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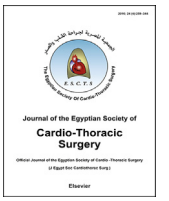

Effect of terminal warm reperfusion (hot shot) and remote ischemic preconditioning, either separately or combined, on myocardial recovery in adult cardiac surgery

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ABSTRACT

Background: Reperfusion injury is a major contributor to morbidity and mortality after cardiac surgery. Among the myocardial protective modalities, terminal warm reperfusion (hot shot) and remote ischemic pre-conditioning techniques were found to protect myocardial function and improve better postoperative outcomes. The aim of this study was to compare the effect of terminal hot shot cardioplegia, the effect of remote ischemic preconditioning and the effect of both techniques on myocardial recovery after adult cardiac surgery.

Methods: One hundred forty-five patients were divided into four groups comparing hot shot group, remote ischemic preconditioning group, combined hot shot and remote ischemic preconditioning group and the control group. The data collected included pre-operative demographic and clinical characteristics, intraoperative data and postoperative short term outcome including inhospital mortality.

Results: Patients of the combined group were found to have significantly better outcome including fewer ventricular arrhythmias, less intra-operative need of intra-aortic balloon pump, low cardiac output, and less length of ICU stay. The in-hospital mortality showed a significant difference between the 4 groups. Among patients without hot shot, the incidence of postoperative temporary epicardial pacing was higher and decreased in patients underwent hot shot and remote ischemic preconditioning but didn't reach a statistical significance.

Conclusions: Both remote ischemic preconditioning and terminal hot shot reperfusion before removal of the aortic cross clamping improved outcome of on-pump adult cardiac surgery patients. There was a significant effect on the in-hospital mortality and there were fewer incidences of arrhythmias and less requirement for postoperative inotropic support with this technique.

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1. Introduction

Even though advances in surgical technique, anesthesia, myocardial protection and postoperative care have reduced the risk involved in open heart surgery; compromised ventricular function and arrhythmias still occur in cardiac surgery patients [1].

Cardiac surgeons and anesthesiologists have sought more optimal methods to protect the myocardium from ischemia-reperfusion injury. It has been well established that antegrade cardioplegia may fail to give adequate protection to all myocardial regions [2]. Retrograde cardioplegia has been proposed as an alternative or additive to antegrade cardioplegia [3], but studies showed that combined delivery of cardioplegia did not provide adequate myocardial protection especially in coronary artery disease cases [4–7]. Thus, consideration of additional myocardial protection strategies is necessary.

Advances in cardioplegic techniques included intermittent antegrade cold blood cardioplegia with terminal warm reperfusion (hot-shot) which has been shown to improve myocardial protection in open heart surgery [8]. Terminal Warm reperfusion (hot shot) refers to the administration of terminal warm perfusate before removing the aortic cross clamp aiming to wash out anaerobic metabolites from the coronary circulation of the arrested heart and to minimize the ischemia-reperfusion myocardial injury and to achieve resumption of effective electro-mechanical myocardial activity [9].

Remote ischemic preconditioning depends on protection of the heart by applying repetitive ischemia and reperfusion to an organ remote from the heart. Ischemic preconditioning was first described by Przyklenk et al. [10], who found that the size of myocardial infarction due to left anterior descending artery occlusion was reduced after intermittent occlusion of circumflex artery. This idea was taken and extended to investigate the effect of ischemic stimulus to an organ remote from the heart on myocardial protection [11–14].

We aimed to compare the effect of terminal hot shot cardioplegia, the effect of remote ischemic preconditioning and the effect of both techniques on myocardial recovery after adult cardiac surgery.

2. Patients and methods

2.1. Study population

One hundred forty-five patients who underwent either valve surgery or coronary artery bypass grafting (CABG) at Cardiothoracic Surgery Department in Tanta University Hospital, Tanta, Egypt between December 2014 and December 2016 were enrolled in this study. Data were prospectively collected and analyzed. The study population was adult cardiac surgery patients who were electively scheduled for valve surgery or CABG. Patients were divided into four groups comparing first group (control group), the second group (Hot shot group) and the third group (remote ischemic preconditioning (RIPC) group) and the fourth group (combined group). Informed consent was taken from patients involved in the study. The protocol was approved by the Tanta faculty of medicine ethical committee.

2.2. Outcome measures

2.2.1. Intraoperative variables included

The time needed by the heart from aortic declamping to restoration of effective electro-mechanical contraction, the heart rate and rhythm after aortic declamping, the occurrence of ST-segment changes in the ECG, the mean arterial blood pressure, the arterial blood pH changes, the need for defibrillation and the response, the need for inotropic support, the need for anti-arrhythmic drugs, the need for artificial pacing, the need for reentry to cardiopulmonary bypass (CPB) for circulatory support, and the need for intra-aortic balloon pump (IABP) circulatory support.

2.2.2. The postoperative (ICU) variables included

The serum troponin I level, the mean arterial blood pressure, the heart rate & rhythm, the ST-segment changes in the ECG, the need for high inotropic support, the need for anti-arrhythmic drugs, the hours of postoperative mechanical ventilation, the length of ICU stay and the incidence of in-hospital mortality.

2.3. Surgical management

Standard anesthetic and operative procedures were used as all the patients had conventional on-pump cardiac surgery in both prosthetic valve replacement cases and CABG cases.

In the RIPC group and in the combined group the patient had repeated intermittent, transient, reversible, and non-lethal upper limb ischemia by inflating a pressure cuff to 200 mmHg around the arm for 4 cycles of 5 min ischemia alternating with 5 min reperfusion starting from the time of induction of anesthesia.

In the hot shot group and in the combined group, the patient received 250 ml of warm perfusate (normothermic cardioplegia) at 37°C temperature infused to the aortic root via the antegrade cardioplegia cannula started 3–5 min prior to aortic decalmping with a constant flow rate of 150 ml/min for 2 min.

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