A QUANTITATIVE HISTOLOGICAL STUDY OF THE VASCULARITY OF THE ROTATOR CUFF TENDON

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Previous perfusion studies of the rotator cuff have demonstrated an area of hypovascularity in the distal part of the supraspinatus tendon. This has been implicated in the pathogenesis of its rupture.

We performed a quantitative histological analysis of the vascularity of the tendons of supraspinatus and infraspinatus. Vessel number, size and the percentage of the tendon occupied by vessels were measured at 5 mm intervals from the humeral insertions to the muscle bellies. Both tendons were hypovascular in their distal 15 mm. No significant difference was demonstrated between the vascularity of supraspinatus and infraspinatus. We conclude that factors other than vascularity are important in the pathogenesis of supraspinatus rupture.

On the basis of his cadaveric studies and operative observations, Codman (1934) described the 'critical area' of the supraspinatus in the distal 10 mm of its tendon. This is the commonest site for rotator cuff tears. Subsequently, cadaveric perfusion studies have demonstrated the presence of a hypovascular area at this site (Rothman and Parke 1965; Rathburn and MacNab 1970; Lohr and Uhthoff 1990). Not surprisingly, hypovascularity has been implicated in the pathogenesis of rotator cuff tears (Rathburn and MacNab 1970; Fukuda 1990; Lohr and Uhthoff 1990).

However, failure of an area to perfuse is not conclusive proof of hypovascularity. For example, the zone in question may be supplied by capillaries while the perfusate may only demonstrate vessels of arteriolar size. To demonstrate hypovascularity, perfusion studies need to be combined with histological examination, and the detailed histological study by Moseley and Goldie (1963) suggested that the whole tendon was well vascularised. Rathburn and MacNab (1970) conducted perfusion studies with the arm in full adduction and at 90° of abduction. They observed that in adduction the supraspinatus tendon was compressed as it passed over the humeral head so that its vessels were occluded: when the arm was abducted they were perfused satisfactorily. A quantitative study by Carr and Norris (1989) of the calcaneal tendon showed a reduction in vascularity of its mid part, which is the frequent site of rupture. We have quantified the vascularity at different sites within the tendons of both the supraspinatus and the infraspinatus muscles.

MATERIALS AND METHODS

Ethical committee permission was obtained for removal of the rotator cuff and upper humerus from eight cadavers aged 62 to 78 years. First, the upper limb was perfused via the first part of the subclavian artery, with the arm in 60° of abduction. One litre of 50% barium sulphate (Micropaque: Nicholas Laboratories, England) in 3% gelatine mixture at 40°C was infused using a constant pressure pump at 34 KPa. A tourniquet was applied at the elbow to limit the field of perfusion. The arm was then cooled to allow the mixture to set prior to the excision, en bloc, of the upper humerus and the rotator cuff muscles. The rotator cuff, with its humeral insertion, was fixed in 10% formol saline. After decalcification, in 40% formic acid, microfocal radiographs were taken of the complete specimen. The supraspinatus and infraspinatus tendons were separated and cut into 5 mm blocks from muscle belly to insertion. These were wax embedded, cut into 8 μm thick histological sections and prepared with Van Gieson stain. Quantitative histological analysis of the tendon was performed using a computerised image analysis system (Microscale: Digithurst Ltd) to measure the total cross-sectional area of the vessels and the tendon. This method measured all vessels with a minimum diameter greater than 20 μm, whether perfused.
or not. The percentage of the cross-sectional area of each tendon occupied by vessels at each plane of section was then calculated. Statistical analysis was performed using Student's t-test.

RESULTS
The radiographs showed that most vessels ran in the long axes of the tendons (Fig. 1). There was poor filling of the vessels of both tendons in their most distal 15 mm. The histological sections showed wide variations in the degree of filling of the vessels (Fig. 2).

In the supraspinatus tendon, the total number of vessels counted and their mean diameter decreased towards its humeral insertion (Figs 3, 4). The decrease in the percentage of the tendon occupied by vessels was most marked between 10 and 20 mm from its humeral insertion (p < 0.01) (Fig. 5).

A similar pattern was found in the infraspinatus tendon. The percentage areas occupied by vessels in

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Figure 3 - Mean vessel diameter in six sections of the supraspinatus tendon (± 1 SD). Figure 4 - Mean number of vessels in six sections of the supraspinatus tendon (± 1 SD).
supraspinatus and in infraspinatus at 10, 20 and 30 mm from their humeral insertions were compared: no significant difference was found between the muscles.

**DISCUSSION**

The cause of rupture of the rotator cuff has been much debated. Hypovascularity, degeneration, trauma and impingement have all been advanced as aetiological factors. Since tears in the supraspinatus occur most frequently in Codman’s ‘critical zone’, it seems logical to consider hypovascularity as a major factor. However, our results demonstrate no difference in the vascular pattern between infraspinatus and supraspinatus, implying that other factors are more important in the pathogenesis of tendon rupture. If vascularity was the main factor one would expect a similar incidence of rupture in both tendons. Neer (1972) found, in 20 rotator cuff repairs, that the tear was in the tendon of supraspinatus in every case.

Our findings also contradict the hypothesis of Rathburn and MacNab (1970) that hypovascularity within the tendon depended on the position of the humeral head. They stated that provided the tendon was relaxed there was: ‘almost complete filling of all vessels throughout the tendon to its point of insertion’. However, position alone cannot explain the findings of the present study which demonstrated a definite decrease in both the number and size of the vessels in both tendons in their distal 15 mm. Nor can we support their conclusion that: ‘The avascular zone in the tendon of the supraspinatus near its insertion was not seen in other tendons comprising the rotator cuff, except for the superior portion of the insertion of the infraspinatus which, on occasions, showed a small avascular area’. In our opinion, findings based on perfusion studies alone, without detailed histological verification, can be misleading.

The practical importance of these findings is in the surgical treatment of the torn rotator cuff. The supraspinatus and infraspinatus tendons are more vascular 20 mm from their humeral insertions. Therefore, using the tendon proximal to this point should provide well vascularised tissue for the repair.

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**REFERENCES**


