Metabolic Demand of Fast Rhythms in Isolated Working Hearts and Langendorff Perfused Hearts

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Background

Accurate metabolic studies of the heart require that the heart perform work within the context of preload and afterload pressures, a feature unique to bi-ventricular (bi-V) working heart preparations[1,2]. The objective of this study was to compare differences in the metabolic demand of fast rhythms in isolated bi-V working hearts and non-working Langendorff[3] perfused hearts. Hearts from New Zealand white rabbits were connected to a bi-V working heart system and perfused with modified Krebs-Henseleit solution[4] at 37°C. Preload and afterload pressures were set at physiological values. An epicardial monophasic action potential electrode was used to monitor electrical activity while hearts were paced at cycle lengths of 300, 200, and 150ms. Fluorescence of NADH (fNADH) was imaged to monitor the redox state of epicardial tissue. Understanding metabolic differences will aid in isolated heart studies of arrhythmias caused by ischemia and reperfusion.

Indication of metabolic state using fluorescence

NADH is the reduced form of nicotinamide adenine dinucleotide (NAD): NADH is a co-enzyme that carries electrons from one reaction to another in the electron transport chain. In absence of oxygen in the cells, NADH accumulates in the mitochondria.

NADH/NAD redox reaction

NADH Emission Spectra

Results: NADH Kinetics

Ventricles are stimulated to contract at 3 different rates (300, 200, and 150 msec). A monophasic action potential (MAP) electrode is placed on the anterior LV epicardium to confirm activation rate and to measure electrical activity.

The system provides for both Langendorff and working heart perfusion. Three pumps are able to supply flow to the heart and four chambers establish preload and afterload pressures.

Conclusions

Fast rhythms elevate the redox state and, concomitantly, metabolic demand in both bi-ventricular working and Langendorff heart preparations. However, elevations are much more rapid for working heart preparations, indicating that the time course of electrical alterations during acute ischemia and reperfusion could be very different between working and non-working heart studies.

References


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