SPLIT RECTUS ABDOMINIS MYOCUTANEOUS DOUBLE FREE FLAP FOR EXTREMITY RECONSTRUCTION

THEODORE T. NYAME, M.D., LCDR(S), PAUL W. HOLZER, M.S., USNR, DOUGLAS L. HELM, M.D., DANIEL Y. MAMAN, M.D., JONATHAN M. WINOGRAD, M.D., FACS., and CURTIS L. CETRULO Jr, M.D., FACS*

A Mathes and Nahai type III muscle, such as the rectus abdominis muscle, can be utilized to cover two separate wounds simultaneously utilizing its dual blood supply thereby minimizing donor site morbidity and operative time. We report a case for treatment of bilateral Gustillo type IIIB lower extremity injuries treated with a single rectus abdominis muscle split into two free flaps, with one based on the deep inferior epigastric vessels and one on the superior epigastric vessels to cover the contralateral wound. In our patient, both lower extremity wounds were covered with muscle flaps from the same donor site in a single operation, salvaging both limbs with progression to unassisted ambulatory status. We show in this case report that the utilization of the vascular anatomy of the rectus muscle allows for division of the flap into two flaps, permitting preservation of the contralateral abdominal wall integrity and coverage of two wounds with a single muscle. © 2013 Wiley Periodicals, Inc. Microsurgery 34:54–57, 2014.

With the improved survival of polytrauma patients, the rise in concurrent open wounds is becoming increasingly common. Despite technical advances in free tissue transfer, donor site morbidity continues to be problematic for patients following lower extremity reconstruction. Often, these patients are young and will contend with the complications of donor site morbidity for many decades. As a consequence, the selection of donor sites is becoming a critical decision. Integration of multiple factors of patient age, aesthetics, and the conservation of upper body strength for assistance with ambulation and activities of daily living as well as the volume of soft tissue needed for transfer is critical when approaching a case of bilateral Gustillo IIIB injuries. The rectus abdominis free flap, first described by Pennington, has been long recognized as an ideal choice for lower extremity reconstruction, and indeed represents a workhorse flap for many microsurgeons.[1] Taylor et al. reported the successful use of the inferior third of the rectus muscle in their early case series of seven patients, noting that a small segmental component of the flap was more than sufficient to cover the soft tissue defect in nearly all cases.[2] Elaborating on this theme, Buntic described a partial medial rectus flap based on the medial branch of the deep inferior epigastric artery and vein, which allows preservation of lateral neurovascular bundles and functional muscle integrity.[3,4] Conversely, Sherman has described the extended deep inferior epigastric artery flap for large lower extremity defects.[5] Most reports of the rectus abdominis free flap identify the deep inferior epigastric artery and vein as the dominant vascular pedicle; however, the superior epigastric artery and vein is consistently encountered in dissection of the free flap and is often of adequate caliber for microanastomoses (1.5–3.0 mm).

Here, we report the use of two free flaps from one rectus muscle for reconstruction of bilateral Gustillo IIIB lower extremity injuries. A split segmental rectus abdominis muscle flap based on the superior deep epigastric vessels was utilized for one limb, whereas the remaining portion of the rectus muscle based on the deep inferior epigastric was used for the contralateral defect. A similar approach utilizing a single split gracilis flap for reconstruction of bilateral heel wounds has been reported by Sherman.[6,7] We applied the "split flap" concept to the rectus muscle to preserve our young patient's contralateral rectus muscle.

CASE REPORT

The patient is a 24-year-old male helmeted motorcycle rider who collided with a cement barrier at 90 mph. On arrival, Glasgow Coma Scale was 15, and the patient was noted to be hemodynamically stable. The initial trauma evaluation was notable for a left lower extremity with only an intact posterior tibialis artery, normal foot sensation, and an open tibial-fibular fracture wound with 4.0 cm of periosteal tibial bone stripping. The right lower extremity had intact foot sensation, patent anterior, and posterior tibialis arteries, and an open tibial-fibular wound with 8.0-cm periosteal-stripped tibial bone. The patient also had severe trauma to his left shoulder with concomitant humerus fractures, which were treated nonoperatively. The patient was emergently taken to the operating room for external fixation of bilateral lower extremity fractures (Fig. 1).

Initial surgical debridement was performed by our colleagues prior to our consultation. Subsequent definitive

Division of Plastic Surgery, Massachusetts General Hospital, Harvard Medical School, Boston, MA

*Correspondence to: Curtis L. Cetrulo Jr., M.D., FACS; Division of Plastic and Reconstructive Surgery, Massachusetts General Hospital, 15 Parkman Street WAC 435, Boston, MA 02114–3117. E-mail: ccetrulo@partners.org

Received 12 June 2013; Accepted 21 June 2013

Published online 7 October 2013 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/micr.22160

Figure 1. Bilateral Gustillo IIIB lower extremity trauma (left); 3D CT (right). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

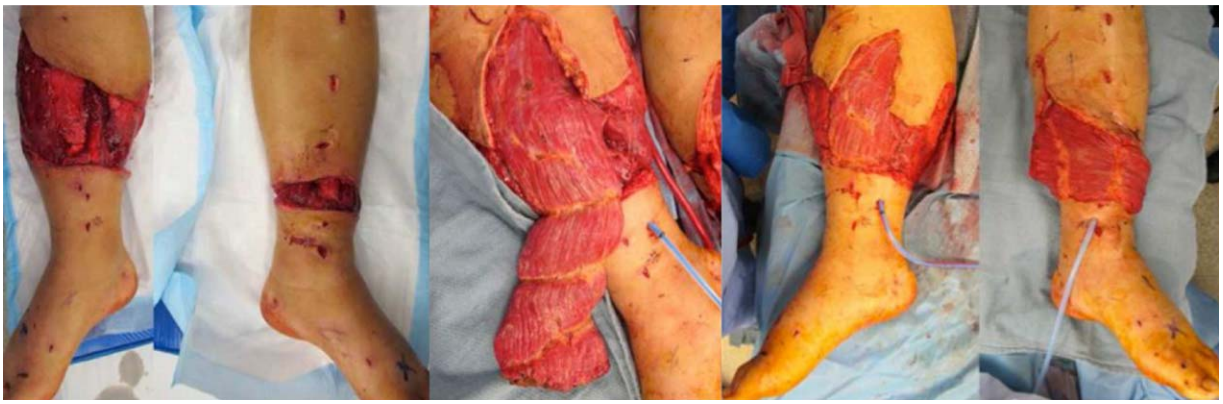

Figure 2. Preoperative lower extremities (left); intraop with rectus in situ (center); bilateral rectus muscle flaps (right). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

radical debridement was performed by our service prior to flap coverage. Following these serial debridements, the patient underwent definitive intramedullary nail fixation of his bilateral low extremity injuries. In our patient, the right lower extremity wound reconstruction was approached first, performing an arterial anastomosis of the inferior epigastric artery to the posterior tibialis artery in end-to-end fashion with a 3.0-mm venous coupler to the venae comitantes. After partly insetting the muscle, the superior epigastric artery was identified and dissected from its intramuscular course. The flap was divided horizontally along a tendonous inscriptions using electrocautery and brought to the contralateral wound. The remaining rectus muscle perfused on the superior epigastric artery was inset to cover the left lower extremity and an end to side anastomosis was performed to the posterior tibialis artery with a 2.0 venous coupler to the venae comitantes. Both wounds were covered with a 2:1 meshed split thickness graft from the thigh.

Subsequently, there was a skin and soft tissue defect of 30×20 cm^2 on the right lower extremity and 15×10 cm^2 on the left lower extremity (Fig. 2). These wounds were managed with a negative pressure wound dressing (vacuum assisted closure) until the time of definitive reconstruction. Bilateral external fixators were placed on post injury day 6 for the tibia and fibula fractures. On hospital day 10 from initial presentation and intramedullary fixation, the lower extremity wounds were reconstructed with a split rectus abdominis free tissue transfer (Fig. 2). The patient recovered in an uncomplicated fashion following reconstruction and is able to ambulate well without assistance (Fig. 3).

Figure 3. Six months following split rectus abdominis free muscle flap operation. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

DISCUSSION

The rectus abdominis muscle flap continues to be an excellent surgical option for management of open tibial-fibular fractures with extensive periosteal stripping. To date, most reports in the literature have utilized the deep inferior epigastric neurovascular bundle for microvascular anastomosis. In most reconstructive situations, the length of the muscle exceeds the length of the defect encountered and the more superior portion of the muscle is discarded. In this challenging clinical scenario with bilateral Gustillo IIIB fractures, we present the first report of a split rectus abdominis muscle free flap.

The reconstructive surgery literature demonstrates that local flap coverage for open lower extremity fractures involving the lower third of the leg is fraught with complication rates as high as 40%. Although free muscle flaps have an overall lower complication rate, the morbidity associated with harvesting two muscle flaps is not negligible in patients who need these muscle groups for extensive rehabilitation. Well-described muscle flaps in the literature include the latissimus dorsi, gracilis, and rectus abdominis free flaps. Although the gracilis muscle flap is associated with lower donor site morbidity, the muscle size is often inadequate for coverage of large soft tissue defects. Experience with the latissimus dorsi muscle flap has been quite favorable for open lower extremity coverage. The pedicle is noted to be of adequate length to perform an anastomosis beyond the zone of injury. However, in the reconstructive breast surgery literature, proponents of this flap site upper extremity functional weakness as one of the more common complications. This makes it a less than ideal flap for patients with bilateral lower extremity trauma who rely on core body and upper extremity strength. The size of the latissimus dorsi flap often exceeds the size of the defect encountered and much of the muscle is discarded.

The advantage of performing a unilateral rectus muscle harvest is well-demonstrated in the post mastectomy reconstructive literature comparing bipedicle transverse rectus abdominis myocutaneous (TRAM) flap to various other reconstructive methods. In comparative physiological evaluations, patients lose up to 40% of trunk flexion strength and 9% of trunk extension strength with loss of both rectus muscles. Subjectively, patients following a bilateral harvest of the rectus muscles, also note a significant decline in functional capacity performing their preoperative activities of daily living. Similarly, numerous breast reconstruction series have reported abdominal bulge rates of up to 48 percent after pedicled TRAM flap reconstruction.[8–10] Other series have demonstrated that single rectus muscle harvest is well-tolerated with no significant change in post operative functional capacity.[11]

Several factors including the patient's age, concurrent injuries, and post operative functional needs were carefully considered before approaching this reconstruction. The extent of lower extremity injury essentially guaranteed some long-term functional limitation that would necessitate upper core strength for ambulation. Severe left shoulder and humeral fracture obviated harvest of the left latissimus dorsi muscle both for concerns of destabilizing the humerus and shoulder, and technical inability to appropriately position the upper extremity intraoperatively. Consideration was given to right latissimus dorsi harvest, but concern for prolonged necessity for crutch-assisted ambulation given bilateral lower extremity trauma lowered our enthusiasm for this muscle. Radial forearm and anterior lateral thigh flaps were possibilities but suboptimal given size of the defects, and, in the case of the radial forearm flap, additional upper extremity morbidity. The rectus abdominis muscles were appropriately sized and outside any zone of injury. Once again, concerns for sacrifice of core body musculature were

considered. Preoperative planning for this case included a unilateral rectus muscle and unilateral anterior lateral thigh or radial forearm free flaps. Intraoperative examination of the unilateral rectus muscle demonstrated technical ability to perform a split rectus operation yielding two free flaps, one based on the superior system and one on the inferior epigastric system.

It has been shown that fasciocutaneous flaps can suppress infection equally well as muscle flaps,[12] and the use of two anterolateral thigh flaps to obviate functional deficits in a young male would have also served as a good option in this case. However, this method would have required harvest of two flaps rather than one, and via this technique we sought to minimize morbidity, although the effectiveness of fascial versus muscle flaps we believe to be equivalent.

The rectus abdominis flap first described by Pennington has gained popularity as an excellent choice for lower extremity reconstruction.[1]The vertical width of the muscle often fits well with the transverse dimension of lower extremity wounds encountered. The donor site complication of abdominal hernia is well-addressed with mesh placement at our center. In this clinical scenario, we show successful microvascular flap coverage utilizing both the superior and inferior epigastric neurovascular bundles and the entire rectus muscle to create two flaps, thereby sparing our young trauma patient both a second operation for a second free flap, as well as a second donor site for another flap. Careful consideration should be given to the use of this flap as a double transfer in cases such as this with two medium-sized defects in which a large portion of the standard inferior-based flap will be discarded. However, it must be recognized that the size and quality of the superior vessels will ultimately determine feasibility and that other available free tissue transfer options may be required.

REFERENCES

1. Pennington DG, Pelly AD. The rectus abdominis myocutaneous free flap. Br J Plast Surg 1980;33(2):277–282.
2. Taylor GI, Corlett RJ, Boyd JB. The versatile deep inferior epigastric (inferior rectus abdominis) flap. Br J Plast Surg 1984;37(3):330–350.
3. Buntic RF, Brooks D. Free partial medial rectus muscle flap for closure of complex extremity wounds. Plast Reconstr Surg 2005; 116(5):1434–1437.
4. Brooks D, Buntic RF. An aesthetic perquisite of rectus muscle transplantation in extremity reconstruction. Ann Plast Surg 2005;54(1): 109–111.
5. Sherman R, Law M. Lower extremity reconstruction. In: Achauer BM, Eriksson E, editors. Plastic Surgery: Indications, Operations, and Outcomes, Vol. I. St. Louis, London: Mosby; 2000. pp 475–496.
6. Wellisz T, Rechnic M, Dougherty W, Sherman R. Coverage of bilateral lower extremity calcaneal fractures with osteomyelitis using a single split free gracilis muscle transfer. Plast Reconstr Surg 1990; 85(3):457–460.
7. Temmen TM, Perez J, Smith DJ. Transverse splitting of the gracilis muscle free flap: Maximal use of a single muscle. Microsurgery 2011;31(6):479–483.
8. Mizgala CL, Hartrampf CR Jr, Bennett GK. Assessment of the abdominal wall after pedicled TRAM flap surgery: 5- to 7-year follow-up of 150 consecutive patients. Plast Reconstr Surg 1994;93:88–1002; discussion 1003–1004.
9. Edsander-Nord A, Jurell G, Wickman M. Donor-site morbidity after pedicled or free TRAM flap surgery: A prospective and objective study. Plast Reconstr Surg 1998;102:1508–1516.
10. Simon AM, Bouwense CL, McMillan S, Lamb S, Hammond DC. Comparison of unipedicled and bipedicled TRAM flap breast reconstruction: Assessment of physical function and patient satisfaction. Plast Reconstr Surg 2004;113(1):136–140.
11. Atisha D, Alderman AK. A systematic review of abdominal wall function following abdominal flaps for postmastectomy breast reconstruction. Ann Plast Surg 2009;63(2):222–230.
12. Lee JH, Chung DW, Han CS. Outcomes of anterolateral thigh-free flaps and conversion from external to internal fixation with bone grafting in gustilo type IIIB open tibial fractures. Microsurgery 2012;32(6):431–437.