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Research article

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Evaluation of electrocardiographic parameters in patients who had lung resections

Mehmet Sait Altintaş [1], Ferhat Eyyüpkoca [2], Mehmet İnanir [3], Ahmet Öz [4], Ali Cevat Kutluk [5]

[1] Department of Cardiology, Yedikule Training and Research Hospital, Istanbul, Turkey
[2] Department of Cardiology, Sincan Training and Research Hospital, Ankara, Turkey
[3] Department of Cardiology, Bolu Abant İzzet Baysal University Training and Research Hospital, Bolu, Turkey
[4] Department of Cardiology, Istanbul Training and Research Hospital, Istanbul, Turkey
[5] Department of Thoracic Surgery, Yedikule Training and Research Hospital, Istanbul, Turkey

ORCID ID of the author(s)

MSA: 0000-0001-8206-8268
FE: 0000-0003-2630-3619
Mİ: 0000-0003-1784-3584
AÖ: 0000-0003-0268-9641
ACK: 0000-0001-9700-4929

Corresponding Author
Mehmet Sait Altintaş
Department of Cardiology, Yedikule Training and Research Hospital, Istanbul, Turkey
Kazlıçeşme Mh. Belgrad Kapı yolu cad. D:1
34020 Zeytinburnu, Istanbul, Turkey
E-mail: dr.mehmetsait@hotmail.com

Ethics Committee Approval
Approval of the SBU Istanbul Research and Training Hospital Ethics Committee (registration number 2019/1660 and date 01/02/2019) was obtained for the study.
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

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Abstract

Background/Aim: The anatomic location of the heart in the mediastinal space may change and significant electrophysiological changes may appear after pneumonectomy, lobectomy, and segmentectomy. The aim of the present study was to perform a comprehensive investigation of electrocardiographic alterations after lung resection.
Methods: In this retrospective cohort study, sixty-six patients (9 females, 57 males) who had lung resections were enrolled. Electrocardiograms of preoperative (24 hours before operation) and postoperative periods (after operation 7 (2) days) were analyzed.
Result: Postoperative mean Pmin and QRS duration levels were lower than the respective preoperative values. In comparison with preoperative values, postoperative mean P dispersion, QTmax, QTmin, QT mean, QTd, QTc, QTc dispersion, JT, JTc, mean Tpe/QTmean, mean Tpe/QTc ratio (%), and mean Tpe/JT ratio (%) levels were found to be significantly higher. Postoperative mean pulse, mean Pmax, mean PR interval, mean RR, and mean Tpe/JTc ratio were not significantly different when compared with preoperative levels.
Conclusion: Alterations in electrocardiography parameters reflecting the electrophysiology of the heart since heart position basically changes after lung resection may appear.

Keywords: Electrocardiography, Pneumonectomy, QRS, P dispersion

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Introduction

Electrophysiological alterations may appear as a result of a change in the physiological position of the heart in the mediastinum [1]. These electrophysiological changes may appear as life-threatening arrhythmias [2]. This usually occurs as a result of lung resection, which impacts a significant part of the mediastinal space [3, 4]. The anatomic location of the heart in the mediastinal space may change after pneumonectomy, lobectomy, and segmentectomy because of lung tumors, infiltrative pulmonary diseases, chronic obstructive lung disease, emphysema, chronic pulmonary infections, and bronchiectasis [5–7]. Moreover, local infection may occur in the neural structures, pericardium, and atrium after such a significant surgical procedure [8].

It has been known since 1940 that supraventricular arrhythmias such as atrial fibrillation (AF) and atrial flutter, as well as cardiac failure, may develop after clinical practice and lung resection procedures [9, 10]. However, there is no comprehensive study on possible electrocardiography (ECG) changes after lung resection. A limited number of studies focused on the PR distance, QT distance, and QRS complex superficially as ECG changes in a limited number of resection types with fewer cases [3, 8, 9].

Therefore, the aim of the present study was to perform a comprehensive investigation on electrocardiographic alterations in multiple cases after lung resection.

Materials and methods

This retrospective cohort study was conducted in the Cardiology and Thoracic Surgery Clinics of Istanbul Yedikule Training and Research Hospital between February 2019 and August 2019. The study was designed in compliance with the 2013 Declaration of Helsinki and good clinical practices. Approval of the SBU Istanbul Research and Training Hospital Ethics Committee (registration number 2019/1660 and date 01/02/2019) was obtained for the study. Written and verbal consent of the participants was also obtained before the beginning of the study.

Study population

Sixty-six patients (9 females, 57 males) who had lung resections due to malignancy, non-specific infections, or trauma were enrolled in the study. Assuming an alpha of 0.05, a power of 0.80, and 30% change after resection in terms of degree of QRS axis consistent with previous reports, the estimated sample size was at least 40 patients in total.

Patients with previous coronary artery disease, cardiac failure, congenital heart disease, history of pulmonary embolism, chronic obstructive lung disease, history of asthma, or use of anti-arrhythmic drugs were excluded.

Clinical (resection type, ECG findings) and demographic (age, gender) data of all patients were recorded from their files via the hospital's electronic information system.

Electrocardiography

For all participants, a 12-lead ECG recording was performed at preoperative (24 hours before operation) and predischarge (postoperative 7 (2) days) period in the supine position at 50 mm/s paper speed (Nihon Kohden, Tokyo, Japan). ECG measurements were performed by two cardiologists who were blinded to the patient data. Heart rate (HR), maximum P wave duration (Pmax), minimum P wave duration (Pmin), P wave dispersion (Pdisp), PR distance, maximum QT wave duration (QTmax), minimum QT wave duration (QTmin), QT dispersion (QTd), corrected QT interval (QTc), QRS interval, Tpeak to Tend (Tpe), mean QT value (QTmean), QTdc, QTdc dispersion, JT, JT interval (JTc), RR interval, Tpe/Qtmean (%), Tpe/QTc (%), Tpe/JT (%), and Tpe/JTc (%) were measured in all derivations and their means were calculated.

The onset of the P-wave was defined as the junction between the isoelectric line and the beginning of the P-wave deflection. The offset of the P-wave was defined as the junction of the isoelectric line and the end of the P-wave deflection. Maximum P-wave duration was accepted as the longest P-wave and the longest atrial conduction time. The difference between the longest and the shortest P-wave duration was accepted as P-wave dispersion. The QT interval was defined as the distance between the onset of the Q-wave and the offset of the T-wave. Heart rate-corrected QT interval (QT_c) was calculated using Bazett's formula. The JT interval was defined as the distance between the onset of the J-wave and the end of the T-wave and was calculated by subtracting the QRS duration from the QT interval. JT_c was calculated by subtracting the QRS duration from the QT_c interval [11, 12].

Statistical analysis

Statistical evaluation was performed using SPSS 20 for Windows (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test was used to evaluate whether the data were normally distributed. Numerical variables were determined as mean (standard deviation), whereas categorical changes were presented as number and percentage. The changes in ECG findings after the procedure were analyzed by paired samples test and Kruskal-Wallis H test for numerical variables with normal distribution. The effect of resection type on ECG findings was assessed by repeated measures mixed model analysis. Values of $P < 0.05$ were accepted as statistically significant.

Results

The research population consisted of 66 patients including 57 (86.4%) males and 9 (13.6%) females. The average age of the patients was 58.5(10.2) years. At baseline, sixty-five patients (98.5%) had normal sinus rhythm, whereas 1 (1.5%) patient had atrial fibrillation. Right bundle branch block was detected in 3% (n=2) of the patients, left bundle branch block was detected in 1.5% (n=1), and left incomplete block was detected in 3% (n=2). Distributions of demographic findings and operation types are shown in Table 1.

The postoperative changes in ECG findings are shown in Table 2. In brief, postoperative mean Pmin and QRS duration levels were lower than the respective preoperative values. In comparison with preoperative values, postoperative mean P dispersion, QTmax, QTmin, QT mean, QTd, QTc, QTc dispersion, JT, JTc, mean Tpe/QTmean, mean Tpe/QTc ratio (%), and mean Tpe/JT ratio (%) levels were found to be significantly higher. Postoperative mean pulse, mean Pmax, mean PR interval, mean RR, and mean Tpe/JTc ratio were not significantly different when compared with preoperative levels.

Table 1: Baseline demographic and clinical findings of the study population

Variables	n=66
Age, years	58.5(10.2)
Gender, n (%)	
Female	9 (13.6)
Male	57 (86.4)
Rhythm, n (%)	
NSR	65 (98.5)
AF	1 (1.5)
Branch blocks, n (%)	
No	61 (92.4)
Right bundle branch block	2 (3.0)
Left bundle branch block	1 (1.5)
Left incomplete block	2 (3.0)
Resection type, n (%)	
Left pneumonectomy	16 (24.2)
Left upper pneumonectomy	14 (21.2)
Left lower pneumonectomy	9 (13.6)
Right pneumonectomy	2 (3.0)
Right upper pneumonectomy	4 (6.1)
Right lower pneumonectomy	13 (19.7)
Double pneumonectomy	3 (4.5)
Right lower lobectomy	5 (7.6)

The values are expressed as mean (standard deviation), NSR: normal sinus rhythm, AF: atrial fibrillation

Table 2: Changes in ECG findings before and after the operation

Variables	Preoperative n=66	Postoperative n=66	*P*-value
HR, beats/min	85.3(16.7)	85.2(15.7)	0.943
Pmax, ms	110.2(16.7)	110.6(19.6)	0.890
Pmin, ms	86.3(16.3)	82.0(21.3)	0.029*
P disp, ms	23.9(12.9)	28.6(12.6)	0.011*
PR, ms	152.2(22.1)	148.1(24.9)	0.117
QTmax, ms	354.2(30.2)	372.0(33.2)	< 0.001*
QTmin, ms	335.7(30.3)	348.2(31.2)	0.001*
QT disp, ms	18.5(12.1)	23.8(11.7)	0.004*
QTc, ms	406.9(25.7)	424.6(26.8)	< 0.001*
QRS, ms	90.2(17.3)	86.5(19.1)	0.025*
Tpe, ms	68.5(7.8)	74.1(11)	< 0.001*
QTmean, ms	344.9(29.6)	360.1(31.7)	< 0.001*
QTc disp,ms	21.7(13.9)	28.1(13.7)	0.003*
JT, ms	289.3(22.8)	306.5(24.9)	< 0.001*
JTc, ms	342.6(36.7)	362.8(37.2)	< 0.001*
RR	0.7(0.1)	0.7(0.1)	0.994
Tpe/QTmean ratio, (%)	19.9(2.4)	20.7(3.2)	0.029*
Tpe/QTc ratio, (%)	16.9(2.2)	17.5(2.7)	0.013*
Tpe/JT ratio, (%)	23.8(3.5)	24.5(4.9)	0.045*
Tpe/JTc ratio, (%)	20.3(3.6)	20.8(4.6)	0.072

The values are expressed as mean (standard deviation), HR: heart rate, max: maximum, min: minimum, disp: dispersion, min: minutes, ms: milliseconds

Discussion

Lung resection was found to be associated with some postoperative thoracic anatomic changes and hemodynamic changes that may cause significant electrocardiographic changes. Depending on the reason for the pulmonary resection, the procedure may vary from a small segmental resection to the resection of a whole lobe or the lung itself. This clinically means that possibly fatal arrhythmias may appear during the postoperative period. So, in the present study, we investigated preoperative and postoperative ECG changes of patients who had lung resections as a result of different causes.

In our study, QRS duration and Pdisp were found to be decreased in the postoperative period when compared with the preoperative period. The QRS complex reflects ventricle depolarization. QRS duration changes depending on the vertical or horizontal position of the heart in slim and overweight individuals. The position of the heart changes after pneumonectomy, and the axis slides. Therefore, the duration of ventricle depolarization changes. Apart from that, decreased QRS durations, or namely narrow QRS complexes, may be associated with aberrant conduction of supraventricular complexes. This is related to pneumonectomy [13–15]. Pmin indicates the minimum P wave duration. Increased preload, presence of right and left atrial dilatation, and external pressure of the heart may cause an increase in the duration of Pmin. The possible cause of the decrease in Pmin level after lung resection may be associated with the elimination of previous pathologies of the lung by the procedure, along with the change of the heart's position. Guntekin et al. [16] reviewed P wave duration according to the altitude level of subjects' places of residence. The Pmin level was found to be higher in people living at higher altitudes than those living at sea level.

The increase of the postoperative Pdisp level may have been caused by the following factors: (a) significant perioperative fluid losses that contribute to increased atrial strain, (b) atrial pressure increased due to postoperative ventricular stunning, (c) increased sympathetic stimulus increased just after the surgery, and (d) mediastinal or cardiac dislocation [8]. Tukek et al. [17] conducted a study of patients with chronic obstructive pulmonary disease and considered an association between newly developed atrial fibrillation and prolonged Pdisp. Senen et al. [18] reviewed P wave duration and Pdisp in patients with dilated cardiomyopathy. They reported that Pdisp was higher in the dilated cardiomyopathy group than the healthy control group. Supraventricular tachycardia, i.e., atrial fibrillation frequency, increases in both situations stated above. We know that the incidence of supraventricular tachycardia increases after lung resection. Therefore, we believe that increased Pdisp durations may be associated with arrhythmia [9].

In the present study, we found that postoperative QTmax, mean QTmin, mean QTd, mean QTc, mean Tpe, mean QTort, and mean QTdc increased after surgery. General mean QRS vector and QRS vector shift presented a quantitative correlation in the majority of the patients for each subtype of lung resection. The most likely cause of the change in mean QRS axis shift towards a mediastinal shift after lung resection is the rapid wave nature of QRS and the appearance of a left ventricle-dependent vector pattern [8]. Dispersion of the QT interval shows regional heterogeneity in myocardial repolarization. An increase is accepted as a non-invasive indicator of the risk of increased ventricular arrhythmia [19]. Because the incidence of arrhythmia may increase after lung resection, increases in QTc, QTd, QTmin, and QT max levels are acceptable.

It is known that the JT interval indicates ventricle repolarization in ECG. Some previous studies reported that the JT interval indicated ventricle repolarization better than the QT interval [20]. An increased JT interval after lung resection indicates the increase of ventricle repolarization. A difference in excitability may appear along with the change in the location of the heart. This may contribute to changes of depolarization and repolarization phases.

Limitations

The primary limitation of the present study is its retrospective cohort design. The retrospective design does not make it possible to provide sufficient information about hemodynamic changes, electrolyte imbalance, or medical therapies used. The second limitation is the relatively small number of patients. Therefore, study population could not be grouped according to the etiology of pneumonectomy. Therefore, there is a need for studies with a larger number of patients and with a prospective design.

Conclusion

Before evaluating the ECG, the clinician should keep in mind that some alterations in electrocardiography parameters reflecting the electrophysiology of the heart may occur because the heart's position can change after lung resection. According to this study analysis, a decrease was detected in Pmin and QRS durations after lung resection. Furthermore, the mean Pdisp, QTmax, QTmin, QTd, QTc, Tpe, QTort, QTdc, and JT were detected to be increased postoperatively.

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