The Effect of Coronary Artery Bypass Graft Surgery on Blood Oxygenation Status

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Abstract

Introduction- Cardiopulmonary bypass (CPB) in patients undergoing coronary artery bypass graft surgery (CABG) carries a number of drawbacks, namely its inflammatory effects on the lung parenchyma due to both the mechanical and inflammatory effects of the bypass circuit. The arterial oxygenation status is a marker that can demonstrate the alveolar performance and the possible detrimental effects on the lung tissue. This study was designed and executed to assess the effects of CPB on the lung oxygenation status.

Methods- In a before-after study, 370 cases among a population of 2000 patients undergoing elective CABG were studied. All the patients were compared with themselves in such a way that there was no need to match them before and after the exposure to the bypass circuit. The partial pressure of arterial oxygen before and after the operation and also the saturation of the oxygen in the arterial blood were checked before and after the operation on the final postoperative day of ICU stay. The Chi-square and non-parametric tests were used for data analysis. A P-value less than 0.05 was considered significant. SPSS software (version 11.5) was used for data analysis.

Results- Among the factors assessed, pump time and age had statistically significant effects on the oxygenation status of the patients undergoing CABG with bypass. Other variables, including the number of the grafts and ejection fraction before the operation were effective, but their effect was not statistically significant.

Discussion- A decreased pump time, especially in the elderly cases and those with an underlying disease, is highly recommended. Further studies regarding other respiratory markers including pulmonary function tests are recommended ***(Iranian Heart Journal 2008; 9 (3):42 - 46).***

Key words: cardiopulmonary bypass ■ coronary artery disease ■ lung function ■ oxygenation

Post-operative lung dysfunction frequently develops in patients after cardiopulmonary bypass (CPB).[1,2] The severity of pulmonary dysfunction varies from mild alterations in gas exchange to the acute respiratory distress syndrome.[2] Although the mechanisms behind CPB-induced lung injury are likely to be complex, the observation that a maintenance of a finite pulmonary artery (PA) blood flow during CPB attenuates CPB-induced lung injury[3] suggests that PA ischemia / reperfusion (I/R) plays a significant role in CPB-related lung dysfunction.

The bronchial artery (BA) blood flow continues during CPB and may influence the effect of pulmonary I/R on the subsequent lung dysfunction.[4,5]

The bronchial circulation originates from the descending aorta and intercostal arteries.[6, 7]

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It supplies the airways, pleura, lymph nodes, nerves, and pulmonary vascular vasa vasorum[8] before draining into the pulmonary circulation through bronchopulmonary anastomoses.[9]

BA perfusion during CPB has been considered by some investigators to be problematic, possibly contributing to pulmonary vascular congestion[10] and systemic hypotension.[11] Others have hypothesized the BA blood flow to be a possible ameliorating factor in CPB-induced lung injury.[4, 12, 13]

Post-operative pulmonary dysfunction in patients undergoing CPB is a significant clinical problem and has long been recognized by cardiac surgeons, anesthetists, and intensive care physicians. The disturbance may be manifested as conditions ranging from subclinical functional changes in most patients to full-blown adult respiratory distress syndrome in less than 2% of cases after CPB.[14-16] The mortality rate associated with adult respiratory distress syndrome is over 50%, [14, 15] not including the morbidity leading to prolonged postoperative recoveries and hospital stays. Despite years of research into this phenomenon, the understanding behind the complex pathophysiology of CPB-induced lung injury remains incomplete.[2]

In this study, the authors examined the arterial oxygenation status of the blood before and after CPB to assess the effects of this treatment modality on this parameter of physiological lung function.

Methods

The proposal of the study, after conformance with the IRB requirements for human and animal trials, was also confirmed regarding the ethical concerns, by the research committee, Department of Research Affairs, Shaheed Rajaie Cardiovascular Medical Center, Tehran, Iran.

In a descriptive, analytical before-after study, the target population was considered all the surgical patients admitted in the operating room of the hospital; which was the location of the study, during a six-month period. Among these cases, 370 cases who were candidates for elective coronary artery bypass graft surgery (CABG) were selected according to the following inclusion criteria: patients' informed written consent for entering the study was available; they were scheduled for elective CABG; they were admitted in the hospital considered for the study and were operated on in the same center; and they were within the age range of 18-65 years.

The exclusion criteria were as follows: patient refusal of entering the study, pre-existing severe debilitating pulmonary disease, previous history of past or present opium abuse.

All the cases were visited the night before the surgery by a constant anesthesiologist and were informed about the study and their enrollment process to reassure them regarding their treatment status and also the process of the study. Also, a pre-medication dose of morphine was prescribed for the patients as 0.1 mg/kg intramuscular administration one hour before surgery.

In the operating room, the patients first received 500 to 750 ml of Ringer's solution in 15-20 minutes. Then, using standard monitoring approaches, including 2-lead electrocardiograms, pulse oxymetry, and invasive blood pressure, the patients were anesthetized with a combination of intravenous midazolam, sufentanil, etomidate, and atracurium. All the patients were intubated using endotracheal tubes, and central venous catheters were inserted for monitoring central venous pressures. All the cases underwent a routine median sternotomy with CPB for the surgical operation. After the termination of the operation, all the patients were transferred to the cardiac intensive care unit and were extubated after regaining full awareness and hemodynamic stability.

For all the patients, arterial blood samples were taken at the start of the operation and at different stages over the operation; also, at

different time intervals in the post-operative period. The variables of the study from the arterial blood samples taken just before the induction of anesthesia through the arterial cannulation site were compared with the samples taken at the first opportunity at which the patients could tolerate room air without any supplemental oxygen or ventilatory support while under postoperative care in the intensive care unit. In these two samples, the measurements of partial oxygen pressure and arterial saturation of oxygen were determined for further comparison.

To make the study compatible with ethical considerations, the patients' data were kept fully confidential. Also, personal freedom was fully adjusted according to the patients' viewpoints in a way that only the patients could make the final decision about whether or not to stay in the study.

Data entry and analysis was performed by SPSS software (version 11.5). For data analysis, Student's *t*-test and Chi-square test were used as the statistical tests, and a P-value less than 0.05 was considered significant.

Results

A total of 370 cases were studied, with an age of 58.53±9.06 years, weight of 74.92±10.03 kg, and height of 163.92±13.22 cm.

The CPB time was 83.88±28.18 minutes. The number of coronary grafts was 2.73±0.59 grafts for each case. The pre-operative left ventricular ejection fraction was 45.5±8.7%, and 31.9% of the cases had a history of proven diabetes mellitus.

Regarding the oxygenation status of the lungs, there was a statistically significant difference between the two samples taken before and after the operation; the results are demonstrated in Table I (P <0.0001).

Discussion

This study suggests a significant detrimental effect of CPB on the oxygenation status of the blood. Those patients undergoing bypass demonstrated a significantly lower arterial oxygen concentrations.

Table I. Oxygenation status before and after operation

	Partial Arterial Oxygen Tension (before the operation)	Partial Arterial Oxygen Tension (after the operation)
Mean	67.99	63.58
SD	7.724	8.619

Table II. Descriptive parameters of the cases of the study

	age	Weight	Height	CPB Time (min)	No. of Grafts	EF (%)
Mean	58.53	74.92	163.92	83.88	2.73	45.50
SD	9.060	10.032	13.219	28.184	0.569	8.708

Post-operative pulmonary dysfunction is a significant clinical problem, ranging from subclinical functional changes in most patients to full-blown adult respiratory distress syndrome in 2% of cases after CPB.[2] There are a number of possible theories describing this phenomenon.

The activation of poly (ADP-ribose) polymerase (PARP) is now considered a final common effector in various types of tissue injury, including systemic inflammation, circulatory shock, and ischemia/reperfusion.[17] Free radical and oxidant production and related cytotoxicity during ischemia/reperfusion leads to DNA strand-breakage, which activates the nuclear enzyme PARP and initiates an energy consuming, inefficient cellular metabolic cycle with transfer of the ADP-ribosyl moiety of NAD^+ to protein acceptors. It has been shown that hypothermic cardiac arrest and reperfusion lead to the activation of PARP and energy depletion.

Also, lung injury after CPB is evident by the presence of post-operative pulmonary functional, physiological, biochemical, and histological changes. Few would argue about the presence of lung injury following CPB.

However, pulmonary dysfunction after CPB may be the result of multiple insults from various aspects of CPB surgery.[18-20] These include extra-CPB factors (i.e. general anesthesia, sternotomy, and breach of the pleura) and intra-CPB factors (i.e. blood contact with artificial material, administration of heparin and protamine, hypothermia, cardiopulmonary ischemia, and lung ventilatory arrest).[19-21] Thus, it is questionable whether lung injury is purely related to the use of CPB. To help answer this, the degree of pulmonary dysfunction has been investigated clinically and experimentally under the following conditions. It has been noticed that lung functional impairment is inevitable after any major surgery, a condition that most likely is related to general anesthesia.

Using CT scanning, researchers have found that general anesthesia induces atelectasis in nearly all patients.[22-24] However, CPB appears to cause additional lung injury and to delay pulmonary recovery compared with other types of major surgery,[25] conditions that generally are believed to be due to the damaging effects of a systemic inflammatory response associated with CPB.[26] Yet, it is also noteworthy that the continuing refinement of CPB materials (i.e. the use of a membrane oxygenator instead of a bubble oxygenator) as well as an improvement in anesthetic management (i.e. early extubation leading to fast-track recovery) has largely limited such additional lung injury.[25, 26]

Regarding the results of this study, it seems logical to assess the oxygenation status of the patients before undergoing CPB to be able to prepare those cases that are at a greater risk of further pre-operative preparation as much as possible.

Conflict of Interest

This study was performed as a research project in the Anesthesiology Department, Shaheed Rajaie Cardiovascular Medical Center, Tehran, Iran.

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