Original Article

Do preoperative pulmonary function indices predict morbidity after coronary artery bypass surgery?

Mahdi Najafi[1,2], Mehrdad Sheikhvatan[2], Seyedeh Hamideh Mortazavi[2]

[1]Departments of Anesthesiology, [2]Research, Tehran Heart Center, Tehran University of Medical Sciences, Tehran, Iran

ABSTRACT

Context: The reported prevalence of chronic obstructive pulmonary disease (COPD) varies among different groups of cardiac surgical patients. Moreover, the prognostic value of preoperative COPD in outcome prediction is controversial. **Aims:** The present study assessed the morbidity in the different levels of COPD severity and the role of pulmonary function indices in predicting morbidity in patients undergoing coronary artery bypass graft (CABG). **Settings and Design:** Patients who were candidates for isolated CABG with cardiopulmonary bypass who were recruited for Tehran Heart Center-Coronary Outcome Measurement Study. **Methods:** Based on spirometry findings, diagnosis of COPD was considered based on Global Initiative for Chronic Obstructive Lung Disease category as forced expiratory volume in 1 s [FEV1]/forced vital capacity <0.7 (absolute value, not the percentage of the predicted). Society of Thoracic Surgeons (STS) definition was used for determining COPD severity and the patients were divided into three groups: Control group (FEV1 >75% predicted), mild (FEV1 60–75% predicted), moderate (FEV1 50–59% predicted), severe (FEV1<50% predicted). The preoperative pulmonary function indices were assessed as predictors, and postoperative morbidity was considered the surgical outcome. **Results:** This study included 566 consecutive patients. Patients with and without COPD were similar regarding baseline characteristics and clinical data. Hypertension, recent myocardial infarction, and low ejection fraction were higher in patients with different degrees of COPD than the control group while male gender was more frequent in control patients than the others. Restrictive lung disease and current cigarette smoking did not have any significant impact on postoperative complications. We found a borderline $P = 0.057$ with respect to respiratory failure among different patients of COPD severity so that 14.1% patients in control group, 23.5% in mild, 23.4% in moderate, and 21.9% in severe COPD categories developed respiratory failure after CABG surgery. **Conclusion:** Among post-CABG complications, patients with different levels of COPD based on STS definition, more frequently developed respiratory failure. This finding may imply the prognostic value of preoperative pulmonary function test for determining COPD severity and postoperative morbidities.

Received: 16-08-14
Accepted: 05-05-15

Key words: Chronic obstructive pulmonary disease; Coronary artery bypass; Outcome; Spirometry

Access this article online
Website: www.annals.in
DOI: 10.4103/0971-9784.159796
Quick Response Code:

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a devastating disorder and is currently one of the main leading causes of mortality and morbidity across the world.[1] Epidemiological investigation has reported that the prevalence of COPD ranges from 9% to 10%, on the basis of the physiological definitions of COPD and spirometry testing.[2] However, this prevalence among patients with coronary artery disease (CAD), especially those scheduled for cardiac surgery, has a wide range: From 5.7%[3] to more than 25%.[4-6] The role of COPD in predicting an adverse outcome after coronary artery bypass graft surgery (CABG)

Cite this article as: Najafi M, Sheikhvatan M, Mortazavi SH. Do preoperative pulmonary function indices predict morbidity after coronary artery bypass surgery?. Ann Card Anaesth 2015;18:293-8.

Address for correspondence: Dr. Mahdi Najafi, Tehran Heart Center, North Karegar Street, Tehran, Iran. E-mail: najafik@sina.tums.ac.ir

is controversial. Some studies have identified COPD as the main predictor of the early and late outcomes of CABG and have shown that it can effectively predict the long-term postoperative complications and survival of these patients.[3,5] This appropriate predictive power has been found in different age groups.[4] Therefore, the routine use of the preoperative pulmonary function test (PFT), as a screening tool, is justified in cardiac patients.[7,8] Nevertheless, there are still debates on the relationship between COPD and increased risk of early morbidity and mortality after CABG.[8,9] It seems that the predictive role of COPD in patients undergoing CABG depends on its severity insofar as the frequency of postoperative poor outcome after this surgery in most patients with mild to moderate COPD tends to be similar to that of patients without COPD.[9] This is partly due to the difficulty of assigning a precise definition for COPD and its severity[11,12] and may explain the wide range of the reported prevalence of COPD in CAD patients in the literature.

These shortcomings warrant the assessment of the prognostic value of preoperative COPD in different populations. The main goal of the present study was to assess the role of the different levels of COPD severity in the prediction of morbidity and prolonged lengths of stay in hospital and intensive care unit (ICU) in patients undergoing CABG.

METHODS

This study included consecutive patients who were candidates for isolated CABG with cardiopulmonary bypass (CPB).

On the basis of preoperative PFT results, COPD was defined as forced expiratory volume in 1 s (FEV1)/ forced vital capacity (FVC) <0.7 (absolute value, not the percentage of the predicted) based on Global Initiative for Chronic Obstructive Lung Disease (GOLD) category.[11] These patients required treatment for chronic pulmonary compromise.

Based on spirometry findings and Society of Thoracic Surgeons (STS) definition, the patients were divided into three groups regarding COPD severity: Control group (FEV1 >75% predicted), mild (FEV1 60–75% predicted), moderate (FEV1 50–59% predicted), severe (FEV1<50% predicted).[13] Patients who underwent insofar redo CABG and patients who had undergone other cardiac procedures were excluded from the study.

The following variables were also completed for each patient on the admission day: Demographic characteristics; history of CAD risk factors; and cardiac status. Intra-aortic balloon pump, inotrope use, and pacemaker dependence were documented. Furthermore, the early post-CABG outcome, comprising mortality (defined as death within 30 days of CABG), morbidity (defined as the existence of at least one of the postoperative complications of poor coronary, wound infection, postoperative arrhythmias, postoperative myocardial infarction (MI), new respiratory failure), prolonged total length of stay in hospital (>7 days), and prolonged ICU stay (>24 h), was assessed. Poor coronary was defined as any patient who required anticoagulant therapy as the form of heparin infusion after the operation due to the inadequacy of performed graft or endarterectomy. Furthermore, morbidity was considered in any patients with at least one of the above-mentioned postoperative complications.[14]

Anesthetic management

The patients were premedicated with intramuscular promethazine (0.5 mg/kg) and morphine sulfate (0.1 mg/kg) 1 h before operation. All patients were monitored by 12-lead electrocardiogram, noninvasive and invasive blood pressure, central venous pressure line, and peripheral oxygen saturation. After administration of 0.05–0.07 mg/kg midazolam, general anesthesia was induced with fentanyl, propofol, and pancuronium to intubate the patient. Controlled ventilation with oxygen alone or with nitrous oxide (equally) with isoflurane adjusted to 0.5 MAC as well as an infusion of propofol, fentanyl and pancuronium were used for maintenance of anesthesia. No regional and/or fast track protocol of anesthesia was employed in these patients.

The results are expressed as mean ± standard deviation (SD) for the quantitative variables and percentages for the categorical variables. The categorical variables were compared between the groups using the Chi-squared test, and the continuous variables were compared using the one-way analysis of variance test. The predictors exhibiting a statistically significant relationship with morbidity in the univariate analysis ($P \leq 0.2$) were taken for a multivariate logistic regression analysis to investigate their independence. Odds ratios (OR) and 95% confidence intervals for OR were calculated. A $P \leq 0.05$ was considered statistically significant. All the statistical analyses were performed using SPSS (version 15.0) for Windows (SPSS Inc., Chicago, IL, USA).

RESULTS

Five hundred sixty-six patients who underwent isolated CABG with CPB were enrolled in the study in a 6 month period. Based on GOLD definitions, 105 patients (18.6%) had COPD. However, based on STS definition for COPD severity, 132 patients (23.3%) had mild, 77 (13.6%) had moderate, and 64 (11.3%) had severe COPD. Thirty days' mortality occurred in 3 patients; hence, no analysis on mortality was performed. The demographic characteristics and the clinical data of the patients with and without COPD are summarized in Table 1 while Table 2 demonstrates the same data between different groups of COPD severity. As shown in Table 1, patients with and without COPD were comparable for baseline demographic and clinical characteristics. As depicted in Table 2, the significantly higher number of control patients regarding COPD severity were male ($P = 0.007$). 43.3% of patients in control group, 50.8% in mild, 62.3% in moderate, and 59.4% in severe categories had hypertension (HTN) ($P = 0.007$). Recent MI was documented in 45.5% of control patients, 56.2% mild, 51.9% of moderate, and 64.1% of severe cases of COPD ($P = 0.02$). Mean ± SD ejection fraction (EF) was significantly higher in control patients and compared to other groups of COPD severity ($P = 0.04$).

Table 1: Baseline characteristics and clinical data of studied patients based on COPD diagnosis by GOLD category

Characteristics	COPD+	COPD−	*P*
Male gender	72 (68.6)	351 (76.5)	0.09
Age (year)	58.2±8.4	59.3±9	0.2
BMI (kg/m^2)	27.2±4.5	27.4±3.9	0.7
Family history of CAD	54 (51.4)	215 (48.6)	0.3
Cigarette smoking	36 (34.3)	167 (36.4)	0.6
Diabetes mellitus	45 (42.9)	187 (40.7)	0.6
Opium addiction	18 (17.1)	64 (13.9)	0.4
Hyperlipidemia	81 (77.1)	317 (69.1)	0.1
Hypertension	59 (56.2)	220 (47.9)	0.1
Peripheral vascular disease	28 (2.7)	130 (28.3)	0.7
Cerebrovascular disease	3 (2.9)	19 (4.1)	0.7
Recent MI	61 (58.7)	225 (49.2)	0.08
Ejection fraction	48.4±10.3	48.5±10.3	0.9
Function class			
I	37 (35.2)	161 (35.1)	0.3
II	57 (54.3)	226 (49.2)	
III	11 (10.5)	72 (15.7)	
Number of coronary involvement			
One	4 (3.8)	17 (3.7)	0.1
Two	27 (25.7)	79 (17.2)	
Three	74 (70.5)	363 (79.1)	

Data are presented as mean±SD or number (%). SD: Standard deviation, BMI: Body mass index, COPD: Chronic obstructive pulmonary disease, GOLD: Global Initiative for Chronic Obstructive Lung Disease, CAD: Coronary artery disease, MI: Myocardial infarction

Table 3 shows postoperative complications in different groups of COPD severity regarding STS definition. As demonstrated, groups were similar with regard to postoperative complications except from respiratory failure. Hence, that we found a borderline $P = 0.057$ with respect to respiratory failure among different patients of COPD severity so that 14.1% patients in control group, 23.5% in mild, 23.4% in moderate, and 21.9% in severe COPD categories developed respiratory failure after CABG surgery. Mean ± SD of pump time was 69.3 ± 23.9 min in COPD and 70.1 ± 21.9 min in non-COPD patients ($P = 0.7$). The value was not significantly different among different severities of COPD patients based on STS definition ($P = 0.2$).

Based on the findings, 130 patients (23%), had restrictive lung disease. Univariate analysis of postoperative complications showed no significant differences between patients with and without restrictive lung disease.

Table 4 demonstrates unadjusted and adjusted (based on age and EF) model for respiratory failure based on STS COPD severity. As shown, there was still a borderline effect of COPD for the occurrence of post-operative respiratory failure (*P*-value=0.059).

DISCUSSION

The present study had two main findings: (1) The rate of COPD may be underestimated by using GOLD category and in case of applying STS definition for severity of COPD, higher number of patients would be defined as having some levels of COPD. (2) The association between the existence of COPD before CABG surgery and the occurrence of postoperation respiratory failure. Our results demonstrated that some CAD risk factors such as HTN, recent MI, and low EF were more prevalent in the patients with different degrees of COPD than the control group while male gender was more frequent in control patients than the others. Furthermore, systemic HTN is frequently encountered in COPD patients.[14] It has been suggested that COPD besides other risk factors such as HTN can lead to high CAD-related mortality and longer hospitalization. Consequently, monitoring and controlling these risk factors with particular care in patients with severe COPD are strongly recommended.

We also found a borderline association between postoperative respiratory failure and COPD severity so

Table 2: Baseline characteristics and clinical data of studied patients based on COPD severity by STS category

Characteristics	COPD severity				
	Control	Mild	Moderate	Severe	*P*
Male gender	233 (80.1)	99 (75)	50 (64.9)	41 (64.1)	0.007
Age (year)	59.8±8.9	57.6±8.8	58.7±9.2	58.9±8.4	0.1
BMI (kg/m2)	27.8±3.9	26.8±4	27.3±3.9	26.6±4.7	0.06
Family history of CAD	134 (46)	65 (49.2)	39 (50.6)	31 (48.4)	0.8
Cigarette smoking	97 (33.3)	53 (40.2)	30 (39)	23 (35.9)	0.5
Diabetes mellitus	110 (37.8)	59 (44.7)	33 (42.9)	30 (46.9)	0.3
Opium addiction	37 (12.7)	22 (16.7)	9 (11.7)	14 (21.9)	0.2
Hyperlipidemia	198 (68)	97 (73.5)	56 (72.7)	47 (73.4)	0.6
Hypertension	126 (43.3)	67 (50.8)	48 (62.3)	38 (59.4)	0.007
Peripheral vascular disease	69 (23.7)	46 (34.8)	23 (29.9)	20 (31.3)	0.1
Cerebrovascular disease	12 (4.1)	5 (3.8)	2 (2.6)	3 (4.7)	0.9
Recent MI	132 (45.5)	73 (56.2)	40 (51.9)	41 (64.1)	0.02
Ejection fraction	49.4±10.2	46.5±10.4	48.8±10.5	48±10.2	0.04
Function class					
I	110 (37.8)	46 (34.8)	21 (27.3)	21 (32.8)	0.2
II	146 (50.2)	62 (47)	40 (51.9)	35 (54.7)	
III	35 (12)	24 (18.2)	16 (20.8)	8 (12.5)	
Number of coronary involvement					
One	11 (3.8)	1 (0.8)	6 (7.8)	3 (4.7)	0.2
Two	58 (19.9)	23 (17.4)	13 (16.9)	12 (18.8)	
Three	222 (76.3)	108 (81.8)	58 (75.3)	49 (76.6)	

Data are presented as mean±SD or number (%). BMI: Body mass index, COPD: Chronic obstructive pulmonary disease, SD: Standard deviation, CAD: Coronary artery disease, STS: Society of Thoracic Surgeons, MI: Myocardial infarction

Table 3: Postoperative complications based on COPD severity by STS category

Characteristics	Normal	Mild	Moderate	Severe	*P*
Poor coronary	10 (3.4)	7 (5.3)	2 (2.6)	2 (3.1)	0.7
Wound infection	2 (0.7)	0 (0)	0 (0)	1 (1.6)	0.4
Postoperative arrhythmia	112 (38.5)	51 (38.6)	33 (42.9)	26 (40.6)	0.9
Perioperative MI	1 (0.3)	1 (0.8)	0 (0)	1 (1.6)	0.2
Respiratory failure	41 (14.1)	31 (23.5)	18 (23.4)	14 (21.9)	0.054
Intra-aortic balloon pump	5 (1.7)	4 (3)	0 (0)	2 (3.1)	0.3
Pacemaker dependent	26 (8.9)	11 (8.3)	9 (11.7)	6 (9.4)	0.8
Inotrope use	126 (43.3)	53 (40.2)	30 (39)	28 (43.8)	0.8
Duration of ICU stay					
<24 h	94 (32.4)	55 (41.7)	22 (28.6)	24 (37.5)	0.1
<24 h	196 (67.6)	77 (58.3)	55 (71.4)	40 (62.5)	
Duration of hospital stay					
≤7	186 (63.9)	87 (65.9)	48 (62.3)	36 (56.3)	0.6
>7	105 (36.1)	45 (34.1)	29 (37.7)	28 (43.8)	
Total time of stay					
>14 days	139 (47.9)	66 (50)	35 (45.5)	34 (53.1)	0.8
<14 days	151 (52.1)	66 (50)	42 (54.5)	30 (46.9)	
Morbidity	263 (90.4)	109 (82.6)	68 (88.3)	54 (84.4)	0.1

Data are presented as number (%). ICU: Intensive care unit, MI: Myocardial infarction, STS: Society of Thoracic Surgeons, COPD: Chronic obstructive pulmonary disease

that patients with different levels of COPD were more frequent to develop respiratory failure than the control patients. This relationship was also confirmed in the presence of some important patient indices such as age and EF. Most of the similar studies have reported the role of an impaired airway flow in the prediction of the postoperative early outcome[5,6,15,16,17] and also long-term survival.[4] However, a relationship between

Table 4: Unadjusted and adjusted model for respiratory failure based on STS COPD severity

Respiratory failure	Unadjusted				Adjusted			
	OR	95% CI for Exp (B)		*P*	OR	95% CI for Exp (B)		*P*
		Lower	Upper			Lower	Upper	
COPD severity				0.057				0.059
Mild vs. control	1.872	1.112	3.150	0.018	1.982	1.142	3.440	0.015
Moderate vs. control	1.860	0.998	3.467	0.051	1.855	0.970	3.548	0.062
Severe vs. control	1.707	0.866	3.365	0.122	1.772	0.871	3.605	0.114

OR: Odds ratio, CI: Confidence interval, COPD: Chronic obstructive pulmonary disease, STS: Society of Thoracic Surgeons, GOLD: Global Initiative for Chronic Obstructive Lung Disease

the pulmonary function parameters and the post-CABG outcome was not observed in some other studies.[8,18,19] We found no association between COPD diagnosis or severity and ICU, in-hospital or total time of stay but some investigations have shown that the index of FEV1 has the main role in the prediction of morbidity and prolonged lengths of stay in hospital and ICU in these patients. Canver *et al*. showed that preoperative FEV1 was a significant predictor of 5 years' survival in young and older individuals undergoing CABG.[4] Furthermore, Fuster *et al*. found that a preoperative FEV1 less than 60% must be considered a primary prognostic factor in patients undergoing CABG procedures.[5] Michalopoulos *et al* [20] reported that there is no significant association between mild or moderate grades of COPD and morbidity and mortality in CABG patients. Durand *et al*. found that a low FVC was associated with higher rate of mortality, more re intubations and higher frequency of prolonged ventilation after surgery.[18] Moreno *et al*. used FVC (as one of three indices) to monitor the pulmonary function in the perioperative period in CABG patients.[21] There is increasing evidence that COPD patients undergoing CABG are at an increased risk of postoperative respiratory complications and arrhythmias, as we found that they were prone to have more events of respiratory failure.[21-23] The high rates of respiratory complications in our study underline the predictive power of FVC. It is well known that respiratory muscle dysfunction following anesthesia and surgery can lead to a reduction in FVC. This may cause atelectasis in the basal lung segments, which compromises the gas exchange through the lung, and predispose this group of patients to pulmonary infections. The consequences of respiratory muscle dysfunction may also give rise to respiratory failure in severe cases and cause notable mortality and morbidity.[24,25] However, the relationship between a low preoperative FVC and postoperative morbidity can be observed in patients with a history of severe COPD, while in cases with mild to moderate pulmonary dysfunction, this association may not be demonstrated.[12,26,27]

In conclusion, among the CAD risk factors, hypertension and recent myocardial infarction were more frequent in the patients with various COPD severities than the patients with a normal PFT, while male gender was more prevalent in the normal group. The frequencies of some CAD risk factors such as HTN, recent MI, and low EF were higher in patients with different degrees of COPD than the control group while male gender was more frequent in control patients than the others. Restrictive lung disease did not lead to significant differences in postoperative morbidity. Furthermore, current cigarette smoking did not have a significant impact on postoperative morbidity in univariate analysis and adjusted model. Among post-CABG complications, patients with different levels of COPD based on STS definition, more frequently developed respiratory failure. This finding may imply the prognostic value of preoperative PFT for determining COPD severity and postoperative morbidities.

Study limitations

We did not analyze mortality as a main outcome index because the frequency of 30 days' mortality was three in our patients. This could be attributable to the small sample size of this study. Obviously, this had no impact on COPD staging as it was performed based on the criteria explained in detail in the method section. Another limitation of the current study was that we do not know about the exact consumed medication for COPD by the patients while some of which may have an impact on postoperative complications.

ACKNOWLEDGMENTS

Source of funding

Academic project (Tehran Heart Center-Coronary Outcome Measurement; THC-COM) study reviewed and approved by Tehran University of Medical Sciences without any external support.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Bednarek M, Maciejewski J, Wozniak M, Kuca P, Zielinski J. Prevalence, severity and underdiagnosis of COPD in the primary care setting. Thora 2008;63:402-7.
2. Halbert RJ, Natoli JL, Gano A, Badamgarav E, Buist AS, Mannino DM. Global burden of COPD: Systematic review and meta-analysis. The European respiratory journa 2006;28:523-32.
3. Medalion B, Katz MG, Cohen AJ, Hauptman E, Sasson L, Schachner A. Long-term beneficial effect of coronary artery bypass grafting in patients with COPD. Ches 2004;125:56-62.
4. Canver CC, Nichols RD, Kroncke GM. Influence of age-specific lung function on survival after coronary bypass. The Annals of thoracic surger 1998;66:144-7.
5. Fuster RG, Argudo JA, Albarova OG, Sos FH, Lopez SC, Codoner MB, *et al*. Prognostic value of chronic obstructive pulmonary disease in coronary artery bypass grafting. European journal of cardio-thoracic surgery: Official journal of the European Association for Cardio-thoracic Surgery 2006;29:202-9.
6. Rosenfeld R, Smith JM, Woods SE, Engel AM. Predictors and outcomes of extended intensive care unit length of stay in patients undergoing coronary artery bypass graft surgery. Journal of cardiac surgery 2006;21:146-50.
7. Grover FL, Johnson RR, Marshall G, Hammermeister KE. Factors predictive of operative mortality among coronary artery bypass subsets. The Annals of thoracic surgery 1993;56:1296-306.
8. Adabag AS, Wassif HS, Rice K, Mithani S, Johnson D, Bonawitz-Conlin J, *et al*. Preoperative pulmonary function and mortality after cardiac surgery. American heart journal 2010;159:691-7.
9. Angouras DC, Anagnostopoulos CE, Chamogeorgakis TP, Rokkas CK, Swistel DG, Connery CP, *et al*. Postoperative and long-term outcome of patients with chronic obstructive pulmonary disease undergoing coronary artery bypass grafting. The Annals of thoracic surgery 2010;89:1112-8.
10. Samuels LE, Kaufman MS, Morris RJ, Promisloff R, Brockman SK. Coronary artery bypass grafting in patients with COPD. Chest 1998;113:878-82.
11. Gold Executive Summary. Global Strategy for the Diagnosis, Management and Prevention of COPD, Global Initiative for Chronic Obstructive Lung Disease (GOLD). Available from: http://wwwgoldcopdorg/ wwwgoldcopdcom. [Last accessed on 2015 Mar, Last Updated on 2014].
12. Saleh HZ, Mohan K, Shaw M, Al-Rawi O, Elsayed H, Walshaw M, *et al*. Impact of chronic obstructive pulmonary disease severity on surgical outcomes in patients undergoing non-emergent coronary artery bypass grafting. European journal of cardio-thoracic surgery : official journal of the European Association for Cardio-thoracic Surgery 2012;42:108-13.
13. Magee MJ, Herbert MA, Roper KL, Holper E, Dewey TM, Snelus T, *et al*. Pulmonary function tests overestimate chronic pulmonary disease in patients with severe aortic stenosis. The Annals of thoracic surgery 2013;96:1329-35.
14. Najafi M, Goodarzynejad H. Determinants of length of stay in surgical ward after coronary bypass surgery: glycosylated hemoglobin as a predictor in all patients, diabetic or non-diabetic. The journal of Tehran Heart Center 2012;7:170-6.
15. Marquis K, Maltais F, Poirier P. Cardiovascular manifestations in patients with COPD. Revue des maladies respiratoires 2008;25:663-73.
16. Manganas H, Lacasse Y, Bourgeois S, Perron J, Dagenais F, Maltais F. Postoperative outcome after coronary artery bypass grafting in chronic obstructive pulmonary disease. Canadian respiratory journal: Journal of the Canadian Thoracic Society 2007;14:19-24.
17. Rabinovich RA, Bastos R, Ardite E, Llinas L, Orozco-Levi M, Gea J, *et al*. Mitochondrial dysfunction in COPD patients with low body mass index. The European respiratory journal 2007;29:643-50.
18. Durand M, Combes P, Eisele JH, Contet A, Blin D, Girardet P. Pulmonary function tests predict outcome after cardiac surgery. Acta anaesthesiologica Belgica 1993;44:17-23.
19. de Albuquerque Medeiros R, Faresin S, Jardim J. Postoperative lung complications and mortality in patients with mild-to-moderate COPD undergoing elective general surgery. Archivos de bronconeumologia 2001;37:227-34.
20. Michalopoulos A, Geroulanos S, Papadimitriou L, Papadakis E, Triantafillou K, Papadopoulos K, *et al*. Mild or moderate chronic obstructive pulmonary disease risk in elective coronary artery bypass grafting surgery. World journal of surgery 2001;25:1507-11.
21. Moreno AM, Castro RR, Sorares PP, Sant' Anna M, Cravo SL, Nobrega AC. Longitudinal evaluation the pulmonary function of the pre and postoperative periods in the coronary artery bypass graft surgery of patients treated with a physiotherapy protocol. Journal of cardiothoracic surgery 2011;6:62.
22. Jacob B, Amoateng-Adjepong Y, Rasakulasuriar S, Manthous CA, Haddad R. Preoperative pulmonary function tests do not predict outcome after coronary artery bypass. Connecticut medicine 1997;61:327-32.
23. Newman LS, Szczukowski LC, Bain RP, Perlino CA. Suppurative mediastinitis after open heart surgery. A case control study of risk factors. Chest 1988;94:546-53.
24. Creswell LL, Schuessler RB, Rosenbloom M, Cox JL. Hazards of postoperative atrial arrhythmias. The Annals of thoracic surgery 1993;56:539-49.
25. Ferraris VA, Ferraris SP. Risk factors for postoperative morbidity. The Journal of thoracic and cardiovascular surgery 1996;111:731-38;discussio 8-41.
26. Laghi F, Tobin MJ. Disorders of the respiratory muscles. American journal of respiratory and critical care medicine 2003;168:10-48.
27. Wynne R, Botti M. Postoperative pulmonary dysfunction in adults after cardiac surgery with cardiopulmonary bypass: clinical significance and implications for practice. American journal of critical care : an official publication, American Association of Critical-Care Nurses 2004;13:384-93.