Case Report

Microsurgical vascular clamp injury causing arterial stenosis and subsequent free flap necrosis: A case report

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ABSTRACT

During microanastomosis, the recipient artery must be controlled both proximally and distally, so that the donor flap artery may be anastomosed. Bulldog vascular clamps are often used; however, these clamps may fail to occlude heavily calcified vessels characteristic of diabetes and end-stage renal disease. Alternative clamps may need to be utilized, with the attendant risk of vessel injury. Herein, we present a case of free flap necrosis secondary to vascular clamp-mediated perianastomotic stenosis of a calcified free flap recipient artery. In this case, a 74-year-old diabetic male underwent anterolateral thigh free flap reconstruction for a left medial foot wound. The recipient's dorsalis pedis artery was noted to be heavily calcified intraoperatively and Bulldog clamps were unable to gain proximal and distal control, requiring the use of small-angled DeBakey vascular clamps. Ischemic flap changes were noted on postoperative day four. Subsequent angiogram demonstrated severe stenosis at the perianastomotic sites of the dorsalis pedis where the DeBakey clamps were placed for control. The ar-

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arterial lesions were treated with balloon angioplasty and the patient underwent multiple debridements and placement of a split-thickness skin graft over the wound. At the six-month follow up, the wound achieved complete healing with insetting of the skin graft. In certain cases, the use of DeBakey or Satinsky clamps for arterial control in microsurgery may predispose the artery to intimal injury, causing stenosis that should be recognized early so that arteriography may be performed expeditiously. In this study, alternative methods of vascular control are described.

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Introduction

Free tissue transfer (FTT) is a technically demanding process. During end-to-side microanastomosis, proximal and distal control of the recipient artery must be obtained. Bulldog vascular clamps are often used to achieve this. However, calcified vessels, commonly seen in diabetic and older patients, lack compliance such that microsurgical Bulldog clamps may not fully occlude the vessel, allowing flow across the artery. In addition, calcified plaques can fracture and puncture the arterial wall, resulting in serious arterial injury.

We present a case of a patient with diabetes and calcified peripheral vascular disease who underwent free flap reconstruction for a chronic lower extremity wound and subsequently developed flap necrosis due to vascular clamp-mediated perianastomotic stenosis and subsequent thrombosis of a calcified recipient artery. This report adheres to STROBE guidelines.

Case

A 74-year-old male with poorly controlled diabetes (HbA1c = 8.7%) presented with a non-healing, malodorous left medial foot ulcer with underlying osteomyelitis. The patient was admitted, placed on broad-spectrum antibiotics, and underwent left foot incision and drainage. He subsequently underwent repeat debridement and first ray amputation. Angiogram of the left lower extremity revealed peripheral arterial disease, and the patient underwent balloon angioplasty of the left tibio-peroneal trunk and posterior tibial and anterior tibial arteries. Repeat angiogram demonstrated patent vasculature, including the dorsalis pedis, and the patient was considered a good candidate for FTT reconstruction of his open left foot wound.

The patient elected to proceed with an anterolateral thigh (ALT) free flap reconstruction. The foot wound measured 4 cm x 3 cm and was debrided and irrigated. The ALT flap was harvested in the standard fashion. Two small perforators, and two veins, were isolated from the descending branch of the lateral circumflex femoral artery. A small incision was made proximal to the left foot wound bed to access the anterior compartment and expose the anterior tibial artery, dorsalis pedis artery, and venae comitantes. After the two veins were anastomosed, attention was turned to the arteries. Diffuse calcification was observed in the donor and recipient arteries. Bulldog clamps were used initially to gain proximal and distal control of the dorsalis pedis artery, but severity of calcification prevented full occlusion. Small 60-degree-angled DeBakey vascular clamps were then used for control. Once the anastomosis was complete, the DeBakey clamps were removed and the flap was observed to have good arterial and venous flow. A Cook Doppler (Cook Medical LLC; Bloomington, IN) and ViOptix (ViOptix, Inc.: Newark, CA) were used to monitor flap perfusion postoperatively. The flap was inset around the defect and closed in layers over two drains. The patient tolerated the procedure well and a heparin drip was started before he was sent to the intensive care unit for close monitoring.
Fig. 1. Ischemic changes on the proximal and distal portions on the free flap noted on postoperative day 4.

Postoperatively, the flap showed strong Doppler signals. On postoperative day (POD) 4, some ischemic changes were observed along the proximal portion of the flap; however, the Doppler signals remained strong, and angiogram was therefore not performed. Instead, the patient underwent multiple rounds of hyperbaric oxygen therapy. Despite this, increased ischemic changes were observed along the proximal and very distal portions of the flap (Fig. 1). The patient returned to the operating room on POD 12 for debridement of necrotic tissue and approximation of viable tissue. An INTEGRA graft (Integra LifeSciences; Princeton, NJ) was used for both distal and proximal defects. The patient continued oxygen therapy after debridement and was discharged home on POD 19 from initial free flap surgery.

At the postoperative appointment one week later, the patient’s flap demonstrated appropriate healing. At the patient’s next follow-up appointment one week later, however, the patient’s wound demonstrated deterioration and he was admitted for further care. Vascular surgery was considered given his non-healing wound. Repeat angiogram showed a patent dorsalis pedis artery but new severe stenosis was observed at the perianastomotic site of the dorsalis pedis where DeBakey clamps had been placed intraoperatively for control (Fig. 2). The stenotic area was treated with balloon angioplasty (Fig. 2). The patient subsequently underwent repeat debridement for partial flap necrosis, which ultimately required split-thickness skin graft (STSG) coverage. The patient achieved complete healing of the wound at six months following initial FTT.
Discussion

Multiple surgical instruments including Bulldog clamps, small 60- or 45-degree angled DeBakey clamps, Satinsky clamps, and vessel loops can be used to achieve vessel occlusion during the anastomotic step of FTT. In microsurgery, microsurgical Bulldog clamps are most commonly used and, anecdotally, rarely do they fail to achieve occlusion. Intraoperative assessment of vessel quality and surgeon preference often guide the selection of the occlusive method. Clamp pressure must be sufficient to prevent through or back bleeding, but not excessive, to avoid the risk of damaging the intima. Closing force and strength of the vascular clamp is positively correlated with arterial wall injury.\(^1\)\(^3\)

In this case, Bulldog clamps did not provide adequate control of perfusion due to the severe arterial calcifications, which necessitated the use of small-angled DeBakey clamps.

Angiography performed after flap necrosis revealed stenosis of the dorsalis pedis artery where the DeBakey clamps had been placed, both proximal and distal to the site of anastomosis. In animal studies, increasing pressure using DeBakey clamps has been correlated with increased endothelial damage.\(^3\) DeBakey clamps closed at three notches are a safe and effective method to occlude healthy arteries 4.5–8 mm in diameter and cause minimal endothelial damage.\(^3\) However, severe arterial calcification may predispose a vessel to intimal damage from conventional clamping methods.\(^1\) Medial intimal injury of a clamped artery results in medial hemorrhage, which incites an inflammatory reaction.\(^5\) Subsequent healing involves fibrin deposition, scar formation, and smooth muscle hyperplasia.\(^5\)

Endothelial damage and exposure also increases platelet adherence and aggregation, increasing the risk of thrombus formation.\(^3\) In our experience prior to this case, this type of damage did not compro-
mise the perfusion of newly anastomosed free flaps. We hypothesize that arterial stenosis secondary to clamp damage and inflammation with subsequent overlying thrombosis compromised arterial flow, resulting in flap necrosis. The correlation between the area of arterial stenosis and intraoperative DeBakey clamp placement suggests injury of a vessel with underlying disease secondary to diabetes, as opposed to progressive flap perfusion compromise. In addition, the reperfusion of the stenotic segment achieved with balloon angioplasty further suggests arterial injury.

Existing evidence suggests that calcified vessels can be safely occluded via other, less-traumatic modalities. Misare et al. demonstrated successful vascular occlusion of severely calcified vessels using intraluminal vessel occluders, with similar long- and short-term bypass graft patency rates between calcified and non-calcified groups. Ballotta et al. similarly found intraluminal occluders to be safe and effective in calcified vessels.

In the absence of intraluminal occluders, 2F or 3F Fogarty arterial embolectomy catheters (Edwards Lifesciences Corp., Irvine, CA) with 3-way stopcocks may be placed perianastomotically (Fig. 3). In our experience, this modality provides adequate arterial control while limiting intimal damage. Georgakarakos and Kostoglou described another “no clamp” technique for calcified vessels in which a 6 or 8 French feeding tube is inserted into the artery and then occluded using a double encircled vessel loop. We do not have experience with this technique; however, it may provide an effective occlusive method for calcified vessels. Although this study does not prove causality, we hypothesize that the use of a less traumatic vascular occlusion modality may have prevented postoperative arterial stenosis and subsequent flap necrosis in this case.

Diffuse vascular calcifications are often observed in patients with diabetes. When a heavily calcified vessel is observed during FTT, intraluminal vessel occluders, or other less traumatic techniques, should be considered for vessel occlusion to minimize intimal trauma of an already compromised endothelium.
Ethical Approval

IRB approval was obtained. IRB 2018–173: MedStar Plastic Reconstructive Surgery Outcomes Registry.

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Declaration of Competing Interest

There are no financial disclosures, commercial associations, or any other conditions posing a conflict of interest to report for any of the above authors.

References

1. Tomonori T, Fumihiro M, Michio Y, Akio M. Prevention of back bleeding during carotid endarterectomy: analysis of clamping techniques. World Neurosurg. 2019;131:e186–e191. doi:10.1016/j.wneu.2019.07.114.
2. Georgakarakos E, Kostoglou P. The “no clamp” technique for anastomosis in calcified vessels. Eur J Vasc Endovasc Surg. 2020;59(3):483. doi:10.1016/j.ejvs.2019.11.036.
3. Margovsky A. The effect of increasing clamping forces on endothelial and arterial wall damage: an experimental study in the sheep. Cardiovasc Surg. 1999;7(4):457–463. doi:10.1016/s0967-2109(98)00154-9.
4. Misare BD, Pomposelli FB, Gibbons GW, et al. Infrapopliteal bypasses to severely calcified, unclampable outflow arteries: two-year results. J Vasc Surg. 1996;24(1):6–16. doi:10.1016/S0741-5214(96)70139-8.
5. Bunt TJ, Manship L, Moore W. Iatrogenic vascular injury during peripheral revascularization. J Vasc Surg. 1985;2(3):491–498. doi:10.1016/0741-5214(85)90110-7.
6. Ballotta E, Renon L, Toffano M, Piccoli A, Da Giau G. Patency and limb salvage rates after distal revascularization to unclam- pable calcified outflow arteries. J Vasc Surg. 2004;39(3):539–546. doi:10.1016/j.jvs.2003.09.029.