Long-Term Palmar Microcirculation After Radial Artery Harvesting: An Observational Study

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Background. **The aim of this study was to assess palmar microcirculation in a long-term follow-up after radial artery harvesting for coronary revascularization.**

Methods. **One hundred fourteen patients (100 male; aged 61.7 ± 6.7 years; preoperative New York Heart Association 2.3 ± 0.6, ejection fraction 61.4% ± 13.9%) were included after undergoing elective coronary revascularization using the radial artery of the nondominant forearm with a nonpathologic Allen's test. Superficial and deep tissue oxygen saturation (SO_2), postcapillary venous filling pressure (rHb), capillary blood flow, and capillary blood flow velocity were determined at a mean 25 ± 5 months after surgery using a combined laser Doppler spectrophotometry system.**

Results. **At 2-mm tissue depth, there was a small, but significant, decrease of 3% of superficial SO_2 at the thumb and the thenar eminence (D1: 75.3% ± 8.9% versus 77.6% ± 9.7%, $p = 0.003$; thenar: 71.5% ± 10.5% versus 73.2% ± 8.2%, $p = 0.027$). Deep palmar SO_2 was changed significantly at 5 of 7 positions by 3%. Deep postcapillary venous filling pressure (8 mm) was significantly increased by 9% only at the fingertip of the fifth finger (112.4 ± 49.7 versus 103.0 ± 25.0, $p = 0.033$), while superficial capillary blood flow decreased by 13% at only 1 of 7 positions at the hypothenar eminence (242.0 ± 153.6 versus 275.6 ± 169.2, $p = 0.009$). Overall, only 2 of 56 positions exceeded a given threshold of 5% change of microcirculation. No clinical signs of malperfusion were found (postoperative New York Heart Association 1.1 ± 0.4, $p < 0.05$), and no patient was impaired in daily palmar motor activity.**

Conclusions. **Long-term objective evaluation of superficial and deep palmar microcirculation confirms that radial artery harvesting for coronary revascularization does not compromise palmar microcirculation.**

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In 1971, Carpentier and associates [1] first described the use of the radial artery as a source for coronary artery bypass graft harvesting. The advantages of the radial artery as a graft source are the ease of harvesting, a low propensity for wound infection, a larger diameter than other arterial grafts, and a thick, muscular wall that facilitates the construction of a coronary anastomosis. Radial artery grafts provide excellent long-term patency. A randomized controlled trial in a total number of 561 patients found a 1-year angiography radial occlusion rate of 8.2% whereas for the saphenous vein, this was 13.6% [2]. Ten-year patency rates of 92% for the radial artery and 98% of the left internal thoracic artery have been reported in an observational study [3]. However, histologic studies [4] of distal and proximal radial artery specimens taken during coronary revascularization revealed the predictive factors for intimal hyperplasia of the radial artery graft to be age greater than 50 years (1.052), cigarette smoking (14.073), and arterial hypertension (2.777).

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Concerns about reduced palmar blood flow after radial artery harvesting have been previously raised. Methods to assess forearm and palmar blood flow include forearm plethysmography [5] or technetium-99m albumin scans [6] and the clinical Allen test. Pulse volume recording plethysmography as a semiquantitative measurement found an overall decrease of digital blood flow after radial artery harvesting 7 days postoperatively in 24 patients predominantly in the first two fingers [7], which is concordant with findings by flow index differences calculated by photoelectric plethysmography [8].

Palmar microcirculation has been studied using a combined laser Doppler spectrophotometry system, the Oxygen to See (O2C) system (O2C OXYGEN TO SEE; LEA Medizintechnik, Giessen, Germany) system in a small initial patient group (n = 15) preoperatively and at the second postoperative day, revealing no significant differences in tissue oxygen saturation, postcapillary venous filling pressures, and capillary blood flow at 2- and 8-mm tissue depths [9]. However, the small patient group and the limited postoperative observation period for the assessment of microcirculation prompted us to examine whether radial artery harvesting changes the palmar microcirculation over the long term. We studied 114 patients, 25 months after radial artery harvesting for coronary revascularization (CABG), using detailed spa-

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Table 1. Characteristics of the 114 Patients Undergoing Radial Artery Harvesting for Coronary Revascularization in This Study

Patient Characteristics	
Enrolled patients	114
Follow-up (postoperative months)	25.4 ± 5.3
Age (years)	61.7 ± 6.7
BMI before operation	27.6 ± 3.9
BMI 2004	27.9 ± 4.0
NYHA before operation	2.3 ± 0.6
NYHA 2004	1.1 ± 0.4
Ejection fraction (%)	61.4 ± 13.9
Duration of operation (min)	211.6 ± 57.4
Cross-clamp time (min)	49.2 ± 24.1
Bypass time (min)	89.1 ± 41.5
ICU stay (days)	1.8 ± 3.5
Previous operations	11.4%
Reoperation	7.8%
Rehospitalization	16.7%
Arterial hypertension	72.8%
Positive family history	31.6%
Lipometabolic disorder	88.6%
Physical activity (units per week)	1.8 ± 2.2
Cardiovascular sportsgroup (units per week)	0.2 ± 0.4
Rehabilitation program	86.8%
Complicated wound healing	12.3%

BMI = body mass index; ICU = intensive care unit; NYHA = New York Heart Association.

tial analysis of palmar microcirculation at 14 positions at each hand using the real-time quantitative laser Doppler spectrophotometry system O2C.

Patients and Methods

Patients' Characteristics

One hundred fourteen patients (100 male; aged 61.7 ± 6.7 years; preoperative New York Heart Association status 2.3 ± 0.6 and ejection fraction 61.4% ± 13.9%; Table 1) participated in the study after informed consent. The Institutional Review Board approval had been given about the study by the local Ethics Committee in Hannover Medical School, Germany, in July 2004 before the study. Every person participated after further individual written consent. All patients had elective coronary revascularization because of coronary artery disease using the radial artery as either a free or T graft additionally to the left internal thoracic artery. Exclusion criteria included emergency revascularization, Raynaud's disease, evident palmar malperfusion or signs of ischemia before the radial artery harvesting, and a pathologic Allen test. The CABG procedure time was 212 ± 57 minutes, aortic cross-clamp time was 49 ± 24 minutes, and extracorporeal circulation time was 89 ± 42 minutes. Mean stay on the intensive care unit was 1.8 ± 3.5 days. Patient cardiovascular risk factors and postoperative physical activity are documented in Table 1. All radial artery grafts were harvested using the same technique from a forearm incision using an electric scalpel using a pedicle technique. Minimally invasive harvesting or radial skeletonized techniques were not used in this cohort. All grafts were perfused with papaverin solution to prevent early vasospasm, and all patients received diltiazem (90 mg twice a day) for at least 14 days to prevent radial artery vasospasm during the immediate postoperative period. The majority of radial arteries were used in the T-graft technique (73.9%), with 24.2% as a free graft and 1.4% as a jump graft.

Power Analysis

Regarding different patient risk factors such as arterial hypertension, lipid disorders, body mass index, and sport activities, we performed a detailed power analysis to determine the number of patients needed to reach a significant difference ($\alpha = 0.050$, two-sided test, power 80%), which is depicted in Table 2.

All palmar perfusion examinations were conducted 25 ± 5.3 months after radial artery harvest and were performed by the same experienced examiner with the O2C system under identical conditions in an ambient light room after equilibration. Seven identical positions on both hands (harvesting side of the radial artery and corresponding nonoperated side) were defined—the palmar side of each fingertip (D1-D5), and the thenar and hypothenar eminence—and measurements were conducted on the sitting patient with the arm in a stable resting position.

Determination of Microcirculation Noninvasively

A combined laser-Doppler and flowmetry system (O2C system; LEA Medizintechnik) was used in this study to evaluate microcirculation at two distinct tissue depths, 2 and 8 mm, noninvasively. The optical method for measuring both blood flow by laser-Doppler technique and hemoglobin oxygenation and hemoglobin concentration in tissue by spectrometric techniques has been described in detail elsewhere [10]. The determination of hemoglobin and the principle of blood flow measurement are combined in the O2C system. The local oxygen supply parameters, blood flow, oxygen saturation of hemoglobin SO_2 (%), and amount of local hemoglobin rHb are recorded by an optical fiber probe (LEA Medizintechnik).

Laser Doppler Flowmetry

The tissue is illuminated with coherent laser light of 830 nm wavelength and 30 mW from a laser diode through a fiber optic light guide. Backscattered light is collected by the same probe, and frequency shifted light extracted by a heterodyne light beating technique. The power-spectral density of shifted light is a linear function of the average velocity of moving cells within the tissue. As laser Doppler flowmetry detects all moved particles of certain velocity, it measures blood flow.

Measurement of Volume

Laser Doppler perfusion measurements can increase sampling depth by using near-infrared laser light and