Hot-Knife Dissection of the Latissimus Dorsi Muscle for Dynamic Cardiomyoplasty

*Masao Takahashi, Shigeyuki Tomita, Hiroshi Ohtake, *Nobuyuki Tanaka, Michio Kawasuji, and Yoh Watanabe at Department of Surgery (I), Kanazawa University School of Medicine, Kanazawa, and *Department of Thoracic and Cardiovascular Surgery, Yokohama Sakae Kyosai Hospital, Yokohama, Japan*

Abstract: The overall purpose of circulatory assistance utilizing skeletal muscle is the most efficient application of muscle power. From the histological viewpoint, hot-knife dissection of the latissimus dorsi muscle (LDM) is presented to preserve muscle tissue. The shaw hemostatic scalpel could be used similarly to standard surgical blades, and its hemostatic performance was efficient in sealing collateral vessels from the thoracic wall. Muscular and nervous twitching was never observed throughout dissecting the LDM. Histological findings revealed that muscle fibers could be preserved by hot-knife dissection rather than by electrocautery. This technique may reduce the inconvenience of the operators, and, therefore, shorten the operation time in dynamic cardiomyoplasty and other experiments. **Key Words:** Hot-knife dissection—Latissimus dorsi muscle—Cardiomyoplasty.

Received February 1996; revised April 1996.

Address correspondence and reprint requests to Dr. Masao Takahashi, Department of Surgery (I), Kanazawa University School of Medicine, 13-1, Takara-machi, Kanazawa, 920, Japan.

FIG. 1. The hot-knife (the hemostatic scalpel) system is shown.

Circulatory assistance utilizing autologous skeletal muscle is the advanced surgical therapy for patients who have severe heart failure refractory to medical treatment. Dynamic cardiomyoplasty (1,2) has been the only acceptable operation for clinical cases. Many other kinds of animal experiments about assisting circulation utilizing skeletal muscle have been reported (3–6) including aortomyoplasty, skeletal muscle ventricle, and the skeletal muscle powered dynamic patch. In all these methods, it is most important to optimize the muscle contractile power. In this study, we present an innovative alternative for dissection of the LDM using a hemostatic scalpel or *hot-knife.* This scalpel has been used in pediatric (7), breast (8), plastic (9), head and neck (10), oral (11), nose (12), and cervical surgeries (13) but has never been reported for skeletal muscle dissection in cardiomyoplasty. In this study, we examined the technical feasibility of the hot-knife and evaluated the histological findings about the latissimus dorsi muscle, which was dissected using hot-knife dissection or conventional electrocautery.

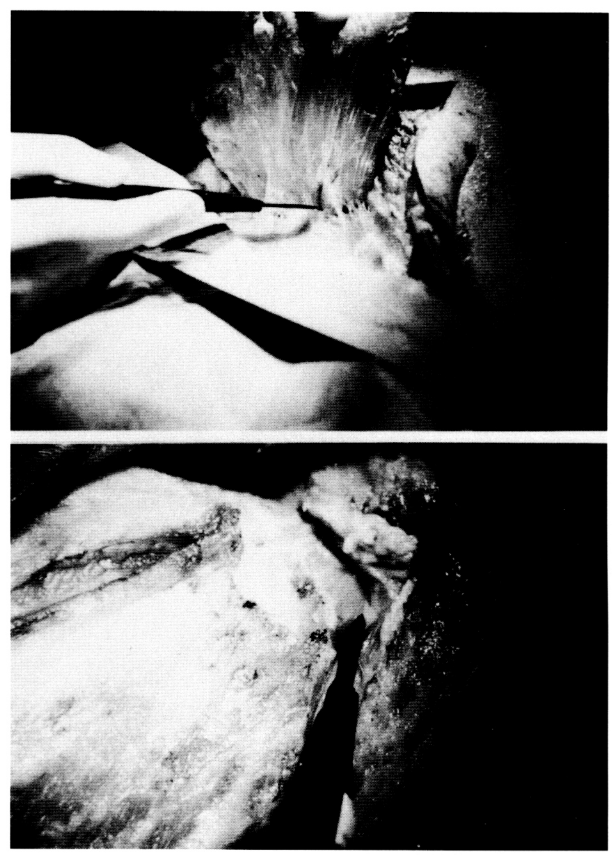

FIG. 2. The hot-knife dissection of the latissimus dorsi muscle is presented. Identification of the thoracodorsal neurovascular bundle **(upper);** dissection of the latissimus dorsi muscle from the other surrounding muscles **(lower).**

Materials and methods

Four pigs, in which the anatomical structure of the LDM is similar to that in humans (14), were used in this study. All the animals received humane care in compliance with the "Principles of Laboratory Animal Care" formulated by the National Society for Medical Research and the "Guide for the Care and Use of Laboratory Animals" prepared by the Institute of Laboratory Animal Resources and published a b

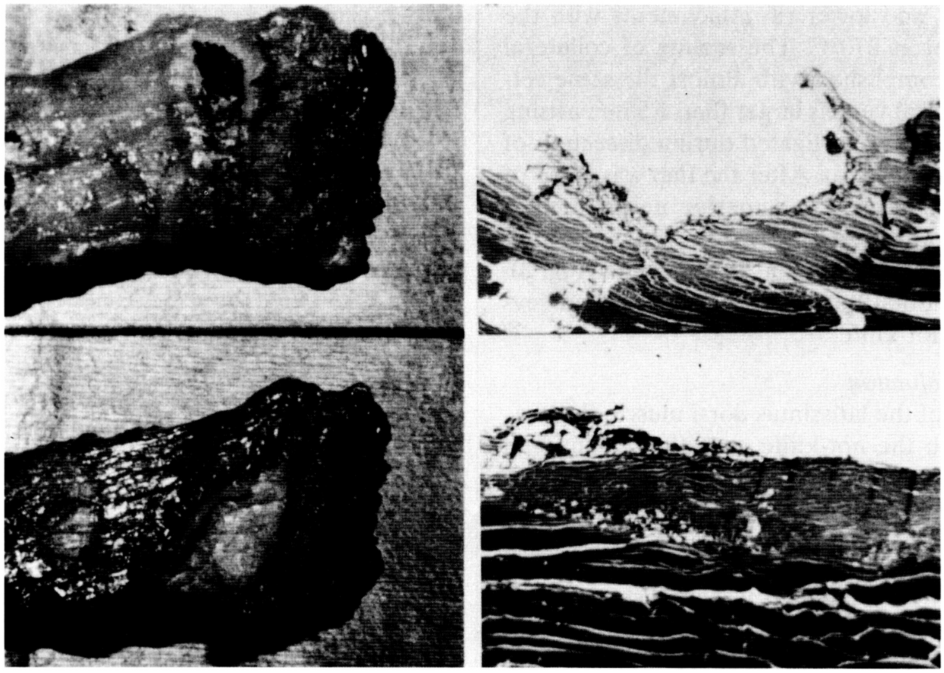

FIG. 3. Macroscopic **(a; left)** and microscopic **(b; right)** findings of the latissimus dorsi muscle are shown. After coagulation of the muscle surface (a) for 5 s, the electrocautery caused remarkable carbonization and defect of the muscle tissue (upper). The muscle surface coagulated with the hot-knife for 5 s (lower), but it was found to be preserved. Defect of the muscle tissue and disconnection of the muscle fiber orientation (b) were observed in the microscopic specimen coagulated with the electrocautery (upper). Compared with this, those phenomena were not observed in the specimen coagulated with the hot-knife (lower).

by the National Institutes of Health (NIH Publication No. 86-23, revised 1985).

The animals were premedicated with an intramuscular injection of ketamine chloride (7 mg/kg), azaperone (2 mg/kg), and atropine sulfate (0.05 mg/kg). They were sedated with thiamylal (4 mg/kg), given intravenously, and maintained with halothane. No muscle relaxants were used. A cuffed endotracheal tube was inserted, and the animal was ventilated through a volume controlled respirator at a rate of about 20 respirations per minute and a tidal volume of about 400 ml.

Hot-knife

The hemostatic scalpel, invented by Robert Shaw, a cardiovascular surgeon in San Francisco, California, is currently manufactured by Hemostatix Inc. (Mountain View, CA, U.S.A.). The system has three major components: an electronic controlling unit, a reusable lightweight scalpel handle, and a disposable Teflon-coated scalpel blade (Fig. 1). The controlling unit uses standard electrical alternating current supply (115–120 V, 50–60 Hz) and emits a pulsed direct current carried through a lightweight flexible cord to the scalpel handle. The scalpel is fitted onto the handle and can be used as a cold surgical blade or heated to a temperature of 110–260°C. The temperature of the blade can be increased or decreased in 10 degree increments using buttons on the controller unit or the scalpel handle. The blade temperature can be maintained within a narrow range of variation via sensors that send feedback to the controller unit. The desired blade temperature can be reached in 3–6 s and can cool down to room temperature within 10 s. The blades are similar in shape and size to regular surgical blades with a sharp steel cutting edge. The scalpels are constructed of surgical steel for the inner skeleton and cutting edge, followed by a layer of copper and several rows of insulated microcircuitry. The outer layer is Teflon, which provides a nonsticking surface and uniform distribution of heat. As a safety precaution, an audible tone is heard when the blade is hot.

Dissection of the latissimus dorsi muscle flap

With the animal in the lateral decubitus position, a cutaneous incision is made at the level of the lateral border of the scapula from the axillary region to the intersection between the iliac crest and paravertebral muscles. The skin incision was performed with the temperature set at 110°C. The subcutaneous tissue was dissected with temperature settings varying from 200 to 270°C. The large skin flap was completed, and the muscle surface was clearly seen. Thereafter, the left latissimus dorsi muscle flap was dissected free from the iliac crest, vertebral, inferior scapular angle, and lower rib attachments with the temperature set at 270°C. The sealing of collateral vessels was accomplished with almost the same setting. The collateral vessels larger than 1.5 mm arising intercostal arteries were ligated during dissection of the distal part of the flap. After the flap was freed of its distal attachments, the superior neurovascular bundle was identified and preserved carefully, mainly with scissors, and with the hot-knife (Fig. 2). The latissimus dorsi humeral tendon was then severed with the hot-knife.

Histological evaluation

The surface of the latissimus dorsi muscle flap was coagulated with the hot-knife or with conventional electrocautery. Macroscopic and microscopic histological findings were evaluated.

Results

Hemostasis was completely accomplished during dissection of the muscle flap. The major difference from electrocautery was the lack of muscular and nervous twitching throughout the hot-knife dissection. The degree of hemostasis obtained during the incision was related to the speed with which the surgeon moved the blade. Long, deliberate strokes of the skin allow hemostasis to be achieved without overexposing the skin to heat. It was easy to dissect subcutaneous fat tissue from the muscle surface. There was no bleeding from the distal attachment of the muscle flap. The hot-knife was especially useful in dissecting the proximal muscle insertion at the humerus because the other muscles did not twitch (Fig. 2).

Macroscopically, the muscle surfaces coagulated by the hot-knife were shallower than those coagulated by electrocautery (Fig. 3a). Microscopic findings showed that muscle fibers were much more preserved in hot-knife than those in electrocautery (Fig. 3b).

Discussion

We demonstrated the hot-knife dissection of the LDM. The hot-knife was very useful and easy to handle during the muscle flap dissection because the muscle never twitched. Histological findings revealed that hot-knife dissection was superior in preserving muscle fibers.

Heart transplantation is radical therapy for patients with end-stage heart failure. This operation, however, is limited by the shortage of donors or complications. Since the first clinical report in 1985 (1), dynamic cardiomyoplasty has been developed as a bridge or a substitute to heart transplantation. There are great advantages to avoiding resection and other problems because autologous tissue is utilized in this surgery. For these reasons, many experiments have been reported about circulatory assistance utilizing skeletal muscle.

The overall purpose of these studies using skeletal muscle is to carry out the most efficient application of muscle power. As one of the techniques to optimize muscle contraction, we reported the linear actuator that could preserve collateral blood flow to the LDM (5,6). From the histological viewpoint, we presented hot-knife dissection of the LDM to preserve muscle tissue in this study. Chachques et al. (2) reported that the muscle flap dissection must be conducted carefully, mainly with scissors; electrocautery is used with great care and with low intensity to minimize injury to the vascular supply. Hot-knife dissection could achieve complete hemostasis of collateral vessels smaller than 1.5 mm. Handling of the hot-knife was similiar to regular surgical blades. We believe that the technique may reduce annoyance of the operators, and, therefore, shorten the operation time.

References

1. Carpentier A, Chachques JC. Myocardial substitution with a stimulated skeletal muscle: First successful clinical case. *Lancet* 1985;1:1267.
2. Chachques JC, Grandjean PA, Carpentier A. Latissimus dorsi dynamic cardiomyoplasty. *Ann Thorac Surg* 1989;47:600–4.
3. Chachques JC, Grandjean PA, Fischer EIC, Latremouille C, Jebara VA, Bourgeois I, Carpentier A. Dynamic aortomyoplasty to assist left ventricular failure. *Ann Thorac Surg* 1990;49:225–30.
4. Acker MA, Anderson WA, Hammond RL, Chin AJ, Buchanan JW, Morse CC, Kelly AM, Stephenson LW. Skeletal muscle ventricles in circulation: One to eleven weeks' experience. *J Thorac Cardiovasc Surg* 1987;94:163–74.
5. Takahashi M, Misaki T, Watanabe G, Ohtake H, Tsunezuka Y, Wada M, Sakakibara N, Matsunaga Y, Kawasuji M, Watanabe Y. Efficacy of a Skeletal Muscle Powered Dynamic Patch, Part 1: Left Ventricular Assistance. *Ann Thorac Surg* 1995;59:305–12.
6. Watanabe G, Misaki T, Takahashi M, Ohtake H, Tsunezuka Y, Wada M, Watanabe Y. Efficacy of a Skeletal Muscle Powered Dynamic Patch: Part 2. Right Ventricular Assistance. *Ann Thorac Surg* 1995;59:313–19.
7. Stauffer UG. The haemostatic scalpel in pediatric surgery: Clinical report on 3000 operations. *Prog Pediatr Surg* 1990;25:39–47.
8. Pilnik S, Steichen F. The use of the hemostatic scalpel in operations upon the breast. *Surgery* 1986;162:589–91.
9. Salyer KE. Use of a new hemostatic scalpel in plastic surgery. *Ann Plast Surg* 1984;13:532–8.
10. Fee WE. Use of the shaw scalpel in head and neck surgery. *Otolaryngol Head Neck Surg* 1981;89:515–9.
11. Takagi R, Ohashi Y, Abe M. Blood loss with use of the shaw scalpel for the treatment of oral cancer. *J Oral Maxillofac Surg* 1985;43:580–4.
12. Eisen RF, Katz AE, Bohigian K, Grande DJ. Surgical treatment of phinophyma with the shaw scalpel. *Arch Dermatol* 1986;122:307–9.
13. Jahshan AE, Kent HL, Loose JH, Ghabra M, Zimmermen R. Hot-knife conization of the cervix: Clinical and pathologic

findings from a study introducing a new technique. *Obstet Gynecol* 1994;83:97–103.
14. Windisch A, Burggasser G, Traxler H, Grabenwöger F, Happak W, Losert U. Arterial supply of the latissimus dorsi muscle: a comparative study in human, sheep, dog, and pig. *Clin Anat* 1994;7:251–6.