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Partial atrial resection in advanced lung carcinoma with and without cardiopulmonary bypass

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Abstract

Combined pneumonectomy and partial resection of the left atrium was performed in 12 patients with advanced lung carcinoma (T_3 and T_4 in the new UICC classification). In the eight patients with a T_3 lung carcinoma intrapericardial atrial resection with vascular clamping was carried out; four of the patients died within a year. The remaining four patients had a T_4 tumour and underwent removal of the right lung and part of the left atrium under total cardiopulmonary bypass. One patient died shortly after the operation from cerebral and cerebellar infarction, and one died 11 months later from brain metastases. Two are alive and well. Complete resection appears to offer a chance for longer survival in patients with advanced lung carcinoma that extends directly into the intrapericardial pulmonary vessels or atrium.

It is now well recognised that an extended surgical approach to lung carcinoma is justified in selected patients. We frequently encounter advanced lung carcinomas that have invaded surrounding organs, including the chest wall, diaphragm, pericardium, heart, and great vessels.[1-3] If the malignant lesion can be removed completely these patients have a relatively favourable prognosis. Some patients with lung cancer that has extended beyond the lung have the potential for improved survival after surgical treatment.[4] Carcinoma around the hilum is more likely to spread into veins than into arteries, and may project from a pulmonary vein into the left atrium.

Bailey *et al* have suggested that extracorporeal bypass might be used to treat certain pulmonary lesions hitherto considered inoperable.[5] Reports on surgery for chest wall invasion of lung carcinoma have been published frequently[1 6]; reports on surgery for tumour invading the atrium are less common. We describe our experience of combined resection of the lung and left atrium for this condition, focusing particularly on the indications and complications of cardiopulmonary bypass.

Patients and operative techniques

Twelve patients (nine men, three women), ranging in age from 34 to 76 years, have undergone en bloc resection of the lung and part of the left atrium since 1978. Three patients had adenocarcinoma, seven an epidermoid carcinoma, one a large cell carcinoma, and one a combined epidermoid and small cell carcinoma (table 1). Preoperative investigation of local extension of the carcinoma was performed by laryngography, computed tomography, magnetic resonance imaging, and angiography with right heart catheterisation. On the basis of the preoperative and postoperative macroscopic and pathological findings, the patients were classified as follows by the new international UICC classification[7 8]: three T_3N_0, two T_3N_1, three T_3N_2, one T_4N_1, and three T_4N_2.

Eight patients with T_3 disease (cases 1–8) had invasion of carcinoma near the left atrial orifice of the pulmonary vein or pericardial invasion at the hilum, and these patients were operated on without cardiopulmonary bypass. Five of the eight underwent left pneumonectomy and three right pneumonectomy (table 2). At operation the pericardium was opened widely and the margin of invasion confirmed by digital palpation. The entire lung was lifted up, the atrium resected partially under atrial clamping (fig 1), and the stump closed in two layers with 3–0 or 4–0 prolene sutures.

In the four patients with T_4 disease (cases 9–12) a combined resection of the right lung and the left atrium was performed with cardiopulmonary bypass. Three had an epidermoid carcinoma and one a large cell carcinoma (table 1). Patient 9 underwent a usual thoracotomy initially, but the invasion of the left atrium was too extensive for an adequate margin to be

Table 1 Clinical features of the 12 patients

	*No of cases**
Sex	
Male	9 (3)
Female	3 (1)
Age (years)	
30–40	2 (1)
40–50	1 (1)
50–60	2
60–70	3 (1)
70+	4 (1)
TNM†	
$T_3N_0M_0$	3
$T_3N_1M_0$	2
$T_3N_2M_0$	3
$T_4N_1M_0$	1 (1)
$T_4N_2M_0$	3 (3)
Histological type of carcinoma	
Epidermoid	7 (3)
Adenocarcinoma	3
Epidermal+ small cell	1
Large cell	1 (1)

*Numbers of tumours resected with a cardiopulmonary bypass in parentheses.
†New UICC classification for the tumour-node-metastasis staging.

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Table 2 Operative method and complications in 12 cases of lung carcinoma

Operative method	*No of cases (No with complication)*
Resection with vascular clamp	
Left pneumonectomy with partial atrial resection	5 (1*)
Right pneumonectomy with partial atrial resection	3 (1†)
Resection with cardiopulmonary bypass	
Exploratory thoracotomy and right pneumonectomy with left atrial resection	1
Right pneumonectomy with left atrial resection	2 (1‡)
Right pneumonectomy with left atrial and septal resection	1 (1§)

*Cardiac failure. †Bronchial stump fistula. ‡Postoperative bleeding. §Brain infarction.

removed by conventional intrapericardial cross clamp exclusion. A second stage operation for en bloc resection of the lung and affected atrium was performed therefore under cardiopulmonary bypass. In patient 10 a large polypoid mass was discovered in the left atrial chamber at operation, so a pump oxygenator was arranged immediately to allow the tumour to be removed. In these two cases the whole operation was performed via a right thoracotomy with the patient in the left lateral position.

In cases 11 and 12 magnetic resonance imaging and cineangiography with cardiac catheterisation were very useful in determining the extent of tumour invasion of the left atrium (fig 2). Consequently the need for total cardiopulmonary bypass was recognised before operation and an en bloc resection was carried out by combining a midsternal incision and lateral thoracotomy. The aorta and venae cavae were cannulated as usual, enabling cardiopulmonary bypass to be instituted. The aorta was cross clamped and myocardial protection provided with crystalloid cardioplegia. The left atrium was entered first near the interatrial groove and the extent of intra-atrial invasion by tumour observed macroscopically and by palpation. The atrial wall was excised at a distance of about 5–7 mm from the margin of the invading tumour, and the stump of the atrium was closed in two layers with 3–0 or 4–0 prolene (figs 2 and 3). Air was completely excluded from the heart and circulation before the patient was weaned from cardiopulmonary bypass.

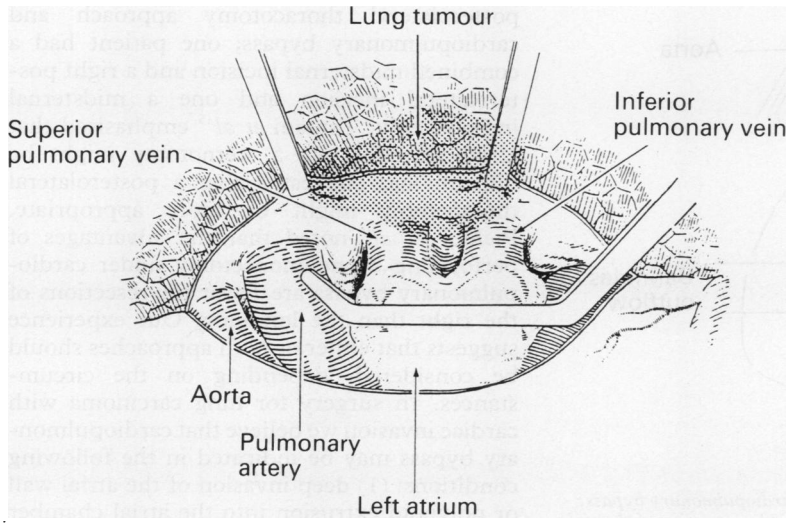

Figure 1 Partial resection of the left atrium with lung under the vascular clamp.

Results

In the eight patients who underwent partial resection of the left atrium with intrapericardial side clamping the surgical procedure was uncomplicated. During the postoperative period, however, one developed cardiac failure and another developed a fistula of the bronchial stump. Histological examination showed carcinomatous invasion around the pulmonary vein, including the hilar pericardium, in all cases; but invasion of the atrial myocardium was not seen. Postoperative survival has ranged from one month to nine years. Four of the eight died within one year, one from heart failure and three from recurrence of lung carcinoma (fig 4).

Of the four patients who underwent en bloc resection of the right lung and part of the left atrium under bypass, two (Nos 9 and 12) showed tumour invasion extending into the atrial wall. Patient 10 had a large tumour protruding into the atrial chamber. In these three patients about a quarter of the atrium was removed. In patient 11 we recognised at operation that the tumour was invading the interatrial septum to a small extent. About a third of the atrium was removed, including part of the atrial septum. The residual atrium was thought to be adequate for maintaining function without need of a patch graft. The total bypass time for this patient was 3 hours 25 minutes, compared with under two hours in the other three cases. All four patients had histological invasion of the left atrial wall by carcinoma.

Postoperatively, patient 10 developed cardiac tamponade from intrapericardial bleeding; this was treated successfully by emergency thoractomy. Patient 11 developed disturbance of consciousness after operation, and computed tomography of the brain showed infarction of the cerebrum and cerebellum. Multiple organ failure developed, and the patient died on the 57th postoperative day. One patient died of brain metastasis 11 months after operation. Two patients are alive and well with no recurrence after 54 and 12 months.

Discussion

The prognosis of advanced lung carcinoma is still poor, and the surgical treatment of advanced tumours invading the hilum is often attended by technical problems.[9] Carcinomatous lesions that invade intrapulmonary vessels are easily resectable. In the case of invasion close to the entrance of the pulmonary vein into the atrium, however, partial atrial resection is also required. We performed eight procedures of partial atrial resection under cross clamping and four under cardiopulmonary bypass. Four patients in the first group died within a year, none of them showing local recurrence.

Almost all the patients in this series had epidermoid carcinoma. Nakagawa and Akahagi[10] reported that, of 13 patients with invasive hilar carcinoma with atrial invasion who had resection performed under vascular clamping, four with epidermoid carcinoma survived for two years. They suggested that

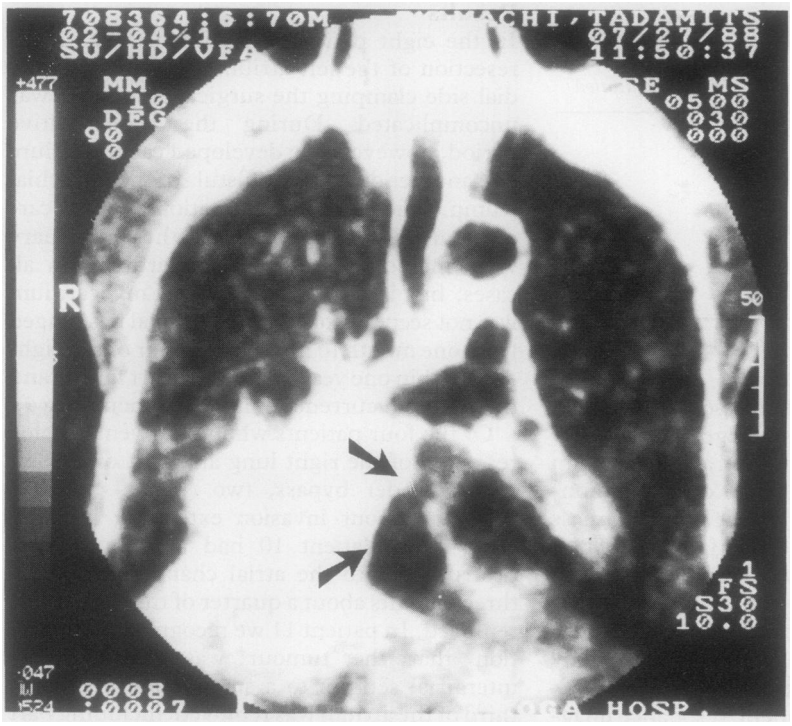

Figure 2 Preoperative magnetic resonance imaging in case 11 showing extension of tumour into the cardiac wall and space (arrows). A cineangiogram also indicated atrial invasion by the tumour (epidermoid carcinoma).

patients with an epidermoid carcinoma were most suitable for combined resection of the lung and the left atrium. Nakagawa and Matsubara[11] reported three cases of combined pneumonectomy and resection of the left atrium in 1985. One of their patients had a polypoid mass in the atrial chamber and underwent resection under vascular clamping. He died soon after the operation from cerebral embolism arising from atrial tumour fragments released during surgery. They suggested that resection should be performed under direct vision with cardiopulmonary bypass when the left atrium is affected in this way to avoid the risk of tumour embolism during surgery. Their two subsequent patients with left atrial invasion by lung carcinoma underwent successful resection with cardiopulmonary bypass.

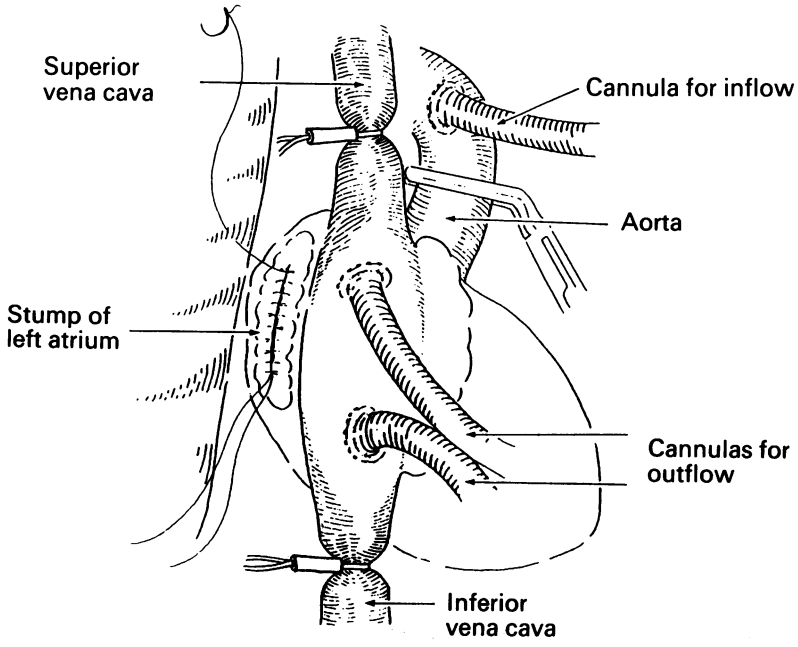

Figure 3 Partial resection of the left atrium with lung with cardiopulmonary bypass: diagram showing the closure of the stump of left atrium after en bloc resection of the right lung and part of the atrium.

To avoid an unnecessary exploratory thoracotomy, accurate diagnosis of the extent of tumour invasion is important. In one of two patients reported by Bailey *et al*[5] and in a case reported by Gardner *et al*,[12] an initial exploratory thoracotomy was followed by an en bloc resection under cardiopulmonary bypass. When the diagnosis is made at thoracotomy cardiopulmonary bypass is usually not available,[13] so the thoracotomy is unnecessary. Echocardiography and cardiac catheterisation are often more effective than computed tomography for diagnosis. In patients 10 and 11 of our series we could not detect the true extent of the tumour using computed tomography. We believe that magnetic resonance imaging is the most effective method for detecting spread of the carcinoma to the left atrium and it is non-invasive. In patients with advanced tumour, however (for example, patient 12), cineangiography may be useful as it enables movement of the whole atrial wall to be seen.

Cardiopulmonary bypass has been used in several different ways for pulmonary surgery. Gardner[12] used it safely to remove a pulmonary metastatic chondrosarcoma with intracardiac extension and several workers in Japan[11 14 15] have reported their experience with an oxygenator pump for resection of lung carcinoma. Neville *et al*[16] have used an oxygenator pump for surgery on the trachea and major bronchi, using total cardiopulmonary bypass for tracheal or carinal resection or both, with airway reconstruction, and partial cardiopulmonary bypass for patients with very poor lung function (bronchial sleeve resection or removal of bullae). Of 11 patients operated on, eight died soon after surgery. Three patients in whom extirpation of the lesion would have been impossible without bypass survived, but are left with some doubt about whether the indications for surgery were reasonable.

In our series two patients underwent en bloc pulmonary and atrial resection by a right posterolateral thoracotomy approach and cardiopulmonary bypass; one patient had a combined midsternal incision and a right posterolateral incision and one a midsternal incision only. Tsutsui *et al*[15] emphasised that atrial resection via a sternotomy might be difficult and suggested that a posterolateral thoracotomy might be more appropriate. Piehler *et al*[9] noted that the advantages of performing a pneumonectomy under cardiopulmonary bypass are fewer for resections of the right than the left lung. Our experience suggests that either or both approaches should be considered, depending on the circumstances. In surgery for lung carcinoma with cardiac invasion we believe that cardiopulmonary bypass may be indicated in the following conditions: (1) deep invasion of the atrial wall or polypoid extrusion into the atrial chamber and (2) invasion of the interatrial septum or of

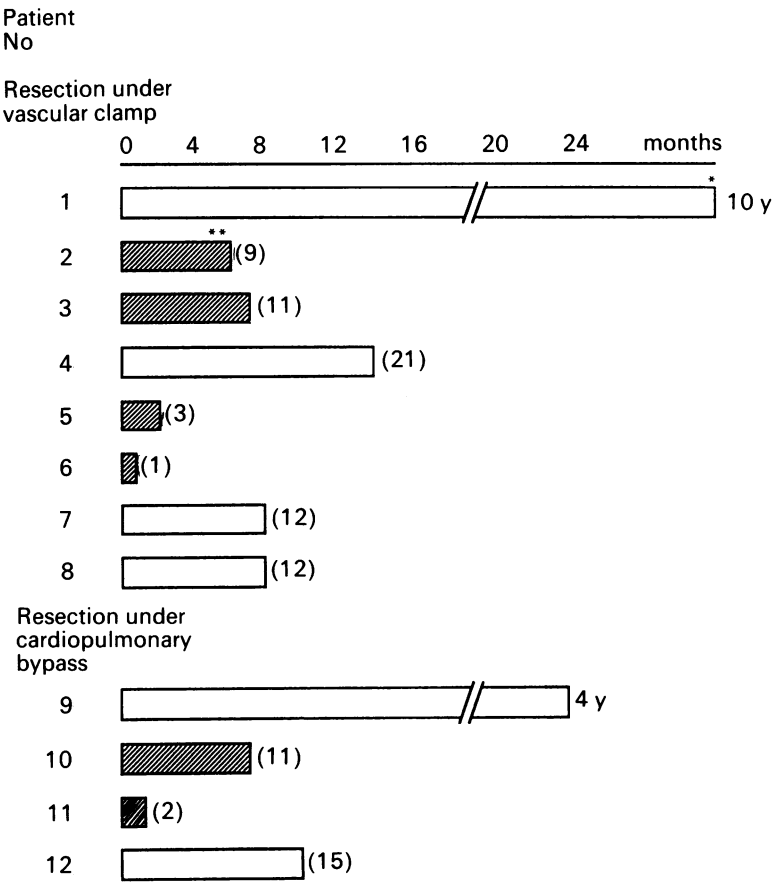

Figure 4 Postoperative survival in 12 patients with lung carcinoma who had lung resected in combination with left atrium. Figures in parentheses give duration (months) of survival or time to death. None of the survivors has evidence of recurrence. □ *Alive;* ▨ *dead.*

the right atrium.

The most common complication accompanying the use of cardiopulmonary bypass is excessive bleeding. Piehler *et al*[9] performed concomitant cardiac and pulmonary surgical procedures in 43 patients with two operative deaths. They found that pulmonary resection performed with systemic anticoagulation was associated with an increased risk of haemorrhage and suggested that anticoagulants should be avoided if possible. In our series one patient required evacuation of a haematoma due to postoperative bleeding, but we had little trouble with haemostasis during surgery. The only fatal complication we encountered was the postoperative brain infarction of patient 11, a patient with moderate hypertension and arteriosclerosis. Cardiac surgery with cardiopulmonary bypass is often needed for patients over 70 years of age, and we consider that cardiopulmonary resection (particularly pneumonectomy) under cardiopulmonary bypass is more invasive and carries an excessive risk for older patients. We suggest therefore that the use of bypass for pulmonary surgery is indicated for patients under 70 years old without severe preoperative complications and preferably with epidermoid carcinoma. Moreover, with an en bloc resection it is very important to keep the bypass time as short as possible to minimise postoperative complications, and to take full precautions to prevent the occurrence of tumour emboli.

The extent to which the left atrium can be resected is uncertain; so far a few experimental studies have been performed. Takeuchi *et al*[17] found that they could reduce the left atrial volume by 35–40% in dogs in addition to performing a pneumonectomy without causing any serious haemodynamic disturbance. We believe that the removal of one third of the left atrium is generally feasible, but patients requiring more extensive resection of atrial tissue may require patching with a suitable graft.

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