Original Article

Thoracic ultrasound versus artificial pneumothorax in complications of medical thoracoscopy—a propensity score matching analysis

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Background: Evaluation and location of the approaches is the key step of medical thoracoscopy. The previous standard for the step in many countries is artificial pneumothorax (AP). Recently, thoracic ultrasound (TU) has been considered as one of the choices for the development of technology. While there was a lack of data in investigating the complications of medical thoracoscopy locating approach with AP comparing TU.

Methods: A total of 108 patients who underwent medical thoracoscopy were retrospectively observed in Peking University First Hospital from January 2011 to April 2017, including 92 patients of the AP group and 16 patients of the TU group. Propensity score matching (PSM) was used to balance the covariance between the two groups. And the complications of the procedures between the groups were compared.

Results: Before PSM, there was one unbalanced covariates in the two groups. The overall complication rate was 7.6% (7/92) in the AP group, comparing 6.2% (1/16) in the TU group. There was no significant difference between the two groups (P=0.848). After balancing the covariate with 2:1 matched, the overall complication rate was 9.4% (3/32) in the AP group, comparing 6.2% (1/16) in the TU group. There was still no significant difference between the two groups (P=0.712).

Conclusions: TU is a locating approach method which does not increase the complication rate comparing with AP. And it could be a good choice in medical thoracoscopy.

Keywords: Medical thoracoscopy; thoracic ultrasound (TU); artificial pneumothorax (AP); complications

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Introduction

Medical thoracoscopy which is defined as the thoracoscopy with intravenous sedation combining local anesthesia, is now widely used in clinical medicine. One of the most important contraindication of medical thoracoscopy is extensive pleural adhesion (1). Therefore, evaluation and location of the approaches is the key step. And the previous standard for the step in many countries is artificial pneumothorax (AP) (2-4), which is complained with the risks of radiation exposure, air embolism and so on (5). Recently, thoracic ultrasound (TU) has been considered as one of the choices to evaluate pleural adhesions and locate approaches for the development of technology (6). The aim of this study was to investigate the complications of medical thoracoscopy locating approach with AP comparing TU.

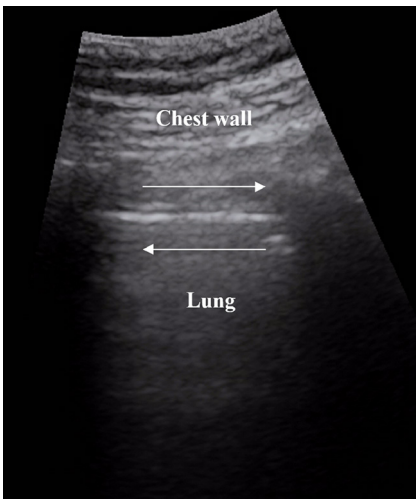

Figure 1 Sliding sign is the movement (arrows) that the visceral pleura moves over the parietal pleura (convex probe, 3.5 MHz).

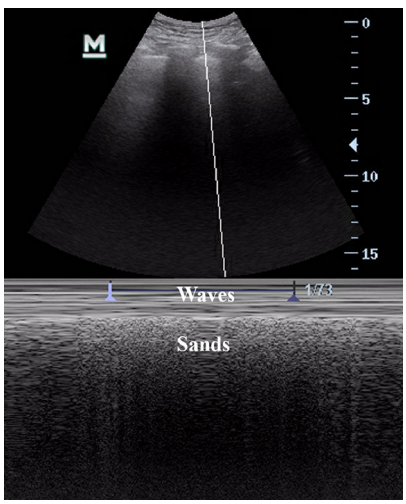

Figure 2 Seashore sign is the pattern that defines normal lung. There are motionless superficial layers that generate horizontal lines which looks like waves. The deep artifacts follow the lung sliding, hence the sandy pattern (convex probe, 3.5 MHz).

Methods

Patients and investigations

A total of 108 patients who underwent medical thoracoscopy in Peking University First Hospital were all retrospectively observed from January 2011 to April 2017, including 92 patients of the AP group and 16 patients of the TU group. The indications of the operations were diagnostic intent, which have conformed to the guideline of British Thoracic Society published in 2010 (2). All the subjects were hospitalized in our department, and had been taken medical histories, routine blood tests, chest computed tomography (CT) scans, etc. The patients were closely monitored during and after the operations, and the complications were recorded as follows: prolonged air leak, hemorrhage requiring treatment, operative incision disunion, mediastinal/subcutaneous emphysema requiring treatment, empyema, respiratory infection, respiratory failure, lung laceration, incision metastasis, local neurovascular injury, acute cerebrovascular event, acute cardiovascular event and death within 28 days after the operations. All patients had signed the informed consent before the operations.

AP

In the AP group, the pleural effusion was removed as much as possible before injecting room air or carbon dioxide. Then a chest X-ray was performed immediately to evaluate the pleura adhesion and determine the location of approach. When the chest X-ray didn't show the extrapulmonary air located inside the pleural cavity, the making pneumothorax step should be repeated (2,7).

TU

In the TU group, we used an ultrasound machine (U.S. General Electric Company, Venue 50) with convex (3.5 MHz) and linear (7.5 MHz) probes (8). The thoracic ultrasonography was performed two times in each patient by the same operator. The first time on the day before medical thoracoscopy in the bed-ward was to evaluated systematically with ultrasound the dorsal, lateral, and anterior chest wall. The operator detected pleural adhesion, measured the depth of pleural effusion, looked for "sliding sign" (*Figure 1*) and "seashore sign" (*Figure 2*) by convex probes, measured the thickness of chest wall and the distribution of blood vessels by linear probe. The initial selected points of approach should be got. When the patient was resting on the healthy side position and fixed by decubitus fixation instrument in the operating room, the position might have a little different from that in the bed-ward. As a result, the second TU was performed to detect the initial selected points to identified the finial ideal approach.

Table 1 Differences between the two groups for clinical characteristics, before PSM

Parameter	AP group (n=92)	TU group (n=16)	t/χ^2 value	P value
Age, years (mean ± SD)	66±12	61±12	t=−1.349	0.032*
Gender, n (%)				
Male	61 (66.3)	10 (62.5)		
Female	31 (33.7)	6 (37.5)	χ^2=0.088	0.767
Smoking status, n (%)				
No smoking	38(41.3)	8 (50.0)		
Former smokers	22 (23.9)	4 (25.0)		
Current smokers	32 (34.8)	4 (25.0)	χ^2=0.640	0.726
Diagnostic outcome, n (%)				
Malignant	53 (57.6)	7 (43.8)		
Benign	39 (42.4)	9 (56.2)	χ^2=1.060	0.303

*, P value <0.05. AP, artificial pneumothorax; TU, thoracic ultrasound.

Medical thoracoscopic technique

All subjects had received medical thoracoscopy as follows. Local anesthesia was induced by injection 2% lidocaine with or without midazolam administered through intravenous line. After premedication, we made a small skin incision to gently introduced curved blunt-point scissors following a medical thoracoscopic trocar into the chest wall as far as the pleural space. Then room air was allowed spontaneously to enter the pleural space with consequent lung collapse. We used a rigid thoracoscope (Germany, Karl Storz GmbH & Co) or semi-rigid thoracoscope (Japan, Olympus Corporation) to take the residual effusion until the pleural cavity was emptied. The lung and pleura were observed, and biopsies were taken in each subject. Other procedures might be performed depends on different cases, while talc poudrage were performed in no one.

Statistical analysis

All statistical analyses were processed by the SPSS for windows, version 22.0 (SPSS Inc., Chicago, IL, USA) software. The continuous variables were described as mean and standard deviations (SD), and compared using the independent sample *t*-test. The discrete variables were described as frequencies and proportion, and compared using the Pearson χ^2-test or Fisher's exact test. Propensity score matching (PSM) was used to balance the covariance with 2:1 matched between the two groups. A P-value of less than 0.05 was deemed significant.

Results

A total of 108 subjects were recruited with mean age of 65 (SD ±9; range, 37–84) years, and 71 (65.7%) subjects were males. As regards smoking, 36 (33.3%) cases were current smokers, 26 (24.1%) cases were former smokers, and 46 (42.6%) cases had no history of smoking. Malignant pleural disease was diagnosed in 60 (55.6%) cases, and benign pleural disease was diagnosed in 48 (44.4%) cases. Ninety-two subjects were in the AP group, 16 subjects were in the TU group, and there was significant difference in ages between the two groups (P=0.032). The details are shown in *Table 1*.

The total rate of complications was 7.4% (n=8), with one case in the TU group, and seven cases in the AP group. No death within 28 days was related to the procedure. In two cases, there were two or more complications being observed. They were respiratory infection and acute cerebrovascular event suspected air embolism in one case, and respiratory infection complicated with respiratory failure in the other. There was no significant difference in the rate of complications between the two groups (P=0.848). The details are shown in *Table 2*.

PSM was used to balance the covariance between the two groups. With 2:1 matched, the overall complication rate was 9.4% (3/32) in the AP group, comparing 6.2% (1/16) in the TU group. There was still no significant difference between

Table 2 Differences between the two groups for complications

Complications, n (%)	AP group (n=92, %)	TU group (n=16, %)	χ^2 value	P value
Prolonged air leak	0 (0.0)	0 (0.0)		
Hemorrhage requiring treatment	0 (0.0)	1 (6.2)		
Operative incision disunion	1 (1.1)	0 (0.0)		
Mediastinal/subcutaneous emphysema requiring treatment	0 (0.0)	0 (0.0)		
Empyema	1 (1.1)	0 (0.0)		
Respiratory infection	2 (2.2)	0 (0.0)		
Respiratory failure	4 (4.3)	0 (0.0)		
Lung laceration	0 (0.0)	0 (0.0)		
Incision metastasis	0 (0.0)	0 (0.0)		
Local neurovascular injury	0 (0.0)	0 (0.0)		
Acute cerebrovascular event	1 (1.1)	0 (0.0)		
Acute cardiovascular event	0 (0.0)	0 (0.0)		
Death within 28 days	0 (0.0)	0 (0.0)		
Total	7 (7.6)	1 (6.2)	0.037	0.848

AP, artificial pneumothorax; TU, thoracic ultrasound.

the two groups (P=0.712). The details are shown in *Table 3*.

Acute cerebrovascular event suspected air embolism was observed in one case of the AP group. The patient had suffered from suddenly disorders on movement and speech. The cerebrovascular computed tomography angiography (CTA) scan showed newly onset multiple cerebral infarction and filling defect in the vessels with the CT value similar with air's. Fortunately, the patient had been fully recovered within 2 weeks. Furthermore, there were three cases had to repeat the making pneumothorax step, because the chest X-ray didn't show the extrapulmonary air located inside the pleural cavity. The reason was considered as the rapid absorption of carbon dioxide for making the AP.

Discussion

Previously reported in the literatures, the complication rate of medical thoracoscopy was 6.3–16.5%, and the mortality was 0.00–0.54% (2,9,10). The complications related to the approach procedure are including lung laceration, hemorrhage, local neurovascular injury, subcutaneous emphysema, and so on (11). Being one of the key steps in medical thoracoscopy, the approach procedure has potential impact on other complications such as acute cardiovascular events. Therefore, the improvement of locating approach methods may help to reduce the incidence of complications.

AP is the previous standard for evaluating and locating approach in medical thoracoscopy, while real-time observation is not available and the risk of radiation exposure is unavoidable (12). By contrast, the advantages of TU are real-time imaging on bedside and, of course, without risk of radiation exposure (13). At the meantime, the capacity of TU for evaluating and locating approach had been fully confirmed recently. TU can well identify the nature of pleural effusion like hemothorax and empyema (14-16). Even if the pneumothorax occurs, TU can also be a good assessment instrument because of some special signs such as the absence of "lung point" and "sliding sign" (17-19). Besides, a cohort study had showed a strong tend to reduction in single port medical thoracoscopy pleural approach failure with TU comparing AP (20).

However, TU is not flawless. Some of the areas are difficult to visualize because of the bony chest cage (21). Furthermore, the ultrasound wave cannot travel through air. As a result, bullae or extensive subcutaneous air make TU hard to examine the pleural (8). Another limitation is

Table 3 Differences between the two groups for clinical characteristics and rate of complications, after PSM

Parameter	AP group (n=32)	TU group (n=16)	t/χ^2 value	P value
Age, years (mean ± SD)	61±12	61±12	t=0.028	0.977
Gender, n (%)				
Male	20 (62.5)	10 (62.5)		
Female	12 (37.5)	6 (37.5)	χ^2=0.000	1.000
Smoking status, n (%)				
No smoking	17 (53.1)	8 (50.0)		
Former smokers	4 (12.5)	4 (25.0)		
Current smokers	11 (34.4)	4 (25.0)	χ^2=1.320	0.517
Diagnostic outcome, n (%)				
Malignant	18 (56.2)	7 (43.8)		
Benign	14 (43.8)	9 (56.2)	χ^2=0.668	0.414
Complications, n (%)	3 (9.4)	1 (6.2)	χ^2=0.136	0.712

PSM, propensity score matching; AP, artificial pneumothorax; TU, thoracic ultrasound.

that ultrasound image prefers experienced operators (22).

On the other hand, there are different opinions in the specific application of TU for evaluating approach. Some authors advocated TU following by AP to prevent the occurrence of lung laceration (9). However, another study had showed that TU could guide medical thoracoscopy approach without pneumothorax even in the complete absence of pleural effusion (23).

While there was spare data in investigating the complications of locating approach with AP comparing TU. After PSM analysis, the overall complication rate of the TU group was a little less than that of the AP group in our study, without significant difference (TU group *vs.* AP group, 6.2% *vs.* 9.4%, P=0.712). We should be noticed that cases of acute cerebrovascular suspected air embolism and repeating making pneumothorax step were observed in the AP group, which could be prevented by TU. Moreover, we used high frequency linear probe to provide definition of chest wall's superficial structures like nerve and blood vessel. This step may reduce the risk of local neurovascular injury.

Conclusions

We believe that our study suggests that TU is a locating approach method which does not increase the complication rate comparing with AP. And it could be a good choice in medical thoracoscopy.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: All patients provided written informed consent, and this study was approved by the Ethical Committee of Peking University First Hospital under approval number 2016[1130].

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