Understanding cardiac injury during complex pediatric cardiovascular surgery

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BACKGROUND: Children with complex congenital heart disease (CHD) are highly vulnerable, and require complex cardiovascular surgery (CVS). From the literature, a dominant variable determining their CVS outcomes is how long the heart must be stopped for repair. Myocardial protection (MP) during pediatric CVS has not been well studied. Currently, MP is achieved through infusions of 'cardioplegia', however the variability in type(s) of solutions used suggests a lack of consensus on best practice. Additionally, there are no large animal model described that accurately reflect pediatric CVS protocols, and thus little is known of the mechanisms determining poor outcomes.

METHODS: We surveyed 10 leading pediatric CVS centres to determine current standards of cardioplegia and MP. Based on this, we developed a new *in vivo* juvenile pig model of long aortic cross clamp (XC) and cardiopulmonary bypass (CPB) to understand the pathways involved in heart damage over 90- and 180-min of XC, representing clinically relevant durations needed for repair of complex CHD. Heart function was assessed by echocardiography and PV-loops. Metabolism and cardiac injury were assessed in serial systemic blood-gas sampling, lactate levels, and the cardiomyocyte injury marker, cardiac Troponin-I [cTnI].

RESULTS: Our survey revealed the most common MP solution to be del Nido cardioplegia. In our model, 90-min XC with del Nido led to significant cardiac dysfunction that inversely correlated with levels of lactate and cTnI. Importantly, 180-min XC with del Nido resulted in strikingly more profound cardiac dysfunction and survival difference off CPB.

DISCUSSION: A juvenile pig model of long XC/CPB simulating current pediatric CVS procedures reveals time-dependent prevalence of significant metabolic stress, cardiomyocyte injury and organ dysfunction. This model will enable us to define the magnitude and mechanisms of cardiac injury in long XC/CPB and provide a translational research platform for therapeutic innovations aimed at these mechanisms.