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Early reperfusion with warm, polarizing adenosine-lidocaine cardioplegia improves functional recovery following 6 hours of cold static storage

Donna M. Rudd MSc and Geoffrey P Dobson PhD

Heart Research Laboratory, James Cook University, Australia 4811

ABSTRACT

Objective: Rewarming and reanimating the donor heart from cold static storage predisposes the organ to injury and graft dysfunction. Our main aim was to investigate the effects of 5 min continuous rewarming using a normokalemic, oxygenated, polarizing adenosine-lidocaine (AL) arrest solution following 6 hours cold static storage (4°C) in AL or Celsior solutions.

Methods: Male Sprague-Dawley rats (350-450g, n=40) were randomly assigned to one of 5 groups: 1) AL cold arrest with modified Krebs-Henseleit (KH) rewarm, 2) AL cold with AL rewarm, 3) Celsior cold with Celsior rewarm, 4) Celsior cold with KH, and 5) Celsior cold with AL arrest rewarm. Hearts were perfused in working mode, arrested (37°C), removed and stored for 6 hours at 4°C, reattached in Langendorff mode and rewarmed for 5 min (37°C). Hearts were switched to working mode and function was compared to pre-storage values. Oxygen consumption (MVO_2) and effluent lactates and pH were measured during rewarming and recovery.

Results: Cold AL hearts rewarmed with KH recovered 40% aortic flow (AF) and 58% coronary flow (CF) at 60 min reperfusion. Rewarming with AL arrest solution led to significantly higher 63% AF and 77% CF at 60 min. Cold Celsior hearts rewarmed with Celsior had 9 times higher effluent lactate with acidosis (pH 6.5) during the last minute of rewarming compared with all groups, and this was associated with early myocardial, vascular and electrical stunning. At 5 and 10 min recovery, the AF was 1.0 and 8 ml/min respectively. If cold Celsior hearts were rewarmed with AL, they generated 18 fold higher AF and 16 fold higher CF at 5 min. At 60 min, cold Celsior with Celsior rewarm hearts recovered 35% AF and 50% AF compared with 44% AF and 67% CF ($P<0.05$) for Celsior with AL rewarm. Celsior with KH rewarm hearts recovered 39% AF and 51% and were not significantly different from Celsior rewarm. The MVO_2 in the last minute of rewarm was 1.6 times higher for cold AL hearts rewarmed with AL compared to cold Celsior and Celsior hearts (19 vs. 12 μmol O_2/min/g dry wt) along with low lactate and no acidosis.

Conclusions: Rewarming the rat heart following cold static storage in polarizing AL arrest solution resulted in significantly higher AF, CF and cardiac output compared with KH or Celsior rewarm. Rewarming cold Celsior hearts with AL solution reduced stunning. AL cardioplegia may offer a new reperfusion strategy following cold static storage.

Utramini-abstract Early continuous reperfusion with a warm, oxygenated, normokalemic polarizing adenosine and lidocaine (AL) cardioplegia improved spontaneous functional recovery following 6 hours cold static storage in the isolated rat heart. The new normokalemic AL arrest and preservation solution may find utility during cold-to-warm 'wash' transitions and implantation of donor hearts.