

# Transit Time Flow Measurement in Peripheral Bypass Surgery

## An introduction to transit time flow measurement in peripheral vascular surgery supported by best evidence abstracts

### Why measure flow in vascular surgery?

The need to measure blood flow intraoperatively became apparent during the development of reconstructive arterial surgery. However, many surgeons unfortunately still rely on pulse palpation as an index of flow, not realizing that a vessel can pulsate even when there is no blood flowing through it. In fact, if the vessel occludes distal to the palpation site, the pulse may even increase, though admittedly not for long. The primary aim of TTFM is to obtain information on the immediate results of the reconstruction, where a technical failure may jeopardize an otherwise successful operation.

There is a clear correlation between the blood flow values obtained following injection of papaverine and the prognosis of the arterial reconstruction. Five-year patency of femorodistal bypasses varies between 40 and 70% in many series. Some of the re-occlusions may be due to intimal hyperplasia, whereas others are caused by technical failures leading to secondary thrombosis formation and graft occlusion. To eliminate technical failures, intraoperative control of the reconstruction is important. Furthermore, such investigations can also be helpful in planning the procedure, and in giving an indication of the long-term prognosis of the operation.

### Detection of side branches during 'in situ' bypass surgery

During in situ bypass surgery, the side branches of the great saphenous vein must be interrupted to prevent them from becoming arteriovenous fistulae after the reconstruction. Following completion of the proximal and distal anastomoses, vessel clamps are removed and blood flow through the bypass is established. Major tributaries of the vein can be visually identified and ligated without difficulty. However, smaller branches often have to be

detected by other means, mainly intraoperative flowmetry, in order to avoid major surgical dissection. It is important to locate these residual fistulae since they may cause graft failure. The detection of arteriovenous connections has a qualitative aim; exact blood flow values are less relevant. A flow probe of appropriate size is placed around the vein, just below the proximal anastomosis. Pulsatile flow curves will immediately appear on the display. Manually or by means of an atraumatic clamp, the vein is occluded successively at different sites along its course, from the transducer to the distal anastomosis. A reverberating flow profile, indicating no net blood flow, is found when there is no leakage flow between transducer and the compression site. If flow is detected during clamping, we can expect to find an open side branch proximal to the site of clamping, which can subsequently be ligated.

### Intraoperative Functional Evaluation of a Vascular Reconstruction

As distal femorotibial bypass grafting has become more common, supplementary methods are necessary for intraoperative control. The primary aim is to obtain information on the prognosis for the immediate result of the reconstruction. Several studies have shown that perioperative flow values have prognostic values. The risk of early postoperative occlusion is significantly increased if the basal blood flow after femoropopliteal reconstruction is less than 100 ml/min or the papaverine-induced flow (intra-arterial injection of 40 mg papaverine) is less than 200 ml/min. The effect of papaverine is reduced if the surgery is performed under epidural anesthesia, since basal flow is already increased.

Methods for the Evaluation of Vascular Reconstruction, Einar Stranden, Department of Vascular Diagnosis and Research, Aker University Hospital, Oslo, Norway.

*Heart Drug* 2004;4:201-217, DOI:10.1159/000082191

## The Role of Peripheral Vascular Resistance in Determining the Infringuinal Arterial Reconstruction Patency

Mihail V. Cheshmedzhiev, Victor V. Knyazhev, Radoslav S. Radev, Emil D. Yordanov.

Department of Vascular Surgery, St Marina University Hospital, Clinic of Vascular Surgery, St Ana University Hospital, Clinic of Thoracic Surgery, St Marina University Hospital, Varna.

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### Objective

To determine if there is any correlation between the peripheral vascular resistance, its change following an intragraft prostaglandin infusion and the infringuinal reconstruction patency.

### Methods

Ninety-seven patients with infringuinal reconstructions were included in the study: in 48 patients they were compromised (32 with graft thrombosis and 16 with stenosis of the distal anastomoses); 49 patients had their bypasses patent for no less than 12 months. Intraoperative flowmetry was performed on the target artery under the distal anastomosis, after de clamping, and after a five-minute intragraft prostaglandin infusion. We measured the peripheral vascular resistance (PVR) by two methods - as a ratio of the invasively measured average pressure to the average blood flow volume (mmHg/ml/min. = peripheral resistance unit [PRU]) and by using the readings by the flowmeter (ohms).

### Results

The decrease of peripheral resistance was calculated in the functioning and the compromised reconstructions after administration of prostaglandin. We found that if PVR decreases 4.5 times (in ohms) the prognosis is good; we can make the same positive prognosis when the ratio of the mean invasively measured pressure to the mean blood flow volume ( $P_{\text{mean}}/Q_{\text{mean}}$ ) decreases more than four times. Values greater than 1.07 ohms, after peripheral vasodilatation, are indicative of high peripheral vascular resistance, at a level of specificity of 86%, and values greater than 0.57 PRU - at a level of specificity of 87%.

### Conclusion

Although PVR measurements cannot predict with absolute certainty that bypasses under the inguinal ligament shall stay patent for a long time, it is a valuable indicator showing the immediate outcome of reconstruction work carried out with the patient on the operating table. Finding any technical errors and dealing with them saves time and money, as well as prevents the stress on the part of patients caused by the required additional revisions and multiple operations.

### Comments

*This study shows that there is a connection between reduced vascular resistance and graft patency. To be able to calculate the resistance you need to measure blood flow. Finding technical errors and addressing them in surgery saves time and money while lowering stress on patients by reducing the need for additional interventions.*

## Intraoperative Flow Predicts the Development of Stenosis in Infringuinal Vein Grafts

Leo H. M. Ihlberg, MD, N. Anders Albäck, MD, Riitta Lassila, MD, and Mauri Lepäntalo, MD.

Department of Vascular Surgery, Helsinki University Central Hospital, Finland. *J Vasc Surg* 2001;34:269-76.

### Objective

There are data to suggest that the development of myointimal hyperplasia is affected by long-term alterations in blood flow. However, the clinical relevance of these findings has not been demonstrated.

### Methods

In this retrospective clinical study, intraoperative volume flow measurement with transit time flowmeter was performed in 257 infringuinal vein grafts carried out in 241 patients. The patients were enrolled in an intensive duplex scanning-based surveillance program. The relationship between the intraoperative graft flow and subsequent occlusion or development of stenosis was evaluated and controlled for other pertinent risk factors.

### Results

The median follow-up time was 13.6 months. A graft stenosis was found in 58 grafts. The mean graft flow for event-free grafts was 98 mL/min, which was significantly higher compared with 78 mL/min for stenosed or 69 mL/min for occluded grafts. The patients were divided into four groups according to quartiles of the sample distribution of graft flow measurements. The respective 2-year primary and assisted primary patency rates in the lowest to the highest graft flow groups were 39%, 49%, 47%, and 72% ( $P = .003$ ) and 55%, 67%, 71%, and 84% ( $P = .01$ ). Analogous significant differences were observed for maximal flow capacity measurements. Female sex ( $P = .009$ ) and low graft flow in maximal flow capacity measurements ( $P = .003$ ) were independent predictors of stenosis development in the multiple regression model.

### Conclusion

Intraoperative graft volume flow is a predictor of bypass occlusion after infringuinal bypass. In addition, this study verifies an association between the development of clinically evident graft stenoses and low graft flow.

### Comments

*Intraoperative graft volume flow is a predictor of bypass occlusion after infringuinal bypass. This study underscores that the use of flow measurements is helpful to guide surgical decision making and to identify bypass grafts more likely to occlude post operation.*

## Preoperative Angiographic Score and Intraoperative Flow as Predictors of the Mid-term Patency of Infrapopliteal Bypass Grafts

A. Alback, W.D. Roth, L. Ihlberg, F. Biancari and M. Lepäntalo.  
Departments of Vascular Surgery and Radiology, Helsinki University Central Hospital, Helsinki, Finland.  
*J Vasc Surg* 2001;34:269-76.

### Objectives

Preoperative angiographic characteristics of the outflow tract have emerged as a predictive factor for the outcome of infrapopliteal reconstructions. Direct flow measurement can be routinely performed intraoperatively, but little is known regarding its impact on graft outcome. The present study was undertaken to compare the value of these parameters in predicting the mid-term patency of infrapopliteal bypass grafts.

### Methods

A retrospective clinical study of 172 infrapopliteal reconstructions using autogenous vein were performed, of which 92 had a crural and 80 a pedal recipient artery. The preoperative angiogram was scored according to the SVS/ISCVS Ad Hoc Committee. At the end of the operation flow was measured with a transit-time flowmeter. Follow-up consisted of pressure measurements and duplex scanning.

### Results

The run-off score had no impact on femorocrural graft patency. For pedal grafts there was a tendency for inferior outcome with high run-off score, as the 1-year assisted primary patency for grafts with a completely occluded pedal arch was 11% compared with 52% for grafts with lower scores ( $p=0.056$ ).

Both intraoperative volume graft flow and maximum flow capacity had a highly significant influence on the outcome on crural reconstructions on univariate analysis. For pedal reconstructions only a severely reduced maximum flow capacity after injection of papaverin was associated with an adverse outcome. Multivariate analysis revealed that maximum flow capacity was an independent significant factor affecting patency of femoroinfrapopliteal grafts (relative risk=0.53 per 30 ml/min increase,  $p<0.001$ ).

The run-off score was also a weak independent predictor of 1-year assisted primary patency in these grafts (relative risk=1.9 for a score  $>4$  in crural and a score  $>5.5$  in pedal grafts,  $p=0.036$ ).

### Conclusions

A completely occluded pedal arch in preoperative angiography was associated with poor infrapopliteal bypass outcome. Graft flow and maximal flow capacity are good predictors of the 1-year graft patency of femorocrural bypasses.

### Comments

*This study confirms that graft flow and maximal flow capacity are good predictors of the 1-year graft patency of femorocrural bypasses. By performing measurements in a systematic way the patients are protected from the need for additional revisions and multiple operations.*



[medistim@medistim.com](mailto:medistim@medistim.com)  
[www.medistim.com](http://www.medistim.com)

**Medistim ASA (Head office)**  
Økernveien 94  
0579 Oslo  
Norway  
Phone +47 23 05 96 60

**Medistim Norge AS**  
Økernveien 94  
0579 Oslo  
Norway  
Phone +47 23 03 52 50

**Medistim USA Inc.**  
14000 25th Ave N. Ste. 108  
Plymouth, MN 55447  
USA  
Phone +1 763 208 9852

**Medistim Deutschland GmbH**  
Bahnhofstr. 32  
82041 Deisenhofen  
Germany  
Phone +49 (0) 89 62 81 90 33

**Medistim Danmark ApS**  
Gøngetofte 13  
2950 Vedbæk  
Denmark  
Phone +45 2276 5669

**Medistim UK Limited**  
34 Nottingham South Ind Est  
Ruddington Lane  
Wilford  
NOTTINGHAM  
NG11 7EP  
Phone +44 (0) 115 981 0871