POSTOPERATIVE THORACIC COMPUTED TOMOGRAPHY CHANGES IN PATIENTS UNDERGOING VALVE REPLACEMENT SURGERY


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Abstract

Background: Pulmonary dysfunction is a well-recognized complication associated with cardiopulmonary bypass (CPB), and is a major cause of morbidity and mortality after cardiac surgery. Computed tomography is a preferred method for imaging the lung because of the widespread availability, resolution, high signal/noise ratio for lung tissue, and speed. The aim of this study is to detect different lung complications using thoracic computed tomography (TCT) in patients undergoing valve replacement surgery with cardiopulmonary bypass.

Methods: Twenty-three patients undergoing valve surgery with cardiopulmonary bypass were studied. In all patients, Thoracic Computed Tomography (TCT) with both pulmonary and mediastinal windows was made preoperatively and 24-30 hours postoperatively.

Results: None of the patients’ had any CT change in the preoperative period. In the postoperative period, one patient had no detectable CT change, five patients had one CT change and 17 patients’ had more than one CT change. These changes were as follows; 19 patients had atelectasis, 15 patients had pleural effusion, 6 patients had consolidation pneumonia and bronchiectasis was detected only in two patients.

Conclusion: Pulmonary complications detected by TCT after valve surgery with cardiopulmonary bypass are common, and new CPB techniques and/or ventilation strategies are required to reduce such changes.

INTRODUCTION

In spite of new surgical approaches, better extracorporeal oxygenation techniques and progress in anaesthetic techniques, organ dysfunction due to cardiopulmonary bypass still remains an object of many clinical and experimental studies.

Pulmonary dysfunction is one of the most serious causes of morbidity in an early postoperative period after cardiac surgery (1). Pulmonary dysfunction prolongs mechanical ventilation, intensive care stay of the patients’, total duration of hospitalization time and increases treatment costs (2,3).

During the last few decades, many pathogenetic factors and mechanisms with negative influence on pulmonary function (factors associated with anesthetic agents, myocardial protection, and extent of surgery, cardiopulmonary bypass and nonspecific inflammatory response syndrome) were found (4).

Early in the postoperative period, 80% of patients undergoing on pump surgery experience atelectasis which causes arterial hypoxemia and increase intrapulmonary shunt fraction (5).

Computed tomography is emerging as the preferred method for imaging the lung because of the widespread availability, resolution, high signal/noise ratio for lung tissue, and speed. From conventional CT images, it is possible to measure whole and regional lung volumes, distribution of lung aeration, and recruitment behavior under various clinical conditions and interventions (6).
Aim of the work

This study was designed to detect different lung complications using thoracic computed tomography (TCT) in patients undergoing valve replacement surgery with cardiopulmonary bypass.

METHODS

After obtaining the local research ethical committee approval and written informed consent 23 patients were studied. Patients with a history of pre-existing lung disease, or considerable preoperative lung changes (e.g. atelectasis, effusion) by CT scan were excluded from the study.

Anaesthetic technique

All patients were premedicated with oral diazepam 10 mg 60-90 minutes before surgery. Anaesthesia was induced by propofol (2-3 mg kg⁻¹), fentanyl (5-10µg kg⁻¹) and pancuronium (0.1mg kg⁻¹) was given to facilitate endotracheal intubation. Anaesthesia was maintained with supplemental isoflurane (0.5%–1.0%) in O2/air, propofol (2-5 mg kg⁻¹ h⁻¹), fentanyl (1-2 µg kg⁻¹ h⁻¹), and incremental doses of pancuronium was given as required.

Cardiopulmonary Bypass

A non-pulsatile heart-lung machine was used (COBE), (Cardiovascular, Inc. ARAVADA, Co. 80004–3599 USA) with a flow rate of 2.4 l.min⁻¹ m⁻² body surface area and a membrane oxygenator with no arterial-line filter. The pump was primed with crystalloid, non-glucose containing solution (Ringers’ solution). Alpha-stat blood gas strategy was used; PaCO₂ was maintained between 35 and 45mmHg and moderate hypothermia (28°C-30°C) was used. Cold crystalloid cardioplegia was used and the solution was administered in the aortic root. The cardioplegia solution was given by the anaesthetist at a dose of 10-20 ml.kg⁻¹. Further half-doses were given every 20-30 min as required. Continuous infusion of fentanyl (1-2µg kg⁻¹ h⁻¹) and propofol (2-5 mg kg⁻¹ h⁻¹) was given to maintain anaesthesia during CPB. Also, the mean arterial blood pressure (MAP) was kept between 50 and 70mmHg by using either glyceryl trinitrate (GTN) or incremental doses of ephedrine, as appropriate.

Continuous monitoring of mean arterial pressure (MAP), right atrial pressure, electrocardiogram, oxygen saturation, and intermittent monitoring of blood gases, electrolytes and clotting analysis were done.

Postoperative ventilation of patients was carried out using the protocol adopted in the postoperative cardiac ICU. Patients were mechanically ventilated using FiO₂ of 0.6, tidal volume (Vt) of 6-8 ml.kg⁻¹, respiratory frequency of 10-12cycles.min⁻¹ and positive end expiratory pressure of 5-10 cmH₂O.

In all patients, Thoracic Computed Tomography (TCT) with both pulmonary and mediastinal windows was made preoperatively and 24-30 hours postoperatively. CT scanning was performed with patients in the supine position. A frontal scout view covering the chest was obtained at the end of expiration. Subsequently, CT scans were obtained at the end of expiration: (1) 2 cm above the right costophrenic angle; (2) at the tracheal bifurcation; and (3) at two levels spaced equidistant between the first two scans.

RESULTS

Patient characteristics′ were described in Table 1. None of the patients had any detectable changes in the Thoracic Computed Tomography (TCT) in the preoperative period (Fig 1). In the postoperative period 22 patients had detectable TCT changes and no complications were detected in one patient. The total number TCT changes were 42 and they were as follows;

- Five patients out of 22 had one CT change.
- 14 out of 22 patients had two CT changes.
- And 3 patients out of 22 had three CT changes.

These TCT changes were in the form of;

- Brochiectasis was detected in two patients (Fig 2 and 3).
- Consolodation pneumonia was detected in six patients, and it was bilateral in five patients and only in the left lung in one patient (Fig 2 and 4).
- Atelectasis was observed in 19 patients, and it was bilateral in 10 patients and unilateral in 9 patients (in 3 patients in right lung and in 6 patients in the left lung) (Fig 2 and 4).
- Pleural effusion was found in 15 patients. This effusion was bilateral in 11 patients and unilateral in 4 patients (in three patients in the right lung and in one patient in the left lung) (Fig 2 and 6).

Statistical analysis

All data were analyzed with SPSS version 11 for Windows (SPSS Inc., Chicago, IL). Data was presented as mean (SD) unless otherwise stated.
Table 1 Mean and SD of patient characteristics

<table>
<thead>
<tr>
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<th>Mean (SD)</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>27.165 (10.42)</td>
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<tr>
<td>Weight (kg)</td>
<td>57.74 (22.6)</td>
</tr>
<tr>
<td>Male/female</td>
<td>10/13</td>
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<tr>
<td>Ejection fraction (%)</td>
<td>57.74 (8.5)</td>
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<tr>
<td>CPB time</td>
<td>122 (36)</td>
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<tr>
<td>Ischemic time</td>
<td>95.5 (33)</td>
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<tr>
<td>Surgery of valve lesion</td>
<td></td>
</tr>
<tr>
<td>- Mitral valve replacement</td>
<td>12</td>
</tr>
<tr>
<td>- Aortic valve replacement</td>
<td>11</td>
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</tbody>
</table>

Fig 1 Normal Pre-operative thoracic CT scan

Fig 2 Number of Thoracic CT Changes in the postoperative period
DISCUSSION

In this study, several lung changes were detected by thoracic CT; atelectasis was detected in most of the patients (19 out of 22), pleural effusion in 15 patients, consolidation in 6 patients and bronchiectasis only in two patients.

Pulmonary dysfunction after CPB may be the result of multiple insults from various aspects of CPB surgery. These include extra-CBP factors (ie, general anesthesia, sternotomy, and breach of the pleura) and intra-CBP factors (ie, blood contact with artificial material, administration of heparin-protamine, hypothermia, cardiopulmonary ischemia, and lung ventilatory arrest) (7-9).

It has been noticed that lung functional impairment is inevitable after any major surgery, a condition that most likely is related to the general anesthesia. Using CT scanning, it has been found that general anesthesia induces atelectasis in nearly all patients (10). However, CPB appears to cause additional lung injury and to delay pulmonary recovery compared with other types of major surgery (11), conditions that generally are believed to be due to the damaging effects of a systemic inflammatory response associated with CPB (9).

Early in the postoperative period, 80% of patients undergoing on pump surgery experience atelectasis which causes arterial hypoxemia and increase intrapulmonary shunt fraction [5].

Such lung changes after cardiac surgery can prolong hospital stay and intensive care days, and increases health care costs. In our study, 22 patients out 23 had one or more CT changes after cardiac surgery with CPB. Therefore, new cardiopulmonary
bypass techniques and/or new ventilation strategies that can prevent or reduce such complication should be thought and used.

Dyhr and others \(^{12}\) reported that in ventilated patients after cardiac surgery positive end expiratory pressure (PEEP) increases lung volumes, but not PaO\(_2\), whereas lung recruitment maneuver (LRM) without subsequent PEEP had no sustained effect. Combination of LRM and PEEP were needed to increase and maintain the increased lung volume and PaO\(_2\).

In addition, the use of off pump surgery in patients undergoing coronary artery bypass surgery is associated with better postoperative pulmonary functions than in those undergoing surgery with CPB \(^{13-15}\).

In conclusion, it appears from this study that pulmonary changes detected by thoracic CT in patients undergoing valve surgery with CPB are common and new CPB techniques and/or ventilation strategies are required to reduce such changes.

REFERENCES


