RESEARCH ARTICLE

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ECG Evaluation in Patients with Pneumothorax Admitted to the Emergency Department: A Three years Analysis

ABSTRACT

Objective: Pneumothorax is one of the life-threatening differential diagnoses of patients presenting to emergency department (ED) with shortness of breath and chest pain. The place of dynamic electrocardiography (ECG) changes in diagnosis of pneumothorax was not well defined. The aim of our study was to reveal the clinical importance of ECG in pneumothorax.

Methods: Between 01.04.2014 and 01.04.2017, 147 patients who applied to our ED and take a diagnosis of pneumothorax were retrospectively examined. The patients were divided as Group 1 (with pneumothorax volume <20%), and group 2 (with pneumothorax volume≥ 20%). Patient demographics, mechanism of pneumothorax formation (traumatic or spontaneous), X ray and tomographic findings, ECG findings, hospitalization-follow-up periods, treatment methods; were derived from the hospital's data recording system and compared between groups.

Results: 109 (74.1 %) of 147 patients had a traumatic pneumothorax, and 38 (25.8%) had a spontaneous pneumothorax (p <0.001). 21 (55.2%) of the spontaneous pneumothorax cases are primary spontaneous pneumothorax. 64.6% (n=95) of the patients had chest pain. The two groups were similar in terms of age, hemoglobin level, GCS, number of days followed, gender and smoking status, (p> 0.05). When the ECG data was analyzed, a difference was found between the two groups. While 52.8% of the patients in group 1 had ECG changes, all of the patients in group-2 (100%) had unusual ECG findings (p = 0.004).

Conclusions: Pneumothorax is a condition that should not be overlooked at ED. Pneumothorax especially with large volume size (size≥20%) should be remembered in cases with abnormal findings in their ECG.

Keywords: Electrocardiography; Spontaneous Pneumothorax; Traumatic Pneumothorax.

Acil Servise Başvuran Pnömotoraks Hastalarında EKG Değerlendirilmesi: Üç Yıllık Bir Analiz

ÖZET

Amaç: Pnömotoraks, nefes darlığı ve göğüs ağrısı ile acil servise başvuran hastaların hayatı tehdit eden ayırıcı tanılarından biridir. Dinamik elektrokardiyografi (EKG) değişikliklerinin pnömotoraks tanısındaki yeri iyi tanımlanmamıştır. Çalışmamızın amacı, pnömotoraksta EKG'nin klinik önemini ortaya çıkarmaktır.

Gereç ve Yöntem: 01.04.2014 – 01.04.2017 tarihleri arasında acil servisimize başvuran ve pnömotoraks tanısı alan 147 hasta geriye dönük olarak incelendi. Hastalar Grup 1 (pnömotoraks hacmi <% 20) ve grup 2 (pnömotoraks hacmi≥% 20) olarak ayrıldı. Hasta demografik özellikleri, pnömotoraks oluşum mekanizması (travmatik veya spontan), Röntgen ve tomografi bulguları, EKG bulguları, hastanede yatış-takip süreleri, tedavi yöntemleri; hastanenin veri kayıt sisteminden elde edildi ve gruplar arasında karşılaştırıldı.

Bulgular: 147 hastanın 109'unda (% 74.1) travmatik pnömotoraks, 38'inde (% 25.8) spontan pnömotoraks vardı (p <0,001). Spontan pnömotoraks vakalarından 21'i (% 55.2) birincil spontan pnömotoraks (PSP) idi. Hastaların% 64.6'sında (n = 95) göğüs ağrısı vardı. İki hasta grubu yaş, hemoglobin düzeyi, GKS, takip edilen gün sayısı, cinsiyet ve sigara içme durumu açısından birbirinden farklı değildi (p> 0.05). EKG verileri incelendiğinde iki grup arasında fark bulundu; Grup 1'deki hastaların% 52,8'inde EKG değişiklikleri varken, grup-2'deki tüm hastaların (% 100) olağandışı EKG bulguları vardı (p = 0,004).

Sonuç: Pnömotoraks acil serviste gözden kaçırılmaması gereken bir durumdur. EKG'sinde anormal bulgular olan durumlarda pnömotoraks (Klinik olarak anlamlı pnömotoraks, boyut≥% 20) hatırlanmalıdır.

Anahtar Kelimeler: Elektrokardiyografi; Spontan Pnömotoraks; Travmatik Pnömotoraks.

INTRODUCTION

Pneumothorax is defined as the presence of free air in the space between the parietal and visceral membranes of the lung and associated lung collapse. Although the air in the pleural space can have many sources, the most common causes are rupture of the visceral pleura and air leakage from the lung parenchyma to the pleural space (1). Pneumothorax can be classified as non-traumatic (spontaneous) or traumatic (blunt or penetrating). Trauma is the most common cause of death in the first 4 decades of life (1, 2, 3). Thoracic trauma constitutes 25% of deaths due to trauma in prehospital settings (1, 4). Pneumothorax is observed in approximately 20% of patients with severe chest trauma (2). Spontaneous pneumothorax (SP) more frequently affects patients between the ages of 20 and 30 years, and 60-70 years (1). The male / female ratio was found to be 2.7 in the distribution by gender (1, 5). Most common complaints of pneumothorax are chest pain, shortness of breath, cough, tachycardia, and tachypnea (1, 2). Elimination of the patient's symptoms as much as possible complete re-expansion of the lung, prevention of complications and recurrences are targets of the treatment (1, 2, 6). Radiological imaging methods (x-ray, tomography) are the most critical parameters in diagnosis. However, the place of dynamic electrocardiography (ECG) changes in diagnosis of pneumothorax was not well defined. Most of the studies were conducted in small groups of patients and most frequently, the reports include isolated cases (7-13). The similar symptomatology of spontaneous pneumothorax and cardiac conditions (chest pain, dyspnea) together with ECG abnormalities may lead to misdiagnosis and delay in the treatment of pneumothorax (7-10). The aim of our study was to reveal the clinical importance of ECG in the diagnosis of pneumothorax in daily emergency department practice.

MATERIAL AND METHODS

After approval by the Institutional clinical research ethics committee (Decision no: 2017/10; date: 06.02.2017), this retrospective and descriptive study was performed in accordance with the ethical guidelines of the Declaration of Helsinki. In the study, 205142 patients who applied to our emergency department between 01.04.2014 and 01.04.2017 were retrospectively examined, and 147 patients aged 18 years and over with a diagnosis of pneumothorax were identified. Patient symptoms, age, gender, Glasgow coma scale (GCS), chronic diseases (diabetes mellitus, hypertension, coronary artery disease, hypothyroidism.), smoking history, mechanism of pneumothorax formation (traumatic or spontaneous), posterior-anterior chest radiography (PACR) thoracic computed tomography (CT), hemoglobin level, ECG findings, hospitalization-follow-up periods, treatment methods; were derived from the hospital's data recording system.

Patients were divided in two groups as Group 1 (patients with pneumothorax volume less than 20% of a hemithorax volume) and Group 2 (patients with pneumothorax volume equal to or greater than 20% of a hemithorax volume) according to the pneumothorax volumes measured using the Kircher method. We used <20% and≥ 20% as limits for patient grouping because pneumothorax up to 20% on PACR is considered as minimal pneumothorax and is followed conservatively in clinically stable patient, however pneumothorax above 20% is classified as massive pneumothorax and requires drainage by tube thoracostomy (1, 2).

12-lead ECG data were evaluated by an emergency medicine specialist and a cardiologist, and the findings were recorded. Distinct P waves, regular rhythm, heart rate of 60-100 / minute, the QRS complex following each P wave, the constant PR interval between 0.12-0.20 seconds, QRS width maximum 0.10-0.12 seconds, and fixed ST-segment on the isoelectric line were accepted as "normal ECG." ECGs other than these definitions were accepted as "ECG with abnormal findings" (14). After confirmation of pneumothorax size via PACR the treatment and follow-up for patients with pneumothorax was made by the same thoracic surgeon.

Kircher method was used to calculate the pneumothorax size (15). This method is based on measuring and calculating the hemithorax and collapsed lung area on chest radiography (%) = [(A x B) - (a x b)] / (A x B) (**Figure 1**). The formula requires measurements of lateral wall at the mid-point of the upper and lower halves of the hemithorax(B), diameter of collapsed lung(a), lateral wall at the mid-point of the upper and lower halves of the collapsed lung(b) and hemithorax diameter (A). A chest tube is required if pneumothorax is > 20% in clinically stable patient.

Statistical Analysis: Statistical evaluation of the data was made with the SPSS 19.0 package program. The compatibility of numerical variables to normal distribution was examined using the Shapiro-Wilk test. Descriptive statistics were expressed as arithmetic mean ± standard deviation and median (minimum-maximum) for numerical variables and as numbers and percentages for categorical data. In comparing the two groups in terms of numerical variables, the Mann-Whitney U test was used because parametric test assumptions were not provided. The differences between groups in terms of categorical variables and the relationships between variables were examined using Chi-square and Fisher's exact chi-square tests. A p-value of <0.05 was considered significant in the analysis. It is commented that a "statistically significant difference exists" for values equal or less than this value.

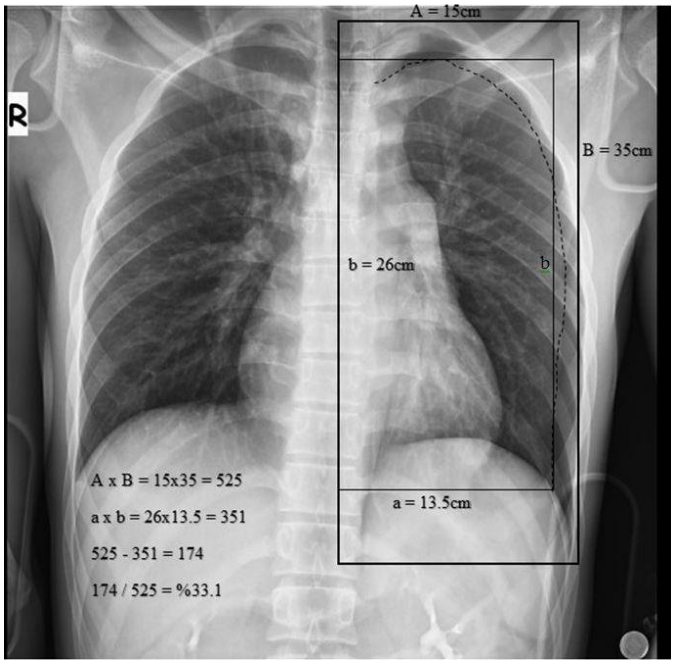

Figure 1. Kircher's technique for calculating pneumothorax size. A: hemithorax diameter- A line started at the mid-tracheal line and finished at lateral wall of hemithorax; B: the lateral wall at the mid-point of the upper and lower halves of the hemithorax; a: diameter of collapsed lung. b: the lateral wall at the mid-point of the upper and lower halves of the collapsed lung. It was taken from the archive of our School of Medicine hospital

RESULTS

Traumatic pneumothorax is seen in 109 (74.1 %) of 147 patients, and 38 of the patients had a spontaneous pneumothorax. While 55.2% of spontaneous pneumothorax cases were primary spontaneous pneumothorax (PSP), 44.7% were secondary spontaneous pneumothorax. The patients had chest pain (64.6% (n = 95)), shortness of breath (17.6% (n = 26)), change in level of consciousness (7.4% (n = 11)) and 6.8% (n = 10) of patients presented with back pain and 3.4% (n = 5) with another complaint during application to our emergency department.

The groups were not different from each other in terms of age, hemoglobin level, GCS, number of days followed, gender, smoking status, and chronic disease history (p> 0.05).

When the mechanism of pneumothorax is examined it was seen that traumatic pneumothorax was more common in group 1 patients and spontaneous pneumothorax was more common in group 2 patients (p = 0.004) (**Table 1**).

Table 1. Descriptive and comparative data of the patients groups

Patient group(n)		**Group1 (n=116)**	**Group2 (n=31)**	**p value**
Age (years)		45.5 (18 – 89)	47 (18 – 83)	0.831
Hemoglobin (g/dL)		14.1 (7.6 - 17.6)	14.3 (10.0-17.4)	0.183
GCS		15 (3 – 15)	15 (5 – 15)	0.192
Length of hospital stay (day)		4 (1 – 33)	3.5 (1 – 11)	0.938
Gender(n)	Male	103 (88.8%)	27 (87.1 %)	0.758
	Female	13 (11.2%)	4 (12.9%)	
Etiology of pneumothorax (n)	Spontaneous	21 (18.1%)	17 (54.8%)	0.001
	Traumatic	95 (81.9%)	14 (45.2%)	
Smoking* n=138	*Non-smoker*	*48 (44.4%)*	*15 (50.0%)*	*0.589*
	Smoker	*60 (56.6%)*	*15 (50.0%)*	
Comorbidity(n)	yes	56 (48.3%)	20 (64.5%)	0.160
	no	60 (51.7%)	11 (35.5%)	

Values are presented as medians (range), or n (%). * n = 138: 9 people with unknown smoking status were excluded from the analysis. Group 1 (patients with pneumothorax volume < 20% of a hemithorax volume); Group 2 (patients with pneumothorax volume ≥20% of a hemithorax volume), GCS: Glasgow coma scale. Significant at p <0.05 level

ECG changes were observed in the 30 (63.8%) (p = 0.004) of 47 patients whose ECG's could be evaluated. Unusual ECG findings were observed in all of the patients with pneumothorax volume ≥ 20% (**Table 2**).Incomplete right bundle branch block was the most common ECG finding **(Table 3)** in both patient groups.

Table 2. Distribution and comparison of ECG changes according to pneumothorax size

Parameter		Total Population (n=47; 100%)	Group 1 (n=36; 76.6%)	Group 2 (n=11; 23.4%)	p value
ECG	Usual findings	17 (36.2%)	17 (47.2%)	0 (0.0%)	0.004
	Unusual findings	30 (63.8%)	19 (52.8%)	11 (100%)	

*Significant at p<0.05 level

Table 3. ECG changes detected in our patients

ECG changes- Unusual findings	n
V1-V4 T negativity	2
V4-V5-V6 ST depression	1
V5-V6 ST elevation + D1 and AVL T negativity	1
V4-V5-V6 T negativity +Right branch block + atrial fibrillation	1
V1-V4 T negativity +Right axis deviation	3
V1-V4 ST depression +Right axis deviation + atrial fibrillation	1
Isolated R wave loss in D1 derivation	1
Reduction of P, QRS and T wave amplitudes in D1 leads	2
Right axis deviation + incomplete right bundle branch block	2
Right bundle branch block + D3 and T negativity in AVF	1
Incomplete right bundle branch block	**7**
Incomplete left bundle branch block	1
Atrial fibrillation	1
P pulmonale	1
D2-D3-AVF showed ST elevation and pathologic Q + V4 V5 V6 with T negativity	1
V2-V4 T negativity +ST segment depression, +Right axis deviation + right bundle branch block	1

DISCUSSION

Pneumothorax is an important life-threatening disease that all physicians must keep in mind and not overlook. Pneumothorax is characterized by collection of air and pressure increase in the pleural space between the lung and the chest wall (1, 2). Although cardiac causes are the first to come to mind, pneumothorax and other thoracic pathologies are the other options in the differential diagnosis in patients presenting with chest pain and shortness of breath in an emergency department. Patients with pneumothorax may be asymptomatic or can present with chest pain, shortness of breath, tachycardia, and tachypnea (1). Chest pain (64.6%) and shortness of breath (17.6%) was most common symptoms in our patients.

Acute chest pain conditions have a quite common symptoms and ECG is one of the most important diagnostic tool used in the differential diagnosis of these disorders (2). Many reasons, such as coronary artery diseases, pericardial diseases, ischemic stroke, electrolyte disturbances, and intoxications, can present with specific or non-specific findings on ECG (16-20). Clinical conditions that decrease venous return to the thoracic cavity, disrupt perfusion, and increase systemic vascular resistance cause ECG changes. Intrapleural pressure that increase in pneumothorax may gradually compress ipsilateral lung directly and opposite lung by mediastinal shift. Increased intrapleural pressure and mediastinal shift act on the venous flow and stroke volume (1, 5, 6). Decreased cardiac output, increased intrathoracic pressure, cardiac rotation around its long axis, right ventricular dilatation due to increased pulmonary artery pressure, and cardiac displacement are estimated with ECG changes in pneumothorax (7-10). In patients with pneumothorax various non-specific ECG findings such as right axis deviation, decreased QRS amplitude in the precordial leads, and T-wave inversion can be observed (7-13, 21, 22). ECG changes may be expected in both left-sided and right-sided pneumothorax alike. Changes reported for left-sided pneumothorax more frequently include right axis deviation, QRS amplitude changes, diminution in precordial R-wave voltage, T- wave inversions, and PR-segment elevation. Reported right-sided pneumothorax changes most commonly involve the QRS complex (particularly right bundle branch block) and T- wave inversion. ST elevation may be seen in both left-sided and right-sided pneumothorax (10-13). The possibility of such changes is most often mentioned in patients with spontaneous pneumothorax and tension pneumothorax (7-13). Yeom et al. found that ST-segment elevation can be observed in a case with minimal pneumothorax and that ECG returns to the normal by reducing the size of the pneumothorax (7). Tomiyama et al. found hypotension, decreased oxygen saturation, and decrease in R wave amplitude of ECG in cases which developed tension pneumothorax intraoperatively. They suggested that this could be an indicator of pneumothorax (8). However, there is evidence that ECG changes are related to the size of the pneumothorax (7, 9, 10). It has been shown that

detected change of ECG in patients with left PSP is helping in estimation of the size of pneumothorax, although it is not the only indicator for pneumothorax (9). Also in male patients with left PSP the size of the pneumothorax can be over 20% if the S wave in the V2 derivation of ECG is <12 mm, and the S wave in the V3 lead is <9 mm (10). In our study 17 (36.2%) of 47 patients whose ECG was examined had normal ECG findings and their pneumothorax volume is <20% of the hemithorax. ECG within normal limits was not observed in any of the patients with pneumothorax volume ≥ 20%. Incomplete right bundle branch block was the most common unusual ECG finding in our study.

We think that, pneumothorax has an important place in the differential diagnosis of the cases considered as cardiac emergencies. Our findings showed that pneumothorax especially with large volume size should be considered in patients with shortness of breath, chest pain, and unusual ECG findings.

Motor vehicle accidents are one of the most important causes of trauma-related mortality and morbidity (1, 5). Thoracic trauma accounts for about a quarter of emergency room admissions for trauma (2, 3, 5). Traffic accidents are a fundamental cause of traumatic pneumothorax due to blunt trauma (3, 23, 24). The most common etiologic cause of pneumothorax in our emergency department was trauma (74.1%). If our pneumothorax patients were compared within themselves rather than the whole population, the rate of traumatic pneumothorax / spontaneous pneumothorax was found to be more than twice of the rate in the study of Melton et al (25). This situation may be related to the differences of the districts where studies were conducted.

PSP etiology includes smoking, male gender, mitral valve prolapsus, Marfan syndrome, atmospheric pressure change, lung bulla/blebs, genetic factors (1, 2). In our study, 73% of PSP cases were smokers also 88.4% of 147 cases were male. Our study finding also showed that spontaneous pneumothorax more frequently presented with pneumothorax volume more than 20%.

The treatment of pneumothorax in emergency department varies according to the pneumothorax size and the severity of the clinic. Besides operative (tube thoracostomy, videothoracoscopy, thoracotomy) and non-operative (needle aspiration, percutaneous aspiration catheter) treatment options and conservative monitoring can also be performed (1, 4, 5, 26). The size of the pneumothorax may affect the treatment and length of stay in the hospital (26, 27). Thelle et al. found that the duration of hospital stay of PSP patients who underwent tube thoracostomy was approximately two times longer than those who underwent needle aspiration (28). In our study, no significant difference was found between the size of the pneumothorax and the length of hospital stay.

The limitations of our study included its retrospective nature, heterogeneity of patients, the small group of patients with ECG data and the absence of previous ECGs of patients. The missing ECG data was conducted with retrospectively design of our study. Lack of comparative ECG data may have affected the accuracy of the results.

CONCLUSION

ECG and Chest X ray are the most important diagnostic tools used in the differential diagnosis of patients with chest pain and dyspnea. Chest X ray should not be forgotten in patients with abnormal findings in their ECG. Pneumothorax (volume size ≥ 20%) should be included in the differential diagnosis in cases admitted to the emergency department with abnormal findings in their ECG. Further prospective studies are required to define the ECG changes in patients with pneumothorax and the underlying mechanisms of ECG changes.

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