Clinical Investigation

Concomitant Cardiac and Pulmonary Operations for Lung Cancer

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From 1973 through 1990, 21 patients (17 men and 4 women) underwent concomitant cardiac operation and pulmonary resection for lung cancer. The mean age was 65.3 years (range, 50 to 80 years). Eighteen patients underwent coronary artery bypass; 1 underwent coronary bypass and mitral valve replacement; 1, aortic valve replacement; and 1, left ventricular aneurysmectomy. Pulmonary procedures included 16 lobectomies, 3 segmentectomies, and 2 wedge resections. Nine resections were performed during cardiopulmonary bypass, and 12 were performed either before or after bypass. On final pathologic diagnosis, 11 patients had adenocarcinoma, 7 had squamous cell carcinoma, and 3 had undifferentiated lesions. Twelve patients were in cancer stage I and 9 were in stage II. Placement of an intraaortic balloon pump was required in 3 patients. No patient sustained excessive blood loss requiring reoperation. Only 2 incidents (9.5%) of disseminated infection were reported. The overall 1-year survival rate was 90.5% and the 5-year survival rate was 52.4%.

We found concomitant cardiac operation and pulmonary resection for lung cancer to be a safe and effective alternative to staged treatment in patients not requiring a pneumonectomy. Combined cardiac and pulmonary surgery spares the patient the risk and cost of a 2nd major surgical procedure without compromising long-term survival. ***(Tex Heart Inst J 1995;22:296-300)***

Few reports on combined cardiac and pulmonary operations have appeared in the world literature.[1-10] Traditionally, surgeons have been reluctant to perform concomitant cardiac surgery and pulmonary resection for 3 reasons: 1) heparinization and cardiopulmonary bypass can increase the patient's risk of excessive bleeding; 2) cardiac surgery requires a median sternotomy approach, which is believed to provide inadequate exposure for pulmonary resection; and 3) cardiopulmonary bypass may alter immunologic response,[11] increasing the patient's risk of mediastinal and pleural infection. However, combined cardiac and pulmonary surgery eliminates the need for a 2nd major procedure and expedites resection of the malignant lesion.

We report our experience with concomitant cardiac surgery requiring cardiopulmonary bypass and pulmonary operation for lung cancer.

Key words: *Extracorporeal circulation; coronary artery bypass; heart aneurysm/surgery; heart valve diseases/surgery; lung neoplasms/surgery; sternum/surgery; survival rate*

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Patients and Methods

We reviewed the records of all patients at the Texas Heart Institute who underwent concomitant cardiac and pulmonary surgery requiring cardiopulmonary bypass between January 1973 and December 1990. These records were reviewed for age; sex; New York Heart Association (NYHA) classification; radiographic and tomographic findings; operative procedures; timing of cardiopulmonary bypass; final pathologic diagnosis; tumor, node, and metastasis classification; morbidity; mortality; and follow-up. Excluded from the study were those patients who underwent pulmonary resection for benign lesions and those who required a pneumonectomy.

Survival was estimated by the Kaplan-Meier method[12] with the date of surgery as the starting point and the date of death or last follow-up as the end point. The operative mortality rate includes deaths occurring within 30 days of operation or during hospitalization.

The patient population consisted of 21 patients (17 men and 4 women) with a mean age of 65.3 years (range, 50 to 80 years). Sixteen patients had a history of

smoking (76.2%). Eighteen were diagnosed with coronary artery disease (85.7%), 1 with coronary and mitral valve disease (4.8%), 1 with aortic valve disease (4.8%), and the last with left ventricular aneurysm secondary to coronary artery disease (4.8%) (Table I).

At the time of operation, lung cancer had been diagnosed by preoperative bronchoscopic biopsy in 3 patients (14.3%). In the other 18 patients (85.7%), the pulmonary lesion was discovered on preoperative chest radiography or computed tomographic scan after the cardiac diagnosis had been made. Lung cancer in all patients was confirmed with final pathologic studies: 11 had adenocarcinoma, 7 had squamous cell carcinoma, and 3 patients had undifferentiated lesions.

TABLE I. Type of Cardiac Procedure in 21 Patients Undergoing Concomitant Cardiac and Pulmonary Procedures for Lung Carcinoma

Procedure	Number of Patients
CABG	18
CABG and left ventricular aneurysm	1
Aortic valve replacement	1
CABG and mitral valve replacement	1

CABG = coronary artery bypass grafting

All procedures were performed on an elective basis. Of the 21 patients, 16 underwent lobectomies, 3 underwent segmentectomies, and 2 underwent wedge resections. The type of pulmonary procedure performed on each patient corresponded to the diagnosis and location of the tumor (Table II). Pulmonary resections were performed through a median sternotomy; lateral extension of the incision was never required. Standard pulmonary techniques were used in all cases. To achieve a more complete resection and to evaluate nodal involvement, hilar and mediastinal lymph node sampling and dissection were also performed. Twelve patients were classified in cancer stage I and 9 in stage II.[13]

In 9 patients, pulmonary procedures were performed during cardiopulmonary bypass: 2 before the cardiac procedure and 7 while the patient was be-

TABLE II. Type of Pulmonary Resection with Respect to Tumor Diagnosis and Location

Pulmonary Tumor Diagnosis	Tumor Location	TNM	Procedure
Squamous cell	R middle lobe	T1 N0 M0	Lobectomy
	R upper lobe	T2 N0 M0	Lobectomy
	R upper lobe	T2 N0 M0	Lobectomy
	R lower lobe	T1 N0 M0	Lobectomy
	L upper lobe	T1 N0 M0	Segmentectomy
	R lower lobe	T2 N0 M0	Lobectomy
	L upper lobe	T2 N0 M0	Lobectomy
Adenocarcinoma	R upper lobe	T2 N0 M0	Lobectomy
	R upper lobe	T2 N1 M0	Lobectomy
	R upper lobe	T1 N0 M0	Lobectomy
	R upper lobe	T1 N1 M0	Lobectomy
	R upper lobe	T1 N1 M0	Lobectomy
	R upper lobe	T1 N1 M0	Wedge resection
	R lower lobe	T1 N1 M0	Lobectomy
	L lower lobe	T2 N0 M0	Lobectomy
	L upper lobe	T2 N0 M0	Lobectomy
	L lower lobe	T1 N0 M0	Wedge resection
	L upper lobe	T1 N0 M0	Segmentectomy
Undifferentiated	L lower lobe	T1 N0 M0	Lobectomy
	L upper lobe	T1 N0 M0	Segmentectomy
	L lower lobe	T2 N1 M0	Lobectomy

L = left; R = right; TNM = tumor, node, and metastasis system

TABLE III. Timing of Pulmonary Resection in Relation to Cardiopulmonary Bypass

Timing of Resection	Lobectomy Pts. (%)	Segmentectomy Pts. (%)	Wedge Resection Pts. (%)	Total Pts. (%)
Before bypass	4 (19)	–	–	4 (19)
On bypass, before cardiac procedure	2 (9.5)	–	–	2 (9.5)
On bypass, after cardiac procedure	5 (23.8)	2 (9.5)	–	7 (33.3)
After bypass	5 (23.8)	1 (4.8)	2 (9.5)	8 (38.1)
Total	16 (76.2)	3 (14.3)	2 (9.5)	21 (100)

ing rewarmed after the procedure. The remaining resections were performed without bypass: 4 before bypass was instituted, and 8 after it was discontinued (Table III).

Results

There was 1 (4.8%) operative death among patients who underwent combined cardiac and pulmonary surgery. This death occurred in an 80-year-old man who had undergone triple-vessel coronary artery bypass grafting with concomitant wedge resection of the right upper lobe for adenocarcinoma. After operation, he developed an acute myocardial infarction and subsequent arrhythmias. Despite pharmacologic support and use of an intraaortic balloon pump (IABP), he died on the 2nd postoperative day.

Two other patients (9.5%) required intraoperative placement of an IABP: 1 had a right lobectomy performed for squamous cell carcinoma along with a coronary revascularization procedure and a left ventricular aneurysmectomy; the other had a right lobectomy along with a coronary revascularization procedure and a mitral valve replacement. Each was successfully weaned from IABP within 72 hours of balloon insertion. Twelve patients (57.1%) required the use of inotropic support, vasodilating drugs, or both, in the immediate postoperative period. Two patients (9.5%), 1 who underwent a lobectomy and 1 who had a wedge resection, developed systemic disseminated infection (pneumonia). No patient required reoperation for excessive blood loss.

Analyses of intraoperative frozen sections were used to verify the presence of tumor-free margins in all patients. Based on the results of these analyses, pulmonary resection was judged to be incomplete in 2 patients (9.5%). One of these 2 patients underwent a lobectomy for squamous cell carcinoma and a 4-vessel coronary bypass procedure. The other patient, a 70-year-old man, underwent a right upper lobectomy for adenocarcinoma and a 2nd reoperation for coronary artery disease (triple bypass); during the operation, malignant cells were found at the margins of the resection, but the patient could not tolerate a more extensive procedure. Both patients underwent a postoperative course of chemotherapy.

Follow-up averaged 4.1 years, ranging from 2 days to 7.4 years. Nineteen patients were alive at 1 year, for a survival rate of 90.5%, and 11 patients were alive at 5 years, for a survival rate of 52.4% (Fig. 1). Two patients were lost to follow-up before 5 years. Five patients died of cancer recurrence, including the 2 patients in whom pulmonary resection was judged incomplete: the patient with squamous cell carcinoma died 4 months postoperatively; the patient with adenocarcinoma died 33 months postoperatively. Of the 3 remaining patients, 2 died of recurring lung cancer and the last died of metastatic disease localized in the brain. The deaths of these 5 patients occurred from 4 months to 6 years postoperatively.

There were 3 other deaths. One patient died 42 months postoperatively, of a 2nd primary malignan-

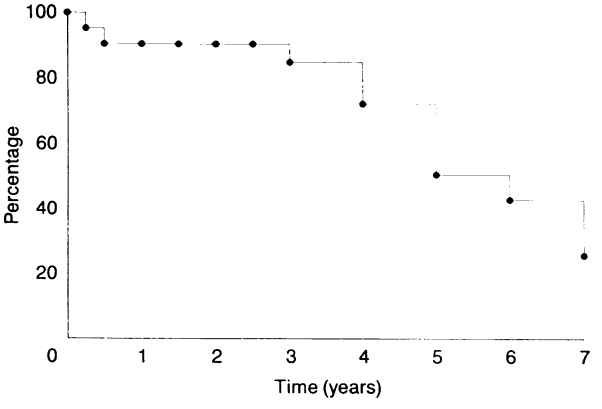

Fig. 1 *Kaplan-Meier survival for patients with concomitant cardiac and pulmonary operations.*

cy originating from the prostate. The other 2 deaths were the result of cardiovascular disease.

Discussion

Our study found combined cardiac surgery and pulmonary resection to be a safe and effective method of treating concomitant cardiac and lung cancer. Concomitant lung cancer in a patient undergoing cardiac surgery can be treated either during the cardiac procedure or in a separate procedure. If the lung cancer is treated in a separate procedure, the condition that poses the most immediate risk to the patient (usually the cardiac disease), should be treated first; the condition that poses a less immediate risk should be treated 4 to 6 weeks later.[11] In patients who have tumors with rapid doubling times, however, such a delay can affect survival. In addition, treating both diseases during the same procedure spares the patient the pain, risk, and cost of a 2nd operation.

The major risk associated with combined cardiac and pulmonary surgery is increased bleeding. The systemic heparinization required for cardiac surgery can cause intrapulmonary hemorrhaging and excessive bleeding during pulmonary resection. Furthermore, cardiopulmonary bypass interferes with coagulation mechanisms. Previous reports, however, show a low incidence of excessive bleeding among patients who undergo combined procedures. In a series of 43 patients, the Mayo Clinic group[1] reported only 1 death, which occurred in a patient who underwent pulmonary resection during cardiopulmonary bypass. Only 11.6% of the resections were performed during cardiopulmonary bypass. In the Mayo Clinic's most recent report,[9] 2 (6.7%) patients out of 30 required reoperation for bleeding. Neither patient had undergone lung resection during cardiopulmonary bypass. Canver and associates[2] performed 21 concomitant procedures either before heparin had been given or after it had been reversed. None of their patients experienced hemorrhagic complications. Yokoyama and colleagues[8] performed 7 lobectomies during bypass on a group of 11 patients, with no postoperative complications. Ulicny and co-authors,[4] however, reported that 3 of their 19 patients (15.8%) encountered bleeding complications. The majority of the lung resections in that study (63.2%) were performed under full heparinization. Although there were not enough patients in that series for a conclusive statistical analysis, those authors recommended staging the pulmonary resection after the cardiac operation or performing the resection after protamine administration.

In our study, 9 (43%) lung resections were performed during cardiopulmonary bypass and 12 (57%) lung resections were performed before or after bypass. Performing lung resection with cardiopulmonary bypass helps prevent cardiac instability due to traction and better exposes the vascular structures, especially the left lower lobe. In addition, dividing the inferior pulmonary ligament gives the surgeon access to more-remote locations in the lung.

A median sternotomy is necessary for most cardiac operations. Despite concerns over the compatibility of this approach with pulmonary operations, a median sternotomy provides adequate exposure for most pulmonary resections with minimal complications.[14,15] Indeed, some authors advocate the use of median sternotomy as the standard approach, not only for synchronous bilateral pulmonary operations, but also for other elective resections.[16] Pulmonary function has been found to return to a higher level at 1 week after median sternotomy than at 1 week after thoracotomy. Therefore, median sternotomy is preferable for patients with a limited lung reserve.[15]

During combined operation, extracorporeal circulation and internal mammary artery dissection[17] may be associated with short-term adverse effects on pulmonary function. In our series, the median sternotomy provided adequate surgical exposure for pulmonary resection; extension of the incision was never required. However, the sternotomy approach does make a complete lymph node sampling of the posterior mediastinum difficult. As in other studies, incomplete lymph node sampling did not affect the long-term results of pulmonary resection in this series.[1,2,8]

Another risk of combined cardiac and pulmonary surgery is mediastinal and pleural infection, which may occur in patients whose immunologic responses are altered by cardiopulmonary bypass.[11] In the previous studies, there were no instances of disseminated infection. In our study, the 2 patients who developed pneumonia were both successfully treated.

Survival after surgical resection of lung cancer varies according to the cell type and the stage of the cancer, both of which must be evaluated.[18-21] Despite advances in preoperative diagnosis, such as cytologic examination of the sputum and bronchoscopy, histologic diagnosis is not always achieved preoperatively. Fortunately, wedge resection or frozen section can be performed during cardiac operation. The location and the extent of both the known lesion and any metastasis discovered during operation, as well as preoperative cardiac risks and myocardial function, should all be considered when deciding which procedure to perform.

Patients who have undergone concomitant cardiac and pulmonary surgery are as yet insufficient in number for compiling a conclusive risk–benefit analysis. Prospective studies that consider such fac-

tors as staged resection and the immunologic impact of cardiopulmonary bypass must be performed in order to examine various aspects of combined surgery for cardiac and lung cancer and its effect on long-term prognosis. We believe cardiac surgery and pulmonary resection should be staged in patients who have a limited cardiac reserve or who may require a longer cardiopulmonary bypass time during the cardiac procedure. In other cases, however, combined surgery should be considered.

In summary, combined surgery for cardiac disease and lung cancer may spare the patient the cost and possible complications of a 2nd major surgical procedure. Concomitant treatment also expedites pulmonary resection, preventing further dissemination of malignant lesions. Our results suggest that concomitant cardiac and pulmonary surgery is safe and effective and should be considered as an alternative to staged treatment.

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