COMBINED ANTEGRADE/RETROGRADE CARDIOPLEGIA FOR MYOCARDIAL PROTECTION

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By
Tarek Ahmed Abdel Aziz
M.B., B.Ch., M.S.

Supervised By

Prof. Mohammed Bassiouny
Prof. of Cardiothoracic Surgery
Ain Shams University

Prof. Ali Seif El Din Maklad
Prof. of Cardiothoracic Surgery
Ain Shams University

Ass. Prof. Mohammed Abdel Aziz Ali
Ass. Prof. of Cardiothoracic Surgery
Ain Shams University

Faculty OF MEDICINE
Ain Shams University
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وقل رب زدني علما

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Tarek A. Abdel Aziz

CONTENTS

Introduction

INTRODUCTION AND AIM OF THE WORK

Adequate myocardial preservation during open heart surgery involves reduction of myocardial oxygen consumption by: core cooling, rapid cardiac arrest, and topical hypothermia. Epicardial cooling is usually induced by application of saline slush to the surface of the heart. Diastolic arrest and myocardial hypothermia are most often achieved by infusion of a cold potassium containing cardioplegic solution via the aortic root (Bhayana et al., 1989).

Intraoperative myocardial protection with cardioplegic solutions requires insurance of adequate distribution to all myocardial segments, using a clinical approach that allows this goal to be accomplished in a safe, simple, and rapid fashion (Buckberg, 1989).

Despite the known advantages associated with the use of cardioplegia when administered in an antegrade fashion, it is associated with a number of actual and theoretic limitations (Masuda et al., 1986). Nonhomogenous distribution of cardioplegia in severe, critical, proximal coronary artery stenosis and in evolving acute myocardial infarction has been demonstrated experimentally (Gundry and Kirsh, 1984). Also, coronary ostial injury has been reported during and after aortic valve surgery (Chawla et al., 1977).

Further limitations of antegrade cardioplegia include poor distribution in patients with aortic regurgitation unless the aorta is opened and the coronary ostia are perfused directly, also the need to interrupt the continuity of mitral valve procedures to remove the retractors and avoid aortic distortion during cardioplegic replenishement (Buckberg, 1989). Finally the antegrade infusion may not be possible technically in patients with aortic dissection type A (Bhayana et al., 1989).

To obviate these limitations, retrograde coronary sinus perfusion (RCSP) has been proposed as an alternative method of providing myocardial protection (Buckberg, 1987).

Retrograde coronary sinus perfusion was introduced in 1956 to facilitate operations on aortic valve. A decade latter, this technique was suggested as a mean of intraoperative myocardial protection during coronary artery procedures. The concept of retrograde coronary sinus perfusion during open heart surgery remained dormant until the late 1970s, when interest in the coronary sinus as a root for delivery of cardioplegia remerged (Diehle et al., 1988), and retrograde coronary sinus perfusion has been employed extensively for aortic valve operations at many European centers since that time (Menasché et al., 1982).

One advantage of RCSP is the ability to infuse cardioplegic solutions continuously with prolonged maintenance of hypothermia and cardiac arrest without interrupting the continuity of other procedures. Also during aortic valve procedures coronary ostial cannulation with its attendant risks of: selective cannulation, coronary artery dissection, and post cannulation ostial stenosis is avoided. There is no problem with inadequate preservation of areas distal to high grade coronary stenosis in cases of coronary artery bypass surgery (Fabiani et al., 1986). In re-do operations for coronary artery disease, RCSP has been used to prevent the embolization of atheromatous material from the diseased veins into the distal coronary arteries (Snyder et al., 1988).

However, concerns about the use of RCSP including inadequate preservation of the right ventricle, which has been raised on the basis of canine studies (Shiki et al., 1986), and on the observation that right ventricular venous drainage does not occur primarily via the coronary sinus (Hochberg and Osten, 1980). Also delay of cardiac arrest, due to the low flow rate used for retrograde cardioplegia (Menasché and Piwnica, 1987 a).

From the aformentioned observations and studies, we assume that the use of combined antegrade/retrograde cardioplegia will be optimum for myocardial protection during open heart surgery, especially in coronary artery bypass surgery as it will obviate the limitations and augment the advantages of both methods.

This study is a prospective randomized clinical study designed to assess and compare the use of combined antegrade/retrograde cardioplegia- versus antegrade cardioplegia in providing adequate myocardial preservation during coronary artery bypass surgery using clinical, haemodynamic, electrocardiographic, and biochemical (enzymatic) parameters.

Review of Literature

HISTORICAL BACKGROUND

The direct relationship between temperature and metabolism has long been appreciated. Hypothermia has been recommended as a therapy for a variety of conditions. As early as 1614, the father of science of metabolism, Sanctorius described a cooling water jacket into which he placed patients afflicted with hypermetabolic state. But it was not until the late 1940s that systemic evaluation started with the purpose of decreasing metabolic demands in order to perform direct vision open heart surgery (Gay, 1987).

Studies by Bigelow and associates in 1950 and Swan et al., 1953 showed that hypothermia was effective in preserving organ structure and function following a limited period of ischemia induced by circulatory arrest. This method was used successfully by Lewis and Tauffic in 1953 to repair an atrial septal defect (Lewis and Tauffic, 1953). Soon afterward, Scott and associates in 1954 employed a similar technique to successfully repair tetralogy of Fallot.(Scott et al., 1954). This technique was abandoned after the development of mechanical cardiopulmonary bypass by Gibbon.

Topical hypothermia was introduced by Shumway in 1959 as a cardioprotective strategy during cardiac operations (Shumway and Lower, 1960). In this technique he used continuous lavage of the heart with ice_cold saline at 2_4 °C. This method provided up to 60 minutes of aortic cross_clamping with good myocardial functional recovery. This method continues to be used by many cardiac surgeons as an adjunct to cardioplegia (Allen et al., 1992). Ebert and associates in 1966,.confirmed this observation but felt that 30 minutes even with cardiac hypothermia, was the tolerable limit of ischemic time (Ebert et al., 1962).

Sanger and co_workers in 1966, used topically applied saline slush with normothermic high flow body perfusion and found that under these conditions the heart tolerated 80 minutes of ischemia very well and 2 hours moderately well (Sanger et al., 1966).

Mundth and colleagues, in a study published in 1970, described 60 minutes of safe ischemia with hypothermia, but found that adding an asangunous perfusate of 0.75% Magnesium sulfate extends this to 90 minutes (Mundth et al., 1970).

Berglund and associates in 1957, noted that a chemically arrested heart consumes less oxygen than one that is fibrillating (Berglund et al., 1957). Latter in the same year, Mckeever and co_workers noted that the arrested heart consumed less oxygen than that either the fibrillating or the beating non working heart (McKeever, 1958). Fuquay and associates in 1962, found that oxygen consumption was further reduced by cooling in the isolated perfused heart preparation (Fuquay et al., 1962).

In 1955, chemical cardioplegia was developed largely by the Europeans and was introduced by Melrose and his colleagues. They used cold hypertonic potassium citrate blood to produce cardiac arrest in order to facilitate intra_cardiac operations (Melrose et al., 1955). Unfortunately, sever structural and functional damage to the myocardium occured as a result of the high potassium content and this method was abandoned for almost 20 years.

Berne et al., in 1958 were among the first investigators to suggest that perfusion of the aortic root with cold blood after aortic cross clamping, can be used as a method of myocardial preservation. Following these initial laboratory studies in 1957, they reported several successful clinical cases. Lillehei applied this technique during the first prosthetic replacement of the aortic valve (Long et al., 1989).

The concept of cardioplegia was kept alive in the 1960s by Bretschneider, who used a low sodium, low calcium, procaine stabilized solution, which achieved rapid cardiac arrest and preservation of high energy phosphate for prolonged periods.(Bretschneider and Uberlebenszeit, 1964). A similar solution was developed by Kirsh et al., in 1972 who introduced a magnesium aspartate, procaine_containing cardioplegic solution. He believed that elimination of Na^+, K^+, and Ca^{++} prevented the utilization of adenosine triphosphate (Kirsch et al., 1972).

In 1973 Gay and Ebert, in the United States reintroduced the concept that potassium chloride induced cardiac arrest, was protective, provided that ionic constituents and osmolarity were controlled. They demonstrated that such solutions were effective in protecting the myocardium for up to 1 hour of normothermic arrest. Clinical experience with the infusion of cold hyperkalemic solution has been excellent and the combination of profound