Tissue Doppler evaluation of the effects of major lung resection on cardiac functions

Majör akciğer rezeksiyonunun kardiyak fonksiyonlar üzerine etkisinin doku Doppler ekokardiyografi ile değerlendirilmesi

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Objectives: The aim of our study was to evaluate the influence of lung resection on cardiac functions by using tissue Doppler echocardiography.

Study design: Nineteen consecutive patients (15 males, 4 females; mean age 55±8 years) undergoing major lung surgery (16 lobectomy, 3 pneumonectomy) were evaluated in a prospective design. Malignant lung cancer (n=15, 79%) was the major cause for lung surgery. Exclusion criteria were a history of myocardial infarction, angina, atrial fibrillation, valvular heart disease, major arrhythmias, diastolic dysfunction, heart surgery, and FEV_1/FVC ratio lower than 60%. Two-dimensional Doppler echocardiography and tissue Doppler imaging (TDI) were performed one or two days before surgery and 4±2 weeks postoperatively.

Results: Compared to the preoperative measurements, right and left atrial and ventricular dimensions did not differ after surgery (p>0.05). Left ventricular ejection fraction, left ventricular end-systolic and end-diastolic volumes were preserved postoperatively. The following Doppler parameters showed significant changes after surgery: mitral A wave (92±23 cm/sec *vs.* 105±27 cm/sec, p=0.005), mitral E/A ratio (1.0±0.2 *vs.* 0.8±0.2, p=0.001), tricuspid A wave (65±19 cm/sec *vs.* 80±30 cm/sec, p=0.006), and tricuspid E deceleration time (327±68 msec *vs.* 274±51 msec, p=0.01). Concerning TDI parameters, there were significant differences in mitral E´/A´ ratio (1.0±0.4 *vs.* 0.8±0.3, p=0.03) and tricuspid E´ wave (9±2 cm/sec *vs.* 8±3 cm/sec, p=0.03) after surgery.

Conclusion: Findings of our study suggest that systolic functions are preserved but diastolic functions are affected after major lung resection in a relatively short time period.

Key words: Echocardiography, Doppler; lung/surgery; lung neoplasms/surgery; ventricular function, left.

Amaç: Majör akciğer rezeksiyonlarının kardiyak fonksiyonlar üzerine etkisi doku Doppler ekokardiyografi ile değerlendirildi.

Çalışma planı: Çalışmada majör akciğer rezeksiyonu uygulanan 19 hasta (15 erkek, 4 kadın; ort. yaş 55±8) ileriye dönük olarak incelendi. On altı hastada lobektomi, üç hastada pnömonektomi uygulandı. Akciğer cerrahisinin en sık nedeni (n=15, %79) malign akciğer kanseriydi. Miyokart enfarktüsü, anjina, atriyal fibrilasyon, kalp kapak hastalığı, önemli aritmi, diyastolik disfonksiyon, kalp cerrahisi öyküsü olan veya FEV_1/FVC oranı %60'ın altında olan hastalar çalışmaya alınmadı. Tüm hastalar ameliyattan 1-2 gün önce ve ameliyattan 4±2 hafta sonra ikiboyutlu Doppler ekokardiyografi ve doku Doppler görüntüleme ile değerlendirildi.

Bulgular: Ameliyat öncesi ile karşılaştırıldığında, cerrahi sonrasında sağ ve sol atriyum ve ventrikül boyutlarında anlamlı değişiklik görülmedi (p>0.05). Sol ventrikül ejeksiyon fraksiyonu, sol ventrikül sistol ve diyastol sonu hacimleri korunmuştu. Cerrahi sonrasında anlamlı değişim gösteren Doppler parametreleri şunlardı: mitral A dalgası (92±23 cm/sn ve 105±27 cm/sn, p=0.005), mitral E/A oranı (1.0±0.2 ve 0.8±0.2, p=0.001), triküspit A dalgası (65±19 cm/sn ve 80±30 cm/sn, p=0.006) ve triküspit E yavaşlama zamanı (327±68 msn ve 274±51 msn, p=0.01). Doku Doppler ölçümlerinde ise, mitral E´/A´ oranı (1.0±0.4 vs. 0.8±0.3, p=0.03) ve triküspit E´ dalgası (9±2 cm/sn ve 8±3 cm/sn, p=0.03) cerrahi öncesine göre anlamlı değişim gösterdi.

Sonuç: Bulgularımız, majör akciğer cerrahisinden sonra oldukça kısa bir zaman dilimi içinde sistolik fonksiyonlarda değişim olmazken, diyastolik fonksiyonların etkilendiğini göstermektedir.

Anahtar sözcükler: Ekokardiyografi, Doppler; akciğer/cerrahi; akciğer neoplazileri/cerrahi; ventrikül fonksiyonu, sol.

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It is well known that major lung operations substantially lessen the pulmonary vascular bed, resulting in a subsequent increase in the right ventricle afterload. Short- and long-term effects of pulmonary surgery on cardiac functions have been studied by using standard echocardiographic techniques.[1,2] Invasive hemodynamic measurements have also been performed before, during, and after pulmonary resections.[3,4] However, these studies were mainly designed to examine the effects on the right heart. There has been no report on the effect of pulmonary operations on left ventricular systolic functions.

Ventricular volume status, left atrial pressure, and rate of myocardial relaxation can significantly affect Doppler measurements of ventricular filling velocities.[5,6] Therefore, Doppler echocardiography has some limitations on evaluation of systolic and diastolic functions. Recently, tissue Doppler imaging (TDI), an ultrasound modality that records systolic and diastolic velocities within the myocardium and at the corners of the annulus, has been shown to provide accurate quantification of regional and global cardiac functions.[7-9]

We investigated, in a prospective design, whether tissue Doppler echocardiographic parameters changed after major lung surgery.

PATIENTS AND METHODS

Nineteen consecutive patients (15 males, 4 females; mean age 55±8 years) undergoing major lung surgery (16 lobectomy, 3 pneumonectomy) were included in this prospective study. We excluded patients with a previous history of myocardial infarction, angina, atrial fibrillation, valvular heart disease, major arrhythmias, diastolic dysfunction, and heart surgery. Patients with an FEV_1/FVC ratio lower than 60% were also excluded to avoid right heart modifications related to severe chronic obstructive pulmonary disease. All patients underwent preoperative chest X-ray, ECG, spirometry, and blood gas analysis. Two-dimensional, Doppler echocardiography and TDI were performed one or two days before surgery and 4±2 weeks postoperatively. Images were obtained according to the guidelines of the American Society of Echocardiography and stored in a GE/Vingmed Vivid 7 digital ultrasound system (GE Vingmed Ultrasound; GE Vingmed Ultrasound AS, Horten, Norway).[10,11] On the same day of echocardiographic examination, echocardiographic variables were measured offline from digital recordings by an observer who was unaware of the results of the study. Peak velocities of early (E) and late (A) diastolic filling, deceleration time, and isovolumic relaxation time were derived from Doppler recordings of the mitral valve inflow and aortic valve outflow.[12] Peak diastolic filling velocities and deceleration time of the tricuspid valve inflow were also recorded. The index of isovolumic contraction time plus isovolumic relaxation time divided by ejection time (Tei index) was calculated.[13] For TDI recordings, from the apical window, a 5-mm sample volume was located at the septal and lateral sides of the mitral valve annulus in the 4-chamber view, and at the anterobasal and inferior sites in the 2-chamber view.[12] Tricuspid annular TDI recordings were obtained only from the lateral side in the 4-chamber view. Peak systolic velocity (S'), early (E') and late (A') diastolic velocities, and E'/A' ratio were measured. Mitral and tricuspid valve E/E' ratios were calculated.[14,15] The average of three measurements was calculated for each patient.

Statistical analyses were performed using the SPSS software (version 10.0). Numerical values were expressed as mean±standard deviation (SD), and categorical variables as percentages. Nonparametric Wilcoxon test was used to analyze quantitative continuous variables for comparison of two related means. Spearman's correlation coefficient was used to assess correlations between echocardiographic variables and age, heart rate, hypertension, FEV_1/FVC ratio, and body mass index (BMI). A p value of less than 0.05 was considered to indicate statistical significance.

RESULTS

Table 1 summarizes surgical and preoperative clinical data. Malignant lung cancer (n=15, 79%) was the major cause for lung surgery. Two patients had tuber-

Table 1. Preoperative and surgical clinical data

	n	%	Mean±SD
Age (years)			55±8
Male	15	79.0	
Smoking	10	52.6	
Diabetes mellitus	2	10.5	
Hypertension	3	15.8	
Body mass index (kg/m²)			25±6
FEV¹/FVC (%)			71±8
Malignant lung cancer	15	79.0	
Tuberculosis	2	10.5	
Inflammatory lung disease	1	5.3	
Lung abscess	1	5.3	
Lobectomy	16	84.2	
Pneumonectomy	3	15.8	

FEV_1: Forced expiratory volume in the first second; FVC: Forced expiratory vital capacity.

Table 2. Echocardiographic data before and after surgery

	Before	After	*p*
Left atrial diameter (mm)	30±4	29±5	0.39
Interventricular septum thickness (mm)	10±2	9±2	0.38
Posterior wall thickness (mm)	1±2	1±1	0.86
Left ventricular			
End-systolic diameter (mm)	30±7	28±6	0.12
End-diastolic diameter (mm)	44±7	41±7	0.07
End-systolic volume (ml)	26±9	26±9	0.90
End-diastolic volume (ml)	79±22	77±23	0.80
Ejection fraction (%)	65±4	61±15	0.30
Right atrial diameter (mm)	29±4	30±5	0.61
Right ventricular end-diastolic diameter (mm)	27±3	27±4	0.64
Mitral velocities			
E (cm/sec)	90±23	87±28	0.42
A (cm/sec)	92±23	105±27	**0.005**
E/A ratio	1.0±0.2	0.8±0.2	**0.001**
E deceleration time (msec)	266±60	277±77	0.49
Isovolumic relaxation time (msec)	69±20	64±16	0.19
Tei index	0.37±0.22	0.32±0.19	0.34
Tricuspid velocities			
E (cm/sec)	67±13	72±27	0.39
A (cm/sec)	65±19	80±30	**0.006**
E/A ratio	1.1±0.2	1.0±0.4	0.30
E deceleration time (msec)	327±68	274±51	**0.01**
Tissue Doppler parameters			
Mitral S´ (cm/sec)	9±1	10±1	0.74
Mitral E´ (cm/sec)	9±2	8±2	0.06
Mitral A´ (cm/sec)	10±2	10±2	0.28
Mitral E´/A´ ratio	1.0±0.4	0.8±0.3	**0.03**
Mitral E/E´ ratio	10±3	11±3	0.50
Tricuspid S´ (cm/sec)	13±2	13±3	0.92
Tricuspid E´ (cm/sec)	9±2	8±3	**0.03**
Tricuspid A´ (cm/sec)	15±3	15±3	0.73
Tricuspid E´/A´ ratio	0.6±0.2	0.6±0.2	0.19
Tricuspid E/E´ ratio	7±2	10±6	0.07
Heart rate (bpm)	78±13	90±12	**0.001**

S´: Peak systolic annular velocity; E´: Peak early diastolic annular velocity; A´: Peak late diastolic annular velocity.

culosis, one patient had inflammatory lung disease, and one had lung abscess.

Standard echocardiographic and Doppler measurements. Pre- and postoperative echocardiographic variables are presented in Table 2. Compared to the preoperative two-dimensional echocardiographic measurements, right atrial, left atrial, right ventricular end-diastolic, left ventricular end-diastolic, and left ventricular end-systolic dimensions did not differ (p>0.05). Left ventricular ejection fraction, left ventricular end-systolic and end-diastolic volumes were preserved postoperatively (Table 2).

The following Doppler echocardiographic parameters of diastolic function showed significant differences after surgery: mitral A wave (92±23 cm/sec *vs*. 105±27 cm/sec, p=0.005), mitral E/A ratio (1.0±0.2 *vs*. 0.8±0.2, p=0.001), tricuspid A wave (65±19 cm/sec *vs*. 80±30 cm/sec, p=0.006), and tricuspid E deceleration time (327±68 msec *vs*. 274±51 msec, p=0.01). Tricuspid deceleration time was inversely correlated with heart rate (r=-0.524, p=0.02) and BMI (r=-0.546, p=0.01). The remaining echocardiographic variables showed no correlations with age, heart rate, hypertension, FEV_1/FVC ratio, or BMI.

TDI parameters. There were significant differences in mitral E´/A´ ratio (1.0±0.4 *vs*. 0.8±0.3, p=0.03) and tricuspid E´ wave (9±2 cm/sec *vs*. 8±3 cm/sec, p=0.03) after surgery. Mitral E´ wave and tricuspid E´/A´ ratio decreased postoperatively, but these did not reach a significant level. There was no difference in other TDI parameters (Table 2).

DISCUSSION

Several studies primarily evaluated the right ventricular function after major lung surgery by using standard echocardiography and Doppler technique.[1,2,16] These reports concentrated on the early postoperative period, medium-term (6 months) and long-term up to the first four years after surgery. The results showed that pneumonectomy caused an important reduction in the vascular bed, resulting in a progressive increase in pulmonary artery systolic pressure starting at the end of the first postoperative week, and induced modifications of the right ventricular morphology.[1,2,16] It should be recalled that mitral inflow determined by Doppler technique is influenced by several variables, such as ventricular loading and heart rate.[5,6,17] Some studies reported that tachycardia did not influence early deceleration time.[18,19] Likewise, parameters of right ventricular diastolic performance are dependent on heart rate, age, and tricuspid regurgitation.[20] Therefore, Doppler echocardiography has some limitations on evaluation of cardiac functions after lung surgery. Tissue Doppler imaging has gained popularity by enabling relatively accurate quantification of regional and global cardiac systolic and diastolic functions.[9,14,21]

To the best of our knowledge, our study is the first to evaluate ventricular systolic and diastolic functions in a medium-term period (up to 3 months) by using TDI in patients undergoing pulmonary surgery. We found that right and left ventricular dimensions and indexes of systolic functions assessed by conventional echocardiography and TDI did not change during the

first three months postoperatively. We determined that diastolic parameters could be affected after surgery and these changes were independent from age and heart rate.

Our study has some limitations. The sample size was small and the duration of the study was relatively short. Larger studies with extended follow-up periods would provide more insight into ventricular systolic and diastolic changes occurring after pulmonary surgery.

In conclusion, systolic functions are preserved, but diastolic functions are affected after major lung surgery.

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