One-year outcomes of percutaneous coronary intervention in native coronary arteries versus saphenous vein grafts in patients with prior coronary artery bypass graft surgery

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Abstract

Background: Patients with prior coronary artery bypass graft (CABG) surgery often require percutaneous coronary intervention (PCI). Data are still limited in regards to the outcomes of native saphenous vein graft (SVG) PCI after CABG.

Methods: We performed a retrospective study in a tertiary reference cardiac center of consecutive patients who underwent PCI after CABG. The data were collected for patients who underwent either native or graft PCI from January 2008 to December 2018. Arterial graft PCIs were excluded. Multivariable Cox regression analysis with propensity matching was performed, and major adverse cardiac events (MACE) outcomes including death or myocardial infarction (MI) or revascularization were assessed at 1-year after each index procedure.

Results: A total of 435 PCI were performed in 401 patients (209 had native PCI and 192 had graft PCI). Target lesions were classified as following: 235 (54%) native coronary arteries and 200 (46%) SVG. Propensity matching resulted in 167 matched pairs. In multivariable Cox regression graft PCI relative to native PCI was an independent risk factor for MACE (hazard ratio [HR] 1.725, 95% confidence interval [CI] 1.049–2.837) which was primarily driven by increased incidence in revascularization (HR 2.218, 95% CI 1.193–4.122) and MI (HR 2.248, 95% CI 1.220–4.142) and with no significant difference in mortality (HR 1.118, 95% CI 0.435–2.870).

Conclusions: Compared with native coronary PCI, bypass graft PCI was significantly associated with higher incidence of MACE at 1-year and this was mainly driven by MI and revascularization. (Cardiol J 2022; 29, 3: 396–404)

Key words: acute coronary syndrome, coronary artery bypass graft, coronary artery disease, major adverse cardiac event, percutaneous coronary intervention

Introduction

Patients with prior coronary artery bypass graft (CABG) surgery often require repeat revascularization either due to graft failure or a combination of graft failure and progression of coronary atherosclerosis. Thrombosis, intimal hyperplasia and atherosclerosis are the main pathological processes underlying saphenous venous grafts disease [1]. Early thrombosis is the principle cause of vein graft attrition during the first month after bypass surgery, with intimal hyperplasia being an issue...
during the remainder of the first year. Thereafter, atherosclerosis predominates. The optimal revascularization strategy of patients with prior CABG and graft failure remains a subject of debate. Redo surgeries are associated with higher morbidity and mortality as well as poorer outcomes compared to initial operations [2]. Furthermore, there is limited evidence on the optimal percutaneous coronary intervention (PCI) option (i.e. native coronary artery or graft PCI) in such population. Present study was conducted to compare 1-year major adverse cardiac events (MACE) of native versus graft PCI.

Methods

This is a retrospective study performed in a tertiary cardiac center of CABG patients who underwent subsequent PCI. The data were collected for consecutive patients who underwent either native or graft PCI from January 2008 to December 2018. Arterial graft PCI patients were excluded from the study. The procedural data for the patients who underwent PCI were collected from our local catheterization laboratory database. If a patient had more than one procedure during the study period, the first PCI was considered as the index procedure and the subsequent procedures were considered as outcomes. If a patient had undergone more than one PCI in the same first procedure during the study time period, all lesions intervened on underwent analysis. However, if those PCI involved both native and saphenous vein graft (SVG) interventions, then the patient was included in the SVG PCI study arm. The primary end point was 1-year MACE defined as a composite of death, myocardial infarction (MI) or target vessel revascularization. Secondary endpoints included angiographic complications (no-reflow, dissection and perforation). Patients’ mortality was identified from the hospital clinical system which is updated regularly from the United Kingdom’s Office of National Statistics. All outcomes were assessed at 1-year after each index procedure.

Statistical analysis

Continuous variables are presented as means (SD) or medians (IQR). For normally distributed variables, Student’s t-test was used, whereas in samples with non-normal distribution Mann–Whitney U test was used. Categorical variables were compared with the use of Fisher’s exact tests (2-sided). To best control for the non-random assignment of patients to 1 of 2 PCI approaches, we have used a combination of matching methods: it is matched exactly on the categorical variables (gender, diabetes, chronic kidney disease, hypertension, urgency of procedures and clinical presentation [angina or acute coronary syndrome; ACS]) and used a propensity score on the age variable. So, in each matched pair the age may vary slightly but the other covariates all take exactly the same value. Matching resulted in 167 matched pairs. Kaplan–Meier curves for outcomes and compared with the use of the log-rank test. For multivariable analysis, the Cox regression model was applied. Estimated hazard ratios (HR) and their 95% confidence intervals (CI) were calculated. Two-sided statistics were performed with a p-value less than 0.05 determining significance. Statistical analysis was performed using SPSS v.25.0 (IBM Corp., Armonk, New York, United States).

Results

A total of 435 PCI were performed to 401 patients during the study period. They were classified as following: native coronary artery (235 [54%]), SVG (200 [46%]), The native vessel and SVG intervention had comparable baseline characteristics, left ventricular ejection fraction and clinical presentation (angina and ACS) as shown in Table 1. Graft age was greater in patients who underwent graft PCI. Femoral access was used in over half of both groups with no statistical difference between two groups. Most bypass graft target lesions were located at the body of the graft 58.6%. Compared with patients who underwent bypass graft PCI, those who underwent native coronary artery PCI were more likely to undergo PCI of a chronic total occlusion (CTO) or to an in-stent restenosis (ISR). In native vessel PCI, there was a greater likelihood of requiring more than one stent. However, in graft PCI stent diameters were larger. Regarding the length of the stents, there was no statistical difference between the two groups. In comparison to native coronary lesions, graft lesions were more likely to be treated with bare-metal stents (BMS) and drug eluting balloon. Patients in native PCI group were more likely to have post-procedural Thrombolysis in Myocardial Infarction III flow. Statistically, there was no difference in fluoroscopy time and contrast amount between both groups (Table 2). No reflow phenomenon was significantly more frequent in patients undergoing graft PCI compared to patients with native artery PCI (10% vs. 0.4%, p < 0.001) (Table 3). Matched groups analysis resulted in a significant difference in age between both groups.
Table 1. Baseline characteristics and presentation of patients undergoing native and graft percutaneous coronary intervention, before and after matching.

| Parameter                                      | Before matching | After matching |
|------------------------------------------------|-----------------|----------------|
|                                                 | Native coronary PCI (209) | SVG PCI (192) | P       | Native coronary PCI (167) | SVG PCI (167) | P       |
| Demographics                                   |                 |                |        |                         |               |        |
| Age, median (IQR)                              | 70 [62–76]      | 70 [65–78]     | 0.090  | 71 [63–76]              | 71 [66–79]    | 0.023  |
| Female                                         | 28 (13%)        | 29 (15%)       | 0.669  | 23 (14%)                | 23 (14%)      | 1      |
| Comorbidities                                  |                 |                |        |                         |               |        |
| Diabetes                                       | 84 (40%)        | 77 (40%)       | 1      | 67 (40%)                | 67 (40%)      | 1      |
| Hypertension                                   | 148 (71%)       | 123 (64%)      | 0.166  | 112 (67%)               | 112 (67%)     | 1      |
| Hyperlipidemia                                 | 99 (47%)        | 87 (45%)       | 0.690  | 78 (47%)                | 80 (48%)      | 0.913  |
| Chronic kidney disease                         | 30 (14%)        | 28 (15%)       | 1      | 23 (14%)                | 23 (14%)      | 1      |
| Dialysis                                       | 3 (1%)          | 4 (2%)         | 0.714  | 3 (2%)                  | 4 (2%)        | 1      |
| Previous MI                                    | 156 (75%)       | 130 (68%)      | 0.151  | 122 (73%)               | 113 (68%)     | 0.338  |
| Previous PCI                                   | 53 (25%)        | 47 (25%)       | 0.908  | 40 (24%)                | 40 (24%)      | 1      |
| Reduced left ventricular systolic function     | 60 (29%)        | 45 (23%)       | 0.256  | 50 (30%)                | 36 (22%)      | 0.103  |
| (LVEF ≤ 40%)                                   |                 |                |        |                         |               |        |
| Years from CABG, median (IQR)                  | 10 [7–14]       | 12 [9–15]      | 0.002  | 10 [7–14]               | 12 [9–15]     | 0.003  |
| Presentation                                   |                 |                |        |                         |               |        |
| Urgent procedure                               | 102 (49%)       | 116 (60%)      | 0.021  | 97 (58%)                | 97 (58%)      | 1      |
| Angina                                         | 106 (51%)       | 76 (40%)       | 0.061  | 70 (42%)                | 70 (42%)      | 0.899  |
| NSTEMI                                         | 66 (32%)        | 80 (42%)       | 0.385  | 63 (38%)                | 66 (40%)      | 0.899  |
| STEMI                                          | 37 (18%)        | 36 (19%)       | 0.899  | 34 (20%)                | 31 (19%)      | 0.899  |

CABG — coronary artery bypass graft; IQR — interquartile range; LVEF — left ventricular ejection fraction; MI — myocardial infarction; NSTEMI — non-ST-segment elevation myocardial infarction; PCI — percutaneous coronary intervention; STEMI — ST-segment elevation myocardial infarction; SVG — saphenous vein graft

Table 2. Lesion characteristics and procedural details, before and after matching.

| Parameter                           | Before matching | After matching |
|-------------------------------------|-----------------|----------------|
|                                     | Native coronary PCI (235) | SVG PCI (200) | P       | Native coronary PCI (189) | SVG PCI (176) | P       |
| Femoral access                      | 121 (52%)       | 111 (56%)     | 0.441  | 93 (49%)                | 97 (55%)      | 0.295  |
| Targeted vessel                     |                 |                |        |                         |               |        |
| LM                                  | 28 (12%)        | –              | –      | 25 (13%)                | –              | –      |
| LAD/diagonal                        | 45 (19%)        | 48 (24%)       | 0.052  | 37 (20%)                | 42 (24%)      | 0.094  |
| LCX/OM                              | 76 (32%)        | 83 (42%)       | 0.052  | 59 (31%)                | 76 (42%)      | 0.052  |
| RCA/PDA/PLV                         | 86 (37%)        | 69 (33%)       | 0.052  | 68 (36%)                | 58 (33%)      | 0.052  |
| Lesion characteristic               |                 |                |        |                         |               |        |
| In-stent restenosis                 | 26 (11%)        | 12 (6%)        | 0.087  | 18 (10%)                | 11 (6%)       | 0.245  |
| True bifurcation                    | 5 (1%)          | –              | –      | 5 (3%)                  | 0              | –      |
| Graft aortic anastomosis            | –               | 63 (31.5%)     | –      | –                       | 58 (33%)      | –      |
| Graft body                          | –               | 119 (59.5%)    | –      | –                       | 102 (58%)     | –      |
| Graft distal anastomosis            | –               | 18 (9.0%)      | –      | –                       | 16 (9%)       | –      |
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Table 2 (cont.). Lesion characteristics and procedural details, before and after matching.

| Parameter                        | Before matching | After matching | P     |
|----------------------------------|-----------------|----------------|-------|
|                                  | Native coronary PCI (235) | SVG PCI (200) |       |
| Number of stents, median (IQR)   | 1 [1–2]         | 1 [1–1]        | < 0.001 |
| Length of stents [mm], median (IQR) | 23 [16–32] | 22 [16–28] | 0.114 |
| Diameter of stents [mm], median (IQR)  | 3 [2.75–3.5] | 3.5 [3.0–4.0] | < 0.001 |
| Bare metal stents                | 22 (10%)        | 42 (20%)       | < 0.001 |
| Drug eluting stents              | 201 (87%)       | 138 (69%)      |       |
| Drug eluting balloons            | 9 (4%)          | 19 (10%)       |       |
| Stents characteristics and TIMI flow |                 |                |       |
| TIMI III flow                    | 165 (70%)       | 135 (68%)      | 0.136 |
| TIMI II flow                     | 20 (9%)         | 14 (7%)        |       |
| TIMI I flow                      | 7 (3%)          | 16 (8%)        |       |
| TIMI 0 flow                      | 43 (18%)        | 35 (18%)       |       |
| Post-procedural TIMI flow        |                 |                |       |
| TIMI III flow                    | 233 (99%)       | 179 (90%)      | < 0.001 |
| TIMI II flow                     | 1 (0.4%)        | 7 (4%)         |       |
| TIMI I flow                      | 1 (0.4%)        | 6 (3%)         |       |
| TIMI 0 flow                      | 0               | 8 (4%)         |       |
| Contrast amount, median (IQR) [mL]  | 230 [170–320] | 230 [160–310] | 0.643 |
| Fluoroscopy time, median (IQR) [min] | 16.5 [11–25] | 16.5 [11–24.5] | 0.824 |

Table 3. Peri-procedural complications before and after matching.

| Parameter                        | Before matching | After matching | P     |
|----------------------------------|-----------------|----------------|-------|
|                                  | Native coronary PCI (235) | SVG PCI (200) |       |
| No reflow                        | 1 (0.4%)        | 19 (10%)       | < 0.001 |
| Dissection                       | 7 (3%)          | 2 (1%)         | 0.188 |
| Perforation                      | 3 (1%)          | 0              | –     |
| Intra-aortic balloon pump        | 6 (3%)          | 3 (2%)         | 0.337 |

IQR — interquartile range; PCI — percutaneous coronary intervention; SVG — saphenous vein graft; TIMI — Thrombolysis in Myocardial Infarction

(p = 0.023), however the size of the difference was not large (median age 71 [63–76] vs. 71 [66–79] in native PCI and SVG PCI groups, respectively). On the other hand, after matching the presentation (stable angina or ACS) was equally distributed across the two groups. The lesion characteristics of matched patient groups were comparable to those prior to matching. Patients who underwent graft PCI had a significantly higher incidence of MACE (Fig. 1), principally driven by MI (Fig. 2)
and revascularization rate (Fig. 3), while there was no significant difference in mortality (Fig. 4).

In multivariable Cox regression analysis (Table 4) the only factor associated with MACE was graft PCI compared to native PCI (HR 1.725, 95% CI 1.049–2.837, p = 0.032). Age, urgency of the procedure, history of MI, diabetes, hypertension, hyperlipidemia, previous PCI, left ventricular ejection fraction, contrast amount used and fluoroscopy time were not significantly associated with MACE. Detailed Cox regression analyses on mortality, MI and revascularization are presented in Tables 5–7, respectively.

**Discussion**

This single-center study which compares outcomes of PCI in patients with previous CABG has a number of interesting findings. Although there was no statistical difference in the baseline demographics of the two patient groups (Table 1), SVG PCIs were more likely to be urgent procedures. To reduce selection bias, there was a preponderance of males in the present study (86%). There was an even greater disproportion as reported by Brilakis et al. (99% of males) [3]. This significant underrepresentation of females with prior CABG
Table 4. Multivariate Cox regression with regard to major adverse cardiac events in matched groups.

| Parameter                                      | Hazard ratio | 95% CI         | P     |
|------------------------------------------------|--------------|----------------|-------|
| Age [years]                                    | 0.990        | 0.964–1.017    | 0.467 |
| Type of procedure (urgent vs. elective)        | 0.913        | 0.551–1.513    | 0.724 |
| Graft PCI vs. native PCI                       | 1.725        | 1.049–2.837    | 0.032 |
| History of MI                                  | 1.444        | 0.759–2.746    | 0.263 |
| Previous PCI                                   | 1.677        | 0.966–2.912    | 0.066 |
| Diabetes                                       | 0.972        | 0.536–1.761    | 0.925 |
| Hypertension                                   | 1.440        | 0.728–2.847    | 0.294 |
| Hyperlipidemia                                 | 1.240        | 0.713–2.157    | 0.446 |
| Chronic kidney disease                         | 1.403        | 0.741–2.656    | 0.299 |
| Fluoroscopy time (1 min increase)              | 0.999        | 0.983–1.015    | 0.878 |
| Contrast amount (1 mL increase)                | 1.001        | 0.999–1.004    | 0.254 |
| LVEF (≤ 40%)                                   | 0.839        | 0.465–1.516    | 0.562 |

CI — confidence interval; MI — myocardial infarction; LVEF — left ventricular ejection fraction; PCI — percutaneous coronary intervention

Table 5. Multivariate Cox regression with regard to revascularization in matched groups.

| Parameter                                      | Hazard ratio | 95% CI         | P     |
|------------------------------------------------|--------------|----------------|-------|
| Age [years]                                    | 0.964        | 0.933–0.995    | 0.025 |
| Type of procedure (urgent vs. elective)        | 0.684        | 0.374–1.252    | 0.218 |
| Graft PCI vs. native PCI                       | 2.218        | 1.193–4.122    | 0.012 |
| History of MI                                  | 1.650        | 0.737–3.691    | 0.223 |
| Previous PCI                                   | 1.824        | 0.953–3.493    | 0.070 |
| Diabetes                                       | 0.972        | 0.581–2.487    | 0.925 |
| Hypertension                                   | 1.003        | 0.453–2.222    | 0.994 |
| Hyperlipidemia                                 | 0.994        | 0.498–1.983    | 0.986 |
| Chronic kidney disease                         | 1.257        | 0.741–2.656    | 0.582 |
| Fluoroscopy time (1 min increase)              | 0.998        | 0.977–1.020    | 0.867 |
| Contrast amount (1 mL increase)                | 1.000        | 0.997–1.004    | 0.853 |
| LVEF (≤ 40%)                                   | 0.953        | 0.472–1.923    | 0.893 |

CI — confidence interval; MI — myocardial infarction; LVEF — left ventricular ejection fraction; PCI — percutaneous coronary intervention

Table 6. Multivariate Cox regression with regard to myocardial infarction in matched groups.

| Parameter                                      | Hazard ratio | 95% CI         | P     |
|------------------------------------------------|--------------|----------------|-------|
| Age [years]                                    | 0.996        | 0.964–1.028    | 0.791 |
| Type of procedure (urgent vs. elective)        | 1.349        | 0.715–2.544    | 0.355 |
| Graft PCI vs. native PCI                       | 2.248        | 1.220–4.142    | 0.009 |
| History of MI                                  | 1.226        | 0.600–2.506    | 0.576 |
| Previous PCI                                   | 1.425        | 0.732–2.772    | 0.297 |
| Diabetes                                       | 0.910        | 0.455–1.821    | 0.790 |
| Hypertension                                   | 2.112        | 0.913–4.883    | 0.081 |
| Hyperlipidemia                                 | 0.885        | 0.472–1.656    | 0.701 |
| Chronic kidney disease                         | 1.667        | 0.804–3.454    | 0.169 |
| Fluoroscopy time (1 min increase)              | 1.001        | 0.984–1.018    | 0.924 |
| Contrast amount (1 mL increase)                | 1.001        | 0.998–1.004    | 0.413 |
| LVEF (≤ 40%)                                   | 1.152        | 0.593–2.238    | 0.675 |

CI — confidence interval; MI — myocardial infarction; LVEF — left ventricular ejection fraction; PCI — percutaneous coronary intervention
in need of subsequent PCI reported in studies to date warrants further prospective assessment. In the current study there was a relatively high percentage of radial approach (47%) in comparison to the other reported studies [4]. RADIAL-CABG Trial [5] was a randomized prospective study which suggested that diagnostic angiography using radial access compared with femoral access was associated with greater contrast use, longer procedure and fluoroscopy time as well as greater patient and operator radiation exposure. However, no significant differences in these parameters were observed among patients undergoing PCI in the present study. Other studies suggested that a radial approach is feasible and is as fast as the femoral approach [6, 7]. It was noted that venous grafts were more likely to be the PCI target vessel with increasing time after CABG, consistent with the accelerated pace of late saphenous venous graft failure [8]. Nearly all target bypass grafts were SVG, a reflection of the excellent outcomes achieved with use of internal mammary arteries [9, 10]. Radial-artery grafts have a lower rate of graft occlusion at 1-year than SVGs [11]. We would thus advocate a randomized study to compare the outcomes of conventional CABG versus a hybrid approach where only arterial grafts would be used, plus PCI for the other vessels. It was found that patients who underwent bypass graft rather than native coronary PCI were more likely to receive BMS. The benefits of drug eluting stents (DES) over BMS in venous graft interventions are still controversial. The DIVA study [12], which is the most recent randomized trial included 597 patients undergoing PCI of de-novo SVG lesions. There was no significant difference in 12-month and long-term (median 2.7 years) incidence of cardiac death, target vessel MI or target vessel revascularization (TVR). DES implantation was associated with improved results in ISAR-CABG trial which randomized 610 patients with diseased SVG to DES or BMS and reported that DES were associated with favorable hard endpoint outcomes (15.4% vs. 22.1%; p = 0.03) [13]. The stenting of saphenous vein grafts trial (SOS), also demonstrated a significant reduction in MACE rates with paclitaxel-eluting stents compared with BMS, which was mainly driven by lower target lesion revascularization (TLR) rates [14]. Sirolimus-eluting stents were studied in the Reduction of Restenosis In Saphenous Vein Grafts With Cypher Sirolimus-eluting Stent RRISC trial [15], which demonstrated a reduction in TLR and TVR, and late stent loss in the DES group compared with the BMS group at 6 months. Conversely, the DELAYED RRISC study [16] found the TVR benefit was lost at 3-year follow-up and BMS was associated with lower long-term mortality. In the present study, no-reflow was significantly higher in graft PCI compared to native artery PCI (10% vs. 0.4%; p < 0.001). Venous graft PCI was an independent risk factor for the peri-procedural complications including no-reflow [17], especially if the presentation was ST-segment elevation MI [18]. From our real-world data, SVG PCI carried a higher risk of MACE at 1 year when compared with native coronary PCI, that was mainly driven by MI and TVR. All of the efforts need to be taken into consideration to attempt native coronary revascularization. Percutaneous revascularization of CTO continues to gain popularity and accept-

| Table 7. Multivariate Cox regression with regard to mortality in matched groups. |
|-------------------------------------------------|-----------------|---------------|--------|
| Parameter                                       | Hazard ratio    | 95% CI        | P      |
| Age [years]                                     | 1.047           | 0.990–1.107   | 0.107  |
| Type of procedure (urgent vs. elective)         | 0.684           | 0.537–5.495   | 0.361  |
| Graft PCI vs. native PCI                        | 1.118           | 0.435–2.870   | 0.817  |
| History of MI                                   | 1.327           | 0.403–4.370   | 0.642  |
| Previous PCI                                    | 0.913           | 0.282–2.954   | 0.879  |
| Diabetes                                        | 0.900           | 0.303–2.674   | 0.850  |
| Hypertension                                    | 4.859           | 0.564–4.829   | 0.150  |
| Hyperlipidemia                                  | 1.942           | 0.660–5.719   | 0.228  |
| Chronic kidney disease                          | 2.296.          | 0.809–6.513   | 0.118  |
| Fluoroscopy time (1 min increase)               | 1.005           | 0.983–1.028   | 0.642  |
| Contrast amount (1 mL increase)                 | 1.004           | 1.000–1.008   | 0.060  |
| LVEF (≤ 40%)                                    | 0.840           | 0.262–2.694   | 0.769  |

CI — confidence interval; MI — myocardial infarction; LVEF — left ventricular ejection fraction; PCI — percutaneous coronary intervention
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