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EVALUATION OF RISK FACTORS FOR CARDIAC COMPLICATIONS AFTER LUNG RESECTION

AKCİĞER REZEKSİYONU SONRASI KARDİAK KOMPLİKASYONLAR İÇİN RİSK FAKTÖRLERİNİN DEĞERLENDİRİLMESİ

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Abstract

Aim: The aim of this study is to evaluate cardiac complications (CC) and risk factors associated with these complications in patients after lung resection.

Methods: Cardiac complications were observed in 136 (11.4%) of 1186 patients who underwent lung resection in a single center between 2017 and 2020. 136 patients who developed complications in the same period and 215 patients who had consecutive operations and did not develop complications were included in the study

Results: 287 (81.7%) of the patients were male and the mean age was 58.9 years. There is a statistically significant relationship between cardiac complications after lung resection with geriatric age, male gender, presence of hypertension (HT), presence of lung cancer, neoadjuvant therapy, high SOFA score, chronic obstructive pulmonary disease (COPD), and cerebrovascular accident (CVA). In addition, CVA, EF<60%, neoadjuvant therapy, pneumonectomy, high Sequential Organ Failure Assessment score (SOFA) and intraoperative blood transfusion were found to be independent risk factors for the development of complications. Among the intraoperative factors, pneumonectomy (p<0.001), thoracotomy (p=0.002), intraoperative blood product use (p<0.001) and inotropic use (p<0.001) were correlated with CC. In multiple logistic regression analysis, preoperative thyroid disease (p=0.04), CVA (p=0.001), neoadjuvant therapy (p=0.002), EF<60% (p=0.01), pneumonectomy (p=0.003), intraoperative blood transfusion (p<0.0001) and high SOFA score (p<0.0001) emerged as independent risk factors affecting the development of cardiac complications.

Conclusions: There is significant relationship between cardiac complications after lung resection with geriatric age, male sex, HT, lung cancer presence, neoadjuvant therapy, high SOFA score, COPD, CVA presence. In addition, CVA, EF< 60%, neoadjuvant therapy, pneumonectomy and high SOFA score and intraoperative blood transfusion were identified as independent risk factors in the development of complications.

Keywords: Lung resection, cardiac complications, atrial fibrillation, thoracotomy, video-assisted thoracoscopic surgery

Öz

Amaç: Bu çalışmanın amacı akciğer rezeksiyonu sonrası hastalarda görülen kardiyak komplikasyonlar (KK) ve bu komplikasyonlarla ilişkili risk faktörlerini değerlendirmektir.

Yöntemler: 2017-2020 yılları arasında tek bir merkezde akciğer rezeksiyonu yapılan 1186 hastanın 136'sında (%11,4) kardiyak komplikasyon gözlendi. Aynı dönemde komplikasyon gelişen 136 hasta ve ardışık ameliyat olan ve komplikasyon gelişmeyen 215 hasta çalışmaya dahil edildi.

Bulgular: Hastaların 287'si (%81,7) erkekti ve yaş ortalaması 58,9'du. Geriatrik yaş, erkek cinsiyet, hipertansiyon (HT), akciğer kanseri varlığı, neoadjuvan tedavi, yüksek SOFA skoru, kronik obstrüktif akciğer hastalığı (KOAH) ve serebrovasküler olay (SVO) ile akciğer rezeksiyonu sonrası kardiyak komplikasyonlar arasında istatistiksel olarak anlamlı bir ilişki vardır. Ayrıca SVO, EF<%60, neoadjuvan tedavi, pnömonektomi, Sıralı Organ Yetmezliği Değerlendirme Skoru (SOFA) ve intraoperatif kan transfüzyonu komplikasyon gelişimi için bağımsız risk faktörleri olarak bulundu. İntraoperatif faktörlerden pnömonektomi (p<0,001), torakotomi (p=0,002), intraoperatif kan ürünü kullanımı (p<0,001) ve inotrop kullanımı (p<0,001) KK ile korele idi. Çoklu lojistik regresyon analizinde, preoperatif tiroid hastalığı (p=0,04), SVO (p=0,001), neoadjuvan tedavi (p=0,002), EF<%60 (p=0,01), pnömonektomi (p=0,003), intraoperatif kan transfüzyonu (p<0,0001) ve yüksek SOFA skoru (p<0,0001) kardiyak komplikasyon gelişimini etkileyen bağımsız risk faktörleri olarak gözlendi.

Sonuç: Geriatrik yaş, erkek cinsiyet, HT, akciğer kanseri varlığı, neoadjuvan tedavi, yüksek SOFA skoru, KOAH, SVO varlığı ile akciğer rezeksiyonu sonrası kardiyak komplikasyonlar arasında anlamlı ilişki vardır. Ayrıca SVO, EF<%60, neoadjuvan tedavi, pnömonektomi ve yüksek SOFA skoru ve intraoperatif kan transfüzyonu komplikasyon gelişmesinde bağımsız risk faktörleri olarak gözlendi.

Anahtar Kelimeler: Akciğer rezeksiyonu, kardiyak komplikasyonlar, atriyal fibrilasyon, torakotomi, video yardımlı torakoskopik cerrahi

Introduction

Patients who have undergone thoracotomy with lung resection encounter cardiac problems that cause high postoperative morbidity and mortality in the perioperative period. Despite advances in surgical technique and approach, the mortality rate is in the range of 2-12% [1]. Despite advanced and aggressive perioperative management, various types of arrhythmias, hemodynamic instability, acute coronary disease, angina, myocardial infarction, heart failure (HF) and thromboembolism can still be observed. These complications bring along many problems such as increased mortality and mortality rate, long-term hospitalization, need for intensive care, and increased costs [2,3]. Risk factors for perioperative mortality such as being over 70 years old, forced expiratory volume in 1 second less than 41%, cardiac disease, chronic diseases such as chronic obstructive pulmonary disease and diabetes, right hemithorax surgery, unsuccessful extubation and perioperative fluid management have been identified [4]. However, it is difficult to determine the effect of these factors on results independently because the number of studies on this subject is limited.

The primary aim of this study is to detect and evaluate the cardiac complications of patients who underwent lobectomy and pneumonectomy for lung resection within 30 days postoperatively.

Materials and Methods

- *Patients and Perioperative Management*

A total of 1186 patients who were operated for lung resection (lobectomy, pneumonectomy) at Yedikule Chest Diseases and Thoracic Surgery Training and Research Hospital between January 2017 and January 2020 were included in the study. We aimed to evaluate the postoperative cardiac complications (PCC) occurring within 15 days postoperatively between these dates. Data of 136 patients who developed PCC during the specified study period were analyzed. 215 patients who were operated in the same period and who did not develop any cardiac complications and who underwent lung resection were randomly selected and evaluated as a control group. The data of these 215 patients were included in the study because they were found to be reliable. Thirty-two patients with preoperative cardiac arrhythmia who were on antiarrhythmic therapy and whose arrhythmia continued after the operation were excluded from the study.

Preoperative clinical cardiological and anesthesia evaluation, PA Chest X-ray, computed tomography (CT), 12-lead electrocardiography (ECG) and pulmonary function tests (PFT) were applied to all patients. Operation capability was determined according to the determined surgical guidelines. Lung resections were performed by open thoracotomy or video-assisted thoracic surgery (VATS).

Surgical and anesthesia teams, standard surgical approach and anesthesia management were used throughout the study period and remained constant throughout the study. Short-term antibiotic prophylaxis was routinely administered intravenously (iv) (ampicillin / sulbactam 3 g) before anesthesia. Premedication was performed with midazolam before the induction of general anesthesia. After applying propofol 2 mg / kg, fentanyl 2-3 mcg / kg, rocuronium bromide (0.5 mg / kg) and endotracheal intubation with a double lumen tube, anesthesia was maintained with 50% 02, 50% air and 2% sevoflurane. Pathological lung cancer staging was evaluated according to the TNM classification. At the end of the operation, two chest tubes were placed in the thoracic cavity and removed when there was no air leak, and the pleural drainage output was <150 mL / 24 hours.

Unless contraindicated, 0.1 mg / kg of morphine, 1000 mg of paracetamol, and 1 mg / kg of tramadol hydrochloride were

administered iv to all patients for pain relief near the end of the operation. During the intensive care follow-up, pain control was provided as patient-controlled analgesia with 300 mg tramadol hydrochloride / 24 hours iv. The pain levels of the patients were evaluated with a visual pain scale. Care was taken to keep the pain level between 0-4 points. Low molecular weight heparin was given for 2-4 weeks postoperatively.

Postoperative patients were transferred to the general intensive care unit (ICU) and were followed up for 24 hours. To prevent hypoxia, nasal (1-2 L / min) or continue positive airway pressure (CPAP) approach was used when necessary. The PO_2 value of the cases was tried to be maintained between 70-100 mmHg and PCO_2 value between 40-55 mmHg. Heart rate (HR), ECG, oxygen saturation (SPO_2), central venous-arterial pressures and arterial blood gases were continuously monitored during the stay at the ICU. Central venous pressure (CVP) was monitored at regular intervals. If ventricular contraction was significantly impaired, inotropic support was provided with norepinephrine bitartarate, dopamine HCl or doputamine HCl. The perioperative need for blood products was determined on an individual, patient basis; In general, blood transfusions were administered when hemoglobin was <8.5 g / dl, efforts were made to keep the hemoglobin value above 10 g / dl. Postoperative fibro-bronchoscopy (FBS) was performed in the case of lung atelectasis and to obtain bronchial secretion samples for microbiological examinations. An active postoperative respiratory physiotherapy program, including deep breathing exercises, was applied to all patients. Mechanical ventilation support was started in case of respiratory failure. Early oral nutrition and mobilization was initiated.

Approval was obtained from the Ethics Committee of Istanbul Yedikule Chest Diseases and Chest Surgery Training and Research Hospital for this study (2020-34) . All patients have written consent for the use of their medical information after the operation.

- *Cardiac monitoring and definition*

Cardiac monitoring was followed by the daily practice of an integrated clinic that shared the same routine and data collection system over heart rhythm, arterial blood pressure, CVP, SPO_2, and included ICU and service level. Patients were monitored with continuous ECG for at least 24 hours postoperatively. Additional records were collected in the presence of a cardiac pathology. Arrhythmia was defined by physician evaluation based on a radiotherapy strip or a 12-lead ECG recording. Arrhythmias are classified as atrial fibrillation (AF), supraventricular tachycardia (SVT), ventricular extra systole (VES), bradycardia, ventricular fibrillation (VF), and ventricular tachycardia (VT). Patients with abnormal cardiac findings were evaluated by a cardiologist with echocardiography (ECHO), and treatments were planned according to the results of the consultation. Amiodarone, administered orally or iv, has formed the standard pharmacological treatment of AF. Amiodorone was administered as a 24-hour infusion after the loading dose. Diltiazem HCI and metoprolol ampoule intravenous forms were also used when necessary. In the case of recurrence of AF, the same protocol was used. In the case of hypotension, sympathomimetic agents (norepinephrine bitartarate, dopamine HCI, doputamine HCI) were administered at the appropriate dose. In the case of hypertension, treatment was provided by iv glyceryl trinitrate or oral antihypertensive drugs.

- *Collection of data*

In 384 patients, demographic data from preoperative, intraoperative and post-operative variables, accompanying diseases, lung function, neoadjuvant therapy, type and degree of cancer, type of surgical procedure and postoperative

complications were recorded retrospectively. Study data were obtained from patients' preoperative anesthesia evaluation form, laboratory information, consultations, intraoperative patient records, service and intensive care follow-up forms. Cardiac complications were collected under the headings of arrhythmias, hemodynamic instability, acute coronary disease, angina, heart failure (HF) and thromboembolism. Non-cardiac complications accompanying cardiac complications were recorded as respiratory failure, pneumonia, renal failure (RF), cerebrovascular accident (CVA), and pulmonary embolism. Patients with chronic heart rhythm disorder were not included in the evaluation.

- *Statistical analysis*

The demographic characteristics of the patients and the collected data were entered into IBM® SPSS® (the Statistical Package for the Social Sciences) Statistics version 23. Variables were characterized using mean, maximum, and minimum values, percentages were used for qualitative variables. Normal distributions were reported as mean ± SD, and Student's t-test was used for comparisons between groups. For the analysis of qualitative variables, Pearson's chi-square test, if the group was small, Fisher's exact test was used. Nonparametric continuous variables were recorded as median and spatial distribution and compared using Mann-Whitney U tests. A $p < 0.05$ value was considered statistically significant. Parametric and nonparametric values were compared in terms of postoperative cardiac complications (PCC). In multivariate analysis, parametric and nonparametric variables were evaluated using only the parametric and nonparametric variables that were statistically revealed to have an effect on PCC development in single variable analysis, and independent risk factors were determined.

Results

Demographic, preoperative, peroperative and postoperative data of the patients in the study are shown in Table 1.

Cardiac arrhythmias include AF (n = 90, 66.2%), SVT (n = 20, 14.8%), Asystole (n = 6, 4.4%), VES (n = 7, 5.1%), and VF/VT (n = 8, 6%) was observed. Hemodynamic instability developed in 27.9% of those who developed PCC, heart failure in 9 (6.6%), angina in 8 (5.9%) and MI in 5 patients (3.7%). Additional complications developed in 45 (33.1%) of the patients who developed PCC. Respiratory failure in 30 (22.1%) patients, pneumonia in 6 (4.4%), CVA in 5 (3.7%), and RF in 3 (2.2%) patients. Mechanical ventilator support (intubation, CPAP) was applied for an average of 1.4 days in the patients who developed respiratory failure.

Considering the preoperative findings, over 65 years old ($p = 0.001$), male ($p = 0.02$), ASA III-IV ($p < 0.001$), CHF ($p < 0.001$), CAD ($p = 0.003$), HT ($p = 0.002$), hyperlipidemia ($p < 0.001$), COPD ($p < 0.001$), thyroid disease ($p = 0.003$), CRF ($p = 0.03$), CVA ($p < 0.001$), rhythm disturbance presence ($p < 0.001$), lung cancer ($p = 0.008$), neoadjuvant ($p < 0.001$) and EF values <60% ($p < 0.001$) were statistically significantly associated with cardiac complication. Considering the peroperative findings, VATS ($p = 0.02$), pneumonectomy ($p < 0.001$), left-sided disease ($p = 0.04$), intraoperative inotropic ($p < 0.001$), intraoperative blood transfusion ($p < 0.001$), and revision due to bleeding ($p < 0.001$) were associated with cardiac complication. It was observed that patients who developed PCC were older than those who did not (62.2 ± 9.9 years versus 56.7 ± 13.0 years, $p < 0.001$). There was no significant difference between patients with and without PCC in terms of other variables (Table 1).

Table 1. Comparison of demographic and pre/intraoperative data in patients with and without postoperative cardiac complications (PCC)

Variables		Total (n=351)	Non-PCC (n=215)	PCC (n=136)	*Odds Ratio*	*95% CI*	*p value*
			Preoperative				
Age (years), n (%)	<65	226 (64.4%)	153 (71.2%)	73 (53.7%)	2.130	1.361-3.333	0.001
	≥65	125 (35.6%)	62 (28.8%)	63 (46.3%)			
Gender, n (%)	Male	287 (81.8%)	168 (78.1%)	119 (87.5%)	0.511	0.280-0.933	0.02
	Female	64 (18.2%)	47 (21.9%)	17 (12.5%)			
CHF, n (%)	yes	43 (12.3%)	8 (3.7%)	35 (25.7%)	0.112	0.050-0.249	<0.001
	no	308 (87.7%)	207 (96.3%)	101 (74.3%)			
CAD, n (%)	yes	61 (17.4%)	27 (12.6%)	34 (25.0%)	0.431	0.246-0.754	0.003
	no	290 (82.6%)	188 (87.4%)	102 (75.0%)			
HT, n (%)	yes	122 (34.8%)	61 (28.4%)	61 (44.9%)	0.487	0.311-0.763	0.002
	no	229 (65.2%)	154 (71.6%)	75 (55.1%)			
HL, n (%)	yes	25 (7.1%)	7 (3.3%)	18 (13.2%)	0.220	0.089-0.543	<0.001
	no	326 (92.9%)	208 (96.7%)	118 (86.8%)			
DM, n (%)	yes	59 (16.8%)	35 (16.3%)	24 (17.5%)	0.907	0.513-1.605	0.738
	no	292 (83.2%)	180 (83.7%)	112 (82.4%)			
COPD, n (%)	yes	158 (45.0%)	83 (38.6%)	75 (55.1%)	0.511	0.089-0.543	<0.001
	no	193 (55.0%)	132 (61.4%)	61 (44.9%)			
Thyroid disease, n (%)	yes	16 (4.6%)	4 (1.9%)	12 (8.8%)	0.196	0.062-0.621	0.003
	no	335 (95.4%)	211 (98.1%)	124 (91.2%)			
CRF, n (%)	yes	6 (1.7%)	1 (0.5%)	5 (3.7%)	0.122	0.014-1.060	0.03
	no	345 (98.3%)	214 (99.5%)	131 (96.3%)			
CVA, n (%)	yes	28 (8.0%)	4 (1.9%)	24 (17.6%)	0.088	0.030-0.261	<0.001
	no	323 (92.0%)	211 (98.1%)	112 (82.4%)			
MI/Angio/Bypass, n (%)	yes	24 (6.8%)	12 (5.6%)	12 (8.8%)	0.610	0.266-1.402	0.241
	no	327(93.2%)	203 (94.4%)	124 (91.2%)			
Operation reason, n (%)	Lung cancer	328 (97.8%)	195 (90.7%)	133 (97.8%)	0.220	0.064-0.755	0.008

	Bronchiectasis	23 (6.6%)	20 (9.3%)	3 (2.2%)			
Neoadjuvant therapy, n (%)	yes	31 (8.8%)	8 (3.7%)	23 (16.9%)	0.190	0.082-0.438	<0.001
	no	320 (91.2%)	207 (96.3%)	113 (83.1%)			
EF, n (%)	≥ 60%	230 (65.5%)	173 (80.5%)	57 (41.9%)	5.709	3.535-9.219	<0.001
	< 60%	121 (34.5%)	42 (19.5%)	79 (58.1%)			
Intraoperative							
Operation mode, n (%)	Thoracotomy	259 (73.8%)	168 (78.1%)	91 (66.9%)	1.768	1.092-2.862	0.02
	VATS	92 (26.2%)	47 (21.9%)	45 (33.1%)			
Operation mode, n (%)	Lbc/segm	277 (78.9%)	188 (87.4%)	89 (65.4%)	3.677	2.151-6.287	<0.001
	Pnmc	74 (21.1%)	27 (12.6%)	47 (34.6%)			
Operation side, n (%)	Right	160 (45.6%)	107 (49.8%)	53 (39.0%)	1.522	1.003-2.400	0.04
	Left	191 (54.4%)	108 (50.2%)	83 (61.0%)			
Inotrope use, n (%)	yes	23 (6.6%)	1 (0.5%)	22 (16.2%)	0.024	0.003-0.182	<0.001
	no	328 (93.4%)	214 (99.5%)	114 (83.8%)			
Blood product received, n (%)	yes	75 (21.4%)	9 (4.2%)	66 (48.5%)	0.046	0.022-0.098	<0.001
	no	276 (78.6%)	206 (95.8%)	70 (51.5%)			
Revision due to hemorrhage, n (%)	yes	13 (3.4%)	1 (0.4%)	12 (8.8%)	0.048	0.006-0.376	<0.001
	no	338 (96.6%)	214 (99.6%)	124 (91.2%)			

*CHF, congestive heart failure; CAD, coronary artery disease; HT, hypertension; HL, hyperlipidemia; DM, diabetes mellitus; COPD, chronic obstructive pulmonary failure; CRF, chronic renal failure; CVA, cerebrovascular accident; MI, myocardial infarction; EF, Ejection fraction; VATS: video-assisted thoracoscopic surgery; lbc, lobectomy; segm, segmentectomy; pnmc, pneumonectomy; CI, confidence interval.

Table 2. Relationship between patients' baseline parameters and postoperative cardiac complications (PCC)

Variables	Total (n=351)	Non-PCC (n=215)	PCC (n=136)	*p*
BMI, mean ± SD	26.4±4.4	26.5±4.5	26.2±4.2	0.688
APACHE II, mean ± SD	8.5±3.5	7.6±2.6	10.0±4.2	<0.001
SOFA, mean ± SD	0.56±1.67	0.12±0.35	1.27±2.49	<0.001
FEV1 (L), mean ± SD	2.29±0.63	2.39±0.64	2.14±0.59	<0.001
Procedure time (hours), mean ± SD	3.8±0.8	3.7±0.7	3.8±1.0	0.097
Ventilation time (days), mean ± SD	1.1±0.6	1.0±0.0	1.3±0.9	<0.001
Intensive care LOS (days), mean ± SD	1.7±1.4	1.0±0.0	2.9±1.8	<0.001

BMI, body mass index; SOFA, Sequential Organ Failure Assessment Score; APACHE, Acute Physiology and Chronic Health Evaluation Score II;
FEV1, forced expiratory volume in the first second, LOS, length of stay; SD, standard deviation

When the relationship between some basal parameters of the patients and the development of PCC was examined, APACHE II (p <0.001) and SOFA scores (p <0.001) were higher in patients with PCC, while FEV1 (p <0.001) and hemoglobin (Hg) (p = 0.04) levels were higher in patients without PCC. (Table 2). Patients who developed PCC had longer operation time than those who did not. However, the difference was not statistically significant (p = 0.097). It was observed that patients who developed PCC had longer periods of ventilation and ICU hospitalization (p <0.001, for both).

Multiple logistic regression analysis was performed using the independent variables determined to affect the development of PCC in Tables 1 and 2. Presence of preoperative thyroid disease (p=0.04), presence of CVA (p=0.0001), use of neoadjuvant (p=0.002), EF <60% (p=0.01), pneumonectomy (p=0.003), intraoperative blood transfusion (p<0.0001) and high SOFA (p<0.0001) were found to be independent risk factors affecting the development of PCC (Table 3). It was observed that the presence of preoperative CHF (p=0.07) and intraoperative inotrope use (p=0.06) were close to significant in terms of affecting the development of PCC.

Discussion

In our study, the relationship between PCC occurring after lung resection and the patient's peroperative factors was investigated. Age, gender, RF, HT, COPD and lymph node dissection may be risk precursors for cardiopulmonary complications [5, 6]. Significant multivariate predictors of postoperative PCC were male sex, advanced patient age, a history of congestive heart failure, a history of arrhythmias, and a history of peripheral vascular disease [7]. In our study, CVA, EF< 60%, neoadjuvant therapy, pneumo-nectomy and high SOFA score and intraoperative blood transfusion were identified as independent risk factors in the development of PCC.

On the other hand, in a retrospective study of 379 patients over 80 years of age who underwent lung resection, male gender and the presence of previous infarction were positive risk factors for morbidity, while age was not evaluated in the same category[7]. Age alone is not one of the risk factors in the ASA classification, but the increase in coronary artery disease (CAD),

Table 3. Multivariate logistic regression analysis for postoperative cardiac complications

Variables	Odds ratio	95% CI	p value
Age ≥ 65 years	0.580	0.233-1.440	0.204
Gender (male)	1.703	0.585-4.959	0.328
CHF	3.392	0.874-13.154	*0.07*
CAD	0.490	0.169-1.421	0.189
HT	1.746	0.805-3.788	0.158
HL	0.747	0.152-3.654	0.719
COPD	1.527	0.706-3.301	0.281
Thyroid disease	5.544	1.079-28.485	0.04
CRF	2.770	0.088-86.335	0.561
CVA	26.952	5.331-136.253	0.0001
Arrhythmia	2.461	0.815-7.399	0.108
Lung cancer	2.232	0.278-17.900	0.449
Neoadjuvant therapy	6.701	1.927-23.306	0.002
EF < 60%	2.997	1.255-7.155	0.01
VATS	1.792	0.606-5.302	0.291
Pneumonectomy	5.315	2.168-13.031	0.003
Left-side operation	1.791	0.806-3.982	0.152
Inotrope use (intraop)	8.654	0.899-83.224	*0.06*
Blood product use (intraop)	12.404	4.506-34.140	<0.0001
Reoperated due to hemorrhage	3.948	0.359-43.355	0.261
APACHE II	0.946	0.800-1.161	0.700
SOFA	6.389	2.766-14.757	<0.0001
FEV1	1.072	0.551-2.086	0.837
Hg	0.873	0.721-1.004	0.891

***** CHF, congestive heart failure; CAD, coronary artery disease; HT, hypertension; HL, hyperlipidemia; COPD, chronic obstructive pulmonary failure; CRF, chronic renal failure; CVA, cerebrovascular accident; EF: Ejection fraction; VATS, video assisted thoracoscopic surgery; intraop: intraoperative; APACHE II, Acute Physiology and Chronic Health Evaluation Score II; SOFA, Sequential Organ Failure Assessment Score; FEV1, forced expiratory volume in the first second; Hg, hemoglobin; EF, ejection fraction; *CI, confidence interval*

DM, HT and peripheral vascular diseases increases with aging [8]. In our study, being over the age of 60 and male gender were among the risk factors.

Fernandes et al. observed that the presence of COPD, hypoxemia, anemia and pneumonectomy increased PCC after lung resection [9]. In our study, the most common chronic diseases of the patients were listed as COPD (45%), HT (34.8%), CAD (17.8%), DM (16.8%) and CHF (12.3%). The incidence of CAD in patients scheduled for lung resection is between 7-16%. The presence of CAD manifests itself with increased morbidity and mortality rates following the operation [10]. If a CAD is diagnosed in a person who has undergone thoracotomy, the risk of cardiac complications is 6%, otherwise 1% [10].In studies, if the EF is below 35%, the perioperative MI risk is 80%, if the EF is 35-56% it is 20%, if the EF is above 56%, the perioperative MI risk is 0% [8]. In our study, a significant relationship was observed between an EF of <60% and complications.

The markers of mortality and morbidity after lung cancer resection are listed as BMI, male gender, renal dysfunction, chemotherapy, pneumonectomy, bilobec-

tomy, and emergency surgery [3,11]. However, it is difficult to assess the effectiveness of which factor independently. In our study, a positive correlation was found between neoadjuvant therapy and complications. Major clinical conditions that increase the perioperative cardiovascular risk are unstable coronary syndromes, decompensated CHF, prominent arrhythmia and severe valvular disease [8]. In our study, a positive relationship was found between HT and arrhythmia. In non-small cell cancers, the incidence of HT in patients with AF is 52% [12]. HT was detected in 44.9% of our complicated patients, and this is consistent with the literature.

The type of lung resection is one of the factors that determine the degree and nature of cardiac complications. Pneumonectomy is associated with higher morbidity and mortality rates compared to other lung resections [3]. While the incidence of AF after pneumonectomy is 40%, this rate may vary between 10-20% after lobectomy [12]. The incidence of AF in left lobectomies was higher than in right lobectomies (62% & 38%) [13]. In our study, while the rate of complication development in left side surgery was 61%, this rate was 39% on the right side. The incidence of respiratory complications after pneumonectomy can be observed in the range of 11-49% [3] . In our study, 25% of 47 pneumonectomy patients who developed cardiac complications also developed respiratory failure.

VATS surgery is characterized by less hospital stay and postoperative pain compared to thoracotomy [14]. Defined by Swanson et al. VATS is more conservative than thoracotomy and relies on the guidance of national and international centers with extensive experience. VATS is preferred in the treatment of early non-small cell lung cancer because it is less invasive than thoracotomy [10,15]. 259 (73.8%) of our cases were operated by thoracotomy, 92 (26.2%) by VATS method. The complication rate of patients who underwent thoracotomy was 1.7 times higher than those with VATS.

Supraventricular arrhythmias are common rhythm disturbances after pulmonary surgery. Its frequency varies between 3.2-30% in various studies, its common form is AF [7,14, 16, 17]. Risk factors for arrhythmia are listed such as male gender, advanced age (> 60 years of age), presence of chronic lung disease, type of lung resection, postoperative hemorrhage, rethoracotomy, paroxysmal AF and pain [16,17]. These arrhythmias appear clinically as hemodynamic problems, potential for systemic embolization, long-term prophylactic drug use, and increased hospital costs. Increased cardiac enzyme level, myocardial ischemia / infarction and hypotension can be observed in 38% of patients with arrhythmia [17]. Postoperative AF is characterized by a 3-6-fold increase in intensive care admission and hospital mortality, and it may extend the hospital stay for 2-3 days [13]. In our study, the average length of stay in the intensive care unit for patients with AF was observed to be 2.9 days. Postoperative AF usually starts in the first 24 hours and peaks on the 2nd and 3rd days [13, 14, 17,18]. In our study, the arrhythmia occurrence time ranged from 1 to 7 days, and the average was found to be 2.29 days.

Amiodarone, metoprolol and diltiazem are frequently used in the treatment of arrhythmias. Although the effectiveness of prophylactic arrhythmia treatment has not yet been proven, there are supporting studies on the use of amiodarone and diltiazem [14,19]. The most preferred drug in our study was amiodarone (69.3%), which has recently become popular and preferred both for treatment and prophylaxis [13, 19]. Amiodarone tablet 2 * 1 po was given to our patients as a prophylactic after the use of amiodarone. The success with Amiodarone was 89.5%. The most common side effects associated with the use of amiodarone are hypotension, bradycardia and respiratory complications [19]. Hypotension developed due to amiodarone treatment in our 5 patients.

Other cardiac complications occurring following the arrhythmia were listed as hemodynamic instability, heart failure, and angina. Preoperative diagnosis of CHF was present in 25% of our patients. In our study, HF / MI findings emerged in 26 patients. In a series of 598 patients who underwent thoracic surgery, transient ischemic changes detected by echocardiography in 23 (3.8%) patients and MI were noted in 7 (1.2%) patients [2]. If the patient has a history of previous infarction, the risk of having a perioperative MI is between 2.8% and 17%, and if there is no cardiac history, it is 0.13% [2]. Nine patients who developed angina symptoms were referred to the cardiology unit for further treatment.

In our study, 25% of the patients who developed PCC had respiratory failure symptoms, and these patients were given mechanical ventilation support. Pulmonary edema is an uncommon complication after lung resection and its incidence is usually 2.5-4% after pneumonectomy. Because it is a precursor of perioperative pulmonary edema, CHF is an important risk factor affecting mortality [8]. Preoperative diagnosis of CHF was present in 58% of our patients who developed respiratory failure.

Limitation of the study: The study was conducted in a single center and in a certain time period.

Conclusion

In summary, this study showed that many factors are effective in the occurrence of cardiac complications after lung resection. Cardiac complications after lung resections are among the most common causes of mortality and morbidity. Geriatric age, male gender, HT, lung cancer, neoadjuvant therapy, high SOFA scores and pneumonectomy operation have been observed to increase the risk of complications. In addition, presence of goiter and CVA disease, EF <60%, presence of neoadjuvant, pneumonectomy, high SOFA score and high correlation between intraoperative blood transfusion and PCC were found. Appropriate preoperative approach, qualified evaluation of patients who are candidates for complications, and proper collaboration of treatment units are of vital importance in minimizing morbidity and mortality.

Author contributions

All authors contributed to the study conception and design.
All authors read and approved the final manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

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Ethical approval

Approval was obtained from the Ethics Committee of Istanbul Yedikule Chest Diseases and Chest Surgery Training and Research Hospital for this study (2020-34)

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