Commentary

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In Situ Reverse Arterialization of the Long Saphenous Vein in a Non-Reconstructable Ischemic Leg, Leaving the Distal Venous Tributaries Open for Full Recovery

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Over the last decades, several attempts have been made to treat non-reconstructable ischemic legs, with arterialization of the venous system. This idea is not new, there are several different techniques (surgical, totally percutaneous, hybrid) but the basic flaw is the lack of standardization of the indications and the procedure, and the high rate of restenosis that patients develop over time.

Most authors reported using the long saphenous vein, which was anastomosed to the distal patent leg artery and ligation of all tributaries up to the ankle. The procedure also included the destruction of all saphenous valves with valvulotome till the foot and as so, the venous return was through the deep system [1,2]. The other alternatives were using the reverse saphenous vein or PTFE graft anastomosed proximally to the femoral or popliteal patent artery, and distally to the pedal superficial or deep veins [1-3]. Postoperative complications were excessive foot edema, wound dehiscence and wound infection, long hospitalization [1], and venous gangrene [4].

Schreve in 2017 reported a Meta-Analysis of 768 patients after venous arterialization with 12 months patency of 59-71% [5]. Houlind reported that 9 of 14 cases of venous arterialization, resulted in amputation. This is a 36% limb salvage [5]. This figure contradicts all other studies reported. This variation in results may be explained by patient selection.

All the attempts for venous arterialization were based on proximal anastomosis to the systemic arterial pressure of 140-160 mmHg and distal connection to the pedal venous system of 5-25 mmHg [5]. Thus the 10 fold arterial pressure to the pedal veins is suggested to be the reason for the postoperative complications. The following complications are the consequence of foot high venous pressure: foot edema due to capillary leak, wound dehiscence and infection, and dorsal foot gangrene [4].

We hypothesize that the flow overload could be the cause of the high rate of restenosis due to intimal hyperplasia, which patients develop over time. We herein present an alternative surgical method of venous arterialization of an ischemic foot by *In Situ* Reverse Arterialization (ISRA), leaving the distal venous tributaries open as safety valves to reduce foot excessive venous pressure. This report describes the case of a 69-year-old male with toe gangrene with no distal arterial tree therefore he was not considered a candidate for arterial reconstruction.

We performed the ISRA operation by anastomosis of the long saphenous vein to the proximal superficial femoral artery. A 7 cm incision was performed over the long saphenous vein at the ankle level. Transverse venotomy enables a proximal insertion of a 6F 5.5 cm introducer with an internal diameter of 2 mm. This is our routine technique in order to prevent tearing of the distal vein venotomy, while retrieving the valvulotome. A Le Maitre valvulotome 98 cm length and 1.8 outer diameter was introduced proximally to destroy all saphenous valves (**Figure 1**). Foot valves were further destroyed up to the toes by olive tip cannula with heparin saline irrigation. The saphenous vein tributaries were ligated from the proximal thigh to the calf until arterial flow reached the ankle level. The rest of the distal saphenous tributaries were left open as safety valves to reduce pedal venous pressure.

The venotomy was closed with 7/0 prolene. A relaxing incision was performed below the medial malleolus to enhance a safe closure of the skin over the venotomy without tension. Open trans-metatarsal amputation was performed for the toes dry gangrene [6]. Postoperatively the foot regained normal pulsation

over the superficial veins with normal foot temperature. The patient did not experience foot edema and foot incision healed within 3 weeks.

Postoperative on-table angiogram demonstrated arterial inflow through the long saphenous vein and dorsal foot veins with returned venous flow through the anterior and posterior tibial veins. MIBI Tc99 CT scan 4 weeks postoperatively demonstrated oxygen uptake of the pedal muscles which was absent preoperatively (**Figure 2**).

Postoperative venous duplex demonstrated a monophasic waveform of a-v fistula pattern which changed to biphasic pattern 1 year later. Preoperative Transcutaneous PO2 (TcpO2) was 3 mmHg at the dorsum of the foot (second and fifth web). Six weeks postoperatively TcpO2 level was 32 mmHg enough for wound healing [7]. 1000 days later the TcpO2 was elevated to 76 mmHg. Flow measurement at the lateral and medial dorsal veins was 450 cc/min and 6 weeks postoperatively, declined to 210 cc/min, and was further reduced to 25 cc/min 1000 days postoperatively.

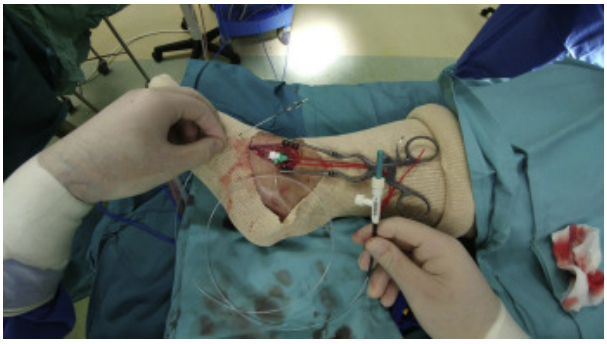

Figure 1 A Le Maitre valvulotome 98 cm length and 1.8 outer diameter was introduced proximally to destroy all saphenous valves.

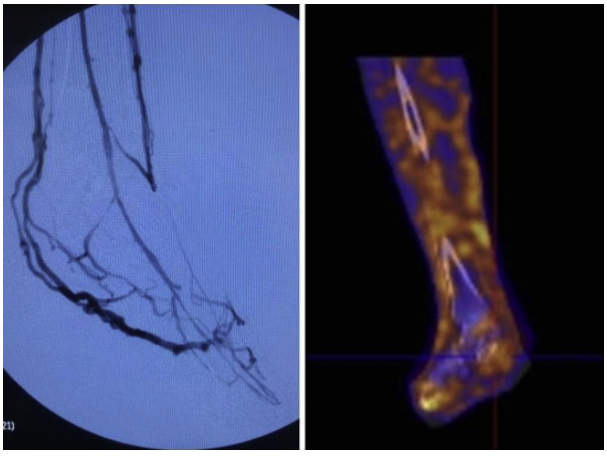

Figure 2 MIBI Tc99 CT scan 4 weeks postoperatively demonstrated oxygen uptake of the pedal muscles.

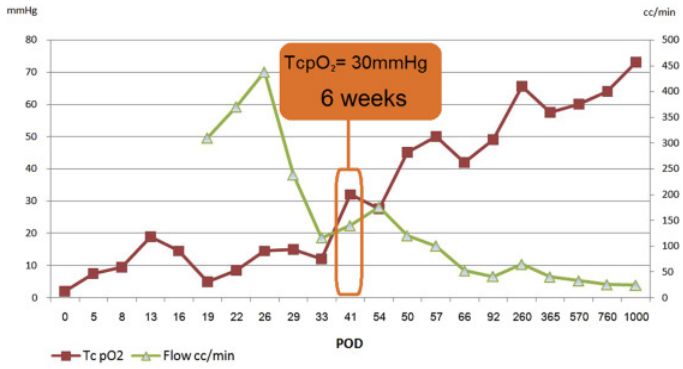

Figure 3 Demonstrated by the increased level of TcpO2 from 3mmHg to 32 mmHg at six weeks to enable wound healing.

These measurements may explain the new physiological concept of the venous arterialization. There is an inverse correlation between the level of TcpO2 and the flow measurements. The Doppler signal of increased peripheral venous resistance (due to intimal hyperplasia), is demonstrated by the change of the waveform from monophasic to a biphasic wave. The high peripheral resistance causes a decrease in venous flow, which enables more time for oxygen exchange at the capillary level. This was demonstrated by the increased level of TcpO2 from 3 mmHg to 32 mmHg at six weeks to enable wound healing (**Figure 3**).

Taken together, in this case report we present an alternative surgical technique of venous revascularization of ISRA using the saphenous vein anastomosis to systemic femoral arterial pressure, valvulotomy to all saphenous and pedal valves.

Saphenous vein tributaries were ligated until arterial pulsation reaches the ankle level leaving the distal tributaries open to reduce pedal venous pressure. The new physiological basis of venous arterialization is explained by the follow up of flow, duplex, and TcpO2 for 1000 days.

This case reinforces our hypothesis that reduction of pedal flow by leaving the distal tributaries open, enables increased oxygenation of the foot which enhances recovery. This hypothesis yet needs to be validated on a larger scale. Currently, we are implementing this technique in additional cases, with the hope that this technique becomes a standard intervention for treating non-reconstructable ischemic legs.

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