ELSEVIER

European Journal of Cardio-thoracic Surgery 20 (2001) 25–29

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

www.elsevier.com/locate/ejcts

Role of physiological lung exclusion in difficult lung resections for massive hemoptysis and other problems ☆

Rajinder S. Dhaliwal[a,*], Pankaj Saxena[a], Deepak Puri[a], Kuldeep S. Sidhu[b]

[a]*Department of Cardiovascular and Thoracic Surgery, Postgraduate Institute of Medical Education and Research, Chandigarh 160012, India*
[b]*Department of CTV Surgery, Government Medical College, Amritsar, India*

Received 9 October 2000; received in revised form 14 February 2001; accepted 14 March 2001

Abstract

Objectives: Pulmonary tuberculosis and bronchiectasis are the major causes of massive hemoptysis in developing countries. Lung resection remains the surgical treatment of choice. This may not always be possible and may even be hazardous in some patients due to fibrosis and dense vascular adhesions between the lung and the chest wall. This leads to marked blood loss and control of hilar vessels becomes dangerous. **Methods**: A series of 20 cases is described here. Nineteen presented with massive hemoptysis where control of bleeding was obtained by physiological lung exclusion. One patient had traumatic left main bronchus transection not suitable for repair or resection. Physiological lung exclusion was performed by surgical interruption of the bronchus and pulmonary artery of the involved lobe or lung, keeping pulmonary veins intact. **Results**: Hemoptysis could be controlled in all these patients without any significant morbidity. There was no mortality. There was no postoperative empyema and recurrence of hemoptysis on long-term follow-up. No patient required anatomical lung resection later on. **Conclusions**: Physiological lung exclusion is a safe and effective method for control of massive hemoptysis in cases where lung resection is technically hazardous or difficult. This should be kept as an alternative or adjunct to anatomical lung resection.

Keywords: Massive hemoptysis; Lung resection; Physiological lung exclusion

1. Introduction

Hemoptysis is the expectoration of blood originating from the tracheobronchial tree or pulmonary parenchyma. Common causes include tuberculosis, bronchiectasis, aspergilloma, bronchogenic carcinoma and lung abscess. Hemoptysis is initially treated with conservative measures. Surgical intervention is indicated in patients presenting with massive hemoptysis where the blood loss is more than 600 ml in 24 h and medical treatment has failed [1,2].

These patients may go into hypovolemic shock and adequate control of their airway and ventilation is difficult to maintain. Lung resection is the standard surgical treatment for massive hemoptysis but it may be difficult or even hazardous in these patients. This is due to dense vascular adhesions between the lung and the chest wall causing marked blood loss and control of hilar vessels is difficult. This is especially seen in cases of tuberculosis where marked fibrosis and calcification make lung mobilization difficult and time-consuming with a lot of blood loss. The first patient in this series had massive hemoptysis from the left lung (post-tubercular). An emergency left pneumonectomy was planned. On opening the chest, the lung was found to be very densely adherent to the chest wall and on attempted mobilization there was marked blood loss. The blood bank could not supply more blood of that group. In order to save the patient it was decided to ligate the main pulmonary artery and divide the main bronchus so that the lung was isolated from the circulation and airways. To our surprise the hemoptysis stopped and the patient recovered. This procedure was used subsequently in a few more patients under similar circumstances and every time it worked. This paper deals with our experience of 'physiological lung exclusion' in patients where standard lung resection was difficult or even dangerous to the patient due to the presence of marked fibrosis, calcification and dense vascular adhesions between the lung and the chest wall.

☆ Presented at the 14th Annual Meeting of the European Association for Cardio-thoracic Surgery, Frankfurt, Germany, October 7–11, 2000.

* Corresponding author. CTV Surgery, P.O. Box 1515, PGI Campus, Chandigarh 160012, India. Tel.: +91-172-711070; fax: +91-172-744401.
E-mail address: rsdhaliwal@glide.net.in (R.S. Dhaliwal).

1010-7940/01/$ - see front matter
PII: S1010-7940(01)00685-6

2. Materials and methods

This technique was used in 20 patients over a 5 year period (from January 1996 to December 2000), 19 with massive hemoptysis and one with traumatic disruption of the left main bronchus. Nineteen patients presenting with massive hemoptysis were referred to us for surgical treatment. All these patients had uncontrollable hemorrhage and failure of conservative treatment. Of all the patients 11 were males and nine were females. The age range was between 16 and 50 years. The duration of the disease varied from 1 to 15 years. All the patients except one were having fibrocavitary pulmonary tuberculosis with destroyed lung or bronchiectasis due to pulmonary tuberculosis. Bilateral involvement was present in 40% of cases. None of the patients had any active lesion. As patients were suffering from chronic pulmonary disease and cachexia, their general condition was poor and eight patients were dyspnoeic at minimal physical activity. The patients' characteristics along with the surgical procedures carried out are depicted in Table 1.

Diagnostic evaluation of these patients was done with a chest roentgenogram and a CT scan of the chest which revealed fibrocavitary, pulmonary tuberculosis in 16 patients and bronchiectasis in three patients (Figs. 1 and 2). Total lung collapse was seen in one of the patients who had post-traumatic disruption of the left main bronchus. Fiber-optic or rigid bronchoscopy was done to confirm the site of origin of hemoptysis in all patients before surgery. Preoperative lung functions were not possible due to active hemoptysis. Therapeutic embolization was tried in the last four cases (patient nos. 15–18) where it failed due to the presence of multiple sites of bleeding. This facility was not available in our institute earlier.

Patients were taken up for surgery on an urgent or emergency basis under general anesthesia which was administered through a double lumen endotracheal tube. Initially posterolateral thoracotomy was used in four patients. However, later on the approach was changed to anterolateral thoracotomy for its various advantages, such as lesser mobilization of the lung for easier control of the hilum, quick opening and closure of the chest, less blood loss and suitability to the anesthetist. In all cases the affected part of the lung parenchyma was found to be destroyed and densely adherent to the chest wall (Fig. 3) causing extensive bleeding at the time of mobilization and making the procedure hazardous and time-consuming. Careful dissection and minimal lung mobilization was done to approach the hilum. In 14 patients the main pulmonary artery was isolated and doubly ligated. In 11 patients it was done outside the pericardium and in three patients it was ligated inside the pericardium. The main stem bronchus was divided and the proximal end was sutured using polyglactin (vicryl) in nine patients and in others prolene was used. In six cases, as the lesion was confined to a lobe, lobar bronchi were divided and their pulmonary arteries were ligated (Fig. 4). Pulmonary veins were not ligated in all the patients for

Table 1
Clinical profile of patients who underwent physiological exclusion of lung/lobe

Total no. of patients	20 (11 M/9 F)
Age range (years)	16–50
Duration of symptoms	12 months to 15 years
Preoperative diagnosis	
Fibrocavitary tuberculosis	15 (9 M/6 F)
Bronchiectasis	4 (2 M/2 F)
Traumatic bronchial disruption	1 (F)
Surgical procedure done (%)	
Entire left lung exclusion	8 (40)
Entire right lung exclusion	6 (30)
Right upper lobe exclusion	3 (15)
Right lower lobe exclusion	1 (5)
Left upper lobe exclusion	2 (10)

Fig. 1. Chest roentgenogram showing scoliosis and pulmonary tuberculosis with fibrocavitary lesions and collapse of the left upper lobe of the lung.

Fig. 2. CT scan of the chest showing fibrocavitary lesions with collapse of the left upper lobe of the lung.

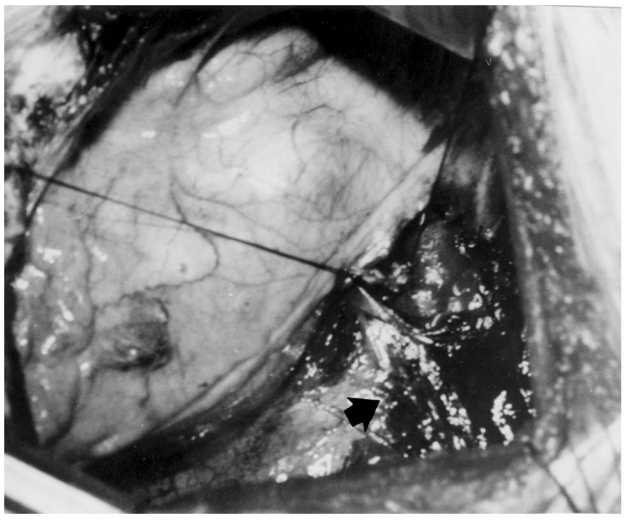

Fig. 3. Operative photographs showing destruction and adhesions of lung parenchyma to the chest wall of the affected lobe (arrow).

proper venous drainage. One or two intercostal drainage tubes were placed in the pleural cavity. The distal bronchial stump was left open in two patients with bronchiectasis as there were a lot of purulent secretions in the lung. An appropriate-sized catheter was placed inside the stump to carry out irrigation with antibiotic solution. This was done two to three times per day for the first postoperative week and then the catheter was removed.

3. Results

Hemoptysis could be controlled in all these patients immediately and on long-term follow-up. In the postoperative period one patient, who had isolation of the right lung for fibrocavitary lung disease due to treated tuberculosis, required postoperative ventilation for 2 days. Another patient with blunt trauma chest who had left main bronchus disruption requiring prolonged mechanical ventilation preoperatively could be weaned off the ventilator within 2 days after physiological left lung exclusion (Table 2). No worsening of dyspnoea was seen in the remaining patients and all patients were discharged from the hospital within 3 weeks following surgery; the mean hospital stay was 14 ± 5 days. There was no operative mortality and minimal morbidity. There was no recurrence of hemoptysis in early or late postoperative follow-up. Follow-up ranged from 3 to 49 months, with a median follow-up of 29 months. There was no empyema in any of these patients. This was very gratifying as two patients with bronchiectasis were diabetics and the lung had purulent secretions at the time of surgery and empyema was a real threat. All patients were able to do their routine work without much restriction in physical activity (Table 2).

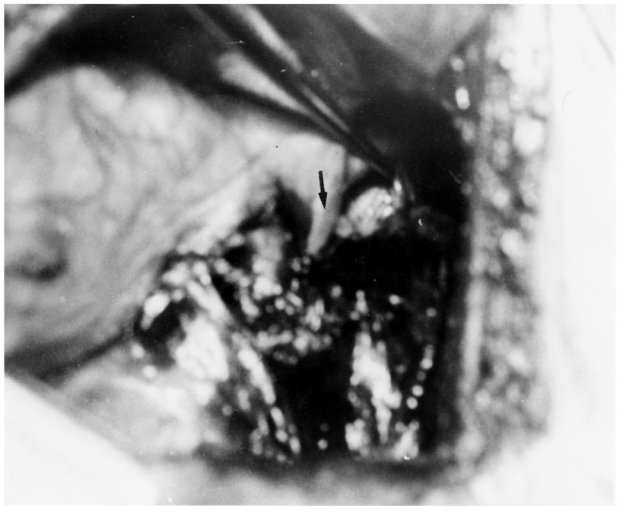

Fig. 4. Operative photograph showing the divided bronchus and ligated branch of the corresponding pulmonary artery (arrow).

4. Discussion

Pulmonary tuberculosis is still a common disease in developing countries like India. Contributory factors to the higher prevalence of disease include low socioeconomic status, ignorance, delayed diagnosis, failure with compliance of chemotherapy and the presence of multi-drug resistant tuberculosis. In the process of chronicity of disease, damage to lung parenchyma is quite extensive causing dense fibrosis, calcification and vascular adhesions between the lung and the chest wall.

Lungs have a dual blood supply originating from the bronchial and pulmonary circulations and anastomosis is present between the two systems. Rasmussen aneurysms are abnormal ectatic vessels located in the wall of the tubercular cavity which are liable to rupture causing hemoptysis [3]. Another cause of hemoptysis in these patients is the erosion of adjacent vessels by calcified tubercular lymph nodes or broncholiths [4]. In bronchiectasis, the enlarged bronchial arteries are prone to erosion by the inflammatory process [5].

The present method has been used in patients with life-threatening hemorrhage in the lung with failed medical management, in whom lung resection was found to be technically hazardous or even impossible. As in the present method, the offending lobe or lung was excluded from the tracheobronchial tree by division of the bronchus and

Table 2
Results of physiological exclusion of lung/lobe

Operative mortality	Nil
Prolonged postoperative ventilation (>24 h) (%)	2 (10)
Mean hospital stay (days)	14 ± 5
Follow-up range (months)	3–49
Median follow-up (months)	29
NYHA Class I	All patients
Recurrent hemoptysis	Nil
Postoperative empyema	Nil

pulmonary artery ligation without removing lung tissue; the term 'physiological lung exclusion' (whole lung or lobe) has been used for this procedure. The term 'physiological lung exclusion' (lobe or lung) explains the isolation of the bleeding lung from the pulmonary circulation and airway by division of the pulmonary artery and the bronchus. The pulmonary veins are preserved.

Bronchial arteries run along the wall of the bronchi and there is a plexus in the peribronchial tissues. By the division of the bronchus this source as a cause of hemoptysis is abolished. The isolated lung continues to receive a blood supply through vessels which are present in the adhesions between the lung surface and the chest wall. This keeps the lung parenchyma viable. Moreover, the pulmonary veins are kept intact and thereby drain the blood from the involved lung, and hence no necrosis of the lung parenchyma occurs. Later on this isolated lung or lobe shrinks in size and the pleural space is also slowly obliterated due to a decrease in the size of the hemithorax. By keeping the native tissue inside the pleural cavity, the risk of pleural space problems like empyema developing later on is minimized in these high risk patients with infection. Following physiological lung exclusion empyema did not develop in any of our patients, which may indicate that there was no empty pleural space. Moreover, the operative blood loss was significantly less than standard lobectomy or pneumonectomy. This procedure is well tolerated and controls hemoptysis effectively.

Our only patient in whom we performed physiological left lung exclusion for chest trauma had suffered from polytrauma including blunt chest injury with flail chest on the left side. The patient was referred from another institution 3 weeks after the accident. She had multiple rib fractures with hemopneumothorax on the left side. There was significant air leakage through the intercostal drainage tube and she required prolonged mechanical ventilation for respiratory support. Fiber-optic bronchoscopy in the ICU showed a large tear in the left main bronchus. The injury was already 4 weeks old before she underwent exploration. At the time of surgery, dense adhesions were present between the lung and the chest wall. The left main stem bronchus was found to be transacted and the gap between the two segments was 4 cm. Due to the friability of tissues and the inability to mobilize the lung in the presence of thick vascular adhesions, a decision was made in favor of physiological lung exclusion (based on our previous experience with this technique). Both the bronchial stumps were securely closed and the left pulmonary artery was ligated. Air leakage subsided postoperatively and the patient could be weaned off ventilatory support on the second postoperative day. We have included this patient in this series because in her case physiological lung exclusion proved a better choice than an anatomical pneumonectomy which would have caused marked blood loss and might have been dangerous due to the friability of the hilar tissues. In the past, only a few case reports of controlling hemoptysis by either division of the bronchus or ligation of the pulmonary artery for the control of bleeding have been published. These include pulmonary artery ligation in one case report, ligation of one lobar in the second case report and one main stem bronchus ligation in the third case report [6–8]. Nobody has reported combined ligation of the pulmonary artery and the bronchus (lobar or main) to produce physiological lung exclusion for the control of hemoptysis. To our knowledge we are presenting the largest experience of this type of procedure (physiological lung exclusion (division of the bronchus and the pulmonary artery and preserving the pulmonary veins)) from any single institute. In the English medical literature we have not come across any paper or case report describing the procedure of physiological lung exclusion. One point of concern is that due to an inability to drain the infected lung of collected blood or secretions, the chances of persistent infection in the isolated lung are always present. However, this has not been encountered by the authors in any of these patients in a follow-up ranging from 3 to 49 months (median follow-up 29 months) after this procedure. None of the patients who had physiological lung exclusion required an anatomical lung resection later on. In fact this procedure is indicated in patients where lung resection is technically difficult due to marked fibrosis and dense vascular adhesions between the lung and the chest wall. An attempt to mobilize the lung may lead to marked blood loss and reaching and controlling the hilar vessels may be dangerous. One may argue that the most risky part of the operation is hilar dissection, but once it is controlled why not perform standard lung resection. It is the presence of fibrosis, calcification and dense vascular adhesions between the lung and the chest wall which leads to marked blood loss on mobilization of the lung even after hilar control, making the procedure time-consuming and risky to the patient. During this period we performed standard lung resection for massive hemoptysis in only five patients where the lung was not or minimally adherent to the chest wall and hilum control was easy. One of these patients developed empyema later on after pneumonectomy.

In conclusion we can say that the procedure of 'physiological lung exclusion' is a very useful and important alternative/adjunct to a standard lung resection in difficult lung resections for various problems, the most important being massive hemoptysis. Every thoracic surgeon should keep this procedure in mind whenever planning for any lung resection, as it can save the patient and the surgeon from a tricky situation.

References

[1] Sehhat S, Oreizis M, Moinedine K. Massive pulmonary haemorrhage: surgical approach as choice of treatment. Ann Thorac Surg 1978;25:12.
[2] Winter SM, Ingbar DH. Massive hemoptysis: pathogenesis and management. J Intensive Care Med 1988;3:171.
[3] Plessinger VA, Jolly PN. Rasmussen's aneurysms and fatal haemorrhage in pulmonary tuberculosis. Am Rev Tuberc 1949;60:589.
[4] Lin CS, Becker WH. Broncholith as a cause of fatal hemoptysis. J Am Med Assoc 1978;239:2153.
[5] Liebow AA, Hales MR, Lindskog GE. Enlargement of the bronchial

arteries and their anastomoses with the pulmonary arteries in bronchiectasis. Am J Pathol 1949;25:211.
[6] Randolph H. Haemorrhage in pulmonary tuberculosis as a surgical emergency. Dis Chest 1955;28:416–420.
[7] Bahabozorshi S, Jallah EA, Cook WA. Tuberculous pulmonary haemorrhage. N Y State J Med 1973;73:959–963.
[8] Epstein TV. Surgical methods in treating tuberculous patients with pulmonary haemorrhage and recurrent hemoptysis. Grudn Khir 1963;5:60.

Appendix A. Conference discussion

Dr K. Jeyasingham (*Winterbourne Down, UK*): It is a fascinating operation. I have not done a single one of them. Tell me, is it the ligation of the pulmonary artery or is it the fact that you resect the bronchus, and, in so doing, divide the bronchial arteries that contributes to control of the bleeding? Secondly, in your preoperative investigations do you perform any contrast studies to decide whether it is necessary to do a physiological pneumonectomy or whether you could do something less?

Dr Dhaliwal: For your second question first, whether pneumonectomy or lobectomy depends upon the area involved. In these patients, although there were 20 patients, pneumonectomy was done only in eight patients. Twelve were lobectomies, and there were seven on the left side and five on the right side.

Your first question, only artery or bronchus or both. Going in the literature, we could get only one case report from Russia in 1963 where they just divided the bronchus in a patient like this and hemoptysis was controlled. This procedure we could not search in the English literature. The first case, how I started 5.5 years back, it was a case of massive hemoptysis and in the night we started surgery. The patient was having a lot of bleeding in the bronchus and the anesthetist was having problems with intubation and the other things. When I opened the chest and tried to mobilize the lung, so much bleeding started, and it was in the night, and the blood banks, there were not more than three bottles available. I thought we may lose the patient on the table due to bleeding. It was a tubercular case. So suddenly it came to my mind that if we just divide the artery and divide the bronchus, maybe he will not die due to hemoptysis. So out of that sort of desperation, I did this procedure, and to my surprise, the patient survived. My main worry was that the lung would go gangrenous, but nothing happened. That was very encouraging. In the next two patients there was a similar situation and I did this procedure and then became bold. Three patients had bronchiectasis. They had childhood bronchiectasis and came in adult life to us. Most of the thoracic surgeons, they can see this thing, that the lungs are so densely adherent to the chest wall. The mobilization itself is the main job there before we can reach the hilum. So in two of the patients I did electively this procedure. They had diabetes. Another thing that I found was no empyema, no space problem, for the lung is still lying inside. There is no space where fluid will collect or empyema will form. So due to these two things, I have carried on now to the extent that any difficult case, we open the chest, we go for this thing, and the number has gone up to 20 patients without any problem. Its a very encouraging procedure. I request to all of you who deal with difficult lungs to please try this thing so that we have a discussion in the next meeting as to what happened.

Dr Jeyasingham: That reply prompts me to ask whether there is a place for temporary occlusion, such as a noncut stapling of the bronchus as well as of the pulmonary artery, rather than total division.

Dr Dhaliwal: Temporary occlusion, you mean stapling or through a balloon? What do you mean by temporary occlusion? You want to try a balloon, you use a balloon and close?

Dr Jeyasingham: Stapling without cutting the artery.

Dr Dhaliwal: You can try that. In our country staplers are not easily available. They are expensive and we are dealing with mostly poor patients. There is nothing wrong with trying a stapler. You can either ligate and divide or you can staple. Stapling will be a quicker procedure comparatively.

Dr W. Klepetko (*Vienna, Austria*): It is fascinating to see how the circumstances influence the operative techniques that you apply, and it is fairly clear for me to understand that under the circumstances where you do not have any blood units available to give to the patient, you really have to do some other techniques. Something really worries me a little bit. You had in your indications three patients who had a very high amount of bronchial purulent sputum. This is something that, of course, one would expect to be a contraindication for a division of the bronchus and stapling of the bronchus. Can you give us a little more detail?

Dr Dhaliwal: I divided the bronchus. The proximal end was sutured. The distal bronchus I kept open and the chest tube was kept up to 2 weeks. We were irrigating the distal bronchus. A small catheter was left in the distal bronchus to irrigate the distal area so that the infection gets cleared, and later on there was no sputum production. The proximal bronchus has been disconnected, so there were no secretions and the patient was not producing any sputum. So we divided bronchus and the proximal end was sutured and the distal was kept open, so that the secretions, whatever collected in the lung, it drained into the pleura and then it comes out. And we irrigated that area, the distal bronchus, by putting in a thin catheter with antibiotics for up to 2 weeks. Both were diabetic patients out of the three. This was the biggest surprise even to me, how nothing happened, no empyema, no problem later on. So that's why I want people to try this thing. Its a very useful procedure.

Dr Klepetko: How did you handle the patients with tuberculosis? Was there a different way of handling them?

Dr Dhaliwal: Tuberculosis, no. The patients who needed lung resection, they are referred to us. Otherwise we have our pulmonary physicians, the medical part and all that. Only the patient who requires surgery with hemoptysis, bronchiectasis or massive hemoptysis, they come to us. We have a separate department of pulmonary medicine.

Dr T. Dosios (*Athens, Greece*): This is an excellent example of iatrogenic extralobar sequestration. This is my opinion. I was very impressed that you did not have postoperative infections. If you are interested in dividing the circulation I would suggest that you can occlude the pulmonary artery or the branches of the pulmonary artery and the bronchial arteries and leave the bronchus open. By that way you maintain the bronchial drainage. Otherwise, since the bronchial epithelium of the sequestered lobe keeps producing mucus, you will have some problem of infection definitely.

Dr Dhaliwal: No. If you leave the bronchus intact, the hemoptysis will not stop. In a hemoptysis case you have to divide both the pulmonary artery and the bronchus. The bronchial vessels are one of the major causes of hemoptysis, so that's why you have to divide the bronchus.