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Coronary Artery Bypass Surgery Versus Drug-Eluting Stent Implantation for Left Main or Multivessel Coronary Artery Disease

A Meta-Analysis of Individual Patient Data

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ABSTRACT

OBJECTIVES The authors undertook a patient-level meta-analysis to compare long-term outcomes after coronary artery bypass grafting (CABG) versus percutaneous coronary intervention (PCI) with drug-eluting stents (DES) in 3,280 patients with left main or multivessel coronary artery disease (CAD).

BACKGROUND The relative efficacy and safety of CABG versus PCI with DES for left main or multivessel CAD remain controversial.

METHODS Data were pooled from the BEST (Randomized Comparison of Coronary Artery Bypass Surgery and Everolimus Eluting Stent Implantation in the Treatment of Patients With Multivessel Coronary Artery Disease), PRECOMBAT (Premier of Randomized Comparison of Bypass Surgery vs. Angioplasty Using Sirolimus-Eluting Stent in Patients With Left Main Coronary Artery Disease), and SYNTAX (Synergy Between PCI With Taxus and Cardiac Surgery) trials. The primary outcome was a composite of all-cause death, myocardial infarction, or stroke.

RESULTS The median follow-up was 60 months, and follow-up was completed for 96.2% of patients. The rate of primary outcome was significantly lower with CABG than with PCI (13.0% vs. 16.0%; hazard ratio [HR]: 0.83; 95% confidence interval [CI]: 0.69 to 1.00; $p = 0.046$). The difference was mainly driven by reduction in myocardial infarction (HR: 0.46; 95% CI: 0.33 to 0.64; $p < 0.001$). There was significant interaction between treatment effect and types of CAD, showing CABG to be superior compared with PCI with DES in patients with multivessel CAD ($p = 0.001$), but no between-group difference in those with left main CAD ($p = 0.427$). The rates for all-cause death and stroke were similar between the 2 groups. By contrast, the need for repeat revascularization was significantly lower in the CABG group compared with the PCI group.

CONCLUSIONS CABG, as compared with PCI with DES, reduced long-term rates of the composite of all-cause death, myocardial infarction, or stroke in patients with left main or multivessel CAD. The advantage of CABG over PCI with DES was particularly pronounced in those with multivessel CAD. (J Am Coll Cardiol Intv 2016;9:2481–9)

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ABBREVIATIONS AND ACRONYMS

CABG = coronary bypass grafting

CAD = coronary artery disease

CI = confidence interval

DES = drug-eluting stent(s)

HR = hazard ratio

PCI = percutaneous coronary intervention

Percutaneous coronary intervention (PCI) is considered a reasonable alternative to coronary artery bypass surgery (CABG) for certain subsets of patients with left main or multivessel coronary artery disease (CAD) (1–3). However, the optimal treatment of such lesions remains challenging despite advances in both percutaneous and surgical revascularization strategies. In a collaborative analysis of 10 randomized trials comparing CABG with PCI, long-term mortality was similar after CABG and PCI in patients with multivessel CAD, but in favor of CABG in elderly patients or patients with diabetes (4). In these trials, balloon angioplasty or bare-metal stents were used in all patients, leading to more recurrent cardiovascular events.

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Drug-eluting stents (DES) have reduced the rates of repeat revascularization compared with bare-metal stents, and are now used as the mainstream device for PCI. Several randomized clinical trials have compared clinical outcomes of CABG versus PCI with DES in patients with left main or multivessel CAD (5–14). However, most of these trials are not large enough to resolve the uncertainties on optimal treatment for these diseases. Furthermore, limited data are available directly comparing the long-term outcomes of these 2 treatment strategies. A meta-analysis of individual patient data from carefully conducted randomized trials may provide more useful information to guide the revascularization strategy than any individual study (15). Such an analysis may have a greater power to assess the effects of a specific revascularization strategy on hard clinical outcomes and its separate effects among specific subgroups, providing robust evidence about the relative merits of CABG and contemporary PCI in these patient populations.

We performed a patient-level meta-analysis of 3 randomized clinical trials comparing CABG versus PCI with DES to investigate the effects of 2 treatment strategies on long-term cardiovascular outcomes in patients with left main or multivessel CAD.

METHODS

PATIENTS AND PROCEDURES. A published data search was performed from 2005 to 2015 of the Cochrane, Embase, and MEDLINE databases by using terms that included: "coronary artery bypass surgery," "drug-eluting stent," "left main," and "multivessel coronary artery disease." Seven randomized trials were found that met the criteria, and 4 trials with long-term outcomes (>3 years of follow-up) were identified (the BEST [Randomized Comparison of Coronary Artery Bypass Surgery and Everolimus Eluting Stent Implantation in the Treatment of Patients With Multivessel Coronary Artery Disease], FREEDOM [Comparison of Two Treatments for Multivessel Coronary Artery Disease in Individuals With Diabetes], PRECOMBAT [Premier of Randomized Comparison of Bypass Surgery vs. Angioplasty Using Sirolimus-Eluting Stent in Patients With Left Main Coronary Artery Disease], and SYNTAX [Synergy Between PCI With Taxus and Cardiac Surgery] trials) (5–10). We excluded 4 trials from the study: the FREEDOM study investigators did not participate in this collaborative analysis (10), and the CARDia (Coronary Artery Revascularization in Diabetes) trial used both DES and bare-metal stents (11), and 2 small trials had no long-term outcomes published (12,13). The designs, detailed entry criteria, and outcomes of individual trials had been reported previously (5–9).

DATABASE POOLING. The principal investigators in each trial (S.-J.P., P.W.S.) set up a protocol with the pre-specified outcomes and a common set of baseline variables. Individual patient data from each trial were sent for merging to the coordinating Asan Medical Center in Seoul, Korea. An independent clinical events committee blinded to randomization adjudicated all endpoints in each study. The pooled database was checked for completeness and consistency by responsible investigators in Asan Medical Center.

The merged database included demographics (age, sex, body weight, height), clinical history (chronic kidney disease, previous myocardial infarction, previous stroke, peripheral artery disease, previous PCI), risk factors (diabetes, hypercholesterolemia, hypertension, smoking), angiographic and echocardiographic findings (number of diseased

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vessels, left main coronary artery disease, proximal left anterior descending coronary artery disease, SYNTAX score, left ventricular dysfunction), revascularization strategies, medication history (aspirin, $P2Y_{12}$ inhibitors, statins), and clinical outcomes during follow-up (all-cause death, cardiac death, myocardial infarction, stroke, repeat revascularization). Unless specified, previously reported definitions from each study were used for variables.

STUDY OUTCOMES AND DEFINITIONS. The primary outcome was a composite of all-cause death, myocardial infarction, or stroke over all available follow-up. The secondary outcomes were death from any causes; death from cardiac causes; myocardial infarction; stroke; any coronary revascularization; a composite of all-cause death or myocardial infarction. Previously reported definitions from each study are used for individual clinical outcomes (5-9). Briefly, in the SYNTAX trial, myocardial infarction was defined as any myocardial infarction occurring after randomization, and its detailed definition was described elsewhere (5). In the BEST and PRECOMBAT trials (6,8), myocardial infarction was defined as new Q waves and increase in the creatine kinase-myocardial band (CK-MB) concentration to >5 times the upper limit of the normal range, if occurring within 48 h after the procedure, or as new Q waves or an increase in CK-MB concentration to greater than the upper limit of the normal range, plus ischemic symptoms or signs, if occurring more than 48 h after the procedure.

STATISTICAL ANALYSIS. All analyses were performed according to the intention-to-treat principle. The baseline variables were tabulated by treatment group for each study. The databases from 3 trials were combined for an overall pooled analysis, and time-to-event outcomes were displayed using Kaplan-Meier methodology, compared by the log-rank test. The stratified Cox proportional hazards survival model was used to analyze the impact of revascularization strategy on clinical outcomes and to determine whether merging of the data from 3 trials would influence the primary outcome. The treatment effect was estimated separately for each trial, and the estimates were combined to provide an overall estimate of the treatment effect. A likelihood-ratio test was performed to assess the homogeneity of the data and the assumption of homogeneity was not violated ($p = 0.17$). The proportional hazards assumption regarding the treatment assignments was confirmed by means of the Schoenfeld residuals test; no relevant violations of the assumption were found. In addition, we performed competing risk analysis for individual event using cause-specific analysis and Fine-Gray analysis. The first provides a direct measure of the association of revascularization strategy (CABG vs. PCI) with a single particular event (i.e., treats any competing events as censored at the time they occurred). The second considers as a single cause of death both the association of revascularization strategy with a single particular event and the contribution of another competing event by actively maintaining individuals in the risk sets (i.e., divides the probability of death into the probability corresponding to each competing event). Analyses were performed by an independent statistician who was unaware of the treatment assignments. All reported p values are 2-sided, and values of $p < 0.05$ were

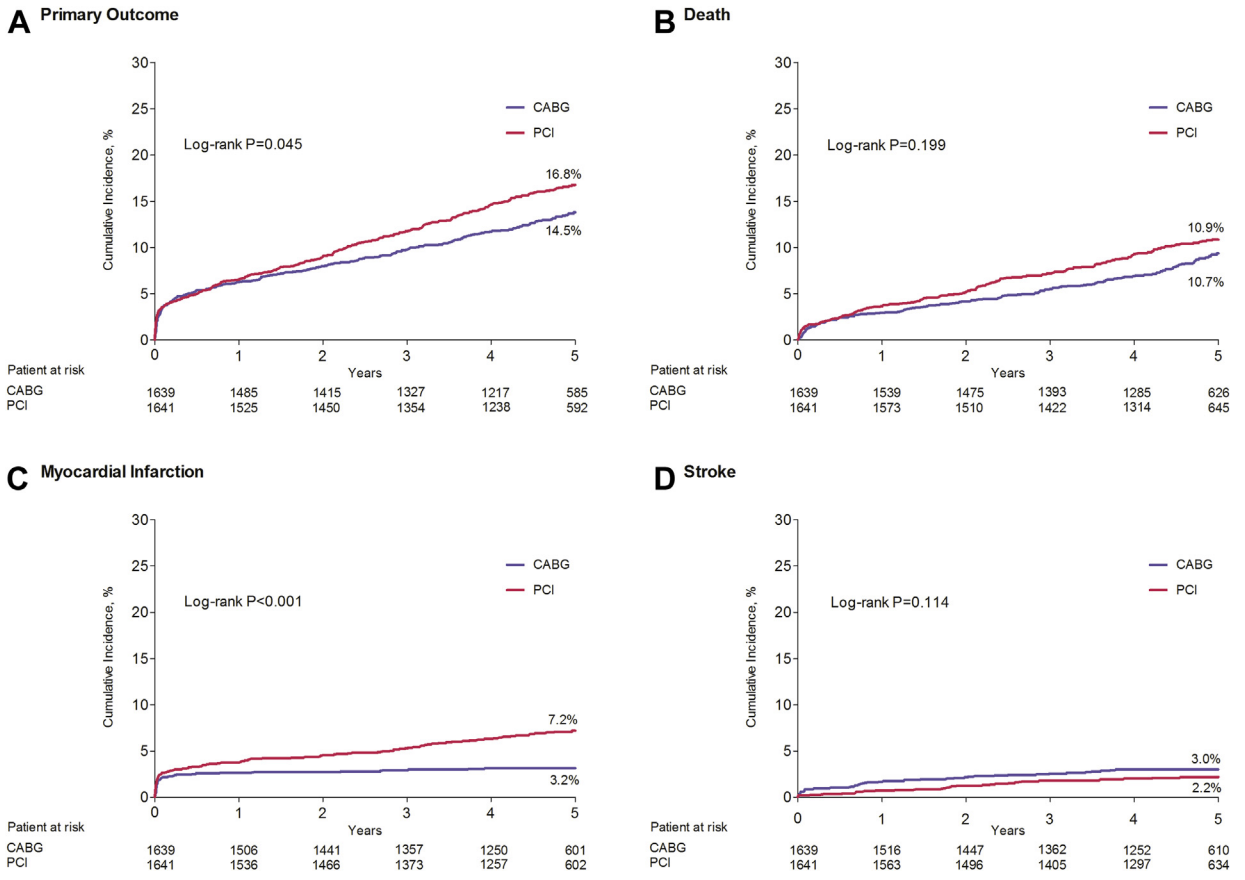
TABLE 1 Patient Characteristics

	All Patients (N = 3,280)	BEST (n = 880)	PRECOMBAT (n = 600)	SYNTAX (n = 1,800)
Age (yrs)	64.4 ± 9.7	64.5 ± 9.4	62.2 ± 9.7	65.1 ± 9.7
Male	2,486 (75.8)	629 (71.5)	459 (76.5)	1,398 (77.7)
Body mass index (kg/m^2)	26.5 ± 4.3	24.8 ± 2.9	24.6 ± 2.9	28.0 ± 4.7
Current smoker	712 (21.8)	177 (20.1)	172 (28.7)	363 (20.2)
Diabetes				
Any	1,066 (32.5)	363 (41.3)	192 (32.0)	511 (28.4)
Requiring insulin	239 (7.3)	38 (4.3)	19 (3.2)	182 (10.1)
Hypercholesterolemia	2,099 (64.3)	461 (52.4)	247 (41.2)	1,391 (77.9)
Hypertension	2,104 (65.1)	591 (67.2)	317 (52.8)	1,196 (66.4)
Clinical presentation				
Stable angina	1,998 (60.9)	414 (47.0)	297 (49.5)	1,287 (71.5)
ACS	1,282 (39.1)	466 (53.0)	303 (50.5)	513 (28.5)
Previous myocardial infarction	672 (20.6)	54 (6.1)	33 (5.5)	585 (32.9)
Previous stroke	148 (5.5)	70 (8.0)	—	78 (4.4)
Peripheral vascular disease	226 (6.9)	27 (3.1)	22 (3.7)	177 (9.8)
CKD	44 (1.3)	16 (1.8)	2 (0.3)	26 (1.4)
Left ventricular dysfunction*	134 (5.2)	30 (3.4)	25 (4.2)	79 (7.0)
Diseased vessels				
Proximal LAD disease	2,018 (61.5)	607 (69.0)	501 (83.5)	910 (50.6)
2-vessel	237 (7.2)	201 (22.8)	0 (0.0)	36 (2.0)
3-vessel	1,738 (53.0)	679 (77.2)	0 (0.0)	1,059 (58.8)
Left main	1,305 (39.8)			
Isolated	152 (4.6)	0 (0.0)	61 (10.2)	91 (5.1)
Plus 1-vessel	241 (7.3)	0 (0.0)	103 (17.2)	138 (7.7)
Plus 2-vessel	409 (12.5)	0 (0.0)	191 (31.8)	218 (12.1)
Plus 3-vessel	503 (15.3)	0 (0.0)	245 (40.8)	258 (14.3)
SYNTAX score	27.0 ± 10.5	24.8 ± 7.7	24.8 ± 10.3	28.8 ± 11.4
Number of stents in PCI	3.9 ± 2.1	3.4 ± 1.4	2.6 ± 1.4	4.6 ± 2.3
Number of arterial grafts	1.7 ± 0.8	2.0 ± 0.9	2.1 ± 0.9	1.4 ± 0.7
Follow-up (yrs)	4.4 ± 1.3	4.1 ± 1.4	4.6 ± 0.94	4.4 ± 1.4

Values are mean ± SD or n (%). *Left ventricular dysfunction defined as left ventricular ejection fraction <40% or moderate to severe left ventricular dysfunction.

ACS = acute coronary syndrome(s); BEST = Randomized Comparison of Coronary Artery Bypass Surgery and Everolimus Eluting Stent Implantation in the Treatment of Patients With Multivessel Coronary Artery Disease; CABG = coronary artery bypass graft surgery; CKD = chronic kidney disease (serum creatinine ≥200 μmol/l); LAD = left anterior descending coronary artery; PCI = percutaneous coronary intervention; PRECOMBAT = Premier of Randomized Comparison of Bypass Surgery vs. Angioplasty Using Sirolimus-Eluting Stent in Patients With Left Main Coronary Artery Disease; SYNTAX = Synergy Between PCI With Taxus and Cardiac Surgery.

FIGURE 1 Cumulative Risk of Clinical Outcomes Among the Overall Population



The cumulative incidences of the primary outcome of death from any causes, myocardial infarction, or stroke **(A)**, death from any causes **(B)**, myocardial infarction **(C)**, and stroke **(D)** are shown. The p values were calculated using the log-rank test with all available follow-up data. The percentages denote 5-year event rates. CABG = coronary artery bypass graft surgery; PCI = percutaneous coronary intervention.

considered to indicate statistical significance. Statistical analyses were performed with SAS software, version 9.1 (SAS Institute, Cary, North Carolina).

RESULTS

STUDY POPULATION. A total of 3,280 patients were randomized to CABG (n = 1,639) or PCI (n = 1,641). The baseline characteristics were largely similar across the trials and well balanced between the 2 groups (**Table 1**, Online Tables 1 and 2). However, there were differences in the extent of CAD in respective trials because of the different study designs. Likewise, PCI was done with previous DES in the PRECOMBAT and SYNTAX trials, whereas newer-generation DES was used in the BEST trial. The median age of the study population was 65 years (interquartile range [IQR]: 58 to 72 years), and 75.8% of patients were men. Patients were well treated with standard medications in the PCI group, which were less frequently used in the CABG group (Online Table 3). The median length of follow-up after randomization was 60 months (IQR: 48 to 61 months). Follow-up was completed for 96.2% of patients, and the remaining patients lost to follow-up were censored at the date of their last contact.

PRIMARY OUTCOME. The primary outcome of death from any causes, myocardial infarction, or stroke occurred in 213 patients (13.0%) in the CABG group and 262 (16.0%) in the PCI group (hazard ratio [HR]: 0.83; 95% confidence interval [CI]: 0.69 to 1.00; p = 0.046) (**Figure 1**, **Table 2**). The difference was mainly

associated with a reduction in the rate of myocardial infarction. The benefit of CABG was significant in patients with multivessel CAD (HR: 0.68; 95% CI: 0.53 to 0.86; p = 0.001), but not in those with left main CAD (HR: 1.12; 95% CI: 0.84 to 1.49; p = 0.427) (Figure 2). In addition, the relative difference became progressively greater with increased SYNTAX scores, which was statistically significant in patients with high SYNTAX scores (≥33) (Figure 2, Online Table 4).

SECONDARY OUTCOMES. Death from any causes occurred in 142 patients (8.7%) in the CABG group and 169 (10.3%) in the PCI group (HR: 0.86; 95% CI: 0.69 to 1.08; p = 0.199) (Figure 1, Table 2). In subgroup of patients with multivessel CAD, however, the rate of all-cause death was significantly lower in the CABG group compared with the PCI group (HR: 0.66; 95% CI: 0.49 to 0.89; p = 0.007). Myocardial infarction occurred in 50 patients (3.1%) in the CABG group and 110 patients (6.7%) in the PCI group (HR: 0.46; 95% CI: 0.33 to 0.64; p < 0.001) (Figure 1, Table 2). The difference was significant for patients with multivessel CAD (HR: 0.38; 95% CI: 0.25 to 0.58; p < 0.001), but not for those with left main CAD (HR: 0.64; 95% CI: 0.37 to 1.10; p = 0.108). Similar findings were observed for the composite outcome of all-cause death, or myocardial infarction. The stroke rate was numerically, but not significantly, higher with CABG (HR: 1.43; 95% CI: 0.92 to 2.24; p = 0.116) (Figure 1, Table 2). Conversely, the need for repeat revascularization was significantly lower among patients who had undergone CABG than among those who had undergone PCI with DES (HR: 0.49; 95% CI: 0.40 to 0.59; p < 0.001) (Table 2). In addition, we performed competing risk analysis, which showed consistent findings (Online Table 5).

SUBGROUP ANALYSIS. The superiority of CABG over PCI on the primary outcome was consistent across most major subgroups (Figure 3). There was no interaction for the primary outcome among the 3 trials (p = 0.499 for interaction). Likewise, we found no evidence of interaction between treatment effect and types of DES (p = 0.800 for interaction). However, there was a significant statistical interaction between treatment assignment and primary outcome for subgroup of patients with left main CAD (p = 0.009 for interaction).

TABLE 2 Overall Clinical Outcomes by Treatment Group

	CABG (N = 1,639)	PCI (N = 1,641)	Hazard Ratio (95% CI)	p Value
Primary outcome				
Death, MI, or stroke	213 (13.0)	262 (16.0)	0.83 (0.69-1.00)	0.046
Secondary outcomes				
Death from any causes	142 (8.7)	169 (10.3)	0.86 (0.69-1.08)	0.199
Death from cardiac causes	80 (4.9)	107 (6.5)	0.77 (0.57-1.02)	0.070
MI	50 (3.1)	110 (6.7)	0.46 (0.33-0.64)	<0.001
Stroke	46 (2.8)	33 (2.0)	1.43 (0.92-2.24)	0.116
Repeat revascularization	155 (9.5)	308 (18.8)	0.49 (0.40-0.59)	<0.001
Death, or MI	181 (11.0)	239 (14.6)	0.77 (0.63-0.93)	0.008

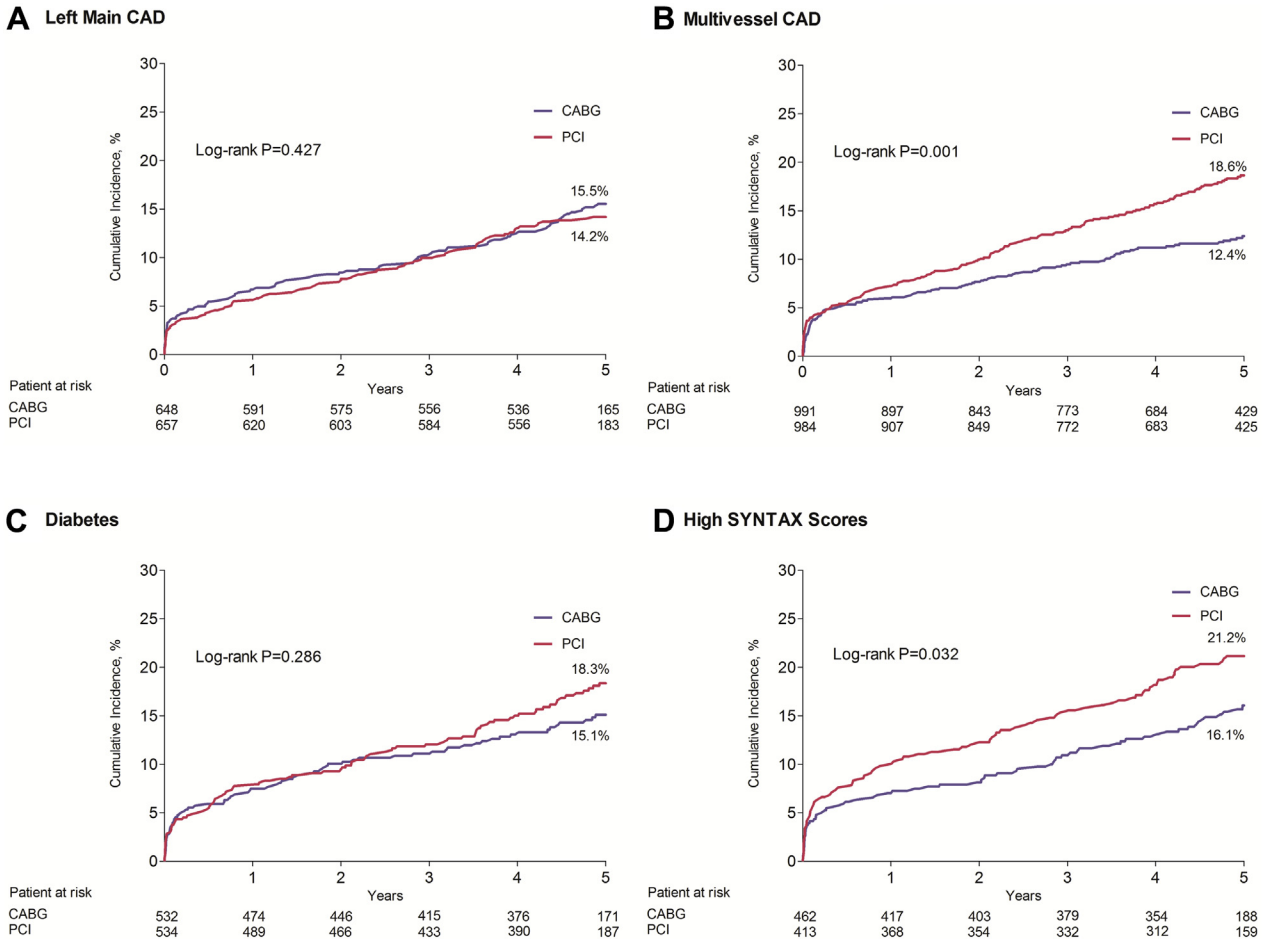
Values are n (%) unless otherwise indicated. The p values were calculated with all available follow-up data.
CI = confidence interval; MI = myocardial infarction; other abbreviations as in Table 1.

DISCUSSION

The major findings from this meta-analysis are that CABG, as compared with PCI with DES, significantly reduced the risk of all-cause death, myocardial infarction, or stroke in patients with left main or multivessel CAD. The advantage of CABG over PCI with DES was consistent in most major clinical subgroups, and it continued to accrue over time. In addition, the benefit of CABG was particularly pronounced in patients with multivessel CAD, but not significant in those with left main CAD.

A number of randomized trials have been conducted to compare CABG with PCI in patients with multivessel CAD. In the majority of these studies, CABG provides more effective angina relief and less need for repeat revascularization, but offered no survival benefit over PCI (16). These trials were performed before the DES era, and the risk difference of CABG versus PCI for repeat revascularization was high. During the past decade, PCI has seen significant changes in both procedural technique and equipment. DES are now routinely used for the treatment of left main or multivessel CAD. However, the optimal revascularization strategy for these patients still remains a topic of debate. Randomized clinical trials comparing CABG versus PCI with DES have not been typically powered to determine the difference of all-cause death, myocardial infarction, or stroke. In the present patient-level meta-analysis, we found that the risk of all-cause death, myocardial infarction, or stroke was significantly lower in the CABG group compared with the PCI group, with a median of 60 months of follow-up. The benefit of CABG over PCI with DES was mostly attributable to a statistically significant reduction in the risk of myocardial infarction. A significant interaction existed between treatment effect and types of CAD, showing that the primary outcome was in favor of CABG in patients with multivessel CAD, but not in those with left main CAD. In addition, the difference between CABG and PCI was significant in patients with high SYNTAX scores, supporting current guidelines that CABG is the

FIGURE 2 Cumulative Risk of Primary Outcome by Subgroup

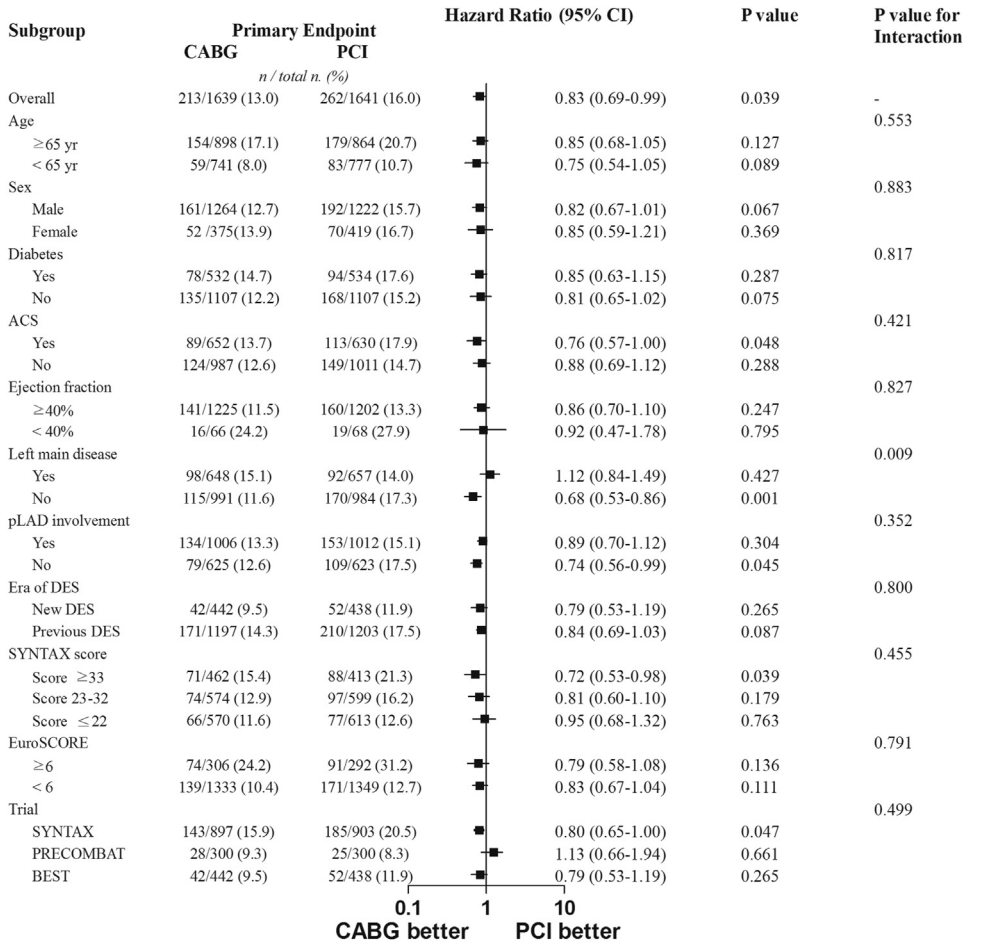


The cumulative incidences of the primary outcome of death from any causes, myocardial infarction, or stroke in patients with left main coronary artery disease **(A)**, multivessel coronary artery disease **(B)**, diabetes **(C)**, and high SYNTAX scores (≥33) **(D)** are shown. The p values were calculated using the log-rank test with all available follow-up data. The percentages denote 5-year event rates. CAD = coronary artery disease; other abbreviations as in Figure 1.

better option for patients with severe CAD (1-3). Three randomized trials using newer-generation DES (the EXCEL [EXCEL Clinical Trial; NCT01205776], the LeftMain NOBLE [Coronary Artery Bypass Grafting Vs Drug Eluting Stent Percutaneous Coronary Angioplasty in the Treatment of Unprotected Left Main Stenosis; NCT01496651], and the FAME 3 [A Comparison of Fractional Flow Reserve-Guided Percutaneous Coronary Intervention and Coronary Artery Bypass Graft Surgery in Patients With Multivessel Coronary Artery Disease; NCT02100722] trials) are ongoing. These trials may be expected to reinforce our findings about the relative merits of both strategies.

The rates of death from any causes were similar between the 2 groups, but lower in the CABG group compared with the PCI group in subgroup of patients with multivessel CAD. A meta-analysis of the trials in the pre-DES era showed that there was a survival advantage with CABG in patients with diabetes or age ≥65 years, whereas there was no advantage in other patients (4). The BARI (Bypass Angioplasty Revascularization Intervention) trial also demonstrated a lower mortality with CABG than with PCI in diabetic subgroups (17). Likewise, data from a large registry showed that the adjusted all-cause mortality at 4 years was lower by 4.4 percentage points with CABG than with PCI with DES in elderly patients (≥65 years) with multivessel CAD (18). Although there was the possibility of residual confounding, these findings support the survival benefit of CABG over PCI with DES for some patients with multivessel CAD. In the present study, CABG significantly

FIGURE 3 HR for Primary Outcome According to Subgroup



Subgroup analyses were performed using Cox proportional hazards regression. ACS = acute coronary syndrome(s); BEST = Randomized Comparison of Coronary Artery Bypass Surgery and Everolimus Eluting Stent Implantation in the Treatment of Patients With Multivessel Coronary Artery Disease; CI = confidence interval; DES = drug-eluting stents(s); HR = hazard ratio; pLAD = proximal left anterior descending coronary artery; PRECOMBAT = Premier of Randomized Comparison of Bypass Surgery vs. Angioplasty Using Sirolimus-Eluting Stent in Patients With Left Main Coronary Artery Disease; SYNTAX = Synergy Between PCI With Taxus and Cardiac Surgery; other abbreviations as in Figure 1.

reduced the risk for all-cause death in subgroup of patients with multivessel CAD, demonstrating that CABG, as compared with PCI with DES, is the preferred method of revascularization for patients with severe CAD.

The rate of myocardial infarction was remarkably lower after CABG than after PCI with DES in subgroup of patients with multivessel CAD, supporting that CABG reduces the risk of myocardial infarction more effectively than does focal therapy of PCI with DES. Recently, a large registry also showed that CABG versus PCI with newer-generation DES for the treatment of multivessel CAD was associated with a lower risk of myocardial infarction (19). Acute coronary occlusion leading to myocardial infarction tends to cluster within the proximal third of each coronary artery (20,21), and the myocardium below the occlusion might be protected by bypass graft. DES treat the focal area of culprit lesions, whereas CABG might bypass the vulnerable area of each coronary artery that could lead to myocardial infarction over time (22). In our study, however, there was no difference in all-cause death or myocardial infarction in subgroup of patients with left main CAD. This finding is in contrast to the result in those with multivessel CAD. The reasons for this difference remain

unknown, but it might be related to the extent and severity of CAD. The left main coronary artery is large and short, and the extent of left main CAD seems to be relatively focal. The target lesion events are related to the stented length and minimal stent area, whereas new lesion events to the burden of residual CAD. Patients with isolated left main or left main plus 1-vessel CAD have favorable outcomes after DES implantation compared with those with left main plus multivessel CAD (5,23). Conversely, the operative mortality is relatively higher among patients with left main versus non-left main CAD, which was shown to be an independent predictor of short-term and long-term mortality following CABG (24). For these reasons, patients with left main CAD may have a lower probability of cardiac events from the stented lesions as well as the new lesions, leading to comparable rates of all-cause death or myocardial infarction between CABG and PCI.

The early risk of stroke might be higher in the CABG group compared with the PCI group. However, the long-term risk of stroke is primarily related to risk factors, requiring life style modification and optimal medical therapy. In our study, CABG did not carry a higher risk of stroke than PCI with DES. The need for repeat revascularization was remarkably lower after CABG, indicating that the gap in repeat revascularization between CABG and PCI is still substantial even in the DES era. Taken together, CABG looks like a more attractive treatment option for patients with left main or multivessel CAD even in the DES era. However, the risk of perioperative stroke, and the inconvenience of the CABG needs to be carefully balanced with the late risk of myocardial infarction or repeat revascularization after PCI with DES.

STUDY LIMITATIONS. First, previous DES was used in the trials except the BEST trial. It remains controversial whether data from the previous DES trials are applicable to current practice. Although a better safety profile of newer-generation DES versus previous DES has been reported (25), several randomized trials have showed similar efficacy and safety outcomes between 2 types of DES (26–29). In the present analysis, similar findings were observed among the 3 trials with no interaction between previous and newer-generation DES. In addition, irrespective of stent types, neoatherosclerosis inside the stent occurs over time (30,31). Considering that it is a major substrate for late DES failure, CABG seems to maintain its superiority over PCI even in the era of newer-generation DES. Second, the present pooled analysis failed to include all randomized data including the FREEDOM trial, and it may have limited power to resolve small differences in mortality and stroke. In addition, the number of high-surgical-risk patients (EuroSCORE ≥6) was relatively small (18.2% of total patients), and our findings should be cautiously applied for these patients. Third, the definition of clinical outcomes was slightly different across trials. However, it will not influence the comparison between the 2 treatment strategies since they were randomized. Finally, antiplatelet agents and statins were less frequently used in the CABG group compared with the PCI group, which may be disadvantageous for the CABG group to protect against cardiovascular events. Nevertheless, CABG was better than PCI with DES in prevention of myocardial infarction.

CONCLUSIONS

CABG, as compared with PCI with DES, was associated with a lower risk of all-cause death, myocardial infarction, or stroke in patients with left main or multivessel CAD. Our findings may be helpful to guide the choice of revascularization strategy in patients with left main or multivessel CAD, supporting the current recommendation that CABG is the better option for patients with severe CAD.

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PERSPECTIVES

WHAT IS KNOWN? Both CABG and PCI with DES is an effective revascularization therapy for certain subsets of patients with left main or CAD.

WHAT IS NEW? CABG, as compared with PCI with DES, significantly reduced the risk of all-cause death, myocardial infarction, or stroke in patients with left main or multivessel CAD. The benefit of CABG was particularly pronounced in patients with multivessel CAD.

WHAT IS NEXT? Future research comparing CABG versus PCI with DES should incorporate optimal medical therapy and functional assessments of coronary lesions to guide appropriate revascularization.

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APPENDIX For supplemental tables, please see the online version of this article.