Preoperative Assessment of the Radial Artery for Coronary Artery Bypass Grafting: Is the Clinical Allen Test Adequate?

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Background. **The clinical Allen test (AT) is widely adopted as the only preoperative assessment of the hand collateral circulation before radial artery (RA) harvest as a coronary artery bypass graft. Nevertheless, in some cases it may be misleading because of clinically undetectable anatomic anomalies of the forearm arteries.**

Methods. **We evaluated the nondominant forearm arterial circulation by echo color Doppler (ECD) technique and by performing static and dynamic tests such as the AT, snuffbox test (SBT), and palmar arch test (PAT) in 150 patients who underwent elective coronary artery revascularization with a RA graft.**

Results. **Although the clinical AT was normal in all patients, in 8 patients (5.3%) preoperative ECD AT, SBT, and PAT did contraindicate RA harvesting. We did not harvest the RA in these patients. In the remaining 142 patients the RA was harvested. We did not observe any case of postoperative forearm or hand ischemia. We examined the blood flow to the hand in all patients at both 5 days and 24 months after surgery. In all patients ECD showed adequate hand perfusion and a significant increase of the peak flow velocity in the ulnar artery at both follow-up times.**

Conclusions. **The clinical AT may be not sufficient to assess the hand collateral flow and the quality of the RA as a coronary artery bypass graft in at least 5% of patients. The ECD technique, performed during static and dynamic tests, does offer a safer and more objective preoperative noninvasive evaluation and it may have an important role also from the medicolegal point of view.**

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The Allen test (AT), introduced into clinical practice in 1929 [1], has been widely adopted as the preoperative evaluation of the collateral circulation of the hand before radial artery (RA) harvesting as a coronary artery bypass graft. Nevertheless, in some patients the clinical AT may be misleading because of anatomic anomalies [2] of the forearm arteries and the subjective performance and interpretation of the test. The consequences of a false-negative AT may be severe after RA harvesting [3] and even catheterization [4], in terms of both clinical outcome and medicolegal issues.

This study compared the clinical AT test with instrumental evidence from the noninvasive echo color Doppler (ECD) evaluation of the forearm and hand blood supply.

Patients and Methods

From October 2001 to December 2002 we tested the nondominant arterial forearm circulation in 150 consecutive patients who underwent elective coronary artery bypass grafting (CABG). Thirty-six patients (24%) were affected by diabetes mellitus. Testing was by means of both a modified clinical AT and an ECD device (Aspen-Acuson, Inc, Mountain View, CA) with a 7-MHz linear transducer. We excluded from RA testing and harvest patients with an history of previous forearm fracture or surgery, subclavian artery stenosis, renal failure, or Raynaud disease.

In brief, in a modified clinical AT, we occlude both the RA and the ulnar artery (UA) while the patient makes a fist. Then, the patient extends the fingers and the examiner releases the pressure only from the UA [5]. In a normal test, adequate collateral circulation is indicated by the return of normal color to the hand within 10 seconds [6]. Before ECD testing, we did not stop any vasoactive drug (β-blockers, calcium antagonists, angiotensin-converting enzyme inhibitors) that had been previously prescribed to the patient. By means of ECD, we performed an evaluation of vessel wall morphology and a static test to record the basal RA flow. Exclusion criteria for RA harvest were an RA peak systolic flow velocity (PSFV) of less than 0.20 m/s, an RA diameter of less than 2.0 mm [7], or evident RA calcifications or atherosclerotic plaques.

Three dynamic tests were performed. The first, the AT, consists of measuring the UA PSFV at the wrist before and after RA compression. An increasing PSFV after RA

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Abbreviations and Acronyms

AT = Allen test
CABG = coronary artery bypass grafting
ECD = echo color Doppler
PAT = palmar arch test
PSFV = peak systolic flow velocity
RA = radial artery
SBT = snuff box test
UA = ulnar artery

compression is a sign of adequate collateral perfusion. Then we performed the snuffbox test (SBT), as previously described [8]. Briefly, we position the probe in the anatomic snuffbox where the RA runs between the first metacarpal bone and the second carpal bone from the dorsal to the palm side and the anastomoses itself with a deep branch from the UA to form the deep palmar arch. After its compression, the ECD RA flow velocity is evaluated, and a backward flow direction is evidence of good collateral hand circulation. The last, the palmar arch test (PAT) is accomplished by positioning the probe on the thenar eminence to measure the superficial palm artery flow direction during RA compression. The backward flow in this artery indicates a good perfusion of the superficial palmar arch of the UA.

Harvest of the RA was performed by dividing collateral branches by means of titanium clips and electrocautery. At the end of the procedure, a drainage tube was inserted below the forearm fascia to prevent hematoma formation and compartmental syndrome.

The patients underwent two postoperative ECD assessments: early postoperative (just before the hospital discharge) and at 24 months after the operation.

A paired samples t test was used to compare mean PSFV into the UA, as assessed by ECD; p values of less than 0.05 were considered significant. Statistical analysis was carried out with SPSS 8.0 software (SPSS Inc., Chicago, IL).

Results

The modified clinical AT result was normal in all patients. However, preoperative ECD AT, SBT, and PAT did contraindicate RA harvesting in the nondominant arm in 8/150 (5.3%) patients even though their clinical AT was normal. We did not perform further investigations (angiography of the nondominant arm or ECD assessment of the dominant arm) in these patients, and we harvested a great saphenous vein for the graft instead of the RA.

Table 1. Preoperative and Early Postoperative PSFV

Vessel	Time	Condition	Mean	Range
RA	preop	basal	0.33 ± 0.02 m/s	0.24–0.39m/s
UA	preop	basal	0.32 ± 0.02 m/s[a]	0.26–0.34m/s
UA	postop	basal	0.46 ± 0.03 m/s[a]	0.41–0.54m/s

[a] $p = 0.0001$.

RA = radial artery; PSFV = peak systolic flow velocity; UA = ulnar artery.

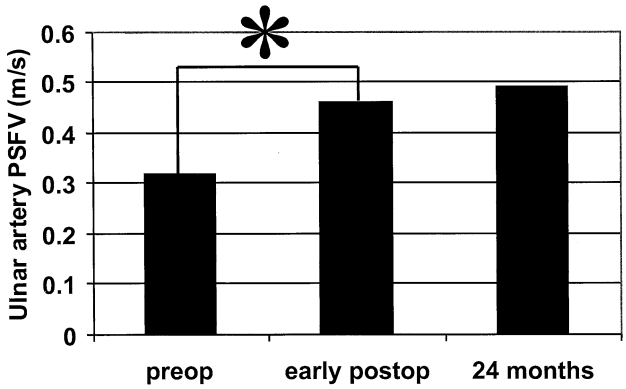

*Fig 1. Peak systolic flow velocity (PSFV) of the ulnar artery measured before and after radial artery harvesting for coronary artery bypass grafting. *p < 0.0001.*

In the rest of the patients (142) we did not observe in any significant anatomic variations, including vessel diameter of less than 2.0 mm or gross calcifications or atherosclerotic changes, that contraindicated RA harvest. We did not record any perioperative death. None of patients who underwent RA harvest had ischemic hand complications or wound infections; 18 of the 142 patients (12.6%) reported a slight thumb paresthesia, likely related to inadvertent traction on the superficial branch of the radial nerve during harvesting.

Before discharge from hospital, we used ECD to reexamine the hand arterial blood supply. RA removal had been fully compensated in all patients by a statistically significant increase of mean PSFV into the UA compared with the preoperative value (preoperative PSFV, 0.32 ± 0.02 m/s; postoperative PSFV, 0.46 ± 0.03 m/s; $p = 0.0001$) (Table 1) and through the anastomotic net existing between the deep and superficial palmar arch and the dorsal carpal arch.

Finally, 97 patients underwent further ECD assessment of the arterial circulation of the forearm and hand at 24 months from the operation. We were unable to follow up the remaining patients because they were living far away from the institution. We did not observe significant differences in terms of mean UA PSFV compared with the early postoperative value (0.46 ± 0.03 m/s vs 0.49 ± 0.03 m/s, $p = 0.37$) (Fig 1). Doppler analysis showed the triphasic wave of a high-resistance arterial system. Mean UA PSFV did not differ significantly between women and men (0.51 m/s vs 0.49 m/s, respectively, $p = 0.87$). The

Table 2. Outcomes at 24 Months From the Operation

Number of patients	97
Hand paresthesia at rest	17/97 (17.5%)
Hand motor deficit	0
Mean UA PSFV	0.49 ± 0.03 m/s (0.42–0.58 m/s)

PSFV = peak systolic flow velocity; UA = ulnar artery.

incidence of neurologic complications at 24 months is shown is Table 2.

Comment

The assessment of adequate ulnar collateral supply to the hand is mandatory before RA catheterization or harvest as a coronary artery bypass graft. Neurologic or ischemic hand complications are reported with a variable incidence [9–14] and may also be partly related to an improper surgical technique. Of more importance is the emerging evidence that hand motor function may be mildly but persistently compromised long term after RA harvest in up to 12% of patients, particularly among diabetic patients [10]. An association between thumb weakness and sensory abnormalities may imply median nerve ischemic damage at least in some patients [10].

Results from a clinical AT may be influenced by anatomic anomalies of the forearm arteries [2], such as the presence of a superficial dorsal branch of the RA or a persistent median artery, and by the subjective performance and interpretation of the test. Uninvestigated anatomic anomalies of the RA, present in up to 8% of patients [2], may compromise hand blood supply after RA harvest.

These limitations have led us to adopt routinely the ECD technique with dynamic tests in the preoperative forearm evaluation before RA harvest [15]. The snuffbox test [8] allows the evaluation of the backflow from the ulnar artery into the more distal part of the RA through the deep palmar arch. Moreover, ultrasound examination also allows the preoperative rejection of an RA graft that is inadequate because of small diameter, vessel wall arteriosclerosis, or calcification, which is present in up to 31% of patients as reported by Ruengsakulrach and colleagues [16].

In our opinion it is mandatory that a preoperative ECD static and dynamic evaluation be performed during static and dynamic tests to prevent hand complications; moreover, this instrumental testing may have importance from the medicolegal point of view. By means of routine preoperative ECD, we did not observe any perioperative or postoperative ischemic complications to the hand. Of more importance was that no case of gross motor hand deficit was detected either at early or midterm follow-up.

Obviously, from the results of this study we cannot draw any conclusion about the outcome of RA harvest in patients with abnormal ECD testing. Nevertheless, in our opinion both ethic and medicolegal issues contraindicate RA harvest in such cases, particularly if another kind of graft is available. In additon, the reliable evaluation of the forearm circulation can be performed by means of other techniques [17] such as pulse oximetry that also allow intraoperative monitoring of collateral blood flow [12].

In conclusion, the clinical AT may be not sufficient to assess the hand collateral flow and the quality of the RA as bypass graft in at least 5% of patients. The ECD technique, performed during static and dynamic tests, does offer a safer and more objective preoperative noninvasive evaluation of forearm arterial circulation before RA harvest. Performing ECD before RA harvest may also have an important role from the medicolegal point of view. It allows the identification of patients with a marginal or inadequate collateral blood supply of the hand, and in these patients, the RA should be not harvested to avoid any injury to the functional integrity of the hand.

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