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1 **Left Main Revascularization with PCI or CABG in Patients with Chronic Kidney Disease:**  
2 **The EXCEL Trial**

3  
4 **Running Title:** Left Main Revascularization and Chronic Kidney Disease

5  
6 Gennaro Giustino, MD<sup>a,b</sup>, Roxana Mehran, MD<sup>a,b</sup>, Patrick W. Serruys, MD, PhD<sup>c</sup>, Joseph F. Sabik  
7 III, MD<sup>d</sup>, Milan Milojevic, MD, MSc<sup>e</sup>, Charles A. Simonton, MD<sup>f</sup>, John D. Puskas, MD<sup>g</sup>, David E.  
8 Kandzari, MD<sup>h</sup>, Marie-Claude Morice, MD<sup>i</sup>, David P. Taggart, MD<sup>j</sup>, Anthony H. Gershlick, MD<sup>k</sup>,  
9 Philippe Généreux, MD<sup>b,l,m</sup>, Zixuan Zhang, MS<sup>b</sup>, Thomas McAndrew, PhD<sup>b</sup>, Björn Redfors, MD,  
10 PhD<sup>b</sup>, Michael Ragosta III, MD<sup>n</sup>, Irving L. Kron, MD<sup>n</sup>, Ovidiu Dressler, MD<sup>b</sup>, Martin B. Leon,  
11 MD<sup>b,o</sup>, Stuart J. Pocock, PhD<sup>p</sup>, Ori Ben-Yehuda, MD<sup>b,o</sup>, Arie Pieter Kappetein, MD, PhD<sup>c</sup>, and  
12 Gregg W. Stone, MD<sup>b,o</sup>

13  
14 From <sup>a</sup>The Zena and Michael A. Wiener Cardiovascular Institute, Icahn School of Medicine at  
15 Mount Sinai, New York, New York; <sup>b</sup>Clinical Trials Center, Cardiovascular Research Foundation,  
16 New York, New York; <sup>c</sup>Imperial College of Science, Technology and Medicine, London, United  
17 Kingdom; <sup>d</sup>Department of Surgery, UH Cleveland Medical Center, Cleveland, Ohio; <sup>e</sup>Erasmus  
18 University Medical Center, Rotterdam, The Netherlands; <sup>f</sup>Abbott Vascular, Santa Clara, California;  
19 <sup>g</sup>Mount Sinai Heart at Mount Sinai St Luke's, New York, New York; <sup>h</sup>Piedmont Heart Institute,  
20 Atlanta, Georgia; <sup>i</sup>Ramsay Générale de Santé, Hopital Privé Jacques Cartier, Massy, France;  
21 <sup>j</sup>Department Cardiac Surgery, John Radcliffe Hospital, Oxford, United Kingdom; <sup>k</sup>University  
22 Hospitals of Leicester, Leicester, United Kingdom; <sup>l</sup>Gagnon Cardiovascular Institute, Morristown  
23 Medical Center, Morristown, New Jersey; <sup>m</sup>Hôpital du Sacré-Coeur de Montréal, Montréal,  
24 Québec, Canada; <sup>n</sup>Division of Cardiovascular Medicine, University of Virginia Health System,  
25 Charlottesville, Virginia; <sup>o</sup>New York-Presbyterian Hospital/Columbia University Medical Center,  
26 New York, New York; <sup>p</sup>London School of Hygiene and Tropical Medicine, London, United  
27 Kingdom

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1 **Twitter handle**

2 @GreggWStone

3 @g\_giustinoMD

4 @Drroxmehran

5

6 **Short tweet (Max 150 characters)**

7 Compared with CABG, PCI is associated with lower rates of adverse events at 30 days and similar  
8 outcomes at 3 years of follow-up in patients with left main disease and CKD.

9

10 **Corresponding Author**

11 Gregg W. Stone, MD

12 Columbia University Medical Center

13 Cardiovascular Research Foundation

14 1700 Broadway, 8th Floor

15 New York, NY 10019

16 tel: 646-434-4134

17 fax: 646-434-4715

18 e-mail: [gs2184@columbia.edu](mailto:gs2184@columbia.edu)

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## ABSTRACT

**BACKGROUND:** The optimal revascularization strategy for patients with left main coronary artery disease (LMCAD) and chronic kidney disease (CKD) remains unclear.

**OBJECTIVES:** We investigated the comparative effectiveness of percutaneous coronary intervention (PCI) versus coronary artery bypass graft (CABG) surgery in patients with LMCAD and low or intermediate anatomical complexity according to baseline renal function from the multicenter randomized EXCEL trial.

**METHODS:** CKD was defined as an estimated glomerular filtration rate (eGFR)  $<60$  mL/min/1.73 m<sup>2</sup> using the CKD-EPI equation. Acute renal failure (ARF) was defined as a serum creatinine increase of  $\geq 5.0$  mg/dL from baseline or a new requirement for dialysis. The primary composite endpoint was the composite of death, myocardial infarction (MI), or stroke at 3-year follow-up.

**RESULTS:** CKD was present in 361 of 1,869 randomized patients (19.3%) in whom baseline eGFR was available. Patients with CKD had higher 3-year rates of the primary endpoint compared to those without CKD (20.8% vs. 13.5%; hazard ratio [HR]: 1.60; 95% confidence interval [CI]: 1.22-2.09;  $p=0.0005$ ). ARF within 30 days occurred more commonly in patients with compared to those without CKD (5.0% vs. 0.8%,  $p<0.0001$ ), and was strongly associated with the 3-year risk of death, stroke or MI (50.7% vs. 14.4%; HR: 4.59; 95% CI: 2.73-7.73;  $p<0.0001$ ). ARF occurred less commonly after revascularization with PCI compared with CABG both in patients with CKD (2.3% vs. 7.7%; HR: 0.28; 95% CI: 0.09-0.87) and in those without CKD (0.3% vs. 1.3%; HR: 0.20; 95% CI: 0.04-0.90;  $p_{\text{interaction}}=0.71$ ). There were no significant differences in the rates of the primary composite endpoint after PCI and CABG in patients with CKD (23.4% vs. 18.1%; HR: 1.25; 95% CI: 0.79-1.98) and without CKD (13.4% vs. 13.5%; HR: 0.97; 95% CI: 0.73-1.27;  $p_{\text{interaction}}=0.38$ ).

**CONCLUSIONS:** Patients with CKD undergoing revascularization for LMCAD in the EXCEL trial had increased rates of ARF and reduced event-free survival. ARF occurred less frequently after PCI compared to CABG. Nonetheless, PCI and CABG resulted in non-significantly different rates of death, stroke or MI at 3 years in patients with and without CKD.

- 1 **KEYWORDS:** Left main; coronary artery disease; percutaneous coronary intervention; coronary
- 2 artery bypass grafting; chronic kidney disease

## CONDENSED ABSTRACT

1  
2 The optimal revascularization strategy for patients with obstructive left main coronary artery  
3 disease (LMCAD) and chronic kidney disease (CKD) remains unclear. We investigated the  
4 comparative effectiveness of percutaneous coronary intervention (PCI) with everolimus-eluting  
5 stents versus coronary artery bypass graft (CABG) surgery in patients with LMCAD and CKD from  
6 the randomized EXCEL trial. At 3 years, there were no significant differences in the rates of death,  
7 myocardial infarction, or stroke between PCI and CABG in patients with (23.4% vs. 18.1%; HR:  
8 1.25; 95% confidence interval [CI]: 0.79–1.98) or without CKD (13.4% vs. 13.5%; HR: 0.97; 95%  
9 CI: 0.73–1.27) ( $p_{\text{interaction}}=0.38$ ).

10

## ABBREVIATIONS AND ACRONYMS

- 1
- 2 ARF = acute renal failure
- 3 CABG = coronary artery bypass graft
- 4 CKD = chronic kidney disease
- 5 CrCl = creatinine clearance
- 6 EES = everolimus-eluting stents
- 7 eGFR = estimated glomerular filtration rate
- 8 LMCAD = left main coronary artery disease
- 9 MDRD = Modification of Diet in Renal Disease
- 10 PCI = percutaneous coronary intervention
- 11





1 Consensus among the members of the heart team for revascularization with either PCI or CABG  
2 was required. Clinical follow-up was performed at 1 month, 6 months, and 1 year and then annually  
3 through 5 years. At the time of the current analysis all patients have completed 3 years of follow-up.  
4 The investigation was approved by the ethics committee or institutional review board at each center,  
5 and all patients signed informed consent.

6 The primary endpoint was the composite of death from any cause, stroke, or myocardial  
7 infarction (MI) at 3 years. Major powered secondary endpoints included this composite rate at 30  
8 days, and death, stroke, MI, or ischemia-driven revascularization at 3 years. Additional secondary  
9 endpoints included the components of the primary endpoint, as well as revascularization, stent  
10 thrombosis, symptomatic graft occlusion, bleeding complications, and a pre-specified composite of  
11 major adverse events occurring within 30 days. These endpoint definitions are reported elsewhere  
12 (12). Study monitors collected source documents of all primary and secondary endpoint events for  
13 adjudication by an independent clinical events committee. The extent and complexity of CAD and  
14 the SYNTAX score were also assessed by an independent angiographic core laboratory.

15 The present study is a pre-specified subgroup analysis from the EXCEL trial comparing PCI  
16 and CABG in patients with and without CKD. CKD was defined as an estimated glomerular  
17 filtration rate (eGFR)  $<60 \text{ mL/min/1.73 m}^2$  (corresponding to CKD stage 3A, 3B, 4, or 5), using the  
18 CKD-EPI equation as per the National Kidney Foundation-Kidney Disease Outcomes Quality  
19 Initiative guidelines (Supplemental Appendix Table 1) (14,15). This equation is preferentially  
20 endorsed by consensus guidelines as superior to other equations to discriminate between patients  
21 with versus without renal dysfunction and to predict adverse events in patients with CKD (16,17).  
22 ARF was defined in the protocol as a serum creatinine increase by  $\geq 5.0 \text{ mg/dL}$  from baseline or  
23 new requirement for dialysis (including hemodialysis, continuous veno-venous hemofiltration or  
24 peritoneal dialysis).

25



1 EPI, MDRD, and Cockcroft-Gault equations was  $77.2 \pm 19.1$  mL/min/ $1.73 \text{ m}^2$ ,  $81.5 \pm 22.8$   
2 mL/min/ $1.73 \text{ m}^2$ , and  $89.5 \pm 32.4$  mL/min in all patients, and  $48.6 \pm 9.9$  mL/min/ $1.73 \text{ m}^2$ ,  $49.2 \pm 9.7$   
3 mL/min/ $1.73 \text{ m}^2$ , and  $47.8 \pm 9.6$  mL/min in patients with CKD, respectively. The distribution of  
4 baseline eGFR using the CKD-EPI equation is illustrated in Figure 1. Only 3/361 enrolled patients  
5 with CKD at baseline were on dialysis (0.8%).

6 Baseline characteristics in patients with and without CKD estimated with the CKD-EPI  
7 equation are reported in Table 1. Patients with CKD were older, were more commonly female and  
8 had more comorbidities. Patients with CKD were also more likely to have a history of prior MI,  
9 atrial fibrillation, valvular heart disease, and lower left ventricular ejection fraction. Baseline  
10 angiographic characteristics and procedural characteristics with PCI or CABG are reported in Table  
11 2. There were no significant differences in site-reported or core laboratory-assessed SYNTAX  
12 scores between patients with and without CKD; however, patients with CKD were more likely to  
13 have diffuse or small vessel disease. There were no significant differences in the number of non-left  
14 main stented or bypassed vessels in patients with and without CKD (Table 2). Medication use at  
15 discharge and through 3 years in patients with and without CKD were similar, except for greater use  
16 of chronic oral anticoagulants in those with CKD (Supplemental Appendix Table 2).

17 **Effect of CKD on outcomes.** Patients with compared to those without CKD had higher  
18 rates of 30-day composite major adverse events, including more frequent blood transfusions, major  
19 arrhythmias, infections, sternal wound dehiscence, and unplanned surgical and radiologic  
20 procedures (Supplemental Appendix Table 3). In addition, the rate of ARF was ~6 times greater in  
21 patients with CKD compared to those without (5.0% vs. 0.8%,  $p < 0.0001$ ). The 3-year primary  
22 composite endpoint of death, stroke, or MI was increased in patients with compared to those  
23 without CKD (Figure 2; 20.8% vs. 13.5%; hazard ratio: 1.60; 95% CI: 1.22-2.09;  $p = 0.0005$ ), driven  
24 by greater cardiac and non-cardiac mortality (Table 3). The rates of adverse outcomes incrementally  
25 increased as renal function worsened from eGFR  $> 60$  mL/min/ $1.73 \text{ m}^2$  (no CKD) to eGFR 45 to 60  
26 mL/min/ $1.73 \text{ m}^2$  (Stage 3A CKD) to eGFR  $< 45$  mL/min/ $1.73 \text{ m}^2$  (Stage 3B, 4, or 5 CKD)

1 (Supplemental Appendix Table 4). When modeled as a continuous variable, progressively lower  
2 eGFR was associated with a steadily greater 3-year risk of death, stroke, or MI (HR per 10  
3 mL/min/1.73 m<sup>2</sup> decrease: 1.09; 95% CI: 1.03-1.15; p=0.004) and all-cause death (HR per 10  
4 mL/min/1.73 m<sup>2</sup> decrease: 1.23; 95% CI: 1.14-1.34; p<0.0001) (Figure 3A and 3B). Results were  
5 consistent using the MDRD and the Cockcroft-Gault equations (Supplemental Appendix Tables 5  
6 and 6).

7 **PCI versus CABG in patients with and without CKD.** PCI was associated with lower 30-  
8 day rates of major adverse events compared with CABG, in patients with and without CKD (Table  
9 4). PCI was also associated with shorter in-hospital stay compared with CABG both in patients with  
10 CKD (6.7±7.0 vs. 16.1±15.2; p<0.0001) and without CKD (5.2±4.7 vs. 11.9±7.4; p<0.0001). At 30  
11 days, PCI compared with CABG resulted in lower rates of the composite endpoint of death, MI, or  
12 stroke both in patients with CKD (6.2% vs. 9.3%, HR: 0.68; 95% CI: 0.32-1.45) and without CKD  
13 (4.5% vs. 7.4%, HR: 0.61; 95% CI: 0.40-0.93) (p<sub>interaction</sub>=0.80). At 3 years (Figure 4), there were no  
14 significant differences in the rates of the primary composite endpoint of death, MI, or stroke after  
15 PCI versus CABG, an effect that was consistent in patients with and without CKD (p<sub>interaction</sub>=0.36)  
16 (Table 5). The 3-year relative rates of the components of the primary endpoint, as well as  
17 revascularization and bleeding after PCI versus CABG were also consistent in patients with and  
18 without CKD (Table 5). CABG was associated with less ischemia-driven revascularization during  
19 follow-up, the risk of which was consistent across varying levels of baseline renal function  
20 (Supplemental Appendix Table 7). In the CKD group, 3-year mortality was increased after PCI  
21 compared with CABG, due to greater non-cardiac deaths, specifically due to sepsis (5.4% vs. 1.1%;  
22 p=0.02), which occurred more than 30 days post procedure. There was no significant difference in  
23 cardiac mortality after PCI vs. CABG either in patients with or without CKD. The comparative  
24 effectiveness of PCI versus CABG on the risk of death, MI, or stroke at 30 days and 3 years was  
25 consistent across varying definitions of CKD (Figure 5).



1 function. Finally, the impact of CKD, and the comparative outcomes of PCI versus CABG in  
2 patients with and without CKD were consistent irrespective of definition of renal dysfunction.

3 Evidence from prior randomized trials to inform revascularization decisions in patients with  
4 CKD is scarce, especially in LMCAD. Among diabetic patients with CKD and non-LM multivessel  
5 disease enrolled in the Future Revascularization Evaluation in Patients with Diabetes Mellitus:  
6 Optimal Management of Multivessel Disease (FREEDOM) trial, CABG compared with PCI with  
7 paclitaxel-eluting stents resulted in a 27% relative risk reduction in major adverse cardiovascular  
8 and cerebrovascular events (MACCE) at a median follow-up of 3.8 years (7). Among CKD patients  
9 with non-LM multivessel disease enrolled in the New York State outcomes registries, PCI with EES  
10 was associated with lower rates of MACCE at 30 days than CABG, but higher rates of MI and  
11 repeat revascularization at 4 years, with similar rates of death (19). In a pooled analysis from the  
12 Bypass Surgery Versus Angioplasty Using Sirolimus-Eluting Stent in Patients With Left Main  
13 Coronary Artery Disease (PRECOMBAT) and SYNTAX trials, PCI with first-generation  
14 paclitaxel-eluting and sirolimus-eluting stents was associated with comparable 5-year rates of  
15 MACCE and death compared with CABG in patients with LMCAD with and without CKD, without  
16 significant interaction (20).

17 The present large-scale study in which contemporary DES and revascularization techniques  
18 were used confirms and extends these prior findings to patients with LMCAD. Patients with CKD  
19 constituted ~25% of the EXCEL trial population, in whom the mean eGFR was  $48.5 \pm 9.9$   
20 mL/min/1.73 m<sup>2</sup>, representing moderately severe CKD. PCI with EES in patients with LMCAD  
21 reduced 30-day periprocedural adverse events and the 30-day composite rate of death, stroke, or MI  
22 consistently in both CKD and non-CKD cohorts. Specifically, PCI resulted in reduced bleeding,  
23 need for transfusions, arrhythmias, and less ARF (including the need for dialysis) compared with  
24 CABG in patients with CKD, adverse events which have been associated with long-term mortality  
25 (21-27). In this regard, ARF in the EXCEL trial was defined as an increase in serum creatinine  $\geq 5$   
26 mg/dL or a new requirement for dialysis, corresponding to acute kidney injury of stage III or greater

1 in the most recent Kidney Disease: Improving Global Outcomes (KDIGO) classification (28). ARF  
2 as so defined was strongly associated with worse outcomes over 3 years of follow-up. The reduced  
3 rate of ARF after PCI compared with CABG in both the CKD and non-CKD cohorts is one factor  
4 that should be considered when deciding between revascularization strategies to avoid further declines  
5 in renal function in patients with CKD. However, the composite 3-year primary endpoint rate of  
6 death, MI, or stroke was similar after PCI and CABG, a finding that was consistent in patients with  
7 and without CKD. The lower rates of MI and revascularization during the follow-up period after  
8 CABG compared to PCI as initially described in EXCEL (7) may have offset the deleterious effects  
9 of ARF and surgical complications in the CKD cohort.

10 Renal dysfunction has been associated with late DES failure (29-31). Nonetheless, the 3-year  
11 rates of definite EES thrombosis were lower than the rates of symptomatic graft occlusion in  
12 patients with and without CKD, and ischemia-driven revascularization after EES within 3 years was  
13 required in only 10.9% of patients with CKD compared to 13.0% of patients without CKD. These  
14 observations demonstrate that the anti-thrombotic and anti-restenotic properties of EES are  
15 preserved in higher-risk CKD patients and lesions (32,33). It thus follows that improved chronic  
16 medical therapy regimens are required to slow progressive atherosclerosis if the long-term  
17 prognosis of high-risk CKD patients is to be improved after PCI (and CABG). Toward this end  
18 insights may be gained from the ongoing International Study of Comparative Health Effectiveness  
19 With Medical and Invasive Approaches–Chronic Kidney Disease (ISCHEMIA-CKD) trial  
20 [NCT01985360] in which patients with stable ischemic heart disease and advanced CKD  
21 (eGFR<30 mL/min/1.73 m<sup>2</sup> or dialysis) are being assigned to an invasive revascularization strategy  
22 versus initial medical management.

23 **Limitations.** First, although the present study was pre-specified, the CKD and non-CKD  
24 subgroups were not individually powered to draw definitive conclusions as to whether PCI or  
25 CABG should be favored. Randomization was not stratified by renal function, and the role of  
26 unmeasured confounders cannot be excluded. Our findings should thus be considered hypothesis-

1 generating. Second, while some patients with severe CKD were included, the majority had  
2 moderate renal impairment. Therefore, our findings cannot be extrapolated to a severe CKD and  
3 end-stage renal disease population. Third, EXCEL enrolled patients with LMCAD and site-assessed  
4 low and intermediate anatomical complexity. Our findings therefore do not apply to patients with  
5 CAD and extreme anatomic complexity. Nonetheless, the mean core laboratory-assessed SYNTAX  
6 score in the EXCEL trial of 26.5 was roughly comparable to that from the FREEDOM trial (mean  
7 26.2) and the SYNTAX trial (mean 28.8), implying that the present results may inform outcomes in  
8 patients with more extensive CAD. Finally, follow-up in EXCEL is complete through only 3 years.  
9 Longer-term follow-up (currently planned for 5 years) is required to determine whether additional  
10 late differences between PCI and CABG emerge.

11 **Conclusions.** In patients with LMCAD and site-assessed low or intermediate SYNTAX  
12 scores undergoing revascularization, the presence of CKD was associated with a substantially  
13 greater risk of periprocedural adverse events and mortality during 3-year follow-up. Although PCI  
14 with EES was associated with significantly lower 30-day rates of ARF and major adverse events  
15 compared with CABG, there were no significant differences between the revascularization  
16 modalities for the primary composite endpoint or components of death, MI, or stroke at 3 years,  
17 with no interaction according to baseline CKD status. Both PCI and CABG are thus acceptable  
18 revascularization approaches in selected high-risk patients with LMCAD and CKD. Individual  
19 patient comorbidities, the likelihood to safely obtain complete revascularization, and patient  
20 preferences as to the early benefits of PCI versus the late benefits of CABG should thus be factored  
21 into the heart team decision-making process in high-risk patients with LMCAD and CKD.

22



1 **CLINICAL PERSPECTIVES**

- 2 • **Competency in Medical Knowledge (1):** Patients with CKD and LMCAD undergoing  
3 revascularization are at substantially greater risk for ARF, periprocedural adverse events,  
4 and mortality over 3 years of follow-up.
- 5 • **Competency in Medical Knowledge (2):** PCI with EES in patients with CKD and LMCAD  
6 with site-assessed low or intermediate anatomical complexity is associated with lower rates  
7 of 30-day adverse events including ARF, major bleeding, and arrhythmias compared with  
8 CABG. Over 3 years of follow-up, PCI and CABG resulted in comparable rates of death,  
9 MI, or stroke, irrespective of baseline renal function.
- 10 • **Competency in Patient Care:** Both PCI and CABG are acceptable revascularization  
11 strategies for high-risk patients with CKD and LMCAD. Individual patient comorbidities,  
12 patient preferences, and the early benefits of PCI versus the late benefits of CABG should be  
13 taken into account by the heart team when deciding between the two revascularization  
14 strategies.
- 15 • **Translational Outlook:** Improved chronic medical therapy regimens are required to slow  
16 progressive atherosclerosis if the long-term prognosis of high-risk CKD patients is to be  
17 improved after PCI and CABG.

18

## 1   **REFERENCES**

- 2   1.    Go AS, Chertow GM, Fan D, McCulloch CE, Hsu CY. Chronic kidney disease and the risks  
3       of death, cardiovascular events, and hospitalization. *The New England journal of medicine*  
4       2004;351:1296-305.
- 5   2.    Mathew RO, Bangalore S, Lavelle MP et al. Diagnosis and management of atherosclerotic  
6       cardiovascular disease in chronic kidney disease: a review. *Kidney Int* 2017;91:797-807.
- 7   3.    Bangalore S. Diagnostic, Therapeutic, and Clinical Trial Conundrum of Patients With  
8       Chronic Kidney Disease. *JACC Cardiovasc Interv* 2016;9:2110-2112.
- 9   4.    Volodarskiy A, Kumar S, Amin S, Bangalore S. Optimal Treatment Strategies in Patients  
10      with Chronic Kidney Disease and Coronary Artery Disease. *Am J Med* 2016;129:1288-  
11      1298.
- 12  5.    Mehran R, Aymong ED, Nikolsky E et al. A simple risk score for prediction of contrast-  
13      induced nephropathy after percutaneous coronary intervention: development and initial  
14      validation. *J Am Coll Cardiol* 2004;44:1393-9.
- 15  6.    Giustino G, Baber U, Mastoris I et al. One-year results of the ICON (Ionic versus non-ionic  
16      Contrast to Obviate worsening Nephropathy after angioplasty in chronic renal failure  
17      patients) Study. *Catheter Cardiovasc Interv* 2016;87:703-9.
- 18  7.    Baber U, Farkouh ME, Arbel Y et al. Comparative efficacy of coronary artery bypass  
19      surgery vs. percutaneous coronary intervention in patients with diabetes and multivessel  
20      coronary artery disease with or without chronic kidney disease. *Eur Heart J* 2016;37:3440-  
21      3447.
- 22  8.    Cavalcante R, Sotomi Y, Lee CW et al. Outcomes After Percutaneous Coronary  
23      Intervention or Bypass Surgery in Patients With Unprotected Left Main Disease. *J Am Coll*  
24      *Cardiol* 2016;68:999-1009.
- 25  9.    Piccolo R, Giustino G, Mehran R, Windecker S. Stable coronary artery disease:  
26      revascularisation and invasive strategies. *Lancet* 2015;386:702-13.

- 1 10. Giustino G, Mehran R. PCI and CABG surgery in 2014: CABG surgery versus PCI in CAD-  
2 -surgery strikes again! *Nat Rev Cardiol* 2015;12:75-7.
- 3 11. Milojevic M, Head SJ, Mack MJ et al. The impact of chronic kidney disease on outcomes  
4 following percutaneous coronary interventions versus coronary artery bypass grafting in  
5 patients with complex coronary artery disease: 5-year follow-up of the SYNTAX trial.  
6 *EuroIntervention* 2017.
- 7 12. Stone GW, Sabik JF, Serruys PW et al. Everolimus-Eluting Stents or Bypass Surgery for  
8 Left Main Coronary Artery Disease. *The New England journal of medicine* 2016;375:2223-  
9 2235.
- 10 13. Kappetein AP, Serruys PW, Sabik JF et al. Design and rationale for a randomised  
11 comparison of everolimus-eluting stents and coronary artery bypass graft surgery in selected  
12 patients with left main coronary artery disease: the EXCEL trial. *EuroIntervention*  
13 2016;12:861-72.
- 14 14. Levey AS, Stevens LA, Schmid CH et al. A new equation to estimate glomerular filtration  
15 rate. *Ann Intern Med* 2009;150:604-12.
- 16 15. Stevens PE, Levin A, Kidney Disease: Improving Global Outcomes Chronic Kidney  
17 Disease Guideline Development Work Group M. Evaluation and management of chronic  
18 kidney disease: synopsis of the kidney disease: improving global outcomes 2012 clinical  
19 practice guideline. *Ann Intern Med* 2013;158:825-30.
- 20 16. Parsh J, Seth M, Aronow H et al. Choice of Estimated Glomerular Filtration Rate Equation  
21 Impacts Drug-Dosing Recommendations and Risk Stratification in Patients With Chronic  
22 Kidney Disease Undergoing Percutaneous Coronary Interventions. *Journal of the American*  
23 *College of Cardiology* 2015;65:2714-23.
- 24 17. Levey AS, Stevens LA. Estimating GFR using the CKD Epidemiology Collaboration  
25 (CKD-EPI) creatinine equation: more accurate GFR estimates, lower CKD prevalence  
26 estimates, and better risk predictions. *Am J Kidney Dis* 2010;55:622-7.

- 1 18. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine.  
2 Nephron 1976;16:31-41.
- 3 19. Bangalore S, Guo Y, Samadashvili Z, Blecker S, Xu J, Hannan EL. Revascularization in  
4 Patients With Multivessel Coronary Artery Disease and Chronic Kidney Disease:  
5 Everolimus-Eluting Stents Versus Coronary Artery Bypass Graft Surgery. J Am Coll  
6 Cardiol 2015;66:1209-1220.
- 7 20. Cavalcante R, Sotomi Y, Lee CW et al. Outcomes After Percutaneous Coronary  
8 Intervention or Bypass Surgery in Patients With Unprotected Left Main Disease. J Am Coll  
9 Cardiol 2016;68:999-1009.
- 10 21. Mehran R, Pocock SJ, Nikolsky E et al. A risk score to predict bleeding in patients with  
11 acute coronary syndromes. J Am Coll Cardiol 2010;55:2556-66.
- 12 22. Filardo G, Hamilton C, Hebler RF, Jr., Hamman B, Grayburn P. New-onset postoperative  
13 atrial fibrillation after isolated coronary artery bypass graft surgery and long-term survival.  
14 Circ Cardiovasc Qual Outcomes 2009;2:164-9.
- 15 23. Warren J, Mehran R, Baber U et al. Incidence and impact of acute kidney injury in patients  
16 with acute coronary syndromes treated with coronary artery bypass grafting: Insights from  
17 the Harmonizing Outcomes With Revascularization and Stents in Acute Myocardial  
18 Infarction (HORIZONS-AMI) and Acute Catheterization and Urgent Intervention Triage  
19 Strategy (ACUITY) trials. Am Heart J 2016;171:40-7.
- 20 24. Giacoppo D, Madhavan MV, Baber U et al. Impact of Contrast-Induced Acute Kidney  
21 Injury After Percutaneous Coronary Intervention on Short- and Long-Term Outcomes:  
22 Pooled Analysis From the HORIZONS-AMI and ACUITY Trials. Circ Cardiovasc Interv  
23 2015;8:e002475.
- 24 25. Genereux P, Giustino G, Witzenbichler B et al. Incidence, Predictors, and Impact of Post-  
25 Discharge Bleeding After Percutaneous Coronary Intervention. J Am Coll Cardiol  
26 2015;66:1036-45.

- 1 26. Baber U, Dangas G, Chandrasekhar J et al. Time-Dependent Associations Between  
2 Actionable Bleeding, Coronary Thrombotic Events, and Mortality Following Percutaneous  
3 Coronary Intervention: Results From the PARIS Registry. *JACC Cardiovasc Interv*  
4 2016;9:1349-57.
- 5 27. Baber U, Mehran R, Giustino G et al. Coronary Thrombosis and Major Bleeding After PCI  
6 With Drug-Eluting Stents: Risk Scores From PARIS. *J Am Coll Cardiol* 2016;67:2224-34.
- 7 28. Section 2: AKI Definition. *Kidney Int Suppl* (2011) 2012;2:19-36.
- 8 29. Lee JM, Kang J, Lee E et al. Chronic Kidney Disease in the Second-Generation Drug-  
9 Eluting Stent Era: Pooled Analysis of the Korean Multicenter Drug-Eluting Stent Registry.  
10 *JACC Cardiovasc Interv* 2016;9:2097-2109.
- 11 30. Lu R, Tang F, Zhang Y et al. Comparison of Drug-Eluting and Bare Metal Stents in Patients  
12 With Chronic Kidney Disease: An Updated Systematic Review and Meta-Analysis. *J Am*  
13 *Heart Assoc* 2016;5.
- 14 31. Baber U, Giustino G, Sartori S et al. Effect of Chronic Kidney Disease in Women  
15 Undergoing Percutaneous Coronary Intervention With Drug-Eluting Stents: A Patient-Level  
16 Pooled Analysis of Randomized Controlled Trials. *JACC Cardiovasc Interv* 2016;9:28-38.
- 17 32. Chieffo A, Tanaka A, Giustino G et al. The DELTA 2 Registry: A Multicenter Registry  
18 Evaluating Percutaneous Coronary Intervention With New-Generation Drug-Eluting Stents  
19 in Patients With Obstructive Left Main Coronary Artery Disease. *JACC Cardiovasc Interv*  
20 2017;10:2401-2410.
- 21 33. Giustino G, Baber U, Aquino M et al. Safety and Efficacy of New-Generation Drug-Eluting  
22 Stents in Women Undergoing Complex Percutaneous Coronary Artery Revascularization:  
23 From the WIN-DES Collaborative Patient-Level Pooled Analysis. *JACC Cardiovasc Interv*  
24 2016;9:674-84.

25

## FIGURE LEGENDS

### **FIGURE 1. Distribution of the Estimated Glomerular Filtration Rate in the EXCEL Trial Population Using The CKD-EPI Equation.**

The left y-axis refers to the histogram of the number of patients with estimated glomerular filtration rate (eGFR) per 5 mL/min/1.73 m<sup>2</sup> increments. The right y-axis refers to the cumulative frequency distribution curve of eGFR values. The median [25%, 75%] eGFR was 79.2 [64.0, 91.3] mL/min/1.73 m<sup>2</sup> and the mean ± SD eGFR was 77.2±19.1 mL/min/1.73 m<sup>2</sup> (range 6.5–139.2 mL/min/1.73 m<sup>2</sup>).

### **FIGURE 2. Three-Year Outcomes in Patients With Versus Without Chronic Kidney Disease.**

Kaplan-Meier time-to-first event curves for death, myocardial infarction, or stroke during 3 years of follow-up in patients with and without chronic kidney disease (CKD). CI = confidence interval; GFR = glomerular filtration rate; HR = hazard ratio.

### **FIGURE 3. Risk of Adverse Events According to Baseline Renal Function.**

Smooth hazard function for the risk of (A) death, myocardial infarction, or stroke, and (B) death at 3 years according to baseline renal function estimated with the CKD-EPI equation. CABG = coronary artery bypass grafting; CI = confidence interval; eGFR = estimated glomerular filtration rate; PCI = percutaneous coronary intervention.

### **FIGURE 4. Three-Year Outcomes in with PCI Versus CABG in Patients With or Without Chronic Kidney Disease.**

Kaplan-Meier time-to-first event curves for death, myocardial infarction, or stroke during 3 years of follow-up according to randomized treatment with percutaneous coronary intervention (PCI) versus coronary artery bypass grafting (CABG) in patients with and without CKD. CI = confidence interval; GFR = glomerular filtration rate; HR = hazard ratio.

1 **FIGURE 5. Thirty-Day and Three-Year Outcomes for Percutaneous Coronary Intervention**  
2 **Versus Coronary Artery Bypass Grafting Using Alternative Chronic Kidney Disease**  
3 **Equations.**

4 CABG = coronary artery bypass grafting; CKD = chronic kidney disease; CKD-EPI = CKD  
5 Epidemiology Collaboration; CrCl = creatinine clearance; MDRD = Modification of Diet in Renal  
6 Disease; MI = myocardial infarction; PCI = percutaneous coronary intervention.

7

8 **CENTRAL ILLUSTRATION. Risk and Benefits of Percutaneous Coronary Intervention**  
9 **Versus Coronary Artery Bypass Graft Surgery in Patients With Chronic Kidney Disease and**  
10 **Left Main Coronary Artery Disease With Site-Assessed Low or Intermediate SYNTAX**  
11 **Scores.**

12 ARF = Acute Renal Failure; CABG = coronary artery bypass grafting; MI = myocardial infarction;  
13 PCI = percutaneous coronary intervention.

14

1 **TABLE 1. Baseline Characteristics.**

	<b>Chronic Kidney Disease (n = 361)</b>	<b>No Chronic Kidney Disease (n = 1508)</b>	<b>p-value</b>
Age, years	72.7 ± 7.8	64.3 ± 9.2	<0.0001
Male sex	239/361 (66.2%)	1200/1508 (79.6%)	<0.0001
Medical history			
Hypertension	306/361 (84.8%)	1073/1508 (71.2%)	<0.0001
Hyperlipidemia	266/360 (73.9%)	1038/1506 (68.9%)	<0.0001
Current smoker	44/359 (12.3%)	365/1497 (24.4%)	<0.0001
Prior stroke or transient ischemic attack	37/361 (10.2%)	80/1507 (5.3%)	0.0005
Congestive heart failure	43/361 (11.9%)	79/1503 (5.3%)	<0.0001
Diabetes mellitus	146/361 (40.4%)	403/1508 (26.7%)	<0.0001
Insulin-treated	46/361 (12.7%)	101/1508 (6.7%)	
Peripheral artery disease	48/359 (13.4%)	131/1503 (8.7%)	0.007
Chronic obstructive pulmonary disease	29/361 (8.0%)	115/1505 (7.6%)	0.80
Anemia	61/358 (17.0%)	121/1505 (8.0%)	<0.0001
Carotid artery disease	45/359 (12.5%)	109/1502 (7.3%)	0.001
On dialysis	3/361 (0.8%)	-	-
Cardiac history			
Prior percutaneous coronary intervention	70/360 (19.4%)	249/1507 (16.5%)	0.19
Prior myocardial infarction	77/357 (21.6%)	246/1497 (16.4%)	0.02
Atrial fibrillation	29/361 (8.0%)	42/1508 (2.8%)	<0.0001
Any baseline mitral regurgitation*	115/327 (35.2%)	400/1405 (28.5%)	0.02
Any baseline aortic regurgitation*	47/325 (14.5%)	143/1401 (10.2%)	0.03
Any baseline tricuspid regurgitation*	94/323 (29.1%)	355/1392 (25.5%)	0.18
Left ventricular ejection fraction, %	55.5 ± 10.6	57.5 ± 8.9	0.002
Clinical presentation			
Stable angina	189/360 (52.5%)	799/1502 (53.2%)	0.81
Unstable angina	87/360 (24.2%)	370/1502 (24.6%)	0.85
Non-STEMI†	43/357 (12.0%)	199/1498 (13.3%)	0.52
STEMI†	5/357 (1.4%)	22/1498 (1.5%)	0.92
Laboratory measures			
HbA1c, %	6.4 ± 1.3	6.2 ± 1.2	<0.0001
White blood cell count, ×10 <sup>9</sup> /L	7.8 ± 2.1	7.8 ± 2.1	0.81
Hemoglobin, g/dL	12.7 ± 1.7	13.8 ± 1.5	<0.0001
Platelet count, ×10 <sup>9</sup> /L	231.6 ± 71.5	226.8 ± 62.4	0.47
Brain natriuretic peptide, mg/L	450.8 ± 981.9	202.2 ± 453.5	<0.0001
High-sensitivity C-reactive protein, mg/L	9.1 ± 15.2	6.3 ± 12.6	0.001
Serum creatinine, mg/dL	1.4 ± 0.7	0.9 ± 0.2	<0.0001

2 Values are n/N (%) or mean ± standard deviation, as appropriate. \*All were moderate or less; severe valve disease  
3 was an exclusion criterion; †within 7 days before randomization. STEMI = ST-segment elevation myocardial  
4 infarction.  
5



1 **TABLE 2. Angiographic and Procedural Characteristics in Patients With Versus Without CKD.**

	<b>Chronic Kidney Disease (n = 361)</b>	<b>No Chronic Kidney Disease (n = 1508)</b>	<b>p-value</b>
<b>Baseline angiographic characteristics</b>			
SYNTAX score, site-reported	21.0 ± 6.0	20.4 ± 6.2	0.11
Low complexity (<23)	211/361 (58.4%)	917/1506 (60.9%)	
Intermediate complexity (23-32)	150/361 (41.6%)	589/1506 (39.1%)	
SYNTAX score, core laboratory assessed	26.5 ± 8.7	26.5 ± 9.4	0.63
Low complexity (<23)	111/348 (31.9%)	534/1457 (36.7%)	
Intermediate complexity (23-32)	157/348 (45.1%)	568/1457 (39.0%)	
High complexity (>32)	80/348 (23.0%)	355/1457 (24.4%)	
Left main diameter stenosis, %	75.7 ± 12.4	75.3 ± 12.0	0.60
Bifurcation or trifurcation disease of the distal left main segment	275/352 (78.1%)	1212/1491 (81.3%)	0.18
Number of non-left main diseased vessels			
0	49/352 (13.9%)	276/1491 (18.5%)	0.04
1	117/352 (33.2%)	455/1491 (30.5%)	0.32
2	122/352 (34.7%)	491/1491 (32.9%)	0.54
3	64/352 (18.2%)	269/1491 (18.0%)	0.95
Diffuse or small vessel disease	36/356 (10.1%)	76/1482 (5.1%)	0.0004
<b>PCI characteristics</b>			
Non-left main lesions stented per patient			
Left anterior descending artery	57/172 (33.1%)	207/750 (27.6%)	0.15
Left circumflex artery	31/172 (18.0%)	122/750 (16.3%)	0.58
Right coronary artery	41/172 (23.8%)	203/750 (27.1%)	0.39
Number of any stented lesions per patient	2.0 ± 1.1	1.9 ± 1.1	0.34
Number of any stented vessels per patient	1.7 ± 0.8	1.7 ± 0.8	0.55
Number of stents implanted per patient	2.6 ± 1.5	2.4 ± 1.5	0.09
Total stent length, per patient	50.9 ± 35.6	48.8 ± 35.8	0.27
Intravascular imaging used	133/172 (77.3%)	579/750 (77.2%)	0.97
Fractional flow reserve used	13/171 (7.6%)	70/750 (9.3%)	0.48
Time in the catheterization laboratory, min	112.6 ± 53.1	111.0 ± 52.5	0.81
<b>CABG characteristics</b>			
Coronary segments of distal anastomosis (CASS)			
Left anterior descending artery	174/176 (98.9%)	718/727 (98.8%)	1.00
Left circumflex artery	154/176 (87.5%)	644/727 (88.6%)	0.69
Right coronary artery	73/176 (41.5%)	268/727 (36.9%)	0.26
Number of vessels bypassed per patient	2.3 ± 0.6	2.2 ± 0.5	0.41
Number of conduits per patient	2.6 ± 0.8	2.6 ± 0.8	0.16
Number of arterial conduits per patient	1.3 ± 0.6	1.4 ± 0.6	0.31
Number of venous conduits per patient	1.3 ± 0.9	1.2 ± 1.0	0.10
Bypass duration, min	77.2 ± 33.1	85.3 ± 48.1	0.17
Time in the operating room, min	291.0 ± 76.6	282.9 ± 75.0	0.11

2 Values are n/N (%) or mean ± standard deviation, as appropriate. CASS = Coronary Artery Surgery Study.

3

**TABLE 3. Three-Year Outcomes in Patients With Versus Without Chronic Kidney Disease**

	<b>Chronic Kidney Disease (n = 361)</b>	<b>No Chronic Kidney Disease (n = 1508)</b>	<b>Hazard Ratio (95% Confidence Interval)</b>	<b>p-value</b>
Death, stroke, or myocardial infarction	20.8% (73)	13.5% (200)	1.60 (1.22-2.09)	0.0005
Death	12.9% (45)	5.4% (80)	2.48 (1.72-3.57)	<0.0001
Cardiac death	7.3% (25)	3.3% (48)	2.27 (1.40-3.69)	0.0006
Non-cardiac death	6.0% (20)	2.2% (32)	2.78 (1.59-4.86)	0.0002
Stroke	3.6% (12)	2.5% (36)	1.46 (0.76-2.80)	0.26
Myocardial infarction	9.0% (31)	8.0% (118)	1.13 (0.76-1.68)	0.54
Death, stroke, myocardial infarction, or ischemia-driven revascularization	24.2% (85)	19.9% (296)	1.25 (0.98-1.59)	0.07
Ischemia-driven revascularization	8.6% (29)	10.3% (149)	0.85 (0.57-1.26)	0.42
Stent thrombosis, definite or probable	1.1% (4)	0.6% (9)	1.93 (0.59-6.26)	0.27
Graft stenosis or occlusion	2.3% (8)	2.7% (39)	0.89 (0.42-1.90)	0.76
Definite stent thrombosis or symptomatic graft occlusion	2.6% (9)	3.1% (45)	0.87 (0.42-1.78)	0.70
TIMI major or minor bleeding	11.1% (39)	6.9% (103)	1.61 (1.12-2.33)	0.01

Values are Kaplan-Meier estimate (number of events). TIMI = Thrombolysis in Myocardial Infarction.

**TABLE 4. Thirty-Day Major Adverse Events After PCI Versus CABG in Patients With Versus Without Chronic Kidney Disease**

	Chronic Kidney Disease (n = 361)				No Chronic Kidney Disease (n = 1508)			
	PCI (n = 177)	CABG (n = 184)	Hazard Ratio (95% CI)	p-value	PCI (n = 757)	CABG (n = 751)	Hazard Ratio (95% CI)	p-value
Major adverse events, any	10.9% (19)	29.8% (54)	0.36 (0.23-0.59)	<0.0001	6.2% (47)	21.5% (160)	0.29 (0.21-0.39)	<0.0001
Death	1.1% (2)	1.7% (3)	0.69 (0.12-4.08)	1.00	0.3% (2)	1.1% (8)	0.25 (0.05-1.16)	0.06
Myocardial infarction	4.0% (7)	6.6% (12)	0.60 (0.24-1.50)	0.27	3.4% (26)	5.9% (44)	0.58 (0.36-0.94)	0.02
Stroke	1.1% (2)	1.7% (3)	0.69 (0.12-4.08)	1.00	0.3% (2)	1.3% (10)	0.20 (0.04-0.90)	0.02
Transfusion of ≥2 units blood	6.3% (11)	24.3% (44)	0.26 (0.14-0.48)	<0.0001	2.7% (20)	15.6% (116)	0.17 (0.11-0.27)	<0.0001
TIMI major or minor bleeding	3.4% (6)	12.2% (22)	0.28 (0.12-0.68)	0.002	2.7% (20)	8.7% (65)	0.30 (0.19-0.50)	<0.0001
Major arrhythmia	2.3% (4)	19.9% (36)	0.11 (0.04-0.32)	<0.0001	1.7% (13)	13.6% (101)	0.13 (0.07-0.22)	<0.0001
Unplanned coronary revascularization for ischemia	1.1% (2)	2.2% (4)	0.52 (0.10-2.79)	0.69	0.1% (1)	1.1% (8)	0.12 (0.02-0.98)	0.02
Any unplanned surgery or therapeutic radiologic procedure	0.6% (1)	8.3% (15)	0.07 (0.01-0.52)	0.0004	0.9% (7)	2.7% (20)	0.34 (0.15-0.81)	0.01
Acute renal failure*	2.3% (4)	7.7% (14)	0.30 (0.10-0.88)	0.02	0.3% (2)	1.2% (9)	0.22 (0.05-1.01)	0.03
Sternal wound dehiscence	0.0% (0)	3.3% (6)	0.08 (0.00-1.40)	0.03	0.0% (0)	0.4% (3)	0.14 (0.01-2.72)	0.12
Infection requiring antibiotics	2.3% (4)	11.6% (21)	0.20 (0.07-0.56)	0.0006	0.8% (6)	8.2% (61)	0.10 (0.04-0.22)	<0.0001
Intubation for >48 hours	0.6% (1)	3.9% (7)	0.15 (0.02-1.19)	0.07	0.4% (3)	2.4% (18)	0.16 (0.05-0.56)	0.0009
Post-pericardiotomy syndrome	0.0% (0)	0.0% (0)	—	—	0.0% (0)	0.3% (2)	0.20 (0.01-4.10)	0.25

\*Defined as a serum creatinine increase of ≥5.0 mg/dL from baseline or a new requirement for dialysis. CABG = coronary artery bypass graft; CI = confidence interval; PCI = percutaneous coronary intervention; TIMI = Thrombolysis in Myocardial Infarction.

**TABLE 5. Three-Year Outcomes for PCI Versus CABG in Patients With or Without Chronic Kidney Disease**

	Chronic Kidney Disease (n = 361)			No Chronic Kidney Disease (n = 1508)			P <sub>interaction</sub>
	PCI (n = 177)	CABG (n = 184)	Hazard Ratio (95% CI)	PCI (n = 757)	CABG (n = 751)	Hazard Ratio (95% CI)	
Death, stroke, or myocardial infarction	23.1% (40)	18.4% (33)	1.25 (0.79-1.98)	13.4% (100)	13.5% (100)	0.97 (0.73-1.27)	0.36
Death	16.9% (29)	9.0% (16)	1.91 (1.04-3.52)	5.9% (44)	4.9% (36)	1.19 (0.77-1.85)	0.22
Cardiac	8.3% (14)	6.2% (11)	1.34 (0.61-2.94)	3.5% (26)	3.0% (22)	1.15 (0.65-2.04)	0.77
Non-cardiac	9.2% (15)	2.9% (5)	3.15 (1.15-8.68)	2.5% (18)	2.0% (14)	1.25 (0.62-2.52)	0.14
Stroke	3.1% (5)	4.0% (7)	0.75 (0.24-2.36)	2.2% (16)	2.8% (20)	0.78 (0.40-1.50)	0.95
Myocardial infarction	9.5% (16)	8.4% (15)	1.11 (0.55-2.24)	7.7% (57)	8.3% (61)	0.91 (0.63-1.30)	0.62
Death, stroke, myocardial infarction, or IDR	27.2% (47)	21.2% (38)	1.28 (0.84-1.97)	21.8% (163)	18.0% (133)	1.20 (0.95-1.50)	0.77
IDR	10.9% (18)	6.4% (11)	1.74 (0.82-3.68)	13.0% (95)	7.5% (54)	1.75 (1.25-2.44)	0.96
Stent thrombosis, definite or probable	2.3% (4)	—	—	1.2% (9)	—	—	—
Graft occlusion, symptomatic	—	4.5% (8)	—	—	5.4% (39)	—	—
Definite stent thrombosis or symptomatic graft occlusion	0.6% (1)	4.5% (8)	0.13 (0.02-1.03)	0.8% (6)	5.4% (39)	0.15 (0.06-0.35)	0.91
TIMI major or minor bleeding	8.3% (14)	13.8% (25)	0.57 (0.29-1.09)	4.8% (36)	9.0% (67)	0.52 (0.35-0.78)	0.80

Values are Kaplan-Meier estimate (number of events). CABG = coronary artery bypass graft; CI = confidence interval; CKD = chronic kidney disease; IDR = ischemia-driven revascularization; PCI = percutaneous coronary intervention; TIMI = Thrombolysis in Myocardial Infarction.

**TABLE 6. Acute renal failure at 30 days in patients with or without CKD undergoing PCI versus CABG.**

	Chronic Kidney Disease (n = 361)			No Chronic Kidney Disease (n = 1508)			Pinteraction
	PCI (n = 177)	CABG (n = 184)	Hazard Ratio (95% CI)	PCI (n = 757)	CABG (n = 751)	Hazard Ratio (95% CI)	
Acute renal failure†	2.3% (4)	7.6% (14)	0.28 (0.09-0.87)	0.3% (2)	1.3% (10)	0.20 (0.04-0.90)	0.71
New requirement for dialysis	1.1% (2)	5.4% (10)	0.20 (0.04-0.92)	0.1% (1)	0.5% (4)	0.25 (0.03-2.22)	0.87
Hemodialysis	0.6% (1)	2.7% (5)	0.20 (0.02-1.76)	0.1% (1)*	0.4% (3)	0.33 (0.03-3.18)	0.76
CVVH	0.6% (1)	2.7% (5)	0.20 (0.02-1.76)	0.1% (1)*	0.1% (1)	0.99 (0.06-15.89)	0.38

†Defined as the rise in serum creatinine >5 mg/dL or a new requirement for dialysis. \*One patient in the no chronic kidney disease group had both CVVH and hemodialysis. CVVH: Continuous veno-venous hemofiltration.