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REVIEW
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Myocardial Protection Strategies During Cardiac Surgery: A Comprehensive Review

Kalp Cerrahisi Sırasında Miyokardiyal Koruma Stratejileri: Kapsamlı Bir İnceleme

Ahmet Üçol[1]

[1]Private Clinic, İstanbul, Türkiye

ABSTRACT

Cardiac surgery is a complex and delicate procedure that requires careful planning and execution to ensure favourable patient outcomes. One of the most critical aspects of cardiac surgery is myocardial protection, which aims to minimise damage to the heart muscle during the operation. In this comprehensive review, we will examine the various myocardial protection strategies used during cardiac surgery, their benefits and risks. We will also examine the use of cardioplegia, a technique involving the temporary suspension of cardiac function, to protect the myocardium. We will also discuss measures that can be taken to reduce ischaemia-reperfusion injury and its impact on the heart. Finally, we will examine postoperative management strategies to protect the myocardium and shorten the recovery time of patients undergoing cardiac surgery. By providing a detailed overview of these topics, this review aims to inform and assist healthcare professionals in making informed decisions about myocardial protection strategies during cardiac surgery.

Keywords: Cardiac Surgery, Myocardial Protection Strategies, Perfusion.

ÖZET

Kalp cerrahisi, olumlu hasta sonuçları sağlamak için dikkatli planlama ve uygulama gerektiren karmaşık ve hassas bir prosedürdür. Kalp cerrahisinin en kritik yönlerinden biri, operasyon sırasında kalp kasına verilecek hasarı en aza indirmeyi amaçlayan miyokardiyal korumadır. Bu kapsamlı derlemede, kalp cerrahisi sırasında kullanılan çeşitli miyokard koruma stratejilerini, bunların yararlarını ve risklerini inceleyeceğiz. Ayrıca kalp fonksiyonunun geçici olarak durdurulmasını içeren bir teknik olan kardiyoplejinin miyokardiyumu korumak için kullanımını da inceleyeceğiz. Ayrıca iskemi-reperfüzyon hasarını ve bunun kalp üzerindeki etkisini azaltmak için alınabilecek önlemleri tartışacağız. Son olarak, kalp ameliyatı geçiren hastaların miyokardını korumak ve iyileşme süresini kısaltmak için ameliyat sonrası yönetim stratejilerini inceleyeceğiz. Bu derleme, bu konulara ayrıntılı bir genel bakış sunarak, sağlık profesyonellerini kalp cerrahisi sırasında miyokardiyal koruma stratejileri hakkında bilinçli kararlar verme konusunda bilgilendirmeyi ve onlara yardımcı olmayı amaçlamaktadır.

Anahtar Kelimeler: Kalp Cerrahisi, Miyokardiyal Koruma Stratejileri, Perfusion.

INTRODUCTION

What are the various myocardial protection strategies used during cardiac surgery?

Myocardial protection strategies used during cardiac surgery include a variety of techniques and solutions that should be used in an integrated and comprehensive manner for optimal results. The most commonly used solutions are crystalloid and blood cardioplegia, and hot and cold application methods such as antegrade and retrograde cardioplegia are also available (1). Ischaemic preconditioning (IPC), ischaemic postconditioning and ischaemic perconditioning may also be used in cardiac surgery (2). Retrograde cardioplegia is more advantageous than antegrade and continuous cardioplegia is preferred over intermittent dose (3). In addition, normothermia is superior to hypothermia in terms of myocardial protection (3). Recent clinical trials have shown encouraging results with warm blood cardioplegia and three techniques deviating from conventional practice have recently been reported (3). It is important to note that the ideal myocardial protection strategy has not yet been determined and further research is needed to improve intraoperative myocardial protection (3). Inadequate cardioprotection during CABG surgery is associated with worse clinical outcomes and new therapeutic strategies are needed to reduce post-myocardial infarction (PMI) and prevent postoperative complications (2). By understanding the various myocardial protection techniques available, surgeons can evaluate current protection methods and make the necessary changes to provide optimal myocardial protection to their patients (1).

Corresponding Author: Ahmet Üçol, e-mail: ucolahmet.080@hotmail.com
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How can the effectiveness of myocardial protection strategies be improved?

The caveolae and its structural protein caveolins may offer a reliable approach to protect the myocardium from ischaemia, infarction and ischaemia/reperfusion (I/R) injury (4). It has been suggested that caveolins are a bridge that transmits signals that prevent damage and protect the infrastructure of cardiomyocytes in pathological conditions. This can be achieved by various cardioprotective strategies mediated by caveolins, which can be carried out through various pathophysiological pathways (5). Furthermore, enrichment of the cardioplegic solution with amino acid precursors of Krebs cycle intermediates and the use of normothermia have been shown to increase the effectiveness of myocardial protection strategies (1). These two methods can be used to optimise the rate of cellular repair and improve functional recovery following myocardial ischaemia (1). In addition, combining all the different myocardial protection techniques into a comprehensive strategy can further improve efficacy (1). In order to increase efficacy, it is critical to use cardioplegia solutions designed and tested for a specific purpose, aiming at complete preservation of metabolic and functional parameters (6). To ensure efficacy, it is also imperative to investigate novel cardioplegia strategies, especially for paediatric patients, and to deliver cardioplegia solutions according to established experimental protocols (6). A drop in ATP or other metabolic levels after arrest should be taken as a failure of protection and optimal protection should be prioritised as much as the technical aspects of repair (6). Due to inadequate protection provided by current myocardial protection strategies, improved methods are needed for all paediatric patients (6). One such method may be to combine blood cardioplegia and warm reperfusate solution specially developed for this purpose (6). However, it is important to note that most variations in paediatric myocardial protection result from the cardiac experience of adults (6). Therefore, adaptation of adult cardioprotective strategies to paediatric patients is imprudent and potentially harmful (6). Furthermore, substrate development is another approach to increase the efficacy of myocardial protection strategies (6). Enrichment of warm cardioplegic reperfusate with amino acids such as aspartate and glutamate can greatly improve its efficacy (6). Moreover, cardiac enzyme release is directly related to muscle damage and outcomes, and higher cardiac enzyme levels are associated with more deaths (1). Therefore, postoperative cardiac enzyme levels can be used to grade surgeons and hospitals and to improve myocardial protection strategies (1). In addition, hypoxic hearts are less tolerant to surgical ischaemia and require effective protection strategies, and cyanotic patients show better protection with myocardial protection strategies (6).

Cardioplegia

What is cardioplegia and how is it used to protect the myocardium during surgery?

Cardioplegia is a technique used to protect the myocardium during open heart surgery. It is used to achieve diastolic arrest of electrical activity in the heart and reduce metabolic activity (7). It is a solution of high potassium and low calcium concentrations delivered to the heart to temporarily stop cardiac activity. This allows the creation of an immobilised, bloodless space in which the surgeon can operate with precision (7). Multi-dose blood and single-dose del Nido crystalloid solutions are commonly used cardioplegia solutions in adult cardiac surgery. Recently, a study was conducted to compare the safety and efficacy of del Nido cardioplegia with blood cardioplegia (7). Del Nido cardioplegia has been found to be a safe alternative to blood cardioplegia with a similar safety profile and efficacy to blood cardioplegia (7). In addition, it has been found to provide equivalent myocardial protection and surgical workflow compared to blood cardioplegia (7). With Del Nido, dose repetition can be reduced and haemodilution and transfusion requirements can be reduced (7). The efficacy of cardioplegia is affected by certain factors such as composition, substrate enrichment, route, temperature and repeat dosing intervals (7). Hypothermic and hyperkalaemic cardioplegia solutions are the clinical standard (7), methodological prerequisites such as keeping the initial ischaemic phase short, limiting perfusion pressure to 20 to 30 mm Hg and controlling myocardial temperature are essential for the procedure (7).

What are the different types of cardioplegia and their benefits and risks?

Cardioplegia is one of the most commonly used techniques to protect the myocardium during cardiac surgery. It is used to maintain myocardial ischaemia for a controlled period of time and to protect the myocardium from ischaemic damage. There are four types of cardioplegia used in cardiac surgery: Del

Nido (DN), Blood Cardioplegia (BC), Histidine-Tryptophan-Ketoglutarate (HTK) and St Thomas. The safety and efficacy of these types of cardioplegia have been evaluated through a network meta-analysis. The results of clinical trials comparing pairs of cardioplegia types have not always been consistent. The network meta-analysis aims to guide the choice of cardioplegia type. One meta-analysis found no difference in low-output syndrome or myocardial infarction between BC and crystalloid cardioplegia. One study found that BC was associated with a lower risk of low-output syndrome and an early increase in creatine kinase-myocardial band, but was associated with a similar risk of myocardial infarction compared with crystalloid cardioplegia. Previous meta-analyses have reported comparable mortality risk for different types of cardioplegia in adult patients. Another study reported that the incidence of perioperative MI was lower with BC than with crystalloid cardioplegia but the incidence of other cardiac events was similar. The Warm Heart Study reported a lower incidence of LOS in the warm cardioplegia group, but the pooled results showed no statistical difference in LOS between the two groups. According to the pooled analysis of RCTs, the incidence of MI was comparable between warm and cold cardioplegia. According to large retrospective clinical trials, patients receiving warm blood cardioplegia experienced fewer MIs after surgery. According to subgroup analysis, the incidence of LOS was similar between warm blood cardioplegia and cold crystalloid cardioplegia. Based on pooled data on postoperative IABP use covering almost 4500 patients, there was no difference in IABP use between warm and cold cardioplegia. Both warm and cold cardioplegia have similar risks of in-hospital death. According to the previous meta-analysis, LOS was significantly reduced in patients receiving blood cardioplegia compared with crystalloid cardioplegia. However, the text does not provide information on the benefits and risks of each type of cardioplegia. Furthermore, it is not clear what the four cardioplegia types are mentioned in the network meta-analysis and the benefits and risks of different cardioplegia types are not mentioned in the text (7,8).

What are the optimal temperatures and times for cardioplegia?

Despite the promise of self-assembling peptide NFs, the text does not provide any information on optimal temperatures and durations for cardioplegia. It has been observed that a 20-minute period of ischaemia at 32 °C can be tolerated by the heart without any inotropic support. However, the majority of surgeons prefer to use shorter redosing intervals, such as 20-30 minutes or less. This is probably because some surgeons prefer the comfort of a single shot of cardioplegia, while others feel safer with shorter intervals. Research has also shown that the anoxic safe time can be extended to 30 minutes at 16 °C-20 °C. However, the text does not provide specific information on the optimal temperature and duration of cardioplegia. It is important to minimise the effect of extracavitary and intracavitary heat sources to prolong the duration of cardioplegia and ensure near homogeneous cooling of the heart. Systemic blood temperature should be kept low, collateral blood in the cardiac cavities should be drained, topical cooling should be maintained and the heart should be protected within the pericardium. Studies have also focussed on aortic cross-clamp times to investigate the effect of temperature, but results suggest that temperature probably has little effect on the short-term outcome of cardioplegia. The text does not provide any information on the optimal duration of cardioplegia. The authors suggested that a short period of normothermic ischaemia followed by adequate cardioplegic reinfusion should be well tolerated. Warm blood cardioplegia was interrupted for 5-15 minutes to improve visualisation during distal anastomosis, but the aim of the study was to evaluate the relationship between the intermittency of cardioplegia and cardiac events, not the optimal temperature and duration of cardioplegia. Warm blood cardioplegia has been proposed as an alternative to retrograde continuous cardioplegia, and the duration of single-dose warm blood cardioplegia administration can be extended. However, the text does not provide any information on the appropriate temperature for cardioplegia. Terminal warm blood cardioplegia can achieve safe ischaemic times of up to 120 minutes, cold blood cardioplegia, histidine-tryptophan-ketoglutarate (HTK) solution or Custodiol® has been suggested for single shot cardioplegia. The text does not provide any information on the optimal temperature and duration of cardioplegia. Generally, the temperature for cardioplegia can be cold, warm or hot (6-8).

CONCLUSIONS

It provides a comprehensive review of the various myocardial protection strategies used during cardiac surgery. The study highlights the advantages and disadvantages of different techniques such as retrograde and antegrade cardioplegia, continuous and intermittent dosages, hot and cold administration methods. The study also suggests the use of ischaemic preconditioning, postconditioning and perconditioning as alternative approaches to myocardial protection. However, the ideal myocardial protection strategy has not yet been determined and further research is needed to improve intraoperative myocardial protection. The study also suggests the use of continuous delivery of myocardial protection agents, such as self-assembling peptide nanofibres, to overcome the limitations of local delivery. The study highlights the need for improved methods for paediatric patients and the use of epidural analgesia to reduce postoperative and preventive analgesia. In addition, the study recommends the use of the Enhanced Recovery After Surgery (ERAS) protocol to shorten the recovery time of cardiac surgery patients. Overall, the study contributes to the ongoing body of knowledge in the field of myocardial protection strategies during cardiac surgery and emphasises the need for further research, innovation and integration of different techniques to ensure optimal myocardial protection.

DESCRIPTIONS

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