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Evaluation of the Management of Air Leak Post Pulmonary Resection

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Abstract

Background: Postoperative air leak is one of the most common complications occurring in a considerable number of patients following pulmonary resection surgery. An air leak is the escape of air from a break in the lung parenchyma or defect in a lung or bronchial staple line. Although most of the air leaks resolve spontaneously, a minor air leak may postpone chest tube removal, contributing to prolonged postoperative pain, delayed functional status, intra-thoracic infections, and increased hospital length of stay.

Aim of Study: The aim of this study is to evaluate the leading factors of air leak following pulmonary resection either anatomical or non-anatomical resections for different reasons and to study the different ways in its management.

Results: The mean age for the study group was 29.4 years and all patients (100%) were males. Smoking history was present in 26 patients (86.67%). Regarding the preoperative diagnosis for the study group; 14 (46.67%) patients had recurrent spontaneous pneumothorax, 5 patients (16.67%) had bullous lung disease, bilateral spontaneous pneumothorax in 2 (6.67%) patients, lung nodule in 4 (13.33%) patients, lung mass in 2 (6.67%) patients, bronchiectasis in 1 (3.33%) patient, lung metastases in 1 (3.33%) patient and huge lung cyst in 1 (3.33%) patient.

Conclusion: Air leak after pulmonary resection is a common complication that have significant morbidity. Smoking was prevalent in most of the patients who had postoperative air leak. Most of the air leak can be managed conservatively and only a few percentages of patients could need an intervention. Blood patch and bronchoscopy with silver nitrate injection are good modalities for control of postoperative air leak.

Key Words: *Pulmonary – Air leak – Resection – Lung.*

Introduction

POSTOPERATIVE air leak is one of the most common complications occurring in a considerable number of patients following pulmonary resection surgery. An air leak is the escape of air from a break in the lung parenchyma or defect in a lung or bronchial staple line. Although most of the air leaks resolve spontaneously, a minor air leak may postpone chest tube removal, contributing to prolonged postoperative pain, delayed functional status, intra-thoracic infections, and increased hospital length of stay **[1].**

Severe or prolonged air leak may also require intervention, including reoperation in selected refractory cases. Prevention and/or treatment of postoperative air leaks is a crucial component of perioperative care for patients undergoing pulmonary resections **[2].**

Preoperative predictors, intraoperative techniques, and postoperative management should all be considered as an important factor in the diagnosis and treatment of postoperative air leak **[3,4].**

The advancement in minimally invasive techniques for pulmonary resection, developing technologies and new enhanced recovery algorithms have also affected to a great extent the management of postoperative air leak **[5-8].**

Management of air leaks is critical aspect during the postoperative course in patients who had lung resections. Many investigations in the last decade are focusing on preventive measures or chest tube modalities. However, little information is known about the pathophysiology of air leak and the patient perception of this common complication **[9].**

Understanding the reasons why pulmonary parenchyma may start to leak air or why air leak may

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List of Abbreviations:

CT scan: Computed tomography scan.

VATS : Video assisted thoracoscopic surgery.

be longer in time from one patient to another is obscure. However, experimental work supports the notion that lung overdistension may favor air leak **[9].**

Some studies represented the basis of future investigations. Furthermore, the standardization of nomenclature in the field of pleural space management and the creation of novel air leak scoring systems have contributed to improving the knowledge among thoracic surgeons and facilitate the organization of trials on this matter **[10-12].**

Patients and Methods

This prospective study was carried out on 30 consecutive patients who underwent different lung resection surgery for different pulmonary pathologies admitted to Alexandria University Hospitals, Alexandria, Egypt in the duration from July 2023 to July 2024.

The study was approved by the Ethics Committee of Faculty of Medicine, Alexandria University, Egypt.

An informed written consent was obtained from each patient.

Inclusion criteria:

- Patients undergoing pulmonary resection surgery for diagnosed malignant tumors or refractory benign disease.
- Patients receiving bullectomy or pulmonary wedge resection for spontaneous pneumothorax.
- Patients receiving lung resection for resection of pulmonary metastases.

Exclusion criteria:

- Patients with cardiovascular risk factors.
- Patients with bleeding disorders.
- Patients morbid obese BMI >35.

Preoperative evaluation:

All patients included in the study have received:

- Detailed history taking.
- Full clinical examination.
- Routine laboratory investigations.
- Radiological examination including Chest X-ray and CT scan of the chest.
- Pulmonary function test.

Intraoperative management:

Operative techniques included a double-lumen endotracheal tube for anesthesia.

Standard posterolateral thoracotomy or VATS were performed according to surgeon preference and patient diagnosis.

Lobectomy, wedge resection, resection of lung metastases or non-anatomical lung resection was done according to each lung pathology and patient performance status using surgical staplers or sutures.

All staple lines were reinforced with the use of 4-0 Prolene (Ethicon, Somerville, NJ) on a small half needle. Warm sterile water was squirted over the lung to localize air leaks. Patients who underwent upper lobectomy had one anterior straight 28F chest tube placed in the apex and another placed posteriorly.

Patients who underwent lower lobectomy had a straight 28F chest tube placed anteriorly in the apex and a 28F right-angle chest tube placed along the diaphragm.

Postoperative management:

Chest X-rays were performed daily for all patients.

Chest tubes were kept under water seal in the postoperative period and were removed when there was no air leak, and the drainage was less than 250 mL day.

The forced expiratory air leak was determined by visualizing bubbles in the analogue drainage system while the patient coughed in an upright sitting position.

Patients remained on water seal unless they had enlarging symptomatic pneumothorax or subcutaneous emphysema developed.

When no air leak was detected, the chest tube was removed. If the air leak was equivocal, the tube was clamped and chest radiography was performed, followed by removal of the chest tube if no new pneumothorax or subcutaneous emphysema was identified.

Air leak was classified according to its severity to the following grades.

Grading of air leak:

- Grade 1: Air leak with forced cough.
- Grade 2: Air leak with expiration.
- Grade 3: Air leak with inspiration.
- Grade 4: Air leak with spontaneous breathing.

If the patient continued to have an air leak, one of the following modalities were used:

1- The patient was discharged with the chest tube attached to a Pneumostat Chest Drain Valve (Atrium Medical Corp, Hudson, NH) and re-evaluated 5 to 7 days later.

2- Blood patch:

50 to 100mL of peripheral venous blood is withdrawn from the patient and injected under a sterile technique through the chest tube into the pleural cavity. The chest tube is then flushed with 10mL of normal saline and either clamped or hooked over a drip stand so that air can escape, reducing the risk of tension physiology developing while allowing the blood to remain in the pleural space. Patient is advised to turn to either side, lie supine and set up after clamping.

3- Chemical pleurodesis:

Sclerosants are chemicals that cause an inflammatory response when administered into the pleural space through chest tube. They allow for sealing of the pleural space, cessation of an air leak, and prevention of recurrent pneumothorax. Common sclerosing agents include tetracycline, minocycline and silver nitrate. Chemical pleurodesis should be performed only if there is no or only a small residual pneumothorax when the chest tube is placed on water seal.

4- Bronchoscopy:

Bronchoscopy to be performed to check and assess the site of air leak. In addition, in some cases, silver nitrate can be injected at the bronchial segment that is the source of air leak.

5- VATS exploration:

Invasive interventions for the management of air leak are usually preserved for the following conditions:

- High grades of air leak.
- Air leak that leads to dyspnea.
- Air leak prevents patients from being weaned from mechanical ventilation.
- Persistent air leak.
- Nonresponsive air leak to conservative management even if it is minimal degrees.

- VATS exploration:

VATS may be used to assess the site of air leak and can define the cause of air leak. In addition, it can accomplish pleural symphysis with application of sclerosing agents under vision, pleural abrasion or pleurectomy. Early surgical reintervention also increases the chance of completing any procedure by VATS including over stapling of parenchymal lesions and application of sealants.

6- *Thoracotomy or Re-thoracotomy:*

In delayed surgical reinterventions and in complicated air leaks or apical spaces; thoracotomy together with muscle or omental flaps can be our good options to obliterate the pleural space and manage the air leak.

Statistical analysis:

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Shapiro-Wilks test and histograms were used to evaluate the normality of the data distribution. Quantitative parametric data were presented as mean and standard deviation (SD). Qualitative variables were presented as frequency and percentage (%).

Results

This study was conducted on 30 patients who underwent lung resection surgery for different pulmonary pathologies during the period from July 2023 to July 2024 in Alexandria University Hospitals.

The mean age for the study group was 29.4 years and all patients (100%) were males.

Smoking history was present in 26 patients (86.67%).

Regarding the preoperative diagnosis for the study group; 14 (46.67%) patients had recurrent spontaneous pneumothorax, 5 patients (16.67%) had bullous lung disease, bilateral spontaneous pneumothorax in 2 (6.67%) patients, lung nodule in 4 (13.33%) patients, lung mass in 2 (6.67%) patients, bronchiectasis in 1 (3.33%) patient, lung metastases in 1 (3.33%) patient and huge lung cyst in 1 (3.33%) patient.

Regarding the operative data for the study group, bullectomy was done in 20 (66.67%) patients, wedge resection in 5 (16.67%) patients, and lobectomy in 5 (16.67%) patients. (Fig. 1).

The surgery duration ranged from 40 to 150 min with a mean value of 78 minutes.

Regarding intra-operative surgical exploration findings, lung blebs were found in 19 (63.33%) patients, huge bulla was found in 3 (10%) patients, lung tumor was found in 1 (3.33%) patients, left upper lobe bronchiectasis was found in 1 (3.33%) patient, lung metastases was found in 1 (3.33%) patient, lung nodule was found in 4 (13.2%) patients and lung mass was found in 1 (3.33%) patient.

Intraoperative air leaks occurred in 10 (33.33%) patients.

Regarding intraoperative management, 5 (16.67%) needed glue, 3 (10%) patients needed sutures, 4 (13.33%) patients needed just application of hemostatic surgical and 18 patients (60%) did not require intraoperative intervention. (Fig. 2).

The postoperative leak ranged from 2 to 9 days with a mean value (± SD) of 6±1.46 days. Regarding the degree of air leak, 12 (40%) patients had

2nd degree, 12 (40%) patients had 3rd degree, and 6 (20%) patients had 4th degree. (Fig. 3).

Regarding post-operative management, 20 (66.67%) patients were managed conservatively, and 6 (20%) patients received a blood patch. Surgical exploration was done in 2 patients, and bronchoscopy was done in 2 patients.

The postoperative hospital stay ranged from 5 to 11 days with a mean of 8 days. 6 patients (20%) needed postoperative ICU.

The postoperative ICU stay ranged from 1 to 2 days with a mean of 1.2 days.

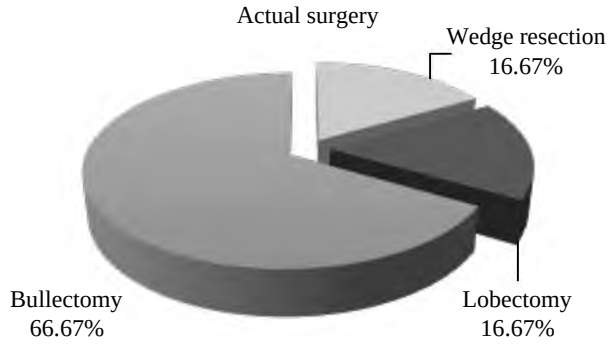

Fig. (1): Type of surgery of the studied patients.

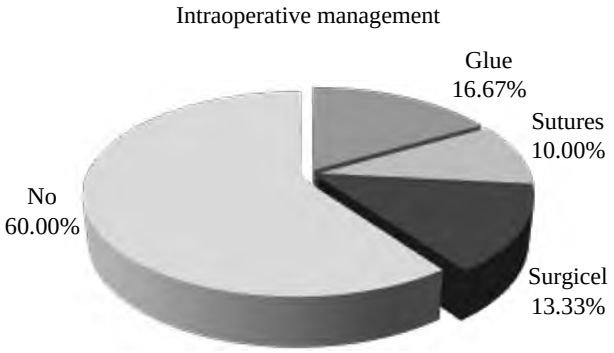

Fig. (2): Intraoperative management of the studied patients.

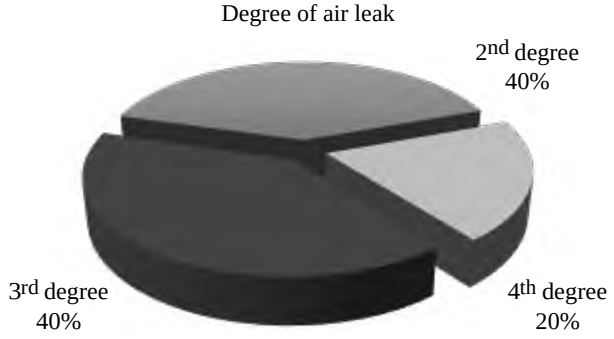

Fig. (3): Degree of air leak of the studied patient.

Discussion

Post operative air leak following lung resection surgery is a common, serious and annoying complication that usually faces most thoracic surgeons. It could occur after open surgery or even after VATS technique.

It could have a great impact on morbidity of the patient, length of hospital stay and affect the quality of life of the patients. Many articles in the literature have discussed the etiology of air leak, ways of its management and possible risk factors.

Our study aimed to evaluate the leading factors of air leak following pulmonary resection either anatomical or non-anatomical resections, for different reasons and to study the different ways in its management.

Our study was conducted on 30 patients who underwent lung resection surgery for different pulmonary pathologies during the period from July 2023 to July 2024 in Alexandria University ꝛospitals.

The mean age for the study group was 29.4 years and all patients (100%) were males.

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There was a big limitations in our study that definitely could affect the results including; small number of patients and surgeon preference that could affect the intraoperative decision to manage air leak as some surgeons prefer using sutures and other prefer using staplers making some sort of bias in the choice of the best intraoperative modality for all patients.

There are various modalities to control and manage postoperative air leak ranging from non surgical modalities like blood patch and bronchoscopic procedures to invasive surgical exploration or VATS.

Lois M et al. **[13]** have concluded in his study that therapeutic success has been variable, and the lack of consensus suggests that no optimal therapy is available; rather, the current therapeutic options seem to be complementary, and the treatment should be individualized for each patient **[13].**

Andreetti C **[14]** et al., have conducted a study to assess the efficacy of the use of the autologous platelet gel for the treatment of postoperative air leak **[14].**

On the other hand, Travaline JM **[15]** et al., have conducted another study to evaluate the role of endobronchial valves using flexible bronchoscopy in the management of post operative bronchopleural fistula and prolonged air leak. The results of this study showed that Nineteen patients (47.5%) had a complete resolution of the air leak, 18 (45%) had a reduction, 2 had no change, and 1 had no reported outcome after using endobronchial valves **[15].**

Rivera C **[16]** et al., have another good study that better characterize prolonged air leak, defined as an air leak longer than 7 days, and to develop and validate a predictive model of this complication after pulmonary resection. Their results showed that the prevalence of prolonged air leak after pulmonary resection was 6.9% (n=1,655) and in the final model, 9 variables were selected: gender, body mass index, dyspnea score, presence of pleural adhesions, lobectomy or segmentectomy, bilobectomy, bulla resection, pulmonary volume reduction, and location on upper lobe **[16].**

Prolonged air leak after pulmonary resection is a serious complication that need to be addressed in terms of preoperative evaluation of risk factors, intraoperative measures and postoperative modalities to control it.

We recommend that other studies are better conducted with bigger sample size to accurately define and delineate risk factors and best ways of management of prolonged postoperative air leak.

Conclusions:

Air leak after pulmonary resection is a common complication that have significant morbidity.

Smoking was prevalent in most of the patients who had postoperative air leak. Most of the air leak can be managed conservatively and only a few percentages of patients could need an intervention.

Blood patch and bronchoscopy with silver nitrate injection are good modalities for control of postoperative air leak.

Larger studies are still needed to deeply investigate the best ways for management of air leak.

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تقييم علاج التسريب الهوائى بعد عمليات الاستئصال الرئوى

يعتبر التسريب الهوائي من الرئة من اكثر المضاعفات شيوعاً فيما بعد حالات الاستئصال الرئوي سواء كان الاستئصال لعلاج حالات اورام الرئة السرطانية او علاج بعض امراض الرئة الاخرى الحميدة.

ويعد التسريب الهوائى الرئوى بعد جراحات الرئة من اهم اسباب زيادة مكوث المريض فى المستشفى كما ان له تاثير كبير على قدرة المريض التنفسية بعد العملية حيث يؤثر وجوده سلبا على وظيفة الرئة. كما انه يتسبب فى زيادة عدد ايام حاجة المريض لوجود انبوبة الصدر وزيادة فترة مكوثه بالعناية المركزة الجراحية بغد العملية.

هناك العديد من الوسائل التى تساعد على علاج التسريبب الهوائى مثل حقن كرات الدم الحمراء فى انبوبة الصدر وحقن نترات الفضة من خلال المنظار الشعبى اللين الا ان معظم الحالات تتحسن من تلقاء نفسها بدون اى تدخل.

وقد اظهرت دراستنا ان معظم حالات التسريب الهوائى كانت من المرضى المدخنين مما يجعل التدخين من اهم عوامل الخطورة لحدوث هذه المضاعفة. كما اظهرت دراستنا ان استخدام حقن كرات الدم الحمراء والمنظار الشعبى اللين من افضل الوسائل لعلاج مثل هذه الحالات.

ومن اهم النتائج التى اظهرتها دراستنا ان معظم حالات التسريب الهوائي بعد جراحات الاستئصال الرئوى يتم تحسنها تلقائيا بدون تدخل جراحى.