Simultaneous Antegrade/Retrograde Cardioplegia Leads to Water Accumulation in Both Intra- And Extra-cellular Compartments

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Objective: The present study was to determine whether simultaneous antegrade/retrograde cardioplegia (SARC) changes myocardial fluid homeostasis and increases intra- and extra-cellular compartments.

Methods and materials: Eight isolated pig hearts were perfused for 2 hours simultaneously through aorta and coronary sinus with blood cardioplegia. To follow the volume of the intra- and extra-cellular compartments, 20 mM dimethyl methylphosphonate (DMMP) and 10 mM phenylphosphonate (PPA) were added to the perfusion medium. DMMP distributes to the entire water space while PPA distributes only to the extracellular compartment. The levels of the two compounds were measured using ^{31}P MR spectroscopy. The volume of the extracellular compartment was calculated based on the level of PPA. Difference between the levels of DMMP and PPA offered an estimate of the volume of the intracellular compartment. Myocardial water content was monitored continuously throughout SARC using near infrared (NIR) spectroscopy. ^{31}P MR spectra were acquired from the pig hearts with a Helmholtz coil in a 7T magnet. A plastic ball filled with 1 ml of 500 mM methylphosphonic acid (MPA) was placed in the right ventricles (RV) serving as a quantification reference. Sixty FIDs were accumulated over a 2-min period for each spectrum. The areas of DMMP and PPA peaks in each spectrum were then converted to the volumes of the intra- and extra-cellular compartments.

Results: NIR spectra obtained from eight hearts showed a significant increase in water content during SARC (Figure 1), indicating tissue edema. Representative ^{31}P MR spectra obtained during SARC showed a gradual increase in both DMMP and PPA peaks (Figure 2). Changes in the volumes of the intra- and extra-cellular compartments during 2-hour SARC were summarized in panels A and B of Figures 3, respectively. Evidently, SARC resulted in a significant enlargement of both compartments. At the end of 2-hour SARC the intra- and extra-cellular compartments increased by 35% and 53%, respectively, relative to their initial volumes (100%). Myocardial energy metabolites (ATP and PCr), however, remained relatively unchanged during 2-hour SARC.

Conclusion: Prolonged use of SARC results in severe expansion of both intra- and extra-cellular compartments. This detrimental effect of SARC may be the fundamental mechanism for postoperative cardiac dysfunction.

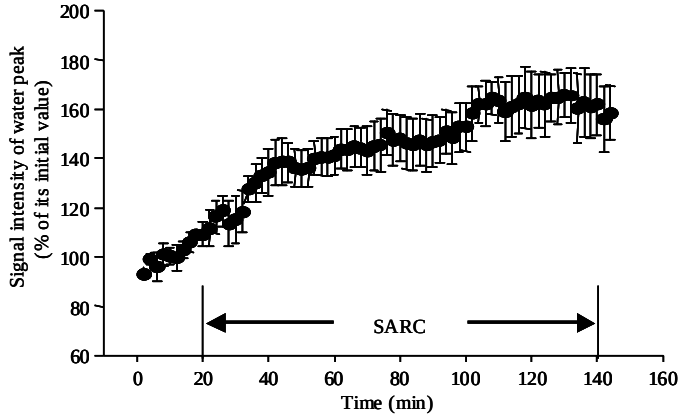

Fig 1. Time course of tissue water content measured during 2-hr SARC.

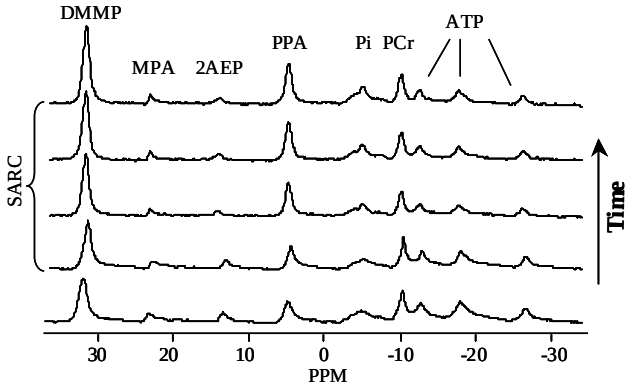

Fig 2. Representative ^{31}P MR spectra obtained during 2-hr SARC.

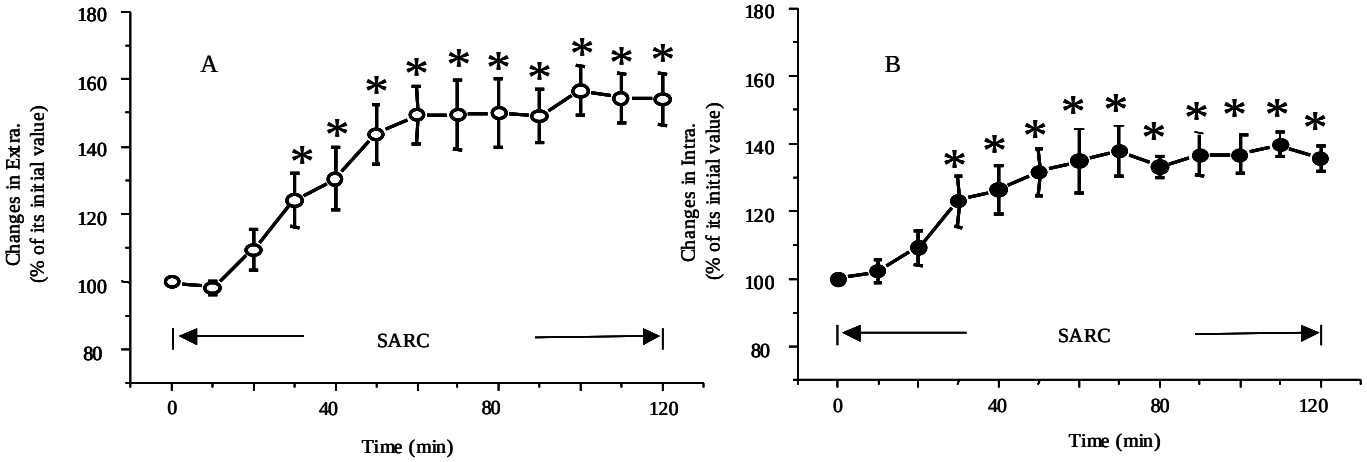

Fig 3. Time courses of the volumes of extra-cellular compartment (panel A) and intra-cellular compartment (panel B).