INTRAOPERATIVE MYOCARDIAL PROTECTION: WHERE ARE WE GOING IN THE FUTURE?

Dear MJM:

One of the limiting factors during cardiac surgery is the amount of ischemia that the heart can be subjected to before the myocardium becomes irreversibly damaged. Over the past half century, advances in intraoperative myocardial protective techniques have dramatically reduced the mortality and morbidity associated with certain invasive procedures such as coronary artery bypass grafting and valve replacement and repair (1). The evolution of intraoperative myocardial protection has traced a fascinating path in recent years and the present discussion provides a brief overview of these advances.

Since its introduction into clinical practice by Bigelow et al. at the University of Toronto over 40 years ago, hypothermia (the cooling of the myocardium) has remained the gold standard for intraoperative myocardial protection. The goal of this technique is to decrease myocardial metabolism during the ischemic period once the aorta is cross-clamped and blood flow to the heart is terminated (2,3).

Cardioplegia, the elective arrest of cardiac activity, is necessary during heart surgery to ensure a quiet surgical field. Recently, cardiac surgeons have used normothermic (37^{o}C) blood cardioplegia as their method of myocardial protection, based on principles developed by Salerno et al. at McGill University and later continued at the University of Toronto (4-6). The aim of these normothermic techniques is to minimize myocardial ischemia bycontinuously supplying oxygen and warm blood to the arrested heart. This allows aerobic resuscitation of injured myocardium. Moreover, normothermic blood cardioplegia avoids many of the adverse effects caused by hypothermia, such as the depletion of high-energy phosphates (7,8) and delays in the recovery of metabolism and function following reperfusion (8,9).

Continuous normothermic blood cardioplegia was initially administered in an antegrade manner by perfusing the coronary arteries and grafts. However, the technique has evolved toward retrograde continuous normothermic blood cardioplegia (5), whereby the cardioplegic agent is perfused via the coronary sinus. This method allows for the rapid perfusion of ischemic or acutely infarcted myocardium, thereby minimizing the period of ischemia. This eliminates the mandatory waiting period required during antegrade delivery when the anastomoses between the graft and the ischemic myocardium are being completed. The retrograde technique eliminates the need for direct ostial cannulation in aortic valve surgery which is required during antegrade delivery. Retrograde cardioplegia is superior to antegrade cardioplegia by providing better cardioplegic delivery in patients with coronary artery stenoses, mild to moderate aortic insufficiency, short left main coronary arteries, or anomalous coronary arteries (10).

Continuous warm blood cardioplegia, whether delivered in an antegrade or retrograde manner, delivers a continuous supply of oxygen and warm blood to the heart. Early clinical results reported by Khan et al. (11) and Panos et al. (12-14) suggest that this technique may be of particular benefit for high-risk patients such as elderly patients (12), patients with diminished left ventricular function (13), and patients with ischemic mitral regurgitation in cardiogenic shock (14). Clinical reviews of cardiac surgery using continuous warm blood cardioplegia in these three patient populations have yielded results that are similar to those of studies using other myocardial protective techniques. The benefits reported in these patient populations may be attributed to the rapid resuscitation of the injured myocardium and the accelerated return of normal metabolic processes (15,16), both occurring while the heart is maintained in aerobic diastolic arrest. Moreover, the period of ischemia associated with hypothermic myocardial protective techniques is significantly reduced.

Some surgeons have recently begun using alternating administration of antegrade and retrograde cold blood cardioplegia to perfuse the heart in order to take advantage of both techniques (17,18). As mentioned earlier, retrograde perfusion enhances perfusion to the ischemic myocardium distal to coronary artery stenoses. Antegrade perfusion, on the other hand, results in rapid diastolic arrest, and provides enhanced perfusion of the right ventricle (17,19,20). Thus, the use of alternating retrograde and antegrade cardioplegia appears to complement each other and ensures a more homogeneous distribution of the cardioplegia (21,22). This approach has recently evolved into simultaneous delivery of antegrade/retrograde cardioplegia (23). Recent experimental and clinical studies using simultaneous antegrade/retrograde cardioplegia have shown encouraging results, since the technique combines the advantages of the two routes of administration without untoward effects on the myocardium (23). This method is an important addendum to the current repertoire of myocardial protective techniques available to the cardiac surgeon.

World-wide interest in both continuous warm blood cardioplegia and simultaneous antegrade/retrograde cardioplegia continues to grow. This is evident by the increasing number of articles and conferences devoted to these techniques and it is likely that they will play an integral role in the future of myocardial protection. Moreover, there has been a re-examination of traditional hypothermic techniques and the principles on which they were based. Further investigations are required to assess the metabolic effects of these new techniques. It is almost certain that the area of intraoperative myocardial protection will continue to evolve as we look toward the 21st century.

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BIOGRAPHY

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