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Research Article

A Retrospective MultiCenter Experience: Does Small Tidal Volume Ventilation During Cardiopulmonary Bypass Help to Decrease Respiratory Complications After Cardiac Surgery

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Abstract

Background: Open-heart surgery with cardiopulmonary bypass (CPB) is associated with a generalized immune response and postoperative lung dysfunction. The aim of this study is to investigate whether low tidal volume lung ventilation during cardiopulmonary bypass helps to reduce the incidence of pulmonary complications after cardiac surgery.

Methods: This retrospective multicenter study was performed in 6 centers in Egypt between March 2020 to December 2024 and included 1979 patients, who received small tidal volume ventilation during cardiopulmonary.

Results: The mean age was 55 ± 10.1 years. Their mean BMI was 26.3 ± 4.4 kg/m^2. 1191 (60.2%) of included patients were hypertensive while 709 (35.8%) of patients were diabetic. 815 (41.2%) of patients had originally CABG procedure. Prolonged ventilation occurred in 289 (14.6%). The need for non-invasive respiratory support happened in 146 (7.4%). Basal Atelectasis in 402 (20.3%) . Pneumonia in 33 (1.7%). Reintubation in 28 (1.4%). None of the cases required Tracheostomy

Conclusion: Small tidal volume lung ventilation during cardiopulmonary bypass is a modality that can be considered to reduce pulmonary complications after cardiac surgery.

Keywords: Cardiopulmonary Bypass; Cardiac Surgery; Continuous-Positive Airway Pressure; Low-Tidal-Volume Ventilation; Mechanical Ventilation; Postoperative Pulmonary Complications.

Introduction

Cardiac surgery performed under Cardiopulmonary Bypass (CPB) is associated with an exaggerated immune response and occurrence of postoperative lung complications [1]. Postoperative pulmonary complications (PPCs) have an impact on surgical morbidity and mortality [2]. The cause of pulmonary complications after cardiac surgery is thought to be multifactorial, occurring as a result of the effects of anesthesia, CPB, and surgical trauma. CPB is well known to activate the inflammatory process, resulting in increased pulmonary capillary permeability and bad effects to lung parenchyma [3]. Pulmonary complications are common after open heart surgery and have been related to lung collapse during Cardiopulmonary Bypass (CPB). No final consensus

exists regarding the effects of keeping mechanical ventilation during CPB to decrease such complications [4]. The aim of this study is to investigate whether low tidal volume lung ventilation during cardiopulmonary bypass helps to reduce the incidence of pulmonary complications after cardiac surgery.

Materials and Methods

This retrospective multicenter study was done in 6 centers in Egypt from March 2020 till December 2024 as shown in table 1 and included 1979 patients, who received small tidal volume ventilation during cardiopulmonary bypass (3 mL/kg 5 times/min, with positive end expiratory pressure of 5 cm H2O).

Hospital Class	City	Name
University	Cairo	Ain Shams University Hospital (Cardiac Academy)
University	Cairo	Ain Shams University Specialized Hospital
Private	Menofia	Elaraby Hospital
Private	Cairo	Dar Al Fouad Hospital
University	Cairo	Badr Hospital
University	Cairo	Elazhar

Table 1: Cardiac centers participated in the study.

The following demographic characteristics were collected: sex, age, BMI, associated comorbidities, and original surgical procedure as shown in table 2.

Variable	Number (%)
Age (years)	55 ± 10.1
BMI (kg/m^2)	26.3 ± 4.4
Hypertension	1191 (60.2%)
Diabetes mellitus	709 (35.8%)

BMI: Body Mass Index

Table 2: Demographic characteristics of included patients.

All patients had normal respiratory function from the history and all patients with history of bronchial asthma or COPD have been excluded from the study. Postoperative respiratory complications, such as prolonged ventilation, need for non-invasive respiratory support, atelectasis, pneumonia and reintubation were recorded.

Statistical Analysis

Data was collected and analyzed using Microsoft Excel. Results are statistically represented, in terms of range, mean, standard deviation, and percentage. All the patients included in the study were elective.

Results

The original procedures performed are shown in Table 3.

The original procedure performed	Number (%)
CABG	815 (41.2%)
MVR	657 (33.2%)
AVR	368 (18.6%)
AVR and CABG	89 (4.5%)
MVR and CABG	45 (2.3%)
LA Myxoma Resection	5 (0.3%)

Table 3: The original procedures performed (n=1979).

The respiratory complications are shown in Table 4.

Complications	N (%)
Prolonged ventilation	289 (14.6%)
Non-invasive respiratory support	146 (7.4%)
Atelectasis	402 (20.3%)
Pneumonia	33 (1.7%)
Reintubation	28 (1.4%)
Tracheostomy	0 (0%)

Table 4: the postoperative complications of patients who underwent low tidal volume lung ventilation during CPB.

Discussion

It is well known that advanced age is an associated risk factor for pulmonary complications after cardiac surgery. In our study, the mean age of included patients was found to be 55 ± 10.1 years old. This was lower compared to the mean age of 68.8 ± 10.3 that was reported by Nguyen et al. , who designed a randomized controlled trial where patients undergoing cardiac surgery at a single center from May 2017 through August 2019 were randomized to the ventilation or no ventilation strategy during CPB [4]. We think that our mean age was lower as a good percentage of our patients were rheumatic valvular cases. Davoudi et al 2010 conducted a prospective randomized study including 100 patients undergoing elective coronary artery bypass grafting. In 50 patients, low tidal volume ventilation [Tidal Volume (TV) = 3 ml/kg, Respiratory Rate (RR) = 12/min, Fraction of Inspiratory Oxygen (FIO(2))= 1.0, Positive End Expiratory Pressure (PEEP) = 5 cmH(2)O] was applied during CPB (group I); and in the other 50 patients (group II), the lungs were open to the air without ventilation. Measurements were taken pre- operatively, after CPB, and before discharge home. They found that Continued low tidal volume ventilation during CPB has improved post-bypass oxygenation and lung function [3]. We studied the effect of low

tidal volume lung ventilation during cardiopulmonary bypass in elective cases. None of the cases were urgent or emergency. So, we think more studies should investigate urgent and emergency cases in the future.In a study aimed to determine the frequency, types, and risk factors for each pulmonary complication after open heart surgery, Setlers et al 2024 performed a retrospective single-center trial which involved 314 adult patients scheduled for elective cardiac surgery under CPB and mentioned that at least one pulmonary complication developed in almost 50% of patients. Left-sided pleural effusion was the most common complication with hypoalbuminemia as a risk factor for development of effusion and atelectasis was the 2nd most common [5]. However, in our study atelectasis happened in 20.3% of the cases which may be explained by the nature of the relatively young age group and most of them have rheumatic valvular pathology. Zhang et al 2021, in a randomized controlled study which tried to determine whether maintaining ventilation during cardiopulmonary bypass with a different Fraction of Inspired Oxygen (FiO2) had an effect on the postoperative pulmonary complications, they concluded that maintaining ventilation during CPB did not reduce the incidence of post-operative pulmonary complications in patients undergoing open heart surgery [6].

Limitations: We believe that the limitation of our study is its retrospective nature.

Conflict of Interests: We acknowledge that there is no conflict of interests

Conclusion: Small tidal volume lung ventilation during cardiopulmonary bypass is a modality that can be considered to reduce pulmonary complications after cardiac surgery.

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