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ORIGINAL ARTICLE

Pneumonectomy in the Indian scenario—a review of current indications and results

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Abstract

Background Pneumonectomy is an important procedure in the armamentarium of the thoracic surgeon dealing with both neoplastic and non-neoplastic diseases of the lung especially in a developing country like India where the sequelae of tuberculosis are still rampant and the incidence of lung cancer is on the rise. The indications for pneumonectomy are varied. The operative techniques are standardized. Assessment of risk-benefit ratio is important as pneumonectomy carries considerable morbidity. We present our experience with 74 cases of pneumonectomy performed for varied etiologies, the outcomes of which are retrospectively analyzed in this study.

Materials and methods We retrospectively reviewed our institutional database for patients who underwent a pneumonectomy from January 2009 to April 2015. Demography, patient profile, indications for surgery, details of operative technique, development of perioperative complications, and mortality were analyzed.

Results Seventy-four patients underwent pneumonectomy, with a male to female ratio of 2:1. The age range was 6 to 72 years out of which six were children (8.1 %). Post-tuberculosis-destroyed lung was the predominant indication (43.24 %). Nineteen (25.67 %) underwent pneumonectomy for various tumors. Completion pneumonectomy was done in four (5.40 %). Left pneumonectomy was performed in 48 patients (64.86 %). The operative time ranged between 110 and 385 min. The mean post-operative stay was 4 days. Two patients (2.70 %) required emergency cardiopulmonary bypass for torrential hemorrhage during hilar dissection. Post-operative complications encountered were reactionary hemorrhage (1), empyema (2), bronchopleural fistula (1), and chylothorax (1). There was one early post-operative death due to fulminant respiratory failure. Early mortality rate was 1.35 %.

Conclusion The outcomes following pneumonectomy are favorable when careful attention to patient selection, preoperative patient optimization, meticulous surgical technique, and post-operative principles are followed. Pneumonectomy in post-pulmonary tuberculosis-destroyed lungs did not carry extra morbidity or mortality. Pneumonectomy in malignant lung/ bronchial diseases is safe. Pneumonectomy in children was remarkably uncomplicated. Completion pneumonectomy can be done with an acceptable morbidity in selected patients. Use of cardiopulmonary bypass when encountered with torrential intraoperative hemorrhage is an acceptable strategy. Outcomes of hand-sewn bronchial closure technique are comparable to stapling devices and cost effective.

Keywords Pneumonectomy · Lung · Tuberculosis

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Introduction

Pneumonectomy for the serious complications of benign lung disease is common in Indian thoracic surgical practice. Benign lung disease is most often caused by pulmonary tuberculosis. Other important causes include whole-lung bronchiectasis, multiple or extensive lung abscesses, complicated pulmonary trauma, multiple arteriovenous malformations, and, occasionally, congenital abnormalities. Extensive parenchymal destruction of the lung by inflammatory disease gives rise to

chronically morbid and sometimes acute life-threatening complications like acute suppurative complications including lung abscess and empyema, septicemia, and often chronic, intermittent, or massive hemoptysis. Lung cancers form the other major group requiring pneumonectomy, especially in a developing country like India where improved health care facilities detect early-stage surgically curable tumors.

Pneumonectomies for both benign and malignant diseases are technically challenging procedures. Surgeons must often operate in conditions of dense scar tissue and inflammation surrounding major vascular structures as well as fused pleural surfaces and adherent tumors. When these technical challenges are combined with the patient's underlying medical comorbidities, the procedure can become fatal. The Society of Thoracic Surgeons General Thoracic Surgery Database reports that patients undergoing pneumonectomy for benign conditions are at almost three times the risk of major perioperative events when compared with lung cancer patients [1]. Understandably, many authors believe that this procedure is one of exaggerated risk [2–7]. We present our experience with pneumonectomy for varied etiologies, our perioperative strategies, and outcomes.

Materials and methods

The records of 74 patients who underwent pneumonectomy between January 2009 and April 2015 at our institute were analyzed retrospectively. There were 50 males and 24 females with age ranging from 6 to 72 years (average 44.41 years). Symptomatology, accompanying comorbid conditions, and general clinical status with regard to ability to withstand pneumonectomy were assessed in all patients. Standard chest radiographs (CXR) and pulmonary function tests (PFTs) were basic investigations supported as needed by blood gas analysis. Bronchoscopy was done in all patients to assess the endobronchial tree, and bronchial aspirate was cultured for initiating appropriate antibiotics. High-resolution computerized axial tomography (HRCT scan) was used in all to determine the severity of disease of the affected lung and, in particular, the nature and extent of disease, when present, in the contralateral lung. Occasionally, ventilation perfusion scans were used to determine contributing function of the affected lung. Simple exercise testing was used where any doubt existed. All patients underwent thorough cardiac evaluation with electrocardiogram (ECG) and transthoracic echocardiogram (ECHO) supported as needed by treadmill testing and coronary angiogram.

Preoperative preparation

Appropriate antibiotic therapy was instituted in patients whose bronchial aspirate showed growth of pathogenic bacteria. Duration of antibiotic therapy was for a minimum of 7 days, and bronchial aspirates were re-cultured and patients were operated only after the cultures became negative. When acid-fast bacilli staining was positive, surgery was deferred for 1 month, and anti-tuberculous therapy was initiated. Patients with post-lobectomy or post-decortication pleural space empyema were treated with prolonged intercostal tube drainage, and their nutritional status was improved with high-protein diet and supplements. Patients with lung carcinoma were extensively evaluated by CT scans and bone scan to rule out distant metastasis. All patients were trained to do respiratory exercises and incentive spirometry exercises.

Operative technique

Preoperative bronchoscopy was carried out to ensure there was no active infection/inflammation and also to assess the extent of bronchial tumors. Airway protection and separation were maintained by means of a double-lumen endotracheal tube. An epidural catheter was inserted in all patients for perioperative analgesia.

The incision of choice was a standard postero-lateral thoracotomy and the pleural cavity was entered through the fourth intercostal space. When needed, a second entry was made through a higher or lower rib space to facilitate dissection. Rib resection was done in 12 patients for enhancing the exposure. Appropriate adhesiolysis was done. Dissection was carried out in the intrapleural plane. Pulmonary artery was temporarily clamped and hemodynamics was observed before proceeding with the procedure. Pulmonary arteries were doubly ligated using no. 1 silk ligature. Pulmonary veins were ligated with no. 1 silk ligature and divided and were always reinforced using 3-0 Prolene. The bronchus was divided at appropriate length taking care not to leave excess stump length. The stump was closed using 3-0 polyester suture by intermittent suture technique and reinforced with 3-0 polypropylene suture by continuous suture technique. The bronchial stump was tested under water at a pressure of 40 cm of water. Hemostasis was meticulously achieved. The pleural cavity was thoroughly washed with povidone-iodine and saline. One pleural drain was placed. Ribs were approximated using no. 6 polyester suture. Muscles were approximated using 3-0 Vicryl suture. Seven patients required myoplasty (pectoralis major flap in 3, latissimus dorsi flap in 4) for bronchial reinforcement and pleural space obliteration. Two patients required emergency cardiopulmonary bypass in view of torrential hemorrhage during hilar dissection. Femoral cannulation was used in both these patients. All the excised lungs were sent for histopathological study.

Table 1 Age distribution

Age group (years)	Number of patients
<15	06 (8.10 %)
16–59	48 (64.86 %)
>60	20 (27.02 %)

Post-operative course

Patients were extubated on table or within 2 h of transfer to the intensive care unit. Appropriate antibiotics were administered for 7–10 days. The intercostal drain was removed on the first post-operative day. Serial chest X-rays were carried out till discharge. All patients were started on oral digoxin (0.25 mg once daily) and continued for 1 month. A diuretic (furosemide 20 mg once daily) was given to all patients and continued for 1 week. Aggressive chest physiotherapy was commenced from the first post-operative day. Epidural analgesia was continued for 48 h post-operatively. Anti-tubercular medication was continued for a total of 6 months (including preoperative course).

Follow-up

Patients were followed up after 10 days, 1 month, 3 months, 6 months, and yearly after discharge with physical examination and chest X-rays.

Statistical methods

Categorical variables are expressed as percentages. Continuous variables are expressed as mean.

Results

Patient characteristics

Seventy-four patients underwent pneumonectomy. More males (67.56 %) than females were operated (32.43 %). The age range was 6 to 72 years (Table 1). Six were children below 15 years (8.1 %). Indications in children included congenital

Table 2 Symptomatology

Symptom	Percentage
Cough	60.81
Hemoptysis	37.83
Dyspnea	24.32
Chest pain	8.10
Fever	9.45
Weight loss	5.40

Table 3 Comorbidities and risk factors

Comorbidity	Number of patients
Obesity	02
Diabetes mellitus	12
Hypertension	16
Chronic kidney disease	03
Epilepsy	01
Neo-adjuvant chemotherapy	03
Smoking	36
Prior radiation therapy	01

bronchiectasis (2), lung abscess (1), trauma (1), and hydatid cyst (2). The presenting symptom was productive cough in most of the patients (48.64 %) (Table 2). Comorbidities included diabetes mellitus, hypertension, coronary artery disease, epilepsy, and chronic kidney disease (Table 3). Thirty-six (48.64 %) had history of smoking. The predicted forced expiratory volume at 1 s ranged between 38 and 144 % (Table 4). Predominant indication (Fig. 1) was post-tuberculosis-destroyed lung in 30 (40.54 %). Nineteen (25.67 %) underwent pneumonectomy for neoplasia out of which 10 (13.51 %) were malignant. Redo thoracotomy for post-decortication empyema (2) and completion pneumonectomy following lobectomy (4) were done in six patients (8.10 %).

Perioperative and early outcome

Left pneumonectomy was done in 48 patients (64.86 %) and right pneumonectomy in 26 patients (35.13 %) (Fig. 2). The mean operative time was 190 min (range 110–385 min). Patients undergoing redo thoracotomy had higher operative times (mean 280 min). Thirty-two patients (43.24 %) received intraoperative blood transfusions. There was one major pulmonary artery injury in a case of squamous cell carcinoma and one pulmonary vein injury during completion pneumonectomy for a fibrocavitary lesion. Both these patients required

Table 4 Preoperative pulmonary function values

Variable	Median (range)
TLC (% predicted)	98 (52–142)
VC (% predicted)	87 (41–131)
FVC (% predicted)	85 (34–151)
FEV1 (% predicted)	71 (38–144)
O_2 saturation, rest (%)	92 (78–100)
O_2 saturation, exercise (%)	94 (83–100)
PaO_2 (mmHg)	72 (50–100)
$PaCO_2$ (mmHg)	36 (26–56)

Fig. 1 Indications for pneumonectomy
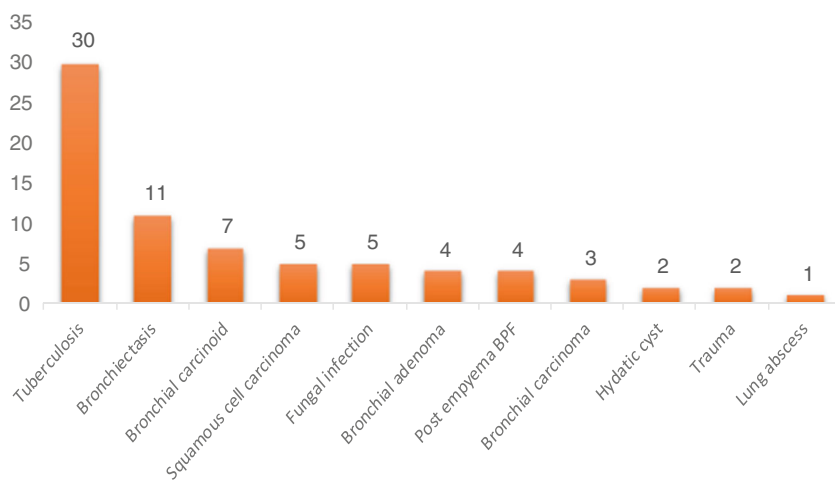
emergency cardiopulmonary bypass through femoral cannulation in view of torrential hemorrhage (2.70 %).

One patient had reactionary hemorrhage for which he was re-explored. Two patients developed empyema which was conservatively managed with intercostal drainage and antibiotics. One patient developed bronchopleural fistula for which myoplasty with pectoralis major flap was done. One patient developed chylothorax which was managed conservatively. One patient operated for post-tuberculosis-destroyed lung required prolonged ventilator support for fulminant respiratory failure who subsequently expired on the fifth post-operative day (early mortality—1.35 %) (Table 5).

Discussion

Pneumonectomy proved an expeditious and effective management for both inflammatory and neoplastic lung disease in this study. The hospital mortality rate of 1.35 % compares with other series of pneumonectomy for both inflammatory and malignant diseases [1].

Present-day preoperative evaluation, preparation, and precise anesthesia techniques, particularly airway separation, are important factors. Pulmonary function tests, even though considered to give an accurate pulmonary function, may be misleading in some cases. This is because this test requires significant patient comprehension which cannot be expected in the elderly and in children. Arterial blood gas analysis and bedside pulmonary function testing give a rough guide to proceed with pneumonectomy.

The ablation of active infection, especially active tuberculosis, before operation is critical. We recommend a minimum of 1 month of anti-tubercular therapy before operation. Clinical lung abscess and empyema associated with destroyed lung should be managed by either closed or open drainage before operation is done.

Epidural analgesia in the perioperative period reduces postoperative pain significantly. This avoids the use of additional analgesics, especially NSAIDs, with its accompanying side effects. Minimal post-operative pain also assures faster patient
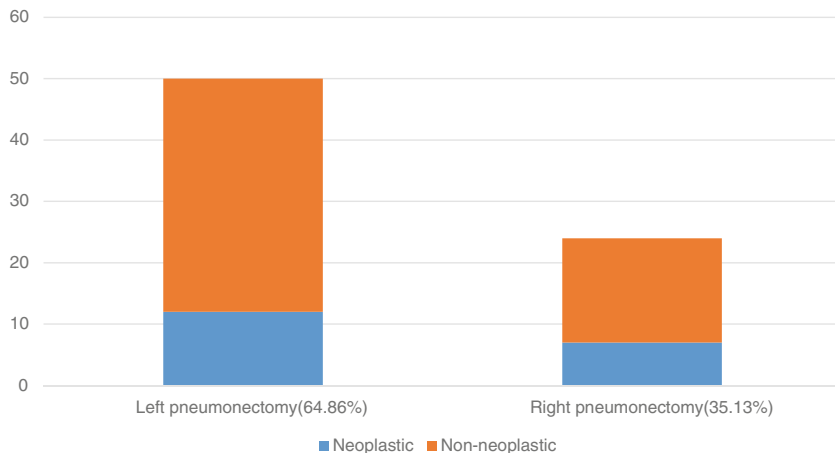

Fig. 2 Side of pneumonectomy

Table 5 Major complications

Type	Number	Management	Outcome
Bleeding	1	Re-explored	Controlled
Vascular injury	2	Went on CPB, hemostasis secured	Controlled
Wound sepsis	4	Local irrigation, antibiotics, secondary suturing	Healed
Empyema	2	Intercostal drain, antibiotics	Sterilized
Bronchopleural fistula	1	Fistula closure with pectoralis major flap	Healed
Chylothorax	1	Intercostal drain, antibiotics	Healed
Respiratory failure	1	Prolonged ventilatory support	Expired

recovery and initiation of early breathing and shoulder exercises.

Destroyed lung caused by tuberculosis is non-functional with demonstrable absent perfusion and ventilation. It is nonetheless richly vascularized by systemic arterial connections. This neovascularization bleeds readily. Hence, meticulous hemostasis is important during adhesiolysis and dissection to prevent post-operative pleural space bleeding which might further get infected. Aggressive use of electrocautery and tight mop packing for few minutes are useful techniques to achieve hemostasis.

Use of double-lumen endobronchial tubes minimizes the risk of contralateral bronchial spillage. Intrapleural spillage may occur from a peripheral ruptured or breached abscess cavity during operation. Thorough wash with saline and povidone-iodine seems to reduce this contamination rate. Use of intercostal muscle flaps to secure the bronchial stump in such cases gives an added protection against stump infection and bronchopleural fistula. We believe that the use of antibiotics for 24±48 h preoperatively, intraoperatively, and post-operatively for 5 days and where contamination has occurred for 7±10 days post-operatively is vital in preventing post-pneumonectomy empyema. Space and wound irrigation with povidone-iodine and saline was used, as supported by animal and clinical studies [8].

Bronchial stump was closed by traditional hand-sewn anastomosis. We did not use bronchial staplers. Avoidance of electrocautery, clamp application and extensive skeletonization, use of intercostal muscle flaps in selected cases, and adherence to meticulous suture technique resulted in better outcomes. Our hand suture technique of bronchial closure was complicated by BPF in 1.35 % and compares well with a 2 % incidence with staple closure [9].

In patients with borderline pulmonary function, the decision to proceed with pneumonectomy is particularly challenging. We follow a staged approach. Apart from routine pulmonary function test, bedside evaluation in the form of a 6-min walk test is done. Cardiac evaluation to rule out pulmonary

hypertension is done. Intraoperatively, after intubation with a double-lumen endotracheal tube, single-lung ventilation (contralateral lung) is initiated and arterial blood gas is done. If pO_2 is >50 mmHg and pCO_2 <40 mmHg, then hilar dissection is done and pulmonary artery is temporarily clamped and hemodynamics are observed. If there is no major hemodynamic alteration, only then do we proceed with pneumonectomy. We did not require physiological lung exclusion in any of the cases.

In children, lung isolation is particularly challenging. As double-lumen tubes of small sizes are not readily available, single-lung isolation was achieved by the use of a Fogarty catheter as a bronchus blocker. There was adequate lung isolation with this technique.

Conclusion

The outcomes following pneumonectomy are favorable when careful attention to patient selection, preoperative patient optimization, meticulous surgical technique, and post-operative principles are followed. Pneumonectomy in post-pulmonary tuberculosis-destroyed lungs did not carry extra morbidity or mortality. Pneumonectomy in malignant lung/bronchial diseases is safe. Pneumonectomy in children was remarkably uncomplicated. Completion pneumonectomy can be done with an acceptable morbidity. Use of emergency cardiopulmonary bypass when encountered with torrential intraoperative hemorrhage is an acceptable strategy. Use of traditional hand-sewn suture techniques instead of stapling devices considerably reduces the cost of the surgery, especially in a country like India where limited health care resources are available.

Declaration and its later amendments. Informed consent was obtained from all individual participants included in the study.

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