

Title : INTRAMYOCARDIAL pH MONITORING IN ELECTIVE CARDIAC ARREST

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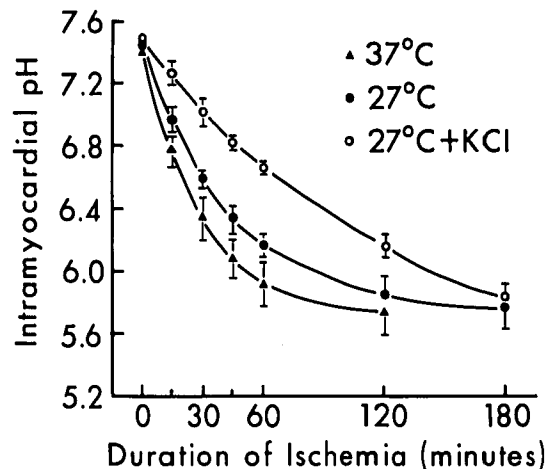
Introduction. Elective arrest of the heart is commonly induced during cardiac surgery to facilitate intracardiac repair. At present, for each patient the maximum duration of elective arrest is arbitrarily determined on the basis of clinical and experimental evidence. If the metabolic state of the heart could be continuously monitored during the ischemic period, it might be possible to judge the safe period of elective arrest with more accuracy. We have developed a system for continuously monitoring intramyocardial pH (using miniaturized needle electrodes) to follow changes in the metabolic state of the heart muscle. The purpose of the present study was to compare quantitatively the relative effects of moderate hypothermia and potassium cardioplegia on myocardial metabolism during elective arrest by measuring intramyocardial pH.

Methods. The electrode system for tissue pH measurement comprised a hydrogen ion sensitive glass miniature electrode housed in the bevelled end of a 21 gauge (0.8 mm diameter) needle and a reference electrode consisting of an internal silver-silver chloride electrode coupled to tissue through a saline bridge (150 millimolar NaCl) and housed in a 2 mm. diameter flexible polyvinyl tube with a microporous plug at its tip. A Beckman Model 3500 pH meter was used to measure the difference in electrical potential between the pH and reference electrodes. The electrodes were calibrated in vitro in phosphate buffers containing 150 millimolar NaCl at the temperature of planned elective arrest (i.e. 37°C or 27°C).

Three groups of five dogs each were used. The dogs were anesthetized and placed on cardiopulmonary bypass. The pH needle probe, the reference electrode and a needle thermometer probe were inserted into the anterior wall of the left ventricle. In Groups I and II elective arrest of the heart was achieved by aortic cross-clamping at myocardial temperatures of 37°C and 27°C, respectively, and the electrode pH was continuously recorded until no further change in pH occurred. In Group III, aortic cross-clamping at 27°C was immediately followed by the infusion of 600-800 ml. of cardioplegic solution (40 mEq./L. KCl, temperature 27°C, pH 7.50) into the aortic root. In each group the cardiac temperature at the time of cross-clamping was maintained constant throughout the ischemic period (i.e. Group I 37°C, Groups II and III 27°C). At the end of each experiment the electrode system was recalibrated.

Results. The intramyocardial pH (mean \pm S.D.) profiles for the 3 groups are compared

on the accompanying figure.



Statistical analysis (t test, unpaired data) of the pH measurements (reveals (1) significantly lower ($p < 0.01$) intramyocardial pH in Group I (37°C) compared with Group II (27°C) at 15, 30, 45 and 60 minutes (2) significantly lower ($p < 0.001$) intramyocardial pH in Group II (27°C) compared with Group III (27°C + KCl) at 15, 30, 45 and 60 minutes. Recalibration of the pH electrode system showed a range of deviation from the initial calibration values of 0 to 0.06 units.

Discussion. We have succeeded in quantitating the metabolic advantage conferred by potassium cardioplegia under conditions of moderate hypothermia. However, at more profound levels of hypothermia the relative benefit of cardioplegia may not be as great and warrants further investigation. We anticipate that continuous monitoring of intramyocardial pH with miniature electrodes will prove feasible in the clinical setting, and that it may be a useful technique in determining the safe period of elective arrest of the heart. Intramyocardial pH measurements also have the potential to detect an imbalance between regional myocardial oxygen supply and demand and, therefore, may also find application in assessing the adequacy of myocardial perfusion following revascularization procedures and in the post-operative monitoring of patients after open heart surgery.