Biceps-to-Triceps Transfer in Tetraplegia: The medial route
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Journal of Hand Surgery (British and European Volume) 1999; 24; 235
DOI: 10.1054/JHSB.1998.0184

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The biceps-to-triceps transfer seems to have been first performed in 1951 by Leo Mayer in a 16-year-old tetraplegic patient (Friedenberg, 1954). Friedenberg performed this procedure in one poliomyelitis case. In his description, the biceps muscle was passed subcutaneously across the lateral border of the arm. Zancolli (1979) and Zancolli and Zancolli (1991), advocated the biceps-to-triceps transfer in tetraplegia with weak or strong wrist extension, rerouting the biceps round the lateral border of the arm and fixing its tendon in the olecranon. Although the biceps-to-triceps transfer has been the topic of communications in international conferences (McDowell et al., 1986; Moberg, 1990), there has been no significant published material about the results of this procedure. By and large, the biceps-to-triceps transfer has had a bad reputation in comparison with the deltoid-to-triceps transfer advocated by Moberg to restore elbow extension (Hentz et al., 1988; Lamb and Chan, 1983; Moberg, 1975; Moberg and Lamb, 1980). The main drawbacks of the biceps-to-triceps transfer have been. (1) it is not a reliable procedure, (2) the flexion strength of the elbow is weakened; and (3) there is a risk of radial nerve injury when the biceps is rerouted round the lateral border of the arm (Zancolli and Zancolli, 1991).

Active stability of the shoulder is very important in tetraplegic patients (Keith and Lacey, 1991), therefore in agreement with Allieu et al (1993), we do not advocate the deltoid-to-triceps transfer when the upper pectoralis major is paralysed, to avoid the risk of weakening the shoulder. In these cases, we prefer the biceps-to-triceps transfer, and have used the medial route, to avoid the risk of radial nerve injury. In this study we present our technique and our initial results.

PATIENTS AND METHODS

From July 1993 to March 1997, 13 biceps-to-triceps transfers were performed on eight patients by the first author (MR). A summary of patient data is shown in Table 1. Five patients were operated on bilaterally (patients 1, 2, 3, 5, 6). Except for the first case, the biceps-to-triceps transfer was always indicated in patients without any triceps function, when the upper part of the pectoralis major muscle was paralysed, and when the strength of elbow flexion was strong. In the first case, the

Table 1—Patient details

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Age at operation</th>
<th>Side</th>
<th>International group</th>
<th>Follow-up (months)</th>
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Eight tetraplegic patients (13 elbows) were treated by biceps-to-triceps transfer. To avoid the risk of radial nerve injury, we chose a medial routing of the biceps. The mean follow-up after surgery was 17.8 months (range, 4–47 months). No complications were encountered. Active extension of the elbow was achieved in each case. The mean postoperative active range of motion of the elbow was 6° extension and 137° flexion. After the biceps-to-triceps transfer mean extension torque of the elbow was 3.7 Nm and mean flexion torque was 10 Nm. In eight elbows in which it was measured, there was a 47% reduction in elbow flexion power. Nevertheless no patient complained about that reduction, and all of them were satisfied.
biceps-to-triceps transfer was performed 14 months after failure of a deltoid-to-triceps transfer related to an infection of the synthetic material. The mean follow-up after surgery was 17.8 (range, 4–47) months.

The postoperative active range of motion of the elbow was measured by the second author (EB) when the shoulder was abducted 90°. The postoperative active flexion torque and active extension torque of the elbow were measured when the elbow was in 90° flexion on a sitting patient by a one degree of freedom rotation device, a dynamometer and rehabilitation pulleys and ropes. Ten normal elbows were also measured in the same conditions (control group). In addition, the flexion torque was measured before the biceps-to-triceps transfer in eight elbows.

SURGICAL TECHNIQUE

After preparing and draping the arm and the shoulder, a sterile Esmarch bandage was applied to the arm as proximally as possible.

A bayonet-shaped incision was made vertically along the medial aspect of the arm (15–20 cm long), then horizontally at the anterior crease of the elbow (5–7 cm long), and then vertically along the proximal forearm, over the brachioradialis belly (3–5 cm long).

The skin margins were elevated along with the underlying deep fascia, and care was taken to preserve the cephalic and basilic veins and the lateral cutaneous nerve of the forearm.

The bicipital aponeurosis was divided, and the tendon of the biceps was dissected to its insertion into the radius, where it was transected as far distally as possible. Care was taken at this point to avoid any damage to the recurrent radial vessels since they are the main blood supply of the brachioradialis and extensor carpi radialis muscles.

The muscle belly of the biceps was then dissected proximally and raised up to its vascular pedicle, which always entered the deep aspect of the muscle in its proximal third. Some minor distal vessels were frequently encountered and ligated.

A posterior separate curved incision was then made on the dorsal aspect of the distal third of the arm. The tendon of the triceps was exposed in its entire length, and a wide tunnel was made under the deep fascia of the medial aspect of the arm, leading from the posterior to the anterior wound. The proximal border of this tunnel was located near the distal end of the Esmarch bandage. Once the skin flap had been elevated, the deep fascia was entirely excised to prevent its adhesion to the transferred tendon.

The Esmarch bandage was then removed, allowing the incision on the medial aspect of the arm to be lengthened proximally, to improve the dissection of the proximal part of the biceps. At this stage, it was always useful to make certain that the biceps were entirely freed up in a straight line between its vascular pedicle and the new distal reinsertion of its tendon, and that the subcutaneous tunnel at the medial aspect of the arm was large enough.

The tendon of the biceps was then interwoven into the tendon of the triceps, and secured with multiple 2/0 non-absorbable sutures. The tension of the transfer was set to the maximum while the elbow was held in full extension, so that the elbow could not be flexed passively beyond 30° when the arm was abducted about 30 to 40°. In some cases, the tendon of the biceps was lengthened proximally by up to 3 cm at its musculotendinous junction by carefully stripping away the insertions of the distal muscular fibres of the biceps from the tendon.

Finally, haemostasis was secured, two suction drains were placed, and the skin was sutured. A well-padded long arm fibreglass splint was applied to hold the elbow in full extension or 10° flexion, and the wrist in 30° extension. The shoulder was left free.

Postoperative management

Immobilization was continued for 4 weeks. An active exercise programme was then started, in order to gain flexion of the elbow at a rate of 15 to 20° per week. Intensive occupational therapy was used to train the biceps to extend the elbow.

RESULTS

Active extension of the elbow was always obtained. Active extension movements were achieved about 3 months after surgery, and functional integration of the transferred biceps was obtained about 6 months after surgery. We did not observe any complications or problems with functional integration of the transferred biceps. Active supination of the forearm was preserved in all cases. The postoperative active range of motion of the elbow was 6° extension (range, 0–20°), and 137° flexion (range, 115–145°). After the biceps-to-triceps transfer, mean (SD) extension torque of the elbow was 3.7 (2) Nm, and mean (SD) flexion torque was 10 (4.6) Nm. In the control group mean extension torque was 41.3 (6.4) Nm, and mean flexion torque was 51.5 (9.6) Nm.

In the eight elbows in which it was measured before surgery, the mean (SD) flexion torque of the elbow was 17.1 (12.1) Nm before the transfer, and 9.0 (5.3) Nm after the transfer. Therefore there was a 47% decrease in the elbow flexion torque compared with the preoperative condition. However, no patient complained about the reduction in elbow flexion power. No activities of daily living, including body transfers, were impaired.

DISCUSSION

The outcomes in our cases showed that the technique was effective, and reliable. No complication was encountered, and obviously no radial nerve injury was observed because of the medial routing of the biceps. Similarly,
although the tension of the transfer was set to the maximum, we did not observe clinical evidence of median nerve compression, or vascular compression.

The major potential drawback we found was the 47% reduction in elbow flexion power after biceps transfer. This figure is much higher than the 24% reduction noted with the lateral routing technique (McDowell et al, 1986; Zancolli and Zancolli, 1991). However, as in the 13-patient Zancolli series, none of our patients complained about the reduction in strength. Moreover all of our patients who could benefit from the same procedure on the opposite arm requested it and were satisfied.

We therefore advocate the biceps-to-triceps transfer using the medial route instead of the lateral one.

Acknowledgement

The authors would like to thank Richard A. Gosselin, MD, FRCS(C), for reviewing this article.

References


