

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900

Open access books available

186,000

International authors and editors

200M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com



Work-Related Upper Limb Pain and Its Diagnosis: Contribution from the Neurological Examination

Jørgen Riis Jepsen

Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/50884>

1. Introduction

Painful upper limb conditions affect more than 1/5 of the adult population. They have a major influence on the level of functioning and cause significant social costs. Being regarded as frequently work-related, many of these disorders are potentially preventable.

Clinicians are often challenged with respect to the diagnosis, treatment and prevention of upper limb disorders. One reason for this is the lack of consensus on diagnostic case definitions and the unknown or poor validity of many of the applied physical diagnostic tests [1,2]. Diagnostic case definitions are important for epidemiological as well as clinical purposes. Their value lies in their practical utility in distinguishing groups of people with the same symptoms and/or physical characteristics or whose illness share the same causes or determinants of outcome. This means that the best case definition for a disorder may vary according to the purpose for which it is being applied [3]. Never the less, we need valid case definitions for clinical purposes as well as for surveillance and preventive purposes. The prognosis in potential scenarios should also be known, such as with various future work-demands and exposures [4].

We have made little progress with regard to all those issues over the last decades. Ignorance to the role of the peripheral nerves in upper limb pain conditions may be one of the reasons for this inadequacy.

It has been estimated that 75 % of work-related upper limb disorders are not covered by diagnostic criteria [5]. Therefore they are often described as “non-specific”, “repetition strain injury” or, e.g. as “mouse arm”, which may suggest causation but neither the responsible pathology nor its location.

1.1. The conventional physical approach to upper limb patients

The conventional physical approach to upper limb patients is often insufficient. It is basically based on the traditions in e.g. orthopedic surgery to identify conditions such as tendinitis, epicondylitis, or osteoarthritis and among rheumatologists to relate pain conditions to inflammatory joint and muscle disorders. Unless there are clear and severe pareses or sensory disturbances, neurologists tend to follow the same path and relate upper limb pain to similar disorders of insertions or muscles – in particular when subsequent imaging and electrophysiological assessment have not been helpful.

A few typical examples of common interpretations will be provided:

- *Relating to location of symptoms:* Lateral elbow pain or shoulder pain may be attributed to lateral epicondylitis or rotator cuff tendinitis without meeting the criteria for these conditions. There is often no apparent consideration and mostly no exclusion of potential alternative causes for the pain.
- *Relating to localized soreness:* Pain may in broad terms be attributed to tendinitis or to a myofascial disorder even without the identification of the involved tendon(s) (e.g. “forearm tendinitis”) or muscle(s) (e.g. myofascial pain in the neck or shoulders). Alternative causes are rarely considered and excluded. Indications of e.g. tendinitis such as swelling, redness etc. are usually absent in these patients.
- *Relating to the character of pain, or paresthesia:* Carpal tunnel syndrome is always considered. When carpal tunnel syndrome is excluded, the next step tends to be a focus on the potential presence of cervical root compression. Following further investigations such as electrophysiological or imaging, the clinician frequently tends to exclude a neurological condition and to leave the patient untreated. In many of these patients the pain is now regarded as deriving from muscles or – in case of being mainly located at the elbow or shoulder – possibly as relating to insertional tendinitis. The intermediate portion of upper limb nerves with an extension of almost one meter tends to be ignored. If laboratory studies do suggest a neuropathic condition, patients may be treated accordingly (e.g. with carpal tunnel surgery). Other patients may still receive such treatment in spite of negative laboratory examinations and with variable results.
- *Relating to weakness or sensory abnormalities:* There is a tendency to attribute muscular weakness to the presence of pain (“pain-induced weakness”) even in the absence of pain/pain provocation during testing of a specific muscle. Similarly, sensory abnormalities that involve several dermatomes or the cutaneous innervation-territories of several peripheral nerves tend to be termed “diffuse”. With painful testing of a muscle, alternative painless testing of other muscles with the same innervation is rarely done. The possibility of simultaneous afflictions of several upper limb nerves, or of the brachial plexus is also rarely considered in patients presenting with a challenging pattern of sensory abnormalities.

In summary, clinicians examining upper limb patients tend to direct their main attention to tendons, muscles or insertions rather than to the peripheral nerves. Practitioners in occupational medicine tend to follow the same track as orthopedic surgeons, rheumatologists, and neurologists. Consequently patients with work-related upper limb complaints are likely to

be diagnosed as, e.g. tendinitis, epicondylitis, or a myofascial condition – even in the absence of objective evidence to support these diagnoses (or patients are not diagnosed at all) rather than being diagnosed with a disorder confined to or involving the nerves.

In addition, there is a tendency to focus on the location where the symptoms dominate (but where the disease is not necessarily located), and to neglect that the disease may be situated elsewhere. This is unfortunate since the location of the disease may well be distant to symptoms – in particular in case of a neurological condition.

1.2. Neuropathic upper limb pain

The pain in many upper limb conditions – including many “non-specific” conditions – is frequently of a neuropathic character. The pain typically worsens following use when the arm is at rest, such as during the night. Another characteristic feature is the tendency for the pain to move from one location to another. The presence of muscle weakness/fatigue, paresthesia and/or other sensory disturbances, and the inadvertent loss of handgrip are other common complaints. All these symptoms are compatible with a neuropathic condition such as an affliction of the upper limb peripheral nerves at one or several locations.

Therefore, the conventional physical examination (inspection, movement, palpation of muscles and tendons, etc.) should be supplemented with an examination of representative physical items that reflects the function of the peripheral nerves.

The clinical neurological examination is based on a classical paradigm which is accepted by all physicians. Still, it is rarely applied in a comprehensive manner. While the neurological upper limb examination usually includes an evaluation of items such as handgrip force, fingertip sensibility and the Tinel sign at the volar wrist, the examination does not always represent a systematic and detailed approach to the upper limb peripheral nerves. One example is the bedside examination of strength in representative upper limb muscles. Manual muscle testing seems to be forgotten or discredited – perhaps because of an unjustified confidence in the potentials of electrophysiological assessment of the peripheral nerves [6]. Therefore, patients may be misinterpreted, misdiagnosed and consequently not offered the proper treatment.

A precise diagnosis is an essential prerequisite for treatment as well as prevention, and requires the identification of the involved tissue and where it is located, and of the character of the involved pathology. This task is not always easy but it always requires an examination that reflects the symptoms.

This review describes an easy neurological screening approach to the upper limb patient based on manual testing of nine muscles.

1.3. Studies of upper limb patients and exposed workers

Previous studies have demonstrated the reliability of a comprehensive neurological examination, which included manual testing of the individual and patterns of strength in a representative sample of upper limb muscles. Strength (14 muscles), sensibility to touch,

pain and vibration (seven territories), and mechanosensitivity of nerve trunks (ten locations) were predominantly assessed with moderate to very good reproducibility (median κ -values 0.54, 0.69, 0.48, 0.58, and 0.53, respectively). In addition, neurological patterns could be reliably identified (median correlation coefficient 0.75) [7,8].

The examination permitted the classification of each of 82 upper extremities as with or without any of the defined neurological patterns with a high agreement (kappa = 0.75) [7,8]. This is an acceptable reliability, which is in fact superior to that of other parts of the neurological examination that one usually trusts, e.g. the Babinski sign [9]. This examination had a high predictive ability in terms of distinguishing between symptomatic and non-symptomatic limbs (positive/negative predictive values of 0.93/0.90 in limbs with agreement between the two blinded examiners) [10].

Using this approach indicated that upper limb peripheral nerve afflictions were frequently responsible for work-related upper limb pain in the majority of the examined upper limb patients in a hospital based clinic of occupational medicine [10], general practice [11], and occupational groups such as computer operators [12]. The infraclavicular part of the brachial plexus, the posterior interosseous nerve at the edge of the supinator muscle, and the median nerve at elbow level were the most common locations of nerve afflictions, and these locations were often combined in the same limb [7,8,10].

The high frequency of relatively clear neurological patterns in accordance with afflictions at various locations within the brachial plexus is in accordance with a few reports of plexopathy in a work-related context [13-15]. Brachial plexopathy is, however, still regarded by many as a rare condition or as a condition that cannot be diagnosed by a physical examination. The previous studies also indicated that the isolated occurrence of carpal tunnel syndrome and of ulnar nerve entrapment at the elbow level, both of which are generally regarded as the most frequent upper limb nerve entrapments, seem to have less importance as work-related conditions [8].

Exit position for the physical examination	Muscles (Innervation)
Position I (Figure 2)	Pectoral (Ventral thoracic nerves) Posterior deltoid (Axillary nerve)
Position II (Figure 3)	Biceps brachii (Musculocutaneous nerve) Triceps (Radial nerve)
Position III (Figure 4)	FCR (Median nerve) ECRB (Radial nerve) APB (Median nerve) ECU (Posterior interosseous nerve) ADM (Ulnar nerve)

Table 1. The studied muscles and their innervation. The shaded fields indicate the three antagonist pairs of muscles. Abbreviations: See text

These experiences may be useful for others – not least with regard to the many upper limb pain conditions that cannot otherwise be explained by the current diagnostic approaches. Therefore, a review will be provided on the techniques for the manual testing of muscle strength in a few representative upper limb muscles. Manual muscle testing is now an integrated routine in the author's physical examination of patients with upper limb complaints in an occupational context.

1.4. The neurological examination

The upper limb neurological examination is based primarily on a systematic semi-quantitative examination of the following items, of which the first is regarded as the most important:

- Manual assessment of the strength in selected indicator muscles [7,16] (Table 1).
- Mechanosensitivity of nerve trunks at locations where they tend to be compromised. This may be assessed by the demonstration of mechanical allodynia of nerve trunks by mild pressure [8] (Figure 1).
- The sensibility in homonymously innervated cutaneous territories can be evaluated through an assessment of the perception of, e.g. touch, pain or vibratory stimulation with a tuning force (256 Hz).

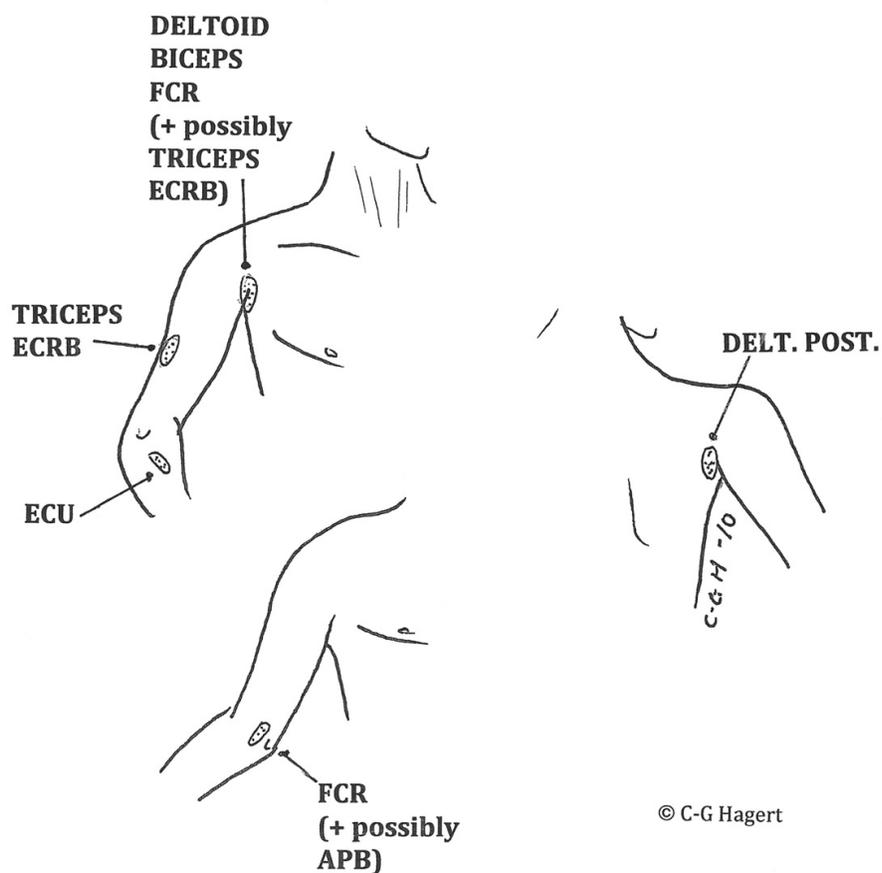


Figure 1. Locations of nerve trunks examined for mechanosensitivity. Abbreviations: See text

The neurological upper limb examination requires a familiarity with anatomy. This acquaintance is not necessarily possessed by all clinicians that meet patients with work-related upper limb complaints. I regard it as essential that the expertise must be maintained by regular lookups in textbooks, since previously acquired knowledge is easily forgotten.

The examiner should know the biomechanical function of the muscles since each of them should be tested in a position that favours its isolated action. The understanding of the neurological patterns and the palpation of nerves also requires knowledge of the motor (and sensory) innervation of each nerve, and of the location of narrow passages, where there is a particular risk of external compromise of the nerve (Figures 1, 3 - 7) [8].

The importance of testing the individual muscle strength is due to the fact that this assessment (in contrast to an evaluation of sensation) permits the examiner to locate a focal nerve affliction along the course of a nerve. Therefore, I suggest that the physical examination should always – in particular in patients with upper limb pain conditions that can otherwise not be explained – include an assessment of the strength in a number of individual muscles. These muscles should be selected to reflect the function of the upper limb nerves taking into consideration the branching and innervation pattern of each nerve. The presence of weakness in one or several muscles – and the occurrence of weaknesses in patterns in accordance with anatomic facts – strongly suggest the presence of a peripheral neuropathic condition and indicate the location along the nerve. At this location one would expect mechanical allodynia of the implicated nerve trunk.

Manual muscle testing and the interpretation of the outcomes may be regarded as complicated. This review aims to make it simple by focussing on a limited amount of muscles.

I will describe how manual testing of these muscles is performed, how the outcome is interpreted, and how this examination can contribute to the diagnosis of upper limb conditions.

1.5. Rationale

The rationale for focal diagnostics based on muscle testing is simple and would be accepted by any neurologist: Muscles innervated peripherally to a focal neuropathy such as following compression are expected to be weak while those innervated from branches leaving more proximally would tend to be intact. The following three examples illustrate the rationale.

1. *Median nerve:* A weak abductor pollicis brevis (APB) muscle but an intact flexor carpi radialis (FCR) muscle suggests a carpal tunnel syndrome. A weak FCR muscle (sometimes along with a weak APB muscle) suggests a more proximal nerve affliction, such as, e.g. of the median nerve at the elbow level (pronator syndrome) [9].
2. *Radial nerve:* A weak extensor carpi ulnaris (ECU) muscle together with intact extensor carpi radialis brevis (ECRB) and triceps muscles suggests an affliction of the posterior interosseous nerve at the edge of the supinator muscle (radial tunnel syndrome). Weak

triceps and ECRB muscles suggest a more proximal affliction, such as, e.g. of the radial nerve at the triceps arcade at the mid upper arm (in which case the ECU tends to be intact).

3. *Ulnar nerve*: A weak abductor digiti minimi muscle (ADM) suggests an ulnar nerve affliction, the level of which, however, cannot be defined without examining an extra muscle, the flexor digitorum profundus to the small finger (FDP V). If that muscle is weak, the affliction will be at the elbow level, cubital tunnel syndrome, whereas, if intact, the affliction will be at the wrist level, Guyon's canal.

When a nerve is focally affected by compressive or tensile forces, one would also expect an abnormal tenderness (mechanical allodynia) on palpation of the nerve trunk at the site of affliction/compression. I therefore search for this phenomenon by palpating the nerves at locations known from experience as critical (Figure 1). The assessment of abnormal nerve trunk tenderness must take into account that nerves located superficially are easily palpated while palpation may be more difficult with deeply located nerves.

1.6. Muscles in the neurological examination

In the upper limb we have 60 muscles. The examination of all of these takes a long time and is not necessary. A previous validation study dealt with 14 muscles [7] but even this number may be regarded as difficult to deal with and time consuming for many clinicians.

Therefore manual testing of the strength in nine muscles only is proposed:

- Six muscles representing three antagonist pairs (flexors – extensors) (Table 1) are tested in the following succession: Pectoral – Posterior deltoid; Biceps – Triceps; FCR – ECRB.
- This is followed by testing of three additional individual muscles: ECU, APB and ADM.

In order to make the examination as comprehensive and accessible as could possibly be, it is additionally proposed to examine for the presence of mechanical allodynia of nerve trunks at the locations indicated in Figure 1.

2. Physical examination

2.1. The technique for manual muscle testing of the three antagonist muscle pairs

The strength in each muscle is manually assessed and compared in between the two sides by simultaneous examination on the two sides. In case of bilateral afflictions, the observed strength is compared with the expected taking into consideration the sex, age and constitution of the examined subject. The patient is examined while comfortably seated in a chair without armrests.

The three individual antagonist muscle pairs are evaluated from proximal to distal, each with a standard position of the upper limbs (Table 1, Figures 2-4) [8]:

Position I (Figure 2)

The patient's arms are elevated horizontally forward, with the elbows kept fully extended, the forearms pronated, the wrists kept at neutral and the hand clenched. Standing in front of the patient, arm adduction (Pectoral muscles) and abduction (Posterior deltoid) is tested by applying force against the patient's wrists from inward out and from outward in, respectively. The preferred exit position for testing of the posterior deltoid is to have the patient keep the arms 30 degrees outward.

Position II (Figure 3)

The patient's upper arms are now kept along the sides of the chest, the elbows flexed at a right angle with the forearms pointing forward and kept at neutral position, the wrists kept at neutral and the hands clenched. Standing in front of the patient, the examiner leans forward toward the patient's wrists, asking the patient to "carry" the examiner (elbow flexion, defined as Biceps brachii). Standing behind the patient, the examiner lifts the patient's wrists upward (Triceps) against the patient's resistance.

Position III (Figure 4)

The patient leans forward, resting the forearms on the thighs with the wrists just distal to the knees. First, the patient's forearms are fully supinated. With the patient's hands clenched and the wrists slightly flexed, the examiner leans forward, pressing toward the proximal interphalangeal joint knuckles of the index and long fingers to extend the wrists of the patient (FCR). Then the patient's forearms are fully pronated. The patient keeps the hands open and the wrists extended while the examiner leans forward and presses against the knuckles of the index and long fingers to flex the patient's wrists (ECRB).



Figure 2. Position I. Testing of the posterior deltoid muscle



Figure 3. Position II. Testing of the triceps muscle



Figure 4. Position III. Testing of the FCR muscle. Abbreviations: See text

2.2. Interpretation of the outcome of the testing of the three antagonist muscle pairs

Position I (Figure 2)

Being innervated through all the cervical roots, the major pectoral muscle is mostly kept intact in cases of peripheral upper limb nerve afflictions. Therefore, a normal strength in this muscle provides evidence on patient cooperation and we can rule out malingering. This is why I prefer to start the examination with testing of the pectoral muscle. A weak deltoid muscle may be due to an affliction of the axillary nerve in isolation or of the brachial plexus (Figure 5). The assessment of whether the C5 and C6 root is involved may rely on other findings, including weakness of additional muscles (Figure 6).

Position II (Figure 3)

Weakness of the biceps brachii or triceps muscle (or of both muscles) may be due to an involvement of the musculocutaneous nerve and/or the radial nerve at upper arm level, respectively, or (more often) of the brachial plexus. The latter is particularly likely if a deltoid weakness has already been demonstrated (Figure 5). A cervical root impingement is less likely with weakness in both muscles, since this would require the involvement of multiple roots (Figure 6).

Position III (Figure 4)

Weaknesses in the FCR and the ECRB muscles may be due to a brachial plexopathy. A brachial plexus involvement may be suspected when a deltoid weakness has already been demonstrated. Weaknesses of any of the two muscles can also occur in isolation. Of particular importance in this context is the weakness of FCR, which indicates a median nerve affliction at the elbow level (Figure 7).

2.3. Examination of three additional muscles

The examination of the three antagonist muscle pairs captures a major part of the upper limb peripheral nerve-morbidity including many upper limb conditions that cannot be identified with a standard physical approach (“non-specific” upper limb disorders, “repetition strain disorders”).

However, this examination cannot identify frequent entrapment neuropathies such as radial tunnel syndrome, carpal tunnel syndrome and ulnar nerve compression. This requires study of the strength of the ECU, APB and ADM muscles, respectively.

The testing of these three muscles is also simple. The distal part of the patient’s forearm is firmly held by the examiner’s one hand while pressing the ulnar-deviated wrist in the radial direction (ECU) (Figure 8). The patient brings the thumbs into opposition and the examiner presses them down toward the palms (APB) (Figure 9). While the patient has the small finger abducted, the examiner applies pressure at the tip of the finger in the radial direction toward the ring finger (ADM) (Figure 10).

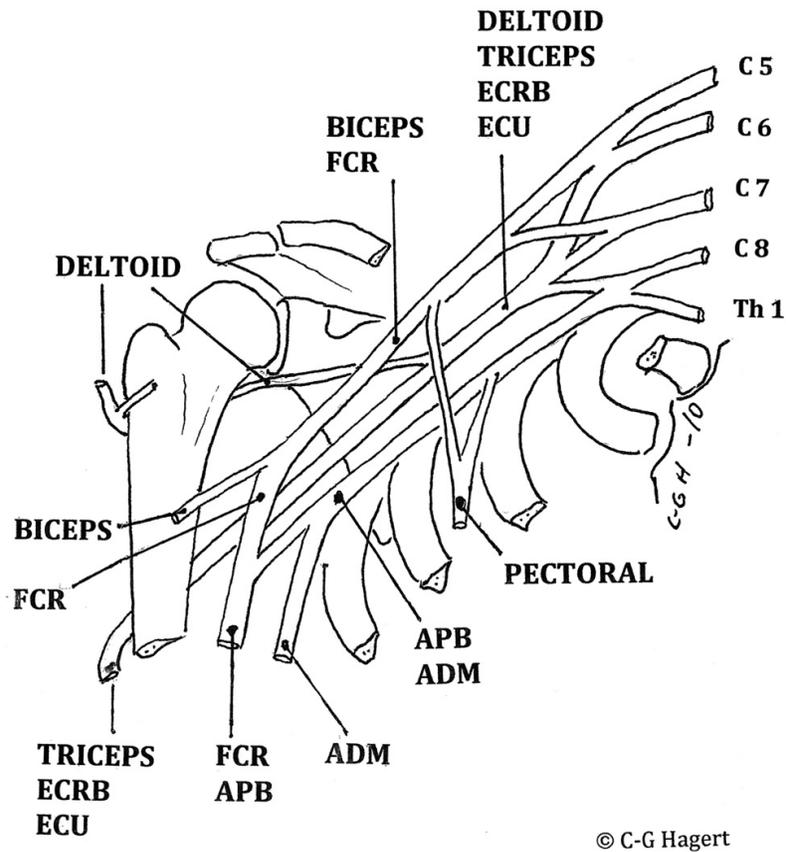


Figure 5. Brachial plexopathy. Abbreviations: See text

C 5	C 6	C 7	C 8	Th 1
	PECTORALIS			
DELT. POST.				
BICEPS				
		TRICEPS		
		FCR		
		ECRB		
		ECU		
				APB
				ADM

© C-G Hagert

Figure 6. The innervation of upper limb muscles from the roots forming the brachial plexus. Abbreviations: See text

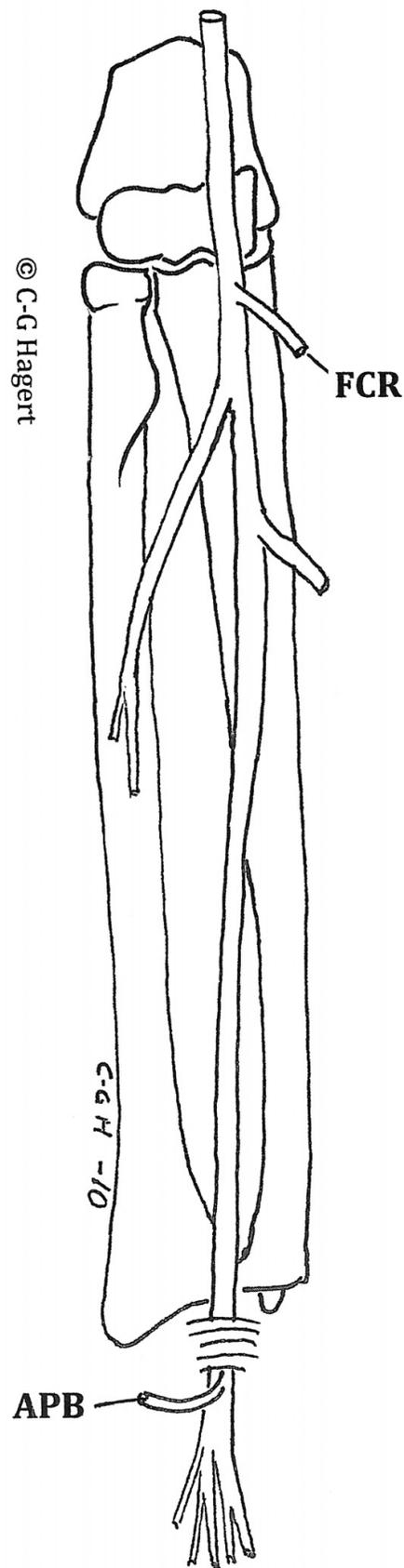


Figure 7. Median neuropathy. Abbreviations: See text



Figure 8. Testing of the ECU muscle

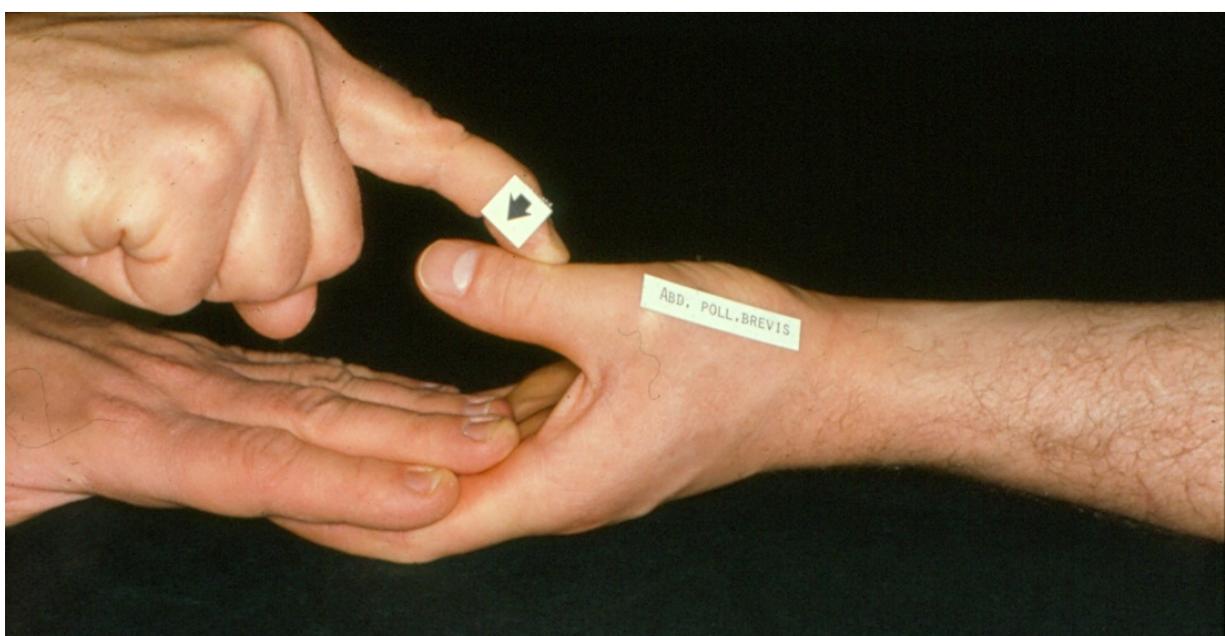


Figure 9. Testing of the APB muscle

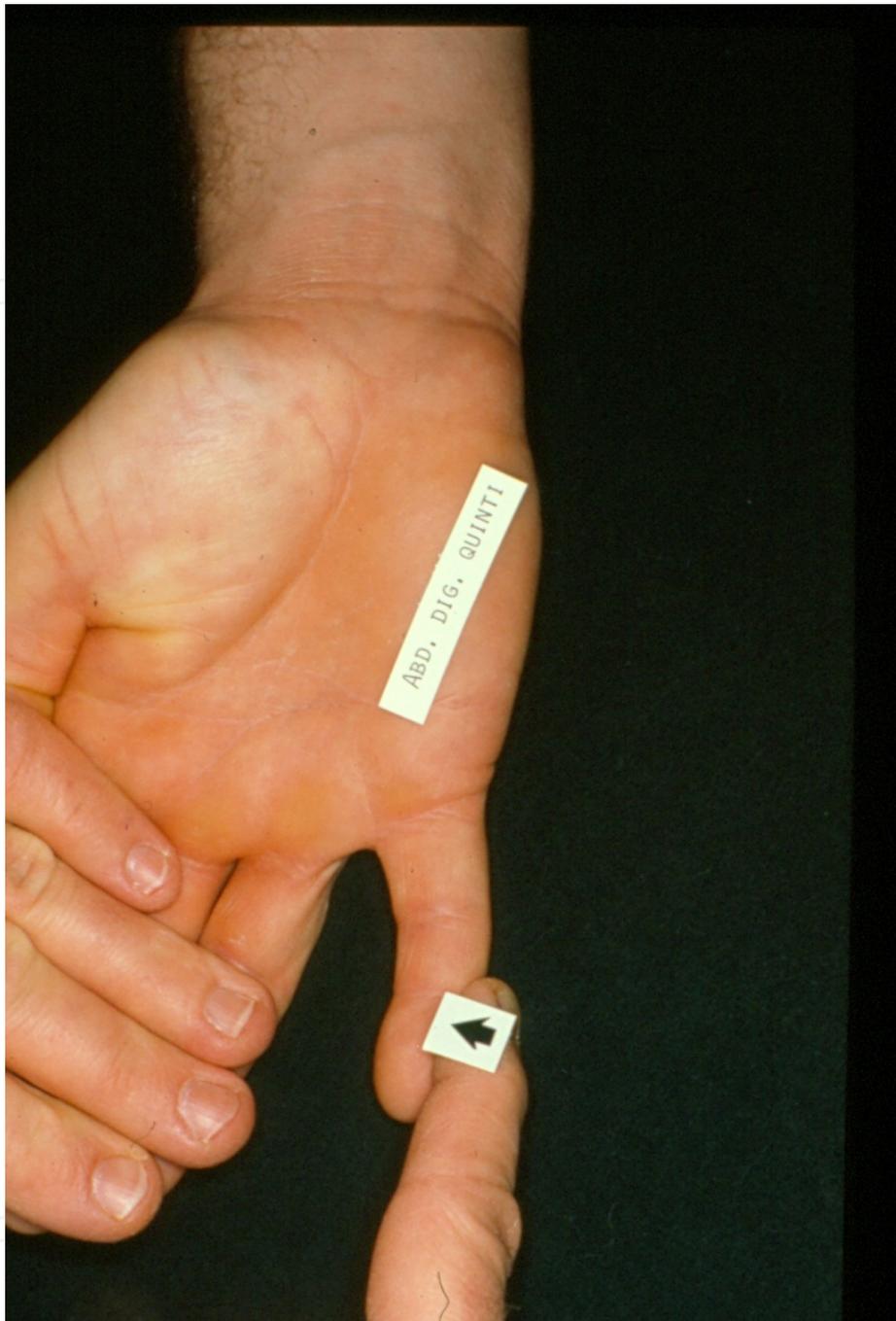


Figure 10. Testing of the ADM muscle

2.4. Interpretation of the outcome of testing three additional muscles

A weak ECU indicates a radial tunnel syndrome (Figure 11). APB weakness indicates a carpal tunnel syndrome. It should, however, be noted that an isolated carpal tunnel syndrome requires an intact FCR (Figure 7). A weak ADM indicates an ulnar nerve involvement, either at the elbow level (in which case the strength in the FDP V will also be reduced) or at the wrist level (in which case the FDP V will be found normal) (Figure 12).

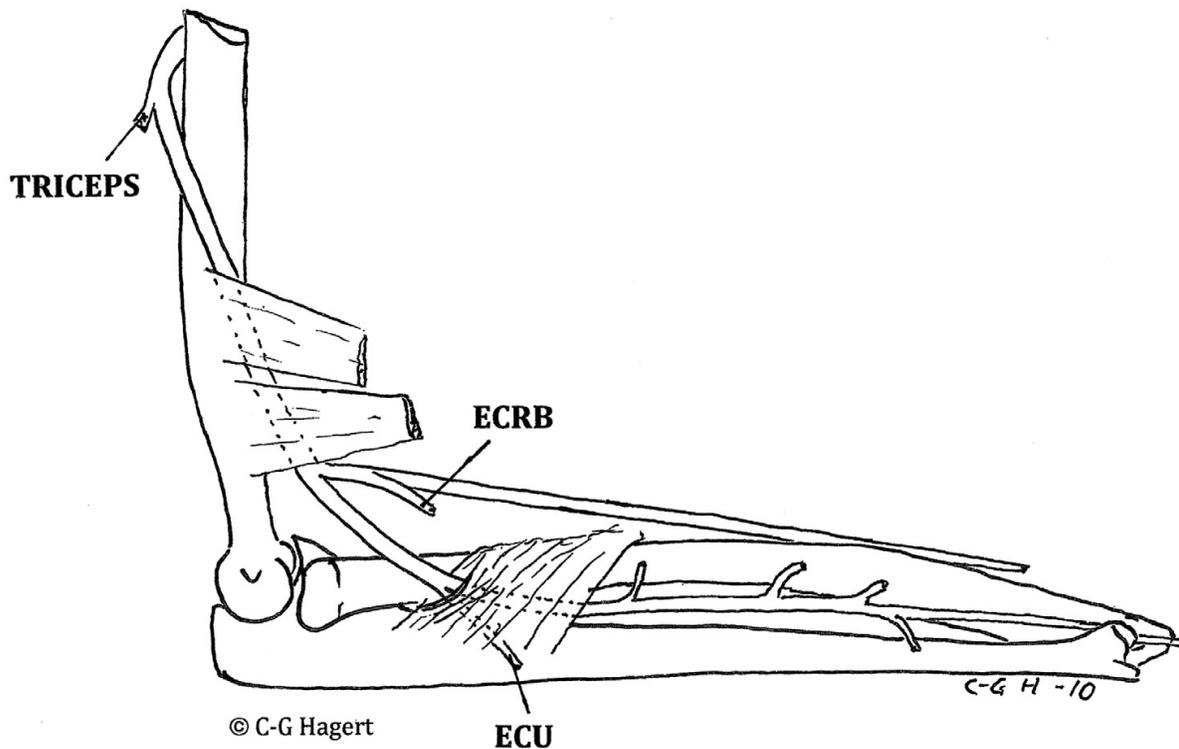


Figure 11. Radial/posterior interosseous neuropathy. Abbreviations: See text

2.5. Consequences of the examination

If weakness is found in one or more of these nine muscles, focal neuropathy cannot be excluded. In this case, further muscles with the same innervation are to be tested. With the identification of individual or patterns of weakness that may reflect peripheral nerve affliction(s), one would expect mechanical allodynia of nerve trunks at the implicated locations and this feature should therefore be looked for (Figure 1).

Due to the rarity of other locations of nerve afflictions of the upper limb, focal upper limb neuropathy can be excluded with a high certainty if all nine muscles are intact and of equal strength bilaterally. Therefore, it is recommended that these muscles are routinely investigated in all upper limb patients.

2.6. Validity of the examination

As previously demonstrated, the strength in these nine muscles can be reliably assessed by blinded manual testing of individual muscles (median κ -value = 0.56 (range 0.33-0.72)). Patterns of weakness (in combination with sensory deviations from normal and mechanical allodynia of nerve trunks at locations appropriate to the innervation and course of nerves) were also reliably assessed (median κ -value = 0.77 (range 0.83-0.70) [7].

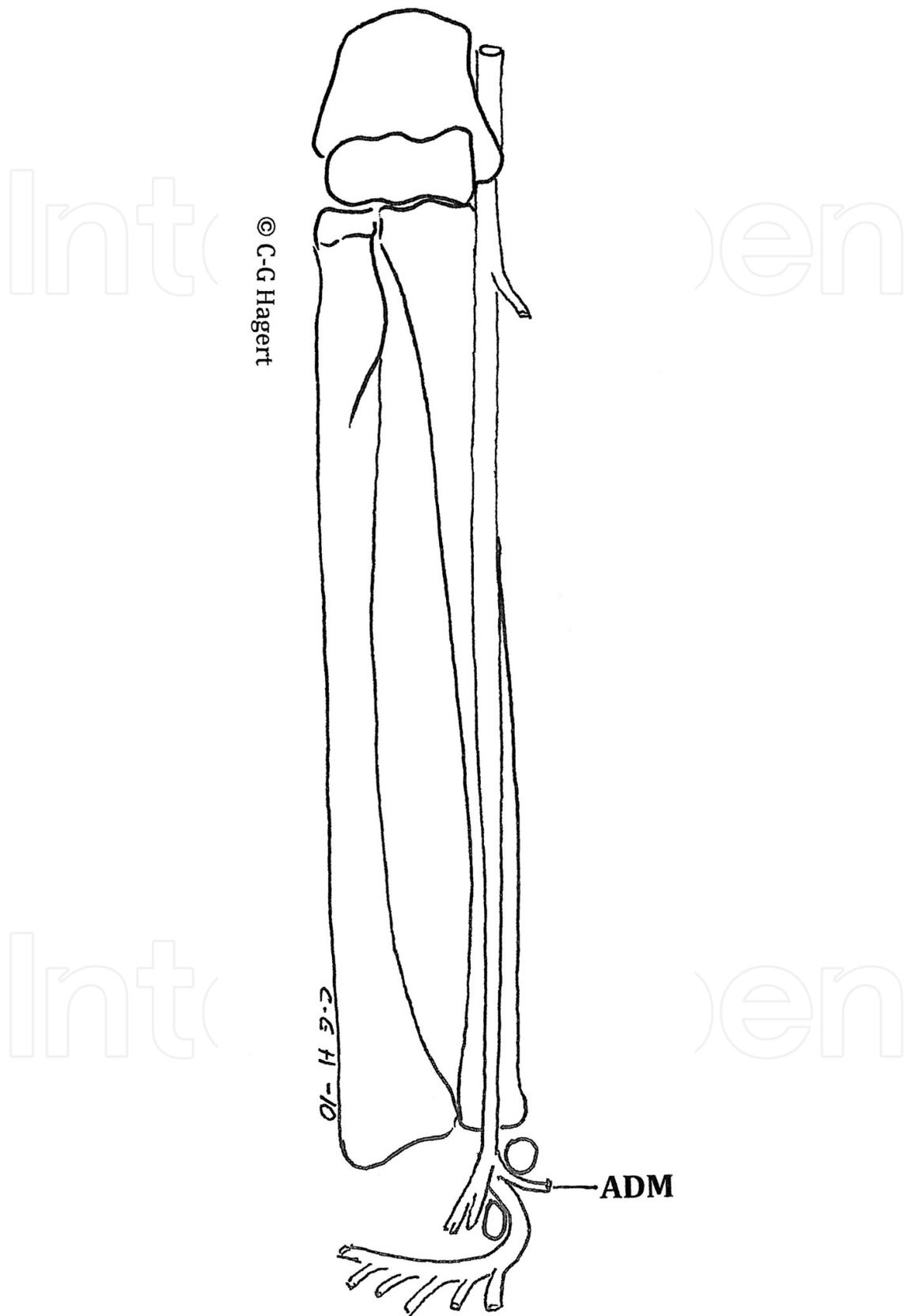


Figure 12. Ulnar neuropathy. Abbreviations: See text

If the examination was limited to just six muscles (the three antagonist pairs, Table 1) the diagnostic sensitivity of the assessment with symptoms (pain, weakness and/or numbness/tingling) by each examiner was 0.92 and 0.84, respectively, but the specificity only 0.70 and 0.50, respectively. The positive/negative predictive values were calculated to 0.73/0.91, respectively, for one of two blinded examiners and 0.59/0.79 for the other. These figures indicate that an examination limited to just these muscles can identify weaknesses in almost all symptomatic limbs, and consequently demonstrate the minimal contribution of the additional examination of the three additional muscles (ECU, APB and ADM) in the studied sample, in which isolated radial tunnel syndrome, ulnar nerve entrapment, and carpal tunnel syndrome was rare [10]. However, the low sensitivity of the examination means that this limited examination cannot stand alone but must be supplemented with an examination of additional neurological parameters, notably of mechanical nerve trunk allodynia.

3. Discussion

To provide our patients with the best management, and to better prevent upper limb conditions many of which are apparently work-related, it is of importance to diagnose them correctly. This chapter presents a simple physical approach to the upper limb nerves that can contribute to do so in a reliable and accurate way.

The research and clinical experiences of our team have suggested that the majority of upper limb pain presented at a department of occupational medicine is of a neuropathic character and is caused by peripheral nerve afflictions with specific locations [7,8,10]. Application of the same physical examination in upper limb patients in the primary health sector [11], and in occupational risk groups [12,17] identified similar disorders displaying the same physical neurological abnormalities.

The locations of neuropathy was dominated by the infraclavicular brachial plexus (behind the minor pectoral muscle – pectoralis minor syndrome), the median nerve at elbow level (frequently just proximal to the elbow joint and also at times more distally, e.g. pronator syndrome), and the posterior interosseous nerve (Arcade of Frohse – radial tunnel syndrome). As also noted among computer operators with severe upper limb complaints, these three locations were often combined [17].

For several reasons, it was not feasible to confirm the observations at the physical examination by electrophysiological studies. In a validation study with multiple outcomes, e.g. nerve afflictions with many locations, it is not possible to perform an extensive bilateral examination of nerve conduction at a high number of locations and of electromyography in many muscles. It takes time, it is costly and it is very uncomfortable for the patients. Furthermore, the electrophysiological examination should always be designed from physical findings at a preceding neurological examination of sufficient meticulousness.

In addition to these constraints, many nerve afflictions including median or interosseous nerve entrapment at elbow level, and brachial plexopathy are frequently quite inaccessible

by electrophysiological methods. This is due to a low sensitivity with respect to minor and mixed and partial peripheral nerve lesions that are characteristic to many of these patients [6]. The regeneration of nerve lesions may also complicate the electrophysiological assessment.

The electrophysiological examination of upper limb patients should take these limitations into account. In the absence for example of a detailed previous physical examination, the electrophysiological examination is likely to target an irrelevant disorder, e.g. carpal tunnel syndrome when the problem is really an entrapment that is located more proximally, e.g. at elbow level or involving the brachial plexus. This is a major problem since many clinicians tend to regard electrophysiological examinations as the golden standard for upper limb focal neuropathies. Consequently, clinicians may be reluctant to trust the outcome of their own physical examination and rather regard that the truth is the outcome of the electrophysiological study, which may well be false negative or false positive. For these reasons, electrophysiological studies are not always of diagnostic help in this type of patients and to my experience may often confuse the clinician.

The presented screening examination of the upper limb nerves is reliable and valid. It consists of an assessment of the strength in nine muscles with the focus on the identification of patterns of weakness and of focal mechanical allodynia of nerve trunks.

The significance of this approach is evident from previous studies [10-12]. As an example, one third of a series of 82 pronator syndromes in 73 patients had previously undergone carpal tunnel decompression without remission and the remaining patients were given various other diagnoses. The average duration of symptoms was three years. On examination, all patients had a weak FCR. Following release of the median nerve at the elbow, 55 out of the 73 patients reported that they were free of symptoms and had regained normal strength. The remaining 18 patients had regained strength, but still complained of elbow pain [18].

Extending the examination of the three muscle antagonist pairs to include three additional muscles would be important with any possibility of a peripheral neuropathy that is not identified by weakness in the first six muscles examined. In particular, this is the situation with radial tunnel syndrome, carpal tunnel syndrome and ulnar neuropathy.

As an example of the first location of entrapment, radial tunnel syndrome, almost all 43 patients in a series of operated cases were previously misinterpreted as lateral epicondylitis because the strength in the ECU was not assessed. The average duration of symptoms in this series was 4.7 years, and the patients were over time given various kinds of treatment and even surgical release of the epicondylar muscle insertion without any positive effects. Following nerve release, 88% of the cases reported that they were symptom-free [18].

Upper limb disorders of a non-neurogenous character may occur in isolation, complicate, cause or co-exist with upper limb neuropathy. For that reason such disorders should also be examined for. E.g. brachial plexopathy may complicate shoulder tendonitis; lateral epicondylitis or radio-humeral joint inflammation may harm the adjacent radial or posterior

interosseous nerves; carpal tunnel syndrome may arise secondary to increased carpal pressure from inflamed flexor tendons at the volar wrist. Upper limb nerve afflictions are, however, more often seen in isolation without other demonstrable pathology [8,11].

Although testing of the presented nine muscles enables the examiner to diagnose or (with the additional examination of the mechanosensitivity of nerve trunks) to exclude an upper limb neuropathy with a high degree of certainty, the acknowledged weaknesses of this approach should be mentioned. In addition, the consequences of diagnosing peripheral upper limb nerve afflictions in terms of management and prevention shall be discussed.

3.1. Weaknesses of the method

Manual muscle testing (and other neurological assessment) is based on comparison between the two sides. For that reason it is more difficult (but still possible [7]) to assess patients with a symmetrical bilateral disorder. Weakness in a particular muscle (or an altered cutaneous sensitivity) should not be confused with paralysis (and analgesia/anesthesia, which, however, as well as cutaneous allodynia may occur). One should rather expect mild weaknesses, some of which may even become apparent only after the deliberate attempt to eventually create fatigue by testing a specific muscle several times. Sensory changes are also mostly modest only.

Moreover, patients are different. The internal and external topography and the innervation patterns of the peripheral nerves may vary considerably in between individual patients. The internal structure of the nerves may differ with the neurons innervating a specific muscle or with afferent function from a certain cutaneous area located superficially or more centrally in the nerve. This may be of importance because superficial fascicles are more vulnerable than those protected by a deeper location within the nerve trunk. In addition, anastomoses between nerves are quite frequent, and the clinician who does not recognize this is likely to be confused by non-expected findings. These circumstances may cause physical findings to diverge considerably from drawings in anatomy textbooks. Therefore, all physical findings should be interpreted humbly.

One can speculate whether the phenomenon that I term weakness in this chapter is actually synonymous with paresis. Paresis is a condition typified by partial loss of voluntary movement or by impaired movement, and neurologists use the term paresis to describe weakness. However, a weakness may occur with many disorders or even in an individual with a poor physical condition and without the occurrence of disease in neither nerve nor muscle.

Certain situations suggest that the identification of muscle weakness does reflect a paresis: Weakness in a muscle innervated by a nerve which is abnormally sore on palpation indicates that the weakness does represent an actual paresis. A pattern of weaknesses in several muscles in accordance with anatomic facts is another feature that suggests a relation to a focal nerve affliction and therefore represents a pattern of muscular pareses. Further support may derive from the identification of sensory alteration at appropriate locations, and e.g. differences of other neurological items in between the two sides.

3.2. Consequences of the diagnosis

The prognosis of the individual patient with peripheral nerve afflictions varies but relies on a correct diagnosis, a proper treatment, the severity of disease, predisposing conditions, complications, and patient cooperation. In addition to implications for prevention and treatment, the diagnosis is essential for optimizing the prognosis and therefore for the advice given to the patient with respect to the future life and work. To the experience of the author, the mere ability to coherently and understandably explain the background for the symptoms is important for the patient – even in cases where no effective treatment is available.

Some advice with regard to management such as avoiding the provocation of pain may be common to many upper limb disorders. To the experience of the author it is of particular importance for patients with upper limb neuropathic conditions that they should not provoke the pain so that it increases after use of the upper limbs. Otherwise, repetitive pain provocation may induce chronic pain due to factors such as sensitization and central nervous system plasticity.

This advice stands frequently in contrast to suggestions to many patients from the previously involved physicians and therapists. To my experience, well-intentioned advice, e.g. on universal working out to improve the upper limb muscle strength by machines in a gym, or by swimming, may have inadvertent and potentially harmful consequences. On the other hand, selective strengthening of weak antagonists to shortened muscles that should be stretched may be indicated, and this correction of an anomalous posture may be a prerequisite for the reestablishment of muscular balance and consequently for restoring nerve mobility. This type of treatment has been advocated by others [15]. It is, however, clear that for being efficient, any treatment whether surgical, physiotherapeutic, or pharmacologic should target the specific condition for which it is indicated. Similar considerations apply for preventive intervention, e.g. at worksites.

Patients with upper limb peripheral neuropathies may be treated by physiotherapy based on neurodynamic principles. This treatment, which is only mastered by a minority of physiotherapists, aims to mobilize nerves by resolving perineurial adhesions with manual techniques. The physiotherapeutic treatment is followed by instructions to the patient about carrying out stretching exercises specified to target the diagnosed nerve affliction(s) with its specific location(s). The effect of physiotherapy based on restoring muscular balance and neuromobilization has been sparsely documented [19]. It is, however, appreciated by most patients.

Surgery can lead to fine outcomes provided a precise previous location of nerve entrapment and the application of correct operative techniques. In cases of compression of the posterior interosseous nerve at the edge of the supinator muscle (radial tunnel syndrome) [20] and/or the median nerve at elbow level (pronator syndrome) [21], long-term follow-up studies have shown excellent results of surgery [18].

The pharmacological treatment of neuropathic pain is challenging and certainly differs from that of treatment of nociceptive pain. Although it is well known that antidepressants and

antiepileptics are currently the drugs of choice for neuropathic pain, paracetamol, acetylic salicylic acid and non-steroid anti-inflammatory drugs are still used extensively in spite of being largely ineffective. The tendency to treat patients with opioids when milder analgesics fail is also worrying if prior treatment with drugs directed against neuropathic pain has not been tried.

Even with reduced pain and improved function following treatment, impairment may persist. Switching to a new job or vocational rehabilitation may be necessary. Thus, only two out of 21 patients with severe computer-related upper limb pain were able to resume graphical computer work [17]. This observation emphasizes the importance of early diagnosis and treatment, and in particular of preventive interventions at worksites in order to safeguard not only the patient but also colleague workers that are exposed to the same risk factors.

3.3. Causation and prevention

Painful upper limb neuropathic conditions are frequent consequences of trauma or adverse work-exposures such as prolonged static position such as with intensive PC work [17]. The condition seems to be further exacerbated by repetitive tasks or by the use of force as is prevalent in many manual occupations such as e.g. crafts, assembly work, food industry, and cleaning. Currently, the insufficient knowledge of causality with regard to work-related neuropathic upper limb conditions implies that evidence-based prevention is not feasible. However, certain work-exposures have been previously implicated with upper limb nerve afflictions with specific locations. Werner [22] and Hagert et al. [20] have reported on rotational load of the forearm causing radial tunnel syndrome rather than epicondylitis. Stål et al. has described pronator syndrome in a high proportion of female milkers [23]. Other researchers have also dealt with the work-relatedness of ulnar neuropathy [24], carpal tunnel syndrome [25,26], and brachial plexopathy, [13,27], of which the latter in particular was prevalent in our studies [8,10,11,17].

The limited evidence base with regard to causation complicates interventions aiming to prevent the development of upper limb neuropathic conditions at workplaces. Consequently, preventive interventions have to be mainly based on clinical experiences from exposure descriptions by patients and pathophysiological reasoning. General ergonomic principles may be applied with some effect. Pain exacerbation should not be provoked, and the patient should try to minimize the use of upper limb force and speed, to ensure task-variations to the maximal extent, and to predominantly use the upper limb close to the body. Preventive systematic stretching also seems of importance [28].

4. Conclusion

Manual muscle testing is an important part of the physical examination of upper limb patients. I have presented the rationale and methods for applying manual muscle testing as a key part of the physical neurological examination emphasizing a simple, rapid and valid

assessment of the strength in nine upper limb muscles. To the experience of the author, the outcome of this screening can explain symptoms in a major proportion of patients with work-related upper limb disorders including those regarded as “non-specific”.

This diagnostic contribution may represent a significant step towards a better understanding of these frequent conditions, which constitutes a major diagnostic challenge to clinicians. The patient will always favour of having the condition diagnosed but of equal importance is the demonstration of a positive impact on management or prevention of the application of the examination. The latter, however, demands further studies.

Colleagues are encouraged to routinely include the presented examination in their physical assessment of upper limb patients. For a precise diagnosis, subsequent complement with a more extensive neurological examination may be required.

Author details

Jørgen Riis Jepsen

Department of Occupational Medicine, Østergade 81-83, DK-6700 Esbjerg, Denmark

Centre of Maritime Health and Safety, Institute of Public Health, University of Southern Denmark, Niels Bohrs Vej 9-10, DK-6700 Esbjerg, Denmark

Acknowledgement

Professor Carl-Göran Hagert, Lund, Sweden has developed the method of the presented and validated manual examination of muscle strength and has kindly allowed me to use his hand-drawn figures in this chapter.

5. References

- [1] Marx RG, Bombardier C, Wright JG (1999) What do we know about the reliability and validity of physical examination tests used to examine the upper extremity? *J Hand Surg (Am)*; 24 (1): 185-93.
- [2] Katz JN, Stock SR, Evanoff BA, Rempel D, Moore JS, Franzblau A, et al. (2000) Classification criteria and severity assessment in work-associated upper extremity disorders: Methods matter. *Am J Ind Med*; 38 : 369-72.
- [3] Coggon D, Martyn C, Palmer KT, Evanoff B (2005) Assessing case definitions in the absence of a diagnostic gold standard. *Int J Epidemiol*; 34 (4): 949-52.
- [4] Hagberg M (2005) Clinical assessment, prognosis and return to work with reference to work related neck and upper limb disorders. *G Ital Med Lav Ergon*; 27 (1): 51-7.
- [5] Palmer K, Cooper C (2000) Repeated movement and repeated trauma affecting the musculoskeletal disorders of the upper limbs. In: Baxter P, Adams P, Aw T, Cockcroft A, Harrington J, editors. *Hunter's Diseases of Occupations*. 9 ed. London: Arnold. p. 453-75.
- [6] Krarup C (1999) Pitfalls in electrodiagnosis. *J Neurol*; 246 (12): 1115-26.

- [7] Jepsen J, Laursen L, Larsen A, Hagert CG (2004) Manual strength testing in 14 upper limb muscles. A study of the inter-rater reliability. *Acta Orthop Scand*; 75 (4): 442-8.
- [8] Jepsen JR, Laursen LH, Hagert C-G, Kreiner S, Larsen AI (2006) Diagnostic accuracy of the neurological upper limb examination I. Inter-rater reproducibility of findings and patterns. *BMC Neurology*; 6 : 8.
- [9] Miller TM, Johnston SC (2005) Should the Babinski sign be part of the routine neurologic examination? *Neurology*; 65 (8): 1165-8.
- [10] Jepsen JR, Laursen LH, Hagert C-G, Kreiner S, Larsen AI (2006) Diagnostic accuracy of the neurological upper limb examination II. The relation to symptoms of patterns of findings. *BMC Neurology*; 6 : 10.
- [11] Laursen LH, Sjogaard G, Hagert CG, Jepsen JR (2007) Diagnostic distribution of non-traumatic upper limb disorders: vibrotactile sense in the evaluation of structured examination for optimal diagnostic criteria. *Med Lav*; 98 (2): 127-44.
- [12] Jepsen JR, Thomsen G (2006) A cross-sectional study of the relation between symptoms and physical findings in computer operators. *BMC Neurology*; 6 : 40.
- [13] Pascarelli EF, Hsu YP (2001) Understanding work-related upper extremity disorders: clinical findings in 485 computer users, musicians, and others. *J Occup Rehabil*; 11 (1): 1-21.
- [14] Novak CB (2003) Thoracic outlet syndrome. *Clin Plast Surg*; 30 (2): 175-88.
- [15] Novak CB, Mackinnon SE (2002) Multilevel nerve compression and muscle imbalance in work-related neuromuscular disorders. *Am J Ind Med*; 41 (5): 343-52.
- [16] Hagert C-G. Clinical assessment of the upper limb nerve tree. *Scandinavian Society For Surgery Of The Hand, Autumn Meeting, Malmö* , 50. 1993. Ref Type: Abstract
- [17] Jepsen JR (2004) Upper limb neuropathy in computer operators? A clinical case study of 21 patients. *BMC Musculoskeletal Disorders*; 5 : 26.
- [18] Hagert C-G, Hagert E (2008) Manual muscle testing - A clinical examination technique for diagnosing focal neuropathies in the upper extremity. In: Slutsky DJ, editor. *Upper extremity nerve repair - Tips and techniques: A master skills publication*. American Society for Surgery of the Hand, 6300, North River Rd. Suite 600, Rosemont, IL 60018-4256. p. 451-65.
- [19] Ellis RF, Hing WA (2008) Neural mobilization: a systematic review of randomized controlled trials with an analysis of therapeutic efficacy. *J Man Manip Ther*; 16 (1): 8-22.
- [20] Hagert C-G, Lundborg G, Hansen T (1977) Entrapment of the posterior interosseous nerve. *Scand J Plast Reconstr Hand Surg*; 11 : 205-12.
- [21] Stål M, Hagert CG, Englund JE (2004) Pronator syndrome: a retrospective study of median nerve entrapment at the elbow in female machine milkers. *J Agric Saf Health*; 10 (4): 247-56.
- [22] Werner CO (1979) Lateral elbow pain and posterior interosseus nerve entrapment. *Acta Orthop Scand*; Suppl.174 .
- [23] Stål M, Hagert C-G, Moritz U (1998) Upper extremity nerve involvement in Swedish female machine milkers. *Am J Ind Med*; 33 : 551-9.

- [24] Descatha A, Leclerc A, Chastang J-F, Roquelaure Y, The Study Group on Repetitive Work (2004) Incidence of ulnar nerve entrapment at the elbow in repetitive work. *Scand J Work Environ Health*; 30 (3): 234-40.
- [25] Roquelaure Y, Ha C, Pelier-Cady MC, Nicolas G, Descatha A, Leclerc A, et al. (2008) Work increases the incidence of carpal tunnel syndrome in the general population. *Muscle Nerve*; 37 (4): 477-82.
- [26] Roquelaure Y, Ha C, Nicolas G, Pelier-Cady MC, Mariot C, Descatha A, et al. (2008) Attributable risk of carpal tunnel syndrome according to industry and occupation in a general population. *Arthritis Rheum*; 59 (9): 1341-8.
- [27] Mackinnon SE, Novak CB (2002) Thoracic outlet syndrome. *Curr Probl Surg*; 39 (11): 1070-145.
- [28] Jepsen JR, Thomsen G (2008) Prevention of upper limb symptoms and signs of nerve afflictions in computer operators: The effect of intervention by stretching. *J Occup Med Tox*; 3 : 1.