In vivo functional flowmetric behavior of the radial artery graft: Is the composite Y-graft configuration advantageous over conventional aorta–coronary bypass?

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Introduction: Intraoperative flowmetric results of different configurations (Y-graft or aorta–coronary) of radial artery grafts have been poorly investigated.

Methods: We report the results of an observational study designed to analyze transit-time flow measurements at baseline and during 1:1 intra-aortic balloon pumping in 114 consecutive patients receiving the radial artery as a aorta–coronary bypass (group A, 72 patients) or as a Y-graft with the left internal thoracic artery (group B, 42 patients). Graft flow reserve, recruited by 1:1 intra-aortic balloon pumping) greater than 1 indicated recruitment of surplus graft flow. Results were stratified by grafted territory and surgical technique.

Results: Hospital outcome was comparable. Baseline transit-time flow results were similar between the 2 groups in terms of maximum diastolic flow, minimum systolic flow, mean flow, and pulsatility index. Graft flow reserve was not recruited by intra-aortic balloon pumping in 3 (2.7%) malfunctioning single aorta–oronary radial artery bypass grafts ($P = .005$ versus successful radial artery bypass grafts). Graft flow reserve was recruited (>1) by intra-aortic balloon pumping in the remaining 111 patent radial artery bypass grafts. Y-grafts showed higher maximum diastolic flow $P < .0001$), mean flow ($P < .0001$), graft flow reserve ($P < .0001$), percentage improvement of maximum diastolic flow ($P < .0001$), and of mean flow ($P < .0001$) compared with aorta–coronary radial artery bypass grafts. These results were confirmed for the right coronary ($P \leq .004$) and the circumflex territory ($P \leq .001$), for off-pump ($P \leq .008$) or cardiopulmonary bypass ($P < .0001$) and for patients undergoing isolated bypass grafting ($P < .0001$).

Conclusions: Intraoperative flows of radial artery bypass grafts showed comparable baseline results in single aorta–coronary conduits and Y-grafts. Graft flow reserve recruited by intra-aortic balloon pumping was higher in Y-conduits, regardless of the grafted territory and the perfusion strategy chosen. Failed radial artery bypass grafts did not improve transit-time flow results during 1:1 intra-aortic balloong pumping nor showed any recruitment of graft flow reserve. (J Thorac Cardiovasc Surg 2010;140:292-7)

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The recent demonstration of improved survival in patients undergoing arterial revascularization stimulated surgeons to an increasing use of arterial grafts other than internal thoracic arteries (ITAs) to completely revascularize the heart.[1] In this setting, the radial artery (RA) is the most frequently used arterial conduit worldwide.[1] Different configurations of RAs as conduits for myocardial revascularization have been reported.[2] However, despite comparable clinical outcomes, few studies have addressed the in vivo functional flowmetric behavior of different surgical configurations.[2] In particular, the recent availability of transit-time flowmetry (TTF) has allowed surgeons to explore in vivo the functional behavior of different conduits.[3,4] Moreover, the correlation between TTF results and graft patency at short-term angiographic follow-up has popularized the use of TTF technology in daily practice.[4]

Furthermore, despite previous concerns that have arisen toward the appropriateness of a single blood supply through other arterial conduits in composite configurations, it has been clearly demonstrated that the main stem of an ITA supplies sufficient blood in composite Y- or T-graft configurations.[5] However, the literature lacks studies reporting the in vivo amount of blood flowing through the 2 different branches of composite grafts with RAs. Moreover, although comparable blood flow has been reported in composite grafts

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Abbreviations and Acronyms

CABG	= coronary artery bypass graft
CPB	= cardiopulmonary bypass
GRF	= graft flow reserve
IABP	= intra-aortic balloon pump
ITA	= internal thoracic artery
LAD	= left anterior descending coronary artery
LITA	= left internal thoracic artery
OPCABG	= off-pump coronary artery bypass grafting
PI	= pulsatility index
RA	= radial artery
TTF	= transit-time flowmetry

using either double ITAs or ITA-RAs,[5,6] to the best of our knowledge no literature data have ever addressed differences in flowmetric results of the RA in coronary artery bypass grafting (CABG) when used as single aorta–coronary conduits or as composite Y-grafts; similarly, no stratification of TTF results based on the grafted territory and the surgical technique used (off-pump/on-pump) has ever been reported.

Therefore, the aim of the present observational study was to investigate TTF results of RA CABGs in 2 different configurations (single aorta–coronary [(group A] or composite Y-graft with left ITA [LITA; group B], in different target territories, either off-pump (OPCABG) or on cardiopulmonary bypass (CPB), during a 16-month period at a single academic institution.

PATIENTS AND METHODS

Patients

We analyzed data from 114 consecutive patients undergoing CABG with preoperative intra-aortic balloon pump (IABP) support at our institution during the past 16 months (January 2008–May 2009). Seventy-two patients (group A) underwent aorta–coronary RA CABG, the remaining 42 (group B) underwent composite Y-graft with RA and LITA. All patients received preoperative IABP, according to institutional policy.[4] The study protocol was approved by the institution's ethical committee/institutional review board, and informed consent was obtained from each patient.

Surgical Technique

To better support hemodynamic function before CABG, institutional policy called for percutaneous insertion of an IABP with the technique already described.[4] Surgery was performed through a median sternotomy by the same surgeons (A.R., F.O.). Harvesting of the LITA and RA has been standardized and already reported in the literature.[3] In brief, the composite LITA-RA anastomoses were performed in advance, after systemic heparinization. The RA was spatulated 2 mm and anastomosed to a 4- to 5-mm incision in the pleural aspect of the LITA at the level where the LITA enters the pericardial space anterior to the left atrial appendage. Obtuse marginal branches and the right coronary territory were the targets of RA grafts. Distal anastomoses were performed with 8-0 polypropylene stitches. Intravenous or oral vasodilators, except for enoximone infusion, were never used after RA grafting. So that the risk for ''string sign'' and/or competitive flow from the native coronary circulation could be avoided, RA grafting was only accomplished on target vessels with more than 80% stenosis at least. The choice for aorta–coronary conduit configuration or for the Y-configuration was left to surgeon's choice, except in 4 (3.5%) patients with diffuse calcifications of the ascending aorta and 1 (0.8%) patient with ''egg-shell'' aorta, in whom composite Y-grafting was considered mandatory. Proximal anastomoses of all RA grafts were directly done on the ascending aorta. The use of CPB and OPCABG protocols was standardized.[3] Both surgeons were able to perform either traditional or Y-conduit grafts.

Flowmetric Analysis and Evaluation of Graft Flow Reserve

Graft flowmetry was evaluated during IABP support and during its temporary cessation to avoid intraoperative bias and to standardize the technique. Thus patients served as their own controls. Graft function was assessed under stable hemodynamic conditions, generally 30 minutes after protamine administration. Considering that graft flow reserve (GFR) is also influenced by loading conditions, TTF analysis was performed under similar volume loading (central venous pressure: group A 9.7 $\pm$ 2.4 mm Hg vs group B 10.2 $\pm$ 1.9 mm Hg; $P = .689$). Flowmetry of the grafts was performed with a transit-time flowmeter (HT313 Transonic; Transonic Systems Inc, Ithaca, NY). Different probe sizes (2, 2.5, or 3 mm) were available to avoid distortion or compression of grafts. Skeletonization of a small segment of the proximal RA branch and of the proximal LITA branch was necessary to reduce the quantity of tissue interposed between the vessel and the probe.

The curves were always coupled with the electrocardiogram tracing to differentiate systolic from diastolic flow. The following variables were calculated—maximum diastolic, minimum systolic, and mean flows (expressed in mL/min)—directly derived from the flowmeter, and pulsatility index (PI, derived from maximum diastolic flow − minimum systolic flow/mean flow). The flow pattern (systolic, diastolic) was directly derived from the flow curve of the trace. Data from LITA and RA conduits, stratified by grafted territory (circumflex and right coronary) and surgical technique (OPCABG/CPB) were recorded. So that the potential of IABP to recruit GFR could be evaluated, TTF measurements were recorded both during 1:1 IABP support and after 5 minutes of temporary cessation (''IABP off''). Systolic, end-diastolic, and mean arterial pressures were recorded invasively through a pressure transducer connected to the RA and compared during 1:1 IABP support and during its temporary cessation. Percent improvements in maximum diastolic, minimum systolic, and mean blood flows were calculated. The GFR was calculated from the mean flow occurring during 1:1 IABP support divided by the mean flow during temporary cessation, as already reported.[3]

Data Collection

According to an institutional policy, inotropes were started immediately either in on-pump CABG or in OPCABG, starting with enoximone at a dosage of 5 $\mu g \cdot kg^{-1} \cdot min^{-1}$ in respect with the protocol already reported.[7] Troponin I from the peripheral venous line was collected preoperatively and on the first and second postoperative days.

Hospital mortality and morbidity were defined as previously reported.[3,7]

Statistical Analysis

All data were prospectively recorded by means of the institutional database. Statistical analysis was performed with use of the SPSS program for Windows, version 13.0 (SPSS Inc, Chicago, Ill). Continuous variables are presented as means $\pm$ standard deviation, and categorical variables are presented as number (percentage) of patients. Data were checked for normality before analysis. The paired-sample *t* test was used to evaluate differences in continuous variables during 1:1 IABP support versus during its temporary cessation (''IABP-off''). One-way analysis of variance was used to evaluate the significance of differences among types of bypass grafts. Two-way analysis of variance for repeated measures was used for comparisons within (1:1