

Acute Kidney Injury in Infants Undergoing the Arterial Switch Operation; Impact of Early Post-Operative Hemodynamics

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Background

- Acute kidney injury (AKI) is common following neonatal surgery with cardiopulmonary bypass (CPB), and is associated with increased morbidity and mortality.
- Risk factors for AKI in the pediatric cardiac surgery population include age, surgical complexity, CPB time, and pre-existing renal injury.
- Little is known of the impact of the early ICU course on the incidence of AKI in this population.

Aims

- To investigate the impact of early post-operative hemodynamics on AKI
- To identify threshold levels of vital signs and ICU parameters associated with AKI to better guide goal directed therapy

Methods

- Single center review of 98 consecutive infants undergoing ASO ± VSD closure from 2002-2012
- Exclusions: pre-existing renal anomaly
- Physiologic Data: hourly for 24 post-op hours;
 - Urine output
 - Renal perfusion pressure (RPP=MABP-CVP)
 - Renal a-v saturation difference, from arterial saturation and renal somatic saturation by NIRS: ($\Delta rSO_2R = SaO_2 - rSO_2R$)
 - Inotrope doses; Vasoactive inotropic score (VIS)
- Outcomes of interest:
 - AKI: defined as increase in creatinine of $\geq 50\%$ or $\geq 0.3\text{mg/dL}$ from pre-op to 48 hours postop
 - Peak post-operative creatinine (at 48 hours)
- Statistical Analysis:
 - Outcome AKI:
 - Bivariate analysis using: Fisher exact or Wilcoxon as appropriate
 - Stepwise logistic regression analyses
 - Outcome Peak Creatinine:
 - Multiple linear regression with backward elimination

Results

Clinical Variables Stratified by AKI

Variable (median, IQR)	No AKI (n=79)	AKI (n=19)	p
Age at OR (days)	8 (6-14)	7 (6-11)	.49
Gestational Age	40 (39-40)	40 (37-40)	.74
Diagnosis			.8
ASO	53 (67%)	12 (63%)	
ASO + VSD	26 (33%)	7(37%)	
CPB Time	194 (170-225)	207 (188-237)	.1
XCT	130 (110-147)	136 (115-151)	.37
LOS (days)	11 (8-15)	13 (9-20)	.13
Pre-op Creat (ng/dL)	0.6 (0.47-0.63)	0.5 (0.4-0.5)	.016
Peak 48 hour Creat	0.6 (0.51-0.8)	0.8 (0.78-1)	<.001
Change in Creat	0.1 (0.02-0.12)	0.3 (0.3-0.5)	<.001

Vital Sign and ICU Variables Stratified by AKI

Variable (median, IQR)	No AKI (n=79)	AKI (n=19)	p
Urine output (ml/hr)	11.2 (9.3-13.5)	8.6 (5.3-12.9)	.007
Hours UOP < 2 mL/hr	0 (0-1)	1 (0-5)	.024
HR (bpm)	172 (155-180)	172 (160-179)	.62
MABP (mmHg)	49.6 (47-52)	46.9 (45-51)	.052
CVP (mmHg)	8.1 (7.2-9.6)	9 (7.7-10)	.1
RPP (MAP-CVP)	41.3 (39-44)	38.6 (37-42)	.015
Hours RPP<30	0 (0-0)	1 (0-1)	.002
VIS	12.3 (8.8-18)	14.2 (10.5-19)	.14
Hours VIS>30	0 (0-0)	0 (1-1)	.034
rSO ₂ (%)	89 (82-92)	87 (80-91)	.44
ΔrSO_2R	7.3 (4.2-12.3)	8.7 (5-14.5)	.35

Table Abbreviations: AKI, acute kidney injury; ASO, Arterial switch operation; VSD, ventricular septal defect; CPB, cardiopulmonary bypass; XCT, cross clamp time; LOS, length of stay; Creat, creatinine; UO, urine output; HR, heart rate; MABP, mean arterial blood pressure; CVP, central venous pressure; RPP, renal perfusion pressure;

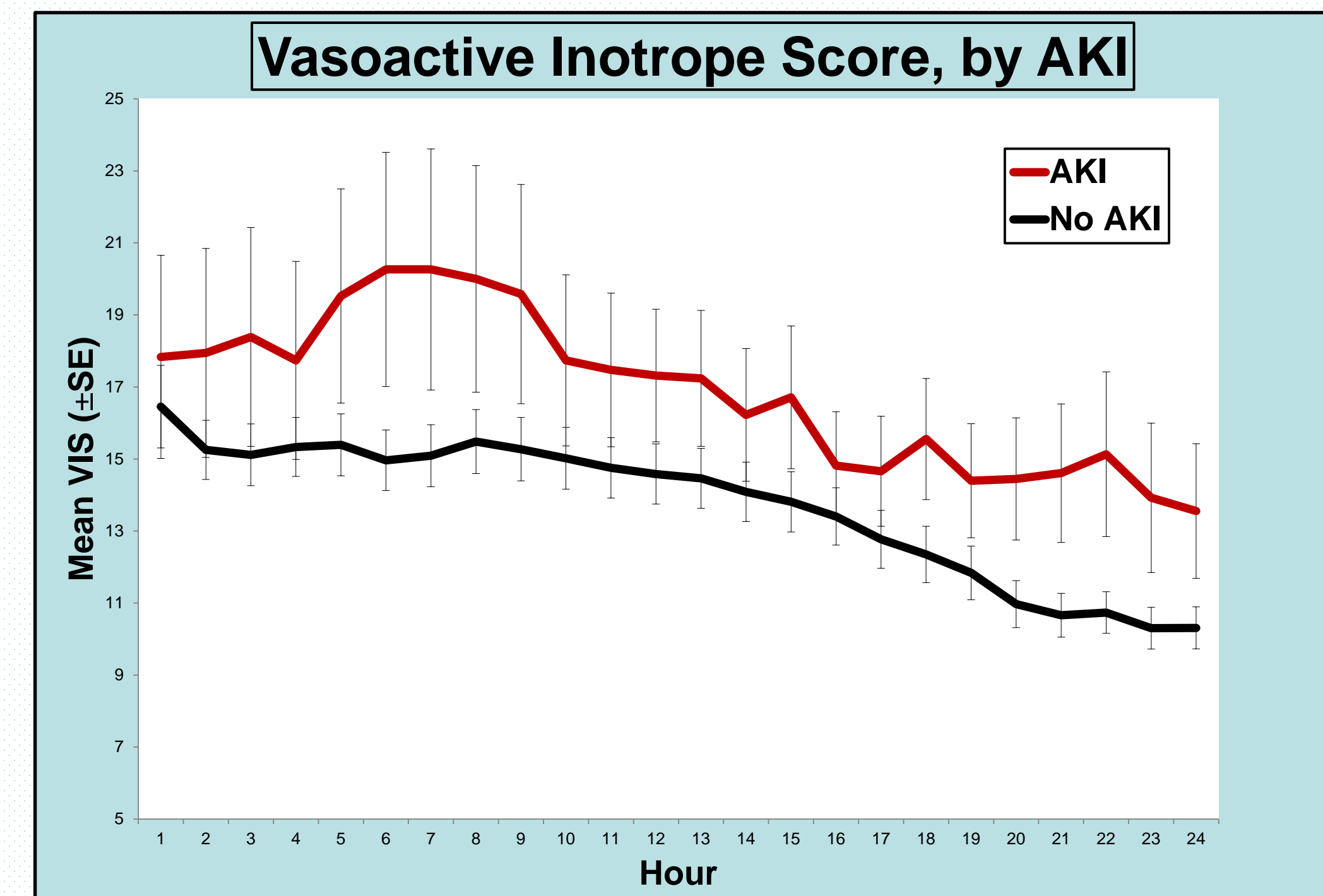
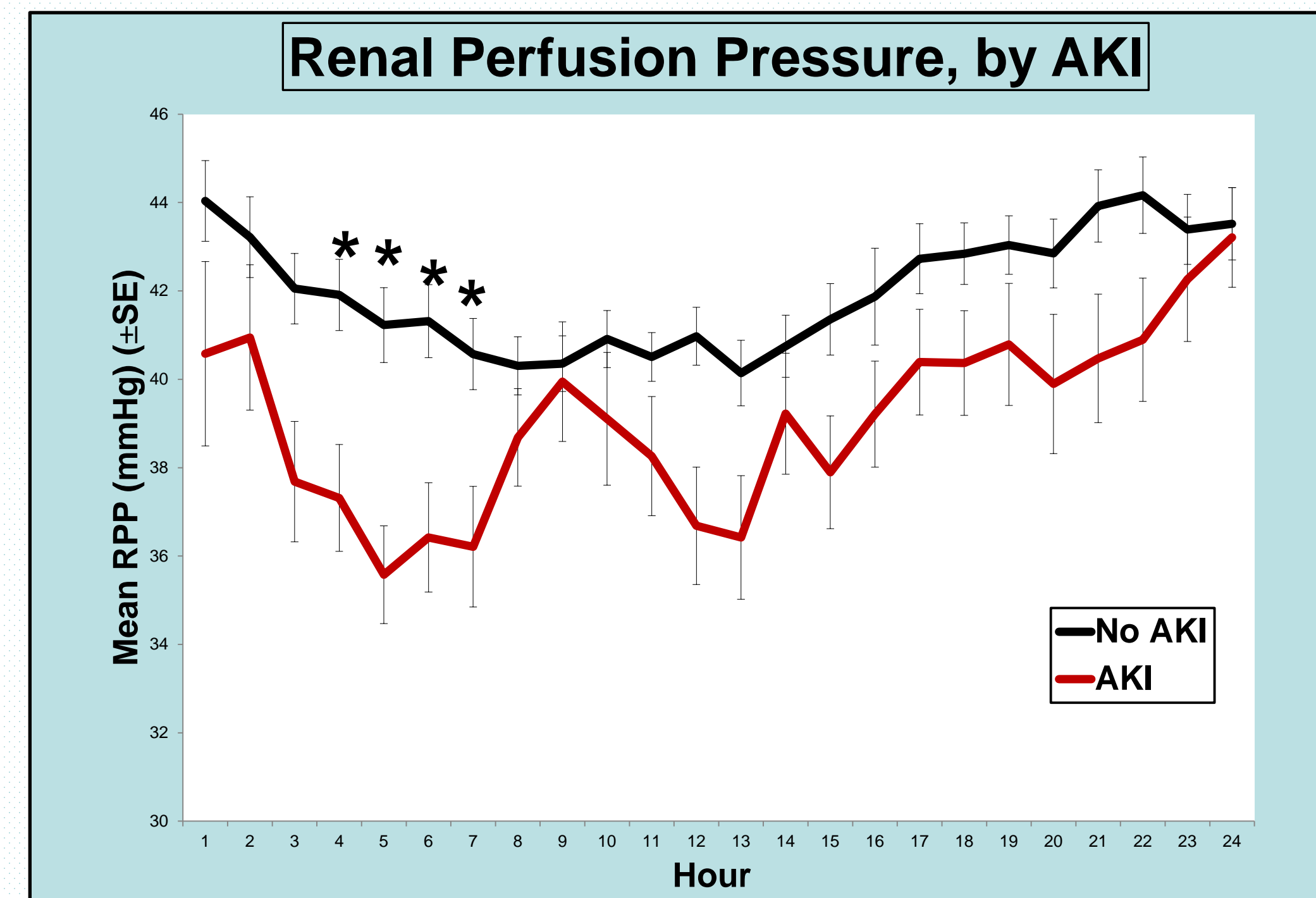
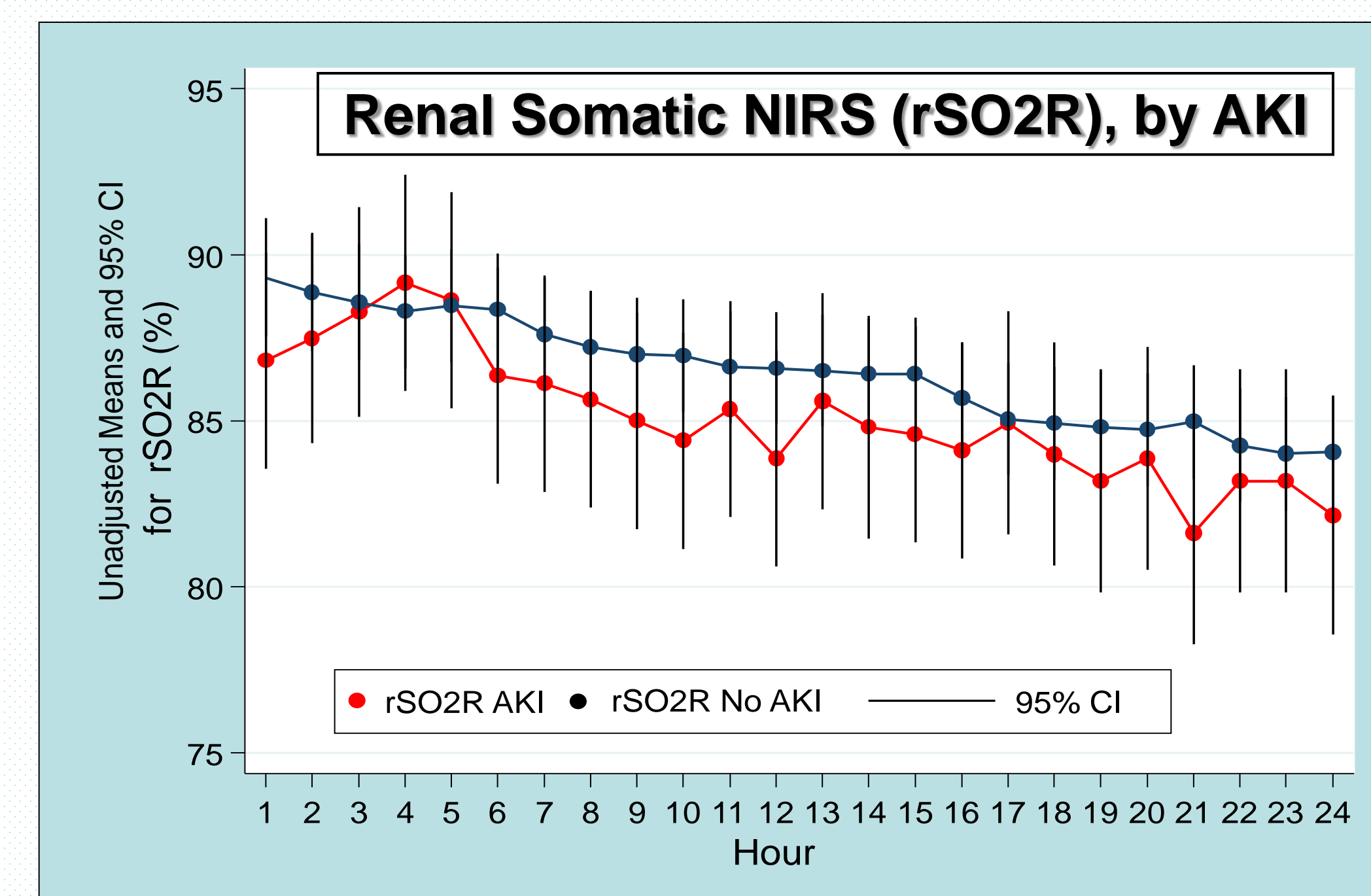
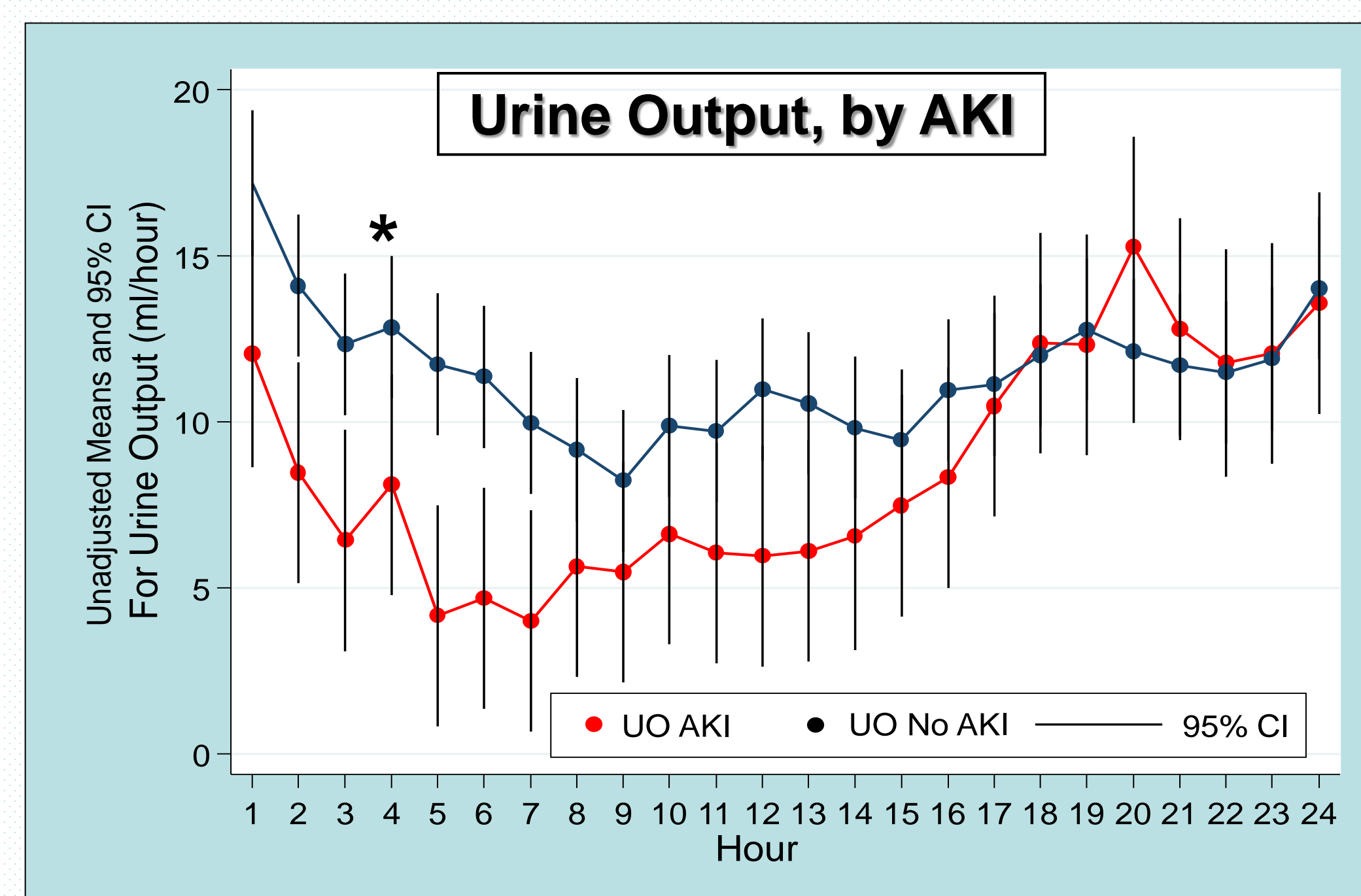


Figure notes: Data points represent mean values with 95% CI or SE; * denotes statistical significance at the p<.002 level between curves with correction for multiple comparisons



Multivariable Analysis

Outcome: AKI

Variable	OR (95% CI)	P-value
Urine Output	0.821 (0.697, 0.966)	.018
Hours with RPP < 35 mmHg	1.183 (1.049, 1.335)	.006

Outcome: Peak Creatinine

Variable	Parameter estimate	P-value
Hours with RPP < 30 mmHg	0.043	0.010
Age at surgery	-0.009	<.0001
Hours with $\Delta rSO_2R > 30$	-0.062	0.037

Conclusion

- In this cohort the incidence of AKI is 19% (19/98)
- Variables associated with AKI include:
 - Lower pre-operative creatinine
 - Lower urine output
 - Lower renal perfusion pressure
 - Wider renal a-v difference
- This data may provide therapeutic targets for the prevention and treatment of post-CPB AKI
- For each hour of RPP<35 the risk of AKI increased by 18%, and those with RPP < 30 or a $\Delta rSO_2R > 30$ had higher peak creatinine**

Future Directions

- AKI definitions incorporate pre-op creatinine, which may be artifactually elevated in neonates.
- Future studies are needed to refine AKI risk scores specific to neonates undergoing CPB
- The inclusion of urine output in AKI risk scores should be reconsidered in this population
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