Cold Blood Potassium Cardioplegia: A Clinical Study on 419 Cases

From The Second Department of Surgery, Kagoshima University School of Medicine,

Shinji Shimokawa, Yasuo Morishita, Minae Maruko, Toshiyuki Yuda,
Nobuyuki Chosa, Taizo Harada, Kagemitsu Uehara, Akira Taira

Introduction

An excellent operative result in open-heart surgery has been obtained since the introduction of cold blood potassium cardioplegia (BPC) in our institute. This paper deals with clinical evaluation of this method through 419 consecutive cases.

Patients

From August, 1978, to October, 1983, 419 operations including 228 acquired valvular heart diseases (Group I), 39 other acquired diseases than Group I (Group II), and 132 congenital heart diseases (Group III) have been performed by means of cold BPC (Table 1), Group I consisted of 122 males and 106 females; age between 21 to 63 years (mean 43 years). There were 173 single
valve and 55 multi-valve surgery. Group II consisted of 30 males and nine females, between the ages of 26 and 66 years (mean 53 years). They included 26 of ischemic heart disease, six of annuloaortic ectasia, three of dissecting thoracic aneurysm, three of cardiac tumor and one of right atrial diverticulum. There were 75 males and 77 females; 107 cyanotic and 45 acyanotic cases in Group III. Their ages ranged eight months to 59 years (mean 16 years). Durations of aortic cross-clamp were 110±40 minutes (mean±SD) in Group I, 89±52 minutes in Group II and 70±41 minutes in Group III.

### Methods of Arrest

The aorta was cross-clamped under perfusion hypothermia with systemic temperature of 27 or 28°C. A bolus of 350–400ml of pump blood at 10°C containing potassium in a concentration of 30mEq/l was used in adult via an aortic root to the coronary arteries in a fashion of multi-dose infusion by hand. Replenishment with a half of initial doses was carried out every 20–25 minutes or at the recovery of electromechanical activity of the heart. Topical cooling was added and left ventricular free wall or ventricular septal temperature of 15 to 20°C was obtained. An aortic root pressure of 60 to 80mmHg was maintained at the time of infusion. At the time of declamping the aorta, flow rate in cardiopulmonary bypass was lowered for several minutes for prevention of myocardial injury with reperfusion. In perfusion, roller pumps and bubble or membrane oxygenator were conventionally used.

### Results

In Group I, hospital death occurred in 23 patients; nine were due to cardiac-related causes and 14 were not. The late death occurred in five; one was due to cardiac-related cause and four were not. There were four hospital deaths and one late death in Group II. All of them were due to cardiac-related causes. In Group III, hospital death occurred in 12 with nine of cardiac-related and three of no related. The late death occurred in four. An equal of two cases was cardiac-related or no related, respectively.

Of all 419 cases, overall cardiac-related hospital death occurred in 22 patients (5.4); 17 with low cardiac output, two with perioperative myocardial infarction, one with intrathoracic bleeding plus infectious endocarditis, one with stuck valve and one with ruptured ventricular wall. Noncardiac-related hospital death occurred in 17 patients; six of multiple organ failure, four of acute renal failure, three of infection, two of hepatic failure, and two of miscellaneous. There was no significant difference between the operative results in single and multi-valve surgery in Group II. In the cases with more than 150 minutes of aortic cross-clamping, cardiac-related hospital mortality was 7.4%, comparing with 3.5% in the cases with less than 150 minutes. (Table 3). There was no close relationship between the length of aortic cross-clamp time and cardiac-related hospital death.

### Discussion

Hypothermic potassium cardioplegia is now widely
The main role of potassium is to stop the heart rapidly before its energy stores are depleted, while hypothermia produces a marked reduction of myocardial metabolism. Since August, 1978, we have adopted the technique of multi-dose sanguineous potassium arrest utilizing cold oxygenated pump blood with a potassium concentration of 30-35mEq/l. This solution provides not only some substantial of the blood components but also carries enough oxygen for repayment of minimal debt incurred during ischemia. These functions are advantageous for sanguineous cardioplegia comparing with crystalloid cardioplegia. Our present study shows that cold BPC provides adequate myocardial protection during prolonged periods of ischemia more than 150 minutes. No significant difference was found between the occurrence of cardiac-related hospital death and the length in aortic cross-clamping time.

The presence of aggregates and rouleau formations may be a possible criticism on the cold BPC in comparison of the use of an asanguineous solution. However, hemodilution and several additives to the perfusate such as mannitol in cold BPC may resolve this problem. The myocardial temperature of 15-20°C may be optimal or the reason of not only maintaining low myocardial metabolism but also preventing the critical potential of red cell aggregates or rouleau formations.

The ideal concentration of potassium or other metabolic components of a cardioplegic solution is unknown. However, the principles of rapid stopping of the electromechanical activity are the most important to be emphasized. In addition, it is not difficult to prepare the cardioplegic solution when we use the primes of bypass circuit. Multi-dose replenishment by hand also provides extreme safety together with adequate correspondence to individuality of various clinical cases. Proper application of this technique will provide the most sufficient myocardial protection during aortic cross-clamp time, at present.

References