# Outcomes After Percutaneous Coronary Interventions in Patients With CKD: Improved Outcome in the Stenting Era

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• ***Background:*** **Percutaneous coronary intervention (PCI) with stenting reduces adverse events in the general population compared with balloon angioplasty. The benefit of stents in high-risk patients normally excluded from clinical trials has not been well studied. Outcomes after PCIs in patients with chronic kidney disease (CKD) before and after widespread use of stents were compared.** ***Methods:*** **All patients undergoing PCIs at our center within 2 periods selected for high and low stent use were included. Demographic, kidney and cardiac function, and PCI data were collected. Kaplan-Meier curves were constructed, and Cox proportional hazards analysis was used to assess the effect of high stent use on major adverse cardiac event, a composite of cardiac revascularization, myocardial infarction, or death 3 years after PCI.** ***Results:*** **A total of 1,879 patients (780 patients, low stent use; 1,099 patients, high stent use; 18% and 94.1% stent use, respectively) with a mean age of 63 years, 73% men, and 26% of patients with a glomerular filtration rate less than 60 mL/min were included. At baseline, there was a greater prevalence of severe CKD, cardiac risk factors, and cardiovascular disease in the high-stent-use cohort. Major adverse cardiac events were reduced in the contemporary cohort (hazard ratio, 0.61; 95% confidence interval, 0.52 to 0.72); this benefit extended across all stages of kidney function.** ***Conclusion:*** **Patients with CKD undergoing PCI in the stenting era show improved outcomes. Additional studies are needed to determine optimal revascularization strategies in patients with CKD.** ***Am J Kidney Dis*** **45:1002-1009.**
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**INDEX WORDS: Chronic kidney disease (CKD); stents; percutaneous coronary intervention (PCI); cardiovascular disease; diabetes mellitus; survival.**

CARDIOVASCULAR DISEASE is the leading cause of death in dialysis patients[1] and increasingly is recognized as a major cause of morbidity and mortality in those with chronic kidney disease (CKD) not requiring dialysis therapy.[2-6] In CKD cohorts, clinically evident cardiovascular disease and angina have been reported in 38% to 49% and 16% to 19%, respectively.[4,5] Compared with the general population, poorer survival after percutaneous coronary intervention (PCI) has been documented in patients with kidney disease,[7] as has worse cardiac outcome with successively lower levels of kidney function.[8] Given the high prevalence and poor prognosis of coronary artery disease in patients with CKD, effective therapeutic strategies are needed. However, the optimal strategy for coronary revascularization in patients with CKD remains undefined.

During the balloon angioplasty era, high restenosis rates and reduced long-term survival were described in CKD and dialysis cohorts undergoing PCI compared with coronary artery bypass grafting (CABG).[9-11] CABG thus commonly was perceived as the revascularization strategy of choice in patients with kidney disease. Stents are effective in the general population,[12] with reduced restenosis rates compared with balloon angioplasty alone. Because similar high procedural success and low in-hospital event rates have been reported in the general and dialysis populations with stent use,[13] stents likely also reduce restenosis in patients with kidney disease.

The impact of stent use in patients with CKD before dialysis therapy is not well described. Publications that report a progressively worse outcome after PCI by strata of kidney disease severity have variable stenting rates (22% to 100%).[8,14-16] Reduced stent effectiveness might be expected in the CKD population because of diffuse vascular dis-

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ease, extensive vascular calcification, smaller vessel diameter, high diabetes prevalence, and, possibly, increased prothrombotic activity.[17]

Although the efficacy of stent use in reducing adverse events after PCI has been shown in several randomized controlled trials of the general population, the benefit of stent use in patients with CKD, normally excluded from these studies, has not been well studied. We sought to document the prevalence of kidney dysfunction in a population-based cohort of patients undergoing PCI and evaluate the impact of widespread stent use on patients with CKD.

## METHODS

### *Patients*

All patients who underwent PCI at St Paul's Hospital, a tertiary-care institution in British Columbia, Canada, between April 1, 1994, and August 31, 1995 (historic cohort), and between August 1, 1999, and November 30, 2000 (contemporary cohort), were included. These periods were selected specifically because they represent periods of low and high stent use, with the latter period allowing analysis of 3-year follow-up after the index procedure. If patients underwent more than 1 PCI, the index PCI is defined as the patient's first PCI during the study period. Thus, patients already identified in the historic group were excluded from the contemporary cohort. Patients with missing baseline creatinine values were excluded, as were out-of-province patients, because of the lack of availability of revascularization and death data.

All analyses were reviewed and approved by the BC Cardiac Registry Steering Committee.

### *Data Collection and Outcomes*

Demographic information, cardiovascular risk factors and comorbidity, and revascularization-related information (prior PCI or CABG and stent use) were collected at the time of the index PCI. Number of diseased vessels (defined as number of vessels with ≥50% stenosis) was obtained at the time of cardiac catheterization. Baseline clinical and procedural information was obtained from BC Cardiac Registries (BCCR), a prospective database that captures information on all advanced cardiac procedures in the province, including diagnostic coronary angiography, PCI, pacemaker implantation, and cardiothoracic surgery.[18] For patients registered before 1997, supplemental information was obtained from hospital charts (baseline comorbidities). Preprocedure creatinine values (within 1 week of the PCI date) were obtained from BCCR, hospital charts, and the clinical information system, as necessary.

Kidney function was determined from the preprocedure serum creatinine level by using the abbreviated Modification of Diet in Renal Disease formula.[19] Patients then were classified a priori into 4 groups according to glomerular filtration rate (GFR): (1) 90 mL/min or greater, (2) 60 to 89 mL/min, (3) 30 to 59 mL/min, and (4) 29 mL/min or less or on dialysis therapy.

The outcome of interest is the major adverse cardiac event rate, a composite of subsequent revascularization (defined as repeated PCI or CABG), myocardial infarction (MI), and all-cause mortality at 3 years after the index PCI. Revascularization data for the historic and contemporary cohorts were obtained from BCCR. MI data were obtained from the BC Ministry of Health Hospital Database. Mortality was identified through linkage with BC Vital Statistics.

### *Statistical Analysis*

Baseline demographic and clinical characteristics of patients are presented as mean ± SD for continuous variables and percentages for categorical variables. Student's *t*-test and chi-square analyses were performed for comparison of continuous and categorical variables, respectively. $P$ less than 0.05 is considered statistically significant, and all tests were 2 tailed.

Using the Kaplan-Meier method, 3-year event-free survival curves were constructed, with survival time calculated from the date of the index PCI to the date of the first event (revascularization, MI, or death).

Cox proportional hazards analysis was used to determine the effect of PCI era (contemporary versus historic) on rate of major adverse cardiac events at 3 years, after adjusting for other risk factors. Potential confounders were determined by means of univariate analyses. Variables univariately associated with the outcome ($P < 0.1$), as well as age and sex, were entered into the multivariable model by using stepwise selection. To determine the impact of PCI era on primary end point for patients with different levels of renal function, the interaction term (cohort × GFR) was forced into the model. Hazard ratios for the primary end point in the contemporary compared with historic cohort then were calculated for each level of renal function.

## RESULTS

### *Baseline Characteristics*

At our institution, 1,995 patients underwent PCI in the periods of interest. For 116 of these patients (5.8%), GFRs could not be calculated because of missing serum creatinine or sex data. These patients were excluded from further analysis; thus, 780 patients from the historic cohort and 1,099 patients from the contemporary cohort were included in the analysis.

Overall, 263 patients (14.0%) had a GFR of 90 mL/min or greater; 1,123 patients, (59.8%), 60 to 89 mL/min; 429 patients (22.8%), 30 to 59 mL/min; and 64 patients (3.4%), 29 mL/min or less or on dialysis therapy. Baseline patient characteristics, stratified by cohort, are listed in Table 1. Stent use was 18% and 94% in the historic and current cohorts, respectively.

Sixteen (2.1%) and 26 patients (2.3%) in the historic and contemporary cohorts were receiving long-term dialysis, respectively. There were more patients with advanced kidney disease in

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