Original Article

Causes of Dyspnea after Cardiac Surgery

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Abstract

OBJECTIVES: Postoperative dyspnea is common after cardiac surgery, even in low-risk patients. Cardiac surgeons and anesthesiologists are familiar with patients suffering from dyspnea in the early postoperative period, but in some cases, conventional treatment strategies may be ineffective, and a consultation with a pulmonologist may be required. The aim of this study is to investigate the causes of dyspnea after cardiac surgery in this particular patient group.

MATERIALS AND METHODS: The hospital database was searched for non-emergency cardiac surgery for the period January 2014–October 2015. Individuals with an impaired spirometry result and a history of any pulmonic disease were excluded. Only patients for whom a pulmonary consultation was needed because of dyspnea in the postoperative course were enrolled in the study. Causes of dyspnea were analyzed according to consultation reports and computed tomography findings.

RESULTS: One hundred and three patients were enrolled in the study. Of those, 67 (65%) were male, and the mean age was 61.50±9.43. The most common procedure was the coronary artery bypass grafting. Atelectasis (n=57, 42%) was the most common cause of dyspnea. The length of the intensive care unit (ICU) stay was significantly longer in the pneumonia group (p=0.012). Hospital mortality in the pneumonia group was significantly higher compared with other subgroups (p<0.001).

CONCLUSION: After cardiac surgery, atelectasis was the most common cause of dyspnea, followed by pleural effusion and pneumonia. Patients who experienced dyspnea due to pneumonia had a longer ICU stay. Developing the treatment strategies with consideration of these causes may help reduce the length of stay, morbidity, and mortality in this patient group.

KEYWORDS: Pulmonary rehabilitation and chronic care, respiratory intensive care, thoracic surgery, clinical problems, respiratory infections

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INTRODUCTION

As a result of advances in the cardiac surgical and anesthetic techniques, more patients have been recently referred to cardiac surgery [1,2]. Patients undergoing a cardiac surgical procedure tend to be older and sicker because of the aging population nowadays [1,2]. Dyspnea in the early postoperative period is a major complaint, and postoperative pulmonary complications (PPCs) still remain one of the major causes of morbidity, mortality, increased cost, and prolonged hospital stay after cardiac surgery, particularly in this patient group [1,3–9]. Predicting the high-risk patients for PPCs causing dyspnea and developing a plan to reduce the risk is worthwhile [1,6,9]. Several studies were conducted to investigate the incidence of the PPCs following cardiac surgery [8]. These studies reported diverse results, because of the different patient groups and the variability of the signs and symptoms in a spectrum ranging from dyspnea, cough, and fever to respiratory failure requiring reintubation [8,9]. The success of the surgery is to some extent associated with the effective prevention and management of the PPCs [2]. After general anesthesia, some patients may suffer from dyspnea. However, causes of dyspnea may differ because of the incision, operation site, cardiopulmonary bypass, and internal thoracic artery harvesting, which are unique to cardiac surgery. Although cardiac surgeons are familiar with the patients suffering from dyspnea in the early postoperative period, occasionally, a consultation with a pulmonologist is required to overcome the issue in some patients. The aim of this study is to investigate the incidence, causes, and the risk factors of PPCs causing dyspnea in the early postoperative period after cardiac surgery in this particular patient group.

MATERIALS AND METHODS

Patients who underwent a non-emergency cardiac surgery in from January 2014 to October 2015 were searched in the hospital database. Individuals with an impaired spirometry result preoperatively and a history of any pulmonary disease, such as asthma and chronic obstructive pulmonary disease, were excluded by reviewing the routine preoperative assessment data to obtain a more homogeneous patient group. Among remaining patients, those for whom a pulmonary consultation was needed because of dyspnea in the postoperative course, were enrolled in the study (Figure 1). Spirometries including a ratio of forced expiratory volume in 1 second to forced vital capacity greater than 0.7, a forced vital capacity greater than 80% of the predicted, and no artifacts in spirogram and flow-volume loop were accepted as normal.

Because dyspnea is a relatively subjective symptom reported by patients, we defined dyspnea according to clinical signs and physical examination as well as patient complaints. The presence of one or more findings such as shortness of breath at rest or with minimal effort, tachypnea (the frequency greater than 20 breaths per minute), oxygen inhalation requirement, and oxygen desaturation (lower than 94%) measured by the arterial blood gas analysis or pulse oximetry were accepted as dyspnea in a patient. Dyspnea was assessed first in the intensive care unit (ICU) after extubation and in daily rounds in both the ICU and ward. In the ICU, anesthesiologists and surgeons cooperatively, and in the ward, surgeons on their own, decided to consultation according to clinical status of the patients. Data of the patients including age, sex, spirometry results, ejection fraction (EF), And the ICU and ward progress were collected.

The same anesthetic medications and routine postoperative care of the hospital applied to each patient. Patients were provided with an incentive spirometer after extubation and were encouraged to cough. A postoperative pulmonary toilet regimen included chest physiotherapy and walking on the first postoperative day. All operations were performed through a median sternotomy with mild hypothermic cardiopulmonary bypass. Warm blood cardioplegia and topical cold saline were used for myocardial protection. Valvular procedures included valve replacements with biological or mechanical prosthesis, ring implantations, and De Vega annuloplasty for the tricuspid valve. Thoracic aorta procedures included valve-sparing aortic procedures, supracoronary replacement of the ascending aorta, Bentall procedure, hemiarch, and

total aortic arch replacements. Procedures related to a descending thoracic aorta and thoracoabdominal aorta carried out via a thoracotomy incision were excluded. The use of an intra-aortic balloon pump and inotropic agents were noted.

All patients consulted with the same pulmonologist who was unaware of the study. Plain radiographs were obtained on the operation day and on the first postoperative day routinely, and on the following days when needed. The pulmonologist decided to carry out a computed tomography (CT) of the thorax to ascertain the diagnosis, because plain radiographs were not able to provide adequate information in some patients. Diagnoses were made with plain radiographs in only 21 (20%) individuals, in whom the pulmonologist was able to define the pathology without the need of further investigation. The same radiology team, unaware of the study, interpreted all CT scans. The clinical diagnoses of the pulmonologist were compared with the radiological diagnoses derived from CT scans. In the case of co-occurrence of two or more pathologies in a patient, or a mismatch between the clinical and the radiological diagnoses, the pulmonologist was requested to reassess the case and elucidate the major pathology causing dyspnea.

Diagnosis of pneumonia was made when a new lung infiltrate was observed radiologically accompanied by fever, purulent sputum, leukocytosis, and a decline in oxygenation.

Informed consents were obtained from all patients. The local ethic committee of the Dr. Siyami Ersek Cardiothoracic and Vascular Surgery Training and Research Hospital approved the study on 16/12/2015, document number 9342.

Statistical Analyses

The normal distribution of continuous data was checked by the Kolmogorov-Smirnov test. Normally distributed data were presented as the mean±standard deviation, whereas a median (25th quantile-75th quantile) was used to express non-normal distribution. Continuous data between the groups were analyzed by the Student's t test, or by nonparametric tests for small subgroups. The Mann-Whitney U test was used for the evaluation of differences in non-normally distributed data. Differences in categorical outcome measures were analyzed by the Fisher's exact test and Yates' correction of continuity test. Data were analyzed using the NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) software. A p<0.05 was considered to be statistically significant.

RESULTS

A total of 103 patients were enrolled in the study. Of those, 67 (65%) were male, and the mean age was 61.50±9.43. The mean body mass index (BMI) was 29.35±5.70, and the median preoperative EF was 55% (40–60). A CT scan of the thorax was conducted in 82 (80%) patients. The most common surgical procedure was the coronary artery bypass grafting (CABG), followed by isolated valvular procedures and a combination of valvular procedures with CABG. Table 1 demonstrates the surgical procedures carried out on the patients.

Table 1. Surgical procedures

CABG	63 (61.2%)
Valvular	16 (15.6%)
CABG+valvular	13 (12.6%)
CABG+thoracic aorta	7 (6.8%)
Thoracic aorta+valvular	2 (1.9%)
Thoracic aorta	2 (1.9%)
Total	103 (100%)

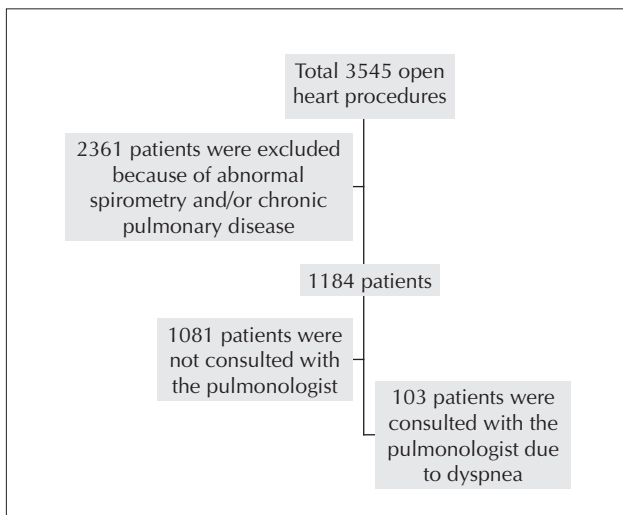CABG: coronary artery bypass grafting
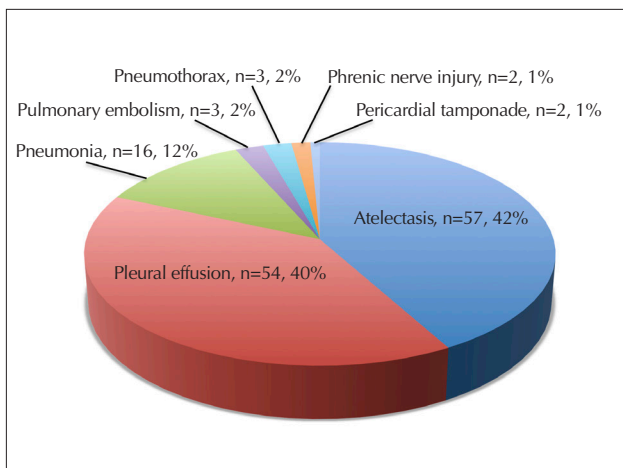
Figure 1. Patient flow in the study

Figure 2. Distribution of dyspnea causes

The median length of the ICU and hospital stay were 2 (1-4) and 12 (8-19) days, respectively. Other parameters observed in the postoperative course are shown in Table 2.

The most common cause of dyspnea was atelectasis, which was reported in 57 (55%) patients. The left lower lobe was the most frequently affected segment (n=34, 60%). Pleural effusion (n=54, 52%) and pneumonia (n=16, 16%) were the second and third most common causes of dyspnea, respectively. Figure 2 shows the distribution of the dyspnea causes. The atelectasis, pneumonia, and pleural effusion rates did not differ among the groups of surgical procedures (p=0.60, p=0.29, p=0.42).

In 57 patients in whom atelectasis was the major cause of dyspnea, accompanying minor findings were pleural effusion and pneumonia, which were seen in 39 (68%) and 7 (12%) individuals, respectively. On the other hand, pleural effusion was accompanied by atelectasis in 39 (72%) of 54 patients. In the pneumonia subgroup, accompanying pathologies were atelectasis and minor pulmonary embolus in 7 (44%) and 1 (6%) patients, respectively. Comparisons of the observed parameters within the groups are demonstrated in Table 3. Age, sex, the BMI, and preoperative left ventricular EF did not differ between groups. The length of the ICU stay in patients with pneumonia was longer than that in patients in who dyspnea was attributed to other causes, significantly (p=0.012). The length of hospital stay in patients with pneumonia and the length of the ICU stay in patients with atelectasis were longer than those in who dyspnea was attributed to other causes, but the differences were not statistically significant (p=0.249 and p=0.902, respectively). Pleural effusion did not affect the length of the ICU or hospital stay. Hospital mortality in the pneumonia group was significantly higher compared with other subgroups (p<0.001).

DISCUSSION

Among cardiovascular, thromboembolic, and infectious complications, PPCs require a considerably longer hospital stay as well as higher health care costs [6,7,9]. Whereas dyspnea causes in high-risk patients with a history of lung disease such as asthma or chronic obstructive pulmonary disease may be anticipated, in patients without a pulmonary disease, as in our group, dyspnea causes are unpredictable [1,3,8-10]. In addition, conventional strategies including oxygen inhalation or bronchodilator medications in the postoperative period may be sometimes insufficient in the treat-

Table 2. Data related to postoperative course

Length of the ICU stay (median day)	2 (1-4)
Length of hospital stay (median day)	12 (8-19)
Prolonged ICU stay, n(%)	53 (51.5%)
Use of inotropic agents, n(%)	19 (18.4%)
Use of IABP, n(%)	9 (8.7%)
Hospital mortality, n(%)	8 (7.8%)

IABP: intra-aortic balloon pump; ICU: intensive care unit

Table 3. Parameters observed within groups

	Atelectasis			Pleural effusion			Pneumonia		
	Yes	No	p	Yes	No	p	Yes	No	p
n	57 (55%)	46 (45%)		54 (52%)	49 (48%)		16 (16%)	87 (84%)	
Age (mean±SD year)	60.23±8.80	63.07±10.04	0.13	61.67±9.31	61.31±9.66	0.848	60.81±11.01	61.62±9.18	0.755
Sex (male)	33 (58%)	34 (74%)	0.09	37 (69%)	30 (61%)	0.438	13 (81%)	54 (62%)	0.139
Preoperative EF (median)	60 (45-60)	50 (40-60)	0.117	55 (45-60)	57.5 (40-60)	0.930	57.5 (35-60)	55 (40-60)	0.627
ICU stay (median day)	2 (1-4)	1 (1-5)	0.902	1 (1-3)	3 (1-5)	0.259	5 (1-7)	1 (1-4)	0.012
Hospital stay (median day)	12 (8-18)	12 (8-20)	0.883	12 (8-20)	12 (8-18)	0.766	14 (10-28)	12 (8-19)	0.249

EF: ejection fraction; ICU: intensive care unit

ment of dyspnea, and a consultation with a pulmonologist is required. Determining the causes and dyspnea risk factors in this patient group may help reduce the length of the ICU and hospital stay, morbidity, and mortality after cardiac surgery.

In our patient group, atelectasis was the most common cause of dyspnea consistent with the literature [8,9]. Lower lobe segments of the left lung were the most frequently affected segments, according to the CT scan findings. A direct trauma to the lungs, pleurotomy for internal thoracic artery (ITA) harvesting, diaphragmatic dysfunction secondary to phrenic nerve injury, and a high oxygen concentration may cause atelectasis and explain the predominance of atelectasis development in the left lower lobe [1,4,8-10]. After beginning the cardiopulmonary bypass, ventilation is stopped, and the lungs collapse. A reduced alveolar distention results in and impaired surfactant production, which increases the alveolar collapse [1,9]. Stagnation of the microcirculation, shearing forces, and increased pulmonary capillary permeability owing to exposure of the blood to the foreign mechanical surfaces lead to the closure of small airways [1]. Thus, atelectasis is an unsurprising consequence of cardiac surgery, even in patients without a history of preoperative lung disease.

Pleural effusion was the second most common cause of dyspnea in our patient group. Several factors such as heart failure, electrolyte imbalance and pericardial inflammation after surgery, hypoalbuminemia, ITA harvesting and pleural dissection, atelectasis, pneumonia, and pulmonary embolism may contribute to the development of pleural effusion [1,3,8,9,11,12]. The effects of administration of anticoagulant drugs on pleural effusion occurrence after valvular procedures may be questionable [1,11,12]. Pleural effusion incidence did not differ among the groups of surgical procedures in our study.

Some studies reported that pleural effusions were the most common PPC following cardiac surgery, and atelectasis was found to be associated with preoperative EF and BMI contrary to our results [1,8,10,11,13]. This may be due to patient selection criteria or the definition method of the major pathology in the patients. We, therefore, confirmed the clinical diagnosis with the findings of the CT scan and obtained more accurate diagnoses.

The incidence of pneumonia reported after cardiac surgery ranges from 2% to 22% [1,9]. Accompanying atelectasis and pleural effusion, which are common pulmonary complications after cardiac surgery, may hinder diagnosing pneumonia by physical examination and chest radiographs in this patient group (9). In our patient group, CT scans, which enhanced the diagnosis, were available in 15 out of 16 patients with pneumonia. Nosocomial pneumonia increases the length of the ICU and hospital stay, as well as morbidity and mortality after cardiac surgery [9,14]. Carrel and colleagues reported preoperative smoking, preoperative positive tracheal aspirate, postoperative low cardiac output, and transfusion of more than 4 units of concentrated erythrocyte as independent predictors for the development of early postoperative pneumonia in their prospective study investigating pneumonia after CABG [14]. These factors were not found to be associated with postoperative pneumonia in our patient group. This may be due to absence of a control group which consists of patients with an uneventful postoperative period. However, the length of the ICU stay of patients with pneumonia was longer than that of patients in whom dyspnea was attributed to other causes significantly. The length of hospital stay was also longer in this group, but the difference was not significant, most probably because of a small patient group.

The reported incidence of pulmonary embolism and deep venous thrombosis (DVT) after cardiac surgery are 0.4%–9.5% and 23%, respectively [9,15]. Edema, tenderness, swelling, and pain are generally acceptable symptoms in the leg from which the saphenous vein was harvested. In addition, the usual symptoms of pulmonary embolism, including chest pain, dyspnea, tachycardia, rales, and cough, may be widely seen in patients after cardiac surgery [15]. Thus, the diagnosis of the pulmonary embolism after cardiac surgery mostly depends on the suspicion of the physician. Relatively uncommon occurrence of DVT and pulmonary embolism after cardiac surgery compared with other major surgical subspecialties may be a result of a routine use of heparin during the cardiopulmonary bypass and antiplatelet drugs after surgery [15]. Furthermore, the incidence of pulmonary embolism may be lower after valve surgery compared with coronary bypass grafting because of administration of anticoagulant drugs in the early postoperative period [9]. In our study, the incidence of pulmonary embolism did not differ among groups of surgical procedures, and DVT was not detected in patients with pulmonary embolism.

Pneumothorax is a rare complication after cardiac surgery with an incidence of 0.7%–1.7% [1,9,13]. However, this incidence may reach 5.3% in patients with an ITA graft [9]. Pneumothorax caused by air leaks results in tension pneumothorax in intubated patients in the ICU. Other causes of pneumothorax in the early postoperative period are air accumulation in an intact pleura, misplacement of chest tubes, and blockage caused by coagulum or kinking [9]. Surgeons or anesthesiologists may easily diagnose pneumothorax in the early postoperative period, and counseling of pulmonologist may not be required. However, pneumothoraxes in our patient group were challenging cases in whom pneumothorax developed in the ward and was diagnosed in the thoracic CT scan. This may be an additional cause for the low incidence of this complication in our patient group.

Phrenic nerve dysfunction results in diaphragmatic paralysis and alterations in pulmonary mechanics, thereby impairment in lung capacity after cardiac surgery [1]. Myocardial cooling techniques were implicated in the hypothermic injury to the left phrenic nerve and the left-sided predominance of the atelectasis after coronary bypass surgery [16]. Topical cooling with ice slush rather than applying cold saline for only a few minutes may be responsible for the phrenic nerve paralysis [1,5,9]. The ice slush was not used in our patient group, and the phrenic nerve injury was relatively rare.

Postoperative cardiac dysfunction is one of the major causes of poor pulmonary outcome after cardiac surgery [9]. A low cardiac output state may result in pulmonary edema, acute

respiratory distress syndrome (ARDS), as well as atelectasis and pneumonia, which are consequences of fatigue, weak coughing, and lack of deep breathing related to heart failure. Although a low cardiac output state was evident in some of the patients in our group, neither pulmonary edema nor ARDS was the major cause of dyspnea. The rationale underlying this result may be the successful management of pulmonary edema and ARDS by anesthesiologists and surgeons without counseling of the pulmonologist in the early postoperative period.

There are several limitations to this study. A small patient group might have a negative effect on some results that were not statistically significant. In this study, dyspnea causes were investigated in patients for whom a consultation with a pulmonologist was needed. The results were compared with other subgroups, in which dyspnea was attributed to other causes, instead of a control group which consisted of patients with an uneventful postoperative period. Thus, some results, which may be otherwise statistically significant, need further studies. However, more accurate diagnoses were made with the aid of CT scan of the thorax, which was available in high proportion of the patients (n=82, 80%) in this study.

In conclusion, after cardiac surgery, atelectasis was the most common cause of dyspnea followed by pleural effusion and pneumonia in patients for whom a consultation with a pulmonologist was required in the early postoperative period. Patients who experienced dyspnea due to pneumonia had a longer ICU stay than those in whom dyspnea was related to other pulmonary complications. Developing the treatment strategies with consideration of these causes may help reduce the length of stay, morbidity, and mortality in patients with postoperative dyspnea after cardiac surgery. The phrenic nerve dysfunction, pulmonary embolism, and pneumothorax were relatively rare causes of dyspnea. Randomized controlled trials should be conducted with large groups to detail the causes of dyspnea, preventive strategies, and their effects on the ICU and hospital stays, morbidity, and mortality in the early postoperative period after cardiac surgery.

Ethics Committee Approval: Ethics committee approval was received for this study from the local ethic committee of the Dr. Siyami Ersek Cardiothoracic and Vascular Surgery Training and Research Hospital (Approval Date: 16.12.2015, document number 9342).

Informed Consent: Informed consent was obtained from the patients.

Peer-review: Externally peer-reviewed.

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