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Coronary Artery Bypass Grafting in Patients With COPD*

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Objective: **To more fully define the influence of COPD in patients undergoing coronary artery bypass grafting (CABG).**
Methods: **One hundred ninety-one patients with COPD underwent CABG from March 1, 1995, to June 21, 1996. There were 129 male and 62 female patients. The mean age was 69 years (45 to 86 years). Patients with COPD were defined according to the Summit Database definition: requires therapy for the treatment of chronic pulmonary compromise or has an FEV_1 <75% of predicted value.**
Results: **Hospital mortality was 7%. Hospital morbidity was 50%. Statistically significant ($p<0.05$) morbidity included general pulmonary complications (12%) and atrial fibrillation (27%). Hospital mortality for COPD patients with postoperative pneumonia was 11%. Hospital mortality for patients with COPD receiving steroids was 19%. The hospital mortality for patients ≥75 years of age was 17%. The combined mortality for patients with COPD who are ≥75 years of age and receiving steroid therapy was 50%. The mean length of stay was 12 days. Late mortality was 1% at a mean of 1.5 years.**
Conclusions: **Hospital mortality in most patients with mild-to-moderate COPD undergoing CABG is similar to those without COPD. In the minority of patients with severe COPD who are receiving steroids and >75 years, the hospital mortality is exceptionally high. These findings support CABG in patients with mild-to-moderate COPD. Nonsurgical therapy should be considered for elderly COPD patients with severe disease taking steroids.** ***(CHEST 1998; 113:878-82)***

Key words: chronic obstructive pulmonary disease; coronary artery bypass grafting

Abbreviations: ABG=arterial blood gas; CABG=coronary artery bypass grafting; CPB=cardiopulmonary bypass; ITA=internal thoracic artery

COPD is a term used to describe a condition in which there is impaired pulmonary function because of long-standing deterioration in the respiratory elements involved with gas exchange. Traditionally, arterial blood gas (ABG) analysis and pulmonary function testing have been used to define the presence and severity of COPD. However, because of the broad spectrum of the disease, a precise definition is difficult to assign. Depending on whether the condition is mild or severe, the results of ABGs and pulmonary function tests can vary. As such, a clinical-based definition has become an alternative means of assigning a COPD diagnosis. Patients with long-standing smoking histories coupled with progressive noncardiac dyspnea requiring intervention with β-agonist inhalers and steroids have been considered to have COPD. The Summit Database, a national service with >700,000 cases in 750 hospitals with 1,750 participating surgeons, records the outcome of cardiac surgical procedures and defines COPD as follows: requires therapy for the treatment of chronic pulmonary compromise or has an FEV_1 <75% of predicted value.

The impact of COPD in patients undergoing general surgery and thoracic surgery is well known. The influence of COPD in patients undergoing open heart surgery is problematic because of the additional influence of cardiopulmonary bypass (CPB). At one time, significant pulmonary disease was considered a contraindication to open heart surgery.[1] As a result of improvements in cardiac anesthesia, advances in the techniques of CPB, and progress in critical care management, cardiac surgery in patients with COPD has become acceptable and more com-

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mon. The purpose of this article is to more fully define the outcome of coronary artery bypass grafting (CABG) in patients with COPD.

Materials and Methods

From March 1, 1995, through June 21, 1996, 1,929 patients underwent CABG at Allegheny University Hospital, Hahnemann Division, Philadelphia. One hundred ninety-one patients (11%) had COPD, which was defined according to the Summit Database definition: requires therapy for the treatment of chronic pulmonary compromise or has an FEV_1 <75% of predicted value. There were 129 male and 62 female patients. The mean age was 69 years (45 to 86 years).

CPB was conducted with standard cannulation, moderate hypothermia, and antegrade/retrograde cardioplegia. A roller head pump and hollow fiber membrane oxygenator were employed. Bypass conduits consisted of saphenous vein grafts and internal thoracic arteries (ITAs). The presence of COPD did not influence the use of the left ITA.

The hospital course and outcome for COPD patients were retrospectively compared with non-COPD counterparts. A comparison of proportions test was utilized to determine statistical significance of data. Follow-up of 100% of the patients was completed through telephone interviews with patients or family members.

Results

The medical records of 191 consecutive patients with COPD undergoing CABG from March 1, 1995, through June 21, 1996 were reviewed. Preoperative risk factors included the following: smoking in 160 (84%), angina in 156 (82%), hypertension in 132 (69%), prior myocardial infarction in 122 (64%), and family history of coronary artery disease in 73 (38%) patients. Other factors included congestive heart failure in 66 (35%) patients, diabetes in 52 (27%), hypercholesterolemia in 52 (27%), arrhythmias in 40 (21%), and morbid obesity in 21 (11%). Twenty-seven patients (14%) were receiving steroids preoperatively. Forty-seven (25%) patients with COPD were ≥75 years of age. Six (13%) patients were ≥75 years of age and receiving steroids preoperatively (Table 1).

The mean number of bypasses was three (one to six bypasses). The left ITA was used in 165 (87%) cases. The mean CPB time was 109 min (35 to 228 min) and the mean aortic cross-clamp time was 68 min (17 to 180 min).

There were 13 (7%) hospital mortalities. The hospital mortality for the 47 COPD patients ≥75 years of age was 17%. The hospital mortality for the 27 COPD patients receiving steroids was 19%. The combined mortality for the six COPD patients ≥75 years of age and receiving steroids was 50% (Table 1). Morbidities were noted in 96 (50%) patients, including 23 (12%) pulmonary, 16 (8%) renal, 14 (7%) neurologic, and 13 (7%) infectious. The average length of stay was 12 days (4 to 101 days). Follow-up was complete. Six (3%) patients were readmitted to the hospital within 30 days of surgery. There was 1 (1%) late mortality at a mean follow-up of 1.5 years.

Using the comparison of proportions test, a comparative analysis of CABG in 191 patients with and 1,738 patients without COPD was performed. Morbidities were significantly higher in patients with COPD (50%). The occurrence of general pulmonary complications (12%), incidence of atrial fibrillation (27%), incidence of prolonged ventilation (7%), and the occurrence of pneumonia (4%) were higher in patients with COPD. The mean length of stay was higher in patients with COPD (12 days) (Table 2).

Discussion

The influence of COPD on the results of open heart surgery is variable depending on the severity of the preoperative pulmonary dysfunction, overall condition of the patient, and the resources available to manage high-risk cases. Indeed, the impact of severe lung disease in patients undergoing cardiac surgery has been well described such that it was considered a relative contraindication to surgery for coronary artery disease in 1963.[1] Since the first successful application of a pump oxygenator,[2] the deleterious effects of CPB on pulmonary function have been appreciated. The term "pump lung" was used to

Table 1—*Comparison of Outcome: Effect of Age and Steroids*

	Morbidity (%)	p Value	Mortality (%)	p Value	Total
COPD	95 (50)		13 (7)		191
COPD, no steroids	81 (49)	>0.05	8 (5)	<0.05	164
COPD, steroids	14 (52)		5 (19)		27
COPD, <75 yr	70 (49)	>0.05	5 (4)	<0.05	144
COPD, ≥75 yr	25 (53)		8 (17)		47
COPD, <75 yr, steroids	13 (62)	<0.05	2 (10)	<0.05	21
COPD, ≥75 yr, steroids	1 (17)		3 (50)		6

Table 2—*Comparison of COPD and Non-COPD Patients: Outcome*

	Patients Without COPD (%)* 1,738 patients Mean age=65 yr	Patients With COPD (%)* 191 patients Mean age=67 yr	p Value
Complications			
Hospital mortality	4	13	<0.05
Morbidity	35	50	<0.05
Pulmonary (general)	6	15	<0.05
Prolonged ventilation	3	7	<0.05
Pneumonia	2	4	<0.05
Transient stroke	0.35	0.53	>0.05
Permanent stroke	3	4	>0.05
Atrial fibrillation	21	27	<0.05
Renal (general)	7	8	>0.05
Infectious (general)	4	11	>0.05
Neurologic (general)	6	7	>0.05
LOS,† d	10	12	<0.05

*Contemporaneous patients.
†LOS=length of stay.

describe a form of respiratory distress syndrome following open heart surgery with extracorporeal circulation.[3] In 1964, Kirklin[4] reviewed the pulmonary dysfunction after open heart surgery and remarked that patients who came to surgery with abnormal lungs would be likely to develop significant respiratory problems postoperatively. Thus, for more than 3 decades, it has been well known that the relationship of COPD and open heart surgery was a potentially dangerous one. Nevertheless, cardiac surgeons have been confronted with the challenge of managing this population, and doing so in an environment that demands cost containment, efficiency, and favorable outcomes. In our experience, and from a review of other studies, a more complete understanding of the problem of open heart surgery in patients with COPD is possible, and strategies to improve results are available. In general, the knowledge base can be divided into preoperative, intraoperative, and postoperative categories.

Several studies have examined the preoperative factors that impact on the postoperative outcome of patients with COPD undergoing cardiac surgery. Braun et al,[5] for example, found significant ventilation-perfusion abnormalities that persisted beyond 2 weeks postoperatively and recommended preoperative pulmonary function studies with ABGs and spirometry in smokers scheduled for elective coronary revascularization. Cain and coworkers,[6] however, believed that routine quantitation of clinically apparent pulmonary dysfunction was of little value in predicting postoperative morbidity. Instead, clinical assessment was a more rational basis for therapy. Their study,[6] however, did show a correlation between preoperative arterial hypercapnia (Pco_2>50 mm Hg) and the development of major postoperative problems. In a study by Grover and colleagues,[7] the presence of COPD preoperatively increased the operative mortality by 1.5 times. Furthermore, the operative mortality correlated with the FEV_1 of 3.8% for FEV_1 >1.25 L/s vs 11.7% for FEV_1 <1.25 L/s. In our study, there was a twofold increase in hospital mortality for COPD patients compared with non-COPD patients. Since we did not measure FEV_1 routinely preoperatively, we cannot confirm the findings of Grover et al. We did, however, observe a significant difference in outcome for steroid-dependent COPD patients and older COPD patients. To our knowledge, there are no other studies demonstrating the difference in mortality between steroid-dependent and nonsteroid-dependent COPD patients. The effects of advanced age, however, are documented.[8] As demonstrated by Ghattas,[9] postoperative decreases in pulmonary function were more profound in older patients and patients with previous lung disease, such that patients with underlying lung disease may not be able to tolerate further reduction in lung volumes and would be susceptible to more complications. Cosgrove et al,[10] in a review of the trends in surgical mortality following CABG, found that cardiac causes of death decreased and were replaced by other system failure. The respiratory system was no exception. In a similar report by Naunheim and others,[11] there has been a trend in operating on more patients with serious associated medical diseases. In 1975, there were no patients with COPD in the first 100 consecutive CABG patients, compared with 9 patients in 1985. As a consequence of this trend, there were marked increases in morbidity and mortality, including prolonged (>48 h) ventilator dependence. At our institution, we have observed a similar trend. Prolonged ventilator dependence was observed in 5.2% of COPD patients compared with 2.8% of non-COPD patients. Thus, we would agree with Jackson,[12] who argues for prevention of postoperative complications in COPD patient beginning in the preoperative period with discontinuation of smoking before surgery and vigorous pulmonary toilet prior to operation. While the time frame for these maneuvers is subject to debate, we would argue that it is worthwhile in the older and sicker patient with COPD whose mortality is significantly higher than his or her younger and healthier counterpart.

Intraoperatively, there are factors related to the conduct of the operation and the pathophysiologic state of CPB that directly and indirectly impact on

pulmonary function. The pump itself, for example, has been implicated in postoperative respiratory dysfunction. Roller-head pumps and centrifugal pumps both cause blood trauma that results in the liberation of vasoactive substances that have deleterious pulmonary and systemic effects. In addition, the sequestration of leukocytes and the effects of platelets in the lungs are other contributing causes of postoperative complications. The use of leukocyte filters and ultrafiltration during CPB remains controversial in the prevention of these problems. The oxygenators, perhaps the most important culprit in postoperative pulmonary dysfunction from the equipment standpoint, come in two varieties: bubble and membrane. Although there is little difference when the CPB time is short, membrane oxygenators cause less problems when CPB times are between 2 and 3 h. At our institution, we use roller-head pumps and membrane oxygenators and could not observe an appreciable difference in outcome compared with our affiliate hospital in which centrifugal pumps and membrane oxygenators are utilized. Finally, the issue of ITA graft as a contributing factor in postoperative respiratory disability has been described. Several authors[9,13,14] have argued that takedown of the ITA, opening of the pleura, and placement of a thoracostomy tubes all contribute to postoperative discomfort which, in COPD patients, translates into worse pulmonary function. Others[15] have not found this to be the case. Although we did not directly compare COPD patients with ITA grafts and those without, it is our impression that this was not a major factor. Rather, we were more concerned with avoiding injury to the phrenic nerve during ITA harvesting, since a paralyzed hemidiaphragm in a COPD patient can be disastrous. Thus, we avoid ice slush in the pericardium and take particular care during dissection of the ITA at the subclavian artery where the phrenic nerve is vulnerable.

Postoperatively, there are several events that influence outcome. As demonstrated by Gaynes et al,[16] the development of pneumonia following CABG in a patient with COPD was associated with a 27% mortality. Although the mortality was lower in our series (11%), this figure is nearly five times higher than the general mortality of CABG at our institution. As a result of this, we are currently examining the role of broader-spectrum antibiotic coverage, particularly Gram negative, in this population of patients, since it is well known that patients with COPD are colonized with a variety of organisms. Although this may not be justified in the non-COPD patients, the immune suppressing effects of CPB combined with the respiratory flora of COPD patients may predispose them to an increased risk for lower respiratory tract infections. Atrial arrhythmias are another postoperative problem that has been observed more frequently in patients with COPD.[17,18] In addition to the hemodynamic compromise, atrial arrhythmias are associated with increased incidence of stroke and length of stay. Furthermore, it has been shown that the major causes of mortality in COPD patients undergoing CABG were arrhythmia[19] and other nonpulmonary factors.[20] The situation is further compounded by the problem of using β-blockers to control atrial arrhythmias in COPD patients with a bronchospastic component. To address this issue, we are now investigating the use of prophylactic calcium-channel blockers (diltiazem) in the prevention of atrial arrhythmias. Thus far, we have reduced the incidence of atrial fibrillation by 50%. Finally, the fact that COPD patients are at risk of prolonged ventilation is well observed. Indeed, in our study, the incidence of prolonged ventilation was twofold that of non-COPD patients. In addition, the need for tracheostomy postoperatively is higher in patients with preexisting pulmonary dysfunction and is associated with a significant mortality. As a result of these findings, we have modified our criteria for extubation in COPD patients. Rather than focus on ABGs and weaning parameters, we emphasize the clinical assessment of the patient. This change has enabled us to extubate sooner with satisfactory results.

In summary, the treatment of COPD patients undergoing open heart surgery has evolved considerably over the past 3 decades from a relative contraindication to an everday encounter. Nevertheless, the presence of COPD remains a formidable problem in the perioperative period. Depending on the severity of the COPD, the morbidity and mortality can be almost prohibitive. This was the case in elderly patients with steroid-dependent COPD. In such cases, it would be imperative to institute vigorous preoperative measures to maximize the respiratory status. If this were not possible, then consideration toward an alternative approach, such as minimally invasive direct coronary artery bypass, without the use of CPB should be entertained. In conclusion, it is incumbent on the physicians and surgeons treating these high-risk patients to provide appropriate preoperative, intraoperative, and postoperative care.

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