Case Report
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Reconstruction of High-Pressure Paint Gun Injection Injured Finger Using Free Flaps with T-Shaped Pedicles and Multiple Venous Anastomoses

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High-pressure (HP) injection injury to the upper extremity often causes a very serious clinical problem, leading to poor outcomes, including amputation, so that a true surgical emergency is required. The outcomes can be improved with emergent wide surgical debridement. However the diagnosis of these injuries is often delayed due to underestimated evaluation at first appearance and lack of common knowledge of the seriousness of this injury. The type and pressure of the infecting material is an important factor in prognosis and organic solvents infected pressure injury can cause poor outcome and increased amputation rate. In this case, we report on reconstruction of HP oil-based paint injection injuries of the finger using T-shaped pedicles and multiple venous anastomoses. In this concept, arterial flow can be maintained by the reverse flow of distal anastomosis when there is difficulty with the proximal anastomosis. And venous flow can be preserved by deep and superficial vein anastomosis. This concept has various advantages including preserving patency of the pedicle in chronic vasculopathy or trauma cases and maintaining the arterial flow by the reverse flow of distal anastomosis and can improve the free flap survival by a two vascular anastomosis system.

Key Words: High pressure, Paint, Anastomosis, Free flap

High-pressure (HP) injection injuries to the hand are uncommon but often cause very serious clinical problem and lead to poor outcomes. Initial treatment should include urgent evaluation by a hand surgeon, broad-spectrum antibiotics, tetanus prophylaxis, radiographic imaging and early surgical debridement.[1] Prognostic factors include type of the material injected, pressure of the injected material, and initial neurovascular status of the digit at presentation. For the type of injected material, injuries caused by organic solvents such as paint, thinner, diesel fuel, gasoline, jet fuel, oil have a significantly increased risk of amputation when compared with less caustic substances. Also the type of paint injected also has a significant effect on amputation rate, with latex paints (6%) being less damaging than oil-based paints (58%).[2] Wound management varies and may consist of loose closure, dressing changes, or negative-pressure wound dressing. And there are some reconstructive options including amputation, delayed primary closure, local flaps, and heterodigital or free island flaps.[1] In this report, we performed anterolateral thigh (ALT) free flap with T-shaped pedicles and multiple venous anastomoses for reconstruction of HP injection jnjured finger and it showed the necessity of multiple anastomoses.

CASE REPORT

A 61-year-old male presented with left 4th finger injury by HP oil-based paints injection. At first, we conducted early wide debridement and applied broad-spectrum antibiotics.

Fig. 1. Ischemic necrosis of left 4th finger was shown.

But ischemic necrosis with complete demarcation at distal interphalangeal joint level and infection occurred with loss of sensitivity because of severe soft tissue injury with neurovascular damage including common digital artery (Fig. 1). So we considered amputation for ischemic digit, but the patient strongly expected salvage operation. Then we planned 10×5 cm sized ALT free flap coverage for reconstruction. In harvesting pedicles, a selected perforator which had largest diameter and both end of the descending branch of lateral circmuflex femoral artery (D-LCFA) and two venae comitantes (VC1, VC2) formed T-shape pedicle. After flap insetting, harvested T-shaped arterial pedicle was interpositioned between each end of the divided superficial palmar arch (SPA). And proximal and distal end of D-LCFA were anastomosed to proximal and distal end of SPA by T-anastomosis to rebuild deficient vascular flow. In venous anastomosis, proximal end of VC1 and VC2 of flap were anastomosed to proximal end of dorsal metacarpal vein (DMV) and proximal end of VC1 of SPA. Distal end of VC1 of flap were anastomosed to distal end of VC1 of SPA (Fig. 2).

Postoperatively, the flaps survived well and there were no notable complications. About 6 months later, we performed the secondary debulking procedure to achieve a thin viable flap (Fig. 3). The distal flow from anastomosis site was patent in computed tomography angiography (Fig. 4).

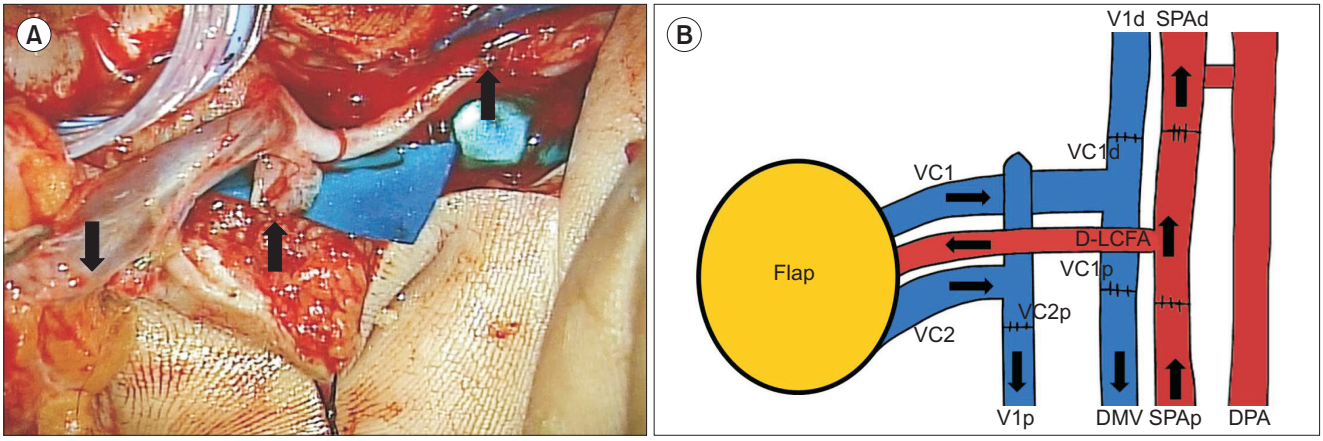

Fig. 2. (A) Vascular anastomoses were perforemd using dual supercharging. Left arrow: anastomosis between proximal end of VC1 and dorsal metacarpal vein. Middle arrow: anastomosis between proximal end of VC2 of flap and proximal end of V1. Right arrow: anastomosis between proximal end of D-LCFA and proximal end of SPA, anastomoses between 1) distal end of SPA and D-LCFA, 2) dorsal metacarpal vein and VC1, 3) distal end of V1 and VC1 were not shown in photograph. (B) A diagram of dual supercharging. In arterial anastomsis, proximal and distal end of D-LCFA were anastomosed to proximal and distal end of SPA (SPAp, SPAd) by T-anastomosis to rebuild deficient vascular flow. In venous anastomosis, proximal end of VC1 and VC2 of flap (VC1p, VC2p) were anastomosed to proximal end of DMV and proximal end of V1 of SPA (V1p). Distal end of VC1 of flap (VC1d) were anastomosed to distal end of V1 (V1d). Connecting vessel between SPA and DPA was not shown. D-LCFA: descending branch of the lateral circumflex femoral artery, VC1 and VC2: venae comitant 1 and 2 of flap, V1: venae comitant 1 of recipient, SPA: superficial palmar arch, DMV: dorsal metacarpal vein, DPA: deep palmar arch.

Fig. 3. In postoperative finding after debulking procedure (6 months), the flaps survived well and there were no notable complications.

Fig. 4. In postoperative computed tomography angiography after 6 months, distal flow from anastomosis site was patent.

DISCUSSION

HP injection injury to the upper extremity remains a true surgical emergency. Outcomes can be improved with emergent wide surgical debridement in 6 hours after trauma. In classification of severity for HP injection injuries by Wong et al.,[3] out case corresponded with severe state that need emergent debridement and late reconstruction. And it is impossible to prevent ischemic change of injuried finger because of severe soft tissue injury by oil-based paint injection that have a significantly high risk of amputation. In this situation, we performed dual connecting ALT free flap for reconstruction of injuried digit.

To discuss about multiple venous anastomoses, it means arterial and venous dual vascular system in vascular anastomosis and flap can survive with other intact vascular system or back-up system when a single anastomotic vessel causes any problems like thrombosis or obstruction.

For arterial dual connecting, it is similar to flow-through flap or T-anastomosis that recipient and donor vessel is connected to forward direction.[4] The difference is that dual connecting can be applied where more than two major arterial communication site such as ankle, finger, hand should be located around anastomosis site. In this case, we selected SPA as pedicle recipient vessel because common digital artery was injured. For harvesting long pedicle which was enough to anastomoses to SPA, ALT was chosen for reconstruction. And then T-shaped pedicle was interpositioned between each end of the divided SPA. Deep palmar arch which was anatomically connected to SPA functioned as back-up vascular system by reverse flow when proximal anastomosis of SPA was obstructed. So this concept involve vessel communication around anastomosis site as well as characters of T-anastomosis concept.

In venous system, two VC of D-LCFA also showed T-shape pedicle including both end of VC and perforating vessel. They were anastomosed to at least 3 veins such as VC of recipient site and superficial vein. In this case 3 venae comitantes of LCFA were anastomosed to one superficial dorsal vein and two deep veins and it allowed to back-up flow when deep to deep anastomosis were obstructed. Separate double venous anastomosis (superficial and deep vein) for the radial artery forearm flap was known as useful method that can improve success and minimize morbidity.[5] On the basis of this study, we attempted direct anastomosis between superficial and deep vein system and make two independent T-shaped anastomosis. Also, it is unclear whether or not multiple anastomoses reduce the risk of free-flap failure. Some reports demonstrated that

performing two venous anastomoses reduced incidence of flap failure compared with those of a single vein anastomoses.[6,7] Based on these results, we hypothesized that multiple venous anastomosis is helpful for extremities reconstruction because it reduce the possibility of total occlusion by increasing the number of anastomoses.

The limitation of this study is that we hypothesized the concept of back pedicle based on vascular anatomy and physiology, and could not haemodynamically confirm whether or not arterial communication vessels function as back pedicle by reverse flow when one of two arterial anastomosis was obstructed.

This concept has various advantages such as preserving patency of pedicle in chronic vasculopathy or trauma cases and maintaining the arterial flow by the reverse flow of distal anastomosis. For these reasons, we assumed that the survival rate of the flap will be increase and demonstrated that patent vascular anastomosis without arterial insufficiency and venous congestion was possible with improvement of functional and aesthetic outcome.

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