

Stretch-induced cervicobrachial pain syndrome

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The case records of 22 patients who presented with severe and persistent cervicobrachial pain were reviewed. The onset of their pain followed the performance of a forceful activity (lifting, pulling or pushing) using one or both arms in the outstretched position. Their symptoms and the findings on physical examination were both consistent with stretch-induced damage to neural tissues related to the painful upper limb. The predominant site of painful neural pathology appeared to be within the cervical spine.

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Wall (1987) suggested that most intractable pain could be classified as arising from damage to deep tissues, damage to peripheral nerve or damage to dorsal nerve root. Pain that arises from a deep structure may be felt in a body region remote from the site of pathology. This phenomenon is known as referred pain (reviewed by Grieve 1988). Kellgren (1949) stated that "deep pain sensibility has certain attributes, such as characteristic quality, frequent false localisation, associated muscle spasm and susceptibility to cooling which distinguish it clearly from cutaneous pain."

Two forms of pain following peripheral nerve injury (neuropathic pain) have been recognised: dysaesthetic pain and nerve trunk pain (Asbury and Fields 1984).

Dysaesthetic pain is perceived in that part of the body served by the damaged axons. This pain has features which are not found in deep pain arising from either somatic or visceral tissues. These include: abnormal or unfamiliar sensations, frequently having a burning or electrical quality; pain felt in the region of sensory deficit; pain with a paroxysmal brief shooting or stabbing component and the presence of allodynia (Fields 1987).

Nerve trunk pain is described as deep and aching, felt along the course of the nerve trunk, familiar "like a toothache", and made worse with movement, nerve stretch or palpation.

In an individual patient with nerve injury, dysaesthetic pain, nerve trunk pain or both may be present (Asbury and Fields 1984). For this reason, it can sometimes be difficult to distinguish, on subjective grounds, between referred pain arising from somatic tissues and referred pain arising from neural tissues (Grieve 1988, Dalton and Jull 1989).

This study reviews the clinical features of a group of patients who each presented to the author with persistent cervicobrachial pain, often accompanied by upper limb paraesthesiae, which followed a forceful activity performed with one or both arms outstretched. The hypothesis of this study was that the pain syndrome in these patients arose from a stretch-induced injury of the neural tissues related to the painful limb(s).

Method

A review was undertaken of the records of all patients who attended the author's rheumatology practice between January 1987 and December 1988 reporting the onset of cervicobrachial pain following an activity involving the use of one arm or both arms outstretched. There were 22 patients in this category. None described a previous history of neck or arm pain.

In each patient, the history of onset of pain and the subsequent anatomical

From Page 99

spread of pain was carefully noted. An attempt was made to categorise the arm paraesthesiae on a dermatomal basis (Keogh and Ebbs 1984).

A complete musculoskeletal examination had been performed on each patient, with particular emphasis on the neck, thoracic outlet, shoulder and arm. The physical examination included assessment of the response to the brachial plexus tension test (BPTT) in each arm (Elvey 1986, Kenneally et al 1988). A clinically relevant test result in a symptomatic arm consisted of reproduction of pain in the presence of a limitation of the normal range of extensibility.

A normal test result consisted of the subjective responses at the end of a normal range of extensibility as recorded by Kenneally et al (1988). The so-called thoracic outlet tests had not been performed due to their apparent inability to discriminate between normal asymptomatic individuals and patients with postulated nonspecific neurogenic thoracic outlet syndrome (Cuetter and Bartoszek 1989).

Evocative tests for symptoms of carpal tunnel syndrome had included Phalen's test and percussion over the tunnel to elicit Tinel's sign. The examination of the neck had recorded an estimation of whether or not the active range of cervical movements in lateral flexion and rotation to either side were within normal limits. In addition, anterior palpation of the lower cervical transverse processes for tenderness had been performed on either side (Smythe 1986).

Where available, cervical radiology and the results of electrodiagnostic testing had been recorded.

Results

Demographic data

There were 19 females and 3 males. Their ages ranged from 19 to 57 years (mean age = 36 years). The interval between the onset of symptoms and referral ranged from 2 to 47 months (mean interval = 11 months). There

Table 1. Distribution of pain (22 patients)

Anatomical site	Initial pain	Pain on presentation
Neck	11	21
Upper back/shoulder	8	22
Head	0	15
Whole arm	1	12
Upper arm	1	8
Hand/wrist/forearm	1	7

were 21 right hand dominant patients.

Occupations were varied and included clerical duties (5 patients), nursing (3), shop assistant (3), manual trades (2), and domestic work (2). Only 9 patients were in employment at the time of their referral for examination. All had been accepted by the respective insurers as having worker's compensation claims.

Details of injury

The activities performed by the patients at the time of onset of pain were described as lifting (14 patients), pushing (4) and pulling (2). The remaining 2 patients developed pain after their outstretched arm was jerked; in one patient, this injury occurred when she was restraining a client, and in the other, when a heavy roll of material which she was grasping and trying to lift rolled off the shelf. One arm (in 8 patients) or both arms (in 14 patients) were outstretched in the forward plane during the pain-provoking activity.

The arm or arms were positioned above shoulder height during the activity by 6 patients, at shoulder height by 8 patients and below shoulder height by 8 patients.

The forces involved in the pain-provoking activity were difficult to estimate in each case. Thirteen patients perceived the load which they were acting upon (pushing, pulling or lifting) to be unduly heavy.

In the case of the 2 patients whose arms were jerked forwards, the forces involved were also felt to have been considerable. Five patients placed more emphasis on having had to outstretch

their arms in order to perform the activity.

The remaining patient described onset of pain when twisting her neck and trunk to one side as she lifted a moderately heavy load from the floor.

Distribution of pain and paraesthesiae

Initial pain was felt on the right side in 13 patients, and on the left side in 9 patients. As shown in Table 1, it was proximally situated in 19 of the 22 patients. The pain distribution on presentation to the author remained predominantly proximal but was more widespread, both into the arm and head. There were 26 painful arms as 4 patients reported pain in both arms at the time of presentation although their initial symptoms had been unilateral.

Nineteen patients reported distal paraesthesiae in the painful arm. They were in the C6 distribution in 4 patients, C7 in 3, C8 in 3, C7/8 in 3, C6/7/8 in 3, C6/7 in 2 and C5 in 1. One patient described bilateral paraesthesiae.

Physical examination findings

Apart from the one patient with a rotator cuff tear, confirmed at operation, there was no evidence of a local musculoskeletal condition in any of the painful arms. The rotator cuff tear was attributed to the same injury which resulted in the ipsilateral cervicobrachial pain syndrome. Evidence of a C7 radiculopathy was found both on clinical examination and on electrodiagnostic testing in this patient.

The responses to BPTT are shown in

Table 2. Brachial plexus tension test (22 patients)

	Total number	Positive	Negative	Equivocal
Painful arm	26	26	0	0
Pain-free arm	18	0	16	2

Table 2. In each painful arm, the test had been positive for the patient's pain as well as demonstrating a loss of the normal range of extensibility of the neural tissues related to the arm. In the asymptomatic arms, two tests were judged to have been equivocal due to slight loss of the normal range of extensibility.

Clinical tests for carpal tunnel syndrome had not reproduced pain or paraesthesiae in any of the symptomatic arms.

On examination of the cervical spine, tenderness had been noted to gentle anterior palpation over the transverse processes of the lower cervical vertebrae on the side corresponding to the painful arm in each patient. As seen in Table 3, arm pain was frequently found to be accompanied by limitation of lateral neck flexion to the contralateral side.

Neurological examination had detected abnormalities in the painful arm of 7 patients. In these patients, sensibility to light touch and to pinprick was diminished: in the C6 dermatome (5 patients), in the C6/7/8 dermatomes (1) and in the C8 dermatomal distribution (1). Diminution of the triceps reflex accompanied the loss of sensation (C6/7/8) in one patient; in another patient, wasting of the spinati had been noted, along with sensory loss in the C6 distribution.

Investigations

Electrodiagnostic testing had been performed on 10 patients. No abnormality was found in 4 patients. Sensory conduction abnormalities of the median nerve in the carpal tunnel were reported in 4 patients, and changes suggestive of cervical nerve root abnormality (C5/6 in one patient, C7 in the other patient) were reported

on electromyography in the other two patients. In the four patients with electrodiagnostic abnormalities of the median nerve in the carpal tunnel, initial pain was felt proximally (neck, upper back, shoulder) in two, in the whole arm in one and distally (wrist) in the other.

Cervical radiology had been available for 18 patients. Changes of cervical spondylosis were present in eight patients, all of whom were over the age of 40 years. A minor congenital vertebral anomaly was present in one patient. In nine patients, radiology was normal.

Discussion

Clinical findings

The brachial plexus tension tests (BPTT) of Elvey (1986) have proven helpful in the differential diagnosis of patients with upper limb pain of presumed neural origin (Elvey et al 1986, Selvaratnam et al 1987, Simionato et al 1988, Quintner 1989). When used as part of a full examination of the tissues of the upper limb and neck, the BPTT enables the examiner to assess the responses to movement and tension of the cervical and brachial plexus neural tissues related to the upper limb (Kenneally et al 1988).

The positive (clinically relevant) responses to BPTT in the painful arms of all patients in this study, and the

paraesthesiae reported by 19 patients, support the hypothesis of this study that neural tissue was the tissue predominantly "at fault" and therefore the major source of the upper limb pain and paraesthesiae. Paraesthesiae, a common accompaniment to pain of peripheral neural origin, are thought to arise from ectopic impulse generation in cutaneous afferent nerve fibres (Ochoa 1982, Rasminsky and Bray 1986, Ng et al 1987).

The paucity of signs of sensory deficit in the painful upper limbs of 15 of these patients is not inconsistent with the presence of partially damaged nerves (Ochoa and Noordenbos 1979).

Dalton and Jull (1989) studied patients with unilateral neck and arm pain of cervical origin. Their aim was to distinguish referred pain of somatic origin from referred pain of neural origin.

They concluded that there was no correlation between the presence or absence of neurological deficit in the painful arm and the characteristics of the pain reported by the patient (the distribution, quality and depth of pain, the area of greatest pain intensity and the subject's ability to localise the pain). However, their method of physical examination did not include a technique to selectively stress cervical neural tissues in order to determine whether such tissues may have been "at fault".

The proximal site of the initial pain in 19 of the 22 patients in this study is consistent with proximally situated tissues (neck/shoulder girdle) being the site of injury in these patients. In two of the other three patients, the initial site of injury may also have been proximal, with pain referred distally into the whole arm (one patient) or

Table 3. Relation of neck movement to arm pain (22 patients).

Neck limitation	Right arm pain	Left arm pain	Bilateral Pain
To right	0	3	0
To left	9	0	0
To right and left	0	3	4
No limitation	0	3	0

From Page 101

into the upper arm (one patient).

In the remaining patient, who reported pain initially in the hand, wrist and forearm, the possibility of either proximal or distal neural injury needs to be considered. Table 1 illustrates the widespread distribution of pain, both proximal and distal, which followed the initial traumatic event. Spread of pain to sites remote from the site of injury is a feature of deep pain of somatic or visceral origin as well as pain of neural origin (Fields 1987).

Localised tenderness over the lower cervical transverse processes on the side corresponding to the painful arm or arms was an important finding in this study. According to Smythe (1986), tenderness found in these sites relates to the anterior aspect of the intertransverse ligaments.

However, it is possible that in this study, palpation may have detected tenderness in a hyperalgesic portion of the spinal nerve exiting from the gutter in its respective transverse process. Similarly, the limitation of contralateral neck flexion observed in relation to the painful arm(s) of 19 patients may have been due to muscle spasm reflexly protecting the irritable cervical neural tissue(s) on the contralateral side of the neck against stretch (Bowden 1971).

Postulated mechanism of injury

Peripheral nerves adapt to changes in the length of a limb by straightening, stretching and untwisting (Sunderland 1978).

Nerve tissue also undergoes longitudinal sliding so that tension which is generated at one site along its length can be reduced by unstretched portions of the nerve sliding into the extended region (McLellan and Swash 1976). Ewing (1950), in a cadaver study, showed that tension developed within the brachial plexus during downward traction on the adducted arm and during depression of the shoulder girdle.

On abduction and external rotation of the shoulder with the elbow in

extension, the nerve trunks were observed to become "as tight as bowstrings". These findings have been confirmed by Elvey (1986).

Additional factors of importance in the development of tension within the neural tissues related to the upper limb, brachial plexus and neck of the patients in this study are discussed by Schaafsma (1970). They include the weight of the object lifted, pulled or pushed, the rapidity of the action performed, the position of the arm in relation to the horizontal plane, the muscle groups which are used as prime movers, and the position of the neck in relation to the shoulder girdle.

Effects of stretch upon nerve tissues

Stretch has been shown to cause varying degrees of structural damage to blood vessels, nerve fibres and perineurium of peripheral nerves (Denny-Brown and Doherty 1945, Sunderland and Bradley 1961, Kwan et al 1988).

Stretch can also impair the epineurial circulation, with compromise of intraneural microvascular flow leading to endoneurial anoxia and oedema (Denny-Brown and Doherty 1945, Lundborg 1988).

According to Olsson (1984), "as the interior of nerve fascicles lack lymphatic drainage, and the perineurium probably restricts the oedema out of fascicles ... it may well be that such an oedema is a stimulating factor in fibrosis ... and perhaps ... has an influence on nerve fibres themselves."

Adverse tension can be concentrated and thereby cause damage to neural tissue at a point where it is relatively fixed in relation to its surrounding tissues (Sunderland 1978, McLellan and Swash 1976). As a result of injury (and other pathologies), nerve tissue may become hyperalgesic and thus the source of persistent pain (Asbury and Fields 1984, Loeser 1985).

Anatomical factors which serve to protect the brachial plexus from stretch-induced damage include the plexiform arrangement of its

components, the spiral ligaments and the funicular arrangements of nerves (Wynn Parry 1987). In contrast, the spinal nerves (C5, C6 and C7) are relatively fixed in the gutters of their respective transverse processes (Sunderland 1974).

It is therefore postulated that, in the patients in this study, the spinal nerves related to the upper limb, and the intraforaminal neural tissues in continuity with them, were the tissues injured by stretch (Cailliet 1981).

Further examples of relative fixity (and vulnerability) of neural tissues include the median nerve in the carpal tunnel (Sunderland 1976) and the ulnar nerve in the condylar groove behind the medial epicondyle (Thompson and Kopell 1959).

The electrodiagnostic evidence of median nerve dysfunction in the region of the carpal tunnel found in 4 of the 10 patients who underwent this investigation may represent damage caused by a concentration of high tension occurring distally, as well as proximally, during the activities described by these patients.

Although the pain of carpal tunnel syndrome can radiate proximally to the shoulder and neck (Crymble 1968), the fact that the initial pain was felt in the wrist in only one of these patients makes it unlikely that damage to the median nerve in the carpal tunnel was the sole explanation for their ongoing pain.

Conclusion

The clinical correlates of severe injury to the brachial plexus are well known (Walton 1977, Sunderland 1978, Wynn Parry 1987). To date however, the *in vivo* effects of stretch (tension) which is insufficient to cause functional or structural failure of the conducting elements of nerves are poorly understood (Kwan et al 1988).

From this study, it is evident that persistent cervicobrachial pain can follow a forceful activity performed with one or both arms in the outstretched position.

Evidence for dysfunction of neural

tissue in these patients includes the widespread pain, the frequent reporting of arm paraesthesiae, the abnormal response to BPTT in each of the painful arms and the finding of a neurological deficit in the painful arm of some patients.

The clinical findings which appear to implicate the cervical spine as the predominant site of the painful pathology include local tenderness invariably found on anterior palpation of the transverse processes of the lower cervical vertebrae and painful limitation of contralateral active cervical lateral flexion.

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