Iatrogenic Pneumothorax: Etiology, Incidence and Risk Factors

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Key words
- pneumothorax
- iatrogenic
- incidence
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- etiology

Abstract

Background: We discuss the etiology and incidence of iatrogenic pneumothorax (IPnx) which can develop after invasive procedures performed for diagnostic and/or therapeutic purposes, and the efforts to prevent this complication and its consequences.

Methods: The records of patients who were treated for the diagnosis of IPnx between December 1998 and December 2006 were retrospectively reviewed. The patients were evaluated according to their age, gender, the procedure which caused IPnx, the department which performed the procedure, the treatment and its consequences.

Results: 12010 invasive procedures were performed in our hospital during the period and 164 patients (1.36%) developed IPnx. Their mean age was 49.27 (range: 8 months – 93 years). Of the patients, 101 (61%) were male and 63 (39%) were female. The 56.7% of the invasive procedures which caused IPnx were performed under emergency conditions and 43.3% were performed under elective conditions. In 69 patients (42%) the procedures were performed due to underlying lung diseases and in 95 patients (58%) for diseases other than lung diseases. The most frequent procedure type causing IPnx was central venous catheterization, with 72 patients (43.8%). The other frequent causes were thoracentesis with 33 patients (20.1%) and barotrauma due to mechanical ventilation with 15 patients (9.1%).

Conclusion: At training hospitals the incidence of IPnx will increase in parallel to the increase in invasive procedures. Invasive procedures should be performed by experienced personnel or under their supervision when risk factors are involved.

Introduction

Pneumothoraces which develop after diagnostic or therapeutic invasive procedures are called iatrogenic pneumothorax (IPnx). In some series in the literature, the incidence is as high as 6% and, in some series, it has been reported to occur more often than spontaneous pneumothorax [1,2]. The most frequently involved invasive procedures in the etiology of IPnx are transthoracic lung biopsy (TTLB) performed for the diagnosis of underlying lung and pleural diseases; transbronchial needle biopsies (TBNB) and pleural biopsies; thoracentesis for diagnosis or treatment; central venous catheterization (CVC); mechanical ventilation (MV); intercostal nerve blockage; acupuncture; tracheostomy; and pacemaker replacement [1–4]. This complication, which can develop after invasive procedures, worsens the clinical course of patients who have been hospitalized for other reasons, prolongs the hospitalization period and increases the costs of treatment [3]. The aim of this study was to determine the incidence of iatrogenic pneumothorax in our hospital and the invasive procedures that caused it, and to discuss the results in the light of the literature.

Material and Methods

One hundred and sixty-four patients with a diagnosis of iatrogenic pneumothorax occurring between December 1998 and December 2006 were included in the study. A previous study on IPnx, its prevention and the protocols to be established, was conducted in our hospital by Sahin et al. [3]. We took the period that their study had been conducted as the 1st period (December 1998–December 2002), and evaluated the results of the established protocols and precautions for the 2nd period (January 2003 – December 2006). We

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Bibliography
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Table 1 Demographic data of the patients with iatrogenic pneumothorax.

n	164
Sex (M : F)	101 : 63
Mean age (years)	49.27 (8 months – 93 years)
IPnx right : left : bilateral	93 : 68 : 3
Chest tube drainage duration (days)	6.03 (1–46)

compared the percentages of the invasive procedures performed and the incidence of IPnx in both periods.

Patient data reviewed included age, gender, the department they were hospitalized in, the department which performed the procedure, the underlying disease, the invasive procedure which caused IPnx, the treatment and its results. The patient history, physical examination and chest radiography were used for diagnosis. For patients who required urgent diagnosis due to respiratory insufficiency, the diagnosis was made based on physical examination and thoracentesis without waiting for the chest radiograph. Tube thoracostomy was performed in patients whose pneumothorax size was greater than 20% in direct chest radiography, while conservative treatment methods (oxygen and follow-up) were used for patients with a pneumothorax size of under 20%.

A chest tube was inserted under local anesthesia and placed usually anterior to the midaxillary line. It was inserted by blunt dissection of a tunnel through the intercostal muscles and parietal pleura. After the cessation of the air leakage, the tube was clamped for 24 hours, and then removed under chest radiography control.

Statistical analysis

The study period was divided into two periods. Fisher's exact test and chi-square test were used to compare the incidence of the invasive procedures between the periods. Statistical analyses were performed using the SPSS statistical software package (version 15.0, SPSS, Chicago, IL, USA). $P < 0.05$ was considered statistically significant.

Results

During the study period, 12 010 diagnostic or therapeutic invasive procedures capable of producing a pneumothorax were performed in our hospital. In this period, 164 patients (1.36%) were referred to our clinic and diagnosed as having iatrogenic pneumothorax. Of those patients, 101 (61%) were male and 63 (39%) were female. Demographic data of the patients are presented in **Table 1**.

Of the 164 patients who developed IPnx, 100 patients (61%) came from surgical departments and 64 (39%) from departments of medical science. In 120 of the patients (73%) surgical departments and in 44 (27%) departments of medical science, had performed the procedure which caused the IPnx. The most frequent IPnx cause in our series was subclavian vein catheterization with 64 patients affected (39%). The second most frequent IPnx cause was thoracentesis with 33 patients (20.1%). The other invasive procedures causing IPnx are given in **Table 2**.

When the etiologies of the patients included in the study were investigated, it was found that in 95 patients (58%) invasive procedures were performed for diseases other than pleuropulmonary diseases, while in 69 patients (42%) the procedures were performed for pleuropulmonary diseases. The most frequent procedure type causing IPnx in patients with primary pleuropulmonary diseases was thoracentesis with 33 patients; in patients with diseases other than pleuropulmonary diseases it was central venous catheterization with 72 patients. Of the procedures in our series, 56.7% were performed under emergency conditions and 43.3% were performed under elective conditions.

Table 2 Invasive procedures causing iatrogenic pneumothorax.

Procedure	n	%
Subclavian vein catheterization	64	39.0
Thoracentesis	33	20.1
Barotrauma due to MV	15	9.1
Diaphragmatic injury	10	6.1
Pacemaker replacement	8	4.8
Jugular vein catheterization	8	4.8
Pleural biopsy	6	3.7
Tracheostomy	6	3.7
CT-guided TTLB	5	3.1
Bronchoscopy	5	3.1
Others	4	2.5
Total	164	100

During the first period of the study, the number of invasive procedures performed was 5055, while in the second period the number of procedures rose to 6955, an increase of 37%. On the other hand, the incidence of IPnx decreased to 1.25% (87/6955) in the second period while it stood at 1.52% (77/5055) in the first period. Subclavian vein catheterization, which was ranked as the first cause of iatrogenic pneumothorax, was performed in a total of 2875 patients, and 64 patients (2.22%) developed IPnx. Thoracentesis, which was ranked as the 2nd cause, was performed in a total of 898 patients during the study period, and 33 patients (3.67%) developed the complication. During the study, 3625 patients received mechanical ventilation (MV) therapy and 15 patients (0.41%) developed barotrauma due to MV, with mechanical ventilation constituting the 3rd most frequent cause of IPnx. Other IPnx causes and their percentages are shown in **Table 3**.

When the incidence of invasive procedures in the two periods were compared, the only significant difference between the periods was for thoracentesis ($p < 0.001$).

When the invasive procedures which led to IPnx were evaluated according to the departments involved, it was found that of the surgical departments the Department of Anesthesiology and Reanimation with 38 patients (23.2%) and among the departments for medical science the Department of Pulmonary Disease with 23 patients (14.1%) were in the first rank (**Table 4**). For subclavian vein catheterization, the Department of Anesthesiology and Reanimation was the first with 23 patients (35.9%) and Department of Cardiovascular Surgery was the second with 22 patients (34.4%). Both of these are departments which perform central venous catheterization most frequently. Thoracentesis, the second most frequent cause of IPnx, was identified in 33 patients; 17 (51.5%) of these procedures were performed by the Department of Pulmonary Diseases and 10 (30.3%) by the Department of Thoracic Surgery. Thoracentesis is most frequently performed by these departments (**Table 5**).

In 164 patients followed up by our clinic with the diagnosis of IPnx, a total of 169 procedures were performed for treatment. Tube thoracostomy was performed in 159 patients (97%), and 5 patients (3%) recovered with oxygen support and follow-up. Four

Table 3 Invasive procedures performed in the study over two periods, and the distribution and percentage of IPnx which developed due to these procedures.

Invasive procedure	Number of iatrogenic IPnx/procedures			*p*
	Total	1st period	2nd period	
Subclavian vein catheterization	64/2 875 (2.22%)	31/1 150 (2.69%)	33/1 725 (1.91%)	0.163
Thoracentesis	33/898 (3.67%)	18/230 (7.82%)	15/668 (2.24%)	< 0.001
Barotrauma due to MV	15/3 625 (0.41%)	5/1 358 (0.36%)	10/2 267 (0.44%)	0.741
Jugular vein catheterization	8/1 240 (0.64%)	6/468 (1.28%)	2/772 (0.25%)	0.059
Pleural biopsy	6/132 (4.54%)	5/73 (6.84%)	1/59 (1.69%)	0.224
Tracheostomy	6/607 (0.98%)	3/283 (1.06%)	3/324 (0.92%)	1
Rigid bronchoscopy	5/543 (0.92%)	3/250 (1.2%)	2/293 (0.68%)	0.664
CT-guided TTLB*	5/75 (6.66%)	0/0 (0%)	5/75 (6.66%)	NA
F. Bronchoscopy ± transbronchial biopsy	1/1 952 (0.05%)	1/1 206 (0.08%)	0/746 (0%)	1
Mediastinoscopy	1/63 (1.58%)	0/37 (0%)	1/26 (3.84%)	0.413
Others**	20	5	15	NA
Total	164	77	87	0.204

NA: Not analyzed, *CT-guided TTLB only began to be performed in our hospital in the 2nd period of the study. ** IPnx cases which developed due to cardiopulmonary resuscitation, perioperative diaphragmatic injury and pacemaker replacement, whose total numbers were inaccessible or where the incidence could not be given.

Table 4 Departments in which iatrogenic pneumothorax occurs.

Department	n	%
Anesthesiology and reanimation	38	23.2
Cardiovascular surgery	29	17.7
Pulmonary disease	23	14.1
Thoracic surgery	21	12.8
Surgery	19	11.6
Cardiology	12	7.3
Ear, nose and throat	6	3.7
Neurosurgery	5	3.0
Radiology	5	3.0
Internal medicine	4	2.4
Urology	2	1.2
Total	164	100

patients had to undergo more than one tube thoracostomy. Out of the cases in which tube thoracostomy was not enough, 4 patients underwent thoracotomy and one patient underwent open drainage. Seven patients had hemothorax and 5 patients had tension pneumothorax. The mean chest tube drainage duration was 6.03 days (1 day – 46 days). Thirty-four patients (20.7%) died of their primary diseases.

Discussion

As the number of operative procedures performed for diagnostic and therapeutic purposes increase in training and research hospitals, iatrogenic pneumothorax will become the most encountered type of pneumothorax after traumatic pneumothorax. This complication prolongs the hospitalization period, worsens the patients' physical condition and increases morbidity and mortality, especially in patients who develop barotrauma due to mechanical ventilation [5].

In most series, central venous catheterization ranks high among the causes of IPnx. CVC is most frequently used to monitor central pressure, in total parenteral nutrition, in chemotherapy and in cases requiring prolonged venous passage [6]. For central venous catheterization the jugular or subclavian veins are mostly preferred. The incidence of pneumothorax due to CVC varies between 0.5 and 5% when performed by experienced personnel (resident doctor under the supervision of a specialist doctor or directly by a specialist doctor) [7]. Molgaard et al. reported the incidence of pneumothorax as 0.4% in their series in which they performed jugular and subclavian veins catheterization, and Yılmazlar et al. reported a rate of 0.5% [7,8].

In central vein catheterization procedures, the risk factors which depend on the patient include the vascular anatomy, the underlying disease and coagulopathy; however, there are other risk factors such as the type of catheter, the experience of the staff and requiring more than 3 needle passes [6,7]. During the first period of our study, CVC procedures constituted 48% of the IPnx cases. It

Table 5 The invasive procedures and departments which most frequently cause iatrogenic pneumothorax.

Procedure	AR	CVC	PD	TS	S	CAR	ENT	NEU	Total
Subclavian vein cathet.	23	22	–	2	10	5	–	2	64
Thoracentesis	–	4	17	10	2	–	–	–	33
Barotrauma due to MV	10	–	–	3	–	–	–	2	15
Jugular vein cathet.	2	5	–	1	–	–	–	–	8
Tracheostomy	–	–	–	0	–	–	5	1	6
Pleural biopsy	–	–	6	–	–	–	–	–	6
Total	35	31	23	16	12	5	5	5	132

AR: anesthesiology and reanimation, CVS: cardiovascular surgery, PD: pulmonary disease, TS: thoracic surgery, S: surgery, CAR: cardiology, ENT: ear, nose and throat, NEU: neurosurgery

was also the most frequent cause in the second period, with a rate of 40%. While the number of CVC procedures increased by 55% in the second period, the rate of IPnx it caused decreased from 2.69% to 1.91%. There were no significant differences between the periods. We believe that this decrease in the rate of IPnx occurred because the Department of Anesthesiology/Reanimation and the Department of Cardiovascular Surgery, the departments which perform CVC most frequently, have started to catheterize the jugular vein in compliance with the suggested protocol.

In our series, the 2nd most frequent cause of iatrogenic pneumothorax was thoracentesis. In the literature the reported incidence is 3 and 19% [2,9,10]. Yılmaz et al. reported the rate of IPnx due to thoracentesis as 1.5% and that due to pleural biopsy as 7.1% [4]. The risk factors in thoracentesis are the experience of the personnel, coughing of the patient during the procedure, the underlying lung disease and the number of passes performed [10]. When the procedure is performed with the assistance of ultrasound, the rate of complications decreases to 2–3%. Ultrasound is especially beneficial when there is a very low amount of fluid present and for loculated fluids [10]. In our series, the rate of IPnx which developed due to thoracentesis was 3.67% and that which developed due to pleural biopsy was 4.54%. When the two periods were compared for thoracentesis, it was found that the rate of complications significantly decreased (**Table 3**). We consider the reason for that is that these procedures are being performed more carefully by the Departments of Pulmonary Disease and Thoracic Surgery, the departments which perform these procedures most frequently, and that they have started to make more use of supportive imaging techniques.

The incidence of IPnx in the intensive care unit has decreased to 3% today, while it was more than 20% in the 1990s. The overall incidence of barotrauma related to mechanical ventilation is 0.5% in postoperative patients, but this rate increases up to 87% in patients being treated for ARDS [11–14]. The incidence of ventilator-associated barotrauma, which was the third most frequent cause of IPnx in our series, was 0.41% (15 patients). Pneumothorax occurs especially within the first 3 days of mechanical ventilation in 80% of the patients with barotraumas, and the most important risk factors are reported to be ARDS, pneumonia and COPD [14]. In our study, 3 patients had COPD, 3 patients had ARDS and 2 patients had pneumonia as risk factors. Although some studies have reported that the occurrence of barotrauma was not correlated with the mode of ventilation and ventilator settings, there are articles reporting that 3 parameters – peak inspiratory pressure, plateau pressure and PEEP – are of importance in barotrauma [12,14].

Mortality in IPnx due to ventilator-associated barotrauma is significantly high. The underlying pulmonary disease (ARDS, COPD, etc.), the duration of MV and the length of stay in the intensive care unit are especially important in such cases [11,14]. Special attention should be paid to patients who have undergone MV, and a sudden change in the pressure of the ventilator or an unexpected decrease in the patient's oxygenation should be taken as a warning. Tension pneumothorax is a serious complication for mechanically ventilated patients and it occurs when there is a continuous alveolar air flow into the pleural space without any possibility of evacuation. Immediate decompression of the pleural space with a needle, chest tube or other instruments is required [15]. In the second period of our study, the number of patients who required MV increased, but no increase was observed for the rate of IPnx. We suggest that technical advances in ventilators and minimization of the treatment period in the intensive care unit have had an effect on this improvement.

The IPnx rate due to flexible bronchoscopy and transbronchial biopsy has been reported to be 1–6% [16]. The incidence of IPnx due to transbronchial lung biopsy was 16.6% in the study of Yılmaz et al. [4]. In our series the rate of IPnx due to rigid bronchoscopy was 0.92% and that for flexible bronchoscopy was 0.05%. In such cases it is very important that the clinician should suspect pneumothorax and the diagnosis can easily be made by chest radiography.

Transthoracic lung biopsy with computerized tomography guidance has been widely used. The most likely complication of this procedure is pneumothorax. In the literature the incidence has been reported as 8–61% and in some series it has risen to over 10% [17,18]. The risk factors of this procedure are the depth of the lesion in the lung parenchyma, its diameter, the area of emphysema surrounding the lesion and the experience of the physician performing the biopsy [17,18]. In our hospital TTLB began to be performed in 2003, and 75 cases have been performed since then. The rate of IPnx was identified as 6.66%. The low IPnx incidence can be attributed to the small number of procedures performed.

Tracheostomy is a surgical procedure which is performed to provide an air passage. It is mostly used in intensive care units. Development of pneumothorax during tracheostomy is a serious complication with a reported incidence of 1–3% [19]. In our series the IPnx rate due to tracheostomy was 0.98%, indicating that the procedures were performed successfully by the departments of Thoracic Surgery, Ear, Nose and Throat, and Neurosurgery.

Chest pain and/or shortness of breath starting after an invasive procedure on the thorax should remind the physician of the possibility of IPnx, and direct chest radiography should be employed for urgent diagnosis. Tube thoracostomy is a safe and effective method for treatment and it is specifically preferred in patients with underlying lung diseases [5]. In patients where the size of the pneumothorax is under 20%, observation and oxygen support can be used and monitoring can be maintained with chest radiographies.

While the mortality for simple IPnx is 2%, it can increase up to 50% in IPnx due to barotrauma. As the diagnostic and therapeutic methods improve, iatrogenic pneumothorax will increase in parallel to the increasing number of invasive procedures. Since invasive procedures are a part of training, IPnx will be inevitable, especially in training hospitals. If there are risk factors, the procedures should be performed under the supervision of experienced personnel and should comply with the suggested algorithms. To keep this complication at minimum is important, but once it has developed, it should be noticed and treated immediately.

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