RADIAL PALSY FOLLOWING MUSCULAR EFFORT

A Nerve Compression Syndrome Possibly Related to a Fibrous Arch of the Lateral Head of the Triceps

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The radial nerve is liable to compression injury. Radial palsy is a fairly common complication of fracture of the humerus. It may also result from compression by a tourniquet, from the use of crutches, and from allowing the arm of an anaesthetised patient to hang over the operation table. It may develop during sleep, especially when the patient is intoxicated (“Saturday night palsy”). Cases have been described of radial mono-neuritis caused by alcohol, lead, arsenic and serum sickness. The nerve may also be damaged by deep intramuscular injection into the posterior or lateral aspects of the upper arm.

Radial palsy after muscular effort is rare. It is mentioned in textbooks (Baker 1955, Wilson 1954), but only a few cases have been described in the literature. During the last year we have seen three such cases conforming to a particular nerve compression syndrome. To the best of our knowledge no description of such a syndrome is to be found in the literature.

CASE REPORTS

Case 1—A Yemenite worker aged forty was sent because three days previously, a few hours after he had finished a day of unusually heavy work which entailed loading a truck with pipes weighing fifty kilograms each, he felt sudden weakness in his right arm which gradually increased. He noted “drop” hand accompanied by loss of sensibility on the dorsum of the hand in the area between the first and the third metacarpals. He had also noted weakness of elbow flexion, but this had disappeared within twenty-four hours. This man had always been in good health and was not an alcoholic. On examination the abnormal findings were confined to the right upper limb, which showed total paralysis of the extensors of the wrist and fingers and of the long abductor of the thumb and the supinator muscle. There was a patch of anaesthesia on the dorsum of the hand in the space between the first and second metacarpals. The power of extension and flexion of the elbow was normal. Radiographs of the arm and elbow showed no abnormality. A radial splint was applied.

Three days later (six days after the onset) further examination showed that the extensors were beginning to recover: muscle power was now Grade 2 (Medical Research Council Grading). Twelve days after the onset extensor power had increased to Grade 3. Active supination was noted, but there was still an impairment of sensibility. Improvement continued until full recovery, twenty-five days after the onset.

Electrical reactions—The first examination was six days after the injury. Electromyography was performed on the triceps, biceps, extensor indicis, thenar muscles and hypothenar muscles. In the extensor indicis, the only muscle that showed abnormal findings, no resting potential or voluntary activity was found. Radial nerve conduction (Jebsen 1966), after a stimulus of 0·1 millisecond duration at 150 volt intensity applied to the lateral aspect of the arm above

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§ This case was reported by Lotem and Solzi in 1970.
the elbow, revealed normal conduction velocity and normal amplitude of the action potentials. Conduction velocity of the musculo-cutaneous, median and ulnar nerves was within normal limits. A second examination four days later revealed a reduced interference pattern in the electromyograph of the extensor indicis. Improvement continued until full recovery, twenty-five days after the injury, when the recording showed a normal interference pattern.

Case 2—A forty-five-year-old manual worker was washing his hands immediately after pushing a heavy container a few metres when he noticed weakness of his right forearm, drop hand, and sensory impairment over the dorsum of the forearm and hand. In his words, “My hand had become so weak that I could not even hold a cigarette”. The patient was examined a few hours after the onset of his symptoms. There was no abnormality except in the right upper limb. He had drop hand with complete paralysis of all the extensors of the wrist and fingers including the long abductor of the thumb. Movement of the elbow was normal, without any weakness of flexion, extension, pronation or supination. Sensory impairment of indefinite quality and extent was found on the dorsum of the forearm and hand in the distribution of the posterior cutaneous nerve. One patch of anaesthesia between the first and second metacarpals was clearly defined. There was tenderness of the lateral side of the arm proximal to the lateral epicondyle. Radiographs of the arm and elbow showed no abnormality. Blood sugar and urea levels were normal. Next day there was great improvement, the power of the extensors being Grade 3.

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**Fig. 1**

Case 2—Action potentials in the right extensor indicis evoked by nerve stimulation.  
a) Stimulation of the radial nerve in the forearm 40 millimetres above the pick-up electrode. Response is normal.  
b) Stimulation of the radial nerve on the lateral aspect of the arm above the elbow 280 millimetres from the pick-up electrode. Response is normal.  
c) Stimulation of the brachial plexus in the axilla using a pulse of 200 volts for a duration of 1 millisecond. Response is similar to that in lowest tracing.  
d) Stimulation of the median nerve in the elbow lateral to the tendon of the biceps. The response belongs to the activity of the adjacent muscles innervated by the median nerve.

Five days after the onset of symptoms motor power had increased to Grade 4, but sensibility had not returned. On the ninth day after the onset of the symptoms the extensor power of the wrist was Grade 5, and of the other muscles 4+. However, sensibility was still affected. The patient returned to work twenty days after the incident with some residual muscular weakness and impairment of sensibility.

**Electrical reactions**—The first examination was made on the second day after injury. Electromyography of the right triceps, biceps, extensor indicis, thenar, and hypothenar

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muscles and of the left extensor indicis was done. All muscles except the right extensor indicis showed a normal pattern. In this muscle neither resting potentials nor voluntary activity was recorded. When the radial nerve was stimulated, in the forearm or arm with a stimulus of 0·1 millisecond duration and 150 volt intensity, normal action potentials were evoked from the extensor indicis (Fig. 1 a and b). A minimal response was obtained when a stimulus of 1 millisecond duration at an intensity of 200 volts was applied in the axilla and above the clavicle (Fig. 1 c). This response was similar in shape to that obtained when the median nerve was stimulated at the elbow (Fig. 1 d). This means that the activity seen in the lower two tracings belonged to adjacent muscles innervated from the median nerve. The electromyograph of the triceps was normal. Conduction through the radial nerve to the triceps from the axilla or supraclavicular region was normal, as was the conduction velocity in the left radial nerve from the four points of stimulation (forearm, arm, axilla, and supraclavicular point). The conduction velocity along the musculo-cutaneous, median and ulnar nerves was normal.

The patient was examined again four days after the first examination. Some voluntary activity was seen in the right extensor indicis, and there was nerve conduction after stimulation at each of the four points. Two weeks after the first examination the electromyographic pattern and conduction velocity returned to normal.

Case 3—A labourer aged forty-nine was involved in a road accident in 1968, sustaining fracture of the right transverse process of the seventh cervical vertebra, fracture of the right scapula, acromio-clavicular dislocation and an incomplete lesion of the right brachial plexus. There was a complete lesion of the circumflex nerve and a partial lesion of the musculo-cutaneous, median and ulnar nerves. The radial nerve was intact.

Two years after the injury, while the patient was performing extension exercises of the elbow against weights, he suddenly noticed a right hand drop. Examination four days later showed drop hand with paralysis of the extensors of the wrist, fingers and long abductor muscle of the thumb. A patch of anaesthesia was present between the first and second metacarpal bones. Radiographs of the arm and elbow showed no abnormality.

Nine days after the onset of these symptoms there was motor recovery to Grade 3 to 4, but impairment of sensibility continued. A week after this there was almost complete recovery. Electrical reactions—The patient had been examined several times in 1968. In 1970 he was examined again four days after the heavy exercise. The findings regarding the radial nerve were the same as those in Case 2. Examination two weeks later showed complete recovery of the radial nerve.

**COMMENT**

In each of the three cases there was complete palsy in the muscles innervated by the radial nerve below the branches to the triceps. It is evident that there was preservation of axonal continuity because in a few days conduction through the nerve returned to normal. The nerve suffered a complete block, probably caused by a segmental lesion in the middle of the arm. This lesion affected the nerve at a point distal to the branches of the triceps and presumably proximal to the posterior cutaneous branch. It is also possible that the cutaneous branch was affected at a point where the two trunks were close together.

The electrophysiological evidence favours this site, because a stimulus in the lower arm propagated distally with a normal velocity, whereas a stimulus in the axilla activated only the triceps and did not advance distally. Mayer and Denny-Brown (1964) believed that pressure on a nerve caused local ischaemia which resulted in demyelination of a segment that acted as a block to axonal conduction. Gilliatt (1966) thought that direct pressure itself contributed to demyelination. Clearly, the electrophysiological examination does not determine the nature of a segmental lesion of this type. We can only say that in the present cases there was neurapraxia—a brief physiological loss of function (Seddon 1943).
ANATOMICAL CONSIDERATIONS

We suspected that there might be a mechanical cause for pressure on the nerve along its course from the posterior to the antero-lateral part of the arm. We could not find any abnormality such as an exostosis, a scar or a tumour that might cause pressure, so we did a number of dissections on cadavers to determine if some particular anatomical structure could be the agent. It was found that the radial nerve in its course through the posterior compartment of the arm, along the spiral groove posterior to the humerus under the lateral head of the triceps, passed quite consistently through a fibrous arch (Figs. 2 to 4). This arch is located close to the lateral border of the humerus, slightly proximal to the level where the spiral groove reaches that border, about two centimetres distal to the insertion of the deltoid.

The arch is formed mainly by fibres coming from a strong, conspicuous, glistening tendon belonging to the lateral head of the triceps. This tendon is deep and located medially, and runs parallel to the muscular fibres. When the muscle crosses over the spiral groove, some fibres of the tendon can be seen leaving the main band and, after making a turn, they become inserted into the humerus immediately below the lateral part of the spiral groove. Additional muscular fibres of the lateral head take origin from the fibrous arch thus formed, as well as directly from the humerus close to the arch. Thus an accessory part from the lateral head originates below the spiral groove.

The existence of the arch and the accessory origin of the lateral head is not mentioned in the current textbooks or other anatomical literature. Rouvière (1954) mentioned an inconstant origin of the lateral head of the triceps, distal to the spiral groove. It should be stressed that the fibrous arch is quite distinct from the opening in the lateral intermuscular...
septum through which the nerve passes from the posterior to the anterior compartments of the arm.

We found this fibrous arch in almost every case. It appeared generally more conspicuous and stronger in muscular subjects. The passage of the radial nerve under the arch was usually loose and free with no signs of compression. However, in some cases the arches were tighter than in others. In the light of these observations we may reasonably presume that in certain cases an exceptionally strong, tight arch may act as a cause of compression of the radial nerve.

**DISCUSSION**

In each case there was evidence of compression of the radial nerve in the spiral groove after continuous muscular effort (Fig. 5). We were unable to find a similar case in the literature in the last thirty years. Wilson (1954) wrote: "...sudden muscular effort, notably one of extension, can injure the nerve..."; and he noted the papers by Bernhardt (1902) and Gerulanos (1915). He cited a case of Gowers from that period: "An energetic stone-throw was succeeded by complete palsy, with bruised appearance over the lower triceps. Such happenings are, however, rare...and it may be questioned whether some predisposition is not here also to the fore".

A number of cases of paralysis of the posterior interosseous nerve after muscular effort have been described. Sharrard (1966) described three such cases. Goldman, Honet, Sobel and Goldstein (1969) reviewed the literature. This condition is different from that observed by us. There is no wrist drop, because the nerve supplying the extensor carpi radialis longus is intact, but there is weakening of wrist extension accompanied by radial drift and, of course, there is no sensory disturbance.

The nature of the lesion in these cases was that of neurapraxia: the clinical features, the electrophysiological evidence and the benign course all pointed to this (Sunderland 1968). The variations in degree and extent of motor and sensory affection are of course explained "on the basis of individual variations of susceptibility among motor fibres, and to the fact that some occupy more protected positions in the nerve than others" (Sunderland 1968).

Compression of nerves by fibrous bands is well known. In the case of the posterior interosseous nerve a fibrous arch may compress the nerve in its passage through the supinator muscle (Frohse and Fränkel 1908, Sharrard 1966, Spinner 1968, Goldman and colleagues 1969). A similar cause for affection of the anterior interosseous nerve was described by Fearn and Goodfellow (1965), Sharrard (1968) and Vichare (1968). In these cases, however, release of compression by operation was necessary to permit recovery. In our cases recovery occurred spontaneously. It is possible that normally the fibrous arch of the lateral head of the triceps is not tight enough to compress the nerve, except in very muscular individuals with well developed tight arches. The nerve in these people may then be exposed to compression and prone to injury. When additional factors intervene—namely the swelling of the triceps in connection with unusual exertion—nerve compression can occur.
The swelling of a muscle during exertion is the result of increased blood flow and the absorption of water. Grant (1938) found an increase of blood flow to thirty times the resting value. He noticed that vasodilation of the arterioles was proportional to the severity and duration of activity and that it reached a maximum immediately after the activity ended. The vasodilation and high blood flow subsided comparatively slowly; it might be ten to fifteen minutes before the flow returned to that of the resting state.

French and Price (1962) cited Barcroft and Kato (1916) who showed that the specific gravity of muscle decreased during activity as it absorbed water. The weight of the muscle increased by up to 20 per cent of the resting value. This finding persisted up to seven and three-quarter hours after the termination of activity.

The pressure on the radial nerve is transient because the muscle returns gradually to its original resting volume after the termination of the exertion. It is presumed that this mechanism was the agent in the three cases described. The patients were muscular individuals and the palsy followed unusually intensive extension exertion of the elbow.

The syndrome seems to be rare, but we believe that many cases may remain undiagnosed because the patient may recover quickly and may never seek medical advice. Yet the surgeon must be prepared for the possible instance where the syndrome does not disappear spontaneously and surgical release is required.

SUMMARY

1. Three cases of paralysis of the radial nerve after intensive muscular effort in extension of the elbow are described. Clinical and electrophysiological evidence is recorded.
2. There was motor and sensory affection of varying degree and extent in the distribution of the radial nerve.
3. The type of lesion in each case was that of neurapraxia, and rapid spontaneous recovery occurred in each case.
4. The level of the lesion was in the arm, below the origin of the branches to the triceps.
5. The cause of the lesion was thought to be compression by a fibrous arch related to the lateral head of the triceps.
6. The cases are discussed in relation to other instances of compression of nerves by fibrous arches, and an explanation is advanced for spontaneous recovery.

REFERENCES