POSTERIOR CERVICAL ELECTROMYOGRAPHY IN THE DIAGNOSIS
AND PROGNOSIS OF BRACHIAL PLEXUS INJURIES

C. BUFALINI and G. PESCATORI, FLORENCE, ITALY

From the Orthopaedic Clinic of the University of Florence

In traction lesions of the brachial plexus nerves may be severed at two different levels: within the foramina by avulsion of the spinal root, and outside the foramina, above or below the clavicle. In intraforaminal lesions the prognosis for nerve recovery is bad and the only treatment consists in muscle and tendon transplants, arthrodesis or, in cases in which paralysis of the limb is complete, amputation. In extraforaminal lesions the prognosis is somewhat better, because nerve regeneration is possible, and treatment consists in suture of the severed branches.

It is therefore important to determine as early as possible whether the lesion is intraforaminal or extraforaminal. The possibility of successful nerve suture depends on prompt action. When suture is impossible, it is necessary to encourage the patient to re-enter society after all orthopaedic measures have been performed, and this may take time.

Determination of the level of the brachial plexus lesion presents difficult problems. Clinical examination, the presence or absence of Horner’s syndrome, and the behaviour of the pilometer reflex, give some indication, but they are usually insufficient to allow definite diagnosis and prognosis.

Murphy, Hartung and Kirklin (1947) demonstrated that cervical myelography may show an appearance of pseudomeningocele which indicates spinal root avulsion; but in the later cases the meningeal tear may undergo repair by scar tissue and the picture of meningocele will be absent (Tarlov and Day 1954). Sometimes the periarachnoidal scar tissue gives the appearance of a filling defect in the meningeal sac (Yeoman 1968).

In 1959 Bonney described a useful method of differential diagnosis of preganglionic and postganglionic lesions by examining the axone reflexes. He admitted, however, that in a certain proportion of cases with postganglionic lesions a coexisting preganglionic one may go unnoticed. Recently, Yeoman (1968) demonstrated in a series of cases of traction lesions of the brachial plexus a lack of parallelism between the findings from myelography and those from testing the axonic reflex.

We have also found an incompatibility between Bonney’s reflexes and the appearance found at operation. Many writers, including ourselves, have explored all brachial plexus traction lesions as early as possible in order to perform nerve suture or neurolysis in the small number of cases that are suitable.

For about fifteen months we have used a method which allows differentiation between intraforaminal lesions and extraforaminal ones. This is based on electromyography of the

FIG. 1
Diagram of a transverse section of the neck at the level of C.6, to demonstrate the origin and the course of the posterior branches of the spinal nerves. On the right side is shown intraforaminal avulsion of the spinal root. The electromyograph of the deep posterior neck muscles will show fibrillation potentials: an unfavourable prognosis. On the left side is shown extraforaminal damage of the brachial plexus. The electromyograph of the deep posterior neck muscles will be normal: a favourable prognosis.
deep posterior neck muscles, which are innervated by the posterior branches of the cervical spinal nerves. These nerves have not previously been considered, although the posterior branch, being postforaminal, makes an ideal medium for differentiating between the two types of lesion. The probable reason for their neglect is that the posterior deep muscles are inaccessible to clinical examination, being covered by the trapezius muscle. Only electromyography makes functional examination possible. Marinacci (1955) foresaw the possibility of making this differentiation by electromyography of the posterior paravertebral muscles, but the method has not previously been used in patients with brachial plexus lesions (Licht 1961).

APPLIED ANATOMY

The nerve roots, soon after emerging from the intervertebral foramina, are called spinal nerves and at once divide into the large anterior branch, which forms part of the brachial plexus, and the short slender posterior branch, which innervates the deep muscles of the neck and the skin of the back of the neck (Fig. 1). The posterior cervical muscles can be divided into four levels. Level 1 is formed by the trapezius muscle, innervated by the spinal accessory nerve; level 2 by the splenius and angularis scapulae muscles innervated by the cervical plexus. The muscles with which we are concerned in this paper, which are innervated by the posterior branches of the brachial plexus, form levels 3 and 4, and consist of the large and small complex muscles, the transversalis colli, the transversalis spinosi, the interspinosi, the intertransversalis and the semispinalis muscles. All these muscles lie in the paravertebral region of the neck. It should be noted that the muscles in level 3—the large complex muscle (in this part under
the tendon) and the small complex muscle—have a longitudinal innervation in that the medial parts are innervated by the posterior branches of the spinal nerves C.3 and C.4, and the more lateral parts by C.7 and C.8. The muscle of level 4 (transversus spinosus and interspinosus, intertransversalis) are horizontally innervated and get nerve fibres from the corresponding spinal nerves at each level.

The posterior branches of the spinal nerves, after sending the motor fibres to the above-mentioned muscles, become sensory and innervate the skin of the back of the neck. Their distribution is irregular and inconstant, and sometimes they receive fibres from the nerve of Arnold as well.

The sensory fibres from C.4 and C.5 are the ones most constantly present, those from C.6 and C.7 being often absent, and those from T.1 always being absent.

TECHNIQUE OF ELECTROMYOGRAPHIC EXAMINATION

After disinfection of the skin, two bipolar needles (Disa's type) are inserted into the paravertebral region of the neck. The examination begins with the first tracing at the level of the spinous process of C.4 and continues by applying the needles at the levels of the spinal processes below it, down to C.8 (Fig. 2). The needles are introduced deeply until they touch the bone, and are then slightly withdrawn to be certain of recording the electrical activity from the muscles. In order to eliminate any trace of voluntary or postural muscle activity, complete relaxation of the extensor muscles of the neck must be obtained. This can be achieved by resting the patient's head on a chin support. If the muscles examined are undamaged, a tracing is obtained at rest which is called electrical silence or an iso-electric line is obtained. (Fig. 3). On the other hand, if the muscles have been denervated as a result of an intraforaminal lesion of the spinal nerve, after about twenty days the tracing will show fibrillation potentials, which represent the best evidence of a nerve lesion (Fig. 3). The tracing of the unaffected side is
obtained for comparison and control. Further, by active movement of the patient's neck, motor unit potentials are recorded if the muscles are undamaged, whereas the fibrillations persist if they are denervated.

During the past fifteen months electromyographic recordings have been made in thirteen patients with brachial plexus lesions. All of them were operated upon, and the electromyographic diagnosis was confirmed in each case. Of the thirteen patients, six had extraforaminal lesions, five had intraforaminal lesions and two had mixed lesions (intraforaminal lesions involving the superior roots and extraforaminal the inferior).

It should be noted that in only three of the eight cases with extraforaminal lesions (total or mixed) was it possible to perform nerve suture (Fig. 4). In the other cases the nerve branches were too far retracted to allow approximation without excessive tension. Moreover, the lesions in which the nerve suture was successful were of one to three months' duration. Clinical follow-up five to twelve months after the operation revealed in all three cases clear evidence of recovery of the motor and sensory function, and recovery continues.

DISCUSSION

It is evident that in intraforaminal lesions of the brachial plexus, consisting of avulsion of the roots from the cord, the deep posterior muscles of the neck are also paralysed. In extraforaminal lesions, where the lesion is beyond the exit of the posterior branches of the
spinal nerves, these muscles are, on the contrary, free of damage (Fig. 1). Electromyography is the only means of verifying the activity of the deep posterior muscles of the neck, which are inaccessible to clinical or functional examination because they are covered by the trapezius muscle. The examination of sensation on both sides of the back of the neck may give some information about the integrity of the posterior branches of the spinal nerves, but the inconsistency and wide variation of the sensory branches of the spinal nerves prevents real diagnostic value from this examination.

We believe that the electromyographic method described is superior to previous methods. In comparison with clinical methods (pilomotor reflex, axone reflexes, Horner’s syndrome) it is better because it gives direct information on the condition of the segment of the nerve roots between the spinal cord and the intervertebral foramen. The clinical methods provide only indirect information about the integrity of the peripheral part of the nerve beyond the spinal canal. Compared with radiological and surgical methods (myelography and surgical exploration) it has the advantage of being simple and harmless, the more so because myelography becomes indefinite in long-standing cases. Electromyography should not be performed during the first twenty days after the injury, in order to allow the appearance of fibrillation in the denervated muscles. While it allows a distinction to be made between intraforaminal and postforaminal brachial plexus lesions, it does not give a certain indication of the roots affected. This information is obtained by clinical neurological examination. Study of the electromyographic tracing is easy and unequivocal: the presence of fibrillation and the absence of normal action potentials are clear and indisputable signs of an intraforaminal lesion, whereas iso-electric silence and presence of motor action potentials are symptoms of an extraforaminal lesion.

The treatment of brachial plexus lesions has been made easier by the early diagnosis and prognosis offered by electromyographic examination of the posterior muscles of the neck. In intraforaminal lesions, in which there is no hope of improvement, there need be no delay in proceeding with arthrodesis or muscle and tendon transplantations. In extraforaminal lesions, operative inspection of the brachial plexus is necessary to decide whether the damaged nerve branches can be sutured: this is possible within three months of the injury. Our results in this respect are limited and early, but it is clear that this way of treatment is capable of giving good results.

SUMMARY

1. The deep posterior muscles of the neck are innervated by the posterior branches of spinal nerves, which branch off immediately after the root emerges from the intervertebral foramen. Electromyographic examination of these muscles permits a differential diagnosis to be made between intraforaminal and extraforaminal brachial plexus lesions.

2. The earlier diagnosis and prognosis thus achieved permit definitive treatment, in particular suture of the torn nerve trunks in recent extraforaminal cases.

REFERENCES


