FUNCTION OF THE SUPRASPINATUS MUSCLE AND ITS RELATION TO THE SUPRASPINATUS SYNDROME

An Experimental Study in Man

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The action of the supraspinatus muscle is subject to controversy. "The humerus cannot be abducted by the deltoid alone. The supraspinatus is an essential synergist with function like that of a builder's mate who stands on the bottom rung of a ladder to fix it while it is being raised. The supraspinatus fixes the head of the humerus to the glenoid to provide a fulcrum for the deltoid" (Watson-Jones 1955). And on the other hand: "The role of the supraspinatus as an abductor of the shoulder is a very minor one, and only in exceptional acute traumatic lesions does a tear of this tendon require surgical repair" (Kleinberg 1944).

De Palma (1950) demonstrated that extensive cuff lesions are compatible with good function, at least in elderly people who were near death. However, he questioned the validity of his findings when applied to cuff lesions in young muscular individuals.

In the present investigation an attempt is made to shed new light on this unsolved question in shoulder pathology.

In our experiments the supraspinatus muscle was temporarily paralysed with a local anaesthetic injected next to the suprascapular nerve. The completeness of the paralysis was checked with the aid of electromyography.

MATERIALS AND METHODS

For the exact location of the suprascapular nerve the method described by Highet (1942) was used. A hypodermic needle which was insulated except at its tip was thrust in the direction of the suprascapular nerve at the point where the nerve enters the supraspinous fossa. The needle and an indifferent electrode were then connected to the exit of a square wave generator. Under the circumstances of the experiment the generator guaranteed a constant current, independent of tissue resistance.

Twelve healthy men aged from twenty-one to twenty-six were subjected to one experiment each. All shoulders were normal on clinical examination and none of the subjects could recall an injury or disease in relation to the investigated shoulder.

At the start of each experiment an intracutaneous test dose of Xylocaine was injected to detect a possible adverse reaction to the drug.

Bipolar needle electrodes connected to the inputs of the differential amplifiers of the electromyograph were inserted into the supraspinatus and infraspinatus muscles.* During abduction of the arm strong activity was recorded from the supraspinatus muscle (Fig. 1). The infraspinatus muscle was most active during lateral rotation, but it was hardly active during abduction.

With the insulated hypodermic needle connected to the stimulator a search was made for the suprascapular nerve, using a current of 0.75 milliamps with a pulse duration of 3 milliseconds. When the tip of the needle approached the nerve, contractions of the supraspinatus muscle were observed. As soon as contractions were elicited the current was

* A bipolar needle electrode was chosen because in preliminary experiments with a concentric needle electrode disturbing cannula potentials were picked up from the trapezius muscle. In control experiments during maximal effort of the anterior tibial muscle cannula potentials were as high as 300 µV.
lowered and the position of the needle was changed carefully until contractions reappeared. This procedure was repeated several times until a current varying between 0-1 and 0-3 milliamps was sufficient to produce contractions. At this point even the slightest movement of the needle resulted in disappearance of the contractions. At this moment we presumed that the tip of the needle was in the immediate vicinity of the suprascapular nerve. Two millilitres of 1 per cent Xylocaine with adrenalin were then injected. Sometimes another two millilitres were needed to block the nerve completely. The completeness of the nerve block was tested by having the subject abduct his arm against slight resistance. Whereas before the injection of the local anaesthetic abduction was always accompanied by a burst of electrical activity in the supraspinatus muscle (Fig. 1), after a successful nerve block no action potentials were seen or heard. There was complete electrical silence in the muscle except during movement of the needle, which provoked typical insertion potentials. The absence of action potentials during voluntary effort was verified by moving the needle in the muscle in many directions from several points of entry. After a successful nerve block, when the bipolar needle was moved from the subcutaneous tissue through the trapezius muscle into the supraspinatus muscle, a typical sequence of events was noted during attempted abduction against resistance. As soon as the tip of the needle entered the trapezius muscle abundant activity was recorded. On penetrating the fascia over the supraspinatus muscle a slight resistance was felt; after this the

![Figure 1](image1)  ![Figure 2](image2)

**Figure 1**—Action potentials from the supraspinatus muscle at 15 degrees of abduction against gravity. **Figure 2**—After the supraspinatus muscle has been paralysed an attempt to produce maximum force in abduction causes some irregularity of the base line.

needle entered an area of silence interrupted only by the crackle of insertion potentials as long as the needle was moving. Whereas before the nerve block the periosteum was extremely painful when touched with the tip of the needle, no pain was experienced by the subject at the same event after the nerve block. With the bipolar needle in the paralysed supraspinatus muscle an effort to produce maximum force in abduction was accompanied by a droning noise in the loudspeaker of the myograph and by some irregularity of the base line (Fig. 2), caused probably by activity of adjacent muscles. When all the above criteria were fulfilled it was assumed that the supraspinatus muscle was completely eliminated.

Paralysis of the infraspinatus muscle was tested in the same way, with outward rotation instead of abduction of the arm. Because the infraspinatus lies with its greater part immediately underneath the skin, absence of contraction of this muscle could be felt on palpation as well as seen and heard on the myograph.

Two out of the twelve experiments failed despite repeated injection of Xylocaine. In one of these there was no detectable decrease in the number of action potentials from the supraspinatus muscle; in the second there was a substantial decrease but some action potentials could still be noted on maximal effort. In the remaining ten subjects the activity of the supraspinatus muscle on voluntary effort was completely eliminated. In eight of these, nerve conduction to the infraspinatus muscle was blocked also.
OBSERVATIONS

With the supraspinatus muscle eliminated all ten subjects could move the arm against gravity in a normal way through its full range in the shoulder joint. However, on the paralysed side the power of abduction against resistance was consistently lower. Maximum force and the power of endurance were determined before and after elimination of the supraspinatus muscle. At the start of the experiment a determination was made of the weight that could be lifted during abduction of the extended arm (Fig. 3). In our ten subjects this varied from 2 to 8 kilograms. After the elimination the maximum weight which could be abducted varied from nil to 2 kilograms. To compare the power of endurance in the paralysed and in the normal arm the subjects were given this maximum weight in each hand and were asked to hold both arms in 90 degrees of abduction for as long as possible (Fig. 4). After approximately thirty seconds the first signs of fatigue appeared: in an attempt to keep the weight on the same level the trunk was bent to the healthy side, and the shoulder was pulled up (Fig. 5). Unknowingly the subjects used these compensatory mechanisms to assist the failing deltoid muscle. After one minute most subjects said they could not hold the arm in abduction any longer. By that time they had exhausted the possibilities of compensating the deltoid's failing power (Fig. 6). The posture is identical to what is considered as a typical picture of a tear of the supraspinatus tendon. The subjects were encouraged to raise the arm again but this proved to be impossible and before two minutes had passed the arm dropped alongside the trunk. At this moment the normal arm still carried its weight and no fatigue was felt on this side.
After a few minutes rest the arm on the side of the experimental paralysis could again be abducted normally with the weight in the hand.

In forward lifting the maximum force and the power of endurance were also considerably diminished. A sequence of events comparable to that described above was seen in an endurance test (Figs. 7 to 10).

Elimination of the infraspinatus muscle manifested itself by a marked decrease in power during lateral rotation. While the subjects held the hand with the palm on the abdomen, attempted lateral rotation could be resisted by the examiner with one finger only. No exact estimation was made of the loss of force during lateral rotation.

As the suprascapular nerve contains fibres for both the supraspinatus and infraspinatus muscles, it is a matter of chance whether or not the conduction to both muscles is blocked. This probably depends on whether the Xylocaine is deposited along the main trunk of the suprascapular nerve or along the branch for the supraspinatus muscle only. In eight out of ten successful experiments conduction to both muscles was blocked. In the other two only the conduction to the supraspinatus muscle was interrupted. In these two subjects the power of lateral rotation remained normal, otherwise they behaved exactly like the other eight subjects.

**DISCUSSION**

With the supraspinatus muscle completely eliminated in ten normal young men, all could move the arm in the shoulder joint against gravity in a normal way through its full range.
On the paralysed side, however, the power of abduction against resistance was consistently lower, and the power of endurance in 90 degrees of abduction with a weight in the hand was also diminished. The same was true of the power in forward lifting of the arm.

It is concluded that the role of the supraspinatus muscle is of a quantitative nature only, and that it has no specific function of its own, except that of retracting the joint capsule.

In the light of these experimental findings the usual explanation of the disturbance of shoulder function after rupture of the supraspinatus tendon should be reviewed. The authors feel that it is not the loss of supraspinatus function which prevents abduction of the arm but the impingement of the painful tendon between the humeral head and the acromion. To this may be added the loss of power caused by atrophy of the deltoid muscle. Consequently, more emphasis should be laid on the importance of the deltoid muscle, as this is the only muscle which can move the arm away from the body after rupture of the supraspinatus tendon.

After a recent tear of the supraspinatus tendon a period of rest in a sling or in an abduction splint is usually prescribed. This provokes atrophy of the deltoid muscle. When after this period exercises are started to recover joint movement the need for strengthening of the deltoid muscle is often ignored. In the light of our experiments it may be supposed that in the absence of an active supraspinatus muscle, an atrophic deltoid muscle will not be able to abduct the arm.

**SUMMARY AND CONCLUSIONS**

1. In ten healthy young men an experimental paralysis of the supraspinatus muscle was induced with the aid of Xylocaine injected in or near the suprascapular nerve.
2. The completeness of the paralysis was checked by electromyography.
3. With the supraspinatus muscle completely eliminated, all subjects could move the arm against gravity through its full range in the shoulder joint, though the force and the power of endurance during abduction were diminished.
4. It is concluded that the role of the supraspinatus muscle is of a quantitative nature only.

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**REFERENCES**


