Acute kidney injury following coronary angiography is associated with a long-term decline in kidney function

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To determine whether acute kidney injury results in later long-term decline in kidney function we measured changes in kidney function over a 3-year period in adults undergoing coronary angiography who had serum creatinine measurements as part of their clinical care. Acute kidney injury was categorized by the magnitude of increase in serum creatinine (mild (50–99% or $\geqslant$0.3 mg/dl) and moderate or severe ($\geqslant$100%)) within 7 days of coronary angiography. Compared to patients without acute kidney injury, the adjusted odds of a sustained decline in kidney function at 3 months following angiography increased more than 4-fold for patients with mild to more than 17-fold for those with moderate or severe acute kidney injury. Among those with an estimated glomerular filtration rate after angiography less than 90 ml/min per 1.73 m^2, the subsequent adjusted mean rate of decline in estimated glomerular filtration rate during long-term follow-up (all normalized to 1.73 m^2 per year) was 0.2 ml/min in patients without acute kidney injury, 0.8 ml/min following mild injury, and 2.8 ml/min following moderate to severe acute kidney injury. Thus, acute kidney injury following coronary angiography is associated with a sustained loss and a larger rate of future decline in kidney function.

Kidney International (2010) **78,** 803–809; doi:10.1038/ki.2010.258; published online 4 August 2010

KEYWORDS: acute kidney injury; chronic renal disease; coronary artery disease; glomerular filtration rate

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This study was presented in preliminary form as an abstract at the 42nd annual meeting of the American Society of Nephrology; 28 October 2009, San Diego, California.

Received 21 January 2010; revised 3 May 2010; accepted 25 May 2010; published online 4 August 2010

Acute kidney injury (AKI) following coronary angiography is often transient, with improvement in kidney function observed within days to weeks.[1–3] Although severe AKI that requires dialysis is a rare event in this setting,[4,5] even AKI of lesser severity has been consistently associated with adverse outcomes including death.[6,7] Patients with preexisting chronic kidney disease (CKD) constitute a high-risk group for AKI in the setting of radiocontrast administration.[2] Furthermore, CKD itself is associated with graded increases in risk of mortality with incremental reductions in glomerular filtration rate (GFR).[8–10] These observations suggest that the long-term effects of AKI on the development and progression of CKD are important to understand.

The long-term trajectory of kidney function following an episode of AKI remains unclear. The majority of what is currently known relates to the risk of developing end-stage renal disease (ESRD) requiring dialysis among survivors of severe AKI.[11–13] The effects of lesser degrees of AKI have not been characterized, nor have the long-term effects of AKI on kidney function based on the rate of decline in estimated GFR (eGFR) after hospital discharge. Furthermore, the effects of AKI on serial post-procedure measurements of kidney function have not been examined following coronary angiography specifically, an event which is particularly relevant given the high cardiovascular risk and use of this procedure in patients with or at risk for CKD. Identification of patients at high risk for progressive loss of kidney function after these procedures would provide important prognostic information to guide subsequent patient care.

The purpose of this study was to examine the association between AKI and long-term changes in kidney function following coronary angiography. We hypothesized that a graded association would exist between the severity of an AKI episode and loss of kidney function at 3 months after angiography. We also hypothesized that AKI would be an independent predictor of the subsequent rate of decline in GFR beyond 3 months following coronary angiography.

RESULTS

Cohort formation and characteristics

We identified 19,022 Alberta residents 18 years of age or older undergoing coronary angiography with ⩾1 outpatient serum creatinine measurement performed in both the pre- and greater than 3-month post-angiography time periods. We excluded 327 patients receiving renal replacement therapy before study entry, and 616 patients who underwent coronary artery bypass surgery within 7 days following angiography.

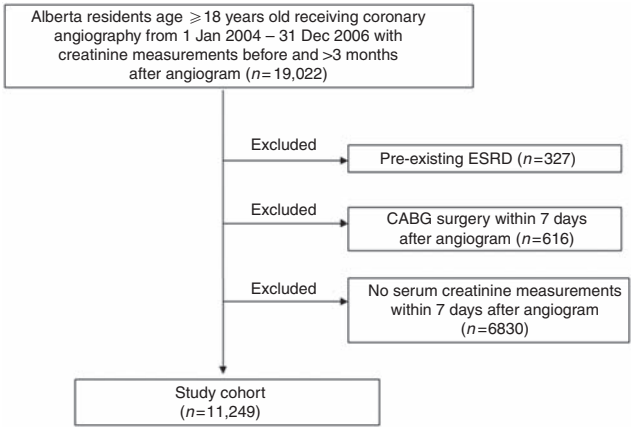

Figure 1 | Cohort formation.

Of the remainder, 11,249 (62.2%) had a serum creatinine measurement within 7 days following coronary angiography, and were included in the final cohort (Figure 1).

The mean age of the cohort was 63.6 years, 69.6% were men, and the mean eGFR before coronary angiography was 73.8 ml/min per 1.73 m^2. A total of 853 participants (7.6%) developed AKI following coronary angiography; 716 (6.4%) with mild AKI (increase in serum creatinine 50–99% or by ⩾0.3 mg/dl) and 137 (1.2%) with moderate or severe AKI (increase in serum creatinine ⩾100%). Patients who developed AKI were older, more likely to be women, with lower pre-angiography eGFR, proteinuria, and several comorbidities including diabetes mellitus, hypertension, and heart failure (Table 1).

Median follow-up from the date of coronary angiography was 2.5 years (interquartile range (IQR) 2.2, 2.8 years). The median number of serum creatinine measurements obtained between 7 days and 3 months after angiography was 6 (IQR 4, 9), whereas the median number of outpatient serum creatinine measurements obtained >3 months after angiography was 3 (IQR 2, 4), with a median interval between measurements of 7 months (IQR 1, 11 months). During follow-up beyond 3 months after coronary angiography, 638 participants (5.7%) died, whereas 46 (0.4%) initiated chronic renal replacement therapy.

Table 1 | Characteristics of patients undergoing coronary angiography, according to AKI status

	No AKI (*n*=10,396)	Mild AKI (*n*=716)	Moderate or severe AKI (*n*=137)	*P*-value[a]
Age, years, mean (s.d.)	63.3 (12.2)	68.3 (11.8)	66.8 (12.0)	<0.0001
Sex, male, no. (%)	7263 (69.9)	490 (68.4)	79 (57.7)	0.007
Pre-angiography eGFR, ml/min per 1.73 m^2, mean (s.d.)	74.0 (19.8)	62.4 (24.3)	61.8 (26.2)	<0.0001
Pre-angiography eGFR, categories, no. (%)				
⩾90 ml/min per 1.73 m^2	1897 (18.2)	84 (11.7)	16 (11.7)	<0.001
60–89 ml/min per 1.73 m^2	6195 (59.6)	280 (39.1)	49 (35.8)	
30–59 ml/min per 1.73 m^2	2196 (21.1)	315 (44.0)	59 (43.1)	
<30 ml/min per 1.73 m^2	108 (1.0)	37 (5.2)	13 (9.5)	
Proteinuria, no. (%)				
Absent	6779 (65.2)	424 (59.2)	71 (51.8)	<0.001
Microalbuminuria	1225 (11.8)	161 (22.5)	50 (36.5)	
Proteinuria	40 (3.8)	11 (1.5)	1 (0.7)	
Unmeasured	2352 (22.6)	120 (16.8)	15 (10.9)	
Comorbidities, no. (%)				
Diabetes mellitus	2730 (26.3)	265 (37.0)	62 (45.2)	<0.001
Hypertension	7024 (67.6)	537 (75.0)	93 (67.9)	<0.001
Hyperlipidemia	8098 (77.9)	538 (75.1)	90 (65.7)	0.001
Heart failure	1450 (13.9)	224 (31.3)	60 (43.8)	<0.001
Cerebrovascular disease	751 (7.2)	83 (11.2)	25 (18.2)	<0.001
Peripheral vascular disease	786 (7.6)	84 (11.7)	20 (14.6)	<0.001
Chronic pulmonary disease	1709 (16.4)	190 (26.5)	29 (21.1)	<0.001
Liver disease	141 (1.4)	14 (2.0)	5 (3.6)	0.014
Malignancy	451 (4.3)	41 (5.7)	8 (5.8)	0.16
Current smoker	3030 (29.1)	166 (23.2)	25 (18.2)	<0.001
Procedures following diagnostic angiogram, no. (%)				
Percutaneous coronary intervention	5356 (51.5)	329 (45.9)	50 (36.5)	<0.001
Coronary artery bypass surgery	1335 (12.8)	112 (15.6)	21 (15.3)	0.072

Abbreviations: AKI, acute kidney injury; s.d., standard deviation.
[a]ANOVA or χ^2-test.