Clinical Outcomes of Treatment by Percutaneous Coronary Intervention Versus Coronary Artery Bypass Graft Surgery in Patients With Chronic Kidney Disease Undergoing Index Revascularization in Ontario

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Background—There is a paucity of data on the comparative effectiveness of percutaneous coronary intervention using contemporary drug-eluting stent (DES) compared with coronary artery bypass graft (CABG) surgery in patients with chronic kidney disease.

Methods and Results—A population-based study was performed using the Cardiac Care Network, a provincial registry of all patients undergoing cardiac catheterization in Ontario, to evaluate patients treated with either percutaneous coronary intervention using DES or CABG between October 1, 2008, and September 30, 2011. Chronic kidney disease was defined as creatinine clearance <60 mL/min. A total of 1786 propensity-matched patients from 4006 patients with chronic kidney disease undergoing index revascularization for multivessel disease with either DES or isolated CABG (n=893 each group) were analyzed. Baseline and procedural characteristics between percutaneous coronary intervention and CABG groups were well-balanced, including urgent revascularization priority, diabetes mellitus, left ventricular function, and 3-vessel disease. The 1-, 2-, and 3-year Kaplan–Meier survival analyses in propensity-matched patients favored CABG (93.2% versus 89.3%; 86.6% versus 80.3%; 80.8% versus 71.5%, respectively; P<0.001). The CABG cohort had greater 1-, 2-, and 3-year freedom from major adverse cardiac and cerebrovascular events (89.4% versus 71.2%; 81.9% versus 60.5%; 75.2% versus 51.8%, respectively; P<0.001). Cox regression analysis identified DES use to be associated with greater hazard for late mortality (hazard ratio, 1.58; 95% confidence interval, 1.32–1.90) and major adverse cardiac and cerebrovascular events (2.62; 2.28–3.01; all P<0.001).

Conclusions—In this large provincial registry, CABG was associated with improved early and late clinical outcomes when compared with percutaneous coronary intervention using DES in patients with chronic kidney disease undergoing index revascularization.

Key Words: angioplasty ■ coronary disease ■ kidney ■ registries ■ surgery

Cardiovascular disease is the leading cause of morbidity and mortality in patients with chronic kidney disease (CKD). However, these patients have been systematically under-represented in clinical outcome studies of revascularization, despite accounting for 30% to 40% of patients presenting for diagnostic and revascularization procedures. The management of patients with CKD is challenging, attributed to greater underlying comorbidities, coronary lesion calcification and complexity, increased thrombotic and bleeding risk, and tendency for restenosis with bare-metal stents. There is a paucity of data comparing the effectiveness of percutaneous coronary intervention (PCI) using contemporary drug-eluting stent (DES) compared with coronary artery bypass graft surgery (CABG) in patients with CKD. Although there have been 2 large randomized controlled trials (RCTs) comparing PCI using DES versus CABG in patients with multivessel disease (Synergy Between PCI With Taxus and Cardiac Surgery trial [SYNTAX]) and in patients with diabetes mellitus Future Revascularization Evaluation in Patients With Diabetes Mellitus: Optimal Management of
WHAT IS KNOWN

- Cardiovascular disease is the leading cause of morbidity and mortality in patients with chronic kidney disease.
- There is a paucity of data comparing the effectiveness of percutaneous coronary intervention using contemporary drug-eluting stent compared with coronary artery bypass graft surgery in patients with chronic kidney disease.

WHAT THE STUDY ADDS

- In this large provincial registry, revascularization by coronary artery bypass graft was associated with lower early and late (≤5 years) clinical event rates compared with percutaneous coronary intervention using drug-eluting stent in patients with chronic kidney disease undergoing first revascularization.
- Thirty-day mortality was not significantly different between the 2 modes of revascularization, but late survival significantly favored coronary artery bypass graft surgery.
- Late major adverse cardiac and cerebrovascular event in the percutaneous coronary intervention group was driven by excess repeat revascularization and myocardial infarction.

Multi-vessel Disease (FREEDOM), there are no RCTs evaluating revascularization strategies in patients with CKD. The lack of clinical outcome data to guide decision making in this large group of high-risk patients has been acknowledged by recent consensus statements and guidelines.

Published studies have reported conflicting longer term outcome data. Data from Medicare enrollees and the United States Renal Data System suggest that the long-term risks of death or combined death and end-stage renal disease were lower after CABG when compared with PCI in patients with CKD or those on dialysis. However, other studies have suggested that DES seemed to compare favorably with CABG in terms of mortality. Therefore, we aimed to evaluate the long-term clinical outcomes of PCI using DES versus CABG in a large cohort of patients with CKD undergoing index revascularization in the province of Ontario, Canada.

Methods

Study Design

This was a retrospective, population-based analysis of patients with CKD undergoing index (first) revascularization for multivessel disease with PCI using DES or CABG between October 1, 2008, and September 30, 2011 in Ontario, Canada. All consecutive adult patients aged ≥20 years undergoing cardiac catheterization during the study period for suspected coronary artery disease were eligible for inclusion. We excluded patients with missing renal function, single-vessel disease, any previous revascularization, patients undergoing emergent revascularization (primary PCI or PCI for cardiogenic shock), patients with preserved renal function, and non-DES PCI and nonisolated CABG to derive our final study sample as shown in the study flow diagram (Figure 1). This study was approved by the Research Ethics Board of Sunnybrook Health Sciences Center.

Data Source

All patients’ data were obtained from the Cardiac Care Network of Ontario Cardiac Registry, which prospectively records patient information related to their demographics, clinical presentation, and procedural variables in those undergoing cardiac catheterization and revascularization procedures. The Cardiac Care Network database contains data elements with standardized data definitions that permit comparisons between PCI and CABG cohorts. Long-term clinical outcome data were obtained by linkage to the Canadian Institutes for Health Information Discharge Abstract Database to capture coronary revascularization rates and the Registered Persons Database to capture deaths after cardiac catheterization in Ontario.

Definitions and Clinical Outcomes

Estimated creatinine clearance (CrCl) was calculated using the Cockroft-Gault formula: CrCl (mL/min)=(140−age)×weight (kg)/[(serum creatinine [mg/dL]×72) ≤0.85 for women) from baseline blood samples obtained before cardiac catheterization. CKD was defined as a CrCl ≤60 mL/min. Indications for revascularization were defined as follows: elective referred to revascularization performed for stable angina or in the non–acute coronary syndrome setting; urgent included revascularization performed while in-hospital with index illness (for example, any procedure for non–ST-segment elevation acute coronary syndrome or >48 hours after ST-segment elevation myocardial infarction [MI]).

Clinical outcome data were available for time-to-event for all-cause mortality, repeat PCI or CABG, as well as hospitalization for MI, heart failure, or stroke (defined by primary hospital coding for admission). Major adverse cardiovascular and cerebrovascular events (MACCE) were defined as death, MI, repeat revascularization, or stroke.

Statistical Analysis

Continuous variables are reported as mean±SD. Categorical variables are reported as proportions. Between-group univariate comparisons were performed using χ² tests for categorical variables, and t tests for continuous variables. A propensity score for PCI (DES) selection was developed with the use of logistic regression analysis. The following variables were selected for the model (based on significant difference by univariate analysis between the unmatched PCI versus CABG cohorts or if considered clinically significant): age/decade, female sex, urgent revascularization priority, New York Heart Association class IV status, dyslipidemia, cerebrovascular disease, CKD stage, number of diseased vessels, left main disease, left anterior descending disease, smoking history, acute coronary syndrome, diabetes mellitus, left ventricular ejection fraction <40%, peripheral arterial disease, recent MI <30 days, and dialysis. The DES propensity score was defined as the predicted probability of any 1 patient being selected for DES. The %GMATCH macro was used to form random pairs of patients with CABG and PCI matched by calipers of width equal to 0.2 of the SD of the logit of the propensity score (log of the predicted probability of DES selection). Standardized differences (difference in means or proportions divided by SE) in both unmatched and propensity-matched groups were used to assess the magnitude of change in effect size between the 2 groups. A standardized difference of <0.20 was accepted for the propensity-matched PCI and CABG cohorts as indicating <15% nonoverlap in the 2 groups.

Kaplan–Meier methods and the log-rank P value were used for time-to-event outcomes comparisons. Survival was determined from the time of index revascularization to death or censored at the closing date of the study (March 31, 2012).

Cox multiple regression analysis was performed in the unmatched cohort to identify independent predictors of late mortality, and MACCE by entering all variables that had a univariate association with each outcome at P<0.25 or those of known clinical significance but failing to meet the critical α level for submission to the model. The α for variable retention in multivariable models was 0.10. The following variables were used for the Cox multiple regression analysis: DES group, age by decade, female sex, CKD stage, left ventricular ejection fraction <40%, urgent revascularization priority, left main disease, number of diseased vessels, diabetes...
mellitus, hypertension, chronic obstructive pulmonary disease, cerebrovascular disease, and peripheral arterial disease. Correlation analysis for testing of collinearity between variables was performed, and where 2 variables displayed strong collinearity (ie, $R^2>30\%$), only 1 variable was selected for the COX regression model. Proportionality assumptions were evaluated for each covariate in the Cox models of late mortality and MACCE. Proportionality assumptions were verified by (1) visual examination of the $-\log$(survival) graphs to ensure parallel slopes, and by plotting Schoenfeld residuals to ensure slopes did not deviate from zero; and (2) statistically by assessing the proportional hazard assumption for each covariate. Linearity assumptions were verified by the overall proportionality test of the log(survival time) interaction with each covariate. We also evaluated separately Cox proportional hazard models for late mortality, and MACCE with incorporation of the DES propensity score (logit of the propensity score) as a covariate. Overadjustment of these Cox models was mitigated by using only the propensity score and DES group. All $P$ values for proportionality assumptions and linearity were $>0.05$. All data analyses were performed using SAS, version 9.2 for Windows (SAS Institute, Cary, NC) statistical software. A 2-sided $P$ value <0.05 was considered statistically significant.

Results
Baseline Clinical and Procedural Characteristics
A total of 44,740 patients underwent coronary revascularization between October 2008 and September 2011 in Ontario. After excluding patients with any previous revascularization, single-vessel disease, emergent revascularization priority (primary PCI and PCI for cardiogenic shock), concomitant revascularization with bare-metal stents, nonisolated CABG, missing renal function, and those with CrCl $\geq$60 mL/min, 996 and 3010 patients undergoing first PCI with DES and CABG, respectively, were included in the analysis (Figure 1). After propensity-score matching, the baseline clinical characteristics between the PCI and CABG groups (n=893 in each group) were well-balanced with the exception of weight being lower in the CABG group and a greater proportion of CABG patients with Canadian Cardiovascular Society angina class IV (Table 1). The prevalence of diabetes mellitus was $\geq43\%$ in both groups. Calculated standardized differences were $<0.20$ between propensity-matched PCI and CABG cohorts, suggesting well-balanced baseline clinical characteristics (data not shown).

Baseline procedural variables were similar between the 2 groups after propensity-matching with respect to number of diseased vessels (approximately two thirds 2-vessel disease and one third 3-vessel disease in both PCI and CABG cohorts), diseased vessel location, or left main coronary artery involvement (Table 2).

Early and Late Clinical Outcomes
Early 30-day and late clinical outcomes after revascularization are shown in Tables 3 and 4. Early mortality and admissions for stroke were similar between PCI and CABG groups, 3.4% versus 3.1%, $P=0.79$ (mortality), and 0.2% versus 0.5%, $P=0.41$ (stroke), respectively. However, most other adverse clinical outcomes and the composites of MACCE occurred more frequently in the PCI cohort, including repeat revascularization, and MI. During late follow-up of $\leq$3 years (mean, 1.76±0.96 versus 1.92±0.96 years in the PCI and CABG cohorts, respectively; $P<0.001$), mortality was higher in the PCI compared with the CABG group, as were repeat revascularization, MI, and MACCE (all $P<0.01$). Admissions for stroke occurred with similar frequencies between the 2 groups over time.

Kaplan–Meier cumulative survival and freedom from MACCE comparisons between propensity-matched PCI and CABG cohorts are shown in Figures 2 and 3. The 1-, 2-, and 3-year Kaplan–Meier survival analyses favored CABG (93.2% versus 89.3%; 86.6% versus 80.3%; 80.8% versus 71.5%, respectively; $P<0.001$). The CABG cohort had greater 1-, 2-, and 3-year freedom from MACCE (89.4% versus 71.2%; 81.9% versus 60.5%; 75.2% versus 51.8%, respectively; $P<0.001$) because of excess MI and repeat revascularization in the PCI cohort.

Predictors of Clinical Outcomes in Patients With CKD Undergoing Revascularization
In unmatched patients (n=4006), the use of PCI with DES compared with CABG was associated with an increased hazard for late mortality (hazard ratio, 1.58; 95% confidence
interval, 1.32–1.90; \( P < 0.001 \)) and MACCE (2.62; 2.28–3.01; \( P < 0.001 \); Table 5). Other independent predictors of adverse clinical outcomes include CKD stage, age, diabetes mellitus, left ventricular dysfunction, and urgent revascularization priority. Female sex was a negative predictor for late mortality but not for MACCE.

In additional analyses of predictors of late mortality and MACCE, the DES propensity score was incorporated into separate Cox proportional hazard models. The hazard ratios for late mortality, and MACCE with PCI using DES was 1.57 (1.31–1.88; \( P < 0.001 \)) and 2.56 (2.21–2.95; \( P < 0.001 \)), respectively.

We further evaluated the association between DES use across various prespecified subgroups (in propensity-matched PCI and CABG cohorts), including age, sex, diabetes mellitus, CKD stage, urgency of revascularization, and number of diseased vessels (Figure 4). The use of DES exhibited increased hazard for late MACCE when compared with CABG across all subgroups (all \( P < 0.001 \)).

**Effect of Severity of CKD on Clinical Outcomes**

When stratified according to the severity of renal insufficiency, the majority of patients (>80%) had CKD stage 3 (CrCl 30–59 mL/min; Table 1). Thirty-day and 1-year mortality were similar between the PCI and CABG cohorts among those with CKD stage 3, but late mortality and MACCE were significantly higher in the PCI group (all \( P < 0.05 \); Table I in the Data Supplement). In patients with stage 4 CKD, only 30-day death was similar between the 2 groups, whereas all other adverse outcomes occurred more frequently in the PCI cohort (Table II in the Data Supplement; all \( P < 0.001 \)).

Kaplan–Meier cumulative survival and freedom from MACCE comparisons between propensity-matched PCI and CABG are presented in Figure 4.
Diseased vessels, n (%)

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<thead>
<tr>
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<th>Unmatched</th>
<th>Propensity Matched</th>
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|        | Patients, n | 996 | 3010 | ... | 893 | 893 | ...
|        | No. of diseased vessels, n (%) | ... | ... | <0.001* | ... | ... | 0.48
|        | 2 | 704 (70.7) | 1331 (44.2) | ... | 605 (67.7) | 591 (66.2) | ...
|        | 3 | 292 (29.3) | 1679 (55.8) | ... | 288 (32.3) | 302 (33.8) | ...

Diseased vessels n (%)

|        | Left anterior descending | 742 (74.5) | 2368 (78.7) | <0.001* | 652 (73.0) | 654 (73.2) | 0.92
|        | Left circumflex | 778 (78.1) | 2798 (93.0) | <0.001* | 720 (80.6) | 731 (81.9) | 0.50
|        | Right coronary artery | 764 (76.7) | 2533 (84.2) | <0.001* | 702 (78.6) | 703 (78.7) | 0.95
|        | Left main | 132 (13.3) | 1108 (36.8) | <0.001* | 132 (14.8) | 131 (14.7) | 0.95

CABG indicates coronary artery bypass graft; and PCI, percutaneous coronary intervention.

P<0.05.

Table 2. Baseline Procedural Characteristics

Current clinical practice and decision making in these complex patients are guided only by retrospective studies.19,20 Interestingly, the proportion of patients with renal insufficiency in SYNTAX and FREEDOM were only ≈16% and 7%, respectively,17,18 highlighting the difficulty and reluctance to enroll high-risk patients into revascularization strategy trials. Therefore, important results from large provincial registries, such as ours, add to the growing body of literature favoring surgical over percutaneous revascularization in these patients as an initial strategy.

There are several reasons that might account for the observed improved clinical outcomes associated with CABG over PCI for multivessel revascularization with particular relevance to patients with CKD. First, numerous studies have suggested a survival advantage with complete compared with incomplete revascularization, and that complete revascularization is more frequently achieved with CABG rather than PCI.32 Indeed, there are studies reporting an underuse of revascularization and of incomplete revascularization in patients with CKD because of concerns about contrast-induced nephropathy, increased bleeding and thrombotic diatheses, and comorbidities.8,33 Second, reduced PCI procedural success has been reported to occur more frequently in patients with CKD, further highlighting the risk of incomplete revascularization in these patients.5,8,34 Third, it has been postulated that CABG provides prophylactic protection of future coronary events by virtue of bypassing vulnerable plaques that are commonly located in the proximal coronary tree.35

Existing studies suggest that patients with CKD undergoing CABG have high postoperative events when compared with their preserved renal function counterparts with respect to mortality, stroke, reoperation, and deep sternal infection.36,37 Similarly, short- and long-term morbidity and mortality post PCI in this high-risk group of patients are also increased commensurate with the severity of renal insufficiency.5,38 Therefore, comparisons of the comparative effectiveness of revascularization strategies in this group of patients, with

Discussion

In this large contemporary provincial registry, surgical revascularization was associated with improved early and late (≤3 years) clinical outcomes compared with PCI using DES in patients with CKD undergoing index (first) revascularization. Although 30-day mortality was not significantly different between the 2 modes of revascularization, late survival significantly favored CABG. Late MACCE also occurred less frequently in the CABG cohort during the 3-year time period driven by excess repeat revascularization and MI but not stroke in the PCI cohort. These important findings underscore the results of 2 recent large RCTs comparing the effectiveness of PCI with DES versus CABG in patients with complex multivessel disease and diabetes mellitus (SYNTAX and FREEDOM).17,18 In both these trials, CABG demonstrated superiority over PCI with respect to MACCE, MI, and repeat revascularization particularly in the subset of patients with intermediate to high SYNTAX scores (with mortality reduction at 5 years in FREEDOM).18,39 It is well documented that patients with CKD have complex coronary lesions,6 which are often calcified30 superimposed on a background of accelerated atherosclerosis.30 Moreover, the prevalence of diabetes mellitus is high (≥30%) among patients with CKD (>43% in our cohorts).31 Taken together, these data would suggest that patients with CKD would be better served with CABG over PCI. However, there is a paucity of data and to date no RCT comparing the effectiveness of either strategy in this high-risk group of patients,21 who comprise up to 40% of patients presenting for either diagnostic or revascularization procedures.7

Table 3. Thirty-Day Clinical Outcomes

P<0.05.

CABG indicates coronary artery bypass graft; MACCE, major adverse cardiovascular and cerebrovascular events; MI, myocardial infarction; and PCI, percutaneous coronary intervention.

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limited life-expectancy and significant comorbidities, are of significant interest to not only cardiac surgeons and interventional cardiologists but also general internists and nephrologists who are frequently involved in the care of these patients.

Data from observational studies comparing PCI versus CABG in patients with CKD have reported conflicting longer term outcome data. Data from Medicare enrollees and the United States Renal Data System suggest that the long-term risks of death or combined death and end-stage renal disease development were lower after CABG when compared with PCI (bare-metal and DES) in patients with CKD or those on dialysis. Conversely, the early risk of death and end-stage renal disease was higher in the CABG cohort with later catch-up in the PCI cohort beyond 6 months of revascularization. The results of our study are consistent with these findings from Charytan et al, confirming the longer term risks of mortality with PCI. Another study reporting lower long-term mortality, MI, and repeat revascularization in the CABG arm came from a large Northern Californian registry. By design, Chang et al included patients with CKD who had also received bare-metal stents (1996–2008) and did not specifically elucidate the risk of mortality over time because they only reported 5-year event rates, which might be important when considering revascularization options in patients with limited life expectancy. In contrast, other studies have suggested that PCI with DES seemed to compare favorably with CABG in terms of mortality. Most of these studies, however, were single center or with smaller study populations or with a focus on only dialysis patients, limiting the generalizability of their findings.

An important consideration affecting decision making for revascularization is the perioperative risk of stroke and quality of life post revascularization. In both SYNTAX and FREEDOM, the rates of stroke at 12 months and 5 years were increased in the CABG arm. Interestingly, we did not observe an increased risk of stroke in our study out to 3 years. The precise reason(s) for this remains to be clarified. However, this finding deserves further study because in some patients the risk of perioperative stroke could be an important determining factor. Finally, quality of life seems also to favor CABG over PCI although the magnitude of benefit is small relating to greater angina relief and fewer repeat revascularizations. Thus, this additional benefit of CABG should theoretically favor CABG over PCI in this group of patients with severe coronary artery disease. However, despite knowledge of greater repeat revascularization procedures and even mortality associated with PCI compared with CABG, patients still frequently prefer PCI over CABG because of the perceived less invasive nature of the PCI procedure and the quicker recovery post PCI. In context of such complexities, decision making in this challenging group of patients with complex multivessel coronary artery disease should be reviewed in the framework of a Heart Team to define the optimal revascularization strategy for each individual patient.

The strengths of our study include its large sample size of patients enrolled in a multicenter registry with robust linkage to provincial administrative databases that accurately record death, repeat revascularization procedures, and admissions for stroke. To our knowledge, ours is also the largest study to date evaluating exclusively the merits of index PCI with DES versus CABG as revascularization strategies in patients with CKD.

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<th>Table 4. Late Clinical Outcomes</th>
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<td>Patients, n</td>
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<td>Years follow-up, y</td>
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<tr>
<td>Death, n (%)</td>
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<tr>
<td>MI, n (%)</td>
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<td>Heart failure, n (%)</td>
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<td>Stroke, n (%)</td>
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<td>MACCE, n (%)</td>
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<td>Repeat revascularization, n (%)</td>
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<tr>
<td>CABG</td>
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<td>PCI</td>
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CABG indicates coronary artery bypass graft; MACCE, major adverse cardiovascular and cerebrovascular events; MI, myocardial infarction; and PCI, percutaneous coronary intervention.

*P<0.05.

Figure 2. Kaplan–Meier survival analysis in propensity-matched patients with chronic kidney disease undergoing percutaneous coronary intervention (PCI) vs coronary artery bypass graft surgery (CABG).
Limitations

The results of our study should be interpreted in context of several limitations. This was not an RCT, and results should be considered hypothesis generating. The Ontario Cardiac Care Network registry does not capture detailed angiographic or procedural characteristics precluding the assessment of SYNTAX scores, and subgroup analysis of various DES types (first versus second generation) or bypass grafts especially internal thoracic artery usage. Similarly, the registry currently does not capture sufficient clinical variables that permit calculation of the Society of Thoracic Surgeons (STS) or European System for Cardiac Operative Risk Evaluation (EuroSCORE) as mortality risk prediction. Consequently, propensity-matching neither included the SYNTAX score nor STS or EuroSCORE in the derivation of the final matched PCI and CABG cohorts. The registry also does not record whether repeat revascularization procedures were planned (ie, staged) or ischemia-driven repeat revascularization procedures and, thus, this might have significantly increased the rates of repeat revascularization in the PCI group. However, this would not have affected the hard outcome of death between the 2 revascularization strategies. As with any large registry, the possibility of missing data, unmeasured confounders, and selection bias (confounded by indication) favoring a particular type of revascularization strategy for any given patient exists and might have influenced...
clinical outcomes. Although we think that all patients who were referred for either CABG or multivessel PCI would have had an informed Heart Team discussion between noninterventional cardiologists, nephrologists, interventional cardiologists, cardiac surgeon, and the patient themselves as per contemporary revascularization practice, we did not have documentation in all cases given the nature of the administrative databases. Therefore, the potential for selection and referral bias favoring the CABG cohort exists because the PCI cohort might have included patients who were considered not eligible for CABG. Other short-term (30 days) complications, such as renal failure, dialysis, sternal infections, and reoperations pertinent to the CABG cohort were not available for analysis. Thus, a high postoperative CABG complication rate in this high-risk patient cohort might favor PCI in certain patients, despite the lower overall mortality and MACCE rates observed with CABG. In addition, even careful propensity-matching and multivariable Cox regression analysis cannot fully adjust for unmeasured confounders. Finally, it is possible that patients with PCI might have included patients with no surgical options who are likely to have high event rates and thereby augment the overall event rates in the PCI group. As such, a properly conducted RCT focusing on this high-risk group of patients is warranted.

Conclusions

In this contemporary large observational study, CABG was associated with improved early and late clinical outcomes compared with PCI using DES in patients with CKD undergoing index revascularization.

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Disclosures

Dr Džavík has received research and educational grants and speaker’s honoraria from Abbott Vascular and educational grants from St Jude Medical. The other authors report no conflicts.

References


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Table 1. Clinical outcomes and Kaplan-Meier analyses in patients with Stage 3 CKD (propensity-matched PCI and CABG cohorts)

A. Early and late clinical outcomes

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<th>PCI</th>
<th>CABG</th>
<th>p-value</th>
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<tr>
<td><strong>Propensity-matched</strong></td>
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<tr>
<td>Patients, n</td>
<td>873</td>
<td>849</td>
<td></td>
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<tr>
<td>Death, n (%)</td>
<td></td>
<td></td>
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<tr>
<td>30 days</td>
<td>40 (4.6%)</td>
<td>41 (4.8%)</td>
<td>0.81</td>
</tr>
<tr>
<td>1 year</td>
<td>91 (10.4%)</td>
<td>83 (9.8%)</td>
<td>0.66</td>
</tr>
<tr>
<td>Late</td>
<td>173 (19.8%)</td>
<td>129 (15.2%)</td>
<td><strong>0.01</strong></td>
</tr>
<tr>
<td>MACCE, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 days</td>
<td>143 (16.4%)</td>
<td>52 (6.1%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1 year</td>
<td>261 (29.9%)</td>
<td>109 (12.8%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Late</td>
<td>348 (39.9%)</td>
<td>163 (19.2%)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
B. Kaplan-Meier analysis for freedom from death and MACCE in patients with Stage 3 CKD (Creatinine Clearance 30-59 ml/min)

### Propensity-matched cohorts

<table>
<thead>
<tr>
<th></th>
<th>PCI</th>
<th>CABG</th>
<th>Log-Rank p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Death</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>89.4 ± 1.1%</td>
<td>90.1 ± 1.0%</td>
<td></td>
</tr>
<tr>
<td>2 year</td>
<td>83.2 ± 1.4%</td>
<td>85.7 ± 1.3%</td>
<td></td>
</tr>
<tr>
<td>3 year</td>
<td>73.8 ± 2.3%</td>
<td>81.2 ± 1.8%</td>
<td>0.0255</td>
</tr>
</tbody>
</table>

**MACCE**

<table>
<thead>
<tr>
<th></th>
<th>PCI</th>
<th>CABG</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>69.7 ± 1.6%</td>
<td>87.0 ± 1.2%</td>
<td></td>
</tr>
<tr>
<td>2 year</td>
<td>62.2 ± 1.8%</td>
<td>81.5 ± 1.5%</td>
<td></td>
</tr>
<tr>
<td>3 year</td>
<td>53.4 ± 2.3%</td>
<td>75.7 ± 2.0%</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Estimates are for freedom-from the event. Number of patients remaining at risk at 1, 2, 3 years for CABG (625, 356, 135) and PCI (637, 385, 106) for mortality. Number of patients remaining at risk at 1, 2, 3 years for CABG (604, 345, 115) and PCI (498, 289, 90) for MACCE. MACCE = death, MI, repeat revascularization or stroke.
Table 2. Clinical outcomes and Kaplan-Meier analyses in patients with Stage 4 CKD (propensity-matched PCI and CABG cohorts)

A. Early and late clinical outcomes

<table>
<thead>
<tr>
<th></th>
<th>PCI</th>
<th>CABG</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patients, n</strong></td>
<td>160</td>
<td>184</td>
<td></td>
</tr>
<tr>
<td><strong>Death, n (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 days</td>
<td>19  (11.9%)</td>
<td>18  (9.8%)</td>
<td>0.53</td>
</tr>
<tr>
<td>1 year</td>
<td>49  (30.6%)</td>
<td>36  (19.6%)</td>
<td><strong>0.02</strong></td>
</tr>
<tr>
<td>Late</td>
<td>79  (49.4%)</td>
<td>65  (35.3%)</td>
<td><strong>0.01</strong></td>
</tr>
<tr>
<td><strong>MACCE, n (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 days</td>
<td>40  (25.0%)</td>
<td>24  (13.0%)</td>
<td><strong>0.005</strong></td>
</tr>
<tr>
<td>1 year</td>
<td>80  (50.0%)</td>
<td>47  (25.5%)</td>
<td><strong>&lt;0.001</strong></td>
</tr>
<tr>
<td>Late</td>
<td>106 (66.3%)</td>
<td>72  (39.1%)</td>
<td><strong>&lt;0.001</strong></td>
</tr>
</tbody>
</table>
B. Kaplan-Meier analysis for freedom from death and MACCE in patients with Stage 4 CKD (Creatinine Clearance 15-29 ml/min)

Propensity-Matched

<table>
<thead>
<tr>
<th></th>
<th>PCI</th>
<th>CABG</th>
<th>Log-Rank P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>68.9 ± 3.7%</td>
<td>80.3 ± 3.0%</td>
<td></td>
</tr>
<tr>
<td>2 year</td>
<td>51.9 ± 4.4%</td>
<td>64.6 ± 4.2%</td>
<td></td>
</tr>
<tr>
<td>3 year</td>
<td>43.2 ± 5.3%</td>
<td>52.2 ± 5.3%</td>
<td>0.04</td>
</tr>
</tbody>
</table>

MACCE

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>49.4 ± 4.0%</td>
<td>74.2 ± 3.3%</td>
<td></td>
</tr>
<tr>
<td>2 year</td>
<td>33.5 ± 4.2%</td>
<td>59.4 ± 4.2%</td>
<td></td>
</tr>
<tr>
<td>3 year</td>
<td>26.9 ± 4.3%</td>
<td>47.9 ± 5.3%</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Number of patients remaining at risk at 1, 2, 3 years for CABG (125, 52, 25) and PCI (97, 47, 17) for mortality. Number of patients remaining at risk at 1, 2, 3 years for CABG (115, 47, 22) and PCI (72, 30, 18) for MACCE.