

Differential Impact of Bypass Surgery and Angioplasty on Angiosome-Targeted Infrapopliteal Revascularization

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WHAT THIS PAPER ADDS

For the first time, the impact of angiosome-targeted revascularization has been studied in terms of wound healing and limb salvage. Unlike previous studies, the results of percutaneous transluminal angioplasty and bypass surgery were compared according to the angiosome concept. Differences in outcomes after bypass surgery and PTA were adjusted by estimating a propensity score, which was employed for one to one matching as well as adjusted analysis.

Objective: The aim of this study was to evaluate the impact of angiosome targeted revascularization according to the revascularization method.

Design: Retrospective observational study.

Materials and methods: This study cohort comprised 744 consecutive patients who underwent infrapopliteal endovascular or surgical revascularization between January 2010 and July 2013. Differences in outcomes after bypass surgery and PTA were adjusted by estimating a propensity score, which was employed for one to one matching as well as adjusted analysis.

Results: Cox proportional hazards analysis showed that angiosome-targeted revascularization (HR 1.29, 95% CI 1.02–1.65), bypass surgery (HR 1.79, 95% CI 1.41–2.27), C-reactive protein ≤ 10 mg/dL (HR 1.42, 95% CI 1.11–1.81), and the number of affected angiosomes (HR 0.85, 95% CI 0.74–0.98) were independent predictors of improved wound healing. When adjusted for the number of affected angiosomes and C-reactive protein ≤ 10 mg/dL, angiosome-targeted bypass surgery was associated with a significantly higher rate of wound healing than non-angiosome-targeted angioplasty (HR 2.27, 95% CI 1.61–3.20). This was confirmed in propensity score adjusted analysis (HR 1.72, 95% CI 1.35–2.16). Among patients who underwent angiosome-targeted revascularization, the propensity score adjusted analysis showed that bypass surgery was associated with a significantly better rate of wound healing (HR 1.54, 95% CI 1.09–2.16) but similar limb salvage rates when compared with angioplasty (HR 0.79, 95% CI 0.44–1.43).

Conclusion: Rates of wound healing and limb salvage in patients with critical limb ischemia (CLI) were significantly better after angiosome-targeted revascularization, bypass surgery achieving significantly better wound healing than angioplasty.

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INTRODUCTION

The angiosome concept, which has been successfully used in plastic surgery for years, has recently been the topic of lively discussion in the field of vascular and endovascular surgery. In 2006, Attinger et al. described six angiosomal regions in the foot and ankle, each supplied by one of the crural arteries and its terminal branches.^{1,2} Based on this

knowledge, several consecutive studies have been carried out applying the angiosome concept to the treatment of critical limb ischaemia (CLI) with tissue lesions.^{3–17} Most of the studies have compared so called targeted versus non-targeted revascularization in patients who have undergone endovascular revascularization. Targeted revascularization is defined as a percutaneous transluminal angioplasty which achieves recanalization from the abdominal aorta to the angiosomal artery.⁶ Two recent meta-analyses of angiosome-targeted versus non-targeted revascularization showed better results in terms of wound healing and limb salvage for angiosome-targeted revascularization procedures.^{18,19} The main benefits of angiosome-targeted revascularization have been observed in patients with

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diabetes and renal failure.^{10,20,21} The very few studies applying the angiosome concept in open surgical treatment of CLI suggested that better wound healing is dependent on the quality of the pedal arch rather than angiosome-guided revascularization.^{11,17} No comparative analysis of surgical versus endovascular angiosome-targeted and non-angiosome-targeted revascularization of patients with CLI and tissue loss (lesions) has been performed so far, thus this issue was investigated in the present study.

MATERIAL AND METHODS

The vascular surgical center in this study is the only provider of treatment of CLI in a population of 1.3 million inhabitants, with an annual number of about 1,000 revascularization procedures for CLI. About one third of the patients are treated on an emergency basis, and 60–70% of the patients are first referred to the outpatient clinic for evaluation and treatment of their CLI. The center has an active policy for the treatment of CLI, whereby a patient is declined for revascularization only if she/he is not mobile, has progressive dementia, extremely short life-expectancy, or no possibilities for revascularization. All patients undergo magnetic resonance imaging (MRI) angiography if not contraindicated, with the method for revascularization chosen on the basis of the results. Usual practice for revascularization is endovascular first, but in cases with extensive atherosclerosis and long occlusions, bypass is preferred as a first line treatment. Difficult cases are discussed in a daily meeting of vascular surgeons and interventional radiologists. A rough threshold for CLI is toe pressure ≤ 30 mmHg in patients without diabetes and ≤ 50 mmHg in diabetic patients, but in cases in whom there is an evident arterial stenosis and non-healing wound, intervention can be done at higher threshold pressure values. The operative techniques offered have been described in detail in previously published articles.^{6,22,23}

This is a retrospective study including 744 consecutive patients with CLI and tissue loss (Fontaine IV), who underwent infrapopliteal endovascular or surgical revascularization between January 2010 and July 2013. The study plan was accepted by the ethical committee of the Helsinki University Central Hospital.

Data collection was performed using a prospectively collected database and scrutinized retrospectively by reviewing patient records as well as patients' angiograms. In patients who underwent endovascular treatment, the angiograms were reviewed before and after the revascularization to evaluate whether the procedure had been angiosome-targeted or not. In patients undergoing surgical bypass, the pre-operative MRI angiograms and digital subtraction angiograms, if available, were reviewed as well.

The patients' baseline characteristics and operative data are summarized in Table 1.

Glomerular filtration rate (eGFR) was estimated by the Modification of Diet in Renal Disease (MDRD) formula.³¹ Angiosome-targeted revascularization was defined as any angioplasty or bypass surgery procedure of the source

artery perfusing the affected area, therefore aiming to create direct flow from the abdominal aorta into the angiosomal source artery.^{5,6}

Wound healing and limb salvage were the main outcome endpoints of the study. Survival and amputation free survival were secondary endpoints.

Statistical analysis

Statistical analysis was performed using SPSS statistical software (SPSS v. 22.0, SPSS Inc., Chicago, IL, USA). Continuous variables are reported as mean and standard deviation. Nominal variables are reported as absolute number and percentage. Pearson's chi-square test, Fisher's exact test, and the Mann–Whitney test were used for univariate analysis. Long-term outcome was assessed by Kaplan–Meier's method with the log-rank test and the Cox proportional hazards method.

Differences between study groups were adjusted by estimating a propensity score. The propensity score was calculated by non-parsimonious logistic regression. Hosmer–Lemeshow's test was used to assess the regression model fit. Receiver operating characteristic (ROC) curve analysis was used to estimate the area under the curve of the model predicting the probability of being included in the groups of patients with and without angiosome-targeted infrapopliteal revascularization. The calculated propensity score was employed for one to one matching, as well as to adjust for other variables in estimating their impact on the post-operative outcome. One to one propensity score matching between study groups was performed according to a caliper width equal to 0.2 times the standard deviation of the calculated propensity score's logit. Outcome in the propensity matched pairs was evaluated by Kaplan–Meier's methods as well as the Cox regression method. A $p < .050$ was considered statistically significant.

RESULTS

Wound healing

Univariate analysis showed that C-reactive protein ≤ 10 mg/dL ($p = .002$), bypass surgery as opposed to angioplasty ($p < .0001$), crural as opposed to pedal revascularization ($p = .001$), and a low number of affected angiosomes ($p < .0001$) were associated with improved foot wound healing. Angiosome-targeted revascularization was associated with a trend towards better wound healing ($p = .071$, Table 2). The Cox proportional hazards analysis revealed that angiosome-targeted revascularization ($p = .036$, HR 1.294, 95% CI 1.017–1.647), bypass surgery ($p < .0001$, HR 1.791, 95% CI 1.412–2.272), C-reactive protein ≤ 10 mg/dL ($p = .005$, HR 1.416, 95% CI 1.110–1.806), and the fewer angiosomes affected ($p = .024$, HR 0.854, 95% CI 0.744–0.979) improved wound healing. Actuarial analysis demonstrated the positive impact of angiosome-targeted bypass surgery on wound healing compared with angiosome-targeted angioplasty (Log-rank: $p < .0001$, Fig. 1). When adjusted for the number of affected angiosomes and C-

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