Re-expansion Pulmonary Edema after Chest Drainage for Pneumothorax; Evaluation of Risk Factors in 630 Episodes

Motoki SAKURABA*, Taijiro MISHINA, Akihiko TANAKA

Sapporo City General Hospital, Department of General Thoracic Surgery, Hokkaido 060-8604, Japan

*Corresponding Author: *Motoki SAKURABA, Sapporo City General Hospital, Department of General Thoracic Surgery 1-1, West13 North11, Chuou-ku, Sapporo city, Hokkaido 060-8604, Japan.*

Abstract

Background: *Re-expansion pulmonary edema (RPE) is a rare complication after chest drainage of spontaneous pneumothoraxs. We report RPE cases in our hospital over 5 years.*

Methods: *Clinical records of patients treated for spontaneous pneumothorax from April 2012 to March 2019 at our institute were retrospectively reviewed. Chest tube placement was performed 630 times. RPE is diagnosed by chest x-ray or chest computed tomography within 24 to 48 hours after drainage. Patients were categorized into RPE and non-RPE groups.*

Results: *Forty five (7.1%) of 630 treated cases were diagnosed with RPE (15 [2.4%] symptomatic RPE, 30 [4.8%] asymptomatic). Forty cases of 45 were 3rd degrees in lung collapse classification and 11 cases showed total lung collapse. Oxygen was administered in 15 cases. Thirteen cases presented with dyspnea after intense cough. Periods from onset to drainage, cough and aterectasis or lung collapse classification are significantly difference between RPE and non-RPE groups on univariate analysis and multivariate analysis*

Conclusions: *Large pneumothorax or total lung collapse of greater than 4 days of duration is associated with RPE development in the presence of intense cough. Management of cough after pneumothorax treatment may be a potential therapy to prevent RPE.*

Abbreviations: *RPE, Re-expansion pulmonary edema*

Keywords: *Re-expansion pulmonary edema, Primary spontaneous pneumothorax, Chest tube drainage*

1. INTRODUCTION

Re-expansion pulmonary edema (RPE) is a complication of tube thoracostomy for pneumothorax and massive pleural effusion, and was initially reported after spontaneous pneumothorax by Carlson in 1958 [1]. The incidence of RPE for spontaneous pneumothorax treatments ranges from 0.9% to 29.8% [2, 3]. Although most patients with RPE recover without any treatment, it can lead to prolonged hospital stay, increased chest discomfort, dyspnea, and in severe cases hemodynamic and respiratory instability, making early recognition and understanding of associated risk factors of utmost importance. We aim to describe the incidence, risk factors, and outcomes for RPE cases at our institution.

2. PATIENTS AND METHODS

We analyzed medical records of all patients treated for spontaneous pneumothorax between April 2012 and March 2019 at Sapporo City General Hospital Pneumothorax Center. Chest tube drainage was performed 630 times. Cases complicated by 13 hemopneumothorax, 32 traumatic pneumothorax and 8 iatrogenic pneumothorax were excluded. RPE was diagnosed by chest x-ray or chest computed tomography within 24 to 48 hours of drainage. We used modified lung collapse classification in Japan society of pneumothorax and cystic disease on chest x-ray. First degree shows that top of lung locates the clavicle or head side. Second degree shows that the top of lung locates below clavicle or the width of the lungs is located two-thirds of whole or more. Third degree shows that the width of the lungs is located two-thirds of whole or less. According to our experience, for the patient suffering from a pneumothorax sized more than 40% (Third degree of collapse classification) during more than 24 hours steroid were administered

intravenously before chest drainage in advance and continuous suction were not performed. Under such condition patients were categorized into groups with RPE and non-RPE. Age, gender, time from pneumothorax onset to drainage, smoking habits, lung collapse classification, presence of atelectasis (one lobe or more), cough after treatment, steroid administration before drainage, drain tube size, and continuous suction were compared between the 2 groups. 20Fr trocar catheter or 12 Fr aspiration kit were used for chest drainage.

Analysis

All analysis were performed using IBM SPSS Statistics for Windows, Version 22.0（IBM Corp., Armonk, NY, USA). Continuous variables were analyzed using Mann-Whitney U test. Categorized variables were analyzed using $\chi 2$ test or Fisher's exact probability test as appropriate. Statistical significance was set at $p<0.05$. To determine risk factors for RPE, variables with $p<0.05$ in univariate analysis were used in multiple logistic regression.

3. RESULTS

The characteristics of all patients show Table.1. The mean age of the patients was 39.9 (range 12 to 98) years. The mean duration from onset of pneumothorax to duration was 3.6 (range 1 to 30) days. Steroid were administered intravenously before chest drainage for 169 (26.8%) episodes. Forty-five (7.1%) of the 630 cases were diagnosed as RPE. Fifteen (2.4%) cases were defined as symptomatic RPE, and 28 (4.8%) cases were asymptomatic. Treatment ranged 1 to 13 days (average: 4.4 days) from onset of pneumothorax in the RPE group. Forty cases of 45 were 3rd degrees in lung collapse classification and 11 cases showed total lung collapse. In all cases, 100mg of hydrocortisone sodium succinate was intravenously administered before drainage. Time from pneumothorax onset to drainage, lung collapse classification, and cough, were significantly difference between 2 groups $(p<0.05)$ in univariate analysis and multivariate analysis (Table.2).

Treatment of symptomatic RPE and outcomes are shown in Table 3. All symptomatic patients required additional oxygen administration for an average of 1 day after RPE development. All patients were alive without any complications during until a discharge.

Table1. *Patient characteristics*

Cases		630
Age		12-98(39.9)
Gender	Male/Female	549/81
Time from pneumothorax onset to drainage (day)	(mean)	1-30(3.6)
Smoking	Yes/No/Unknown	341/285/4
Lung collapse classification	I,II/III	384/246
Aterectasis	Yes/No	107/523
Cough	Yes/No	52/578
Steroid administration before drainage	Yes/No	169/461
Drain Tube	20Fr/12Fr	570/60
Continuous Suction	Yes/No	579/51

Table2. *Risk factors of RPE in univariate analysis and multivariate analysis*

		REPE	non-REPE	univariate analysis	multivariate analysis		
		n=45	n=585	p	p	OR	95%CI
Age		13-93(42.0)	12-98 (37.8)	0.068			
Gender	Male/Female	37/8	512/73	0.3375			
Time from pneumothorax onset to drainage (day)	(mean)	1-13(4.4)	1-30(2.8)	<0.001	0.002	1.117	1.043-1.196
Smoking	Yes/No	29/16	312/269	0.2207			
Lung collapse classification	I,II/III	5/40	379/206	<0.001	<0.001	10.122	3.623-28.282
Aterectasis	Yes/No	40/5	67/518	<0.001	＜0.001	3.01	1.977-4.582
Cough	Yes/No	18/27	34/551	<0.001	<0.001	27.914	10.315-75.538
Drain Tube	20Fr/12Fr	41/4	529/56	0.7744			

Table3. *Symptom, treatment and outcome of symptomatic RPE*

		n=15
Steroid administration before drainage	Yes/No	15/0
Continuous Suction	Yes/No	1/14
Cough	Yes/No	15/0
Oxygen device	Nasal highflow	1
	Non-rebreather mask	5
	Nasa canula	9
Time to recover	(hours)	0.5-44
	average	23.4
Mortality		0

4. DISCUSSION

The incidence of RPE for spontaneous pneumothorax treatment ranges from 0.9% to 29.8% [2, 3]. However, a recent report in Japan indicated an incidence of 14.6-15.6% [4, 5]. Kim et al report that actual RPE develops in 29.8% of patients and symptomatic RPE incidence is 19% [3]. In our study, the incidence of RPE was 7%, and symptomatic RPE was 2.4%, which is smaller than prior reports, and may be related to our drainage management. First, 100mg of hydrocortisone sodium succinate was administered intravenously for pneumothorax patients with large lung collapse before chest drainage. Second, after insertion of chest tube, patients were not treated with continuous suction but rather underwent water seal for 24 hours. In addition, patients were restricted from activity for one day.

In cases with large lung collapse for 3 days or more, it was previously reported that RPE occurred within 24 hours due to rapid lung expansion, and the mortality rate is 22% [6]. However, mortality rates are decreasing due to advances in early diagnosis and treatment. In our study, patients with symptomatic RPE required oxygen, but all recovered without further complications. Currently, we does not experience the case of ventilator management, and it has become possible to teat by administrating high-flow oxygen. In our study, of the 15 cases that required oxygen supplementation, there were 9/15 cases of nasal canula use, 5/15 cases of non-rebreather mask use, and 1/15 cases of nasal high-flow use.

Previously reported risk factors of RPE include young age [4], large pneumothorax [4,7], pneumothorax for 3 days or more [8], rapidly pulmonary expansion [7,9,10] and continuous suction [6]. In our study, risk factor for development of RPE included pneumothorax for 4 days or more prior to treatment and with large pneumothorax, especially aterectasis involving more than one lobe. We also found that incidence of cough increased after chest drainage, likely due to the underlying rapidly pulmonary expansion. The expanding lung by cough induced sever cough, in result rapidly pulmonary expansion induced RPE. It is also thought that continuous suction may be an initial cause leading to rapidly pulmonary expansion, and its avoidance may lead to better outcomes after pneumothorax treatment. Morioka et al previously reported that cough was the most frequent symptom in RPE patients, and cough preceded severe RPE, as well [5].

Steroids were administered with the aim of decreasing pulmonary vascular permeability as part of the treatment of RPE. However, the effectiveness of intravenous steroid use is unclear. Steroids are reported to contribute to the suppression of humoral factors leading to vascular endothelial damage, as well as the suppression of irreversible fibrosis due to diffuse alveolar damage [11]. It may be related to the steroid administration to have lowered the frequency of the RPE onset in our center. However, their usefulness was not proved in our study.

There were several limitations in our study. First, the study was retrospective and single centered, whereas a prospective study in multi-centered study would allow for more generalizable data and analysis. Second, the diagnostic methods of RPE were not uniform. Almost patients with initial pneumothorax underwent chest computed tomography the next day after chest drainage, but patients with two or more pneumothorax often underwent chest x-ray. In these patient, RPE might be overlooked. Finally, the retrospective nature of the study limits the information available as some medical records may be lacking in details regarding inpatient symptoms, management, or outcomes.

5. CONCLUSIONS

Large pneumothorax or lung collapse of greater than 4 days of duration is associated with RPE

development in the presence of intense cough. Management of cough just after the thoracic drainage to become the cause of pulmonary rapidly expansion after pneumothorax treatment may be a potential therapy to prevent RPE.

CONFLICT OF INTEREST

The authors declare no conflicts of interest

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There is no source of funding to report for this study.

ETHICS APPROVAL

This retrospective study was approved by the ethics committee of our institution (IRB No. R01-059-609).

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