Endovascular Technique for Arterial Shunting to Prevent Intraoperative Ischemia

K. Österberg [a,*], **M. Falkenberg** [b], **T. Resch** [c]

[a] Department of Vascular Surgery and Institute of Medicine, Department of Molecular and Clinical Medicine, Sahlgrenska University Hospital and Academy, Blå Stråket 5, S-413 45 Gothenburg, Sweden
[b] Department of Radiology, Institution of Clinical Sciences, Sahlgrenska University Hospital and Academy, Gothenburg, Sweden
[c] Vascular Center, Skåne University Hospital, Malmö, Sweden

WHAT THIS PAPER ADDS

Severe ischemia—reperfusion injury to the lower limb is a feared complication of prolonged vascular procedures and of acute conditions caused by sudden obstruction of arterial blood flow. This paper describes a novel and simple technique for arterial shunting to prevent intraoperative ischemia. The method is applicable in both endovascular and open surgical procedures.

Objectives: The use of an intraoperative shunt is an established technique used to reduce the ischemic time after acute arterial obstruction or in the prevention of hypoperfusion due to complex open vascular or endovascular operative procedures. To date, described methods of temporary extremity blood perfusion have required open surgical techniques.

Methods: An endovascular shunt (ES) was formed by connecting two introducer sheaths to each other, one positioned proximal and one distal to an arterial obstruction. The ES method was used in patients considered to be at high risk for prolonged lower limb ischemia in conjunction with a vascular procedure and where shunt creation by open surgical technique was not considered to be a practical alternative. The flow capacity of the ES was defined in a desktop model.

Results: The ES method was used clinically in 15 vascular interventions including eight complex endovascular aortic procedures, three open aortic operations, and four procedures for acute limb ischemia. The shunts were functional in all patients and there were no shunt occlusions. Postoperatively, there were no evident clinical reperfusion injuries. Flow analysis revealed that the ES had a flow capacity of 73% flow capacity compared to a Pruitt-Inahara shunt.

Conclusion: A new method of temporary blood shunting in connection to vascular procedures has been demonstrated.

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INTRODUCTION

Acute ischemia caused by a sudden obstruction of arterial blood flow can result in severe tissue damage. Common causes are trauma, thromboembolism, or arterial dissection. The ischemia and subsequent reperfusion can result in tissue necrosis, compartment syndrome, and transient or permanent nerve injury. In addition, reperfusion may cause systemic injuries to the heart, lung, and kidneys.[1,2] Permanent extremity injury can occur after 4—5 hours of ischemia,[3] and rapid restoration of flow is vital.[4] As vascular reconstructions may take several hours, temporary vascular shunts can be useful.[5,6]

Prolonged ischemia can also occur during elective complex vascular procedures. Large introducer sheaths may obstruct the ilieofemoral arteries during endovascular aortic repair (EVAR) and arterial clamping obstructs flow during open reconstructions.[7,8]

The concept of using an intraoperative arterial shunt to prevent prolonged ischemia is well established in open carotid and trauma surgery.[9,10] The use of temporary axillobifemoral bypass was recently described to prevent iatrogenic limb ischemia during complex fenestrated EVAR (FEVAR).[11] Until now, the methods described for temporary shunting have required open surgical techniques.

This report presents a new and simple method of arterial shunting using an endovascular technique.

METHODS

Technical description

An introducer positioned proximal to the arterial obstruction communicates with a second introducer positioned distal to the obstruction. The two introducers are connected

* Corresponding author.
E-mail address: klas.osterberg@vgregion.se (K. Österberg).

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by their side arms, either directly through an adapter or through extension tubing together with an adapter. The blood first enters the tip of the proximal introducer, flows through the sheath and out through the sidearm, continues via the connecting adapter or extension tube into the sidearm of the second introducer, and finally out through its sheath into the receiving artery.

If the shunting system is used to prevent ischemia caused by a large occluding introducer during a prolonged endovascular procedure, the blood can be deviated either from the obstructing introducer's side arm or from an introducer in the contralateral groin (Fig. 1). The second introducer is then placed in an antegrade position distal to the occluded segment either percutaneously or by cut-down technique, depending on which method is used for the endovascular aortic procedure. In this situation, the introducer hubs are in close proximity to each other, allowing the two side arms to be connected by a short male-to-male Luer—Lock adapter.

When the endovascular arterial shunt is used for acute ischemia caused by trauma or thromboembolism, the proximal introducer can be placed in an artery of an uninjured extremity. The distal introducer is again placed in an antegrade position distal to the occlusion. If the side arms are not close to one another, extension tubing bridges the distance between the introducers.

Material

The ES method used standard introducers (Super Sheath®; Boston Scientific, Natick, MA, USA) with side arms and Luer—Lock connections. A male-to-male adapter (Combifix® Adapter; Braun, Kronberg, Germany) was used to connect the female Luer—Lock connections of the introducers' side arms to each other. If the distance between the two introducers was too long, an extension tube was used (Perfucor® Tubing, Heidelberger Extension 30-cm Luer—Lock; Braun). In a select case, a shunt was also created by simply connecting the two introducers with a short piece of silicon tubing. This was introduced into the sidearm of the "donor" sheath and into the end-valve of the receiver sheath (7-F).

Clinical use

Data collected prospectively between March 2011 and March 2013 at the Vascular Center, Skåne University Hospital, Malmö, Sweden, and the Department of Vascular Surgery, Sahlgrenska University Hospital, Gothenburg, Sweden were analyzed retrospectively. The risk of intraoperative limb ischemia for patients undergoing endovascular aortic procedures was evaluated. During the study period, 607 endovascular aortic procedures were performed at the two vascular centers. Indication for the endovascular shunt (ES) method included procedures considered to have a high risk for lower limb ischemia due to obstruction of the access arteries for more than 3 hours. Probable occlusion was assumed when the sheath diameter was the same or nearly the same as the inner diameter of the access vessels. In these patients, the ES was established at the start of the procedure. During interventions with unexpectedly prolonged occlusion times, an extra-antegrade-positioned introducer was placed in the common femoral artery (CFA) or superficial femoral artery (SFA) after 4—5 hours. The ES method was also used in some patients with acute ischemia due to vascular trauma or aortic dissection. Only patients with ES were included in the study.

The anticoagulant regime was not altered by the use of an ES. For EVAR procedures, the heparin dose was titrated to result in an activated clotting time between 250 and 300 seconds. During open surgical operations, 2,500—5,000 IU heparin was given intraoperatively before arterial clamping.

The function of the shunt was verified by intermittent closure of one of the three-way stopcocks followed by injection of a small amount of saline into the transparent sidearm, and, finally, opening of the stopcock again. The visible effluence of clear saline confirmed a functioning shunt. Angiography through the shunt can also be used to control shunt function and to survey outflow vessels.

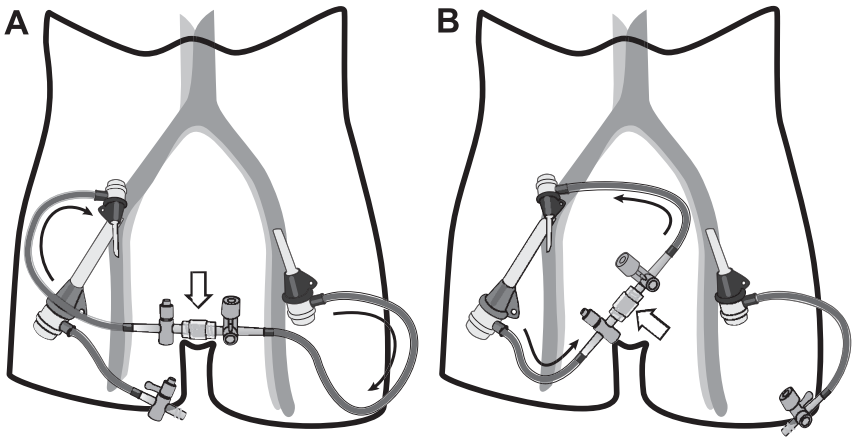

Figure 1. Illustrations of the endovascular shunt deviating blood from an introducer sheath from the (A) contralateral side and from a large introducer sheath in (B) the ipsilateral side. Blood runs through introducer side arms, interconnected by a male-to-male Luer—Lock adapter (open arrow). Arrows indicate flow direction.