Latissimus Dorsi Transplantation for Loss of Flexion or Extension at the Elbow

A Preliminary Report on Technic*

AUGUST P. HOVNANIAN, M.D., F.I.C.S., F.A.C.S.

Beirut, Lebanon

From the Department of Surgery, School of Medicine, American University of Beirut, Lebanon.

THE TWO SETS of prime movers of the elbow in the act of flexion and extension are the biceps brachii, the brachialis, and their antagonist, the Triceps. These movements are lost when there is a complete and permanent discontinuity in their trophic neuroconduction as in poliomyelitis and Erb's palsy. Other local causes, such as extensive soft tissue trauma and post-infection muscle tissue necrosis, may impair completely and permanently the function of the elbow. Occasionally, the surgical treatment of soft tissue tumors requires a wide local extirpation, thus sacrificing one muscle component with its subsequent loss of function. Mesenchymal dystrophies such as *arthrogryposis congenita multiplex* or etiologically unknown diseases like *myositis ossificans progressiva* do not present elbow movement disability as the main problem. Perhaps the commonest form calling for surgical repair is the post-poliomyelitis paralytic arm.

Of the two movements, undoubtedly the act of flexion is the more important one. It is used for innumerable necessities of life. It is a movement of self-preservation, bringing the "business" end of the upper extremity toward the head and trunk. The extension movement is occasionally needed, too, as in rising from a sitting position, in the use of crutches, and as a prop to protect the face and the head from hitting the ground during a fall. The extensors of the arm are phylogenetically an anti-gravity set of muscles. They are used in the erect *homo sapiens* for self-protection by warding off the enemy, wielding a club, or landing an uppercut.

THE OPERATIVE PROCEDURES USED IN LOSS OF FLEXION

A review of the literature shows an array of ingenious procedures for the treatment of loss of flexion at the elbow. Steindler's[12] operation of re-treating the origin of forearm muscles and re-implanting it higher up in the lower third of the humerus has stood the test of time. Hohmann[7] in 1918 suggested the transplantation of the insertion of pectoralis major into the proximal end of biceps brachii. Lange[10] in 1930 proposed a slightly different technical procedure, again uniting the insertion of the pectoralis major tendon to the flexor mechanism, either directly on the biceps belly, or indirectly, to its tendon of insertion, via long silk lines. Clark[5] solved the mechanical shortcomings of these procedures by transplanting the outer part of pectoralis major, phylogenetically, the pectoralis externus of Keith,[9] to the anterior aspect of the arm, replacing the non-functioning flexors.

Biesalsky in the early years of this century transplanted the long head of the triceps to the biceps brachii tendon. Biscofberger,[2] Bunnell[3] and Carroll[4] several years ago suggested the transplantation of the whole extensor tendon to the forearm, fixing it to the radial tubercle. Again Bunnell[3] described another technic of hooking up the sternocleidomastoid muscle to the radial tubercle *via* a long fascial graft.

All the operations illustrate the inadequacy of one single procedure in coping

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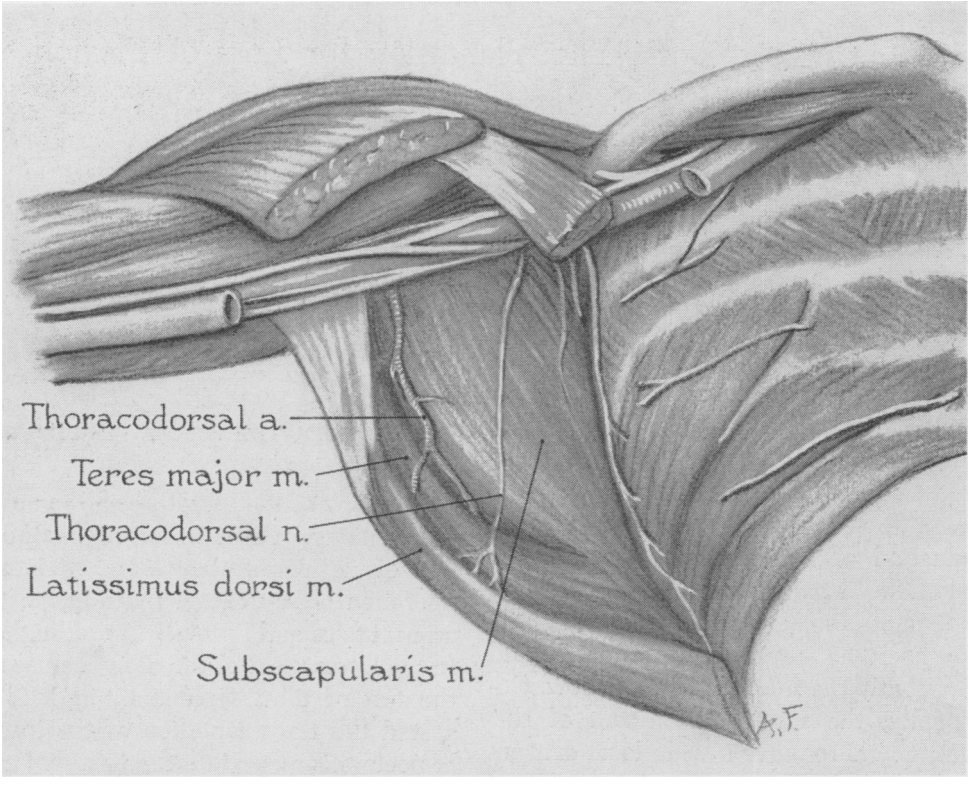

FIG. 1. An anterior axillary anatomical dissection. The latissimus dorsi is retracted outwards. The thoracodorsal vein and its tributaries, which follow a similar pattern as the artery, are omitted for clarity.

with the set of problems associated with the loss of flexion, not to mention their inherent mechanical and/or physiological shortcomings.

THE OPERATIVE PROCEDURES USED IN EXTENSOR LOSS

Lange[10] in 1930 used the Trapezius by detaching it from the acromion and joining it through long silk lines to the olecranon. Ober and Barr[11] some years later described a technic of flapping the brachioradialis belly to the posterior aspect of the humerus onto the weakened triceps. Hohmann[8] as late as 1950 proposed transplanting the flexor carpii radialis and ulnaris muscle bellies onto the triceps, trying to re-establish an extension movement.

Hohmann,[7] Lange[10] and Harmon[6] each, almost ten years apart, proposed the use of latissimus dorsi as a transplant in triceps palsy. The principle used by the three was the same in that the *insertion* of the latissimus dorsi was fixed one way or another to the extensor mechanism at the back of the arm. Harmon added to the latissimus dorsi, the teres major insertion, and joined them to the triceps at the mid-arm posteriorly.

It is beyond the scope of this communication to discuss the relative merits and shortcomings of each procedure used in the treatment of either flexion or extension paralysis at the elbow.

The technic described herein is not proposed to replace the above mentioned procedures. This technic is another means of correcting the flexion or extension loss at the elbow, and is suggested as an alternative in case the simpler methods enumerated above seem to be inapplicable for one reason or another.

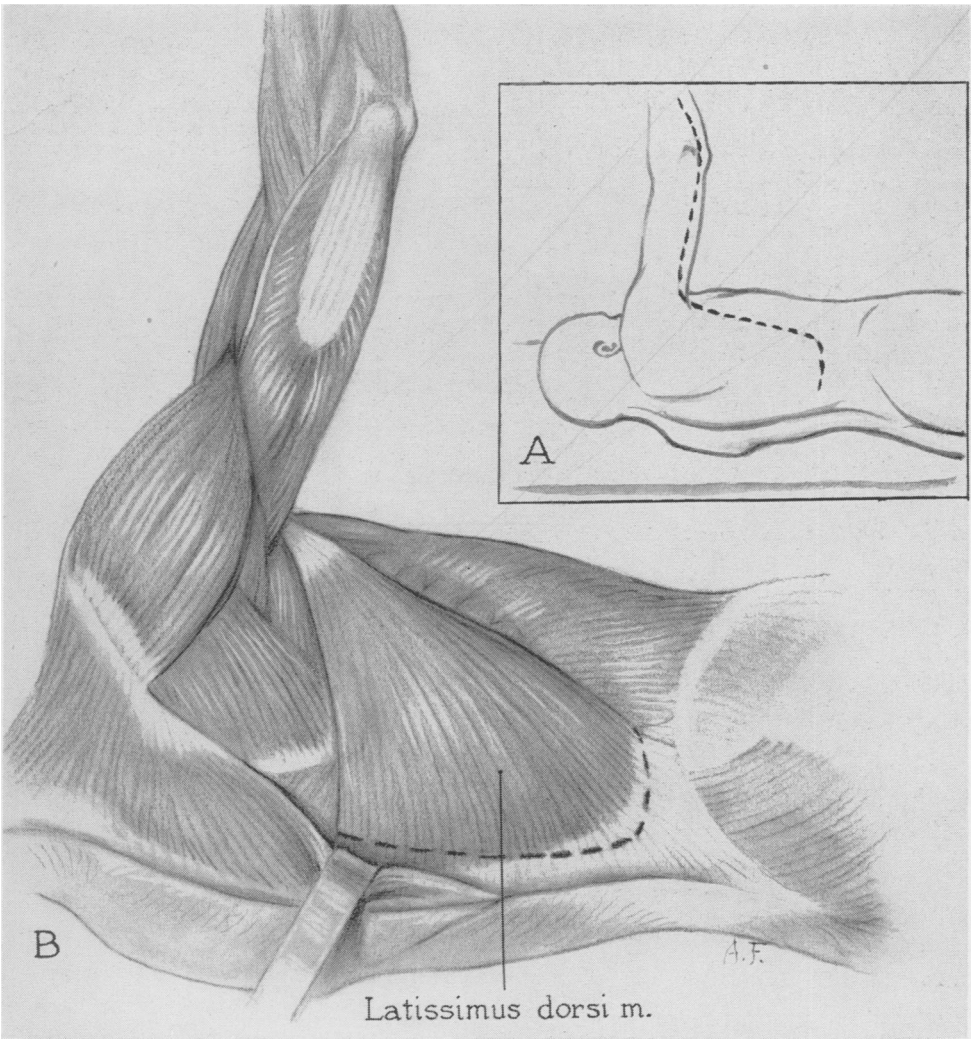

FIG. 2. The dotted line in the insert A shows the skin incision. This is used when an extensor repair is contemplated. The dotted line in B illustrates the muscle cut. The aponeurotic fascial strip of the ilio-lumbar region helps in the same anchoring to follow. This is either done to the radial tubercle, or the olecranon process as described in the text.

OPERATIVE TECHNIC

(For flexion repair)

Position. The patient, under general anesthesia, is laid on the good side. Sand bags are placed, keeping the pelvis and the thorax some 80° off the flat table. This angle is to be varied, depending on the field of dissection.

Preparation. The involved arm, half of the thorax, the loin and the gluteal region are in the field of operation. These must be thoroughly cleansed, paying especial attention to the axilla.

The Incision. The finished incision is a long one, starting over the loin, and then extending onto the lateral margin of the latissimus dorsi, reaching the posterior axillary fold. From here the incision is prolonged across the neurovascular bundle of the arm and extended into the anti-cubital fossa (Fig. 3A).

Dissection. The dorsal and lateral aspects of the latissimus dorsi are carefully dis-

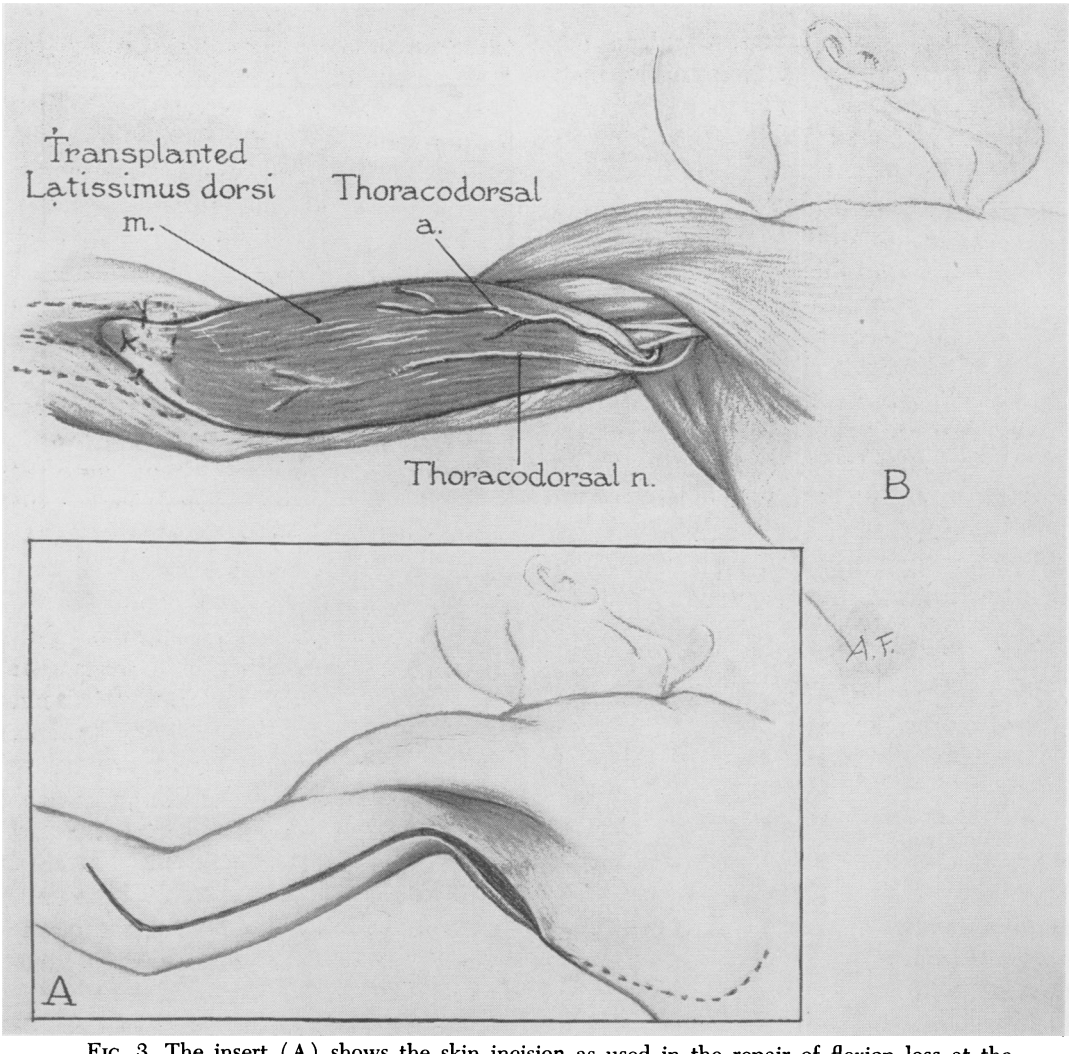

FIG. 3. The insert (A) shows the skin incision as used in the repair of flexion loss at the elbow. The dotted prolongation is the posterior lumbar extension of the skin incision; (B) illustrates the transplanted latissimus dorsi muscle to the anterior aspect of arm in cases of flexion loss at the elbow.

sected, leaving its fascial investment intact. The muscle is cut off from its insertion at the myofascial aponeurotic junction. The upper margin is cut across its muscle fibers (Fig. 2B). The muscle is detached gradually from the underlying abdominal and flank muscles. The four muscular slips arising from the lower four ribs, and a few arising from the angle of the scapula are cut. In the upper third, where the neurovascular bundle enters into the muscle belly, due attention is paid to the vascular supply of the muscle. These are the thoracodorsal vessels and their branches running parallel between the serratus anterior and the latissimus dorsi, supplying it and the teres major. The anastomosing branches with the lateral thoracic vessels are ligated on the thoracic side to prevent inadvertent injury to the latissimus dorsi vessels. The nerve to the latissimus dorsi (the thoracodorsal nerve, arising from the posterior cord of the brachial plexus, derives its fibers from the 6th, 7th, 8th C nerves) is easily identified and

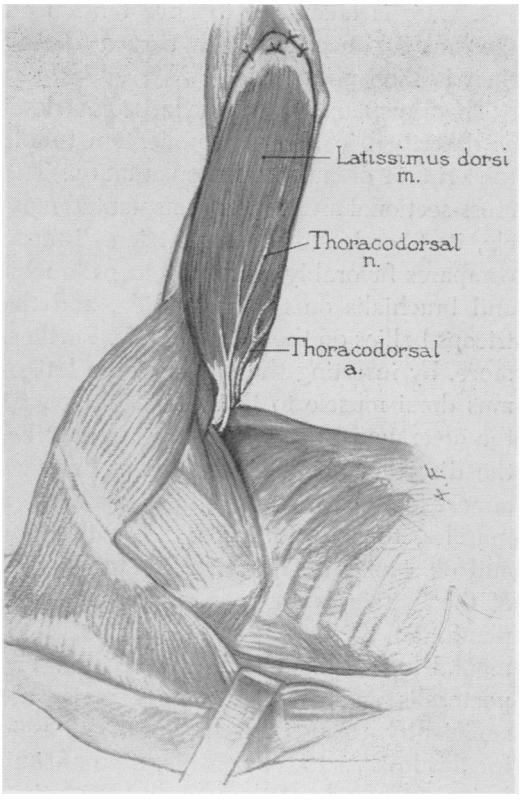

FIG. 4. Illustrates the transplanted latissimus dorsi muscle to the posterior aspect of arm in cases of extension loss at the elbow.

gently freed. Its trunk is about 15 cm. long, and runs from the apex of the axilla toward the under-surface of the latissimus dorsi belly.

The muscle freed from its origin is now swung carefully to the prepared bed in the arm. This new position of the muscle should not twist the vessels and the nerve. If there are fascial bands that are kinking the vessels, these are undone. The intercostobrachial nerve and the lateral cutaneous branches of the third and fourth intercostals are divided to prevent such a mishap. The rim of fibrous aponeurotic fascia of the muscle origin is now sutured to the biceps brachii tendon and the periosteal tissues of the radial tubercle. (Fig. 3B). Advantage is taken of the remaining aponeurotic fascia by suturing it to the connective tissue sheaths of the forearm muscles and the lacertus fibrosis. These serve as tethers taking off the tension from the main anchor, which is the radial tubercle and its tendon.

Closure. The wound is closed in layers; the forearm is kept in flexion and pronation. The arm is bandaged loosely to the thorax, keeping it in adduction.

Drainage. When excessive oozing is expected a 24 hour Penrose drain may be used at suitable sites. However. with meticulous care for hemostasis, drainage becomes unnecessary.

Postoperative treatment. Early ambulation and finger exercises are recommended. Passive and active movements may be started the third or fourth week. The patient is followed in the physical therapy clinic.

OPERATIVE TECHNIC

(For extension repair)

For the repair of extension loss an identical principle is applied. The technic of freeing the latissimus dorsi and mobilizing its neurovascular pedicle is the same as described. The incision on the arm, however, is carried over from the posterior axillary fold onto the postero-medial aspect of the arm without crossing over the brachial neurovascular bundle of the arm. The incision, after reaching the medial epicondyle, is curved laterally on the posterior aspect of the ulnar shaft (Fig. 2A).

After the preparation of the arm bed for the laying of the latissimus dorsi muscle belly, its aponeurotic fascia at the free end of the muscle is sutured to the triceps tendon, the periosteum of the olecranon and the connective tissue muscle septa on the extensor surface of the forearm (Fig. 4).

The arm is immobilized in extension, and bandaged to the side of the body. Early ambulation and finger movements are encouraged, and on the third and fourth week passive and active elbow movements are begun.

DISCUSSION

Some of the surgical considerations in the muscle and tendon transplantations are the following:

1. Attempt by surgical repair is made only when it is considered that the muscle, or the set of muscles producing that essential movement, are irreparably and completely lost.

2. The muscle or muscles taking over the function must be healthy and equal in strength. The cross-sectional area of the muscle belly to be transplanted, its muscle fiber length and its excursion distance are the factors to be considered in evaluating its strength. To have the full advantage of muscle fiber strength a straight linear pull is the most efficient one. Angles and curves in the direction of force act adversely on work per unit of time.

3. The gain by transplantation must be worth the sacrifice, and should not entail the loss of another important movement.

4. Those muscles which act as one unit should not be partially transplanted expecting their parts to work as antagonists against each other.

5. If possible, the function of the transplanted muscle should resemble that of the paralyzed one. Although exceptions are numerous, some failures of rehabilitation are attributed to the use of opponent muscle group transplants.

6. The candidate must have a satisfactory mental and emotional capacity to be helpful to the physical therapist during the period of muscle reeducation.

Some of the technical considerations during a transplantation operation are the following:

1. Due attention is paid to creating a suitable bed for the tendon and the muscle by burying them in fat or loose areolar tissue to prevent fixation by fibroplasia.

2. If possible, a bone transfixation of the transplanted tendon is done. However, this does not seem to be imperative in the upper extremity.

3. The neurovascular supply of the muscle is handled with care so as not to jeopardize muscle vitality.

4. Care is taken not to have tension on the healing mesenchymal tissues during their healing phase.

The transplantation of the latissimus dorsi as described in this communication fulfills the criteria of muscle transplantation. The cross-sectional area of the transplanted muscle, its fiber length and excursion distance compares favorably with the biceps brachii and brachialis on the flexor side, and the triceps bellies on the extensor side. Furthermore, by inserting the *origin* of the latissimus dorsi muscle to the radial tubercle or the olecranon process, as the case may be, the direction of its muscle fibers becomes almost identical with that of the paralyzed muscles, thus instituting a straight, linear and efficient pull. Concerning the sacrifice of the latissimus dorsi action in this transplantation, this loss is apparently not detrimental to the patient's daily activities. The pectoralis major and the teres major are sufficiently strong muscles to compensate for this loss. As to the consideration of similarity of function of the muscles, the latissimus dorsi is not an antagonist of the muscles of flexion, and acts synergistically with the long head of Triceps.[1]

The operation is ideally suited for those cases where either the extensor or the flexor compartment of the arm is sacrificed during an operation. Adequate local treatment of selected soft tissue tumors frequently necessitates a wide local excision. The reassurance of an efficient reconstruction of the sacrificed muscles in the future, encourages the surgeon to institute the contemplated surgery unhampered.

In traumatic wounds of the arm ending in a total loss of one of the major muscle compartments latissimus dorsi transplantation also gives favorable end results.

The treatment of post-paralytic elbow is fraught with multiple problems. The outcome, however brilliant, is overshadowed by the presence of other incapacitating functional defects. In the presence of an intact latissimus dorsi and of a clear indi-

cation of elbow movement reconstruction, this intervention might be of great help.

To date three cases have been operated upon, two for extension loss and one for flexion, the follow up periods being 21, 24 and 27 months. The results have been so far satisfactory and encouraging, with a sufficient regain of function to allow the patients to resume work as vendor, shopkeeper and salesman.

Some cautionary hints. Occasionally some technical variations are introduced during the operation when the latissimus dorsi muscle belly is too long. The flat tendinous insertion of the muscle, which has an average length of 7 cm., is shortened either by folding it on itself or excising and suturing it back to the bicipital groove. Also, this variation in technic is resorted to whenever there is any doubt of tension put on the latissimus dorsi nerve and blood vessels. If the muscle belly is found to be too bulky and wide, part of its vertebral border might be sacrificed or folded or transfixed on itself. A large branch of the thoracodorsal nerve is prominent on the free lateral border of the muscle, reaching almost to the origin of the muscle at the iliac crest. With such an anatomical arrangement it is inadvisable to shape the muscle by sacrificing its lateral border. It is appropriate to mention the avoidance of needless injury to vital arm structures—*e. g.* the axillary vessels and nerves, the radial and the ulnar nerves. While dissecting the under surface of the muscle, sweeping finger dissections from above downwards are apt to tear the neurovascular bundle of the muscle. This dissection is better done from below up, avoiding the danger of hooking the finger between the muscle and the thoracodorsal vessels and nerves. The success of the operation depends upon the careful preservation of the nerve and blood supply. Sometimes it is difficult to find the right plane for muscle separation between the latissimus dorsi and the adjoining muscles. Here the golden rule of following the dissection from the known toward the unknown is very helpful.

CONCLUSION

The transplantation of the latissimus dorsi, either for flexion or extension loss of the elbow, is feasible and physiologically and mechanically sound.

SUMMARY

A new technic is described by which the latissimus dorsi *origin* is transplanted either to the radial tubercle or the olecranon process in cases of flexion or extension loss at the elbow.

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