

# Total Arterial Off-Pump Coronary Artery Bypass Grafting: A 10-Year Experience

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## Abstract

**Background:** Arterial grafts had better mid-term and long-term patency than saphenous vein grafts in coronary artery bypass grafting (CABG). We summarized our experience with total arterial off-pump coronary artery bypass grafting (OPCAB) and assessed the early clinical results, surgical complications, and follow-up.

**Methods:** From January 2007 to May 2017, 508 coronary artery disease patients undergoing total arterial OPCAB were enrolled. Clinical features, approaches, outcomes of surgical treatments, and follow-up data of these patients were studied retrospectively. A total of 122 patients underwent single left internal mammary artery (IMA)-left anterior descending artery grafts, whereas the other 386 patients underwent multiple vessel grafts.

**Results:** The average distal anastomosis was  $2.34 \pm 0.97$  (range: 1–4). All the patients were discharged from hospital except one died. A total of 457 (90.32%) patients were followed up. In the 4-, 7-, and 10-year follow-up groups, the rate of death from any cause was 1.19%, 6.47%, and 10.67%; rate of cardiac death was 0.60%, 2.88%, and 3.33%; rate of repeat revascularization was 0.00%, 3.60%, and 8.67%; rate of ischemic symptoms was 1.79%, 7.91%, and 11.33%; and incidence of stroke was 2.38%, 4.32%, and 6.67%, respectively. Poor medication adherence was observed in 9.38% of the follow-up population.

**Conclusions:** Total arterial OPCAB with bilateral IMA, radial artery, and right gastroepiploic artery grafting yielded satisfactory early and midterm outcomes in this patient group, without a significant increase in early mortality or morbidity. Moreover, the long-term outcomes are also positive.

**Key words:** Coronary Artery Bypass Grafting; Gastroepiploic Artery; Off-Pump; Skeletonized Internal Mammary Artery; Total Arterial Revascularization

## INTRODUCTION

Coronary artery bypass grafting (CABG) is one of the most commonly performed operations worldwide and has been established as an effective treatment for symptomatic multivessel coronary artery disease (CAD). The standard surgical approach for CABG involves anastomosis of the left internal mammary artery (LIMA) to the left anterior descending artery (LAD), or the use of a saphenous vein graft (SVG) or radial artery (RA) graft to bypass other coronary arteries. However, an artery needs to be harvested to bypass an artery, and additional arteries are needed for more bypasses. The procedure is termed as total arterial CABG. In recent years, bilateral internal mammary artery (BIMA) grafting has been used for patients undergoing surgical coronary revascularization for multivessel disease. Compared with single internal mammary artery (SIMA) grafting, BIMA grafting has greater late cardioprotective

effects. However, BIMA and total arterial CABG are still not commonly used in China or other countries. In this report, we present our 10-year experience with BIMA and total arterial off-pump coronary artery bypass grafting (OPCAB) and highlight the advantages and disadvantages of the technique.

## METHODS

### Ethical approval

This study was approved by the Ethics Committee of our hospital. In view of the retrospective nature of the

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study, the need for obtaining written informed consent was waived.

## Patients

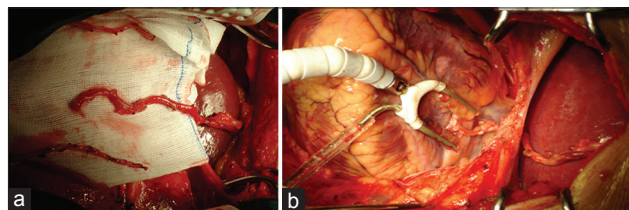
From January 2007 to May 2017, 508 CAD patients undergoing total arterial OPCAB were enrolled. All operations were performed by the same surgeon. The patients' ages ranged from 36 to 81 years. Patients, who underwent a concomitant cardiac or aortic surgical procedure, such as valve replacement, valvuloplasty, or replacement of a valvular prosthesis, were excluded from the study. The pre- and postoperative strategy, as well as grafting approach, was not altered throughout the entire study period.

## Surgical procedure and treatment

Patients, who underwent single LIMA-LAD or LIMA-LAD plus right gastroepiploic artery (RGEA)-posterior descending artery (PDA) anastomoses, underwent minimally invasive direct coronary artery bypass grafting (MIDCAB) through lower median mini-sternotomy. All the other patients underwent this procedure through conventional median sternotomy.

If only the LIMA was harvested, the traditional pedicled approach was used for grafting, which included harvesting of the surrounding parietal pleura, venae comitantes, muscle, and fascia, thus leaving the chest wall completely devascularized. Moreover, we used the traditional pedicled approach to harvest the RA using classical electrocautery (approximately 25 J), the RGEA, and a harmonic scalpel. Following explantation, the RA was first stored in a solution of blood, heparin, and papaverine. We then used the "skeletonized technique" to free the artery from excess tissue using metallic clips. We usually harvested the RGEA through a small midline extension (approximately 5–7 cm) followed by a conventional median sternotomy. If the BIMA was harvested, we used the skeletonized technique [Figure 1].

In general, the LIMA was anastomosed to the LAD, and the right internal mammary artery (RIMA) was grafted to the left circumflex artery (LCX) system or diagonal branches (Diag). In some cases, the RIMA was grafted to the right coronary artery (RCA), although in most cases, the RGEA was grafted to the PDA (particularly in cases where stenosis was  $\geq 90\%$ ) [Figure 1]. The combinations and numbers of



**Figure 1:** Representative images of the off-pump coronary artery bypass grafting. (a) Classical three artery grafts *in situ*: skeletonized bilateral internal mammary arteries and right gastroepiploic artery. (b) Right gastroepiploic artery was grafted to the posterior descending artery.

other arterial grafts were selected based on the coronary angiographic findings. The internal mammary arteries (IMAs) and RGEA were used as *in situ* grafts. The RA was used preferentially as a free graft from the aorta to the LCX, Diag, and/or distal RCA. The RA was anastomosed to the ascending aorta using an easy buckle anastomosis device. Sequential anastomoses were performed in the branches of the same coronary artery.

Intraoperative graft flow measurement of 176 patients was performed using transit-time flow measurement (TTFM) (Medistim VeriQ Systems, Medistim ASA, Norway). Graft flow measurements were performed just before chest closure and after hemodynamic stabilization. The mean graft flow (MGF) and pulsatility index (PI) were evaluated using TTFM.

We used prophylactic calcium channel blockers after the RA was harvested and not when the RGEA was harvested. If arterial graft spasm was suspected in the RGEA, an intravenous milrinone solution was infused. Nasogastric (NG) tube drainage was routinely performed to prevent acute gastric dilatation, which could lead to tension on the anastomosis. This NG tube was usually retained for approximately 2–4 days.

Tight blood glucose control was ensured to maintain the blood glucose level  $< 8$  mmol/L through continuous insulin microinfusion.

## Early outcomes and follow-up

Early outcomes were defined as those associated with the hospitalization period and death within 30 days of surgery. In-hospital mortality due to any cause was recorded, regardless of the length of stay (LOS). Other early outcomes included LOS, bleeding requiring re-exploration, stroke, and sternal infection, with the need for surgical debridement and sternal refixation.

Follow-up information, including survival or death of the patient, time and cause of death, re-intervention for CAD, ischemic symptoms, and stroke, was collected from outpatient clinical records or through telephone interviews performed at 6-month intervals. Follow-up data were obtained for 457 (90.32%) of the hospital survivors. Due to the long follow-up duration, we assigned the patients to three groups based on the time after operation: 4 years, 7 years, and 10 years.

Graft patency was assessed only in 112 patients through coronary computed tomography angiography (CCTA) or coronary angiography in symptomatic or asymptomatic patients. Graft patency was evaluated by cardiologists using diagnostic coronary angiography and by radiologists through CCTA.

## Statistical analysis

Continuous variables are presented as a mean  $\pm$  standard deviation, and categorical data are expressed as numbers and percentages. Long-term conduit patency was calculated by the Kaplan–Meier method and log-rank analysis. All

statistical analyses were performed with the IBM SPSS version 19.0 for Windows (IBM Corp, Armonk, NY, USA). A value of  $P < 0.05$  was considered statistically significant.

## RESULTS

### Characteristics and clinical results

The baseline characteristics of the 508 patients are shown in Table 1. All the patients received the standard LIMA-LAD anastomosis, except for one patient who underwent LIMA dissection with RIMA-LAD anastomosis. Of the 129 patients (25.34%) who underwent MIDCAB through lower median mini-sternotomy, 7 (0.14%) underwent LIMA-LAD and RGEA-PDA operation. The skeletonized BIMA (sBIMA) was harvested in 150 patients (29.53%). In addition to the LIMA, the RA was the other most common artery used in this study. The left RA was harvested in 372 patients (73.24%), whereas the right RA (RRA) was harvested in only one patient (0.02%). Of the 508 patients, 86 (16.90%) underwent harvesting of the RGEA.

### Early outcomes and follow-up

One patient died of small bowel obstruction and sepsis on the 10<sup>th</sup> postoperative day. All the other patients were discharged alive from the hospital. Two patients underwent repeat exploration because of bleeding. Seven patients had sternal wound complications that required treatment. Five patients had stroke after CABG without any serious neurological sequelae. No cases of gastrointestinal complication and perioperative myocardial infarction were noted. No cases of death were noted within 30 days of surgery. The most serious operative complication included permanent physical impairment of the right forearm, which was caused by bleeding after harvesting of the RRA.

The results of TTFM are shown in Table 2. MGF is expressed in milliliter/minute and is useful for indicating how a bypass is flowing. However, it is a poor indicator

of the quality of the anastomosis. All of the MGF is  $>20$  ml/min. The PI is expressed as an absolute value and is considered to be a good indicator of the anastomotic flow pattern, and consequently, of anastomotic quality. All of the PIs ranged from 1 to 5.

A total of 90.32% (457) of the patients were followed up. Poor medication adherence was present in 9.38% of the follow-up population. The results of follow-up in the 4-, 7-, and 10-year groups are provided in Table 3. The death from any cause, cardiac death, repeat vascularization, ischemic symptoms, and stroke increased along with the follow-up period.

The patency of the LIMA, RIMA, RA, and RGEA is described in Table 4 and Figure 2. There were statistically significant differences between the four groups ( $P = 0.015$ ). The patency rate of LIMA was better than that of RA ( $P = 0.005$ ) and RGEA ( $P = 0.003$ ). The differences between the patency rates of RIMA and RA ( $P = 0.337$ ), LIMA and RIMA ( $P = 0.096$ ), RIMA and RGEA ( $P = 0.254$ ), or RA and RGEA ( $P = 0.707$ ) were not significant. Only 112 patients underwent CCTA or coronary angiography. The patency of the LIMA, RIMA, RA, and RGEA decreased along with time [Table 4]. When analyzed by the Kaplan–Meier method, patency of the LIMA, RIMA, RA, and RGEA declined over time [Figure 2].

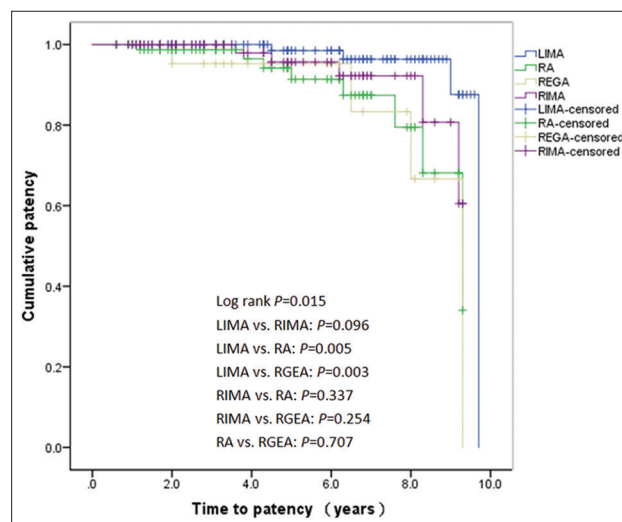
## DISCUSSION

Graft patency depends on various important variables, including the type of conduit used, size of the native coronary artery, severity and location of the lesions, territory of the runoff, surgical technique and experience of the surgeon, perioperative use of antispasmodic medications, and postoperative antiplatelet therapy and antilipid therapy.<sup>[1]</sup>

**Table 1: Baseline characteristics of the 508 coronary artery disease patients**

Baseline characteristics	Value
Age (years)	58.75 ± 9.89
Male, <i>n</i> (%)	453 (89.17)
Diabetes, <i>n</i> (%)	245 (48.23)
Dyslipidemia, <i>n</i> (%)	182 (35.83)
Hypertension, <i>n</i> (%)	265 (52.17)
History of MI, <i>n</i> (%)	192 (37.80)
Peripheral artery disease, <i>n</i> (%)	229 (45.08)
History of cerebrovascular disease, <i>n</i> (%)	67 (13.19)
Chronic kidney disease, <i>n</i> (%)	14 (2.76)
Left ventricular end diastolic dimension (cm)	5.32 ± 0.37
Ejection fraction (%)	58.24 ± 8.04
Average number of distal anastomoses	2.34 ± 0.97
Length of hospital stay (days)	23.61 ± 7.93
Length of Intensive Care Unit stay (days)	3.54 ± 3.51
Mechanical ventilation time (h)	5.58 ± 6.09

MI: Myocardial infarction.



**Figure 2:** Total arterial graft patency of the LIMA, RIMA, RA, and RGEA through CCTA or coronary angiography by the Kaplan–Meier method. LIMA: Left internal mammary artery; RA: Radial artery; RGEA: Right gastroepiploic artery; CCTA: Coronary computed tomography angiography.

At present, total arterial revascularization is the preferred procedure in patients below the age of 70 years and life expectancy  $\geq 5$  years. However, it is not the primary procedure. Compared to conventional bypass surgery, it requires higher levels of surgical dexterity. Many consider total artery CABG as an esoteric procedure, and when surgeons harvest sBIMA, they need to remain focused on the procedure. Moreover, this technique requires a longer duration. These factors could explain the widespread nature of SVG.

The European Society of Cardiology Guidelines recently recommended BIMA grafting as a Class IIa indication for patients aged  $<70$  years.<sup>[2]</sup> Moreover, a survival advantage with no increase in early mortality can be expected from BIMA grafting in patients aged  $\geq 75$  years.<sup>[3]</sup> Using a Cox proportional hazards model for 10-year mortality and 10-year major cardiac and cerebrovascular events (MACCEs), Nicolini *et al.*<sup>[4]</sup> found that chronic kidney disease (CKD), male sex, age, peripheral arterial disease (PAD), and SIMA usage (nonuse of BIMA) were predictors for late death, whereas CKD, male sex, age, and PAD were predictors of MACCE. There was no significant difference between

males and females with regard to the use of totally arterial grafts (23% in males vs. 22.6% in females;  $P = 0.602$ ). In the present study, BIMA was used in only approximately 29.53% of cases; only 9.86% of this group was female, which was markedly lower as compared to that in Nicolini *et al.*'s report.<sup>[4]</sup> Moreover, approximately 20.09% of female patients underwent CABG during the same period, which was markedly greater than the proportion of patients who underwent total artery bypass grafting in the present report.

Arterial grafts are not only superior in terms of patency and survival, but they also protect the native coronary arteries against further progression of atherosclerotic disease.<sup>[5]</sup> The incidence of disease progression in grafted native coronary arteries in the anterior territory between patent RA grafts and patent SVGs to the Diag of the LAD artery was 10% and 40%, respectively (log-rank test;  $P < 0.0001$ ). The incidence of disease progression in grafted native coronary arteries to the lateral territory with a patent RA graft was 11%, compared to 50% with a patent SVG (log-rank test;  $P < 0.0001$ ). Thus, multiple arterial grafting may improve long-term survival by preventing atherosclerosis progression in the native coronary vessels.

We used the skeletonized technique to harvest the BIMA, as the skeletonized IMA is longer (5–7 cm) and its spontaneous blood flow is greater (approximately 20%), which enables the use of both IMAs as grafts to all necessary coronary vessels. The risk of sternal wound infection in BIMA grafting remains unclear. As in previous studies, our study did not show that BIMA grafting increased the risk of sternal wound infection, even in elderly patients.<sup>[3,6,7]</sup> The risk factors for deep sternal wound infection (DSWI) include diabetes, female sex, peripheral vascular disease, chronic obstructive pulmonary disease, chronic renal insufficiency, and body mass index  $>35$  kg/m<sup>2</sup>.<sup>[8]</sup> Tight blood glucose control is useful for preventing DSWI following CABG.<sup>[9]</sup> We maintained

**Table 2: The results of TTFM in the 176 total arterial OPCAB patients**

Items	n	MGF (ml/min)	PI
LIMA to LAD	176	25.71 $\pm$ 9.52	2.48 $\pm$ 0.63
RIMA graft	50	23.17 $\pm$ 10.54	2.66 $\pm$ 0.76
RA graft	130	32.67 $\pm$ 18.51	3.31 $\pm$ 1.61
RGEA graft	28	21.06 $\pm$ 5.52	4.14 $\pm$ 0.83

TTFM: Transit-time flow measurement; OPCAB: Off-pump coronary artery bypass grafting; MGF: Mean graft flow; PI: Pulsatility index; LIMA: Left internal mammary artery; LAD: Left anterior descending artery; RIMA: Right internal mammary artery; RA: Radial artery; RGEA: Right gastroepiploic artery.

**Table 3: Follow-up data of the 457 total artery OPCAB patients**

Items	4-year group (n = 168)	7-year group (n = 139)	10-year group (n = 150)
Follow-up period (months)	26.86 $\pm$ 14.99	73.81 $\pm$ 32.16	109.56 $\pm$ 49.63
Death from any cause, n (%)	2 (1.19)	9 (6.47)	16 (10.67)
Cardiac death, n (%)	1 (0.60)	4 (2.88)	5 (3.33)
Repeat revascularization, n (%)	0	5 (3.60)	13 (8.67)
Ischemic symptoms, n (%)	3 (1.79)	11 (7.91)	17 (11.33)
Stroke, n (%)	4 (2.38)	6 (4.32)	10 (6.67)

OPCAB: Off-pump coronary artery bypass grafting.

**Table 4: Patency of the LIMA, RIMA, RA, and RGEA (%)**

Items	4-year group (n = 40)	7-year group (n = 41)	10-year group (n = 31)
Time to CCTA or angiographic (months)	26.47 $\pm$ 10.87	68.28 $\pm$ 11.42	102.19 $\pm$ 9.00
LIMA	100.00	95.12	93.55
RIMA	96.67	93.55	91.67
RA	93.10	90.00	86.96
RGEA	87.50	87.50	66.67

LIMA: Left internal mammary artery; RIMA: Right internal mammary artery; RA: Radial artery; RGEA: Right gastroepiploic artery; CCTA: Coronary computed tomography angiography.

the blood glucose level under 8 mmol/L through continuous postoperative insulin infusion in all patients with or without diabetes, and accordingly, aimed to reduce DSWI and central nervous system complications.

Postoperative medical therapy is effective for maintaining graft patency after CABG in both SIMA and BIMA patients. We routinely used aspirin 4 h after extubation, as well as statins after transfer from the Intensive Care Unit (ICU), as recommended by the 2015 American Heart Association Scientific Statement.<sup>[10]</sup>

The RA exhibited marked spastic responses to vasoconstrictors and hypothermia, which required antispasmodic drug treatments during harvesting, postoperatively, and during the early follow-up period. We generally used the RA, along with the IMAs, in a traditional configuration (LIMA/RA, LIMA/RA/RGEA, BIMA/RA, or BIMA/RA/RGEA). Although the skeletonized RA reportedly yields a longer graft with larger diameters, fewer spasms, and higher patency rates, it also significantly increases the harvest time and the risk of severe graft injury. Hence, we routinely harvested the RA through a pedicled approach. After the RA was removed from the forearm, we used the “skeletonized technique” to free the artery from excess tissue using metallic clips.

There were no histological differences between the structure of the wall of RGEA and IMAs. However, the RGEA has more smooth muscle cells in the media than in the IMAs, resulting in a greater spastic response following simple surgical manipulation.<sup>[11]</sup> We did not use a skeletonized RGEA. Recent studies indicated that the initial patency of the RGEA (97.1% at 1 month, 92.3% at 1 year, 80.9% at 7 years, and 66.5% after 10 years) had improved after using skeletonized grafts (97.8% immediately, 97.8% after 5 years, and 90.2% at 8 years after surgery).<sup>[12]</sup>

Because the RGEA is a visceral artery and the fourth branch of the aorta (abdominal aorta, coeliac artery, common hepatic artery, gastroduodenal artery, and RGEA), its diameter and flow volume are smaller than both the IMA and SVG grafts. Therefore, it is difficult to determine the quality of the RGEA anastomosis using a cutoff MGF value. When using an RGEA graft for RCA, the MGF is lower, PI value is higher, and diastolic filling percentage value is lower, as compared to the values typically observed when using IMA or SVG grafts for left coronary artery (LCA). The previously reported cutoff values for intraoperative TTFM parameters could not be adapted for the early patency of the RGEA grafts to the RCA. However, the smoothness of the graft flow curve may be a reliable predictor of postoperative graft patency.<sup>[13]</sup> Several articles on intraoperative bypass graft flow have been published: an MGF of >20 ml/min is considered indicative of a good graft and the PI <3 is considered an adequate value for a good graft.<sup>[14,15]</sup> Lowensohn *et al.*<sup>[16]</sup> stated that the RCA systolic flow was proportionately significantly greater than the LCA systolic flow, and the differences between the RCA and LCA systolic flow may be explained by the temporal relationships between the coronary perfusion pressure and

intramyocardial tension. Therefore, an antegrade flow occurs more easily during cardiac systole when using an RGEA graft to the RCA than when using an IMA graft to the LCA.

Mean duration of ICU stay was 1–2 days longer in our study than the patients underwent CABG with LIMA+SVG during the same period, probably because harvesting of the RGEA led to gastric dilatation. Moreover, the mean length of hospital stay was markedly longer as compared to published data, potentially because our department is a tertiary referral cardiovascular center. The length of hospital stay included the time of internal medicine treatment, particularly for those with acute myocardial infarction.

A meta-analysis<sup>[17]</sup> indicated the angiographic superiority of the RIMA and RA over SVG. The better patency rate from the RIMA and RA over SVG was particularly evident when angiographic follow-up was performed at 4 years after surgery. The RIMA is expected to achieve a better patency rate than the RA, although further studies are needed. The RGEA is the least preferable choice for arterial CABG, as it demonstrates no angiographic superiority compared with SVG. Of note, the researchers identified the target vessel as the source of heterogeneity when comparing the RA and SVG, thus indicating a significant advantage of using the RA over the SVG for circumflex artery targets. In the present study, the RA was grafted to the LCX system in approximately 55.77% of the cases; most of these cases were from the BIMA group. Hence, it is unclear whether BIMA plus SVG-RCA, PDA, or posterior branches of left ventricle (PLV) was better than BIMA plus RA-RCA, PDA, or PLV.

The IMA graft patency decreases as the coronary artery competitive flow increases. However, the effect of competitive flow on the IMA graft patency is mild, and no severe decline in IMA patency is noted, regardless of the degree of proximal coronary stenosis. This finding suggests that IMAs should not be avoided when bypassing coronary arteries with moderate degrees of stenoses. The risk of graft occlusion due to competitive flow becomes more prominent in grafts to non-LAD, women, RIMA grafts, and smokers.<sup>[18]</sup> Hence, coronary arteries with <70% stenosis in the left heart side and <90% in the dominant right system should be left untouched.<sup>[19]</sup> In contrast, the concept of “prophylactic” grafting has emerged as an option for patients with even mildly stenotic lesions but with concomitant severe medical illness.<sup>[20]</sup> In these patients, the minimally diseased vessels are expected to deteriorate with time and the risk from reoperation increases.

We suggest that the RIMA should be the second choice arterial graft, and the RA should be the third choice arterial graft. Although the RGEA might be the least preferred choice for arterial CABG, sBIMA + RGEA could provide three grafts *in situ* and cover most coronary artery target sites without any manipulation of the ascending aorta. Thus, complications of the central nervous system were minimized. The use of a third or fourth arterial graft in elderly patients should be carefully determined based on

the types of comorbidities that may be present, the patient's daily activity level, and angiographic findings.

This study has several limitations. The retrospective nature of the study and the lack of a comparison group are obvious limitations. The procedure was performed by a single surgeon, and hence, the total number of cases ( $n = 508$ ) was small. A total of 457 patients were followed up at most for 120 months and at least for 2 months. The time for follow-up was long, and hence, 57 cases were lost to follow-up. Follow-up angiography was not performed routinely in all the patients, and hence, the number of angiographic arterial grafts was limited, particularly the RGEA.

Conclusively, the harvesting of arterial grafts might be safe with no surgical complications. However, this procedure might not be suitable in emergent conditions as the artery harvesting time is longer. The bilateral use of the skeletonized IMA and RGEA could provide three grafts *in situ* and could cover most coronary artery target sites, without any required manipulation of the ascending aorta. Thus, the complication of the central nervous system could be minimized. It is reasonable that the skeletonized RIMA is used for Diag, intermediate branch, LCX, and RCA. *In situ*, the RGEA could perfectly anastomose to the PDA. Our study showed that total arterial OPCAB with the BIMA, RA, and RGEA grafting yielded satisfactory early and midterm outcomes in this patient group, without a significant increase in early mortality or morbidity. Moreover, the long-term outcomes were also positive.

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### Conflicts of interest

There are no conflicts of interest.

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# 全动脉化非体外循环冠状动脉旁路移植术10年经验

## 摘要

**背景：**背景 冠状动脉旁路移植术中静脉桥中远期通畅率不理想催生了动脉桥的应用。总结全动脉化非体外循环冠状动脉旁路移植术（OPCAB）的临床应用经验，并观察早期临床结果、手术并发症及随访结果。

**方法：**从2007年1月至2017年5月，共完成了508例全动脉化OPCAB，回顾总结这些患者的临床特点、手术方式、手术效果及随访资料。其中122例患者单纯行左乳内动脉-前降支搭桥，其余386例患者行多支血管吻合。

**结果：**平均远端吻合口 $2.34\pm 0.97$  (1-4)，院内死亡1例，其余患者均痊愈出院。随访457（90.32%）例患者，4，7，10年随访组全因死亡率分别为1.19%，6.47%及10.67%；心源性死亡率分别为0.60%，2.88%和3.33%；再血管化率分别为0.00%，3.60%和8.67%；再发缺血症状分别为1.79%，7.91%和11.33%；脑卒中发生率分别为2.38%，4.32%及6.67%。9.38%随访人群未正规服用冠心病二级预防药物。

**结论：**应用双侧乳内动脉、桡动脉及胃网膜右动脉进行全动脉化搭桥的此组患者，在未增加早期死亡率及并发症的情况下，得到了满意的早期及中期结果，另外，也有令人满意的晚期结果。