Intraoperative Renal Resistive Index with Adjustment for Aortic Insufficiency for Acute Kidney Injury Prediction in Cardiac Surgery Patients

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Background

- Acute kidney injury (AKI) following cardiac surgery is associated with significant morbidity and mortality.
- Serum creatinine has limitations; renal resistive index (RRI) is a novel biomarker for earlier AKI diagnosis. Figure 1.
- Elevated RRI, via TEE after cardiopulmonary bypass (CPB), predicts subsequent AKI [1].
- Aortic insufficiency (AI) causes low diastolic flow, and likely falsely elevates RRI after CPB [2]
- **We hypothesized that pre-CPB RRI values, with adjustment of RRI for AI, could improve AKI prediction in cardiac surgery (vs. without adjustment for AI).**

Methods

- Single center, IRB approved, retrospective convenience sample study of adult cardiac surgery patients from July 1, 2013 through August 1, 2017 with pre-CPB TEE renal Doppler blood flow measurements.
- Exclusion criteria: surgeries without CPB, pts without aortic valve assessment, missing creatinine values, or preoperative GFR<60
- AKI defined via Kidney Disease: Improving Global Outcomes (KDIGO) criteria (no urine criteria). “AI” defined as moderate or severe AI on pre-CPB TEE.
- Linear regression was used to assess relationship between AI and RRI in pre-CPB setting. RRI elevation due to AI was then corrected.
- Several logistic regression models to predict AKI were then assessed: (1) unadjusted pre-CPB RRI alone; (2) adjusted pre-CPB RRI alone; (3) unadjusted pre-CPB RRI in addition to post-CPB RRI (Post-Pre); (4) adjusted Post-Pre CPB RRI; and (5) unadjusted post-CPB RRI alone.
- Models were compared using receiver operator characteristic (ROC) curves and the c-statistic (area under the ROC curve).

Figure 1: Renal resistive index formula using pulsed wave doppler on TEE

$$RRI = \frac{\text{peak systolic velocity - trough diastolic velocity}}{\text{peak systolic velocity}}$$

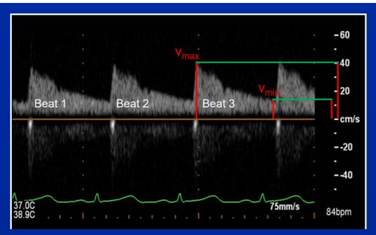
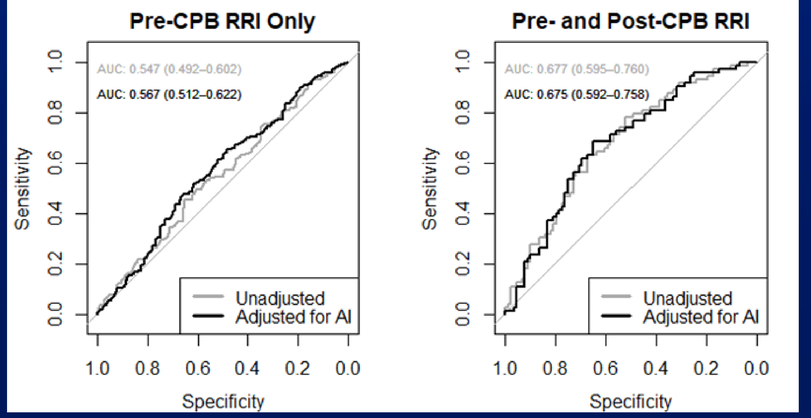


Table 1: RRI values stratified by AKI and aortic valve status

	n Pre Total = 421	Pre-CPB mean RRI (SD)	n Post-Pre Total = 161	Post–Pre mean CPB RRI (SD)	n Post Total = 253	Post-CPB mean RRI (SD)
Aortic Insufficiency	61 (14 %)	0.736 (0.083)	30 (19%)	0.0049 (0.114)	50 (20%)	0.734 (0.090)
AKI	28 (46%)	0.750 (0.074)	15 (50%)	-0.0116 (0.0952)	17 (34%)	0.731 (0.075)
No AKI	33 (54%)	0.725 (0.089)	15 (50%)	0.0215 (0.131)	33 (66%)	0.736 (0.098)
No Aortic Insufficiency	360 (86%)	0.683 (0.081)	131 (81%)	0.0512 (0.0801)	203 (80%)	0.728 (0.076)
AKI	170 (47%)	0.688 (0.081)	58 (44%)	0.0560 (0.0708)	88 (43%)	0.736 (0.074)
No AKI	190 (53%)	0.679 (0.082)	73 (56%)	0.0473 (0.0870)	115 (57%)	0.722 (0.078)

Figure 2: ROC curves for AKI predictive models utilizing RRI



Results

- 421 pre-CPB renal Doppler studies were included for analysis, of which 161 had paired post-CPB studies. AI was present in 61 cases (14% of Pre group) and AKI occurred in 198 cases (47% of Pre) (table 1).
- Pre-CPB RRI alone was a poor predictor of post-operative AKI (AUC 0.547; fig. 2) and adjustment for AI did not improve predictive ability (AUC 0.567).
- Similarly, post-CPB RRI AUC was 0.539.
- Models utilizing both pre- and post-CPB RRI improved predictive performance for AKI vs. pre-CPB RRI or post-CPB RRI only, but adjustment for AI did not substantially improve prediction (AUC unadjusted 0.677; adjusted 0.675).

Conclusion

- Utilization of both pre- and post-RRI values improved predictive performance for post-operative AKI over pre-CPB or post-CPB RRI alone.
- The change from Pre- to Post-CPB RRI should reflect the clinical characteristics of CPB period, which may contribute to renal insult.
- However, RRI adjustment for AI did not improve performance; evaluation of other perioperative factors that impact RRI variability is warranted.

References

1. Cherry AD et al. Intraoperative renal resistive index threshold as an acute kidney injury biomarker. J Clin Anesth. 2019. 2020 May;61:109626.
2. Andrew BY et al. The Association of Aortic Valve Pathology With Renal Resistive Index as a Kidney Injury Biomarker. Ann Thorac Surg 2018;106:107-14