Severe acute kidney injury after Norwood operation predicts subsequent injury at the superior cavo-pulmonary anastomosis.

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Background: Acute kidney injury (AKI) is a common complication of neonatal cardiac surgery. AKI has been associated with an increased risk of mortality and prolonged hospitalization following cardiac surgery, yet the long term implications of AKI are poorly understood. Children with hypoplastic left heart syndrome (HLHS) and other related single ventricle defects requiring aortic arch reconstruction typically undergo palliation consisting of three stages, with the Norwood operation (stage 1) during the early newborn period, followed by stage 2 at 4-6 months of age and stage 3 at 18-36 months of age. The primary objectives of this study were to: 1) measure the incidence of severe post-operative AKI in neonates with HLHS and related single ventricle defects following stage 1 operation and 2) determine the association of stage 1 post-operative AKI with post-operative AKI at stage 2 and at stage 3. Secondary objectives included investigating the association of severe AKI at stage 1 with stage 2 and 3 post-operative outcomes of interest such as need for extracorporeal membrane oxygenation (ECMO), mechanical ventilation time, total intensive care unit (ICU) length of stay, and death.

Methods: We performed a single center, retrospective study of patients with HLHS and other related single ventricle defects who underwent a Norwood operation between September 2007 and November 2012. Using the Kidney Disease: Improving Global Outcomes (KDIGO) criteria, severe AKI was defined as a post-operative serum creatinine increase of greater than 300% from pre-operative serum creatinine (stage 3 AKI). Fisher's exact test and Wilcoxon rank sum test, as appropriate, were used to determine the univariate association of severe AKI at stage 1 with severe AKI and other post-operative outcomes at stages 2 and 3. Multivariable logistic regression was then employed to examine an independent association of severe AKI at stage 1 with severe AKI at stage 2 adjusting for other variables.

Results: Of the 136 subjects who underwent stage 1 palliation during the study period, 98 (72%) underwent stage 2 palliation, and 73 (54%) underwent stage 3 palliation at our site. The incidence of severe AKI was 20.6% following stage 1, 12.2% following stage 2, and 9.6% following stage 3. On univariate analysis, severe AKI after stage 1 palliation was associated with an increased risk of developing severe AKI at stage 2 ($p=0.055$) but not at stage 3 ($p=0.59$). A multivariable model adjusting for gestational age and type of stage 1 operation demonstrated that severe AKI at stage 1 is an independent risk factor for severe AKI at stage 2 (adjusted odds ratio=4.28, 95% confidence interval=1.08-16.9). There was a significant association between severe AKI after stage 1 and total duration of mechanical ventilation at stage 3 (median 1 day vs. 0 days, $p=0.047$). There were no significant associations between severe AKI at stage 1 and the stage 2 or 3 outcomes of ECMO, total ICU length of stay, or death.

Conclusions: Severe AKI after stage 1 is an independent risk factor for severe AKI at stage 2 and should lead to increased awareness for developing severe AKI after stage 2. The small sample size at stage 3 limits our ability to draw conclusions about the impact on post-operative AKI following stage 3.