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IDEAS AND INNOVATIONS

Reconstructive

A Shaped Pectoralis Major Muscle Flap under Indocyanine Green Fluorescence Angiography for Sternal Wound Infection

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Summary: The treatment of a sternal wound infection is challenging because it requires radical debridement and reconstruction with a well-vascularized flap. The defects after debridement are three-dimensionally complex, especially if synthetic grafts are involved. Although the pectoralis major muscle (PMM) flap is useful for reconstruction, it is difficult to fill up the complex dead space surrounding the vascular prosthesis when using a conventional PMM flap. Herein, we describe a new technique of splitting and shaping the PMM flap to fit the complex defect. Intraoperative indocyanine green fluorescence angiography was used to assess dynamic blood flow of the PMM supplied by internal mammary artery perforators. This technique allows the PMM flap to be split and shaped to securely fit the dead space, which may improve the healing rate. *(Plast Reconstr Surg Glob Open 2024; 12:e5876; doi: 10.1097/GOX.0000000000005876; Published online 6 June 2024.)*

PROCEDURE DESCRIPTION IN A REPRESENTATIVE CASE

A representative case was a 51-year-old woman with an exposure of axillo-axillary bypass graft. She had Takayasu's arteritis, which is a type of autoimmune vasculitis that causes inflammation of the large arteries. The first cardiac surgery of axillo-axillary arterial bypass graft was performed at 50 years old due to the occlusion of the left subclavian artery. At 1 year after the first surgery, she underwent total arch replacement because of ascending and arch aorta stenosis. At 1 month after total arch replacement, the axillo-axillary bypass graft was exposed following surgical site infection. [**See figure, Supplemental Digital Content 1,** which displays the sternal infection in the postoperative course of open-heart surgery resulted in exposure of the axillo-axillary bypass graft. (a) The yellow arrow indicates the prosthetic vascular graft was exposed in the middle of the wound. (b) The left axillary artery was supplied from the right subclavian artery via the graft (purple). **http://links.lww.com/PRSGO/D266**.]

The surgery of debridement and filling the dead space was performed. The defect size was about 10 cm × 3.5 cm × 3.5 cm (length × width × depth), and the form was complicated with the graft crossing the space after removal of the infected sternum. It was reconstructed with a pectoralis major muscle (PMM) flap shaped under the guidance of intraoperative indocyanine green fluorescent angiography (ICG-FA). ICG-FA was recorded by the near-infrared imaging system "PGE-neo" (Hamamatsu Photonics, Japan).

A PMM flap pedicled with an internal mammary artery perforator (IMAP) was elevated from the prior incision of left mammary carcinoma. The thoracoacromial artery was identified at the back side of the PMM flap. ICG-FA with clamping of thoracoacromial artery and lateral thoracic artery enabled optimization of blood flow from the third IMAP intraoperatively. Under the guidance of ICG-FA, the flap was split and shaped like a "crab claw" to fit the complex three-dimensional wound. The splitting procedure was performed through the near-infrared camera image and a macroscopic view (Figs. 1 and 2) [**See Video (online),** which shows that blood flow from the third intercostal perforator was identified intraoperatively and traveled in the direction of the thoracoacromial and lateral thoracic vessels. Using near-infrared video, the PMM flap was split and shaped like a crab claw

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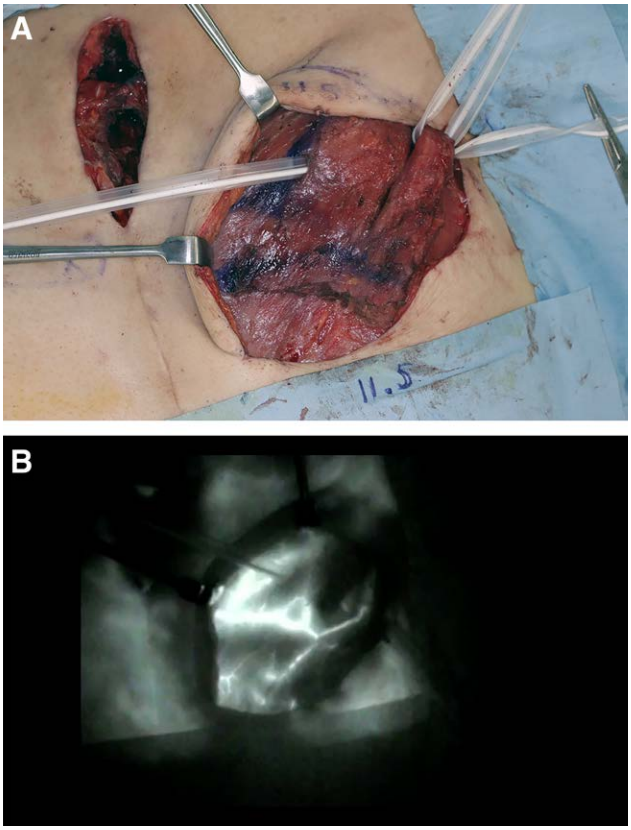

Fig. 1. The PMM flap was pedicled with the third intercostal internal mammary artery perforator (IMAP). A, Macroscopic view: the flap was split and shaped like a "crab claw" under indocyanine green fluorescent angiography (ICG-FA). B, The dynamic blood flow from the IMAP was identified with ICG-FA. The blood flow bifurcated toward the thoracoacromial artery and the lateral thoracic artery.

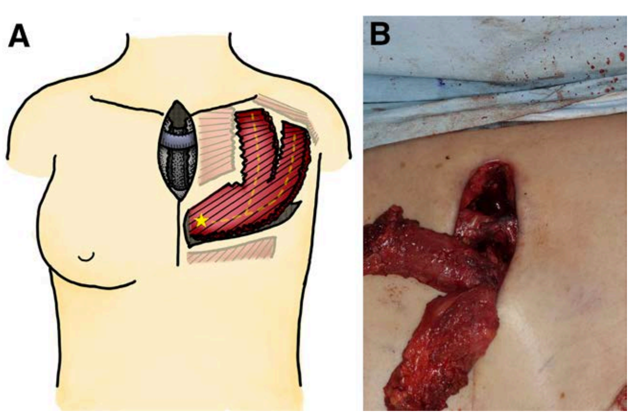

Fig. 2. Schematic and intraoperative view. A, A schematic of the flap shape and transposition to the defect. The yellow star indicates the third IMAP of the flap pedicle. The dotted line indicates the blood flow in the flap identified by ICG-FA. B, The defect was spread wide and deep behind the exposed synthetic graft. The split PMM flap was transposed to the defect.

Takeaways

Question: The treatment of a sternal wound infection is challenging because radical debridement is necessary. The defects are usually three-dimensionally complex; therefore, the flap for the reconstruction has to be a flexible form to fill the dead space.

Findings: The application of indocyanine green fluorescence angiography enables us to clarify the angiosome of muscle flaps in detail dynamically; therefore, muscle flaps could be shaped and split into intricate forms.

Meaning: Indocyanine green fluorescense angiography helps split and shape muscle flaps.

to cover the entire circumference of the exposed graft. The exposed graft was sanded with a "claw." Using indocyanine green fluorescent angiography guidance, the pedicle of the PMM flap was refined and could expand to reach the flap area.] The vascular pedicle of PMM flap was dissected finely to increase the flap mobility. The PMM flap was about 21 cm in length from the pivot point of the third IMAP. It could reach the cranial end of the defect sanding the graft with crab claw–shaped muscle flap. The surface of the muscle flap was covered with a split-thickness skin graft. Antibiotic treatment had been kept for 2 months, and no wound dehiscence or recurrence of wound infection were identified in 4 years of follow-up after the surgery.

DISCUSSION

Sternal wound infection is a life-threatening complication of open-heart surgery. Careful treatment is often required, especially if synthetic grafts are involved. Treatment typically involves an aggressive debridement, a wound bed preparation to remove bacteria, and reconstruction with well-vascularized flaps to adequately fill the dead space.[1,2] If surgical procedures cannot be performed, it is reported that lifelong antibiotic treatment should be taken into consideration. For sternal wound reconstructions, a PMM flap pedicled with IMAPs was reported to be a reasonable option.[3] However, its shape is unsuitable in some cases for filling the complex three-dimensional defect involving prosthetic vascular grafts.

To overcome this problem, we used ICG-FA to split and shape a PMM flap. Numerous clinical studies have described the various utilities of ICG-FA, such as selecting suitable perforators of flaps, detecting microvascular anastomotic problems, evaluating the blood perfusion area of flaps, and optimizing subcutaneous lymphatic circulation.[4,5] However, to our knowledge there have been no reports that used ICG-FA for shaping muscle flaps. Onoda et al[6] suggested that ICG-FA could detect perforators in flaps with a tissue thickness of less than 20 mm. Indeed, the average PMM thickness ranges approximately 5–25 mm depending on sex, age, race, and medical history.[7–9] Furthermore, Koo et al[9] reported an average PMM thickness of 21.4 mm in healthy young White men. Thus, the use of intraoperative ICG-FA of PMM for visualizing blood flow should be suitable in most patients. While skin blood perfusion is supplied by spreading the dermal plexus from the perforators (in a random pattern), most muscle flaps have axial blood supplies. Thus, ICG-FA can visualize the blood flow of muscle flaps dynamically and enables the PMM flap to be safely split and shaped to fit the defect.

Rikimaru et al[10] reported that the first, second, or third IMAP has a direct anastomosis with a thoracoacromial artery and the detailed blood circulation of the caudal area of a PMM flap. Additionally, IMAPs are indirectly linked to a lateral thoracic artery. These vascular anatomy findings support the reliability of the entire PMM flap pedicled with IMAPs, as previously reported in clinical studies. Splitting a PMM flap allows coverage of larger and deeper defects compared with the use of one flap, and also allows treatment of complex three-dimensional defects surrounding a prosthetic vascular graft.

The splitting technique under ICG-FA guidance may also be applied to the latissimus dorsi muscle flap, which is thinner than the PMM. The use of the latissimus dorsi muscle flap is also suitable for treating mediastinal wound infections that can reach deep mediastinal regions. The defects after radical debridement can be complex, especially if prosthetic vascular grafts are involved. The defects should be filled up without any dead space using a well-vascularized tissue flap. Thus, the splitting and shaping of the muscle flap using ICG-FA guidance may be a useful technique to achieve a successful reconstructive surgery.

CONCLUSIONS

ICG-FA is useful for intraoperative visualization of vessel anatomy of a PMM flap and allows a PMM flap pedicled with IMAPs to be safely split and shaped. As such, the PMM flap is expanded to reach the target area, and it can be shaped to fit the complex three-dimensional muscle wound. Intraoperative ICG-FA increases the utility of a PMM flap for reconstruction of sternal and mediastinal wounds and can also be applied to other muscle flaps and improve their plasticity.

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DISCLOSURE

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

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