipital nerve block. The target points lie on a vertical midline through the C3 articular pillar (dotted line). The injection points lie opposite the tip of the superior articular process of C3 (upper arrow), opposite the top of the pedicle of C3 (lower arrow) and midway between these latter two points (middle arrow).

Table 1. The Frequency of Symptoms and Associated Features in 50 Consecutive Patients With Chronic Pain After Whiplash Injury

Symptom	Number	Percent
Neck pain	50	100
Disturbance of concentration or memory	32	64
Headache	28	58
Paresthesia in the upper limb	28	56
Weakness or heaviness in the arms	27	54
Dizziness	25	50
Visual disturbance	13	26
Back pain	12	24

Patients were classified as having a painful cervical zygapophysial joint only if they achieved definite or complete relief of pain with both anesthetics and a longer duration of pain relief after the use of bupivacaine. Because the present study was explicitly designed to rule-in true-positive responders, all other patterns of response were taken to exclude the diagnosis.

To determine whether ostensibly positive responders simply might have guessed which local anesthetic had been used on each occasion, the probability that the observed proportion of correct results constituted a chance result was calculated using a binomial distribution in which P (the chance of a correct guess) was set at 0.5, and N was the number of patients with positive responses to both local anesthetics.[11]

■ Results

All of the first 50 eligible patients referred for assessment consented to participate. The study population was made up of 29 women (58%) and 21 men (42%) with a mean (±SD) age of 41 ± 11 years. Pain had been present for an average of 54 months (range, 5 to 272 months). In 84% of the patients, pain had developed within 3 days of the accident. In only two patients did the current pain develop after more than 3 months.

The majority of patients were drivers (76%) or front-seat passengers (14%) in cars at the time of the accident. The remaining five patients were two pedestrians struck by motor vehicles and three motor bike riders who suffered hyperextension injuries. Of those who were in a car at the time of the accident, 46.5% were struck from the rear and 23.5% had front-end collisions.

In addition to the symptom of neck pain, a number of associated symptoms were reported by a substantial proportion of the patients (Table 1). Although many patients complained of paresthesia or weakness in the upper limbs, none satisfied criteria for the diagnosis of radiculopathy as the basis of their neck pain. Their upper limb symptoms were nondermatomal and nonmyotomal—features that have been recognized previously in studies of whiplash patients, and whose physiological basis has been explained elsewhere.[8,13] All patients had undergone cervical spine radiography be-

Table 2. Demographic Features and Reasons for Withdrawal for Patients Who Withdrew From the Present Study

Age	Sex	Duration of pain (mo)	Blocks	Reason for Withdrawal
23	F	6	No	Pain settled to a tolerable level
26	M	39	No	Attempting other means of treatment
33	F	17	No	Frightened about the anesthetic blocks
34	F	169	No	Pregnancy
39	F	21	1	Lived 2 hours drive from the unit; travel aggravated pain
49	F	100	No	Vasovagal faint during attempted block
69	F	21	No	Pre-existing vestibular damage; feared further ataxia from blocks

fore entering the study, but there were no reports of fracture or dislocation of the cervical spine. The only abnormalities detected were congenital fusion in two patients and age-related degenerative changes in eight others.

Seven patients withdrew from the study. The reasons for withdrawal were obtained by mail to determine whether there was any consistent factor responsible for their decisions. The replies and the patient characteristics are summarized in Table 2. As a group, these patients did not differ significantly from the rest of the cohort group in age, duration, and severity of pain (Table 3). Their pain did not differ from that of the remaining patients regarding site or quality. There were no significant differences between the two groups in the areas of obsessive compulsive behavior, depression, anxiety, phobic anxiety, paranoia, or psychoticism as measured by the SCL-90-R sub-scales, although the patients who withdrew reported significantly fewer somatic symptoms and less hostility.

Five patients were unable to complete a definitive series of diagnostic blocks for extraneous, logistic, or personal reasons. Four of the five had a single positive result on one occasion.

Of the 38 patients who completed the investigation, 27 unequivocally met the predetermined criteria for cervical zygapophysial joint pain. They obtained complete pain relief after each of the two anesthetic blocks and each obtained longer-lasting relief with bupivacaine. This response rate established the prevalence of cervical zygapophysial joint pain as 54% (95% confidence intervals, 40%, 68%).

The 11 patients who completed the investigation but who failed to satisfy the predetermined diagnostic criteria displayed three different patterns of response. One patient had no pain relief from blocks at any cervical level, allowing the diagnosis of cervical zygapophysial joint pain to be confidently excluded. Two patients obtained pain relief at a given level on one occasion, but a subsequent block failed to achieve any pain relief. Eight patients reported that lignocaine had provided a longer duration of pain relief than bupivacaine, so that although their response to blocks was otherwise positive and convincing, they did not satisfy the criteria for a true-positive response. Thus, for the purposes of the present study, they were not diagnosed as having cervical zygapophysial joint pain. Thirty-five patients experienced pain relief after blocks with both agents, 27 of whom correctly identified the longer-acting local anesthetic. The likelihood that 27 out of 35 patients correctly guessed, by chance, which agent lasted longer is less than 1 in 500 ($P = 0.0019$).

Omitting four patients who reported more than 36 hours relief with either agent, the mean duration of relief after lignocaine was 354 minutes; that following bupivacaine was 592 minutes. The most common levels for symptomatic joints were C2–C3 and C5–C6 (Figure 3). Further investigations of the positive responders revealed that four of these patients had a second, symptomatic joint. The most common patterns of double-level, positive responses were C5–C6, C2–C3, and C5–C6, C6–C7.

Discussion

The far-reaching implications of the present study for whiplash patients and their doctors dictate that the findings be accurate and not overestimate the true prevalence of the condition because of sampling bias, an overly sensitive or invalid diagnostic test, or a sample that is too small or unrepresentative.

Sampling bias could not have unduly inflated the prevalence estimate because there is no reliable way to

Table 3. Comparison of the Clinical Features of Those Patients Who Completed the Study and Those Who Withdrew

	Study Subjects (n = 43)	Withdrawals (n = 7)	P Value
Age (median)	42	34	0.35
Months of pain—median (Q1, Q3)	42 (24, 73)	21 (17, 100)	0.48
VAS scores—median (Q1, Q3)	46 (32, 58)	29 (19, 40)	0.10
MPQ total word count median (Q1, Q3)	13 (10, 14)	13 (12, 15)	0.37
MPQ PRI-TT—median (Q1, Q3)	30.7 (22.6, 40.2)	30.4 (25.9, 45.9)	0.62
SCL-90-R‡ subscales—median (Q1, Q3)			
Somatization	1.6 (1.2, 2.0)	0.9 (0.7, 1.2)	0.01*
Obsessive-compulsive	1.7 (1.0, 2.5)	1.7 (0.4, 1.6)	0.07
Interpersonal sensitivity	0.8 (0.3, 1.4)	0.4 (0.1, 0.8)	0.10
Depression	1.5 (0.7, 1.8)	0.9 (0.6, 1.7)	0.29
Anxiety	0.8 (0.5, 1.2)	0.3 (0.2, 0.9)	0.10
Hostility	1.0 (0.7, 2.0)	0.7 (0.2, 0.7)	0.03*
Phobic anxiety	0.1 (0.0, 0.6)	0.1 (0.0, 0.8)	0.90
Paranoid ideation	0.7 (0.2, 1.3)	0.2 (0.1, 0.8)	0.15
Psychoticism	0.3 (0.1, 0.7)	0.2 (0.0, 0.6)	0.29

All characteristics were compared using the Mann-Whitney U test.
* Significant at $P < 0.05$.
† Total pain rating index.
‡ Median raw score and inter-quartile range.
VAS = visual analog scale.
MPQ = McGill pain questionnaire.

identify painful cervical zygapophysial joints short of performing diagnostic blocks. Consequently, the referring doctors in the present study could not have preselected the patients to favor a higher prevalence of cervical zygapophysial joint pain. The only indications for referral were that the patients had neck pain and wanted to seek relief of their pain.

Antecedent studies have established the validity of cervical medial branch blocks for detecting symptomatic zygapophysial joints. In particular, it has been shown that 0.5 ml aliquots of local anesthetic do not spread consistently to anesthetize structures other than the target medial branch and that the cervical zygapophysial joints are the only structures innervated by the medial branches of the cervical dorsal rami that might be held to be a source of chronic pain.[5] Consequently, a positive response to medial branch blocks can be interpreted only as indicating that the joint supplied by the nerves blocked is the source of the patient's pain. Of concern is whether the purported relief of pain obtained is genuine. In particular, if single blocks are used, there is no way to determine whether the response is truly positive or false-positive. The use of double-blind, controlled blocks effectively circumvents these concerns and dramatically enhances the reliability of the diagnostic blocks.

The use of a second, active agent, rather than a true placebo, as a control perhaps is novel or innovative, but is nonetheless legitimate when the purpose is simply to rule-in a positive diagnosis.[7] Only a patient with genuine pain could reliably determine whether a long-acting or a short-acting local anesthetic was used. A malingerer or an otherwise disturbed patient could only guess which agent was used. The present study demonstrates that the chances of the observed number of patients having correctly guessed the correct agents is less than 1 in 500. In addition, the mean duration of relief with each of the two local anesthetics used was concordant with the expected duration of action of each agent.[26,29,31]

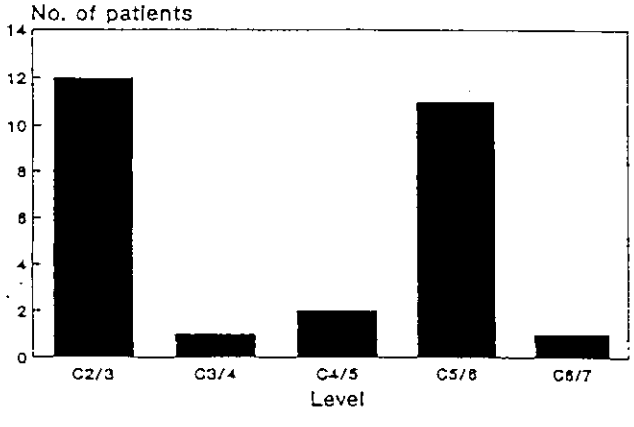

Figure 3. The distribution of symptomatic, zygapophysial joints by segmental level in 27 patients with cervical zygapophysial joint pain.

In other words, the vast majority of the patients behaved physiologically in accordance with the known pharmacology of the drug used.

Problematic are the patients who failed to meet the *a priori* diagnostic criteria through an unexpectedly long response to lignocaine. They may have been reporting genuine, yet poorly understood phenomena. Nevertheless, for the purposes of this study they were not admitted to the diagnosis of cervical zygapophysial joint pain. Similarly, all patients who withdrew from the study or who did not complete investigations were classified as negative. Therefore, the prevalence established by the present study constitutes a worst-case analysis. Because the patients who withdrew did not differ clinically or demographically from those who completed the study, there is no reason to believe that all those who withdrew would have been negative. Thus, the withdrawals do not detract from the study. Had they remained, their responses could have only increased the observed prevalence.

For the present study, the confidence limits of the observed prevalence are 40% to 68%. Thus, whatever aspersions might be intuitively cast on the size of the sample studied, formal statistical treatment of the data establishes that, in the worst case, the prevalence of cervical zygapophysial joint pain is at least 40%, but could be as high as 68%, and is most likely to fall close to the observed value of 54%.

We believe this to be the first study to use a double-blind, controlled diagnostic technique to address the diagnosis of any cause of neck pain. Some patients may suffer discogenic neck pain; others may have chronic muscle pain. However, despite any entrenched, contrary beliefs, there is no comparable epidemiologic evidence to indicate that the prevalence of any of these other conditions approaches that of cervical zygapophysial joint pain.

The pathology of painful cervical zygapophysial joints is unknown because this condition rarely has been recognized to date. Nevertheless, it is known that these joints may be afflicted by occult fractures,[1,2,10,15,21,35] capsular ruptures,[14,21] and intra-articular hemorrhage.[21,33] What are now required are studies correlating morphologic evidence of such injuries with responses to diagnostic blocks.

By the same token, therapy for cervical zygapophysial joint pain is in its infancy. There are encouraging reports of intra-articular corticosteroid[18,20,28,32] and percutaneous radiofrequency zygapophysial joint denervation,[19,30] but a recent study disputed any useful efficacy of intra-articular steroids.[9] Radiofrequency denervation of the cervical zygapophysial joints has yet to be subjected to a controlled trial.

Notwithstanding the absence of proven therapy, for patients with chronic whiplash, pursuing the diagnosis of cervical zygapophysial joint pain with diagnostic blocks has immediate utility to the doctor and the pa-

tient in medico-legal practice. A negative response to diagnostic blocks can be interpreted only as excluding one possible diagnosis—that of cervical zygapophysial joint pain—and cannot rule out genuine pain from other sources. However, if the diagnosis of cervical zygapophysial joint pain is established, many questions regarding the veracity of a patient's claim can be dispersed and appropriate legal settlement can be facilitated.

References

1. Abel MS. Moderately severe whiplash injuries of the cervical spine and their roentgenologic diagnosis. Clin Orthop 1958;12:189–208.
2. Abel MS. Occult traumatic lesions of the cervical vertebrae. Critical Reviews in Clinical Radiology and Nuclear Medicine 1975;6:469–553.
3. Aprill C, Bogduk N. The prevalence of cervical zygapophyseal joint pain: A first approximation. Spine 1992;17: 744–7.
4. Aprill C, Dwyer A, Bogduk N. Cervical zygapophyseal joint pain patterns. II: a clinical evaluation. Spine 1990;15: 458–61.
5. Barnsley L, Bogduk N. Medial branch blocks are specific for the diagnosis of cervical zygapophysial joint pain. Regional Anesth 1993;18:343–50.
6. Barnsley L, Lord SM, Wallis BJ, Bogduk N. False-positive rates of cervical zygapophysial joint blocks. Clinical Journal of Pain 1993;9:124–30.
7. Barnsley L, Lord SM, Bogduk N. Comparative local anaesthetic blocks in the diagnosis of cervical zygapophysial joint pain. Pain 1993;55:99–106.
8. Barnsley L, Lord SM, Bogduk N. The pathophysiology of whiplash. In: Teasell RW, Shapiro A, eds. Spine State of the Art Reviews. Cervical Flexion-Extension/Whiplash Injuries. Philadelphia: Hanley and Belfus, 1993;7:329–53.
9. Barnsley L, Lord SM, Wallis BJ, Bogduk N. Lack of effect of intraarticular corticosteroids for chronic pain in the cervical zygapophyseal joints. N Engl J Med 1994;330:1047–50
10. Binet EF, Moro JJ, Marangola JP, Hodge CJ. Cervical spine tomography in trauma. Spine 1977;2:163–72.
11. Bland M. An Introduction to Medical Statistics. Oxford: Oxford University Press, 1987:95–111.
12. Bogduk N. The clinical anatomy of the cervical dorsal rami. Spine 1982;7:319–30.
13. Bogduk N, Marsland A. The cervical zygapophysial joints as a source of neck pain. Spine 1988;13:610–7.
14. Buonocore E, Hartman JT, Nelson CL. Cineradiograms of cervical spine in diagnosis of soft-tissue injuries. JAMA 1966;198:143–7.
15. Clemens HJ, Burow K. Experimental investigation on injury mechanisms of cervical spine at frontal and rear-frontal vehicle impacts. Proceedings of the Sixteenth STAPP Car Crash Conference. Detroit: Society of Automotive Engineers, 1972:76–104.
16. Derogatis LR. SCL-90-R: Administration, Scoring and Procedures Manual-II. 2nd ed. Towson, MD: Clinical Psychometric Research, 1983.
17. Dwyer A, Aprill C, Bogduk N. Cervical zygapophyseal joint pain patterns. I: a study in normal volunteers. Spine 1990;15:453–7.
18. Dory MA. Arthrography of the cervical facet joints. Radiology 1983;148:379–82.
19. Hildebrandt J, Argyrakis A. Percutaneous nerve block of the cervical facets—a relatively new method in the treatment of chronic headache and neck pain. Manual Medicine 1986; 2:48–52.
20. Hove B, Gyldensted C. Cervical analgesic facet joint arthrography. Neuroradiology 1990;32:456–9.
21. Jónsson H Jr, Bring G, Rauschning W, Sahlstedt B. Hidden cervical spine injuries in traffic accident victims with skull fractures. Journal of Spinal Disorders 1991;4:251–63.
22. Macnab I. Acceleration-extension injuries of the cervical spine. In: Symposium of the Spine. St Louis: C.V. Mosby, 1969:10–17.
23. Macnab I. The "whiplash syndrome." Orthop Clin North Am 1971;2:389–403.
24. Mendelson G. Not "cured by a verdict." Effect of legal settlement on compensation claimants. Med J Aust 1982;2: 132–4.
25. Mendelson G. Follow-up studies of personal injury litigants. Int J Law Psychiatry 1984;7:179–88.
26. Moore DC, Bridenbaugh LD, Bridenbaugh PO, Tucker GT. Bupivacaine for peripheral nerve block: A comparison with mepivacaine, lidocaine, and tetracaine. Anesthesiology 1970;32:460–3.
27. Radonov PR, Stefano G, Schnidrig A, Ballinari P. Role of psychosocial stress in recovery from common whiplash. Lancet 1991;338:712–5.
28. Roy DF, Fleury J, Fontaine SB, Dussault RG. Clinical evaluation of cervical facet joint infiltration. Journal of the Canadian Association of Radiologists 1988;39:118–20.
29. Rubin AP, Lawson DIF. A controlled trial of bupivacaine: A comparison with lignocaine. Anaesthesia 1968;23:327–31.
30. Schaerer JP. Treatment of prolonged neck pain by radiofrequency facet rhizotomy. Journal of Neurological and Orthopaedic Medicine and Surgery 1988;9:74–6.
31. Watt MJ, Ross DM, Atkinson RS. A double blind trial of bupivacaine and lignocaine. Anaesthesia 1968;23:331–7.
32. Wedel DJ, Wilson PR. Cervical facet arthrography. Reg Anesth 1985;10:7–11.
33. Wickstrom J, Martinez JL, Rodriguez R Jr. The cervical sprain syndrome: Experimental acceleration injuries to the head and neck. In: Selzer ML, Gikas PW, Huelke DF, eds. The Prevention of Highway Injury. Ann Arbor, Michigan: Highway Safety Research Institute, 1967:182–7.
34. Wickstrom J, Martinez JL, Rodriguez R Jr, Haines DM. Hyperextension and hyperflexion injuries to the head and neck of primates. In: Gurdjian ES, Thomas LM, eds. Neckache and Backache. Springfield, IL: Thomas, 1970:108–19.
35. Woodring JH, Goldstein SJ. Fractures of the articular processes of the cervical spine. AJR Am J Roentgenol 1982; 139:341–4.

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