JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
© 2015 BY THE AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION
PUBLISHED BY ELSEVIER INC.

VOL. 66, NO. 15, 2015
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2015.08.395

REVIEW TOPIC OF THE WEEK

The Choice of Conduits in Coronary Artery Bypass Surgery

Mario Gaudino, MD,*† David Taggart, PhD,‡ Hisayoshi Suma, MD,§ John D. Puskas, MD,‖ Filippo Crea, MD,† Massimo Massetti, MD†

ABSTRACT

Coronary artery bypass grafting is the most common cardiac surgery operation performed worldwide. It is the most effective revascularization method for several categories of patients affected by coronary artery disease. Although coronary artery bypass grafting has been performed for more than 40 years, no detailed guidelines on the choice of coronary artery bypass grafting conduits have been published and the choice of the revascularization strategy remains more a matter of art than of science. Moreover, there is a clear contradiction between the proven benefits of arterial grafting and its very limited use in everyday clinical practice. In the hope of encouraging wider diffusion of arterial revascularization and to provide a guide for clinicians, we discuss current evidence for the use of different conduits in coronary artery bypass surgery and propose an evidence-based algorithm for the choice of the second conduit during coronary artery bypass operations. (J Am Coll Cardiol 2015;66:1729–37) © 2015 by the American College of Cardiology Foundation.

Although coronary artery bypass graft (CABG) has been performed for more than 40 years, no detailed guidelines on the choice of CABG conduits have been published to date. Moreover, current practice demonstrates a clear contradiction between the proven benefits of arterial grafting and the very limited use of arterial conduits in everyday clinical practice.

With the aim of encouraging a wider diffusion of arterial revascularization, and to provide a guide for clinicians, we herein discuss the current evidence basis for the use of different arterial conduits for CABG and propose an evidence-based algorithm for the choice of the second conduit during coronary operations.

SEARCH METHOD

In December 2014, the PubMed database was searched using the terms "radial artery," "gastroepiploic artery," and "internal thoracic artery" coupled with "coronary surgery," "myocardial revascularization," "coronary artery bypass," "CABG," and "patency." Relevant abstracts were reviewed and the related articles function was used for all included manuscripts. References for all selected studies were cross-checked. The present review focuses on data from randomized controlled trials (RCT), propensity-matched observational series, and meta-analyses. Unmatched observational series were considered only when data from RCT or propensity-matched studies were not available.

It is important to note that the quality and weight of the evidence for the various conduits is not the same. RCT and propensity-matched series include around 25,000 patients for bilateral internal thoracic arteries (BITA), 2,000 for the radial artery (RA), and a few hundred for the right gastroepiploic artery (GEA).

From the *Department of Cardiothoracic Surgery, Weill Cornell Medical College, New York, New York; †Department of Cardiovascular Sciences, Catholic University, Rome, Italy; ‡University of Oxford, Department of Cardiac Surgery, John Radcliffe Hospital, Oxford, United Kingdom; §Suma Heart Clinic, Tokyo, Japan; and the ‖Department of Cardiovascular Surgery, Icahn School of Medicine at Mount Sinai, New York, New York. Dr. Taggart has received research and travel funding from VGS; research and speaking fees from Somahlution; and research, travelling, and speaking funding from Medistim. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Listen to this manuscript's audio summary by *JACC* Editor-in-Chief Dr. Valentin Fuster.

Manuscript received July 30, 2015; accepted August 13, 2015.

ABBREVIATIONS AND ACRONYMS

BITA = bilateral internal thoracic artery

CABG = coronary artery bypass graft

CI = confidence interval

GEA = gastroepiploic artery

HR = hazard ratio

ITA = internal thoracic artery

LAD = left anterior descending

OR = odds ratio

RA = radial artery

RCT = randomized controlled trial(s)

RITA = right internal thoracic artery

RR = relative risk

SVG = saphenous vein graft(s)

BILATERAL INTERNAL THORACIC ARTERIES

The survival benefits associated with the use of the left internal thoracic artery (ITA) to the left anterior descending (LAD) coronary artery were established in a landmark paper from the Cleveland Clinic almost 30 years ago (1). The improved outcome using the ITA is almost certainly due to its superior long-term patency. Several studies have reported substantially inferior patency rates with saphenous vein grafts (SVG), of which approximately 75% are occluded or significantly diseased at 10 years (2), in comparison to patency rates in excess of 90% for the ITA (3). Its peculiar morphologic features probably explain the superior patency of the ITA. The ITA has a discontinuous internal elastic lamina and a relatively thin media with multiple elastic laminae and the absence of a significant muscular component, which explains its reduced tendency for spasm and the development of atherosclerosis (4). Moreover, compared with all other arterial and venous conduits, it shows increased production of anti-inflammatory and vasoactive molecules, particularly nitric oxide (4).

The highest patency rates have been documented when the ITA (either in situ or as a Y or free graft) is placed to the left-sided coronary vessels (3). Inferior rates have been documented when the ITA is placed to the right coronary artery (probably due to size discrepancy and progression of disease at the crux, or to a lower amount of viable myocardium) (3).

Only 1 published RCT has compared outcomes between single ITA and BITA grafting. The ART (Arterial Revascularization Trial) recruited 3,108 patients in 7 countries. The primary outcome is 10-year survival, but an interim analysis at 1 year (a "safety" endpoint) reported excellent outcomes with both strategies. Mortality, stroke, myocardial infarction, and repeat revascularization were all under 2.5% (5).

While awaiting the outcome of the ART trial, there is currently a substantial body of circumstantial evidence to support the use of a second ITA, as it appears to offer an additional survival benefit over a single ITA graft. Indeed, more than a decade ago, a systematic review of matched cohorts of almost 15,000 CABG patients who received BITA grafts reported a significant reduction in the hazard ratio (HR) for mortality of 0.78 (6). In the past 2 years, 2 independent meta-analyses have supported this finding, not only in larger cohorts of patients, but also with longer-term follow-up. One study included 27 observational reports with over 79,000 patients (approximately one-quarter with BITA), and reported a significant reduction in long-term mortality with BITA (HR: 0.78; 95% confidence interval [CI]: 0.72 to 0.84; $p < 0.00001$) (7). Another study included 9 observational series of over 15,000 patients (approximately one-half with BITA), with follow-up duration exceeding a mean of 9 years, and reported a significant reduction in mortality with BITA (HR: 0.79; 95% CI: 0.75 to 0.84) (8). Importantly, no study has reported any detrimental effect of BITA on survival.

The major concern with the use of BITA grafts is the increased risk of sternal wound complications and mediastinitis. One of the largest meta-analysis on this issue showed that adding a second ITA to the ITA-LAD graft significantly increase the incidence of sternal complications (relative risk [RR] of a single ITA: 0.62; 95% CI: 0.55 to 0.71) (9). This risk is even higher in diabetics and in patients with pulmonary disease (9). In ART, the incidence of sternal wound complications increased from 0.6% in the single ITA group to 1.9% in the BITA group (i.e., an absolute difference of 1.3% or a number needed to harm of 78 patients) (5).

However, the incidence of serious wound problems can be significantly reduced by judicious patient selection and the choice of harvesting technique. Consideration should be given to avoiding BITA in patients with certain potentially morbid characteristics, especially if they occur simultaneously (diabetes, obesity, respiratory problems), and in patients receiving steroids or immunosuppression treatments. Moreover, 2 systematic reviews have both reported that skeletonization, rather than a pedicled harvesting technique, significantly reduces deep sternal wound infections, even in patients with diabetes (9,10). Importantly, the survival benefit of BITA grafting is seen in both nondiabetic and diabetic patients (11).

THE RADIAL ARTERY

Introduced in coronary surgery in the 1970s (12), the RA was "rediscovered" in the early 1990s (13). Concerns over vasospasm, due to the muscular nature of the RA wall, have been reduced after the demonstration of progressive morphofunctional remodeling of the artery toward an elastomuscular profile after implantation in the coronary circulation (14). This finding is probably the anatomic background for the demonstrated lack of utility of long-term antispastic therapy in patients with RA grafts (15), even though