Vascular Specialist International
Vol. 36, No. 3, September 2020
pISSN 2288-7970 • eISSN 2288-7989
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Case Report

Acute Traumatic Arterial Occlusions Combined with Massive Morel-Lavallée Lesions Treated by Percutaneous Angioplasty, Multiple Debridements and Skin Grafts

Sungwoo Cho[1], Sangchul Yun[1], Sung Hun Won[2], Dong-Il Chun[2], Chul Han Kim[3], and Byoung Won Park[4]

Departments of [1]Surgery, [2]Orthopedic Surgery, [3]Plastic Surgery, and [4]Cardiology, Soonchunhyang University Seoul Hospital, Seoul, Korea

Morel-Lavallée lesions (MLL) create pre-fascial space by shearing the subcutaneous tissues away from the underlying fascia, in a patient with trauma. Necrosis of the overlying skin can develop over a wide area of the lesion. The lesion might be contaminated by the surgical site due to careless intrusion when treating the combined arteriopathy. A 70-year-old woman presented with avulsion of the skin over the right foot and bilateral leg pain following a car accident. Computed tomography showed bilateral popliteal artery occlusion with large hematoma on both legs. Percutaneous angioplasty was performed with successful restoration of the flow. However, the skin color changes over time. Necrosis of the skin occurred over a wide area of the right leg. Extensive debridement was performed, and the defect was covered with a skin graft. MLLs can occur in patients with multiple traumas, multiple vascular injuries, and complex skeletal injury. Vascular surgeons treating multiple traumas should be aware of the diagnostic and management options for MLL. It should be diagnosed early because it can be difficult to manage once the overlying skin develops necrosis.

Key Words: Morel-Lavallée, Popliteal artery, Angioplasty, Stents, Thrombosis, Occlusion

Received May 6, 2020
Revised August 12 2020
Accepted September 6, 2020

Corresponding author: Sangchul Yun
Department of Surgery, Soonchunhyang University Seoul Hospital, 59 Daesagwan-ro, Yongsan-gu, Seoul 04401, Korea
Tel: 82-2-709-9243
Fax: 82-2-749-0449
E-mail: ultravascsurg@gmail.com
https://orcid.org/0000-0002-6321-4319

Vasc Specialist Int 2020;36(3):174-179 • https://doi.org/10.5758/vsi.200027

INTRODUCTION

Endovascular treatment for vascular injuries after blunt trauma is feasible and effective [1]. However, it has some limitations in patients with multiple trauma with open fracture, unstable vital parameters, loss of consciousness, or complete loss of arterial patency. Hence, many patients with multiple trauma with concomitant arterial injuries require open surgery. However, endovascular treatment could be a better choice than open surgical technique in some patients with blunt trauma.

Morel-Lavallée lesions (MLLs) can occur in patients with multiple trauma. The main causes are high force, blunt trauma, or crush injuries. MLLs develop by creating cavities in the pre-fascial plane, due to shearing of the subcutaneous tissues away from the underlying fascia, resulting in damaged trans-aponeurotic capillaries and lymph vessels. The blood supply to the overlying skin becomes interrupted, and skin necrosis and wound infection might occur [2]. A skin incision over the area with MLLs is not recommended in this situation. If feasible, endovascular treatment might be a better choice than open surgery in terms of infection control. We report here a case of massive MLLs with progressive skin necrosis despite prompt restoration of the obstructed artery.

The case report was approved by the Soonchunhyang University Seoul Hospital Institutional Review Board (SCHUH 2019-05-024). The patient has provided informed consent for publication of the case.

CASE

A 70-year-old woman was crossing at the crosswalk when a truck loaded with concrete mix passed over the patient's instep. She arrived at the hospital 40 minutes after the accident. She presented with avulsion of the skin of the right foot, and bilateral leg pain. There was no physical injury other than that on the lower limbs. Her past medical history revealed that she had been taking hypertensives and had undergone surgery for retinal detachment in the right eye one year ago. Her blood pressure was 90/59 mmHg, pulse rate was 87 bpm, respiration rate was 20/min, body temperature was 36.1°C, O_2 saturation was 99%, and the numerical pain score was 4 points. The initial Glasgow Coma Scale score was 15 points. Physical examination showed a pale conjunctiva, prolonged capillary refill time, a 7×10 cm skin defect on the dorsal surface of the injured area on the foot, and a light bruise on the right leg (Fig. 1A). The right leg showed reduced skin sensation and increased skin mobility with the presence of fluctuance along the entire leg. Arterial pulsation was not palpable at both ankles. Plain X-ray showed bilateral tibio-fibular fractures and right calcaneal and pelvic bone fractures. These multiple fractures prevented movement of the legs. Her hemoglobin level was 12.5 g/dL and hematocrit was 37.8%. The initial computed tomography (CT) scan showed total occlusion of the right popliteal artery (1 cm length), and the left distal popliteal artery and trifurcation of below knee arteries (Fig. 2A). A large and multifocal hematoma was seen on the right hip and on the both lower extremities without any focus of active bleeding. The digital oximeter showed no pulse at the first and second toes of the right foot. Doppler ultrasound showed no Doppler signal over the right popliteal and anterior tibial artery, and low amplitude of pulsation wave over the left posterior tibial artery. The skin color on the right leg gradually changed over time. Angiogram of the right lower extremity revealed total occlusion of the right popliteal artery due to traumatic dissection with thrombosis. Thrombo-aspiration and stent insertion was performed 9 hours after the patient's arrival at the hospital. A Supera 6.0-mm stent (Abbott, St. Paul, MN, USA) was inserted, and the final angiogram showed patent right

Fig. 1. Temporal change in the right leg after the injury. (A) Eight hours after the injury, purplish discoloration of the entire right leg was seen. (B) Skin necrosis gradually advanced 2 days after trauma, with skin defect on the dorsum of the foot. (C) Skin necrosis was well demarcated 10 days after the injury. (D) Repeated necrosectomy was performed. (E). Split-thickness skin graft was performed with mesh split thickness skin graft and dermal graft with AlloDerm. (F) Complete healing was achieved 4 months after the injury.

https://doi.org/10.5758/vsi.200027

popliteal artery (Fig. 2B, C). To prevent infection, empirical antibiotics were administered. Cefazolin 2 g was injected intravenously every 8 hours. However, the skin color of the right leg showed ongoing changes over time. Gradually, necrosis of the skin occurred over a wide area of the right leg, except for the foot and toes (Fig. 1B). The right foot was warm to touch compared to the left leg, on which the vascular intervention had not been performed yet. The pulsation of the right dorsalis pedis was palpable. The oxygen saturation at the right great toe, which was undetectable before the intervention, was 99% on the digital oximeter. Angiogram of the left lower extremity also showed total occlusion of the below-the-knee popliteal artery and crural arteries due to traumatic dissection with thrombosis.

Balloon dilation was performed 24 hours after the patient's arrival at the hospital (Fig. 2D). Thus, the blood flow in the arteries of both legs was restored. Follow-up CT showed good patency of both popliteal arteries (Fig. 2E). Magnetic resonance imaging (MRI) revealed an extensive hematoma in the subcutaneous fat layer on the lateral aspect of the right proximal thigh and diffuse soft tissue swelling of the right proximal thigh (Fig. 2F, G). CT and MRI imaging revealed MLL lesions distributed in the right proximal thigh, on the lateral/posterior aspect of the distal thigh bilaterally, on the lateral/anterior aspect of the knee joint area bilaterally, and on the proximal portion of the lower legs bilaterally. Despite the first-line therapies for MLLs, including rest, compression bandaging, nonsteroidal anti-inflammatory drugs, physiotherapy, and percutaneous aspiration, a large part of the skin developed necrosis (Fig. 1C). Sclerosing agents were not used due to the risk of necrosis of the overlying skin. Synthetic glues did not seem effective due to a large amount of fluid collection. Instead of repetitive aspiration, we placed a closed drain at the right proximal thigh. After one week, based on the results of the bacterial culture test, piperacillin/tazobactam which

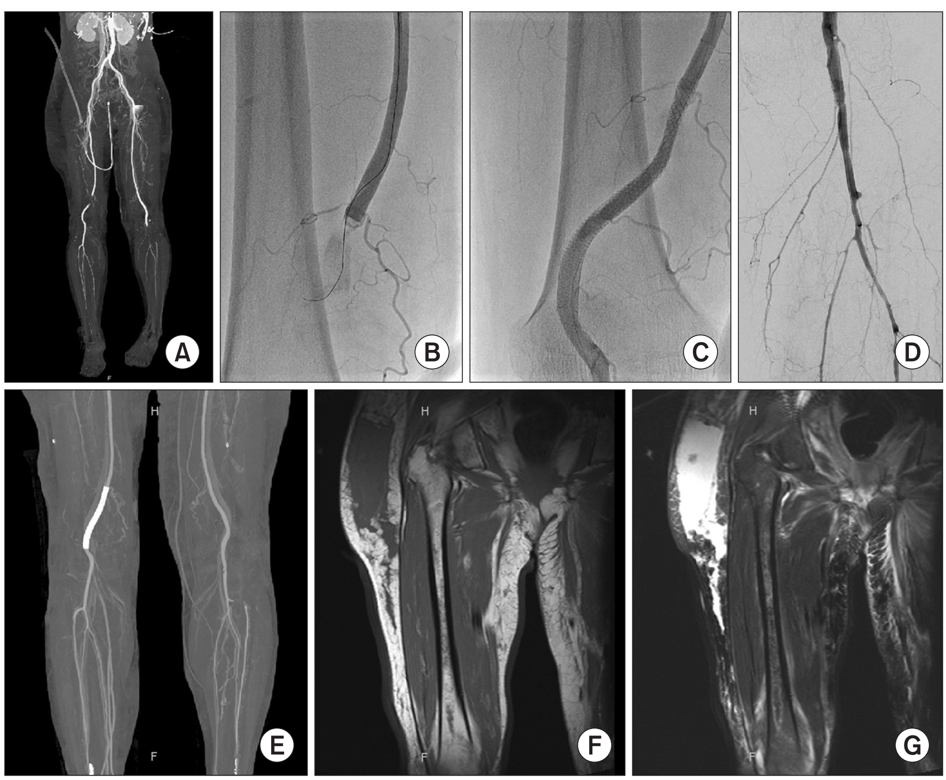

Fig. 2. (A) Computed tomography angiography (CTA) showed segmental total occlusion of the right proximal popliteal artery and total occlusion of the left popliteal artery and trifurcation below-the-knee. Diffuse and multifocal hematomas are seen in the right buttock and in the lower extremities bilaterally, without evidence of active bleeding. (B) Contrast angiography confirmed thrombotic dissection and total occlusion of the right proximal popliteal artery. (C) Supera 6.0×80 mm stent was inserted, and the blood flow was restored. (D) After performing thrombo-aspiration and balloon dilation, distal flow was restored in the left calf with mild residual stenosis in the popliteal artery due to traumatic dissection. (E) Follow-up CTA showed a patent stent in the right popliteal artery and a patent left popliteal artery with proximal anterior tibial artery occlusion. (F, G) Magnetic resonance imaging showed extensive hematoma in the subcutaneous fat layer; lateral aspect of the right proximal thigh with diffuse soft tissue swelling.

has antibacterial activity against both *Staphylococcus aureus* and *Klebsiella pneumonia* was injected at a dose of 4.5 g intravenous injection per 6 hours. Due to the multiple fractures and extensive soft tissue damage, oozing of the exudates, including the blood, continued and the hemoglobin level decreased to 5.5 g/dL. Hence, antithrombotic or antiplatelet agents were not used immediately after the interventional procedure. The bleeding reduced and clopidogrel was started on the 7th day after hospitalization. However, clopidogrel had to be discontinued several times for multiple debridement and skin grafts. About 45 days after hospitalization, several strains such as methicillin-resistant *S. aureus*, *K. pneumonia*, and *Acinetobacter baumannii* were cultured from the wound site, and the antibiotics were changed to ceftriaxone+teicoplanin. About 9 weeks after hospitalization, she developed pseudomenbranous colitis, and the antibiotic was changed to oral vancomycin for 10 days. *Clostridium difficile* infection improved; however, the ceftriaxone+teicoplanin therapy was continued due to signs of local infection such as discharge at the surgical site. Several debridement procedures for the skin necrosis were performed and, finally, the defect was covered with a skin graft (Fig. 1D-F). The treated arteries were patent at the 14-month follow-up period after the intervention. A detailed timeline of the progress and management is listed in Table 1.

DISCUSSION

MLLs were first reported by Victor Auguste-Francois Morel-Lavallée in 1863 [3]. The main causes of MLLs are high-force, blunt trauma, or crush injury. MLLs develop as a result of subcutaneous tissues degloving from the underlying fascial layers, creating a cavity in the pre-fascial plane. As a result of the separation of the skin and subcutaneous layers, the trans-aponeurotic capillaries and lymphatic vessels are damaged. Accumulation of blood and lymphatic fluid creates the subcutaneous cavity. The size of the cavity

Table 1. Summary of the hospital course of the patient

Time	Progress	Management
Admission	Total occlusion of the right popliteal artery, total occlusion of the left tibio-peroneal trunk and left proximal anterior tibial artery	Supera stent, thrombo-aspiration, balloon angioplasty, cefazolin iv
	Bilateral fractures of the proximal tibia and fibular head, right bilateral malleoli, right cuboid, calcaneus, right superior pubic ramus, right side symphysis pubis, coccyx fracture	Splint for multiple fractures of both lower extremities
POD # 2	Open wound, right foot dorsum	Debridement, irrigation
POD # 6	Massive subcutaneous fluid accumulation in the right thigh	Closed hemovac drain insertion
POD # 14	Skin necrosis, right lower extremity, wound culture (*Klebsiella pneumonia*)	Debridement, Piperacillin/tazbactam iv
POD # 17	Skin necrosis, right lower extremity	Debridement, CuraVac[a]
POD # 21	Skin necrosis, right lower extremity	Debridement, CuraVac
POD # 25	Skin necrosis, right lower extremity	Debridement, CuraVac
POD # 29	Skin necrosis, right lower extremity	Debridement, CuraVac
POD # 34	Skin necrosis, right lower extremity	Debridement, CuraVac
POD # 43	Tendon and bone exposure at the right knee, popliteal, ankle area	Split-thickness skin graft [Mesh STSG & dermal graft with AlloDerm]
POD # 48	Wound culture (*K. pneumonia*, MRSA, *Acinetobacter baumannii*)	Ceftriaxone+teicoplanin iv
POD # 63	Granulation tissue over the uncovered raw surface	Debridement
POD # 69	*Clostridium difficile* infection	Oral vancomycin for 10 days
POD # 72	Skin defect at right proximal thigh	Split-thickness skin graft
POD # 76	Bony union at fracture site	Initiation of weight bearing
POD # 90	Superficial wound discharge in the right leg	Ceftriaxone+teicoplanin iv
POD # 98	Wound nearly healed	Initiation of walking exercise
POD # 104	Wound healed	Discontinuation of antibiotics
POD # 120	Recurrence of *C. difficile* infection	Oral vancomycin
POD # 150		Discharge from hospital

POD, post-operative day; iv, intravenous injection; MRSA, methicillin-resistant *Staphylococcus aureus*; STSG, split thickness skin graft.
[a]CuraVac, CGBIO, Seongnam, Korea.

https://doi.org/10.5758/vsi.200027

depends on the number of disrupted lymphatic and blood vessels. MLLs after blunt trauma are frequently combined with underlying fractures, particularly of the acetabulum and pelvis [2].

MLLs covering a large area could lead to necrosis of the overlying skin. This can result in the breakdown of large areas of the skin and exposure of the underlying structures. Several cases of surgical site contamination after inadvertent entry into the MLL cavities during fracture fixation have been reported [4]. The consensus of orthopedic surgeons is that the direct approach to bone fractures via MLLs entails a higher risk of infection. MLLs are considered as a potential cause of hemorrhagic shock and subsequent source of infection. To reduce the risk of infection due to metalwork or osteomyelitis, definitive management of MLLs should be postponed until the fracture fixation is complete and the wound is healed [5]. Knowledge about this consensus approach is useful for the vascular surgeon. Endovascular treatment has been shown to be helpful for patients as it avoids direct entry into the MLLs that possesses a risk of wound infection due to exposure through the overlying skin.

Endovascular treatment in vascular trauma has been described for the treatment of penetrating injuries; however, its use in blunt trauma has rarely been reported [1,6]. One study reported 10 males with peripheral arterial injuries treated by endovascular interventions. The types of lesions included four pseudoaneurysms, four dissections, one expanding hematoma, and one arterio-venous fistula. The limb salvage rate was 100%. One case of late occlusion of a popliteal stent-graft was managed with another endovascular procedure [1]. Another study reported 62 patients with arterial trauma. The success rate of the stent insertion was 93.5%. Stent insertion for vascular trauma showed promising results with comparable patency, and lower rates of major morbidity and mortality, compared with conventional open surgery [6]. If endovascular treatment is possible, it is better than open surgery in terms of skin infection. Hence, we elected to perform stent insertion instead of open surgery. Treatment of huge MLLs with debridement, drainage, and dead space management was continued after successful restoration of arterial insufficiency.

There is no approved management for MLLs. Management options depend on the clinical condition and patient characteristics. Some authors supported a stage-based management approach [2], whereas others prefer to individualize the treatment. A new treatment algorithm that has recently been proposed appears to be reasonable [3]. It helps distinguish between acute and chronic lesions. Absolute indications for surgical exploration include acute lesions associated with open fractures, skin necrosis, and infection. Surgical intervention might also be considered for unsuccessful non-surgical management, chronic symptomatic lesions, and lesions associated with closed fractures requiring open fixation. Minimally invasive techniques prevent the morbidity associated with surgery and anesthesia. Management objectives include drainage, debridement, and dead space management, as well as definitive management of the relevant injuries. If the overlying skin shows necrosis, debridement of the necrotic tissue is required with subsequent skin grafting. If the overlying skin appears viable, drainage can be achieved percutaneously or through an open skin incision. During open drainage, curettage or capsulectomy might be required to induce fibrosis. Quilting sutures, fibrin sealant, and low-suction drains can be used to close the dead space.

The accumulation of hemorrhagic fluid that forms the MLLs is caused by the rupture of cutaneous perforators. It is only the connection between the adjacent angiosomes and the subdermal plexus that maintains skin viability when cutaneous perforators have been disrupted. Skin viability is threatened in areas where these anastomoses are tenuous. In the current patient, large numbers of perforator vessels were involved, which led to massive skin necrosis. Perforators of the profunda femoris, popliteal, descending geniculate, sural, anterior tibial, lateral femoral circumflex, adductor, and superficial femoral angiosomes seem to be associated with skin necrosis [7]. Hence, the skin necrosis progressed rapidly although occlusion of the right popliteal artery was treated immediately with stent insertion. Diagnosis and evaluation of the arterial lesion with concomitant MLLs is a challenge as necrotic soft tissue does not necessarily indicate proximal arterial insufficiency. In the current patient, CT angiography performed in the emergency room did not show active bleeding. However, there was an accompanying fracture, acute subcutaneous bleeding continued, and the skin necrosis progressed rapidly; however, the MLL lesions were initially not known. Skin discoloration progressed even after the stent was inserted, and on re-examination, the accompanying MLL lesions were revealed. The skin of the entire lower extremity was necrosed. The patient fully recovered after repeated debridement and skin flap grafting. Another option to treat this can be open thrombectomy, debridement, and dead space obliteration to prevent skin necrosis.

In conclusion, MLLs are often diagnosed incorrectly or at a late stage. In the current patient with acute trauma, vascular lesions were treated with stents. However, skin necrosis over a large area continued due to an unidentified MLL lesion. As the prevalence of MLL among patients with pelvic trauma approaches 10% [5], vascular surgeons treating multiple traumas should be aware of the diagnostic and management options for MLL. MLLs that cover a wide area can cause necrosis of the overlying skin. Early diagnosis of MLL is recommended because treatment becomes very difficult once skin necrosis occurs.

FUNDING

This work was supported by the Soonchunhyang University Research Fund.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

ORCID

Sungwoo Cho
https://orcid.org/0000-0002-7206-798X
Sangchul Yun
https://orcid.org/0000-0002-6321-4319
Sung Hun Won
https://orcid.org/0000-0002-5471-7432
Dong-Il Chun
https://orcid.org/0000-0001-7255-8984
Chul Han Kim
https://orcid.org/0000-0002-1355-2942
Byoung Won Park
https://orcid.org/0000-0002-7137-9025

AUTHOR CONTRIBUTIONS

Concept and design: SC, SY. Analysis and interpretation: SC, SY. Data collection: SHW. Writing the article: SC, SY. Critical revision of the article: CHK. Final approval of the article: CHK. Statistical analysis: BWP. Obtained funding: SY. Overall responsibility: SY.

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https://doi.org/10.5758/vsi.200027