Revisiting Vascularized Muscle Flaps for Complicated Sternal Wounds in Children

Peter J. Taub, MD, Matthew R. Schulman, MD, Suvro Sett, MD, and R. Michael Koch, MD

Abstract: Surgeons at our center previously reported a case of a 2-month-old infant who underwent closure of an infected sternal wound following open cardiac surgery with debridement followed by closure with bilateral pectoralis muscle flaps and a unilateral rectus abdominis muscle flap. The success of the procedure has spawned refinements in the technique, such as the one described herein. A 2-week-old neonate was evaluated for postoperative sternal dehiscence and instability following open cardiac surgery for severe congenital cardiac anomalies. Management included initial debridement and application of a vacuum-assisted closure (V.A.C.) system (KCI, Oxfordshire, UK). In conjunction with the final V.A.C. dressing change, the patient underwent delay of the left rectus muscle by division of the inferior epigastric pedicle. She subsequently underwent transposition of the left rectus muscle and application of a full-thickness skin graft for coverage of the sternal defect. She has since done well and still requires further invasive cardiac procedures.

Key Words: sternal, wound, pediatric, muscle, flap

(*Ann Plast Surg* 2005;55: 535–537)

A 2-week-old neonate was born full term with severe congenital cardiac anomalies of the heart and great vessels. She underwent surgical repair of a hypoplastic left heart, with closure of the chest by sternal reapproximation. In the immediate postoperative period, the patient required emergent exploration for bleeding. Hemostasis was achieved and the chest was reclosed utilizing minimally elevated bilateral pectoralis major flaps by the cardiac service.

Postoperatively, her course was complicated by dehiscence of the lower portion of the wound, inferior to the extent of the pectoralis muscle flaps. The sternum was visible and there was moderate sternal instability (Fig. 1). At initial contact with the patient, it was the opinion of both the plastic surgery team and the cardiac team that the complication represented a sterile dehiscence, which had been closed under tension. It was also determined that adequate vascularized muscle was necessary to stabilize the sternum and provide durable soft tissue for subsequent cardiac procedures. Because of this infant's small size (2400 g) and recent course of intravenous steroids, any immediate muscle transfer would be associated with a high risk of wound complications, flap failure, and donor-site morbidity. We elected to first debride the sternum of all devitalized tissue and sternal wires, a necessary step in sternal reconstruction. Initial management also included placement of a vacuum-assisted closure (V.A.C.) dressing (KCI, Oxfordshire, UK). She remained ventilator dependent, while serial dressing changes over the next 10 days failed to note significant development of granulation tissue.

The failure of the wound to respond to conservative treatment, combined with the patient's need for future invasive cardiac procedures, warranted coverage with healthy, vascularized tissue. During an intraoperative dressing change, the inferior epigastric pedicle to the left rectus abdominis muscle was ligated as a delay procedure in anticipation of later rectus elevation (Fig. 2). The groin wound was closed primarily.

She was returned to the operating room 10 days later for further debridement and formal closure with a pedicled left rectus abdominis muscle flap. This was performed through 2 incisions: an extended elliptical left groin incision and a left subcostal incision. The rectus muscle was elevated based on its superior pedicle and inset without tension into the sternal defect. The muscle was covered with a full-thickness skin graft, meshed 1:1.5, harvested from the left groin at the beginning of the procedure. A closed suction drain was placed in the muscle donor site. The skin graft and muscle were dressed with a V.A.C. sponge for 48 hours at a negative pressure of 50 to 75 mm Hg. On postoperative day 2, the dressing was removed and the skin graft demonstrated complete take. The patient continued to improve and the wound remained intact, with no evidence of sternal instability (Fig. 3). She will require an additional cardiac procedure in approximately 2 months' time.

DISCUSSION

We have previously described a technique for closure of an infected sternal wound following open cardiac surgery

Received May 17, 2005 and accepted for publication, after revision, July 11, 2005.

From the Division of Plastic and Reconstructive Surgery, New York Medical College, and the Maria Fareri Children's Hospital, Valhalla, NY.

The authors have no conflict of interest with the company KCI (UK) Ltd, the manufacturers of the V.A.C. device. The device was supplied by the hospital through normal channels, and the authors derive no financial or other interests associated with the use of this product.

Reprints: Peter J. Taub, MD, FACS, FAAP, Division of Plastic and Reconstructive Surgery, New York Medical College, and Maria Fareri Children's Hospital, Westchester Medical Center, Macy Pavilion, Valhalla, NY 10595. E-mail: peter@pjtaub.com.

ISSN: 0148-7043/05/5505-0535
DOI: 10.1097/01.sap.0000183681.56595.0a

FIGURE 1. The appearance of the patient's wound during VAC dressing change.

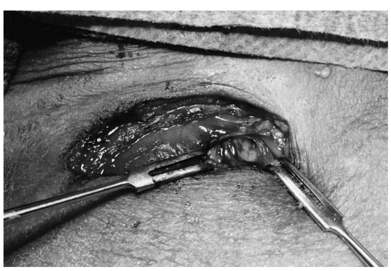

FIGURE 2. Identification of the inferior epigastric pedicle supplying the left rectus abdominis muscle.

FIGURE 3. Appearance of the wound following muscle transfer from the abdomen to the chest.

with a combination of debridement and closure using bilateral pectoralis and rectus abdominis muscle flaps in a 2-month-old infant.[1] We demonstrated that this technique provides excellent muscle coverage and remains durable during future sternotomy. The success of the procedure has spawned refinements in the technique, which have been adapted for a subsequent patient.

Key differences between the patient outlined above and that described previously include the age at surgery, the preoperative preparation, and the postoperative management. The case above was younger than her predecessor but tolerated multiple operative procedures equally well. A V.A.C. system (KCI) was placed on the wound but was not used previously. The pressure was set at 50 mm Hg, the lowest allowable negative pressure, in an effort to prepare the recipient bed and stabilize the sternum during the preoperative period. Postoperatively, the V.A.C. help to secure the skin graft and facilitate graft take. Delay of the rectus muscle was also not previously performed.

Negative-pressure therapy has an established role in the management of infected and complicated wounds.[2–4] Additionally, the benefit of negative-pressure therapy on the pediatric sternal wound has been described and results in local wound improvement, sternal stabilization, and improved mechanics of respiration.[5] In our patient, the V.A.C. dressing also served to temporize the wound, thereby allowing a longer period of time off the intravenous steroids and time to improve nutrition.

Potential obstacles that must be considered when considering ultimate reconstruction in such patients include the size of the muscle available for harvest, the vascular anatomy of the muscle chosen for transposition, and the potential for reoperation and ultimate growth. In this patient, bilateral pectoralis muscles had been used previously. Other choices that have been described include latissimus dorsi muscle, rectus abdominus muscle, omentum, and free tissue transfer.[6–8] In this patient, we chose the rectus abdominus because of the shortfalls of both the latissimus and omentum in this small neonate. Additionally, free tissue transfer would require extended operating time, which was not advisable in this critically ill neonate. All of these options should grow with future growth of the infant. Sacrifice of one rectus muscle is frequently used in adult breast reconstruction and should offer no functional limitations in the future.

The rectus abdominis muscle receives blood supply from both the superior epigastric system and the inferior epigastric system. Division of the inferior system, necessary for muscle transfer, makes it imperative for the superior system to be patent. Examination of the patient revealed scars in the right upper abdomen, precluding the use of the right rectus abdominus muscle because of a potentially compromised superior blood supply. The chest-tube insertion sites, pacing wires, and intracardiac line exit sites were purposefully placed over one rectus abdominus muscle to preserve the vascular supply of the opposite rectus muscle in case it would be required for future reconstruction.

We chose to perform a delay procedure on the left rectus abdominus muscle by ligation of the inferior epigastric artery and vein. It is well established that surgical delay is effective in augmenting the vascularity of cutaneous and myocutaneous flaps. Taylor et al[9] and Callegari et al[10] performed extensive clinical and experimental studies on the delay phenomenon and concluded that the opening or dilation of interconnecting "choke vessels" between 2 adjacent angiosomes following division of the dominant source artery is the main effect of surgical delay; this was confirmed by Hallock and Rice[11] in the rat TRAM flap. The ultimate result is improved superiorly based circulation to the rectus abdominus muscle. This is especially important in this infant with congenital anomalies of the heart and great vessels. It is uncertain whether a shorter delay time is possible in the neonate. However, the delay time described above did not offer problems in the overall management of the patient. The pedicle was ligated during the final V.A.C. dressing change and the muscle transferred 1 week later. No significant increase in hospital stay resulted.

The normal superior pedicle of the rectus abdominis muscle arises from the internal mammary artery, a direct branch of one of the great vessels of the heart. The possibility that the muscle lacked a normal blood supply was considered when the delay procedure was contemplated. Although not described in the literature, the normal anatomy of the internal mammary artery may be absent in children with other congenital anomalies of the heart and great vessels.

Another unique approach is our choice of surgical incisions for the rectus abdominus muscle harvest and transposition. Traditionally, elevation of the rectus abdominus muscle without a skin paddle is performed through a vertical paramedian incision. In an effort to limit surgical scarring, we made an extended elliptical incision in the left groin, which provided 2 advantages: excellent exposure for division and elevation of the inferior portion of the muscle and a full-thickness skin graft with primary closure of the donor site. A left subcostal incision was made to allow elevation of the superior portion of the rectus abdominus muscle and aid in transposition. The combined incision allowed for excellent exposure and simultaneous harvest of a skin graft, while minimizing visible surgical incisions.

Again, we used the V.A.C. system to help secure the skin graft. Because of the anatomic location of this wound, conventional techniques for securing skin grafts, such as a compression wrap or a bolster dressing, were less ideal. Blackburn et al[12] first described utilizing negative-pressure dressings for stabilization of skin grafts. They report increased graft take due to total immobilization of the graft, limiting shear forces, elimination of fluid collections, and decreased bacterial contamination. They also noted decreased edema in rotated muscle flaps, improved contour conformity, and shortened hospitalizations.

CONCLUSION

Poststernotomy wounds in the pediatric population are a difficult problem requiring careful surgical planning and technique. Successful flap closure in the neonatal population requires healthy, uninjured muscle, a well-debrided bed, and meticulous technique. Furthermore, subsequent cardiac procedures are planned to further correct the congenital cardiac anomalies. Future sternotomy will require re-elevation of the rectus flap and division of the bilateral pectoralis flaps. By entering the chest to the right side of the rectus muscle and between each of the pectoralis muscles, it should be possible to preserve the appropriate vascular pedicles and allow primary sternal wound closure using healthy, uncompromised muscle.

REFERENCES

1. Sung K, Niazi ZBM, Salzberg CA, et al. Vascularized muscle flaps and reoperative approach for complicated, dehisced sternal wounds in children. *Ann Plast Surg*. 1998;40:523–527.
2. Davydov IA, larichev AB, Abramov AI. Wound healing after vacuum drainage. *Khirurgiia (Mosk)*. 1992;7:21–26.
3. Obdeijn MC, de Lange MY, Lichtendahl DHE, et al. Vacuum-assisted closure in the treatment of poststernotomy mediastinitis. *Ann Thorac Surg*. 1999;68:2538–2560.
4. Tang ATM, Ohri SK, Haw MP. Novel application of vacuum assisted closure technique to the treatment of sternotomy wound infection. *Eur J Cardiothorac Surg*. 2000;17:482–484.
5. Ramnarine IR, McLean A, Pollock JCS. Vacuum-assisted closure in the paediatric patient with post-cardiotomy mediastinitis. *Eur J Cardiothorac Surg*. 2002;22:1029–1031.
6. Tizian C, Borst HG, Berger A. Treatment of total sternal necrosis using the latissimus dorsi muscle flap. *Plast Reconstr Surg*. 1985;76:703–707.
7. Tortoriello TA, Friedman JD, McKenzie ED, et al. Mediastinitis after pediatric cardiac surgery: a 15-year experience at a single institution. *Ann Thorac Surg*. 2003;76:1655–1660.
8. Weinzweig N, Yetman R. Transposition of the greater omentum for recalcitrant median sternotomy wound infections. *Ann Plast Surg*. 1995; 34:471–477.
9. Taylor GI, Corlett RJ, Caddy CM, et al. An anatomic review of the delay phenomenon, II: clinical applications. *Plast Reconstr Surg*. 1992;89:408.
10. Callegari PR, Taylor GI, Caddy CM, et al. An anatomic review of the delay phenomenon, I: experimental studies. *Plast Reconstr Surg*. 1992; 89:397.
11. Hallock GG, Rice DC. Evidence of the efficacy of TRAM flap delay in a rat model. *Plast Reconstr Surg*. 1995;96:1351.
12. Blackburn JH, Boemi L, Hall WW, et al. Negative-pressure dressings as a bolster for skin grafts. *Ann Plast Surg*. 1998;40:453–457.

