Temporal trends in acute kidney injury in hospitalizations from 2009 to 2018 in Alberta: A retrospective population-based cohort study

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Abstract

Importance: There is limited data on temporal trends in acute kidney injury (AKI) in a general hospitalized population using serum creatinine (SCr) based definitions.
Objective: To identify trends in AKI using diagnostic codes and Kidney Disease Improving Global Outcomes {KDIGO} SCr based definitions and associated severity and mortality.
Design, Setting, and Participants: This population-based retrospective cohort study identified adult patients admitted to hospital in Alberta, Canada from 2009 to 2018.
Exposure/Measure: We identified AKI episodes using validated KDIGO SCr based definitions and AKI diagnostic codes, in-hospital acute dialysis, in-hospital and 90-day all-cause mortality. We used generalized linear models with a Gaussian family to estimate the absolute rates of AKI and in-hospital mortality by year of hospitalization. Rates of AKI and mortality were adjusted for patient demographics and comorbidities.
Results: Between January 2009 and December 2018, there were 348, 242 hospitalizations with an episode of AKI (12.3%); median age 70 (56, 82) and 156, 064 (44.7%) female. AKI rates defined by KDIGO criteria increased over the study period by an unadjusted mean rate of 14.2/1000 hospitalizations (95%CI 12.7,15.6, p <0.01). When fully adjusted, the rates in AKI were stable. Stage 1 AKI was most common (unadjusted mean rate, 88.6/1000 hospitalizations [95%CI 88.2,89.0]). In-hospital mortality decreased across all stages of AKI with the greatest decrease noted in stage 3 AKI (unadjusted rate difference -80.8/1000 AKI stage 3 hospitalizations [95%CI -94.9,-66.8]). Similar trends were identified in 90-day mortality. This trend was preserved when the data was fully adjusted. ICD codes showed low sensitivity (24.6%), but high specificity (98.8%) in recognizing AKI with improvements over time (sensitivities increased from 17.5 in 2009 to 32.9% in 2018).
Conclusion:Rates of AKI in hospitalized patients increased, largely driven by stage 1 AKI. Despite this increase, there was an overall decrease in mortality, especially in the most severe forms of AKI. Coupled with the trends in ICD coding, our findings suggest that recognition of AKI has improved over time, but this alone does not explain the decrease in mortality. Lastly, our study has shown that reliance on ICD coding to identify temporal trends in AKI is insufficient.

Introduction

- AKI complicated 4 to 7% of hospitalizations, affecting more than 180, 000 Canadians each year[1,2]
- Although survival has improved, AKI is still associated with poor short- and long-term outcomes[3-6]
- Recent studies have reported an increase in AKI incidence of 10% annually[7]
- Many studies have relied on the use of diagnostic codes which have exhibited low or variable sensitivity in identifying AKI cases over time or have findings that are not generalizable to the broader hospitalized population
- **In this study, we aimed to:**
  Determine temporal trends in AKI identified using KDIGO SCr based definition and AKI diagnostic codes in a population-based cohort
  Examine demographic changes in the population affected by AKI, trends in severity of AKI, and the mortality associated with AKI

Methods and Materials

- Retrospective cohort study created using the Alberta Kidney Disease Network Database
- Inclusion criteria: adult (≥18 years), hospitalized between January 1, 2009 and December 31, 2018, SCr lab work available
- Exclusion criteria: previous/development of ESKD (initiation of maintenance dialysis, receipt of a kidney transplant, eGFR <15 mL/min per 1.73m^2)
- AKI determined: using 1. serum creatinine KDIGO criteria and 2. ICD codes
- Assessed AKI severity based on KDIGO staging and assessed AKI associated in-hospital all cause mortality and 90-day post discharge mortality
- Rates (per 1000 hospitalizations) along with 95% confidence intervals were reported

Table 1. Characterization of hospitalizations with and without AKI in the province of Alberta from 2009 to 2018

		AKI	No AKI	Total Population
N (%)		348,242 (12.3)	2,480,698 (87.7)	2,828,940
Age median (Q1, Q3)		70 (56, 82)	51 (32, 69)	54 (33, 72)
Sex n (%)	Male	192,718 (55.3)	919,447 (37.1)	1,112,165 (39.3)
Visible minority median (Q1, Q3)		23 (13, 39)	22 (13, 40)	22 (13, 39)
Rural n (%)		49,441 (14.8)	351,879 (14.4)	401,320 (14.4)
Baseline kidney function	Serum creatinine (μmol/L) median (Q1, Q3)	84 (64,111)	72 (59, 88)	73 (60, 90)
	Estimated glomerular filtration rate (mL/min/1.73m^2) median (Q1, Q3)	70 (47, 93)	87 (68,106)	85 (65,104)
Number of comorbidities median (Q1, Q3)		4 (2, 6)	2 (0, 4)	2 (0,4)
Baseline comorbidities n (%)				
	Severe chronic kidney disease	9,753 (2.8)	7,970 (0.3)	17,723 (0.6)
	Hypertension	241,771 (69.4)	938,455 (37.8)	1,180,226 (41.7)
	Diabetes mellitus	122,999 (35.3)	392,527 (15.8)	515,526 (18.2)
	Myocardial infarction	30,118 (8.6)	90,579 (3.7)	120,697 (4.3)
	Heart failure	90,238 (25.9)	216,878 (8.7)	307,116 (10.9)
	Peripheral arterial disease	21,716 (6.2)	60,351 (2.4)	82,067 (2.9)
	Stroke	70,657 (20.3)	251,956 (10.2)	322,613 (11.4)
	Pulmonary disease	117,984 (33.9)	447,736 (18.0)	565,720 (20.0)
	Asthma	25,329 (7.3)	129,613 (5.2)	154,942 (5.5)
	Liver disease	9,099 (2.6)	24,009 (1.0)	33,108 (1.2)
	Peptic ulcer disease	3,310 (1.0)	9,965 (0.4)	13,275 (0.5)
	Cancer	39,296 (11.3)	180,208 (7.3)	219,504 (7.8)
	Pain	78,364 (22.5)	510,683 (20.6)	589,047 (20.8)
Outpatient prescription n (%)				
	ACEi/ARB	169,642 (48.7)	634,414 (25.6)	804,056 (28.4)
	Diuretic	155,906 (44.8)	469,607 (18.9)	625,513 (22.1)
	NSAID	39,030 (11.2)	378,533 (15.3)	417,563 (14.8)
Admission diagnosis n (%)				
	Cardiovascular	65,946 (18.9)	204,118 (8.2)	270,064 (9.5)
	Respiratory	39,905 (11.5)	146,258 (5.9)	186,163 (6.6)
	Gastrointestinal	40,097 (11.5)	240,480 (9.7)	280,577 (9.9)
	Hematologic	18,454 (5.3)	50,029 (2.0)	64,483 (2.4)
	Cancer	23,230 (6.7)	154,999 (6.2)	178,229 (6.3)
	Infection	19,570 (5.6)	34,210 (1.4)	53,780 (1.9)
	Genitourinary	31,610 (9.1)	143,291 (5.8)	174,901 (6.2)
	Orthopedic	11,622 (3.3)	170,933 (6.9)	182,555 (6.5)
	Injury	31,944 (9.2)	229,211 (9.2)	261,155 (9.2)
	Other	65,864 (18.9)	1,107,169 (44.6)	1,173,033 (41.5)
Admission to ICU n (%)		65,594 (18.8)	128,658 (5.2)	194,252 (6.9)

Results

***all rates are per 1000 hospitalizations unless otherwise reported**

Cohort characteristics:
12.3% of hospitalizations complicated by AKI
Participants with AKI more likely to be older, male, have a diagnosis of hypertension/diabetes, and had a lower eGFR
Decrease in ICU admissions for patients with AKI over time (20.1 in 2009 to 18.8% in 2018, p<0.05).

Trends in AKI incidence:
KDIGO AKI: Unadjusted mean rate increase 14.2/1000 hospitalization [95%CI 12.7,15.6], p<0.05, stable when fully adjusted
ICD AKI: Unadjusted mean rate increase 22.5 [95%CI 21.8,23.3], p<0.05; increase remains when fully adjusted
Greatest increase noted in patients >80 years (unadjusted mean rate 68.0 [95%CI 67.1,69.0], p<0.05)

Trends in AKI severity:
Stage 1 AKI most common (unadjusted mean rate 88.6 [95%CI 88.2,89.0], p<0.05))
Increase in rates of all stages of AKI; greatest noted in stage 1 AKI (11.5/1000 hospitalizations)
Stable rates of kidney replacement therapy (unadjusted mean rate difference 0.04 [95%CI -0.01,0.2], p=0.56)

Trends in AKI related mortality: (in-hospital and 90-day post discharge):
Decrease in mortality across all stages of AKI
Greatest decrease note in stage 3 AKI (90-day unadjusted mean rate -85.7/1000 hospitalization with stage 2 AKI [95%CI -101.3,-70.1], p<0.05)

Trends in the performance of ICD diagnostic codes for AKI:
Sensitivity increased from 17.5 to 33.1% over the study period
Increased recognition of AKI over time, particularly in stage 1 AKI

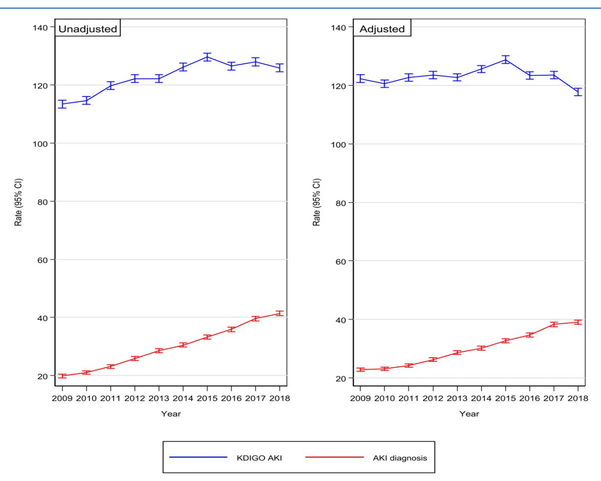

Figure 1. Rates of AKI (per 1000 hospitalizations) in the province of Alberta identified by KDIGO and ICD codes from 2009 to 2018

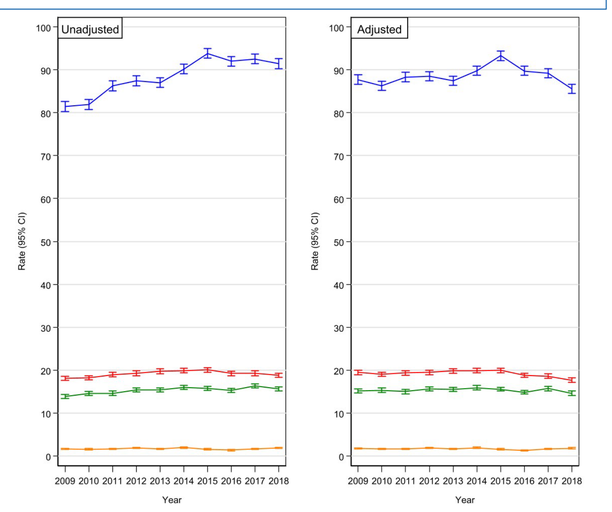

Figure 2. Rates of AKI (per 1000 hospitalizations) stratified by KDIGO severity stage and requirement of kidney replacement therapy in the province of Alberta between 2009 and 2018

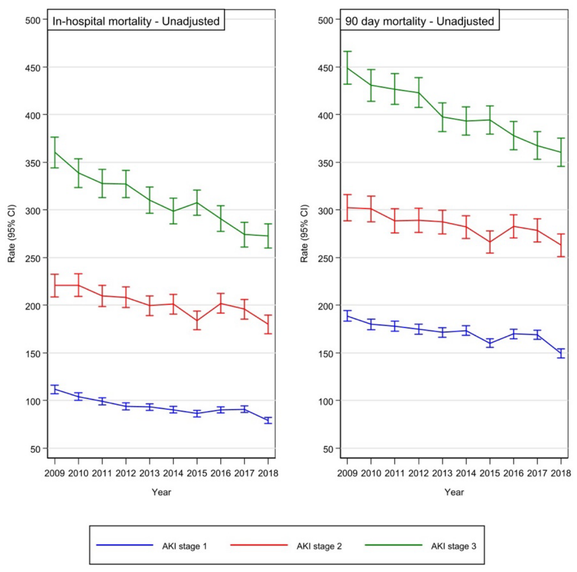

Figure 3. Rates of in-hospital and 90-day mortality (per 1000 stage 1, 2 or 3 AKI hospitalizations)

Discussion/Conclusion

- Rates of AKI are increasing, largely driven by Stage 1 AKI and patients with AKI are older and more comorbid
- Despite increase in AKI incidence, there is a decrease in AKI associated mortality, especially in the more severe stages of AKI, that cannot be attributed to increased recognition of milder stages of AKI alone
- AKI diagnostic codes underestimate AKI incidence and lead to biased estimates of temporal trends in AKI

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