Periodic acceleration improves cardiac function and reduces apoptosis biomarkers in neonatal piglet hearts following cardiopulmonary bypass (CPB) and deep hypothermic circulatory arrest (DHCA)

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Background: Cardiopulmonary bypass in neonates can injure vulnerable immature myocardium by causing vasoconstriction and upregulating the immune system. PGz treatment, a non-invasive, rhythmic rocking in the z-axis, can induce endothelial nitric oxide synthase (eNOS) activity, which increases nitric oxide levels in the vasculature. The increased levels of NO cause vasodilation and decrease the inflammation response leading to less myocardial cell injury and better cardiac function. The hypothesis is that pGz, a simple non-invasive procedure, prior to surgery can reduce ischemia/reperfusion injury in the immature myocardium as seen by a reduction in cell damage and better cardiac function.

Methods: Piglets were randomly assigned to treatment groups. Piglets (n=5) underwent an hour of daily pGz treatment for 4 days before undergoing cardiopulmonary bypass (CPB) and deep hypothermic circuit arrest (DHCA). Another group (n=6) did not have the pGz treatment prior to CPB and DHCA. The piglets went on CPB and were cooled over approximately 45 minutes to 18°C then 120 minutes of cardiac arrest. Next, the hearts were rewarmed for 45 minutes and monitored for the next 120 minutes with ultrasound piezoelectric crystals on three axies of the heart and analyzed with Sonosoft software (Sonometrics, Ontario, CA). After the procedure was complete, tissue was snap frozen from the left ventricles of the patients and protein levels were analyzed by immunoblot and ELISA.

Results: By comparing the two groups baseline values to 120 minutes after DHCA, the data show an improved cardiac function with pGz therapy. The preload recruitable stroke work (PRSW) ($p = 0.002$), isovolumetric relaxation time constant (Tau) ($p = 0.011$), O_2 delivery ($p < 0.001$) and mean arterial pressure (MAP) ($p < 0.001$) all significantly change over time in the control group, but not the pGz treatment group. The immunological data indicate a significant increase in the activity levels of caspase 3 ($p = 0.021$) and the protein levels of calpastatin ($p = 0.048$) and poly ADP ribose polymerase (PARP) ($p = 0.002$) in the control piglets when compared to the pGz treatment group.

Conclusions: PGz might be a useful non-invasive method of preconditioning therapy for patients undergoing ishemia and reperfusion during surgery for repair of congenital heart defects.

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