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Article

A Retrospective Study of the No-Contact Technique to Obtain Radial Arteries for Coronary Artery Bypass Grafting

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Abstract

Background: To retrospectively study the experience with application of no-touch technique in radial artery (RA)-based coronary artery bypass grafting (CABG). **Methods**: Clinical data of patients who underwent RA-based multi- (n = 45) or full-arterial CABG (n = 27) between January 2019 and June 2022 in the Affiliated Hospital of ZunYi Medical University were collected. The incidence of main cardiovascular events at 30-day follow-up, the antebrachial union condition and the vessel patency rate were analyzed. **Results**: A total of 66 RAs were harvested and 70 RAs used as grafts. The number of RA used per patient was 1.46. Delayed antebrachial union occurred in 1 patient (1.45%). There was no death, cerebral infarction, myocardial infarction or revascularization at follow-up. Early coronary computed tomography (CT) after surgery revealed occlusion in 1 RA, with the patency rate being 98.57%. **Conclusions**: The No-touch RA harvesting technique, preservation and postoperative management applied in this study are effective and rational, and the application of RA as the graft in CABG is safe.

Keywords

coronary artery bypass grafting (CABG); multi-arterial; radial artery; no-touch technique

Introduction

Coronary artery disease (CAD) is one of the threats of human heath. As the life style of people is changing, the incidence of CAD in China is rapidly increasing, resulting in approximately 11 million patients at present [1]. Coronary artery bypass grafting (CABG) as the mainstay of treatment of multi-arterial CAD currently is based on the grafts such as left internal thoracic artery (LITA), radial artery (RA) and great saphenous vein (GSV), etc. The LITA is regarded as the first graft (gold standard) for the left anterior descending bypass grafting. The GSV is also one of the most commonly used graft in surgeries for multi-arterial CAD, due to the fact that it is sufficient in length, easy to sample, and the harvesting technique is well established. However, there is an extremely high incidence of vein graft restenosis after CABG, which significantly affects the long-term efficacy [2].

Multiple studies demonstrated that multi- or full-arterial CABG has good therapeutic outcomes in the long term [3–5]. RA as one of the grafts has received increasing attention owing to its superior long-term patency. Nevertheless, it has not been promoted in clinic as it has higher requirements than GSV for the harvest, preservation and postoperative management and safety is a concern in early surgery. The current study retrospectively analyzed the clinical data of patients who received RA-based multi- or full-arterial CABG in the Affiliated Hospital of Zunyi Medical University. A summary was made for the clinical experience with the No-touch harvesting technique, preservation and postoperative management of RA, so as to provide supporting information for the application of RA grafting in patients with CAD.

Materials and Methods

Clinical Data

Clinical data of patients who underwent RA-based multi- or full-arterial CABG between January 2019 and June 2022 in the Affiliated Hospital of Zunyi Medical University were collected. Inclusion criteria: (1) 2-vessel disease and more; (2) critical target vessel stenosis before surgery (left coronary disease ≥75%, right main trunk disease ≥90%); (3) performance of multi-arterial CABG with at least one RA as the graft.

Preoperative Evaluation of RA

The process of No-Contact Technique to Obtain Radial Arteries in this study is detailed in Fig. 1. Before surgery, upper extremity arteries (including subclavian

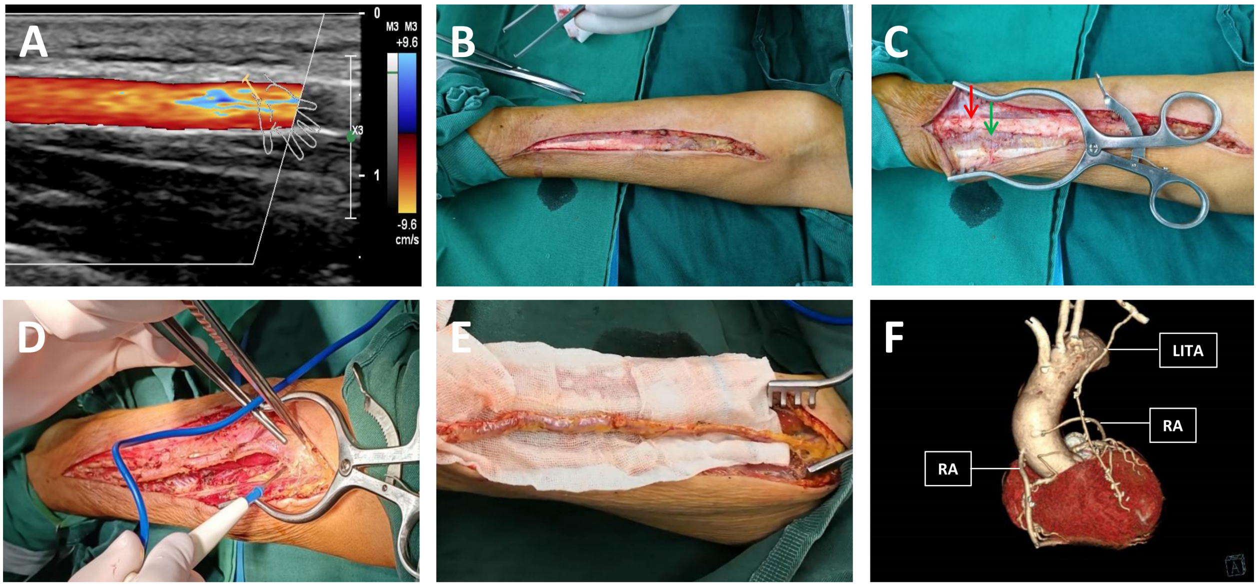

Fig. 1. No-touch technique Radial artery extraction process. (A) The patency of radial artery was evaluated by ultrasound. (B) The brachioradialis, biceps femoris, styloid process of radius and flexor carpi radialis tendons were used as the marks of the surgical incision. Starting from the outside of the biceps tendon, make an arc incision downward along the belly of the brachioradialis muscle to the midpoint of the line between the styloid process of the radius and the flexor carpi radialis. (C) The mastoid spreader separates the brachioradialis muscle and the flexor carpi radialis laterally to expose the radial artery (green arrow). Take the flexor carpi radialis tendon as the free starting point (red arrow). (D) Gently separate the radial vascular pedicle, gently lift the adventitia of the radial vascular pedicle, and free the radial artery with a low energy electric knife. (E) After dissociating the radial artery, the proximal end will not be disconnected temporarily, the distal end will be sutured and disconnected, the radial artery will be disconnected at the styloid process of the radius, and papaverine heparin mixed preservation solution (1 mg/mL) will be injected into the radial artery cavity to avoid the radial artery spasm. (F) Coronary CTA was rechecked after operation. RA, radial artery; LITA, left internal thoracic artery; CTA, coronary artery CT angiography.

artery, ulnar artery and RA) were examined by Doppler ultrasonography to reveal their patency, atherosclerosis, calcification and stenosis conditions (Fig. 1A). In the meantime, Allen test was scheduled to assess the integrity of the ulnar-radial collateral circulation. The workers pressed the RA and ulnar artery of the participants simultaneously until the palms of the participants turned pale. After the ulnar artery was relaxed, the palm of the participants became red within 10 s and the Allen test was negative.

Harvest of RA with No-Touch Technique and Preservation

The patients were instructed to put their palms upward and their arms extended outward on the operation table at 90 degree. Place the patient on the operating table with palms up and arms extended at a 90-degree angle. The brachioradialis, the biceps femoris muscle, the styloid processes of the radius and the tendons of the flexor carpi radialis were marked (Fig. 1B). The brachioradialis, biceps femoris, radial styloid, and flexor carpi radialis tendons were used as landmarks for the surgical incision. An arc-shaped incision was made from the lateral tendon of the biceps brachii to the muscle belly of the brachioradialis downward and the midpoint between the styloid processes of the radius and the flexor carpi radialis. Starting from the lateral side of the biceps tendon, an arc-shaped incision is made downward along the abdomen of the brachioradialis muscle to the midpoint of the line connecting the radial styloid process and the flexor carpi radialis muscle as the end point. The subcutaneous tissues were incised using a 10 J electrosurgical knife (China Erbo (Shanghai) Medical Equipment Co., Ltd, Shanghai, China) and the cephalic vein was cut by ligation. The superficial antebrachial fascia was cut and the RA was exposed by separating the brachioradialis and the flexor carpi radialis using a mastoid spreader (Jinzhong Surgical Instruments, Shanghai, China). With the well-exposed antebrachial middle RA or the flexor carpi radialis as the starting point (Fig. 1C), the radial vessel pedicle (including the RA, bilateral accompanying veins, connective tissues and the outer membrane) was gently separated (Fig. 1D). Then, the outer membrane of the radial vessel pedicle was gently lifted to expose the perforating branches of RA, which were clamped by a titanium clip at the end proximal to the heart and ligated with sutures (No. 3) (Huawei Medical Products Co., Ltd., Hangzhou, China) at the end distal to the heart. The proximal RA was sustained (Fig. 1E), while the distal part was separated by sutures. Following separation of the

RA from the styloid processes of the radius, papaverine-heparin preservation solution (1 mg/mL) (Shanghai Lianmai Bioengineering Co., Ltd., Shanghai, China) was injected into the RA to prevent spasm. After the radial artery was freed, the proximal end was not cut off temporarily, the distal end was sutured and ligated, and the radial artery was cut off at the radial styloid process. Papaverine-heparin mixed preservation solution (1 mg/mL) (Shanghai Lianmai Bioengineering Co., Ltd., Shanghai, China) was injected into the RA to avoid radial artery spasm. In the meantime, the preservation solution was also sprayed to the pedicle surface. Upon full separation of the LITA, cardiopulmonary bypass established and the aorta blocked, the proximal RA was separated from the radial recurrent artery distal to the heart. The separated RA was placed in the preservation solution for further use. The above mixed preservation solution (1 mg/mL) (Shanghai Lianmai Bioengineering Co., Ltd., Shanghai, China) was sprayed on the surface of the RA pedicle. When the LITA was completely freed, cardiopulmonary bypass was established and the aorta was blocked, then the proximal radial artery was severed, and the radial artery was severed at the distal end of the recurrent radial artery. The free radial artery was placed in a mixed storage (Shanghai Lianmai Bioengineering Co., Ltd., Shanghai, China) for protection.

Surgical Procedure

CABG was performed at mild hypothermic cardiopulmonary bypass with an incision located in the midline of the chest. After the aorta was blocked, the aortic root underwent antegrade perfusion with cold K^+-contained Del Nide cardioplegic solution to protect the heart. Ultrafiltration was routinely performed intraoperatively. Strategies targeting the graft and target vessel: Successively, the LITA was anastomosed to the left anterior descending (LAD), the left RA was anastomosed to the right coronary main trunk, and the right RA was anastomosed to the diagonal branch/intermediate branch/circumflex branch/obtuse marginal branch (Fig. 1F). The proximal point was anastomosed to the ascending aorta.

Postoperative Management

Arterial bypass spasm was aggressively prevented postoperatively. After complete anastomosis, Diltiazem (1 µg/kg/min) and low-dose nitroglycerin were instantly and continuously pumped intravenously. After 24 h, Diltiazem was administrated by oral (30 mg, q6h) for at least 6 months. Meanwhile, dual antiplatelet therapy was arranged postoperatively, including 1-year oral Clopidogrel (75 mg/d) and lifelong Aspirin (100 mg/d). In addition, statins were required to regulate lipids and stabilize plaques. Beta-receptor blockers were administrated routinely and the dose was adjusted according to the heart rate (target: 60–70 beats/min). Secondary preventive drugs were prescribed according to the guideline.

Postoperative Follow-Up

Patients were required to undergo biochemical test/electrocardiogram (ECG), echocardiography and coronary computed tomography (CT) to assess the patency rate of the grafts before discharge (within 30 days of surgery). The main clinical endpoint was the graft patency rate. The secondary clinical endpoint was main adverse cardiovascular and cerebrovascular events (MACCE), including death, myocardial infarction (MI), stroke and target vessel revascularization.

Statistical Analysis

All data were expressed as the mean ± standard deviation and analyzed by the SPSS software (version 20.0; IBM, Armonk, NY, USA). Categorical data were presented by frequency or percentage.

Results

Basic Data

There were 34 males and 11 females, aged between 34 and 73 years old (mean, 5.2 ± 8.8). Left main artery stenosis was diagnosed in 42 patients, 2-vessel disease in 4 patients and 3-vessel disease in 38 patients. The preoperative EF was 35%–67%. There were 14 patients with diabetes, 27 patients with hypertension and 31 patients with hyperlipidemia. Three patients had previous percutaneous coronary intervention and 1 patient had old cerebral infarction.

Surgical Information

All the 45 patients underwent CABG at cardiopulmonary bypass within 62 min–140 min (mean, 106.3 ± 29.5). Totally, there were 127 vascular grafts, including the LITA (n = 39), the right internal thoracic artery (RITA, n = 2), vein (n = 20) and RA (n = 66). A total of 66 RAs were harvested and the mean number of RA used per patient was 1.46. The mean harvest time for RA was 58.3 ± 9.8 min. There were 136 anastomoses on the RA, including the proximal (n = 66) and distal (n = 70) anastomoses. The mean flow of the RA grafts was 39.1 ± 17.31. The total time spent in the care unit postoperatively was 52 h and the 24 h drainage volume was 760 mL.

30-Day Follow-Up Data

All the 45 patients were followed up by outpatient, WeChat or telephone in 30 days after surgery. There was no death, MI, cerebral infarction or revascularization. Delayed antebrachial union occurred in 1 patient (1.45%). Most of the RA grafts were patent (98.57%) on early CT examination after surgery, except one which had occlusion.

Discussion

CABG is the main surgical approach for CAD and the LITA-based anterior descending bypass grafting is regarded as the gold standard. In most patients with a need for CABG, usually there are multiple coronary arteries that are diseased and require bypass grafting. The human GSV has become the most popular as a graft in GABG as it is easy to harvest and supports grafting of multiple diseased coronary arteries. However, vein grafting relies on an environment of arterial strain, resulting in a high incidence of graft restenosis postoperatively. It was reported that the 10-year vein graft failure rate could be more than 50% [2]. Growing studies have demonstrated that multi- or full-arterial CABG is associated with a far higher long-term patency rate (80–90%) than CABG using veins as grafts, and the clinical outcomes tend to be significantly improved [3–5]. In addition, research found that RA was safer than GSV when being used as a graft in CABG, as it led to a much lower incidence of death and adverse cardiac events such as MI [4]. Moreover, another study found that the long-term (5.0 ± 3.8 years) patency rate of LITA (85%) and RA (82%) was equivalent after CABG, both of which was significantly higher than that of GSV (47%) [6].

It is essential to prevent RA spasm after CABG. In the present study, there was no evidence of spasm at follow-up. We believed that this might be closely associated with the RA harvesting technique, preservation and postoperative preventive medication.

Previous research noted that RA spasm might be associated with the RA harvesting techniques, such as the separation of RA and high-pressure injection of preservation solution to the RA. Acar *et al*. [7] and Bhan *et al*. [8] adopted a modified harvesting technique for RA, which significantly increased the patency rate. Here, we used the No-touch technique to harvest RA in all participants. During the process, the electrical knife was used at 10 J. The RA was fully exposed by bilateral separation 0.3 cm away from the RA. Branches were clamped by a titanium clip or ligated using. The outer membrane and surrounding tissues of the RA were well protected. In the meantime, the surrounding connective tissue were maximally preserved and the isolated time of RA were minimized.

The preservation solution for RA is also significantly associated with the incidence of spasm. Research found that the mixed solution of calcium antagonist and nitroglycerin had a favorable effect against spasmogenesis [9]. In this study, we adopted different approaches to manage and preserve the RA. To reduce the isolated time, the RA segment distal to the heart was firstly separated from the styloid processes of the radius and injected with a mixture of 2 mL heparin (1 mg/mL), 4 mL papaverine-normal saline solution (1 mg/mL) and 20 mL own blood. In the meantime, the pedicle surface was also sprayed with the papaverine-normal saline solution (1 mg/mL). When the internal mammary artery was fully separated, the RA segment proximal to the heart was separated and the separated RA was preserved in the same preservation solution.

In CABG cases using the RA as the graft, the degree of target vessel stenosis and the diameter of the distal target vessel both can affect the patency of the RA. In order to avoid blood flow competition and long-term patency of the distal target vessel, the proximal part of the target vessel should have 70% severe stenosis and the diameter should be larger than 1.5 mm, as recommended by the 2018 ESC/EACTS guidelines [10]. Another study also revealed that cases with the RA bypass anastomosed to the vessel with >90% stenosis had a lower rate of long-term restenosis [3,11].

What we learned from the current study is that after complete anastomosis and the aorta is fully opened, Diltiazem (1 µg/kg/min) plus low-dose nitroglycerin should be instantly and continuously pumped into the RA, followed by oral Diltiazem (90 mg, q6h) after 24 h and maintained for at least 6 months. In that way, the incidence of postoperative spasm can be positively reduced. In the meantime, the secondary prevention and management strategy for CAD should be strictly executed.

Moreover, the present study demonstrated no death, stroke, MI or revascularization at follow-up. This further proves that the No-touch RA harvesting technique, preservation and postoperative management applied in this study are effective and rational, and the application of RA as the graft in CABG is safe. To conclude, the advancement of No-touch RA harvesting technique, preservation and perioperative management can obtain more favorable clinical outcomes. However, this is a single-center retrospective study without any controls. Besides, the participants were young and the samples were limited, resulting in certain limitation of the current findings.

Conclusions

The No-touch RA harvesting technique, preservation and postoperative management applied in this study are effective and rational, and the application of RA as the graft in CABG is safe.

Abbreviations

CAD, coronary artery disease; CABG, coronary artery bypass grafting; RA, radial artery; LITA, left internal thoracic artery; GSV, great saphenous vein; LAD, left anterior descending; ECG, electrocardiogram; CT, computed tomography; MACCE, main adverse cardiovascular and cerebrovascular events; MI, myocardial infarction; RITA, right internal thoracic artery.

Availability of Data and Materials

Datasets used and/or analyzed for this study are available from the corresponding author upon appropriate request.

Author Contributions

All authors have made substantial and significant contributions to the concept and design of the creative manuscript, as well as the acquisition, analysis, or interpretation of work data. YZ and XZ completed the framework construction and writing of the entire manuscript. YS, YX adjusted, revised and improved the text during the manuscript writing process. DH and JZ have analyzed the cited data in the article. DL and DZ have provided guidance on the construction of ideas and writing guidance throughout the entire process of the paper, and provided project funding support. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (Clinical Trials and Biomedical Ethics Committee of Affiliated Hospital of Zunyi Medical University, number KLL-2019-171). Informed consent was obtained from all patients for this study.

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Conflict of Interest

The authors declare no conflict of interest.

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