Furosemide Stress Test and Renal Angina Index for the Prediction of AKI

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Background

Reliable prediction of acute kidney injury (AKI) has the potential to optimize its treatment. Recently Goldstein SL et. al. (Clin J Am Soc Nephrol. 2010;5: 943–949.) proposed an empiric clinical model of renal angina to identify critically ill children who would be at higher risk of AKI. A different approach was proposed by Chawla et. al. (Crit Care 2013 Sep 20; 17(5): R207) the furosemide stress test (FST). These two different approaches aim to delineate patients at risk for subsequent severe AKI (AKI beyond the period of functional injury) versus those at low risk.

Objectives

a. To assess the performance of the FST and the RAI to predict the subsequent development of AKI using KDIGO serum creatinine and urinary volume criteria.

b. To evaluate which of the tests will have better performance in predicting the subsequent development of AKI

Hypothesis

We test the hypotheses that in a cohort of adult critically-ill patients, the modified renal angina index (RAI) will perform better than the furosemide stress test (FST) in identifying patients at high risk of developing AKI.

Patients and Methods

We analyzed data from 58 hospitalized patients admitted to a Medical ICU.

We measured serum creatinine (sCr) every 24 hours for 7 consecutive days following ICU admission, and urinary volume was assessed hourly each 24 hours.

At admission (day 0), **RAI** was calculated using the following formula: **Risk level** (presence of sepsis, use of vasopressors, use of invasive mechanical ventilation, and presence of DM) ***x*** **Injury level** (changes in eGFR**) [Figure 1]**.

We applied the **FST** at day 0 (as describe by Chawla et. al. in Crit Care 2013 Sep 20; 17(5): R207). We assessed the performance of the FST and the RAI to predict the subsequent development of AKI using KDIGO serum creatinine and urinary volume criteria.

Patients and Methods

Figure 1 - Renal Angina Index (1-40)

RISK LEVEL

Patient Type	Risk Level	Score
Sepsis or ICU admit	Moderate	1
Diabetes or Stem-Cell Transplant	High	3
Ventilation and Inotropy	Very High	5

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INJURY LEVEL

Decrease in eCrCl%	% FO	Score
No change	≤5	1
0 – 24.99%	5-9.99	2
25-50%	10-14.99	4
≥50%	≥15	8

= RENAL ANGINA INDEX (1-40)

Results

Table 1 - General characteristics of patients at ICU admission

	Combined	AKI	NON-AKI	*P-value*
Age	62.6 (16.9)	67(20.8)	60.8(17.3)	0.125
Gender				
Male	16(53.3 %)	4(100%)	12(46%)	0.35
Female	14(46.7%)	0	14(53.8%)	0.69
Weight	68.1 (10.8)	72.5(6.4)	68(11.6)	0.49
Co-Morbidities				
Cardiac failure	4 (13%)	1 (25%)	3 (11.5%)	0.592
Chronic hepatic disease	4 (13.3%)	1 (25%)	3 (11.5%)	0.592
Diabetes	9 (30%)	3 (75%)	6 (23%)	0.524
Sepsis	11 (36.7%)	0 (0%)	11 (42%)	0.166
Hypoalbuminemia	15 (50%)	2 (50%)	13 (50%)	0.656
CKD	2 (6.7%)	0 (0.0%)	2 (7.7%)	0.520
SOFA score	3.6 (2.07)	6.25 (2.6)	3.15 (1.67)	0.016
Previous use of furosemide				
First time	21 (70%)	4 (100%)	17 (80.9%)	0.56
Previous use	9 (30%)	0 (0.0%)	9 (100%)	0.43

Of the 58 patients included in this study, 5 (8.6%) patients met the primary end point of AKI (serum creatinine KDIGO criteria) and 4 (6.8%) using urinary volume KDIGO criteria.

The performance of the renal angina index and the furosemide stress test were as follows: Renal Angina Index had the best performance with a ROC AUC of 1.00 ($p < 0.0021$); followed by the Furosemide Stress Test with a ROC AUC of 0.909 ($p = 0.003$) but we consider a cut-off point of < 600 cc of urine at 2 hours since none of the patients who developed AKI had <200 cc of urine as the original cut-off value proposed by Chawla et. al. **[Figure 2]**

The sensitivity, specificity, PPV and NPV of the 3 tests used are shown on table 2.

Results

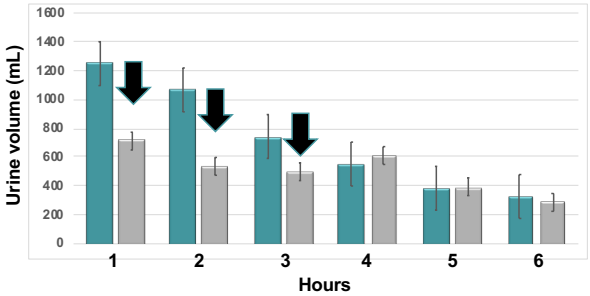

Figure 2. Urinary volume during the first 6 hours post administration of furosemide. The urinary volume was significantly lower during the fist 3 hours in patients who developed AKI (gray bars); *$p < 0.05$.

In relation of adverse events of furosemide stress test 6 patients (10%) developed hypotension (MAP < 65 mmHg) and 11 patuents (17%) developed hypokalemia.

Table 2 - Diagnostic performance of renal angina index and the furosemide stress test

Performance of the FST and RAI	Furosemide stress test	Renal angina index
Sensitivity (%)	100	100
Specificity (%)	79.2	96.2
PPV (%)	31.2	71.4
NPV (%)	100	100
ROC – AUC (p value)	0.909 (0.003)	1.00 (< 0.001)

Conclusions

The Furosemide Stress Test and the Renal Angina Index have robust predictive capacity to identify critically ill patients at high risk of developing AKI before a rise in serum creatinine occurs.

These preliminary data of our ongoing study warrants future studies to validate these findings.

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