Incidence and outcome of pulmonary complications after open cardiac surgery, Thowra Hospital, Cardiac center, Sana’a, Yemen

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Pulmonary complication; Post-operative; Cardiac surgery

Abstract This prospective study was designed to determine the incidence of pulmonary complications after open cardiac surgery as well as to identify predisposing factors of these complications. The cumulative incidence of pulmonary complications was 15.08% with a mortality rate of 18.5% from patients who developed complications and overall mortality among all patients was 2.79%. Pulmonary complications occurred in 7.82% of patients with coronary artery revascularization, 2.23% in patients with valvular replacement and 5.05% in patients with congenital heart disease.

ARDS occurred in 3.35% of patients with a mortality rate of about 66.6%, dehiscence sternum and mediastinitis occurred in 1.6% with mortality 33.3%, pneumonia in 2.79%, atelectasis in 3.35%, pleural effusion in 2.22% and pneumothorax in 0.55%. The most predisposing factors were massive blood transfusion, re-exploration for control of post-operative bleeding, cardiopulmonary resuscitation and prolonged length stay in the intensive care unit.

Introduction

The various components of the respiratory system; airways, lungs, chest wall, intercostals muscles; diaphragm and neural pathways, to and from these various components are subjected to damage caused by a variety of processes associated with cardiac surgery and cardio pulmonary bypass (CPB). Cardiac surgery through either a sternotomy or thoracotomy has deleterious effects on the function of the muscle pump and the chest wall. Additionally, phrenic nerve damage resulting from cold topical solution applied inside the pericardium may cause mechanical problems. Left side cardiac distension
or elevated pressure may cause alveolar edema, and transfu-
sion reaction or allergic reaction to drugs (e.g. protamin) 
may increase capillary permeability leading to alveolar 
flooding [1].

Mechanical alterations in lung function

(A) Atelectasis

It is the most common pulmonary complication after car-
diac surgery occurring in about 70% of cases. During (CPB),
the lungs are not perfused and they are allowed to collapse 
to functional residual capacity. When the lungs are sub-
sequently re-expanded then variable degree of pulmonary atelec-
tasis remains [2].

Etiology of pulmonary atelectasis

Preoperative factors [3]:

(1) Smoking, chronic bronchitis.
(2) Obesity [decreased functional residual capacity (FRC)].
(3) Cardiogenic pulmonary edema.

(B) Acute lung injury [ARDS] and cardio-pulmonary by 

pass

Activation of complement and neutrophils causes seque-
stration of neutrophils in the pulmonary microvasculature 
and an increase in the pulmonary capillary permeability [4].

On the other hand reperfusion injury after ischemia gener-
ates oxygen free radicals and may also contribute to lipid per-
oxidation at this time [5]. There is an increased systemic level 
of thromboxane during (CPB). Thromboxane released from 
platelets activated by extra corporeal circuit, and its profound 
effects on vasoconstriction and platelet aggregation could fur-
ther injure the microcirculation [6].

(C) Postoperative pneumonia

Pneumonia remains the greatest threat to survival that 
exists in a surgical patient. Patients are often debilitated 
by the effects of the disease process, intravenous lines, blad-
der catheters, endotracheal tube and surgical wound. The 
incidence of pneumonia is about 5–19%. More than 90% 
of nosocomial pneumonia is bacterial and in 50–70% of 
cases the responsible organisms are gram negative bacilli.

The most important causative gram negative organisms in-
clude Klebsiella species, Escherichia coli and Pseudomonas 
 aeruginosa [7].

Aim of the work

(1) Determining the incidence of pulmonary complications 
after open heart surgery as well as identifying predispos-
ing factors of these complications.
(2) Minimizing the risk of developing pulmonary complica-
tions as well as mortality after open cardiac surgery.

Materials and methods

This prospective study was performed at the cardiac center, 
Thowra Hospital, Sana’a from Jan 2004 to Dec 2009.

During this period 179 patients (130 males and 49 fe-
males) were included in this study. The patients were divided 
into three groups:

- **Group I**: Included 88 patients (72 males and 16 females) 
  with mean age of 49.58 and 53.6 years, respectively. These 
  patients underwent coronary arteries bypass surgery.
- **Group II**: Included 53 patients (36 males and 17 females) 
  with mean age of 29.6 and 40.7 years, respectively. These 
  patients underwent valve replacement.
- **Group III**: Included 38 patients (22 males and 16 females) 
  with mean age of 5.6 and 4.2 years, respectively. These 
  patients underwent open cardiac surgery for correction of 
  congenital heart disease.

All patients were subjected to the following:

(1) Complete history taking and clinical examination.
(2) Chest X-ray and EGG.
(3) Complete blood picture and serum potassium and 
sodium.
(4) Blood urea and serum creatinine.
(5) Fasting blood sugar.
(6) Serum bilirubin, albumin, SGOT and SGPT.
(7) Prothrombin time, concentration and INR.
(8) Coronary angiography for all patients with ischemic 
  heart disease and patients with valvular heart lesion 
  whose ages are over 40 years and congenital heart lesion, 
  (when indicated).

All patients were followed up for the following:

(1) Total operative time.
(2) Coronary by-pass time.
(3) Cross clamp time.
(4) Ten days follow up in the hospital and 1 month after 
  discharge.
(5) Intraoperative complications and blood transfusion.
(6) Postoperative complications.
(7) Time of post-operative complications.
(8) Post-operative ECG, chest X-ray, complete blood pic-
  ture, blood urea, serum creatinine, serum potassium 
  and sodium. Prothrombin time, concentration and INR.
(9) Amount of post-operative blood transfusion.
(10) Blood gas analysis.
(11) Management of complications and outcome patients.
(12) Trans-tracheal aspiration, gram stain and culture cases 
  of pulmonary infection.

Criteria for diagnosis of post-operative pneumonia:

(1) Fever and purulent sputum.
(2) New chest radiographic shadow.
(3) New onset radiographic shadowing, progressive infla-
  tion, consolidation, caviations or effusion.
(4) Organism isolated from sputum obtained by trans-
  tracheal aspiration.

Criteria for diagnosis of acute respiratory distress 

syndrome:

(1) Bilateral diffuse pulmonary infiltration.
(2) Refractory hypoxemia pao2/Fio2 is 200.
(3) Reduced total lung compliance less than 50 ml/cm H2O.
(4) No evidence of heart failure by clinical examination and 
  echocardiography.
Results

The study included 179 patients (130 males and 49 females) the average age was 41 years that ranged from 15 to 68 years. The patients were classified into three groups:

1. Coronary artery revascularization includes 88 patients (72 males and 16 females with mean age of 51.9 years).
2. Valve replacement includes 53 patients (36 males and 17 females) with mean age of 15–53 years.
3. Congenital heart disease includes 38 patients (22 males and 16 females) with mean age of 4.9 years.

The cumulative incidence of pulmonary complications after open heart surgery was 15.08% (27 of 179) with a mortality rate of 18.5% (5 of 27) and the overall mortality among all patients was 2.79% (5 of 179).

Early pulmonary complications after open heart surgery (within 36 h post-operative)

Acute respiratory distress syndrome (ARDS) developed in; one patient with aortic valve replacement, one patient with congenital heart diseases, and 3 patients with coronary artery revascularization.

The first patient with coronary artery revascularization presented with dyspnea, tachypnea, hypoxemia, and bilateral diffuse pulmonary infiltration. Mechanical ventilation was done, pulmonary compliance measurement was 48 ml/cm H2O, the patient underwent mechanical ventilation for 16 days with no response to supportive therapy and died due to multiorgan failure.

In the second female patient with coronary artery revascularization, post-operative massive blood transfusion was done due to post-operative bleeding which needed re-exploration and ligation of bleeder blood vessels, 13 units of whole blood were transfused (500 ml for unit), after 12 h the patient developed dyspnea, tachypnea, hypoxemia pao2/Fio2 was less than 150, and bilateral diffuse pulmonary infiltration. The patient was subjected to mechanical ventilation for 22 days, but she died from multiorgan failure.

The third patient with coronary artery revascularization developed acute respiratory distress syndrome (ARDS) within 12 h postoperative. Hypoxemia, diffuse bilateral pulmonary infiltration, and reduced total pulmonary compliance were the presenting features. The patient was mechanically ventilated for 7 days and was discharged from hospital after 13 days.

ARDS occurred in a male patient 38 year old in the second post-operative day of aortic valve replacement. The patient was tachypnic with diffuse bilateral pulmonary infiltrations on chest radiography; he was mechanically ventilated for 29 days without improvement and died due to respiratory failure.

ARDS occurred in a female patient 8 years old after closure of ventricular septal defect, after estuation by 8 h she developed tachypnea, hypoxemia, and diffuse pulmonary infiltrations, and intubation and mechanical ventilation was done for 5 days. The patient improved and was discharged 12 days later. The incidence of ARDS in early post-operative was 2.79% (5 of 179).

Late pulmonary complications after open heart surgery

Dehiscence sternum and mediastinitis occurred in two patients after coronary artery revascularization and one patient after total correction of fallot tetralogy. The causes of dehiscence of sternum and mediastinitis in one patient with coronary artery revascularization were cardiac arrest due to ventricular fibrillation, sternal fracture following cardiac massage, wound infection and mediastinitis. Re-exploration, debridement and direct wire fixation, patient developed severe toxemia due to sepsis, isolated organism was Pseudomonas aeruginosa, the patient died after 27 days from multiorgan failure.

The second patient developed dehiscence sternum and mediastinitis 5 days postoperative, culture from the wound revealed no growth, re-exploration, debridement and direct wire fixation was done, then the patient improved and discharged in good condition.

Dehiscence sternum and mediastinitis occurred in a 3 years old female child following total correction of fallot tetralogy in the 7th post-operative day, drainage, debridement and direct wire fixation was done and the patient improved and discharged on the 12th day. The incidence of dehiscence sternum and mediastinitis was 1.76% (3 of 179). Left sided pleural effusion occurred in two patients with coronary artery revascularization and in one patient with congenital heart disease. It was transudative in nature and required drainage in one patient to relieve dyspnea. All patients survived and the incidence of post-operative pleural effusion was 2.23% (4 of 179).

Three patients developed pneumonia; one after coronary artery revascularization, another after mitral valve replacement and the last after closure of atrial septal defect. The isolated organisms were streptococcal in the first two patients, while no growth in the third patient, all patients survived and discharged after 10 days. The incidence of late postoperative
Total number of patients with open heart.

<table>
<thead>
<tr>
<th></th>
<th>Male patients</th>
<th>Female patients</th>
<th>Total number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Mean (age/years)</td>
<td>No.</td>
</tr>
<tr>
<td>Coronary artery revascularization</td>
<td>72(55%)</td>
<td>49.52</td>
<td>16(33%)</td>
</tr>
<tr>
<td>Valve replacement</td>
<td>36(28%)</td>
<td>29.6</td>
<td>17(34%)</td>
</tr>
<tr>
<td>Congenital heart disease</td>
<td>22(17%)</td>
<td>5.6</td>
<td>16(33%)</td>
</tr>
<tr>
<td>Total</td>
<td>130</td>
<td></td>
<td>49</td>
</tr>
</tbody>
</table>

Mortality rate of patients with pulmonary complications.

<table>
<thead>
<tr>
<th>Patients</th>
<th>Mortality</th>
<th>Percentage of mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute respiratory distress syndrome</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Dehiscent sternum and mediastinitis</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>5</td>
</tr>
</tbody>
</table>

All complications after open heart surgery.

<table>
<thead>
<tr>
<th></th>
<th>Total No.</th>
<th>ARDS</th>
<th>LPNP</th>
<th>Pneumonia</th>
<th>Atelectasis</th>
<th>Dehiscence sternum</th>
<th>Pleural effusion</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary artery revascularization</td>
<td>88</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>14</td>
<td>15.5</td>
</tr>
<tr>
<td>Valve replacement</td>
<td>53</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>4</td>
<td>7.54</td>
</tr>
<tr>
<td>Congenital heart disease</td>
<td>38</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>23.68</td>
</tr>
<tr>
<td>Total</td>
<td>179</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>26</td>
<td>–</td>
</tr>
<tr>
<td>Percentage from total</td>
<td>3.35%</td>
<td>3.35%</td>
<td>2.75%</td>
<td>1.11%</td>
<td>1.6%</td>
<td>2.22%</td>
<td>15.08%</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

LPNP = left phrenic nerve palsy.

Late complications after open heart surgery.

<table>
<thead>
<tr>
<th></th>
<th>Dehiscence sternum</th>
<th>Pleural effusion</th>
<th>Pneumonia</th>
<th>Pneumothorax</th>
<th>ARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Sex</td>
<td>Out-come</td>
<td>Age</td>
<td>Sex</td>
<td>Out-come</td>
</tr>
<tr>
<td>48</td>
<td>M</td>
<td>Died</td>
<td>52</td>
<td>F</td>
<td>Survive</td>
</tr>
<tr>
<td>42</td>
<td>M</td>
<td>Survive</td>
<td>46</td>
<td>M</td>
<td>Survive</td>
</tr>
<tr>
<td>38</td>
<td>M</td>
<td>Survive</td>
<td>28</td>
<td>M</td>
<td>Survive</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>Survive</td>
<td>1</td>
<td>M</td>
<td>Survive</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>–</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Total number of patients: 179.
Number of patients with pulmonary complications: 12.
Survived: 10.
Died: 02.

Early complications after open heart surgery.

<table>
<thead>
<tr>
<th></th>
<th>ARDS</th>
<th>Left phrenic palsy</th>
<th>Atelectasis</th>
<th>Pneumonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Sex</td>
<td>Out-come</td>
<td>Age</td>
<td>Sex</td>
</tr>
<tr>
<td>56</td>
<td>F</td>
<td>Died</td>
<td>57</td>
<td>M</td>
</tr>
<tr>
<td>47</td>
<td>M</td>
<td>Died</td>
<td>48</td>
<td>M</td>
</tr>
<tr>
<td>52</td>
<td>M</td>
<td>Died</td>
<td>37</td>
<td>M</td>
</tr>
<tr>
<td>52</td>
<td>M</td>
<td>Survive</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>M</td>
<td>Died</td>
<td>43</td>
<td>F</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>Survive</td>
<td>6</td>
<td>M</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>–</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>

Total number of patients: 179.
Number of patients with pulmonary complications: 15.
Survived: 12.
Died: 03.
Pneumonia was 1.67% (3 of 179). Right sided pneumothorax in one patient after total correction of fallot tetralogy due to pleural injury by central line which required intercostal tube drainage.

One patient developed ARDS on the third day after correction of complete atrioventricular canal. Reintubation, mechanical ventilation, supportive therapy in the form of intravenous fluid, broad spectrum antibiotic without improvement and patient died after 9 days.

Discussion

The aim of this study was to measure the incidence of pulmonary complication after open heart surgery, 179 patients (130 males and 49 females) were included for this study, open heart surgery was done using Cardiopulmonary bypass (CBP) in 165 patients and on beating heart in 14 patients with single vessel coronary artery revascularization, no complication occurred in patients who underwent open heart surgery without the use of CBP.

Pulmonary complications

1. Acute Respiratory Distress Syndrome (ARDS).
2. Left phrenic nerve palsy.
   The incidence of left phrenic nerve palsy was 3.35% (6 out of 179), thermal injury causes both demyelination and axonal degeneration of phrenic nerve with resulting in slowing of conduction and impaired activation of diaphragm. 12 Wilcox, 198.812 found that left phrenic nerve palsy occurs in approximately 10% of patients having coronary artery revascularization, no complication occurred in patients who underwent open heart surgery without the use of CBP.
3. Dehiscence sternum and mediastinitis.
   In our study the incidence of dehiscence sternum and mediastinitis was 1.6% (3 out of 179) and mortality was 33.3% (1 of 3). In 1984, Sar and Colleagues [10] found that the incidence of mediastinitis ranges from 0.4 to 5.0% of patients undergoing median sternotomy. Numbers of factors have been implicated that; patient at risk of mediastinitis as diabetes mellitus, obesity, low cardiac output, history of endocarditis, prolonged preoperative hospitalization, patient requires re-exploration to control bleeding, prolonged length stay in the intensive care unit, mechanical ventilation greater than 24-48 h, the need for tracheostomy and use of cardio pulmonary resuscitation.
4. Atelectasis.
   In our study atelectasis occurred in 1.11% (2 of 179) which was diagnosed both clinically and radiographically, the incidence of atelectasis in our study was very low than the study done by Brooks [2] who found that post-operative atelectasis occurred in 70% of cases, the explanation of low incidence in our study may be due to micro-atelectasis or miliary atelectasis being usually undetectable both clinically and radiographically, or the use of positive end expiratory pressure (PEEP of 7–8 cm H₂O) during the postoperative period of mechanical ventilation.

The incidence of postoperative pneumonia in the present study was 2.79% (5 of 179) which was lower than the study done by Cunnion et al. [16], 13, and Seymour and Vaz, in 1989, 14, they found that the incidence of pneumonia was 15–20% and 17%, respectively. This difference could be explained by the use of third generation cephalosporin (cefotaxim 30 mg/kg/day) in two divided doses, and ampicillin salbactam 40 mg/kg/day in three divided doses for 3 days in all postoperative patients in our study.

Summary

The cumulative incidence of pulmonary complication after open heart surgery was 15.08%, with an overall mortality 18.5% (5 of 27) and mortality among all patients was 2.79% (5 of 179). ARDS occurred in 3.37% of with an ADRS mortality 66.6% dehiscence sternum and mediastini-
tis occurred in 1.6% with mortality 33.3%, pneumonia occurred in 2.79% atelectasis occurred in 1.11%, left phrenic nerve palsy occurred in 3.33%, pleural effusion occurred in 2.22% and pneumothorax occurred in 0.55%.

**Recommendations**

1. CPB time as short as possible as we can prevent postoperative ARDS.
2. Use of postoperative positive airway pressure 7–8 cm H₂O during postoperative mechanical ventilation to prevent postoperative atelectasis.
3. Prophylactic use of postoperative broad spectrum antibiotic to prevent pneumonia.
4. Early ambulation and physiotherapy.

**Conflict of interest**

None declared.

**References**