Latissimus Dorsi Muscle Strengthening and Training before Cardiomyoplasty

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Abstract
Abnormal skeletal muscle bioenergetics during exercise was demonstrated in patients with chronic heart failure. Physical training can improve skeletal muscle metabolism in this population. Latissimus dorsi muscle strengthening and training before cardiomyoplasty are proposed in serial scheduled exercises. The goal of this adaptive physical training 2-month program is to improve muscle quality and function in heart failure patients arriving at surgery with some degree of muscle disuse atrophy.

Key words: cardiomyoplasty, Latissimus Dorsi muscle, cardiac failure, strengthening exercises, respiratory exercises.

The failure of exercise capacity is a major limiting symptom in cardiac dysfunction and has been attributed to skeletal muscle hypoperfusion [16, 14]. Histological alterations have been demonstrated, in skeletal muscles of patients suffering from chronic heart failure [11, 12].

Cardiomyoplasty is based on the chronic systolic compression of the heart by the electrostimulated Latissimus Dorsi muscle, previously transposed and wrapped around the ventricles. Following cardiomyoplasty, the Latissimus Dorsi is submitted to progressive training obtained by an electrostimulation protocol [3]. Prevention of Latissimus Dorsi muscle damage is important in obtaining successful long term results following cardiomyoplasty. Physical training in patients with chronic cardiac failure has been reported to improve skeletal muscle metabolism [1].

The purpose of this work is to present a preoperative 2-month exercise training program to be used in patients with severe chronic heart failure proposed for a cardiomyoplasty; and to discuss the mechanism which appears to limit exercise capacity.

Material and Methods
Cardiomyoplasty clinical experience at Broussais Hospital involves 84 patients operated between January 1985 and January 1996.

Since September 1993, 17 patients (13 males and 4 females) ages 20 to 65 years (mean 48 years) underwent a preoperative Latissimus Dorsi muscle strengthening and training protocol. The etiologies of cardiac failure in these patients were: 5 ischemic cardiomyopathy, 10 idiopathic dilated cardiomyopathy, 1 cardiac tumor, and 1 right ventricular cardiomyopathy following tricuspid valve trauma.

The mean preoperative New York Heart Association functional class was 3.1 ± 0.3, left ventricular ejection fraction (radioisotopic studies) was 19 ± 6%, and mean peak oxygen consumption (VO2) was 15.2 ± 3 ml/min/Kg.

Adaptive exercises
After the decision to perform a cardiomyoplasty on a patient, a program of muscular exercises is designed and tailored to the individual requirements and functional status of a patient (fatigability, angina, dyspnea, etc.).

Although the left Latissimus Dorsi muscle is generally used at operation, exercises must be symmetrically balanced. Likewise exercises must include all trunk muscles. This should include power exercises mixed with relaxation and stretching.

The global action of the Latissimus Dorsi muscle acts via the scapulo-humeral articulation and carries the arm and hand toward the sacrum.

Muscle strengthening exercises
There are five exercises described here, two of which may easily be performed at home and three to be performed in a rehabilitation center.

All exercises are performed symmetrically to avoid distortion of the vertebral column and back strain which could result. Also to this end all positions of hyperlordosis should be avoided. While doing the exercises the patient is asked to breath through the mouth. The Latissimus Dorsi is an extensor, internal rotator and adductor of the shoulder and exercises are designed to incorporate all three movements.
EXERCISE 1
Position: Seated on a stool against a wall, elbows tucked into the side and flexed.
Action: The elbows are pushed posteriorly against the wall (Extension). See Figure 1, A.
Action: The palms of the hands are pushed against the wall. The arms are extended in a position of internal rotation. See Figure 1, B.
Six seconds of pushing
Six seconds of relaxation
Repeat this series ten times.

EXERCISE 2
Position: Sitting or standing, the forearms flexed, elbows tucked into the body.
Action: Press the elbows against the body (Adduction). See Figure 2.

EXERCISE 3
Position: Lying on the back on a table, knees bent and feet flat on the table to protect the lumbar spine.
Action: With counterresistance from the physiotherapist the arm is brought from a position of abduction, flexion and external rotation to a position of adduction, extension, and internal rotation. See Figure 3.

EXERCISE 4
Position: Lying ventrally, arms hanging by the side of the table holding dumbbells (0.5 Kg to start).
Action: Bring the dumbbells behind the back having the palms of the hands facing upwards.
Descend slowly with the dumbbells stopping occasionally during the descent. This is a very effective exercise for developing power and lengthening of muscle fibers of the latissimus dorsi muscle. See Figure 4.

EXERCISE 5
Position: Seated on a stool at a physiotherapy apparatus.
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Action: Bring the arms toward the body until they cross behind the back.
Allow the weights to return to their originally position slowly and stopping at intervals. The weights are brought toward adduction, extension and internal rotation. See Figure 5.

Stretching and relaxation
The Aim: After each exercise adequate time must be given to fully stretch and relax each muscle. This is important to avoid muscular cramps, strain or rupture. By the sliding action of the actin and myosin fibers stretching induces elongation of the muscle.
Adequate stretching before and after exercise protects muscular tendons which may suffer from repetitive exercise in an untrained individual. It also augments the elasticity of the myo-tendinous junctions and associated connective tissue is stretched and made more plastic.

a - Stretching of the Latissimus Dorsi
The exercises aim to perform the movements which reciprocate the action of the muscle. Thus, external rotation of the arm, abduction to 180°.
Position: Standing with the arm above the head.
Action: Bring the palm of the hand backwards (external rotation).
Continue to push the arm behind the head, meanwhile fixing the hip on the opposite side and fully stretching the same side.
Hold the position at full stretch for 10 seconds in expiration.

b - Stretching the wrist and finger flexors
Action: Bring the arms into external rotation. Supinate the forearm. Extend the wrists. Open the hand and stretch all fingers fully. Hold for 10 seconds. See Figure 6.

c - Stretching of the finger and wrist extensors
Action: Internally rotate the arm. Pronate the forearm. Flex fully the wrist. Make a fist closing all the fingers. Hold for 10 seconds.

a - Stretching of the Latissimus Dorsi
b - Stretching the wrist and finger flexors
c - Stretching of the finger and wrist extensors

Figure 4

Adduction, Extension, Internal Rotation

Figure 5

Extension, Adduction, Internal Rotation

Figure 6

Figure 7

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Muscular exercises before cardiomyoplasty

These two stretching exercises are always practiced before muscle strengthening exercise 4 and 5. See Figure 8.

d - Stretching of the spine
  Position: Seated against a wall.
  Action: Deeply inspire.
  Press the lumbar spine against the wall.
  Stretch the shoulder-blades back as far as possible.
  Holding the cervical spine back stretch the head upwards as far as possible.
  Stretch the arms downwards.
  Expire slowly throughout the exercise while holding this position. See Figure 9.

Recommendations

It is important that a trained physiotherapist supervises this preoperative exercise program to ensure that all exercises are executed properly. The physiotherapist should make an individual appraisal of each patient. This is specially important in this group as the variation in ability of congestive cardiac patients is immense and can change from day-to-day. Anaerobic exercises should be excluded as they are over strenuous on the heart.

We recommend also starting shoulder exercises 1 to 2 weeks postoperatively, to avoid restricted range of motion and long term contractures.

Respiratory exercises pre-cardiomyoplasty

It is important to include a schedule of breathing exercises in the operative tune up of these patients. Properly taught diaphragmatic ventilation may reduce morbidity in the postoperative period. Respiratory complications such as lung collapse, retention of secretions, atelectasis may be avoided thus reducing the incidence of respiratory infection. Full inspiration and expiration exercises in the postoperative period may also ameliorate some of the wound pain and healing contractures associated with the procedure.

Patients should undergo 2 weeks of preoperative respiratory therapy (incentive spirometry, deep breathing and coughing exercises). Intensive pulmonary toilet continues after surgery. Major respiratory insufficiency (forced vital capacity < 55% of predicted) is a contraindication to cardiomyoplasty.

Results

All patients included in this study completed the preoperative training period of 7 ± 2 weeks. Physical exercises supervised by physiotherapists never resulted in undesirable consequences for the patients. Furthermore, all patients have shown a remarkable tolerance to the muscular exercise program. Latissimus Dorsi cardiomyoplasty was performed according to a previously described surgical technique [3]. All patients were closely followed during the postoperative period and no cardiac arrhythmias, chest pain, fatigability, dyspnea or discomfort have been observed as a result of this exercise program.

This programmed physical training protocol resulted in an improvement in the muscular performance of all patients with potential clinical impact.

Discussion

The role of passive stretch and repetitive electrical stimulation in preventing skeletal muscle atrophy and in improving fatigue resistance has been previously studied [6]. This is of extreme importance because the amount of skeletal muscle is a determinant of exercise capacity; as can be seen in elderly patients [5].

Patients with chronic heart failure are usually suffering from skeletal muscle atrophy [2] and there is evidence that exertional fatigue and dyspnea are linked via the skeletal muscles [15]. Nevertheless, electrostimulated Latissimus Dorsi muscle flaps wrapped around the heart are used to restore ventricular contractility [4]. Obviously, the use of altered skeletal muscles in order to treat severe cardiac failure involves a risk which stimulated our study of the role of physical training on Latissimus Dorsi performance in patients suffering heart failure [9].

Training programs must take into account the fact that diminished blood flow in skeletal muscles is not the only mechanism of exertional fatigue. In fact, alterations in mitochondrial population or substrate utilization have been proposed as responsible mechanisms of an abnormal skeletal muscle metabolic patterns [14]. The preoperative
N.Y.H.A. functional class was not modified during and/or following the exercise training program.

The long term improvement in N.Y.H.A. functional class observed in patients after cardiomyoplasty is most likely due to: first, the gradual increase in the Latissimus Dorsi muscle resistance to fatigue following chronic electric stimulation; second, better matching of the contracting muscle flap and beneficial effects of the contracting muscle on ventricular function [4].

The duration of the preoperative LD training program is ideally 2 months.

The training protocol followed by our cardiomyoplasty candidates was completed without complications in all cases. In this study no muscle functional parameters were measured, since our aim was a long term follow-up. The training protocol followed by our cardiomyoplasty recipients was completed without complications in all cases. In this study no muscle functional parameters were measured, since our aim was a long term follow-up in order to elucidate the possible relationship between preoperative Latissimus Dorsi muscle performance and the previously reported degeneration of a wrapped skeletal muscle submitted to a long-term pacing protocol [8,10]. Furthermore, a control group will be analyzed in order to determine the risk of adopting a suboptimal Latissimus Dorsi muscle to treat severe cardiac failure. In order to evaluate muscle mass contraction in the chest following cardiomyoplasty, all patients will be submitted to Doppler Tissue Imaging (DTI) studies. This technique allows the visualization and discrimination of Latissimus dorsi muscle contraction from myocardial contraction [7].

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