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Original Article / Özgün Makale

A risk scoring system comprised of right heart failure findings and the New York Heart Association functional classification parameters to predict mortality associated with pericardiectomies

Perikardiyektomi ile ilgili mortaliteyi öngörmek üzere sağ kalp yetmezliği bulguları ve New York Kalp Birliği fonksiyonel sınıflama parametreleri ile oluşturulan bir risk skorlama sistemi

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ABSTRACT

Background: This study aims to develop an easy and feasible risk scoring system by using right heart failure findings as well as New York Heart Association (NYHA) functional classification to predict the early and overall mortality rates in pericardiectomy.

Methods: One third of 79 consecutive patients (50 males, 29 females; mean age 40.0±16.7 years; range 14 to 75 years) who underwent isolated pericardiectomy at the same clinic between January 1997 and September 2010 were retrospectively evaluated and the remaining patients were included in the study prospectively. By adding findings of right heart failure (one point for each including dyspnea, edema, hepatomegaly, ascites, pleural effusion, hipoalbuminemia, and congestive liver dysfunction) and NYHA functional classification's mathematical value, patients were separated into three categories as category 1 (≤6 points), category 2 (7-8 points), and category 3 (≥9 points). Effects of independent variables (sex, NYHA functional classification, symptoms lasting for more than one year, etiology, dyspnea, palpitation, chest pain, hepatomegaly, edema, ascites, atrial fibrillation, pleural effusion, hepatic and renal dysfunction, pericardial effusion and calcification, hyponatremia, hipoalbuminemia, echocardiographic findings, and need for positive inotropic medication) on early and overall mortalities were investigated with univariate and multivariate analyses.

Results: Mean follow-up period was 78.4±54.8 months, and early and overall mortality rates were 12.7% and 18.4%, respectively. While poor functional capacity, symptoms lasting for more than one year, ascites, pleural effusion, congestive liver dysfunction, renal dysfunction, pericardial calcification, hyponatremia, and postoperative positive inotropic medication need were significant risk factors in univariate analysis; advanced age, female sex, NYHA class, ascites, congestive liver dysfunction, hyponatremia, and the scoring system itself were significant risk factors in multivariate analysis. Early mortality rates were 0%, 15% and 70% (p=0.000), and overall mortality rates were 18.4%, 30%, and 70% for category 1, category 2, and category 3, respectively (p=0.004).

Conclusion: The early and overall mortality rates in pericardiectomy increase as do the number of right heart failure findings and NYHA functional capacity. The scoring system is a simple and feasible method to predict risk after pericardiectomy.

Keywords: Chronic pericarditis; constrictive pericarditis; pericardiectomy; risk assessment; risk factors.

ÖZ

Amaç: Bu çalışmada perikardiyektomide erken ve genel mortalite oranlarını öngörmek için sağ kalp yetmezliği bulguları ile beraber New York Kalp Birliği (NYHA) fonksiyonel sınıflandırması kullanılarak kolay ve uygulanabilir bir risk skorlaması sistemi geliştirilmesi amaçlandı.

Çalışma planı: Ocak 1997 - Eylül 2010 tarihleri arasında aynı klinikte izole perikardiyektomi geçiren ardışık 79 hastanın (50 erkek, 29 kadın; ort. yaş 40.0±16.7 yıl; dağılım 14-75 yıl) üçte biri retrospektif olarak değerlendirildi ve kalan hastalar prospektif olarak çalışmaya alındı. Sağ kalp yetmezliği bulguları (dispne, ödem, hepatomegali, assit, plevral efüzyon, hipoalbüminemi ve konjestif karaciğer disfonksiyonunun her biri için 1 puan) ve NYHA fonksiyonel sınıflandırmasının matematiksel değeri toplanarak hastalar kategori 1 (≤6 puan), kategori 2 (7-8 puan) ve kategori 3 (≥9 puan) olarak üç kategoriye ayrıldı. Bağımsız değişkenlerin (cinsiyet, NYHA fonksiyonel sınıflandırması, semptomların bir yıldan uzun sürmesi, etyoloji, dispne, çarpıntı, göğüs ağrısı, hepatomegali, ödem, assit, atriyal fibrilasyon, plevral efüzyon, hepatik ve renal disfonksiyon, perikardiyal efüzyon ve kalsifikasyon, hiponatremi, hipoalbüminemi, ekokardiyografik bulgular ve pozitif inotrop ilaç gereksinimi) erken ve genel mortalite üzerine etkileri tek ve çok değişkenli analizlerle araştırıldı.

Bulgular: Ortalama izlem süresi 78.4±54.8 ay, erken ve genel mortalite oranları sırasıyla %12.7 ve %18.4 idi. Tek değişkenli analizde kötü fonksiyonel kapasite, semptomların bir yıldan uzun sürmesi, assit, plevral efüzyon, konjestif karaciğer disfonksiyonu, renal disfonksiyon, perikardiyal kalsifikasyon, hiponatremi ve ameliyat sonrası pozitif inotrop ilaç gereksinimi anlamlı risk faktörleri iken; çok değişkenli analizde ileri yaş, kadın cinsiyeti, NYHA sınıfı, assit, konjestif karaciğer disfonksiyonu, hiponatremi ve skorlama sisteminin kendisi anlamlı risk faktörleri idi. Erken mortalite oranları kategori 1, kategori 2 ve kategori 3 için sırasıyla %0.0, %15.0 ve %70.0 (p=0.000); genel mortalite oranları sırasıyla %18.4, %30.0 ve %70.0 idi (p=0.004).

Sonuç: Sağ kalp yetmezliği bulgularının sayısı ve NYHA fonksiyonel kapasitesi arttıkça perikardiyektomide erken ve genel mortalite oranları da artar. Skorlama sistemi perikardiyektomi sonrası riski öngörmede basit ve uygulanabilir bir yöntemdir.

Anahtar sözcükler: Kronik perikardit; konstriktif perikardit; perikardiyektomi; risk belirleme risk faktörleri; .

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Constrictive pericarditis (CP) is still encountered throughout the world, but the etiology may differ according to location. While Turkey contributed to the data related to tuberculous CP with various reports in the late 90's, the number of studies has declined because of the eradication of this type of CP in developed countries. However, radiotherapy-induced or post-cardiac surgery-related cases can still be seen in Western countries,[1-9] with early mortality rates of 0 and 14%, respectively. This rate may be even higher in patients who need open heart surgery such as coronary artery bypass grafting (CABG).[4,5,8-16]

Various risk factors are associated with pericardiectomies, with the most frequent being preoperative poor functional capacity, advanced age, longer duration of symptoms, the presence of ascites, atrial fibrillation (AF), hyponatremia, hypoalbuminemia, renal dysfunction, hyperbilirubinemia, moderate/severe tricuspid regurgitation, and the need for inotropic medication.[4,5,9-11,15-19] However, radiation-induced and postsurgical CP are more common risk factors in North American series.[4,5,7,19] Using multivariate risk factors, Bertog et al.[5] proposed an excellent formula for risk prediction that utilized radiation-induced CP, older age, high creatinine levels, low sodium levels, high pulmonary artery pressure, and left ventricular systolic dysfunction, but, unfortunately, this formula is too complex for use in routine daily practice.

Hence, we aimed to develop an easy and feasible risk scoring system by using right heart failure (RHF) findings plus the New York Heart Association (NYHA) functional class to predict the early and overall mortality rates in our pericardiectomy cohort. In addition, we also searched for a correlation between symptom duration and the risk scores.

PATIENTS AND METHODS

Seventy-nine consecutive patients (50 males, 29 females; mean age 40.0±16.7 years; range 14 to 75 years) who underwent an isolated pericardiectomy for CP between January 1997 and September 2010 at a single center were included in this study. The Institutional Education Planning and Ethics Committee approved the study, and the patients' informed consent was obtained before it began.

Our examination of the patients included the identification of their symptoms and an assessment of their physical characteristics as well as an evaluation of their laboratory, radiological, echocardiographic, angiographic, and operative findings. Transthoracic echocardiography (TTE) was routinely employed, and cardiac catheterization was carried out when the diagnosis was inconclusive. In addition, computed tomography (CT) and coronary angiography were performed in select cases.

A diagnosis of tuberculous PC took place in those who had a positive history for this disease, an adenosine deaminase level of more than 15 U/L in the pericardial fluid or a pathology that pointed to this type of PC. The patients who had received radiotherapy for a malignant disease or who had malignant pericardial involvement were classified as having malignant radiotherapy-induced constrictive PC. Furthermore, those who had undergone previous cardiac surgery or who had a history of trauma were categorized as postsurgical traumatic CP cases. The remaining causes of CP were classified as idiopathic CP, which included the patients who had previously had viral PC.

Pericardial calcification was identified via the preoperative chest X-ray or CT, and congestive liver dysfunction was considered when the blood levels of the aspartate transaminase (AST) and alanine transaminase (ALT) were more than twice the upper limit and the total bilirubin level was above 2 mg/dL. In addition, renal dysfunction was defined as having creatinine levels of more than 2 mg/dL and/or when the patient was on a routine hemodialysis program.

The surgery consisted of a wide excision of the pericardium from one phrenic nerve to the other, including the diaphragmatic part. Cardiopulmonary bypass (CPB) was not routinely employed, but it was instituted when hemodynamic deterioration, epicardial bleeding, or a laceration occurred that was difficult to control. Early mortality was defined as mortality observed within 30 days after the operation.

The independent variables in our study were the following: gender, age, etiology, dyspnea, palpitations, chest pain, the symptomatic period, hepatomegaly, ascites, pretibial edema, the functional status according to the NYHA, pre- and postoperative AF, hyponatremia, hypoalbuminemia, pleural effusion, pericardial thickness, the presence of pericardial calcification, chronic obstructive pulmonary disease (COPD), coronary artery disease (CAD), hepatic or renal dysfunction, left ventricular ejection fraction (LVEF), systolic pulmonary artery pressure (sPAP), the left atrial dimensions, atrioventricular valve regurgitation, previous pericardiocentesis, the use of an inotropic agent, the emergent institution of CPB, re-exploration for bleeding, and infection. The dependent variables were early and late mortality and survival length (Tables 1 and 2).

Table 1. Risk factors for early mortality according to univariate analyses and the relative risks for categorical variables

Variables	Total		Survivors (n=69) A		Non-survivors (n=10) B		Relative risk (B/A)	
	n	%	n	%	n	%		*p*
Gender								0.485
Female	29	36.7	24	34.8	5	50	1.4	
New York Heart Association								
Class 2	21	26.6	21	30.4	0	0.0	0.0	0.000
Class 3	40	50.6	38	55.1	2	20.0	0.4	
Class 4	18	22.8	10	14.5	8	80.0	5.5	
Symptomatic period >12 months	25	31.6	18	26.0	7	70.0	2.7	0.021
Etiology								0.585
Idiopathic	49	62.0	41	59.4	8	80.0	1.3	
Tuberculosis	23	29.1	21	30.4	2	20.0	0.7	
Malignant radiotherapy-induced	4	5.1	4	5.8	0	0.0	0.0	
Post-surgical traumatic	3	3.8	3	4.3	0	0.0	0.0	
Dyspnea	73	92.4	63	91.3	10	100.0	1.1	1.000
Palpitation	37	46.8	33	47.8	4	40.0	0.8	0.743
Chest pain	13	16.5	13	18.8	0	0.0	0.0	0.200
Hepatomegaly	57	72.2	47	68.1	10	100.0	1.5	0.054
Pretibial edema	14	17.7	10	14.5	4	40.0	2.8	0.070
Ascites	24	30.4	15	21.7	9	90.0	4.1	0.000
Atrial fibrillation	22	27.8	20	29.0	2	20.0	0.7	0.717
Pleural effusion	30	38.0	23	33.3	7	70.0	2.1	0.037
Congestive liver dysfunction	14	17.7	8	11.6	8	80.0	6.9	0.002
Renal dysfunction	3	3.8	1	1.4	2	20.0	14.3	0.041
Effusive pericarditis	15	19.0	14	20.3	1	10.0	0.5	0.677
Pericardial calcification	39	49.4	31	44.9	8	80.0	1.8	0.048
Hyponatremia	18	22.8	10	14.5	8	80.0	5.5	0.000
Hypoalbuminemia	21	26.6	16	23.2	5	50.0	2.2	0.120
Left ventricular EF <50%	9	17.0	8	17.4	1	14.3	0.8	1,000
sPAP >30 mmHg	27	51.0	23	52.3	4	50.0	1.0	1.000
Left atrial diameter >4 cm	30	56.6	25	56.8	5	55.6	1.0	1.000
Heart valve regurgitation	17	28.8	13	26.5	4	40.0	1.5	0.453
Positive inotropic agent use	30	38.0	23	33.3	7	70.0	2.1	0.037

EF: Ejection fraction; sPAP: Systolic pulmonary artery pressure.

After evaluating the first third of the patients retrospectively, we then decided to conduct the study prospectively using a risk scoring system consisting of the clinical and laboratory findings of RHF (i.e., dyspnea, edema, hepatomegaly, ascites, pleural effusion, hypoalbuminemia, and congestive liver dysfunction) along with the patient's NYHA functional class. Each finding represented 1 point and the mathematical value of the NYHA functional class was then added (2, 3, or 4 points for NYHA 2, 3 or 4 classes, respectively). Therefore, each patient had a score that ranged from 1 point to a maximum of 11. No mortality was observed in the patients who had a total score of ≤6 points. The early mortality rates for those with a score of either 7 or 8 points were similar (16.7% and 12.5%, respectively), but the patients with a score of 9 or 10 had very high mortality rates (50% and 100%, respectively) (p=0.000). Thus, the patients were grouped into low, moderate, and high risk categories according to their risk scores in order to achieve a significant difference with regard to the early mortality rates. Category 1 contained patients with scores ranging from 1-6 points, category 2 was composed of those with scores ranging from 7-8 points, and category 3 was made up of those with scores ranging from 9-11 points (Table 3). Furthermore, all of the patients underwent surgical therapy even if they had high preoperative risk scores.

Table 2. Scale parameters of the survivors and non-survivors

Scale parameters	Survivors (n=69)			Non-survivors (n=10)			
	Mean±SD	Median	Range	Mean±SD	Median	Range	p
Age (years)	39.4±16.6	38.0	14.0-75.0	44.1±17.6	41.5	20.0-7.0	0.406
Symptomatic period (months)	10.3±13.6	6.0	1.0-60.0	45.0±91.7	19.0	2.0-303.0	0.015
Left ventricular EF (%)	58.1±8.8	60.0	38.0-74.0	58.3±10.5	58.3	45.0-74.0	0.929
Sodium (mEq/L)	138.5±4.8	139.0	118.0-146.0	131.9±7.4	132.0	117.0-142.0	0.003
Albumin (g/dL)	4.0±0.8	4.0	2.1-5.6	3.3±0.6	3.4	2.6-4.3	0.009
sPAP (mmHg)	31.9±8.8	32.0	10.0-60.0	33.0±10.6	30.5	19.0-52.0	0.745
Left atrial diameter (cm)	4.3±0.8	4.2	2.7-6.3	4.2±0.8	4.2	3.5-5.7	0.822
Pericardial thickness (mm)	9.6±5.3	8.0	3.0-21.0	7.7±3.2	6.5	4.0-12.0	0.453

SD: Standard deviation; EF: Ejection fraction; sPAP: Systolic pulmonary artery pressure.

Statistical analysis

The data were coded and recorded using the IBM-SPSS for Windows version 17.0.0 software program (SPSS Inc., Chicago, IL, USA). For the univariate analyses, chi-square, Mann-Whitney U, analysis of variance (ANOVA), Kruskal-Wallis, and Kaplan-Meier log-rank tests were used in the subgroups while for the multivariate analyses, a backward stepwise logistic regression method was used to identify the aforementioned significant risk factors as they related to mortality. Correlations between disease duration (symptomatic period), length of hospital and intensive care unit (ICU) stays, and the preoperative total score were evaluated via the Spearman's correlation analysis. In all tests, p values of <0.05 were accepted as being statistically significant.

RESULTS

We found no specific etiology in the majority of patients (62.0%). Trivial to mild mitral or tricuspid valve regurgitation was identified in 17 patients (21.5%), but none of them required surgery. In addition, the emergency institution of CPB was necessary in four patients (5.1%), postoperative bleeding occurred in five more (6.3%), and infection was encountered in two others (2.5%).

The early mortality rate was 12.7% (n=10). One patient died from preoperative cardiopulmonary arrest in the ward and after undergoing emergency CPB with the pericardiectomy. Another patient with a bare metal stent in the right coronary artery (RCA) died due to cardiopulmonary arrest on the first postoperative day after not responding to emergency CPB and resuscitative measures, and another was lost on the fifth postoperative day due to a pulmonary embolus. Furthermore, two died of multi-organ failure after having had a massive blood transfusion and undergoing re-exploration for postoperative bleeding. Low cardiac output was responsible for the five other deaths. No postmortem examinations were performed.

The patients' characteristics and the results of the univariate analyses of the risk factors are given in Tables 1 and 2. There were statistically significant differences between the survivors and non-survivors related to the NYHA class, symptomatic period of >12 months, ascites, pleural effusion, congestive liver dysfunction, renal dysfunction, pericardial calcification, hyponatremia, and the use of positive inotropic agents (Table 1) as well as the mean period of symptoms and sodium and albumin levels (Table 2). Moreover, the patients with renal dysfunction, NYHA class 4, hyponatremia, ascites, or congestive liver dysfunction had relatively higher risks in the univariate analyses [relative risk (RR) >4].

The multivariate analysis revealed that age, female gender, NYHA class, ascites, congestive liver dysfunction, hyponatremia, and the risk scoring system itself were risk factors for early mortality.

The early mortality rates increased as did the number of findings of RHF and our scoring system values (Table 3), and the early and overall mortality rates were significantly different among the three different risk categories ($p<0.05$) (Table 4). No patients with a preoperative score of 10 points survived, and only half of the patients with a score of 9 survived the early period. The mean scores of the patients were 5.5±1.7 (median: 5) and 8.9±1.2 (median: 9) in the survivor and non-survivors, respectively ($p=0.000$).

Four different approaches were used to test the scoring system in the multivariate analyses. In the first approach, each component of the risk scoring system, age, and gender were tested. The second assessment included the sum of the RHF variables, the NYHA

Table 3. Early mortality rates according to the number of variables of right heart failure and right heart failure + New York Heart Association

Variables of RHF	Operative mortality (%)	*p*	Variables of RHF + NYHA (number)	Operative mortality (%)	*p*
1-2	0.0		1-6	0.0	
3	6.3		7	16.7	
4	14.3		8	12.5	
5	33.3		9	50	
6	71.4	0.000	10	100	0.000

RHF: Right heart failure; NYHA: New York Heart Association; The variables of right heart failure were dyspnea, edema, hepatomegaly, ascites, pleural effusion, hypoalbuminemia, and congestive liver dysfunction. No patient had all seven variables, and none had all 11 points when right heart failure was combined with the New York Heart Association status.

class, age, and gender, and the third featured our preoperative risk scoring system with age, gender, and the serum sodium levels served as covariates. In the last model, the risk categories together with age, gender, and the serum sodium levels were included. For each model, the separate components of the risk scoring system or the risk scoring itself were statistically significant (Table 5).

The follow-ups were completed for all of the patients. The mean survival period was 78.4±54.8 months (median 77.1; range 0.0-196.4 months), and the survival rates were 84.9%, 74.9%, and 56.7% at one, five, and 10 years, respectively.

Furthermore, the overall survival rates at one, five and 10 years were 98.0%, 87.2%, 65.0% in the category 1 patients, respectively while they were 80.0%, 66.7%, and 40.0% in the category 2 patients, and 30% at one and five years in the category 3 patients. We also observed a statistically significant difference among the different risk categories and expected survival rates when the Kaplan-Meier log-rank test was applied (p=0.000, Figure 1).

The preoperative duration of symptoms was 10.3±13.6 months (median 6 months, range 1-60 months) in the survivors and 45.0±91.1 months (median 19, range 2-303 months) in the non-survivors (p=0.015) (Table 2), but no significant correlation was not found between the symptom duration and the preoperative scores, RHF scores (Rho: 0.270; p=0.060 and Rho: 0.278; p=0.053, respectively) length of hospital or ICU stays, or preoperative total scores (p>0.05).

DISCUSSION

Tuberculous CP is common in developing countries like Turkey,[5] but our findings showed that the etiology of CP has changed in this country with the decline in the number of reported TB-related cases. The percentage of idiopathic cases in this cohort was similar to other reports (33-75%), but there were fewer radiation-induced and postsurgical cases in our series compared with those that were published previously.[4,5,20] In addition, no specific etiology emerged as a significant risk factor in our study, which was most probably due to the very small number of patients in some of the groups (i.e., post-traumatic and malignant CP).

Our early mortality rate was comparable to other series that have been published after 1985 (6-19%),[4,14,15] and the most frequent cause of death in the perioperative period in our study was low cardiac output (60%), which was also similar to previous findings (44.4-100%).[4,5,12,13] Cardiac failure has been attributed to the myocardial invasion of fibrosis and the atrophy of the myocardial fibers due to prolonged or residual constriction or a concomitant myocardial process.[5] Our postoperative survival rates were also comparable to those found in other series.[4,8,16,17,21]

Table 4. Early and overall mortality rates according to the preoperative risk categories

Risk categories	Patients still alive	Patients who died	Early mortality (%)	*p*	Overall mortality (%)	*p*
Category 1 (≤6 points)	49	0	0.0		18.4	
Category 2 (7-8 points)	17	3	15.0		30.0	
Category 3 (≥9 points)	3	7	70.0	0.000	70.0	0.004

Preoperative score = the number of variables for right heart failure (dyspnea, edema, hepatomegaly, ascites, pleural effusion, hypoalbuminemia, and congestive liver dysfunction) + the NYHA status. NYHA: New York Heart Association.

Table 5. Significant risk factors for early mortality according to logistic regression analysis in four different models

Model 1. Tested covariates: dyspnea, edema, hepatomegaly, ascites, pleural effusion, hypoalbuminemia, and congestive liver dysfunction along with age, gender, and NYHA class.

Variables	Exp (B)	95% CI	*p*
Gender	0.117	0.020-0.692	0.018
NYHA class	0.369	0.219-0.623	0.000
Ascites	29.076	3.882-217.780	0.001
Congestive liver dysfunction	11.916	1.873-75.789	0.009

Model 2. Tested covariates: calculated number of right heart failure findings (dyspnea, edema, hepatomegaly, ascites, pleural effusion, hypoalbuminemia, and congestive liver dysfunction with each representing one point), NYHA class, age, and gender.

Variables	Exp (B)	95% CI	*p*
Age	0.973	0.938-1.008	0.130
Gender	0.225	0.057-0.890	0.034
NYHA class	0.409	0.176-0.952	0.038
RHF scores	2.305	1.298-4.096	0.004

Model 3. Tested covariates: preoperative scoring system (sum of the right heart failure variables ranging from 1 to 7 with dyspnea, edema, hepatomegaly, ascites, pleural effusion, hypoalbuminemia, and congestive liver dysfunction each representing one point + NYHA class 2-4), age, gender, and serum sodium level.

Variables	Exp (B)	95% CI	*p*
Age	1.067	0.994-1.145	0.074
Gender	0.243	0.024-2.433	0.229
Preoperative scores	6.496	1.910-22.100	0.003
Serum sodium level	0.873	0.801-0.952	0.002

Model 4. Tested covariates: scoring system categories (0-6; 7-8, 9-10), age, gender, and serum sodium level.

Variables	Exp (B)	95% CI	*p*
Age	1.075	1.005-1.151	0.036
Serum sodium level	0.922	0.883-0.963	0.000
Preoperative score categories	36.851	5.553-244.541	0.000

NYHA: New York Heart Association; Exp B: Exponential B; CI: Confidence interval; RHF: Right heart failure.

Moreover, the risk factors that we identified for pericardiectomies were also compatible with previous studies.[4,5,9-11,15-19,20] The number of radiation related and postsurgical cases were limited, and the degree of preoperative tricuspid regurgitation ranged from trivial to mild in our patients, which differed from other series, making comparisons impossible.[3,4,10,11,16,22] On the other hand, pleural effusion, which was not encountered in the literature, emerged as a risk factor in our study. It is possible that the different etiological subgroups in our cohort may have accounted for these discrepancies.

Pericardial calcification is a matter of controversy in the literature with regard to whether it is a risk factor for pericardiectomies.[22] In contrast to some studies,[5,19,22] in their large series consisting of 395 patients, Chowdhury et al.[13] reported that calcification was a risk factor for survival in both univariate and multivariate analyses. In our study, higher mortality rates were observed in the patients with calcific CP (20.5% vs. 5% in non-calcific CP; p=0.048). In these cases, the penetration of calcium spurs into the myocardium may make the procedure more difficult perform, which could result in an injury to the epicardium during surgery. In these situations, incomplete resection and meshing (waffle) techniques are usually recommended.[4,9,15,23] Our more aggressive approach without the use of these techniques along with the higher bleeding and massive blood transfusion rates may account for the higher mortality rate observed in our series. However, since calcification is a variable associated with the

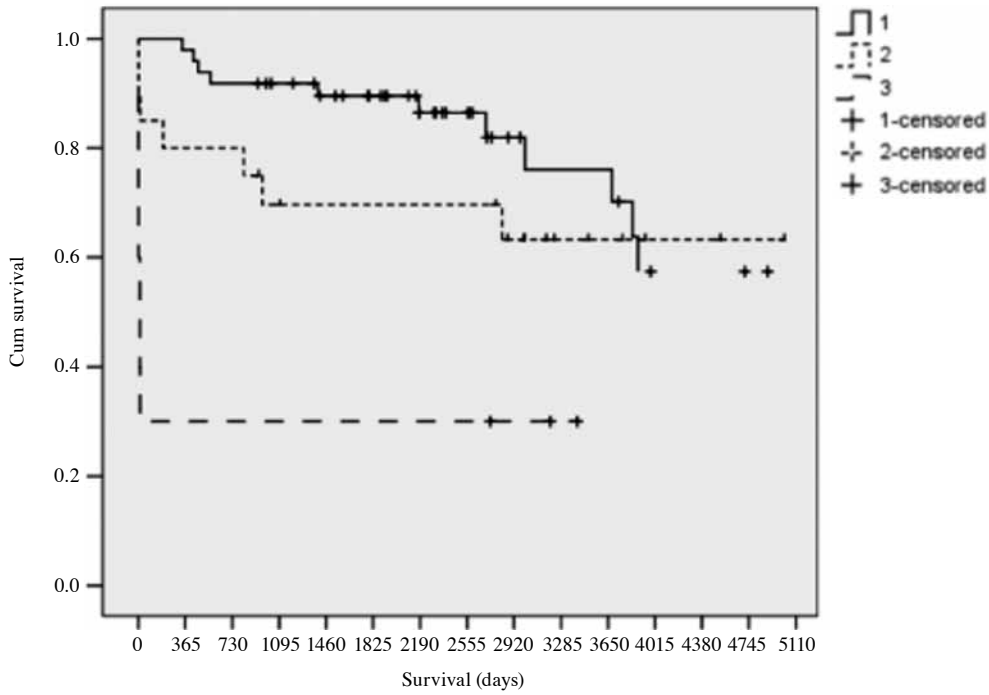

Figure 1. Survival of the patients according to the risk categories. (Kaplan Meier logrank test-chi-square: 25.736; p=0.000). *Category 1(≤6 points), 2: Category 2 (7-8 points), 3: Category 3 (>9 points).*

operator and technique, we did not include it as part of our risk scoring system.

The risk scoring formula proposed by Bertog et al.[5] in their study composed of 163 patients which used predictors of poor survival (prior radiation, worsening renal function, higher sPAP, abnormal left ventricular systolic function, lower serum sodium level, and older age) is excellent, but it is a bit complicated to use. The components of our system were somewhat different than theirs because of the discrepancies between the etiological subgroups since patients with prior radiation and renal dysfunction were very rare in our study cohort. High sPAP and lower EF were also not predictors of mortality in our study. Older age, female gender, and renal failure are common risk factors for any kind of surgery and are not specific only to pericardiectomies. Hyponatremia, on the other hand, was a strong risk factor in both the univariate and multivariate analyses in our study with a relative risk of 5.5. However, hyponatremia is a nonspecific result associated with many chronic disease processes as noted by the fact that it was found to increase mortality rates in hospitalized patients in the study by Waikar et al.,[24] particularly in those with cardiovascular disease, metastatic cancer, and those undergoing orthopedic procedures.[24] We did not want to include hyponatremia in our scoring because of the significant correlations between it and other risk factors included in this study (i.e., edema, pleural effusion, ascites, and hypoalbuminemia). Moreover, because of the single and isolated approach of our study, comparisons with other series may not be appropriate.

After sequentially analyzing a third of the patients retrospectively, we then decided to proceed prospectively with our study design since even the higher risk patients would undergo surgery and our inclusion and exclusion criteria would not change. Now, we hope that an adjustment will take place in our standard clinical practice regarding the preoperative supportive management of these patients. In addition, it is possible that a national awareness program for CP among practitioners with a special focus on early recognition and referrals to cardiologists and cardiac surgeons may be put into place before these patients become more disabled with more serious characteristics of RHF such as ascites and congestive liver dysfunction.

A major limitation of this study was the limited number of patients because over a 14-year period, only 79 consecutive patients were eligible for enrollment. Another limitation was the lack of patients with a total score of 11; thus, we could not determine their fate. However, it is reasonable to predict a very poor outcome for these patients based on the fact that none of the patients with a total score of 10 survived the

early period. We also may be criticized because each risk factor in the scoring system contributed to the total score differently because the relative risks they pose for mortality are different. Accordingly, the NYHA class 4 functional status, presence of hyponatremia, ascites, congestive liver, and renal dysfunction had greater relative risk (>4) in our analysis. Some also may argue that each RHF finding might affect the prognosis differently and therefore should contribute to the risk scoring system accordingly. A new modified scoring system in the future can be developed by incorporating the relative risk values of our RHF findings. Finally, some data from the echocardiographic and cardiac catheterization examinations of a few patients at the beginning of the study went missing, which could have had an impact on our findings.

Conclusion

Our results indicate that regarding pericardiectomy, an increase in mortality rate occurs when the number of RHF findings and numeric value of NYHA functional class status get higher in a patient with constrictive pericarditis. We think that our risk scoring system can serve as a guide for supportive medical therapy in high risk patients before surgery because it is easy to use and can be applied at the patient's bedside. In addition, it may offer a simple risk prediction for mortality associated with pericardiectomies.

Declaration of conflicting interests

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