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Article type : Clinical investigation

Point-of-care creatinine measurements to predict acute kidney injury

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Short title: Point-of care creatinine and AKI

Key words: point-of-care, acute kidney injury, creatinine, prediction, critically ill

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Word count: manuscript 2797, abstract 234

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/AAS.13564

Abstract

Background: Plasma creatinine (Cr) is a marker of kidney function and typically measured once daily. We hypothesized that Cr measured by point-of-care technology early after ICU admission would be a good predictor of acute kidney injury (AKI) the next day in critically ill patients.

Methods: We conducted a retrospective database audit in a single tertiary ICU database. We included patients with normal first admission Cr (Cr_F) and identified a Cr value (Cr_P) obtained within 6 to 12 hrs from ICU admission. We used their difference converted into percentage (delta-Cr-%) to predict subsequent AKI (based on Cr and/or need for renal replacement therapy) the next day. We assessed predictive value by calculating area under the receiver characteristic curve (AUC), logistic regression models for AKI with and without delta-Cr-%, and the category-free net reclassifying index (cfNRI).

Results: We studied 780 patients. Overall, 70 (9.0%) fulfilled the Cr AKI definition by Cr_P measurement. On day 2, 148 patients (19.0%) were diagnosed with AKI. AUC (95% CI) for delta-Cr-% to predict AKI on day 2 was 0.82 (95% CI 0.78-0.86), and 0.74 (95% CI 0.69-0.80) when patients with AKI based on the Cr_P were excluded. Using a cut-off of 17% increment, the positive likelihood ratio (95% CI) for delta-Cr-% to predict AKI was 3.5 (2.9 – 4.2). The cfNRI was 90.0 (74.9-106.1).

Conclusions: Among patients admitted with normal Cr, early changes in Cr help predict AKI the following day.

Editorial Comment:

In a single-centre cohort, the measurement of a change in creatinine from admission to 6-12 hours later using point-of-care technology could predict the development of acute kidney injury on the subsequent day based on KDIGO criteria. The potential clinical impact to improve outcomes once having this kind of result in hand needs to be studied.

Introduction

Approximately 40 to 60% of intensive care unit (ICU) patients suffer from acute kidney injury (AKI), which is independently associated with an increased risk of mortality.[1, 2] Earlier detection of AKI may allow better management of these patients including, for example, avoidance of further insults to the kidney. Great effort has therefore been put in finding novel biomarkers capable of predicting the development of AKI.[3, 4] However, the performance of most novel biomarkers has been variable in an unselected mixed critically ill population.[5]

Plasma creatinine (Cr) has traditionally been measured only once daily even in the critically ill.[6] Along with urine output and need for renal replacement therapy (RRT), Cr is a key diagnostic criterion of the Kidney Diseases: Improving Global Outcomes (KDIGO) definition of AKI.[7] Consequently, more frequent screening for AKI with point-of-care Cr measurements could be a useful tool for predicting AKI and diagnosing it earlier. Promising results have been reported among elective cardiac surgery patients using Cr value obtained 6 hours after surgery.[8] Moreover, a single center prospective study found small changes in point-of-care Cr observed very early (3-4 hours from ICU admission) to be sensitive, but non-specific markers of subsequent AKI.[9] However, the usefulness of point-of-care Cr measurements obtained 6 hours from ICU admission in AKI prediction among unselected mixed ICU patients has not been studied.

Measurement of Cr as a part of routine blood-gas analyses as a point-of-care test, was introduced in our ICU in 2011[10] and has been shown to correlate well with central laboratory Cr results.[10, 11] Thus, we performed a retrospective database audit to assess the value of point-of-care Cr measurement in predicting AKI (based on Cr or RRT) on the following day among patients who were admitted to ICU with normal Cr values. We hypothesized that the difference between the first point-of-care measured Cr and a subsequent point-of-care measurement at least 6 but no more than 12 hours apart would be a good predictor of patient's AKI status on the following day.

Methods

Design and setting

This was a retrospective audit in database consisting of adult patients admitted between 1.1.2011 and 31.12.2012 to Austin Hospital ICU providing tertiary level care. The Human Research Ethics Committee of Austin Health approved the protocol and waived the need for informed consent (LNR/17/Austin/441). Study period was a convenience period with already retrieved data available.

Participants

We included all patients admitted to the Austin Hospital ICU during the study period. Only their first ICU admission was used for analysis. We excluded i) patients with an ICU stay < 24 hours, ii) known end-stage renal disease iii) patients admitted with increased first Cr values (females with first Cr over 90 µmol/l and male patients over 100 µmol/l) and iv) patients with missing data on key variables (Figure 1). We only included patients with normal Cr values, because we aimed to study AKI developing in the ICU.

Data sources

We retrieved data regarding characteristics of the ICU admission from ICU Australian and New Zealand Intensive Care Society adult patient database (local version including patients treated at Austin Hospital ICU) and the ICU patient care computerized database, including data about ICU severity scores, interventions, and fluid therapy. These data were supplemented with the ICU blood gas analyser result database and hospital database regarding diagnostic coding. Point-of-care measurement of Cr values (Radiometer ABL800 flex using non-isotope dilution mass spectrometry enzymatic assay and a two-electrode amperometric technique[12]) and their measurement time were included in the blood-gas analyser data. Patient outcome was followed up to hospital discharge from the hospital database.

Variables and definitions

From the point-of-care Cr database, we identified the following variables: i) the "first Cr" (Cr_F) measured within 2h from ICU admission, ii) the "predictor Cr" (Cr_P) measured at least 6 hours but

no more than 12 hours from the first Cr, and iii) the first Cr measured on Day 2 (Cr_{DAY2}) at least 24 hours but no more than 48 hours from ICU admission.

We subtracted Cr_P from the Cr_F and converted the difference into a percentage (delta-Cr-%). The delta-Cr-% was the primary exposure variable in the analysis.

Outcomes

The primary outcome was AKI on Day 2 based on Cr_{DAY2} measurement and determined according to the Kidney Disease: Improving Global Outcomes (KDIGO) Cr and RRT criteria.[7] Cr_F served as the baseline Cr[13] as no data regarding outpatient Cr values preceding the index hospitalization were available. Data about urine output normalized to patient weight were unavailable which prevented the application of the KDIGO urine output criteria for AKI. We compared ICU and hospital length of stay and hospital mortality between patients with and without the primary endpoint.

Sample size

Analyses were performed on available patients and data on exposure and endpoint variables (n=780) over a two-year period.

Data analysis

We constructed receiver operating characteristic (ROC) curves and calculated the area under the curve (AUC) with 95% confidence intervals to evaluate the predictive ability of delta-Cr-% for the primary endpoint in the entire cohort, among those who did not have AKI based on their Cr_P measurement, and in groups according to admission category. We used Youden's index to derive optimal cut-points to calculate diagnostic characteristics with 95% CIs.

To study the value of delta-Cr-% in addition of clinical risk variables as a predictor of AKI on day 2, we constructed two logistic regression models for AKI on Day 2; Model 1 with clinical risk variables and Model 2 with Model 1 variables and delta-Cr-%. We considered baseline characteristics available at ICU admission (age, sex, admission type, diagnostic category), and details of ICU treatment available before the measurement of Cr_P (use of mechanical ventilation, vasopressors, sedation, blood products, amount of administered intravenous fluids, urine output,

and fluid balance), and additionally acute physiology and chronic health evaluation (APACHE) III score. The clinical predictors were first studied in univariate models and those with univariate P-value less than 0.2 and patient sex as recommended[14] were considered further and a clinical risk model was constructed using forward stepwise regression. We assessed potential collinearity of variables with Pearson's correlation and excluded those with rho > 0.6. Continuous variables regarding fluid input, output and balance were categorized in quartiles to improve model fit. We evaluated model fit with Hosmer-Lemeshow statistics.

Using the two models, we assessed the additional value of delta-Cr-% in risk prediction with category-free net reclassification index (cfNRI) and integrated discrimination index (IDI).[15] Category-free NRI describes the net improvement in predictive ability when a new risk factor is added to an existing model. IDI incorporates the direction and extent of change in the calculated risk. Additionally, we used DeLong's method to test for equality of the AUC's of the two prediction models.[16] We repeated the analyses in a sub-cohort without patients who had AKI based on their Cr_P measurement. Second, due to their varying risk profiles we performed subanalyses among only i) emergently admitted patients ii) cardiac surgical patients.

We report continuous data as medians with interquartile range and dichotomous data as count and percentage and main outcome variables with 95% confidence intervals. Missing data are indicated in the tables. We used Mann-Whitney U-test to compare continuous variables and Chi-Square or Fischer's exact test to compare categorical variables. We set the significance level at 0.05 and report two-tailed P-values. We conducted the analysis with SPSS statistics 24.0. for Mac (IBM, Armonk, NY) and RStudio 1.1.145 for Mac (RStudio Inc.)

Results

Patients

We studied 780 patients treated between 1.1.2011 and 31.12.2012. Figure 1 presents the patient flow and exclusions. Of the 780 patients, 343 (44.0%) were admitted due to medical reasons, 212 (27.2%) due to elective cardiovascular surgery, and 187 (24.0%) were other surgical patients. Altogether 472 (60.5%) were admitted emergently.

Index Cr values

Median [IQR] Cr_F was 66 [54-79] µmol/l and was recorded after a median [IQR] of 0.4 [0.2-0.9] hours from admission. Median [IQR] time between Cr_F and Cr_P was 8.2 [7.2-9.3] hours. The median [IQR] Cr_P was 71 [58-86] µmol/l. Overall, 70 (9.0%) fulfilled the Cr AKI definition with their Cr_P measurement; 62 (88.6%) had stage 1, 6 (8.6%) stage 2, and 2 (2.6%) stage 3. Median [IQR] Cr_{DAY2} was 71 [57-90] µmol/L and it was measured after a median [IQR] of 25.4 [24.3-26.8] hours from ICU admission.

Acute kidney injury on Day 2

On day 2, 148 patients (19.0%; 95% CI 16.2-21.7%) were diagnosed with AKI. Stage 1 AKI was present in 117 (15.0%), stage 2 in 19 (2.4%) and stage 3 (including RRT) in 12 (1.5%) patients. Altogether, seven patients commenced RRT before the Cr_{DAY2} measurement (five of them also fulfilling Cr AKI criteria based on Cr_{DAY2}). On Day 2, of the 70 patients with AKI already diagnosed based on by Cr_P 11 (15.7%) had resolved their AKI, 37 (52.95) had stage 1, 12 (17.1%) stage 2, and 10 (14.3%) stage 3 AKI.

Table 1 presents patient characteristics, ICU treatment, and length of ICU and hospital stay according to the presence of AKI on Day 2. Hospital mortality among patients with Day 2 AKI was 20 of 148 (13.5%; 95% CI 8.0-19.0%) compared to 55 of 631 (8.7%; 95% CI 6.5-10.9%) in those without Cr AKI at that time point, P=0.088. Among the 472 emergently admitted patients, hospital mortality was 69 (14.6%). Of those 68 emergently admitted with AKI 16 (23.5%; 95% CI 13.4-33.6%)) did not survive whereas 53 of 404 (13.1%; 95% CI 9.8%-16.4%) non-AKI patients were non-survivors (P=0.024). Three (1.4%) of 212 elective cardiac surgical patients did not survive hospitalization, 2 of whom had AKI.

Delta-Cr-% and prediction of AKI on Day 2

In all patients, regardless of AKI diagnosed based on Cr_P, the AUC of delta-Cr-% for the development of Day 2 AKI was 0.82 (95% CI 0.78-0.86). After excluding patients who filled the Cr AKI diagnosis with their Cr_P (n=70), 89 (12.5%) of 710 patients had AKI based on Cr_{DAY2}. In these patients, the AUC for delta-Cr-% to predict AKI on day 2 was 0.74 (95% CI 0.69-0.80). Table 2

presents cut-off values for delta-Cr-% in the whole cohort and in the subgroups determined with Youden's index and the derived diagnostic parameters.

Table 3 presents the risk model for AKI on Day 2. The final model included patient sex, diagnostic category, APACHE III severity score as well as use of vasoactives or blood products within 6 hrs of ICU admission. When delta-Cr-% was added in the model, the performance improved significantly (Table 4). The result was robust to a sensitivity analysis excluding patients with AKI diagnosed with Cr_P (n=70). The model with delta-Cr-% performed well also among patients with emergency admission to ICU or elective cardiac surgery (Table 4).

Discussion

Key findings

In a cohort of unselected patients admitted to a general ICU, almost one in five developed AKI by the following day. Change in point-of-care Cr from ICU admission to approximately 8 hours after admission predicted subsequent AKI development the following day with an AUC of 0.82. Adding the delta-Cr-% to a clinical risk model markedly improved the predictive ability of the model. The results were robust to exclusion of those patients who had already developed AKI by the time of measurement of the Cr_P value and remained essentially unchanged in subgroups of emergently admitted patients and elective cardiac surgical patients.

Relationship to previous literature

Our results corroborate those from cohort studies among cardiac surgical patients that have reported that small, early changes of Cr perform well in predicting subsequent AKI.[8, 17] Our results markedly expand these observations as our cohort was a mixed critically ill patient cohort. The AUC of delta-Cr-% for predicting AKI on the following day was 0.82 (0.74 if patients classified as having AKI based on the Cr_P are excluded), which is similar to that of many novel urine or plasma biomarkers and clinical prediction models, especially in undifferentiated mixed populations of ICU patients.[5] Moreover, adding the delta-Cr-% to a clinical risk model predicting AKI improved the predictive power of the model significantly, with cfNRI of 90% and IDI 0.20. For comparison, adding IGFB-7 * TIMP-2 to a clinical risk model yielded an cfNRI of 70% and IDI 0.098.[18] We found a sensitivity of 71.6% and a specificity of 79.4% for the cutoff of 17.1% for Day 2 AKI, also within reasonable limits for diagnostic purposes.

In approximately 40% of the patients with AKI on Day 2, the Cr-based diagnosis could be made much earlier using the Cr value obtained about 8 hrs from ICU admission. A recent prospective analysis found that Cr measured only 3-4 hours from ICU admission was also a sensitive predictor of subsequent AKI.[9] Together these findings support the role of more frequent monitoring of Cr to achieve an earlier diagnosis of developing AKI.

Time to reach AKI diagnosis based on percentage increases in Cr is highly dependent on the baseline Cr.[19] Patients with normal baseline kidney function reached diagnosis of AKI based on percentage or absolute increase in Cr fast, even within a few hours, depending

on the severity of insult in a simulation study.[20] These findings were validated in a cohort of cardiac surgical patients.[21] Our results among patients with normal baseline kidney function corroborate these findings.

Clinical implications

Our findings imply that measuring Cr more frequently using point-of-care technology could help to predict AKI occurring the next day. Its performance in predicting AKI was similar or better than many novel biomarkers.[5] Given that Cr is an easily available and inexpensive laboratory test, our findings also imply that the comparative utility of point-of-care Cr measurements in predicting AKI in a heterogeneous critically ill population should be tested in prospective multicenter cohorts.

Strengths and limitations

The strengths of our analysis include a unique database with routine frequent point-of-care measured Cr values from a large cohort of patients. Moreover, patients were not selected but rather represented a heterogeneous group of ICU patient as are admitted every day where the issue of early diagnosis arises. In addition, delta-Cr-% performed well in subgroups of emergency admissions and elective cardiac surgical patients strengthening our findings. Our results were robust to different assessment methodologies providing evidence of their reliability. Finally, by showing that simply measuring Cr more frequently (a very low-cost test) may be as good as more expensive approaches with novel biomarkers, it provides a novel, simple and inexpensive comparator against which future biomarker studies would have to be tested.

This analysis, however, has some limitations. It was a retrospective database audit from a single center, and thus, has all the inherent limitations of such an approach. In the critically ill, several confounders affecting Cr-based AKI definitions have been identified. These include volume overload and subsequent dilution of Cr,[22] malnutrition, and muscle wasting.[13] We did not find difference in cumulative fluid balances among patients with and without AKI in the first 6 hours, and thus, the Cr_P value is unlikely to be affected by fluid balance.[23] Significant muscle wasting and malnutrition are unlikely to have occurred within the first 24 hours of intensive care. The incidence of AKI in our cohort was slightly lower than in other reports[1, 2] likely

because we excluded patients with increased Cr on ICU admission. This exclusion also led us to study a cohort that had predominantly stage 1 AKI and an overall low hospital mortality rate.

No true baseline Cr[7] was available, and we used the Cr_F instead. This may have led to underestimation of AKI incidence.[24] On the other hand, we restricted analysis to those admitted to ICU with apparently normal Cr to minimize this bias. Furthermore, we did not have sufficient data to assess urine output criteria. Thus, the AKI incidence might have been higher than reported, and the predictive ability of delta-Cr-% less than observed. Additionally, the diagnosis of AKI might have been evident based on urine output before a rise in Cr was detected.[25] However, as such measurement were performed on average within 8 hours and very few patients would have sufficient time to reach the urinary output criteria for KDIGO AKI before such second measurement. Finally, we collected routine data from the databases and could not adjust for many known risk factors for AKI, such as drugs harmful to the kidneys, which might have improved the performance of a clinical risk model without delta-Cr-% and allowed us to use some of the pre-existing risk models.[26] Despite these limitations, the predictive ability of delta-Cr-% appeared very promising and worth investigating in future prospective studies.

Conclusions

Small increases in point-of-care Cr values developing rapidly after ICU admission were frequent among critically ill patients admitted with normal Cr values. The delta-Cr-% from ICU admission value to a value measured approximately 8 hours from admission performed well in predicting subsequent AKI on the following day. More frequent measurement of Cr by point-of-care may be a simple, inexpensive and easy to perform predictive test and represent a performance benchmark for future biomarker studies.

Acknowledgements

STV has received a Fellowship Grant from the Sigrid Juselius Foundation and funding for Clinical Researchers (317061) from the Academy of Finland.

The authors declare no conflicts of interest.

Figure 1: Flow chart

AKI; acute kidney injury, Cr; creatinine, ESRD; end-stage renal disease, ICU; intensive care unit, LOS; length of stay, RRT; renal replacement therapy

Table 1. Characteristics of all patients and compared according to presence of acute kidney injury on Day 2.

	All patients	AKI on Day 2	No AKI on day 2	P-value
No of patients	780	148	632	
Delta Cr umol/L	5.0 [-2.0-13.0]	19.0 [8.3-30.0]	3.0 [-3.0-9.0]	<0.001
Delta %	8.5 [-2.5-20.4]	27.8 [13.6-41.6]	5.6 [-4.2-14.8]	<0.001
Age -years	63.0 [48.9-73.0]	66.7 [54.8-78.0]	62.5 [47.3-71.5]	0.001
Male Sex	478/780 (61.3%)	84/148 (56.8%)	394/632 (62.3%)	0.223
Operative admission	437/772 (56.0%)	105/148 (70.9%)	332/632 (52.5%)	<0.001
Emergency admission	473/780 (60.6%)	68/148 (45.9%)	405/632 (64.1%)	<0.001
Elective cardiac surgery	212/780 (27.2%)	62/148 (41.9%)	150/632 (23.7%)	<0.001
Admitted from				
Emergency department	146 (18.7%)	16/148 (10.8%)	130/632 (20.6%)	0.005
Operating room	438 (56.2%)	105/148 (70.9%)	333/632 (52.7%)	<0.001
Ward	176 (22.6%)	27/148 (18.2%)	149/632 (23.6%)	0.190
Other ICU	20 (2.6%)	0/148 (0%)	20/632 (3.2%)	0.020
Within 6 hrs				
On mechanical ventilation	608/780 (77.9%)	125/148 (84.5%)	483/632 (76.4%)	0.036
Received vasopressors	393/780 (50.4%)	98/148 (66.2%)	295/632 (46.7%)	<0.001
Received sedation	583/780 (50.4%)	115/148 (77.7%)	468/632 (74.1%)	0.401
Received blood products	116/780 (14.9%)	42/148 (28.4%)	74/632 (11.7%)	<0.001
Total amount of iv fluids - mL	743.0 [294.5-1683.8]	973.0[343.0-2084.3]	702.0 [278.5-1582.5]	0.026
Cumulative urine output - mL	770 [420.0-1409.5]	747.5 [416.3-1435.0]	770.0 [420.0-1383.8]	0.923
Fluid balance-mL	-181.5 [-706.5-521.3]	-38.5 [-707.0-716.3]	-205.0 [-704.8-441.3]	0.210
Within 24 hrs				
On mechanical ventilation	622/780 (79.7%)	129/148 (87.2%)	493/632 (78.0%)	0.012
Received vasopressors	509/780 (65.3%)	119/148 (80.4%)	390/632 (61.7%)	<0.001
Received sedation	633/779 (81.3%)	129/148 (87.2%)	504/631 (79.9%)	0.046
Received blood products	180/780 (23.1%)	61/148 (41.2%)	119/632 (18.8%)	<0.001
Total amount of iv fluids - mL	2842.0 [2014.0-4056.0]	3116.0 [2086.8-4331.3]	2808.0 [1974.0-3987.0]	0.092

Cumulative urine output -mL	2147.5 [1557.8-2939.0]	1775.5 [1178.5-2662.5]	2197.0 [1634.0-2992.3]	<0.001
Fluid balance -mL	317.0 [-730.0-1475.0]	619.0 [-313.3-1684.5]	219.0 [-853.0-1379.0]	0.002
APACHE III score	53 [41-67]	58.5 [48.3-71.8]	52.0 [39.0-67.0]	<0.001
ICU length of stay -days	2.8 [1.9-4.7]	3.06 [2.0-6.0]	2.7 [1.9-4.6]	0.001
Hospital length of stay -days	11.3 [7.4-21.9]	13.5 [8.2-15.2]	11.0 [7.3-21.3]	0.011

Continuous data presented as median [interquartile range] and categorical as count and percentage.

AKI; acute kidney injury

APACHE; Acute Physiology and Chronic Health Evaluation

Cr; Creatinine

ICU; Intensive Care Unit

Table 2. Diagnostic parameters of delta-creatinine-percentage to predict acute kidney injury on Day 2.

Patient group (n)	AKI on Day 2 -n (%)	Sensitivity	Specificity	AUC	Cut-off %	Positive likelihood ratio
All patients (780)	148 (19.0)	71.6 (63.3-78.7)	79.4 (76.0-82.5)	0.822 (0.782-0.863)	17.1	3.5 (2.9-4.2)
AKI positive with predictor Cr excluded (710)	89 (12.5)	78.7 (68.7-86.6)	62.5 (58.5-66.3)	0.744 (0.687-0.800)	9.2	2.1 (1.8-2.4)
Emergency admission (473)	68 (14.4)	75.0 (0.63.0-84.7)	76.3 (71.8-80.4)	0.815 (0.755-0.875)	11.1	3.16 (2.53-3.95)
Elective cardiac surgery (212)	62 (29.2)	64.5 (51.3-76.3)	82.7 (75.6-88.4)	0.801 (0.734-0.867)	23.4	3.7 (2.5-5.5)

Numbers in parenthesis indicate 95% confidence intervals.

AKI; acute kidney injury

AUC; area under the curve

Table 3. Construction of the risk model for acute kidney injury on Day 2.

Covariate*	**Univariate odds ratio (95% CI)**	**P-value**	**Multivariable Model 1 odds ratio (95% CI)****	**P-value**
Age	1.02 (1.01-1.03)	<0.001		
Male Sex	0.79 (0.55-1.14)	0.210	0.68 (0.46-0.997)	0.048
Operative admission	2.21 (1.50-3.25)	<0.001		
Emergency admission	0.48 (0.33-0.68)	<0.001***		
Diagnostic category	0.90 (0.84-0.95)	<0.001	0.90 (0.85-0.95)	<0.001
APACHE III score	1.01 (1.00-1.02)	0.006	1.02 (1.01-1.03)	<0.001
On mechanical ventilation within 6 hrs	1.68 (1.04-2.71)	0.035		
Received vasopressors within 6 hrs	2.24 (1.54-3.26)	<0.001	1.70 (1.14-2.53)	0.009
Received sedation within 6 hrs	1.22 (0.80-1.87)	0.358		
Received blood products within 6 hrs	2.99 (1.94-4.60)	<0.001	2.33 (1.49-3.67)	<0.001
Total amount of iv fluids within 6 hrs				
1st quartile (<295mL)	reference			
2nd quartile (295-743mL))	1.11 (0.65-1.91)	0.696		
3rd quartile (744-1684mL)	1.25 (0.74-2.13)	0.405		
4th quartile (>1684mL)	1.85 (1.11-3.06)	0.018		
Cumulative urine output quartile within 6h				
4th quartile (>1410mL)	reference			
3rd quartile (771-1410mL)	0.72 (0.43-1.20)	0.206		
2nd quartile (421-770mL)	0.83 (0.51-1.37)	0.463		
1st quartile (<420mL)	0.87 (0.53-1.42)	0.581		
Fluid balance quartile				

within 6 hrs				
1st quartile (< -707mL)	reference			
2nd quartile (-707 - -182mL)	0.69 (0.41-1.18)	0.178		
3rd quartile (-183-521 mL)	1.03 (0.63-1.70)	0.899		
4th quartile (>521mL)	1.17 (0.72-1.91)	0.533		
Delta Creatinine %	1.07 (1.06-1.09)	<0.001		

*Bolded covariates were entered in a multivariable forward stepwise logistic regression model.

** The variables remaining in the final model. Hosmer-Lemeshow chi-square 6.309, p=0.613

Model area-under-the curve (95% CI) for AKI on day 2 0.69 (0.65-0.74)

*** excluded from the risk model due to collinearity with operative admission

APACHE; acute physiology and chronic health evaluation

Table 4. Performance of the risk model for Day 2 acute kidney injury with and without delta-Cr-percentage.

	N total	N events	Model 1 goodness of fit	Model 1 AUC (95% CI)	Model 2 goodness of fit	Model 2 AUC (95%CI)	P-value for comparison of AUCs	Category-free NRI (%)	IDI
All patients	780	148	6.15, p=0.63	0.70 (0.65-0.74)	6.19 p=0.63	0.83 (0.79-0.87)	<0.001	90.0 (74.9-106.1)	0.20 (0.16-0.24)
AKI positive with predictor Cr excluded	710	89	4.51, p=0.808	0.67 (0.61-0.73)	8.26 p=0.408	0.76 (0.71-0.81)	0.002	64.3 (43.3-85.2)	0.06 (0.04-0.09)
Emergency admissions	473	68	7.68 p=0.465	0.69 (0.63-0.76)	7.65, p=0.468	0.84 (0.79-0.90)	<0.001	101.6 (79.4-123.8)	0.20 (0.14-0.27)
Elective cardiac surgical patients	212	62	3.86 p=0.870	0.70 (0.63-0.78)	4.43 p=0.817	0.82 (0.76-0.88)	<0.001	75.5 (48.0-103.0)	0.20 (0.14-0.26)

Numbers in parenthesis indicate 95% confidence intervals. Goodness-of-fit assessed with Hosmer-Lemeshow test.

Model 1; risk model for AKI without delta Cr

Model 2; risk model for AKI with delta-Cr

Risk model includes: patient sex, APACHE II diagnostic group, APACHE III score, need for vasoctives (within 6 hrs of ICU admission) and need for blood products (within 6 hrs of ICU admission).

APACHE; acute physiology and chronic health evaluation

AUC; area under the curve

NRI; net reclassification index

IDI; integrated discrimination index

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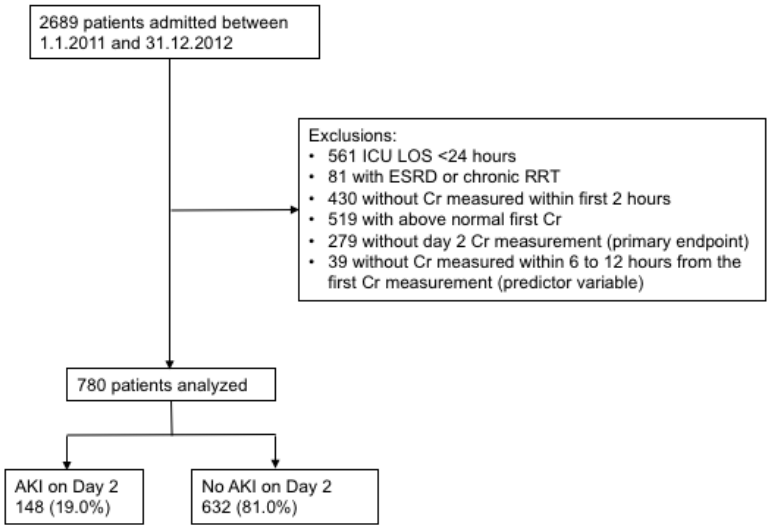

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