



Original Article

Incidence of Air Leak in Stapled Versus Hand Sewn Pulmonary Resections

Shagufta Nasreen¹, Tanveer Ahmad¹, Khalil Ahmed Shaik¹, Nazish Sikander¹, Nadir Ali Wassan¹, Pratikshya Thapaliya¹, Anum Asif¹

¹Thoracic Surgery Department, Jinnah Postgraduate Medical Centre, Karachi, Pakistan

ARTICLE INFO

Key Words:

Pulmonary resection, Surgical intervention, Stapled pulmonary resection

How to Cite:

Nasreen, S. ., Ahmad, T. ., Ahmed Shaik, K. ., Sikander, N. ., Ali Wassan, N. ., Thapaliya, P. ., & Asif, A. . (2022). Incidence of Air Leak in Stapled Versus Hand Sewn Pulmonary Resections: Incidence of Air Leak in Stapled Versus Hand Sewn Pulmonary Resections. *Pakistan BioMedical Journal*, 5(7). <https://doi.org/10.54393/pbmj.v5i7.643>

*Corresponding Author:

Shagufta Nasreen
Thoracic Surgery Department, Jinnah Postgraduate Medical Centre, Karachi, Pakistan
drshaguftanasreen@hotmail.com

Received Date: 14th July, 2022

Acceptance Date: 22nd July, 2022

Published Date: 31st July, 2022

ABSTRACT

Postoperative air leak is a frequent complication after pulmonary resection. Different approaches have been used to control the incidence of air leaks after pulmonary resection. **Objectives:** To compare stapled pulmonary resection and hand-sewn, i.e. manual pulmonary resection for the incidence and duration of resolution of air leaks. **Methods:** This was a prospective comparative study, conducted from August 2019 to July 2020 in the Department of Thoracic Surgery Jinnah Postgraduate Medical Centre, Karachi. Patients indicated for pulmonary resection were randomized to either stapled pulmonary resection (Group A) or manually sutured (Group B) pulmonary resection and were followed till their discharge or resolution of air leak. **Results:** The total number of air leaks in group A was 9(30%), out of which 8 (26.6%) resolved conservatively and only one (3.3%) required re-exploration and surgical intervention. The total number of air leaks in group B was 7(25%), out of which 6(21.4%) resolved conservatively and only one (3.5%) required re-exploration and surgical intervention. The difference was not significant in the incidence of air leak of both groups. Persistent air leak (PAL) was present in 5 (16.6%) patients in group A and 3 (10.7%) patients in group B. **Conclusion:** Our study suggests that both stapled pulmonary resection and manually sutured pulmonary resection techniques are comparable in terms of incidence of air leak and its resolution. Hence, the choice of technique should be based on parameters, including the technical aspects and surgeon's preference.

INTRODUCTION

Postoperative air leak (AL) is a frequent complication after pulmonary resection (PR) [1-2]. It may further lead to other complications, such as prolonged chest tube drainage, empyema, pneumonia, atelectasis and increase duration of hospitalization [3-4]. Hence, while managing air leaks, it is important to rule out if leak originate from lung parenchyma (alveo-pleural) or from bronchial stump (broncho-pleural) [5]. Minor air leaks of parenchymal origin are observed in around 50% of the patients undergoing lung resections and they may resolve spontaneously, taking a few hours up to three days [1, 6]. AL that persists for more than 4 to 10 days after surgery is defined as persistent air leak (PAL). Conservative management of PAL

includes prolonged chest tube drainage, provocative chest tube clamping and permissive chest tube removal, chemical and autologous blood patch pleurodesis, outpatient management with Heimlich valve [6-7]. Female gender, smoking history, steroid use, low preoperative forced expiratory volume in 1 second (FEV1) and pleural adhesions are predictive risk factors for air leak after pulmonary resection [7]. Different approaches have been used to reduce the incidence of ALs after lung resection [8]. PR via manual technique or with the help of stapling devices have been used for decades in various pathologies of lung. Both techniques are reliable and safe, with notable short- and long-term results. Despite routine use of

sutures and stapling devices, AL remain a significant problem in the daily practice of thoracic surgery, occurring in 75% of patients during PR [9]. Locally, very little data is available related to the safety of manual suturing and stapling devices in reducing AL. In this study, we compared the two techniques of pulmonary resection in terms of their safety for reducing air leaks

METHODS

This was a prospective comparative study, conducted in the Department of Thoracic Surgery, Jinnah Postgraduate Medical Centre (JPMC), Karachi, from August 2019 to July 2020. Informed consent was obtained from patients and the study was approved by the Institutional Review Board (IRB no.:F.2-81/2019-GENL/30036/JPMC, dated July 27, 2019). 58 patients were enrolled who needed pulmonary resection during the study period. Patients were randomized into two groups via online randomization software, Research randomizer (<https://www.randomizer.org/>), i.e. 30 and 28 patients in group A and group B, respectively. Group A patients were scheduled for staple PR while Group B patients were scheduled for manual PR. All patients had preoperative pulmonary function tests. Preoperative exclusion criteria were ipsilateral thoracotomy, chronic obstructive pulmonary disease (COPD), bullous lung disease, chronic steroid therapy and uncontrolled diabetes. All patients had PR in double-lumen endotracheal tube in a standard thoracotomy position. The principal surgical stapler used was the COVIDIEN-GIA Auto Suture Stapler with DST series; 4.8 mm for the main bronchus and 3.8 mm for lobar bronchus and for wedge resection. In group B, the bronchial stump was manually closed in double layers in interrupted fashion with a non-absorbable (Silk 2/0) suture and wedge resection was performed in U-shaped manner with the help of cautery and then suturing lung parenchyma in double layers interrupted fashion with non-absorbable (silk 2/0) suture. AL were checked per-operatively with positive pressure of 30-35 cm of H₂O under warm saline. All chest tubes were kept on low suction of -15 to -20 cm H₂O pressure after surgery. ALs were classified as defined by Robert David Cerfolio Classification System for Air Leaks (RDC System). There are four types of AL classified as Continuous (C) AL present throughout respiratory cycle, Inspiratory (I) AL present only during inspiration, Expiratory (E) AL present only during expiration, Forced Expiratory (FE) AL present only with cough (Table 1).

S No.	Description
1	Continuous (C) air leak
2	Inspiratory (I) air leak
3	Expiratory (E) air leak
4	Forced Expiratory (FE) air leak

Table 1: RDC System of Air Leaks

Patients were followed till discharge or resolution of AL, whichever came first. Air leaks were diagnosed on the chest drain. AL that persisted for more than 4 days after surgery were defined as persistent air leak (PAL). Expiratory (E) and Forced Expiratory (FE) AL were first managed conservatively with oral and aerosol bronchodilators and incentive spirometry and observe for any clinical and radiological improvement or deterioration, if still leak persisted for more than 4 days after surgery then patient was labelled as PAL and shifted to Heimlich valve and observe for 12 hours for any deterioration; if stable then patient was discharged with Heimlich valve and managed on outpatient basis. Age, gender, presence and grade of air leak, indication and type of resection were noted in the preformed questionnaire. The Statistical Package for Social Sciences[®] software version 23.0 (SPSS; IBM Corp., Armonk, NY, USA) was used for data analysis. For numerical variables, data was expressed as mean \pm standard deviation. Frequencies and percentages were used for categorical variables. Differences were examined using the student's t-test for continuous variables and the chi-square test and ANOVA for categorical variables. A p-value of less than 0.05 meant that there is a significant difference between the two groups and the null hypothesis is not valid.

RESULTS

This study had 58 patients, out of which group A had 30 patients and group B had 28 patients. There were 21 males and 9 females in group A and 20 males and 8 females in group B. Cough was the most common presentation in both groups. A comparison of demographic and clinical manifestations in group A and group B is given in Table 2.

Characteristics	Group A (n=30)	Group B (n=28)
Age(years)	40 \pm 14	37 \pm 11
Male	21(70%)	20(71.4%)
Female	9(30%)	8(28.5%)
Cough	19(63%)	15(53.5%)
Dyspnea	11(36%)	10(35.7%)
Chest pain	9(30%)	9(32%)
Hemoptysis	9(30%)	7(25%)
Fever	6(20%)	8(28.5%)

Table 2: Comparison of demographics and clinical manifestations of group A and group B

The commonest indication for pulmonary resection was bronchiectasis in both groups i.e. Group A (n=9;30%) and group B (n=7;30.4%), followed by destroyed lung in group A (n=6;20%) and group B (n=6;21.4%) (Table 3).

Indication for pulmonary resection	Group A (n=30)	Group B (n=28)
Bronchiectasis	9(30%)	7(30.4%)
Destroyed lung	6(20%)	6(21.4%)
Pulmonary nodules	5(16.6%)	5(17.8%)
Metastasis	4(13.3%)	2(7.1%)
Chest wall mass	2(6.6%)	3(10.7%)

Indication for pulmonary resection	Group A (n=30)	Group B (n=28)
Aspergilloma	1(3.3%)	3(10.7%)
Lung laceration	1(3.3%)	1(3.5%)
Fibrocystic disease	1(3.3%)	0(0%)
Carcinoid tumor	0(0%)	1(3.5%)
Hydatid cyst	1(3.3%)	0(0%)

Table 3: Indication of pulmonary resection in both groups

In group A, nine (30%) patients had AL and twenty one patients did not. Out of nine, eight (26.6%) patients; (two lobectomies, three wedge resections, three segmentectomies) had expiratory (E) AL which resolved conservatively. One lobectomy patient developed inspiratory air leak on the 2nd postoperative day after episode of forceful cough which became continuous AL in few hours with dyspnea, chest pain and decreased oxygen saturation on room air. Patient was re-explored, revealing dehisced bronchial stump. The stump was re-sutured manually and covered with a pericardial fat pad. No air leak was observed on the next day and the patient was discharged after three days with a radiologically expanded lung. One patient underwent lobectomy had PAL till 5th postoperative day with apical pneumothorax, patient was discharged on Heimlich valve and followed on out-patient basis, resolved air leak on 14th day with radiologically expanded lung. Four patients (one lobectomy, three segmentectomies) also had PAL but without radiological evidence of pneumothorax, they were also managed on out-patient basis with Heimlich valve, and showed resolution of AL on 7th, 9th, 10th and 12th postoperative day respectively. In group B, seven (25%) patients had AL and twenty one did not. Out of seven, 6 (21.4%) patients; (two lobectomies, two wedge resections, two segmentectomies) had expiratory (E) AL which resolved conservatively. One patient with pneumonectomy developed continuous air leak on the 2nd postoperative day and was planned to re-explore in emergency. Finding was partially dehisced bronchial stump which was re-sutured manually and covered with a pericardial fat pad. No air leak was observed on the next day and the patient was discharged on 4th postoperative day. Two patients had PAL (one lobectomy, one segmentectomy) without pneumothorax and managed with Heimlich valve and resolution of air leak were observed on 8th and 12th postoperative day respectively (Table 4).

Procedure	Group A (n=30)	Group B (n=28)	p-value
Wedge resection	10 (33.3%)	10 (35.7%)	0.848
Lobectomy	10 (33.3%)	10 (35.7%)	0.848
Pneumonectomy	6 (20%)	6 (21.4%)	0.893
Segmentectomy	4 (13.3%)	2 (7.1%)	0.439

Table 4: Comparison of type of pulmonary resection in both groups

The total number of air leaks in group A was 9 (30%), out of

which 8 (26.6%) resolved conservatively and only one (3.3%) required re-exploration and surgical intervention. The total number of air leaks in group B was 7 (25%), out of which 6 (21.4%) resolved conservatively and only one (3.5%) required re-exploration and surgical intervention. However, the difference was not significant in the incidence of air leak of both groups. PAL was present in 5 (16.6%) patients in group A and 3 (10.7%) patients in group B (Table 5).

Outcome	Group A (n=30)	Group B (n=28)	p-value
Total air leak	9 (30%)	7 (25%)	0.67
Air leak resolved spontaneously	8 (26.6%)	6 (21.4%)	0.641
Air leak required intervention	1 (3.3%)	1 (3.5%)	0.96

Table 5: Comparison of outcome and grade of air leaks in both groups

DISCUSSION

In concordance with the results of our study, literature provides evidence that patients who underwent anatomical lung resections reported an air leak in 26-58% [10-11]. This is comparable with our results, being 30% in group A and 25% in group B. Moreover, keeping in mind the extent of lung resection, lobectomies and bilobectomies are also known to impose an increased risk of prolonged air leak [12]. Pneumonectomy or lobectomy may lead to a fatal and morbid complication, i.e. BPF in 1-4% of patients. Management includes placement of large-bore chest drains, and surgical repair in refractory cases. However, researchers believe that the operative technique used for the closure of bronchi holds supreme importance [13]. This is because several techniques have been observed to reduce the incidence of BPF. One of the methods includes using monofilament non-absorbable sutures, including staples [14]. No particular technique has been declared to be superior in terms of efficacy, but the use of non-reactive and non-absorptive suture material has been reported to considerably lessen the chances of inflammation at the closure line [15]. Due to this, the use of prolene for hand suturing and stainless steel and titanium staples are being adopted [16]. Moreover, comparison between manual vs stapled bronchial suturing is an ongoing debate to date. Some studies favor manual suturing as it is a reliable, safe, and cheap technique with beneficial outcomes in all types of situations, being performed by an experienced surgeon; whereas, others suggest mechanical suturing as it is also found to be reliable, safe, and easy to apply [17]. The added benefit of stapling devices is their use by junior surgeons, showing commendable results in the short- and long term. Furthermore, staplers are also believed to play a major role in consuming less time during the operation, secure bronchial sealing, and lesser morbidity and mortality rates [18]. Weissberg et al., found that the time taken with stapling was lesser than suture closure of bronchial stump

(90 seconds versus 5-15 minutes), and no incidence of BPF was reported after stapling as compared to 4.5% cases of BPF after manual closure [19]. In contrast, Al-Kattan et al., reported a 1.3% incidence of BPF after 530 consecutive pneumonectomies using a uniform hand-suturing technique, and concluded that bronchial manual suturing is a cheap and reliable technique with good results in the hands of experienced surgeons [20]. Many theories state that thickened bronchi usually seen in chronic bronchitis and proximal tumors could be labeled as contraindications for staple closures [21]. It is also believed that initial mechanical integrity is significant in maintaining a balance between an airtight and watertight barrier between the area resected and the remaining lung to eliminate the chances of aspiration and mediastinal shifts due to resection [22]. PAL is frequently occurring complication after PR which also increases the chances of prolong hospital stay and morbidity. Management of PAL depends on clinical and radiological stability of patient. If patient is stable clinically and radiologically, can be managed successfully with bronchodilators and breathing exercises under observation [23-24]. If PAL still persists after conservative management, then patient can be shifted to ambulatory device i.e. Heimlich valve, one way valve that allow air to escape from chest and prevent it from entering into chest. If patient tolerates Heimlich valve without clinical or radiological deterioration, then patient can be discharged home safely with follow up on outpatient basis to avoid prolong hospital stay. Heimlich valve has shown successful results in managing PAL. If PAL still persists despite managing on bronchodilators, breathing exercises and one way valve, other options like chemical pleurodesis, autologous blood patch pleurodesis and endobronchial valve (EBV) should be sought as all of these have reported successful results in treating PAL. [7, 25]. The results of our study point towards the fact that the treatment modality does not cause any significant difference in postoperative outcomes and air leak. The total air leak was reported in both the groups; in most cases, resolved spontaneously, and very few required intervention. However, future studies including a larger sample size should be carried out to confirm the findings.

CONCLUSION

Following pulmonary resection, AL is a very frequent pulmonary complication. However, the methods adopted for resolving air leak i.e. manual suturing and staples, do not show any significant differences. Therefore, surgeons should make sure to keep other parameters in mind, depending on the condition of the patient, making sure to achieve maximum stump integrity.

REFERENCES

- [1] Mueller MR and Marzluf BA. The anticipation and management of air leaks and residual spaces post lung resection. *Journal of Thoracic Disease*. 2014 Mar; 6(3):271-84. doi: 10.3978/j.issn.2072-1439.2013.11.29.
- [2] Baseer A, Bilal A, Imran M. 12 Years Experience of Surgical Management of Pulmonary Aspergilloma. *Pakistan Journal of Chest Medicine*. 2014; 20(4).
- [3] Varela G, Jiménez MF, Novoa N, Aranda JL. Estimating hospital costs attributable to prolonged air leak in pulmonary lobectomy. *European Journal of Cardio-Thoracic Surgery*. 2005 Feb; 27(2):329-33. doi: 10.1016/j.ejcts.2004.11.005
- [4] Zhou J, Lyu M, Pang L, Gao Y, Ning K, Wang Z, et al. Efficiency and safety of TachoSil® in the treatment of postoperative air leakage following pulmonary surgery: a meta-analysis of randomized controlled trials. *Japanese Journal of Clinical Oncology*. 2019 Sep; 49(9):862-869. doi: 10.1093/jjco/hyz076
- [5] Deslauriers J, Meyerson SL, Patterson A, Cooper JD. *Pearson's Thoracic and Esophageal Surgery 3rd edition*. 2008.
- [6] Liberman M, Muzikansky A, Wright CD, Wain JC, Donahue DM, Allan JS, et al. Incidence and risk factors of persistent air leak after major pulmonary resection and use of chemical pleurodesis. *The Annals of Thoracic Surgery*. 2010 Mar; 89(3):891-7; discussion 897-8. doi: 10.1016/j.athoracsur.2009.12.012
- [7] Yoo A, Ghosh SK, Danker W, Kassis E, Kalsekar I. Burden of air leak complications in thoracic surgery estimated using a national hospital billing database. *ClinicoEconomics and Outcomes Research*. 2017 Jun; 9:373-383. doi: 10.2147/CEOR.S133830
- [8] Dugan KC, Laxmanan B, Murgu S, Hogarth DK. Management of Persistent Air Leaks. *Chest*. 2017 Aug; 152(2):417-423. doi: 10.1016/j.chest.2017.02.020
- [9] Fuller C. Reduction of intraoperative air leaks with Progel in pulmonary resection: a comprehensive review. *Journal of Cardiothoracic Surgery*. 2013 Apr; 8:90. doi: 10.1186/1749-8090-8-90
- [10] Okereke I, Murthy SC, Alster JM, Blackstone EH, Rice TW. Characterization and importance of air leak after lobectomy. *The Annals of Thoracic Surgery*. 2005 Apr; 79(4):1167-73. doi: 10.1016/j.athoracsur.2004.08.069
- [11] Cerfolio RJ, Bass C, Katholi CR. Prospective randomized trial compares suction versus water seal for air leaks. *The Annals of Thoracic Surgery*. 2001 May; 71(5):1613-7. doi: 10.1016/s0003-4975(01)02474-2
- [12] Rivera C, Bernard A, Falcoz PE, Thomas P, Schmidt A,

- Bénard S, et al. Characterization and prediction of prolonged air leak after pulmonary resection: a nationwide study setting up the index of prolonged air leak. *The Annals of Thoracic Surgery*. 2011 Sep; 92(3):1062-8; discussion 1068. doi: 10.1016/j.athoracsur.2011.04.033
- [13] Uçvet A, Gursoy S, Sirzai S, Erbaycu AE, Ozturk AA, Ceylan KC, et al. Bronchial closure methods and risks for bronchopleural fistula in pulmonary resections: how a surgeon may choose the optimum method? *Interactive Cardiovascular and Thoracic Surgery*. 2011 Apr; 12(4):558-62. doi: 10.1510/icvts.2010.251157
- [14] Sawasaki H, Horie K, Yamada M, Tajima G, Naito Y, Watabe S, et al. Postoperative bronchopleural fistula: clinical and experimental study. *Chest*. 1975 Jun; 67(6):702-5. doi: 10.1378/chest.67.6.702
- [15] Yamakawa S and Hayashida K. Advances in surgical applications of growth factors for wound healing. *Burns Trauma*. 2019 Apr; 7:10. doi: 10.1186/s41038-019-0148-1
- [16] El-Gamel A, Tsang GM, Watson DC. The threshold for air leak: stapled versus sutured human bronchi, and experimental study. *European Journal of Cardio-Thoracic Surgery*. 1999 Jan; 15(1):7-10. doi: 10.1016/s1010-7940(98)00285-1
- [17] Barbari SG, Fossdal JE, Kordt KF, Haug M. Bronchopleural fistula after using a suture stapler. *Tidsskr Nor Laegeforen*. 1987 Mar 30; 107(9):841-2, 873
- [18] Potaris K, Kapetanakis E, Papamichail K, Midvighi E, Verveniotis A, Parissis F, et al. Major Lung Resections Using Manual Suturing Versus Staplers During Fiscal Crisis. *International Journal of Surgery*. 2015 Jul. doi: 10.9738/INTSURG-D-15-00116.1
- [19] Weissberg D and Kaufman M. Suture closure versus stapling of bronchial stump in 304 lung cancer operations. *Scandinavian Journal of Thoracic and Cardiovascular Surgery*. 1992; 26(2):125-7. doi: 10.3109/14017439209099066
- [20] Al-Kattan K, Cattalani L, Goldstraw P. Bronchopleural fistula after pneumonectomy with a hand suture technique. *The Annals of Thoracic Surgery*. 1994 Nov; 58(5):1433-6. doi: 10.1016/0003-4975(94)91929-1
- [21] Vester SR, Faber LP, Kittle CF, Warren WH, Jensik RJ. Bronchopleural fistula after stapled closure of bronchus. *The Annals of Thoracic Surgery*. 1991 Dec; 52(6):1253-7. doi: 10.1016/0003-4975(91)90009-f
- [22] Sato M, Saito Y, Nagamoto N, Endo C, Usuda K, Takahashi S, et al. An improved method of bronchial stump closure for prevention of bronchopleural fistula in pulmonary resection. *The Tohoku Journal of Experimental Medicine*. 1992 Nov; 168(3):507-13. doi: 10.1620/tjem.168.507
- [23] Graeber GM, Collins JJ Jr, DeShong JL, Murray GF. Are sutures better than staples for closing bronchi and pulmonary vessels?. *The Annals of Thoracic Surgery*. 1991 Jun; 51(6):901-4. doi: 10.1016/0003-4975(91)91001-c
- [24] Asamura H, Kondo H, Tsuchiya R. Management of the bronchial stump in pulmonary resections: a review of 533 consecutive recent bronchial closures. *European Journal of Cardio-Thoracic Surgery*. 2000 Feb; 17(2):106-10. doi: 10.1016/s1010-7940(00)00318-3
- [25] Chopra A, Doelken P, Judson MA, Huggins T. The pressure-dependent air leak after partial lung resection. *Thorax*. 2017 Mar; 72(3):290-291. doi: 10.1136/thoraxjnl-2016-208884