British Journal of Rheumatology 1989;**28**:528–533

CLINICAL PRACTICE

A STUDY OF UPPER LIMB PAIN AND PARAESTHESIAE FOLLOWING NECK INJURY IN MOTOR VEHICLE ACCIDENTS: ASSESSMENT OF THE BRACHIAL PLEXUS TENSION TEST OF ELVEY

By J. L. QUINTNER

St John of God Medical Centre, 175 Cambridge Street, Wembley WA 6014, Australia

SUMMARY

The brachial plexus tension test (BPTT) appears to offer a means of examining the extensibility and mechanosensitivity of the neural tissues related to an upper limb. This test was used to evaluate possible cervical or brachial plexus neural involvement causing arm pain syndromes in 37 patients presenting for assessment following neck injury in motor vehicle accidents. The BPTT was considered positive in 55 of the 61 symptomatic arms. There were no false-positive responses in the 13 asymptomatic arms although a slight loss of extensibility was evident in five arms.

Twenty patients without clinical evidence of current or previous neck pathology were similarly examined. There were no reports of pain on BPTT in this group. In 36 of the 40 arms a full range of extensibility was present. In the other four arms the loss of extensibility was slight.

This study suggests that arm pain and paraesthesiae which follow neck injury in motor vehicle accidents arise from irritable cervical neural tissues. The study also highlights the persistent nature and widespread distribution of the pain in these patients.

KEY WORDS: Cervical spine, Neuropathic pain, Brachial plexus tension, Motor vehicle accident.

THE assessment of patients with persistent pain syndromes of the head, neck and arm following injury to the neck in motor vehicle accidents has been a difficult area of musculoskeletal medicine [1–3]. Upper limb pain and paraesthesiae are part of the complex symptomatology in these patients [1, 2, 4–7].

Elvey [8] developed the Brachial Plexus Tension Test (BPTT) to help the examiner differentiate between local arm conditions causing pain and cervical/brachial plexus neural conditions with pain referral into the arm. The test utilizes manoeuvres which, used step-wise, increase tension within neural tissues related to the upper limb.

Cadaver studies demonstrated that movement of the arm in certain directions resulted in movement and tension of cervical nerve roots and their investing sheaths, and of anatomically related dura [9]. The greatest movement took place at C5 and C6 with some effect at C7. The position of the upper quarter that placed maximum tension on the cervical nerve root complexes combined glenohumeral joint abduction (110 degrees) and external rotation to maximum range with the arm behind the coronal plane, with elbow extension, wrist extension, supination of the forearm, shoulder girdle depression and lateral flexion of the neck to the contralateral side [10] (Fig. 1).

Further cadaver studies have shown that shoulder abduction to 105 degrees markedly increases tension in brachial plexus components and confirm that the other manoeuvres described by Elvey [8] result in additional tension [11, 12].

Kenneally *et al.* [13] documented the normal responses at end range of the BPTT in more than 400 asymptomatic volunteers. These indicated that C5, C6 and C7 nerve roots were implicated in the test to a greater degree than C8 and T1 roots. The symptoms most consistently evoked were a deep stretch or ache sensation in the cubital fossa extending down the anterior and radial aspects of the forearm into the radial side of the hand, and a definite tingling sensation in the thumb and the first three fingers.

A clinical validation study of the BPTT found that the test had moderate to high intra-examiner reliability (0.825) and that it could be used in the clinical situation to discriminate between the presence or absence of a brachial plexus involvement in patients with upper limb symptoms [14].

The aim of the present study was to assess the

Submitted 16 February; revised version accepted 13 May 1989.

Correspondence to Dr. Quintner.

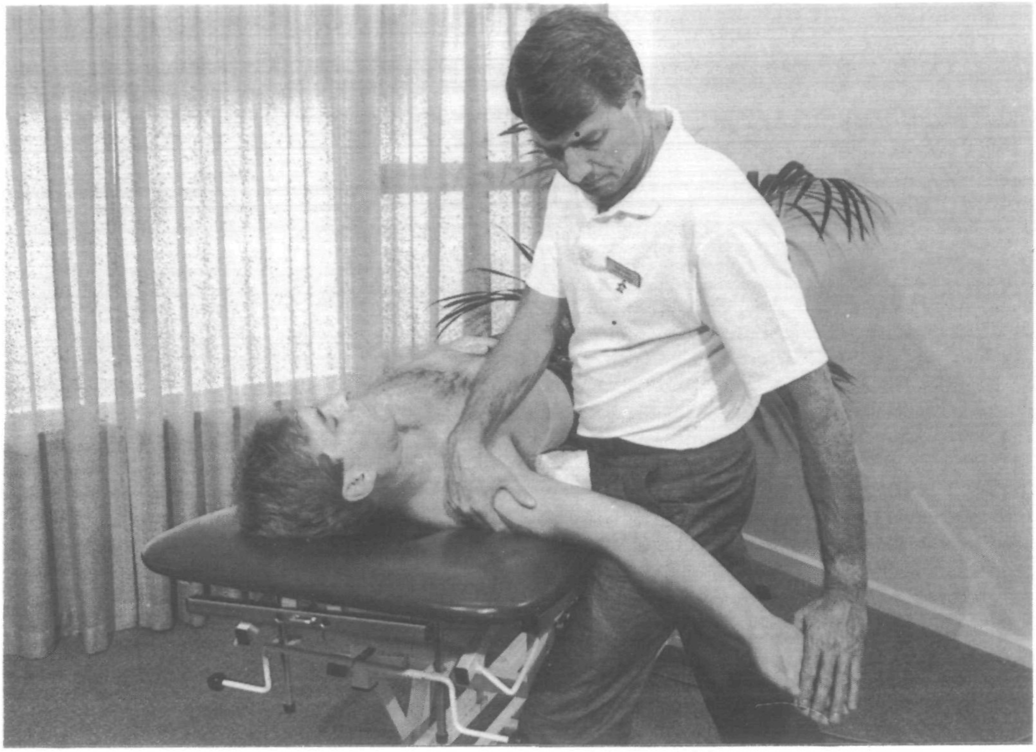

FIG. 1.—Brachial plexus tension test of Elvey. The shoulder girdle is gently depressed. The arm is then positioned in shoulder abduction (approximately 110 degrees) and external rotation, forearm supination, wrist extension and finger extension. In this figure, contralateral flexion of the cervical spine is also shown. The range of elbow extension is then carefully assessed and the subjective response to testing is noted. (Courtesy of Robert Elvey).

response to BPTT, first in patients in whom there was little likelihood of cervical or brachial plexus neural abnormality, and then in a cross-section of patients who presented with a history of neck injury in a motor vehicle accident followed by complaints of persistent neck pain together with arm pain and/or paraesthesiae.

PATIENTS AND METHODS

A study of the response to BPTT was undertaken in patients with no current or past history of neck pain. To be suitable for inclusion as a 'control', each patient was required to have full and pain-free cervical movements in all directions, and a full range of passive movements at shoulder, elbow and wrist. There were 20 patients in this group. In each patient the symptomatic response to tension testing and the range of extensibility possible was noted for each arm. The relevant musculoskeletal diagnosis was recorded as well as details of age, sex and occupational status. No attempt was made to match this group for age and sex with the neck injury group.

Forty patients with complaints of arm pain and/or paraesthesiae as a result of neck injury in a motor vehicle accident who were referred to the author between January 1986 and December 1987 comprised the injury group. Three patients known to have neck pain prior to their accident, were excluded. All were pursuing claims for compensation for personal injury. Apart from one referred by an insurer, all had been sent by family doctors. Eight had been examined by the author on one occasion, six on two occasions and 23 patients on three or more occasions.

A full medical history was obtained. The time of onset of the arm symptoms after the accident was determined. Spinal and lower limb symptoms were also noted. Physical examination was directed toward local pathology in the upper limb which, if present, could be a cause of symptoms.

Brachial plexus tension testing [8] was performed on each arm of each patient in both groups. The author, sequentially, positioned the shoulder joint in abduction and external rotation and then added shoulder girdle depression, forearm supination, wrist and finger extension and, finally, elbow extension. The position of lateral neck flexion to the contralateral side was only used in the examination of the symptomatic arms if the other manoeuvres were of full range and failed to provoke a symptomatic response. This latter position was used in the examination of all asymptomatic arms. The technique of administering the test included sufficient variations of the anatomical positions to make it unlikely that a false-positive response could be obtained. A test result was considered clinically relevant (positive) if symptoms were reproduced and there was loss of the normal full range of extensibility of the arm [13]. If the result was equivocal, testing was repeated at a future consultation and if symptoms were not reproduced, the test was considered to be negative.

The examiner was not blinded but an attempt was made to determine the sensitivity of the BPTT by its ability to reproduce the arm symptoms in the injury group. The specificity of the test was reflected by the extent to which a normal response was obtained in an asymptomatic arm. The values for sensitivity and for specificity could vary between 0 and 1.

Cervical radiology was available for 31 patients. Electrodiagnosis testing of median and ulnar nerve function had been performed on two patients.

RESULTS

Control group

There were 11 females and nine males, mean age 42 years (range 14–75 years). Twelve were employed, three had retired, three were housewives and two were at school. Lower limb arthropathy or enthesopathy was present in 11. Localized synovitis involved the hands in two patients. Two patients suffered from tennis elbow and two from tenosynovitis.

In 36 of the 40 upper limbs, a full range of extensibility was possible. The other four limbs lacked full extensibility by less than 20 degrees at the elbow. The most frequently reported subjective response was a stretch or pulling sensation in the cubital fossa (19 upper limbs); in 12 limbs no symptoms were felt. The remaining upper limb responses consisted of a pulling sensation deep within the forearm (four), a pulling sensation in the palm of the hand (three) and a stretch or pulling sensation in the shoulder region (two). These responses were consistent with those in an asymptomatic population [13].

Injury group

Thirty-one were female, six male, mean age 34 years (range 12–63). Twelve patients were working and 16 were unemployed as a result of their injury. Eight had not been working at the time of injury and one was still at school.

Seven had been involved in two accidents, a total of 44 reported accidents. In 30 of these the patient had been the driver of a vehicle. Twenty-five collisions were rear-end, 10 side-on, five were front-end and four were varied in type. The time interval between the accident (initial) and their referral ranged from 4 to 76 months (mean 28 months). Onset of arm symptoms occurred within 3 months of accident in 24; in 13, the onset was noted 3 or more months later. The mean delay in onset was 12 months (range 3–31 months). Nine of these 13 patients were in employment of a clerical nature at the time of onset of arm symptoms.

Symptoms are shown in Table I. Spinal pain was generally more severe in the neck, upper back and occipital regions than in the mid-back or low back. There were 61 symptomatic arms and 13 asymptomatic arms. One patient reported unilateral paraesthesiae in the absence of pain in either arm. Pain in the absence of paraesthesiae was reported in 17 arms, arm paraesthesiae in the absence of pain in six arms.

Arm pain was more commonly related to components of the upper portion of the brachial plexus than to those of the lower portion (see Table II). The distribution of the paraesthesiae was variable. In 15 they involved the whole hand, in two patients the whole arm and in two the forearm, wrist and hand. Nine described them in all fingers, four in the ring and little fingers, three in the ulnar three fingers, one in the thumb, index and middle fingers and one each involving the thumb and the middle finger. In no patient was a musculoskeletal abnormality of the upper limb detected. All but two patients demonstrated painful limited range of active cervical movement in at least one direction. Fifteen exhibited cervical movements which were limited and painful in all directions.

Table III shows the degree of correlation between the presence of arm symptoms and the result of brachial plexus tension testing in the 61 symptomatic arms. The overall sensitivity value of the BPTT was 0·9. In the 13 asymptomatic

TABLE I
SYMPTOMS IN INJURY GROUP (n = 37)

	Patients (n)	Per cent
Site of pain		
Neck	37	100%
Head	29	78%
Upper back—right	28	76%
Upper back—left	20	54%
Middle back	16	43%
Lower back	23	62%
Right arm pain	30	55%
Left arm pain	25	45%
Bilateral arm pain	19	51%
Unilateral arm pain	17	46%
Arm paraesthesiae		
Bilateral paraesthesiae	13	35%
Unilateral paraesthesiae	18	49%
Arm pain and paraesthesiae		
Bilateral both symptoms	24	65%
Unilateral both symptoms	13	35%
Unilateral paraesthesiae, no arm pain	1	3%

arms, the test produced either no response or the normal response. In five of the asymptomatic arms the test demonstrated a minor (less than 20 degrees) loss of the normal range of extensibility as in four arms of the control group. The specificity value of the BPTT in both the control and the injury group was 1 but it is not known whether a minor loss of normal range could be due to a subclinical abnormality of neural tissues related to the upper limb.

There were two patients in whom BPTT repeatedly failed to reproduce their reported symptoms. They both presented with unilateral arm pain; in addition, one experienced paraesthesiae in that arm, the other paraesthesiae in both arms.

TABLE II
NEUROLOGICAL LEVEL OF ARM PAIN (n = 55 ARMS)

	Right arm			Left arm		
Level	Arms	BPTT pos	BPTT neg	Arms	BPTT pos	BPTT neg
C5	9	8	1	10	9	1
C6	12	12	0	11	7	4
C6/7	5	5	0	4	4	0
C7	1	1	0	0	0	0
C8	3	2	1	0	0	0
Total	30	28	2	25	20	5

Neurological deficits were found in one arm in each of five patients. These comprised absent biceps jerk in two with diminution of C5 sensation in one. Diminished sensation in the C6 and C7 distribution was seen in three. BPTT was positive in each of these five arms.

Radiological changes were reported in 12 of the 29 patients with cervical radiology available for review. A reversal of the lower cervical lordosis was found in one patient; disc degeneration in nine; an end-plate fracture at C6 in one and mimimal compression fracture of C6 in another. CT scan of the cervical spine performed in four patients confirmed the end-plate fracture of C6, showed a discogenic canal stenosis at C6/7 in another and did not reveal an abnormality in two patients.

The nine patients with cervical spondylotic changes were older (mean age 41 years) than the group of patients as a whole (mean age 31 years). Symptoms in these patients were bilateral in four and unilateral in the others.

As shown in Table IV, BPTT was positive in 89% of the symptomatic arms of patients with normal cervical radiology and in 83% of the symptomatic arms of those with abnormal radiology.

One patient with bilateral arm pain and paraesthesiae had a normal nerve conduction study; another with bilateral symptoms had carpal tunnel syndrome. Decompression surgery did not alleviate arm pain but did lessen the severity of paraesthesiae.

DISCUSSION

Sciatic pain has been shown to arise from lumbar and lumbosacral nerve root tissue which exhibits hyperalgesia [15, 16]. Straight-leg-raising is therefore used in the routine examination of patients with lower limb pain syndromes which may arise from these tissues [17–21].

This study supports the use of a comparable test, the BPTT, in a clinical setting where arm pain and/or paraesthesiae could reasonably be expected to arise from hyperalgesic cervical or brachial plexus neural tissues. The positive responses in the symptomatic arms resulted from movement and tension imparted by the test to these tissues. As elbow extension was the last manoeuvre performed as part of the BPTT, and neural tissues are the only tissues with an anatomical connection between the neck and the wrist, elbow extension is likely to have transmitted both movement and tension upwards, particularly along the median nerve, into the

TABLE III
CORRELATION OF ARM SYMPTOMS WITH BRACHIAL PLEXUS TENSION TESTING

Symptoms	Total arms (n)	BPTT positive	BPTT negative
Pain	55	48 (87%)	7 (13%)
Paraesthesiae	44	40 (91%)	4 (9%)
Both symptoms	61	55 (90%)	6 (10%)

cervical and brachial plexus neural tissues [22]. No false-positive responses were noted in the asymptomatic arms of the injury group nor in the arms of the control group.

In the injury group, limitation of the normal range of extensibility of neural tissues between the neck and the wrist was always found when the test reproduced the arm symptoms. This limitation was interpreted as due to reflex contraction of the upper limb and cervical paraspinal muscles in order to protect the hyperalgesic cervical neural tissues.

The BPTT requires further study in patient populations with known (demonstrable) cervical and upper limb neural pathology in order to establish its place in clinical medicine. However, there are no examination techniques comparable to the BPTT which can provide the same positive and objective confirmation of the patient's arm symptoms. For example, the shoulder abduction test of Davidson *et al.* [23] relieved the unremitting cervical radicular pain in 15 of 22 patients with cervical extradural compressive radiculopathy confirmed on myelography. This test is purely subjective; the authors presumed that tension on cervical nerve roots was lessened when the test position was adopted by the patient.

Upper limb pain or numbness occurring shortly after a neck injury may correlate with a bad prognosis for recovery [24, 25]. Both the mechanism of injury to cervical neural tissues in motor vehicle accidents and the resulting pathology have been poorly understood. Direct trauma may stretch or compress nerve roots leading to swelling and vascular congestion. At a later stage, fibrosis may form within the nerve root together with adhesions between the root and surrounding dural sleeve or foraminal tissues [1, 4–6]. Irritation of nerve roots as a result of injury to intervertebral discs, or to intervertebral joints has also been postulated [4]. Symptoms occurring soon after injury may be related to secondary spasm in the scalene muscles causing irritation to the brachial plexus [2, 26]. Animal experiments support the hypothesis that these arm pain syndromes may arise from chronically injured dorsal nerve roots or dorsal root ganglia [27, 28].

TABLE IV
CERVICAL RADIOLOGY AND ARM PAIN (n = 36 PATIENTS*)

Radiology	Total patients	Painful arms	BPTT pos.	BPTT neg.
Normal	17	27	24 (89%)	3 (11%)
Abnormal	12	18	15 (83%)	3 (17%)
None	7	10	9 (90%)	1 (10%)
Total	36	55	48 (87%)	7 (13%)

*One patient did not report arm pain.

Nordin *et al.* [29] demonstrated ectopic impulse formation in patients with paraesthesiae resulting from different types of nerve disorders. These firing patterns were provoked using the different limb manoeuvres which also provoked paraesthesiae, thus confirming increased mechanosensitivity of these neural tissues. In addition, Asbury and Fields [30] recently provided a hypothetical basis for pain of nerve trunk origin. Their hypothesis explains both the neural symptoms following neck injury and their reproduction on BPTT.

Those patients who have objective signs of upper limb neurological deficit after neck injury in motor vehicle accidents have a poorer prognosis [7]. In this study, five patients were found to have neurological deficits and in only two was the deficit objective. More sensitive means of assessing sensory function were beyond the scope of my study but may have revealed abnormality in a larger proportion of patients [31, 32].

ACKNOWLEDGEMENTS

The author thanks Mr. Robert Elvey for his assistance in the preparation of this paper and for much fruitful discussion; he also thanks Professor Lawrence Beilin for his helpful comments and suggestions.

REFERENCES

1. Cammack KV. Whiplash injuries to the neck. *Am J Surg* 1957;**93**:663–6.
2. Macnab I. The 'whiplash' syndrome. *Orthop Clin North Am* 1971;**2**:389–403.
3. De Palma AF, Subin DK. Study of the cervical syndrome. *Clin Orthop* 1965;**38**:135–42.

4. Gay JR, Abbott KH. Common whiplash injuries to the neck. *JAMA* 1953;**152**:1698–704.
5. Seletz E. Whiplash injuries. Neurophysiological basis for pain and methods used for rehabilitation. *JAMA* 1958;**168**:1750–5.
6. Braaf MM, Rosner S. Whiplash injury of the neck: symptoms, diagnosis, treatment and prognosis. *New York State J Med* 1958;**58**:1501–7.
7. Norris SH, Watt I. The prognosis of neck injuries resulting from rear-end collisions. *J Bone Joint Surg [Br]* 1983;**65**:608–11.
8. Elvey RL. The investigation of arm pain. In: Grieve GP, ed. *Modern manual therapy of the vertebral column.* Edinburgh: Churchill Livingstone, 1986: 530–5.
9. Elvey RL. Brachial plexus tension and the pathoanatomical origin of arm pain. In: Glasgow EF, Twomey L, eds. *Aspects of manipulative therapy.* Melbourne: Lincoln Institute of Health Sciences, 1979: 105–10.
10. Reid SA. The measurement of tension changes in the brachial plexus. In: Dalzeill BA, Snowsill JC, eds. *Proceedings of the Fifth Biennial Conference, Manipulative Therapists' Association of Australia.* Melbourne, 1987: 79–90.
11. Ginn K. An investigation of tension development in the cords of the brachial plexus during the upper limb tension test. In: Dalzeill BA, Snowsill JC, eds. *Proceedings of the Fifth Biennial Conference, Manipulative Therapists' Association of Australia.* Melbourne, 1987: appended 1–11.
12. Landers J. The upper limb tension test—the effect of shoulder abduction on the test response. In: Dalzeill BA, Snowsill JC, eds. *Proceedings of the Fifth Biennial Conference, Manipulative Therapists' Association of Australia.* Melbourne, 1987: 1–12.
13. Kenneally M, Rubenach H, Elvey RL. The upper limb tension test: the SLR of the arm. In: Grant R, ed. *Physical therapy of the cervical and thoracic spine.* New York: Churchill Livingstone, 1988: 167–94.
14. Selvaratnam P, Glasgow EF, Mathias T. The discriminative validity of the brachial plexus tension test. In: Dalzeill BA, Snowsill JC, eds. *Proceedings of the Fifth Biennial Conference, Manipulative Therapists' Association of Australia.* Melbourne, 1987: 325–50.
15. Lindahl O. Hyperalgesia of the lumbar nerve roots in sciatica. *Acta Orthop Scand* 1966;**37**:367–74.
16. Smyth MJ, Wright V. Sciatica and the intervertebral disc. An experimental study. *J Bone Joint Surg [Am]* 1958;**40**:1401–18.
17. Charnley J. Orthopaedic signs in the diagnosis of disc protrusion. With special reference to the straight-leg-raising test. *Lancet* 1951;**i**:186–92.
18. Goddard MD, Reid JD. Movements induced by straight-leg-raising in the lumbo-sacral roots, nerves and plexus, and in the intrapelvic section of the sciatic nerve. *J Neurol Neurosurg Psychiatr* 1965;**28**:12–18.
19. Breig A, Troup JDG. Biomechanical considerations in the straight-leg-raising test. Cadaveric and clinical studies of the effects of medial hip rotation. *Spine* 1979;**4**:242–50.
20. Falconer MA, McGeorge M, Begg AC. Observations on the cause and mechanism of symptom-production in sciatica and low back pain. *J Neurol Neurosurg Psychiatr* 1948;**11**:13–26.
21. Edgar MA, Park WM. Induced pain patterns on passive straight-leg-raising in lower lumbar disc protrusion. A prospective clinical, myelographic and operative study in 50 patients. *J Bone Joint Surg [Br]* 1974;**56**:658–67.
22. Ewing MR. Postoperative paralysis in the upper extremity. *Lancet* 1950;**i**:99–103.
23. Davidson RI, Dunn EJ, Metzmaker JN. The shoulder abduction test in the diagnosis of radicular pain in cervical extradural compressive monoradiculopathies. *Spine* 1981;**6**:441–6.
24. Hohl M. Soft-tissue injuries of the neck in automobile accidents. Factors influencing prognosis. *J Bone Joint Surg [Am]* 1974;**56**:1675–82.
25. Greenfield J, Ilfield FW. Acute cervical strain. Evaluation and short term prognostic factors. *Clin Orthop* 1977;**122**:196–200.
26. Wickstrom J, LaRocca H. Management of patients with cervical spine and head injuries from acceleration forces. *Curr Pract Orth Surg* 1975;**6**:83–98.
27. Howe JF, Loeser JD, Calvin WH. Mechanosensitivity of dorsal root ganglia and chronically injured axons: a physiological basis for the radicular pain of nerve root compression. *Pain* 1977;**3**:25–41.
28. Wall PD, Devor M. Sensory afferent impulses originate from dorsal root ganglia as well as from the periphery in normal and nerve injured rats. *Pain* 1983;**17**:321–39.
29. Nordin M, Nystrom B, Wallin U, Hagbarth K-E. Ectopic sensory discharges and paraesthesiae in patients with disorders of peripheral nerves, dorsal roots and dorsal columns. *Pain* 1984;**20**:231–45.
30. Asbury AK, Fields HL. Pain due to peripheral nerve damage. *Neurology (Cleveland)* 1984;**34**:1587–90.
31. Lindblom U, Verrillo RT. Sensory functions in chronic neuralgia. *J Neurol Neurosurg Psychiatr* 1979;**42**:422–35.
32. Szabo RM, Gelberman RH, Dimick MP. Sensibility testing in patients with carpal tunnel syndrome. *J Bone Joint Surg [Am]* 1984;**66**:61–4.