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Clinical Study

Clinical Significance and Prognostic Value of Preoperative Angiographic Assessment in Infrainguinal Arterial Reconstructions

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Objective. To assess the practical implementation of the modified Schwierz T. system for angiographic scoring of the arteries below the distal anastomosis (run-off) after infrainguinal reconstructions. *Methods*. We used the modified Schweierz T. score, which is readily practically applied in each patient for assessment of the run-off segment, independently from the planned level of distal anastomosis. 97 consequently treated patients who underwent infrainguinal arterial reconstructions were followed up during a 12-month period, and we retrospectively compared the results of two groups—48 of failed and 49 of patent bypasses; as for the long term patency there were some discrepancies with the expected good results. Measurements of the flow volume were performed below distal anastomoses in peripheral bypass operations with flowmeter VeriQ, Medistim, Oslo, Norway. Flowmetry was performed before and after a 5-minute infusion of Prostavasin or Ilomedin, causing peripheral vasodilatation. The resulting values were averaged and compared to the beforehand calculated according to the Schwierz score minimal expected flow. *Results*. Schwierz score gives orientation immediately after the reconstruction about the early patency of the bypass. Control angiographies and revisions in cases with inadequate minute blood flow identify some mistakes, the correction of which (if possible) in one operation time improves the results and the early patency. 9% of the failed bypasses in the first month had blood flow above the expected and 37% of the failed bypasses in the eighth month had flow above the expected. Mismatch in the patent bypasses was observed in 6%, probably due to subjective underestimation of some collateral vessels. *Conclusion*. Quantification of the distal flow is very important. The suggested model of assessment must determine as exactly as possible minimal flow to be reached at the end of the operation. We consider the preoperative angiographically calculated expected blood flow, good additional criteria for the quality of the newly constructed bypass. Intraoperative registration of low blood flow has the significance of screening for further assessment through intraoperative arteriography for the morphological identification of the cause. Having in mind the subjective nature of the angiographic scoring system and its dependence on the quality of the image, we consider the preoperative angiographic estimated expected volume of flow referring to the early patency adequate and inappropriate for long term prediction, but useful as an accessory orientation measurement of the state of the run-off arteries and the result of the surgery.

1. Introduction

Quantification of the distal flow is very important. Angiography, intraoperative flowmetry and postoperative duplex ultrasound are related means of control of vascular reconstructions.

The angiographic scoring systems [1] are quite complicated for everyday use and do not consider the different levels of distal anastomoses. Despite the attempts to manage with this no score has derived wide popularity.

We used the modified Schwierz T. score, which is readily practically applied to each patient and assesses the run-off segment independently from the planned level of anastomosis.

Preoperative angiography and modified Schwierz system of angiographic assessment give the surgeon at the end of an operation the result of the reconstruction, probable technical problem, the solving of which spares time, and resources for new revisions and reoperations.

Table 1: Distribution of patients in groups—failed (FB) and patent (PB) and stage—Fontaine.

IIb stage		III stage		IV stage	
PB	FB	PB	FB	PB	FB
5	2	36	25	8	21

2. Material and Methods

In this study we used the results from intraoperative flow measurement of 97 consequently treated patients who underwent infrainguinal vascular reconstructions with autologous venous and artificial grafts, at the Department of Vascular Surgery at St. Marina University Hospital during a one-year period. We have used one and the same preoperative protocol for all the patients who were included in the study. From the study patients with unstable haemodynamics, arrhythmia, and impaired diuresis were excluded, which were contraindicated for prostaglandin administration. Thus we estimated 2 groups—49 with patent bypasses (PB) and 48 with failed bypasses (FB). The patients were at ages between 61 and 82 years. Eight of them were women, the rest were men.

Because in some cases we received results different from the expected and the compromising of the bypasses happened at different moments, retrospectively we studied the data of the PB for the period of one year and we compared it to the data from the FB.

Indications for bypasses were as follows.

(i) Claudication distance less than 200 m.

(ii) Rest pain and ankle pressure less than 60 mmHg.

(iii) Necrosis and gangraena and ankle rest pressure less than 40 mmHg.

Risk factors include smoking (41% of the patients), diabetes mellitus (38%), hypertension (36%), ischaemic heart disease (29%), cerebro vascular disease (13%), chronic obstruction oulmonary disease (5%), renal failure (7%), and preliminary vascular reconstructions and amputations (43%) (see Figure 7). There were no significant differences in the distribution of the risk factors between the early thrombosed and the patent to one year reconstructions (see Table 1).

Measurements were taken with transit time flowmeter (VeriQ, Medistim, Oslo, Norway). Measurement of the flow with transit time gives opportunity for intraoperative real time estimation and an optimization of bypass construction. Prostaglandins are medicaments used for improvement of blood flow in patients with peripheral arterial occlusive disease through an intra-arterial or venous infusion and may be used during operation. They cause limited in time improvement of flow, overcome the vascular spasm, and dilate the run-off segment. We did not use prostaglandin in patients with contraindications—impaired diuresis, arrhythmia, and so forth.

Measurement was performed below the distal anastomosis of bypass after declamping and stabilization of the hemodynamics. Measurement was performed again after a 5-minute infusion of 10 μg Prostavasin or 7 μg Ilomedin in the graft. Prostaglandins act as muscle relaxants, which lead to transient vasodilatation of run-off vessels so that their maximal capacity and elasticity are registered. During the operation the effect of the reconstruction was controlled by arterial pressure measurement and when necessary postoperative control angiography was performed and compared to the preoperative one. If technical correction was necessary after the intraoperative measurements, they were performed once again at the end of the operation and data was analysed.

We used modified system of angiographic score of Schwierz et al. [2], which is readily applicable in every patient and gives assessment of the run-off segment independently from the level of distal anastomosis. The modified score gives 3 points to optimal run-off and 0 points to absent run-off. Multiple stenoses are considered heavier and are given less points (e.g., 0.3 instead of 0.5) (Table 2).

All patients underwent preoperative angiography. In cases where there is a single vessel run-off and anastomosis is on popliteal level, the graft is functioning as a femoral one, independently of the higher level of anastomosis, and the score and flow are low. This is an explanation for the big differences in angiographic score and flow in sites of proximal anastomosis.

If there is one, but intact, tibial artery the relative flow (averaged value of the initial flow and the one after prostaglandin infusion) after bypass construction should not be less than 80 mL/min according to Schwierz et al. [3]. The relative volume of 80 mL/min. per unit tibial vessel is semiconstant (constant of flow). For calculation of expected flow we multiplied the preoperative angiographic score by the constant flow (80 mL/min).

Patients were followed up according to a protocol for graft assessment including physical examination, color flow duplex scan, and ankle-brachial index within 4 to 6 weeks and at 3, 6, 9, and 12 months after surgery. If the registered flow was lower than the expected one and no alternative way of correction was possible, control visits were performed each month.

Noninvasive criteria for postoperative follow up included decrease of ankle-brachial index with 0.15 PSV smaller than 45 cm/sec, or focal interference where V2/V1 exceeds 2.5 (V2 is the peak systolic velocity at the side of stenosis and V1 is the velocity in nonstenotic 2 cm adjacent to the stenotic segment). In these cases diagnostic angiography was performed before revision or redo bypass.

3. Results

To assess the practical implementation of the Schwierz T. angiographic scoring system of the arteries below the distal anastomosis (run-off) after infrainguinal reconstructions, we calculated preoperatively the expected minimal flow, which was expected according to the angiographic image.

Averaged intraoperative flow, measured before and after the application of vasodilatative medicaments, was compared to the calculated expected minimal flow for every constructed bypass. Figure 1 represents the preoperative angiographic image and the estimation of minimal expected flow according to the Schwierz scoring system.

Table 2: Score for angiographic assessment of run-off (Schwierz).

Angiographic image score	Score
Each completely stenosis-free crural vessel	1
Each stenotic but patent crural vessel	0.5
Each crural vessel with short distal segmental occlusion	0.4
Each crural vessel with long segmental occlusion, depending on length of occlusion	0.1 ± 0.3
Each occluded crural vessel	0
In the case of above knee distal bypass anastomosis and collateral formation in the run-off bed, depending on the degree of collateral formation, additional	0.1 ± 0.4
In the case of popliteal below knee distal bypass anastomosis and collateral formation, depending on the degree, additional	0.1 ± 0.2

Figure 1: Patient record 6323/23.02.2012—obliteration of the femoral artery. Anterior tibial artery—1p. Posterior tibial artery—orifice stenosis, missing distal 1/3—0.2p. Peroneal artery—1p. Collaterals—0.2p. Angiographic assessment—2,4. Expected flow—192 mL/min. (2,4 × 80 mL/min).

Average measured flow after declamping was 77.5 mL/min (52 + 103 = 155/2 = 77.5) far below the expected.

The revision revealed the problem at the distal anastomosis. A stenosis at a plaque was found where due to hemorrhage stitches were placed. We reanastomosed the graft with autoartery—plastic reconstruction with superficial femoral artery segment—after eversion endarterectomy. Average flow after revision was 227.5 mL/min., which is above the expected, and no other corrections are needed (Figure 2).

We compared data among patent and failed bypasses (32 thrombosed grafts and 16 with stenoses at distal anastomoses) and calculated the percent of concurrence of the expected and the actual intraoperative blood flows for each reconstruction.

In the group of failed bypasses during the first month (FB) the coincidence is 91%, up to the fourth month—72% and until the end of the study—63% and in other words intraoperative blood flow was below the preliminary calculated minimal expected flow and subsequently we have diagnosed failure in their function (Figure 3).

Figure 2: Postoperative angiography confirmed the preoperative angiographic assessment.

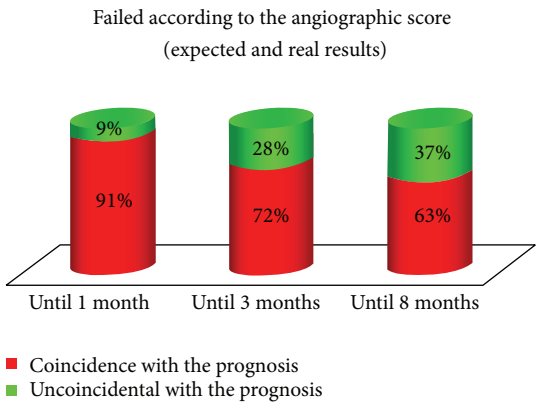

Figure 3: Representation in percent of the concurrence and nonconcurrence rates between the expected and intraoperatively measured blood flow values in the compromised bypasses group.

In the group of patent bypasses the concurrence is 94% and the nonconcurrence is 6% (Figure 4). In 94% intraoperatively measured flow was above expected and these bypasses were patent for the time of follow up. Only 6%

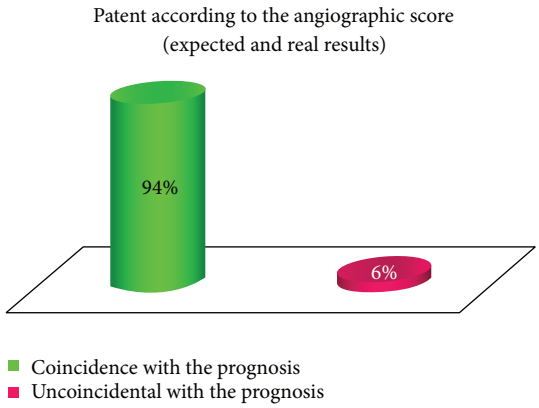

Figure 4: Representation in percent of the concurrence and nonconcurrence rates between the expected and intraoperatively measured blood flow values in the properly patent bypasses group.

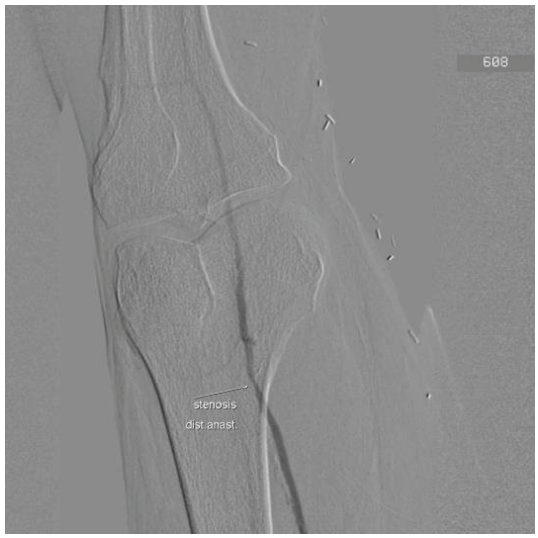

Figure 5: On a routine follow-up visit on the sixth month after femoropopliteal (P1 segment) bypass with autologous vein graft, hemodynamic changes were detected which imposed morphological particularization. Diagnostic angiography revealed stenotic distal anastomosis.

of the reconstructions where the real flow was smaller than expected were patent during the follow-up period.

4. Discussion

In the early postoperative period, bypasses fail due to technical mistakes, graft defects, and poor run-off [4, 5]. Larger part of the late occlusions of bypasses are due to stenotic changes in grafts or in the sites of anastomoses with rate 20% and 35% for 1 to 2-year-period after operation [6].

Patency of infrainguinal bypass and limb salvage is mostly dependent on the quality of run-off [7–10]. In the clinical practice this is estimated by sight by the preoperative angiography; more scientific, quantitative, and repeatable assessment of the run-off arteries would be preferred during the period of preparation of patients for operations, for the confidence of the surgeon and in comparison of different surgical techniques.

Quantifications of the distal flow are very important. The suggested model of assessment must determine as exactly as possible minimal flow to be reached at the end of operation. Due to its simplicity and the use of retrograde flow, modified run-off score makes possible the assessment of the whole run-off, without dependence on the level of anastomosis.

In reconstructions with higher intraoperatively measured flow, long term patency is better and grafts develop less stenotic changes [11].

In the group of failed bypasses, nonconcurrence of the prognosed result is 9%, 28%, and 37%, respectively, which means that despite the measured intraoperative flow corresponding to the expected one, these bypasses have been compromised. In the group of impaired bypasses, 18 were with not concurring data because in higher intraoperative results in 9 cases, where there were stenoses, the flow was with average 29 mL/min. higher and in 9 thrombosed bypasses values were with average 25 mL/min. above expected. This is probably due to subjective underestimation of the distal arteries, leading to a lower expected flow estimation and thus objective measurements exceed the predicted ones. In 37% bypasses developed thromboses or stenosis until the 8th postoperative month, and the control angiographies showed changes in run-off segment, that is not detected in the preoperative studies. The progression of the atherosclerotic disease below the distal anastomosis could not be predicted; that is why we consider that the long term prognostic for the bypass patency based on the momentary angiography could not be given. The subjective character of the assessment of the run-off segment based on the angiography describing the morphology, but not the hemodynamics, is confirmed by the fact that although the actual flow was lower than the expected, the reconstructions remained patent longer—up to the 8th postoperative month.

Best concurrence with the prediction is available in the first postoperative month, when blood flow below the expected is measured, but there were no possibilities for reconstruction because of the heavily impaired distal vascular segment—especially in patients in stage 4.

In the group of patent bypasses, the nonconcurring data between expected and actual flows are a few milliliters—average 10 mL/min.—and are probably due to subjective factors or presence of collaterals which are not contrasted during angiography.

Angiography has proved itself as standard technique for morphological intra- and postoperative control of infrainguinal vascular reconstructions; and duplex sonography is an excellent method for postoperative follow up.

Measurement of the velocity of the flow allows detection of stenoses in the early postoperative period and is a routine method in clinical praxis for follow up of infrainguinal vascular reconstructions [12–16]. Extreme importance of the method is its ability to detect stenoses at the anastomotic site, which makes possible early corrections with invasive procedures or minor surgery (Figures 5 and 6).

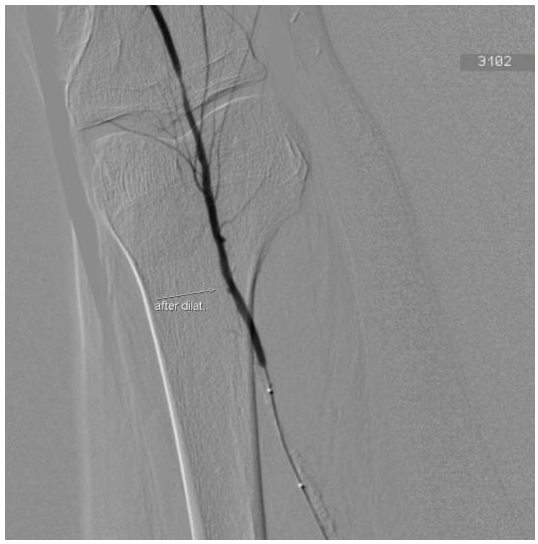

Figure 6: Successful balloon angioplasty (PTA) of the distal anastomosis.

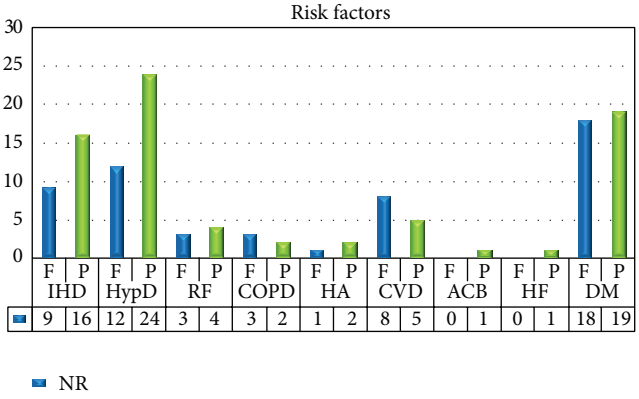

Figure 7: Distribution of the comorbidities by number in both groups—failed (F) and patent (P) IHD—ischaemic heart disease; HypD—hypertension disease, RF—renal failure; COPD—chronic occlusive pulmonary disease; HA—heart attack (chronic); CVD—cerebrovascular disease (chronic or after carotid endarterectomy (CEA)); ACB—aortocoronary bypasses; HF—heart failure; DM—diabetes mellitus.

Intraoperative angiography, although considered golden standard concerning quality control of just constructed bypass, describes only the morphology of the reconstruction, but not the hemodynamics [7]. Angiography is more expensive and more risky procedure in comparison to intraoperative flowmetry [7]. When the flowmetry shows poor results it has sense of screening for detecting of cases requesting hybrid angioplasty, further particularization with Doppler, duplex, or angiography.

5. Conclusion

Having in mind the subjective character of the angiographic score and its dependence on the quality of the image, we consider the preoperative angiographically calculated expected blood flow that could be used as additional indicator for the quality of the newly constructed bypass.

Intraoperative arteriography, considered golden standard referring to the quality control of the bypasses, represents only the morphology of the reconstruction, but not the haemodynamics. When the intraoperative measured flow is low, it has the meaning of a screening for the detection of cases, which need thorough clarification through intraoperative angiography, which represents the morphology of the problem.

Angiography, intraoperative flowmetry, and postoperative duplex sonography are methods related to quality control of vascular reconstructions. Preoperative angiography and modified system for angiographic score of Schwierz give orientation to the surgeon about the early postoperative success of the reconstruction or possible technical mistake, correction of which saves time, resources, revisions, and reoperations.

When the measured flow is lower than expected, but there is no option for operative correction, more frequent postoperative control is prerequisite for minimal-invasive procedures (PTA) with good effect.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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