Technical Issues in the Use of the Radial Artery as a Coronary Artery Bypass Conduit

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The clinical and angiographic benefits related to the use of the radial artery (RA) as a bypass conduit have extensively been proven. However, due to its morpho-functional features and its anatomic position, successful use of the RA requires careful consideration of several technical issues. We herein summarize the current evidence on all the technical aspects related to the RA use in coronary surgery such as the preoperative evaluation of ulnar compensation, the different means of intra-operative vasodilatation, and the various harvesting techniques.

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The radial artery (RA) contends to the right internal thoracic artery (ITA) for the role of the second arterial conduit [1]. In the 20 years since its reintroduction in coronary surgery [2] the most important morpho-functional features and the long-term outcome of RA grafts have been elucidated.

Although several review and meta-analyses have analyzed the current evidence on the RA clinical and angiographic outcome [3–5], to date no overview on the technical aspects of the use of the RA in coronary artery bypass surgery (CABG) has been published. In this manuscript we summarize the actual knowledge on the various technical issues related to the RA utilization during CABG operations.

Material and Methods

In March 2014 the PubMed database was searched using the definition "radial artery coronary surgery," "radial artery harvesting," "radial artery endoscopic harvesting," "radial artery preoperative evaluation," "skeletonized radial artery," "pedicled radial artery," "radial artery proximal anastomosis," "radial artery vasodilatation," and "radial artery harmonic scalpel." All relevant abstracts were reviewed and the function "related articles" was used for all included manuscripts. Careful reference cross-check was performed for all selected studies.

Results

Preoperative Evaluation of the Adequacy of Ulnar Compensation

The RA is usually removed from the non-dominant arm (where, however, it is usually smaller) [6], although bilateral harvesting has been reported [7] (Fig 1A;B). To date no precise guidelines on the method to be used for preoperative evaluation of the adequacy of the ulnar artery (UA) compensation to RA removal exist and several methods of assessment have been proposed.

The modified Allen test is the simplest method in assessing the adequacy of ulnar compensation, but its reliability has repeatedly been questioned [8]. Jarvis and colleagues [9], in an often cited study, found that using a Doppler ultrasound test as gold standard, at a conventional cutoff of 6 seconds the Allen test had a sensitivity of 54.5%, specificity of 91.7%, and diagnostic accuracy of 78.5%; at a cutoff of 5 seconds diagnostic accuracy was maximal (79.6%), with sensitivity of 75.8% and specificity of 81.7%, whereas 100% sensitivity occurred at a cutoff of 3 seconds, with specificity of 27% only and diagnostic accuracy of 52%.

Yet, more than 1 author has reported safe RA removal when the Allen test is coupled with another simple test such as percutaneous oximetry or when cases with abnormal test are more deeply investigated by duplex ultrasonography. Meharwal and colleagues [10] reported safe RA removal in 3,977 patients in whom the preoperative Allen test was supplemented with intraoperative pulse oximetry, and Abu-Omar and colleagues [11] were able to avoid ischemic hand complications in 287 cases submitted to the Allen test coupled with ultrasonography only in case of doubtful or abnormal results. Of note in this study all Allen tests were performed by a single senior surgeon and enabled RA use without need for other evaluations in 88% of the cases.

Pulse oximetry gives indirect information on the status of the forearm vasculature. Although it has never been used as the sole method to assess collateral circulation, it can supplement the clinical or Doppler study. Johnson and colleagues [12] successfully used pulse oximetry in conjunction with the Allen test before RA harvesting in a large series of 452 evaluations. Plethysmography, computed tomography angiography, and intraoperative RA pressure measurement are other useful tools, although less often used for screening [13–15].

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Abbreviations and Acronyms

CaANT = calcium antagonists
CABG = coronary artery bypass graft
HS = harmonic scalpel
ITA = internal thoracic artery
NI = nitrates
PED = pedicled
PHE = phenoxybenzamine
RA = radial artery
SK = skeletonized
SV = saphenous vein
UA = ulnar artery

Routine preoperative echo-Doppler study of the forearm vasculature has also been proposed [16]. Doppler evaluation is usually performed at rest and after RA compression and the variation of flow in the superficial palmar arch and digital arteries is assessed [16]; echo-Doppler study has the additional advantage of providing morphometric information on the artery.

On the basis of the published evidence one can conclude that contraindications to RA harvesting are present in 10% to 20% of cases [11–17] and can be classified as morphologic or circulatory. Morphologic contraindications are RA inner diameter less than 2 mm or diffuse intimal or medial calcification; circulatory contraindications include absence of flow reversal in the RA during compression, less than 20% increase in UA peak systolic flow during RA compression, and greater than 40% decrease in digital pressure during RA compression at digital plethysmography. The current attitude is to couple the modified Allen test with another simple method or to use it as the first line exam, reserving more complex evaluations to doubtful or abnormal cases [17].

Effects of RA Removal on Forearm Blood Supply and Function

The most frequent complications after RA removal are sensory abnormalities in the ulnar or median region and thumb weakness [18]; although the overall incidence of these symptoms is not negligible (around 30%), they are usually minor and tend to improve considerably over time [19, 20]. Direct surgical trauma and devascularization are possible mechanisms of these complications. Recognized risk factors are diabetes, peripheral vasculopathy, renal insufficiency, and active smoking [18]. Hata and colleagues [21] as part of a large prospective randomized study compared the rate of harvest-related complications from different sites and found that RA harvesting was associated with a lower rate of wound infection and scar discomfort compared with saphenous vein (SV) removal.

Radial artery removal leads to an early marked increase in UA flow and to flow redistribution in the common digital palmar arteries (decreased in the first and increased in the second and third) with preserved blood flow to the forearm [22]. Of note, some studies suggest that even in patients with preoperative evidence of good ulnar compensation, RA removal leads to minor, asymptomatic degrees of forearm and hand ischemia, especially in condition of sustained muscular effort [23]. Moreover, probably as a consequence of the flow augmentation, the intima-media thickness of the UA in arms where the RA had been removed increases significantly during the 10 years after surgery and the prevalence of atherosclerotic plaques becomes higher than that of control arms [24].

To summarize, in patients with preoperative evidence of adequate UA compensation RA removal is safe and usually leads only to minor, transient symptoms. However, UA collateral flow is probably inadequate in case of

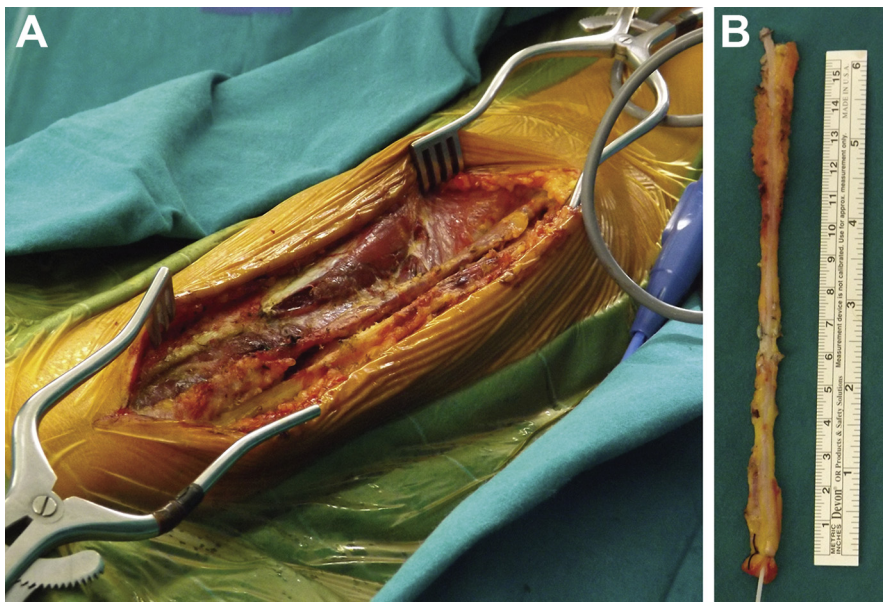

Fig 1. Intraoperative images of surgical harvesting. (A) The surgical harvesting of the conduit and (B) the prepared artery.