OPEN

PRS GLOBAL OPEN

CASE REPORT
Reconstructive

Reconstruction for Severe Extracorporeal Membrane Oxygenation-induced Ischemic Lower Limb Injury Complicated by Osteomyelitis

Takeaki Hidaka, MD*
Masakazu Kurita, MD, PhD*
Shimpei Miyamoto, MD, PhD*
Mika Watanabe, MD*
Yutaro Kitamura, MD*
Keita Okada, MD, PhD†
Sayaka Fujiwara, MD, PhD‡
Mutsumi Okazaki, MD, PhD*

Summary: Extracorporeal membrane oxygenation (ECMO) is a well-established mechanical circulatory support system used in patients with life-threatening cardiopulmonary conditions. However, severe complications associated with vascular access require consideration. We report a patient with fatal ventricular arrhythmia who was successfully resuscitated with ECMO but who developed severe lower limb ischemia, which resulted in compartment syndrome. Even with emergent fasciotomy, tissue necrosis developed in wide areas of the limb, with subsequent tibial osteomyelitis. After extensive debridement and tibial sequestrectomy, the soft tissue and bone defect were simultaneously reconstructed with free tissue transfer of the latissimus dorsi muscle and scapular tip composite flap. The limb was successfully salvaged with satisfactory functional outcomes without major complications. This report discusses limb reconstruction for ECMO-induced compartment syndrome and illustrates the importance of appropriate selection of reconstruction methods among various composite flaps. *(Plast Reconstr Surg Glob Open 2020;8:e3074; doi: 10.1097/GOX.0000000000003074; Published online 25 August 2020.)*

Percutaneous venoarterial (VA) extracorporeal membrane oxygenation (ECMO) is a widely used mechanical circulatory support for life-threatening cardiopulmonary conditions,[1] which is also recently used in cases of coronavirus disease 2019-associated cardiogenic shocks.[2] With this method, however, femoral vascular access frequently leads to severe ischemia of the leg.[1] We encountered a case of lower leg compartment syndrome due to limb ischemia following the use of VA ECMO. Extensive tissue necrosis, infection, and neurological deficit suggested a possible indication for amputation. Nevertheless, we tried to salvage the limb with the use of free tissue transfer to meet the patient's desire and obtained satisfactory functional and aesthetic outcomes. Few reports so far have focused on limb reconstruction after relatively common ECMO-related complications of limb necrosis, and so the therapeutic strategy is discussed in the present report.

*From the *Department of Plastic, Reconstructive and Aesthetic Surgery, The University of Tokyo Hospital, Tokyo, Japan; †Department of Orthopaedic Surgery and Spinal Surgery, The University of Tokyo Hospital, Tokyo, Japan; and ‡Department of Rehabilitation Medicine, The University of Tokyo Hospital, Tokyo, Japan.*

Received for publication June 9, 2020; accepted July 7, 2020.

DOI: 10.1097/GOX.0000000000003074

CASE PRESENTATION

The patient was a 14-year-old boy with arrhythmogenic right ventricular cardiomyopathy, which is known to cause cardiac arrest (CA) in young people.[3]

During a table tennis match, the patient had a heart attack and went into CA. He was immediately transferred to the intensive care unit of a nearby hospital, and a VA ECMO was inserted into his right femoral vessels. On day 3, the circulatory condition was stabilized and the ECMO was removed. On day 4, redness and swelling, which are signs of compartment syndrome, emerged on the right lower limb, and a fasciotomy was performed immediately. After extubation on day 5, myonecrosis progressed with sensory and motor deficits in wide areas of the right lower leg. Repetitive surgical debridement and negative pressure wound therapy were performed, but these could not resolve the infection. Further debridement was unfeasible at the initial hospital; so the patient was transferred to our hospital 2 months after CA for limb reconstruction, which was strongly desired by the patient and his family.

On admission to our institution, necrotic tissue was distributed in wide areas of the anteromedial and anterolateral compartment with 45-degree ankle equinus. Magnetic resonance imaging revealed residual abscesses and tibial osteomyelitis. Additional debridement (including tibial

Disclosure: *The authors have no financial interest to declare in relation to the content of this article..*

sequestrectomy) was conducted (Fig. 1). Negative pressure wound therapy was continued in conjunction with antibiotic therapy. After 1 month of hospitalization at our institution, the tibial osteomyelitis improved, and limb reconstruction surgery was performed using free latissimus dorsi muscle with the scapular tip.[4] The composite flap supplied by a single subscapular artery pedicle was harvested from the ipsilateral side (Fig. 2). The latissimus dorsi muscle was used to cover the anterolateral defect, and the scapular tip, which was based on the angular branch of the thoracodorsal artery, was cut out into 4 × 4 cm to fill the tibial sequestrectomy to ensure bone strength for full weight bearing (Fig. 3). The arterial anastomoses were performed in a flow-through manner: the subscapular artery, including the circumflex scapular artery stump as a T segment, was interposed to the transected anterior tibial artery to preserve distal perfusion.[5] Venous anastomosis to the venae comitantes of the anterior tibial artery was performed in an end-to-end fashion. The surface of the transferred latissimus dorsi muscle and the anteromedial defect was covered with split-thickness skin grafts taken from the edges of the donor site.

The postoperative course was uneventful. Five months after CA, the patient was transferred to a pediatric cardiologist for the treatment of arrhythmogenic right ventricular cardiomyopathy. Although ankle equinus remained, he could walk with the aid of an ankle foot orthosis and went back to junior high school 6 months after CA. There have been no long-term complications related to the reconstruction surgery, and he and his family were satisfied with the aesthetic and functional outcomes at 1 year after CA (Fig. 4).

DISCUSSION

We encountered a case of VA ECMO-induced lower limb ischemia with subsequent compartment syndrome. Soft tissue necrosis and tibial osteomyelitis were successfully treated, and the limb was salvaged by free tissue transfer with a good functional outcome and great patient satisfaction.

VA ECMO is a widely used life-saving procedure for cardiopulmonary failure, but it is known to have a high risk of distal limb ischemia mainly due to retrograde perfusion through the femoral artery cannula obstructing forward flow of the limb. The reported incidence of limb ischemia ranges from 10% to 70%, and subsequent ischemia–reperfusion is known to cause compartment syndrome with an incidence of 4% to 12%.[1] To date, few studies have focused on treatment strategies in cases where compartment syndrome gives rise to severe necrotic tissue damage.

Selecting limb preservation was an essential issue in the present case, although there are currently no established guidelines for deciding between early amputation and reconstruction for severe lower limb injuries.[6] Given that extensive tissue necrosis even involved the osteomyelitis and caused neurological deficits, it was possible that there was no choice but to amputate. However, considering the patient's young age and the family's strong desire, we chose limb reconstruction as the desirable therapeutic option.

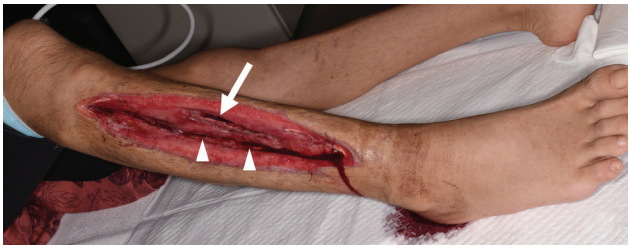

Fig. 1. Patient photograph showing ECMO-induced necrotic injury after extensive debridement, before the limb reconstruction surgery. Tibial sequestrectomy was performed to debride tibial osteomyelitis in the anterolateral defect (arrow). Soft tissue was debrided to connect the lateral and medial compartments (arrowheads).

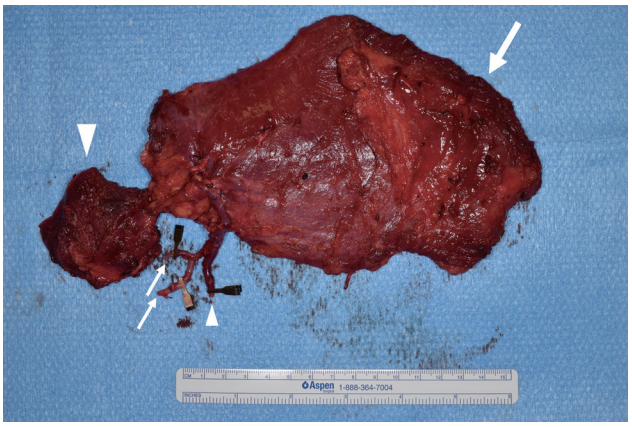

Fig. 2. Image showing elevated flap. Latissimus dorsi muscle (large arrow) and lower part of the scapula (scapular tip; large arrowhead) with the subscapular artery, including the circumflex scapular artery stump (small arrows) and venae comitantes (small arrowhead).

Fig. 3. Postoperative computed tomographic image of the patient's leg. Scapular tip (arrow) was inserted into defects of tibial fenestration.

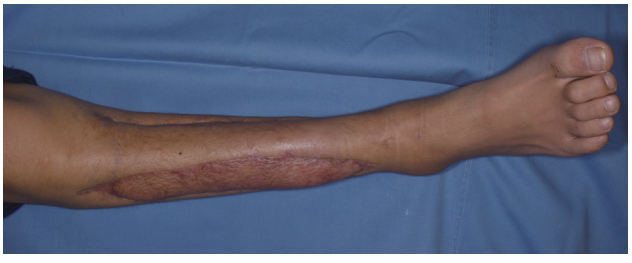

Fig. 4. Postoperative results at 7 months (1 year after cardiac arrest).

The most important point for the satisfactory outcome in this case was the availability of a wide range of composite flaps to reconstruct virtually any kind of defects that could be brought about after extensive debridement. In particular, osseous reconstruction enabled us to perform tibial sequestrectomy. Infection control of the wound bed is critical for flap survival. Without osseous reconstruction, we could not debride the tibial bone to eradicate osteomyelitis; so we would have no choice but to amputate. Among the various free flaps proposed for lower limb reconstruction,[4,5,7–9] the subscapular composite flap was suitable for the present case because of its low donor site morbidity,[7] early bone union,[8] and availability of simultaneous transfer of bone and soft tissue with a single vascular pedicle for limited recipient vessels in the lower extremity. The osseous reconstruction with the scapula bone enabled aggressive tibial debridement not only to enhance flap survival but also to prevent recurrence of osteomyelitis.[10] In addition, it enabled full weight bearing, which definitely contributed to good functional outcome and great patient satisfaction in the present case.

Takeaki Hidaka, MD
Department of Plastic, Reconstructive and Aesthetic Surgery
The University of Tokyo Hospital
7-3-1, Hongo, Bunkyo, Tokyo 1138655, Japan
E-mail: tahidaka1986@gmail.com

ACKNOWLEDGMENT

This study was conducted in accordance with the Declaration of Helsinki.

REFERENCES

1. Bonicolini E, Martucci G, Simons J, et al. Limb ischemia in peripheral veno-arterial extracorporeal membrane oxygenation: a narrative review of incidence, prevention, monitoring, and treatment. *Crit Care*. 2019;23:266.
2. Chow J, Alhussaini A, Calvillo-Argüelles O, et al. Cardiovascular collapse in COVID-19 infection: the role of veno-arterial extracorporeal membrane oxygenation (VA-ECMO) [published online ahead of print April 8, 2020]. *CJC Open*. 2020;2:273–407.
3. Corrado D, Link MS, Calkins H. Arrhythmogenic right ventricular cardiomyopathy. *N Engl J Med*. 2017;376:1489–1490.
4. Allen RJ, Dupin CL, Dreschnack PA, et al. The latissimus dorsi/scapular bone flap (the "latissimus/bone flap"). *Plast Reconstr Surg*. 1994;94:988–996.
5. Miyamoto S, Kayano S, Fujiki M, et al. Early mobilization after free-flap transfer to the lower extremities: preferential use of flow-through anastomosis. *Plast Reconstr Surg Glob Open*. 2014;2:e127.
6. Bosse MJ, Teague D, Reider L, et al. Outcomes after severe distal tibia, ankle, and/or foot trauma: comparison of limb salvage versus transtibial amputation (OUTLET). *J Orthop Trauma*. 2017;31:S48–S55.
7. Sekiguchi J, Kobayashi S, Ohmori K. Use of the osteocutaneous free scapular flap on the lower extremities. *Plast Reconstr Surg*. 1993;91:103–112.
8. Tachi M, Toriyabe S, Imai Y, et al. Versatility of chimeric flap based on thoracodorsal vessels incorporating vascularized scapular bone and latissimus dorsi myocutaneous flap in reconstructing lower-extremity bone defects due to osteomyelitis. *J Reconstr Microsurg*. 2010;26:417–424.
9. Taylor GI, Miller GD, Ham FJ. The free vascularized bone graft. A clinical extension of microvascular techniques. *Plast Reconstr Surg*. 1975;55:533–544.
10. Simpson AH, Deakin M, Latham JM. Chronic osteomyelitis. The effect of the extent of surgical resection on infection-free survival. *J Bone Joint Surg Br*. 2001;83:403–407.