Cardiovascular Topics

Clinical characteristics, diagnostic methods and results of surgically treated histologically benign cardiac myxomas

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Abstract

Background: Myxomas are primary cardiac tumours that may be detected incidentally due to embolic events, intracardiac obstructive features or non-specific structural symptoms. The aim of this study was to share our experience of clinical features, diagnostic methods, surgical procedures and postoperative follow up of surgically treated cardiac myxomas.

Methods: Data of 34 patients who underwent surgery for a cardiac myxoma between January 2006 and June 2022 were retrospectively analysed. Group 1 (n = 19) consisted of patients who were symptomatic and group 2 (n = 15) patients were asymptomatic. The medical records of the patients, their clinical status, diagnostic methods, operation information and postoperative course data were collected and recorded.

Results: A total of 34 patients (16 female; mean age 54.5 ± 8.8 years) underwent cardiac myxoma resection with cardiopulmonary bypass. Fifteen (44.1%) patients were diagnosed incidentally with asymptomatic myxoma. An additional cardiac surgical procedure was performed in six patients (17.7%). The 34 cardiac myxomas that were surgically resected were localised in the left atrium in 25 patients (73.5%) and in the right atrium in nine patients (26.5%). Patients' most common symptoms were dyspnoea (42.1%), palpitations (21.1%), ischaemic stroke (15.8%) and syncope (10.5%). There was no incident of 30-day mortality and no recurrence was observed in any patient during the follow-up period. The duration of surgical intervention in symptomatic patients was significantly shorter than in asymptomatic patients (p = 0.0001), but there was no statistical difference in terms of characteristics. Conclusion: Myxomas are benign tumours, but they are serious pathologies that require early treatment because of signs of obstruction, embolic complications and confusion, with left atrial thrombus in the differential diagnosis.

Keywords: cardiac myxoma, cardiac surgery, clinical characteristics

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Cardiovascular Surgery Clinic, Derince Training and Research Hospital, Health Sciences University, Kocaeli, Turkey Durmuş Alper Görür, MD, alper1976md@yahoo.com Hüseyin Şaşkin, MD Primary cardiac tumours are rare, accounting for only five to 10% of all neoplasms of the heart and pericardium, and about 80% are benign, of which more than half are myxomas.¹ Myxomas are very rare, with an incidence of 0.0017 to 0.19% in autopsies; left atrial myxomas are the most common and constitute 75% of all tumours in this locality.² Cardiac myxomas are the most common benign cardiac tumours, with various clinical presentations.³ These primary tumours of the heart often occur in middle age and are more common in women than men.⁴ Myxomas usually occur sporadically, but familial myxomas have also been reported rarely.¹

Although structural symptoms are common in patients with a cardiac myxoma, this benign tumour has the danger of cerebral or peripheral infarction, intracardiac obstruction, syncope, and sudden death due to systemic embolisation.⁵ These symptoms depend on the location, size and mobility of the tumour. On physical examination, approximately one-third of these patients will have an early diastolic murmur ('tumour plop').² The incidence of incidentally diagnosed asymptomatic cardiac myxoma ranges from zero to 25% in the literature.³

Identification of cardiac tumours is usually done by imaging [echocardiography, computed tomography (CT) and cardiac magnetic resonance imaging (MRI)] methods. Definitive diagnosis of a cardiac myxoma is made after surgical removal of the tumour and histopathological evaluation of the removed sample.¹

Although transthoracic echocardiography is the first and most common imaging modality used for diagnosis of these patients, cardiac MRI has come to the forefront in the last decade as the primary imaging modality in the evaluation of patients with cardiac tumours.⁶ Cardiac MRI provides the best assessment of the location and functional impact of cardiac masses in any imaging plane without exposing patients to ionising radiation.⁷ In particular, cardiac MRI outperforms the most commonly used echocardiography in determining the nature of cardiac lesions and can distinguish cardiac myxomas from thrombus in the cardiac chambers.⁶ In recent years, cardiac CT has been used frequently to evaluate benign primary cardiac tumours and to provide detailed information about anatomical and tissue features.⁸

The most effective treatment of choice for myxomas is surgical removal.⁹ Asymptomatic tumours due to mitral valve obstruction, or coronary artery and/or peripheral artery occlusion as a result of embolic complications should also be surgically removed.² While the surgical mortality rate was zero to 3% in earlier literature, the postoperative mortality rate ranged from zero to 12%. Relapse cases have been described, albeit very rarely and the overall risk of recurrence for sporadic tumours is only one to 3%.¹

In this study, we aimed to share our clinical experience, including clinical features, diagnostic methods, surgical procedures and postoperative follow up of 34 patients who were operated on for intracardiac myxomas.

Methods

Between January 2006 and June 2022, 34 patients who were diagnosed with cardiac myxoma and underwent surgery with cardiopulmonary bypass (CPB) in Private Kocaeli Acıbadem Hospital and Health Sciences University Derince Training and Research Hospital Cardiovascular Surgery Clinics were included in the study. The operations were performed in two different centres but by the same surgical team. The patients included in the study were divided into two groups: a symptomatic group 1 (n = 19) and an asymptomatic group 2 (n = 15).

The demographic and clinical data of the patients were obtained using the software system of the hospital for records and archives. We investigated the patient files, epicrisis, operation notes and laboratory results. The demographic and clinical characteristics of the patients, New York Heart Association (NYHA) class and presentation of cardiac tumours, complete blood counts and biochemical parameters studied routinely before and after surgery, erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) levels were recorded. Operation information, duration of CPB and aortic cross-clamping, postoperative hours of ventilation, mediastinal drainage, postoperative complications, histopathological findings of the tumour, amount of blood products used and length of stay in the intensive care unit and hospital were also recorded.

Transthoracic echocardiography (TTE) was performed on all patients by the cardiology clinic to diagnose myxoma and to evaluate their heart structures and chambers, and they were referred to our clinic for surgery. In doubtful cases, the diagnosis of myxoma was clarified by performing transoesophageal echocardiography (TEE) by the cardiology clinic. A TEE image of a patient's right atrial myxoma with tricuspid valve stenosis is shown in Fig. 1.

Coronary angiography was performed on all patients included in the study to determine the blood supply of the myxoma and to exclude atherosclerotic coronary artery disease and coronary embolism. CT and cardiac MRI were also used in some of the patients as required. CT or cardiac MRI was performed, especially in patients in whom the place of attachment of the myxoma could not be clearly seen on echocardiographic imaging and in patients who needed a differential diagnosis of thrombus.

The date of surgery for all patients was decided according to the clinical condition of the patient. All patients were routinely checked with TTE prior to discharge, and were followed up on an out-patient basis at regular intervals every year thereafter.

This study complied with the Declaration of Helsinki and was carried out following approval of the Ethics Committee for Clinical Trials of Kocaeli Derince Training and Research Hospital of Health Sciences University (ethics committee approval number: 2022/104).

In order to avoid embolic complications or sudden death, a surgical decision was made in all patients after the diagnosis of atrial myxoma. All patients were operated on with a median sternotomy under general anaesthesia. Standard CPB was established with aortic and bicaval venous cannulations, and



Fig. 1. Right atrial myxoma image on TEE

systemic heparin (300 IU/kg) was introduced with maintenance of activated clotting time > 450 seconds. Hyperkalaemic cold blood cardioplegia was applied for cardiac arrest.

Surgery was performed under moderate hypothermia (28–30°C). CPB flow was maintained at 2.2–2.5 l/min/m², mean perfusion pressure between 50 and 80 mmHg, and haematocrit level between 20 and 25%. In order to avoid embolic complications, including in patients requiring additional surgical procedures, the existing myxoma was completely removed first. Left or right atriotomy incisions with a trans-septal approach were used as the surgical approach for myxoma. The mass in the right or left atrium was completely resected.

After the heart cavities were thoroughly checked for tumour residue, abundant irrigation of the atrium and ventricle with cold saline solution was performed after resection to prevent tumour recurrence and intra-operative embolisation. After these procedures, the left or right atriotomy was closed. In the presence of myxoma attached to the interatrial septum, the resected septum with the tumour was closed with a pericardial patch.

Postoperatively, all patients were transferred intubated to the intensive care unit. They were extubated following the onset of spontaneous breathing and normalisation of orientation and co-operation if the haemodynamic and respiratory functions were appropriate. Patients who did not develop major complications in the postoperative period were followed up in the patient rooms of the service.

Statistical analysis

Characteristics of symptomatic and asymptomatic patients were compared using IBM SPSS software version 22.0 (SPSS Inc, Chicago, IL, USA). Among the data measured, those showing normal distribution are expressed as mean \pm standard deviation and those not showing normal distribution are expressed as median (minimum–maximum). The numerical data are given as percentages.

Among the data measured, the normality of distribution was evaluated by histogram or Kolmogorov–Smirnov test, and the homogeneity of distribution was evaluated by Levene's test for equality of variance. In the analysis of continuous variables, the

Table 1. Clinical characteristics of patients with symptomatic and asymptomatic cardiac myxomas								
Patients' characteristics	All cardiac myxomas (n = 34)	Group 1 symptomatic myxomas (n = 19)	$\begin{array}{c} Group \ 2\\ asymptomatic\\ myxomas\\ (n=15) \end{array}$	p- <i>value</i>				
Age, years (mean \pm SD)	54.8 ± 8.8	53.9 ± 8.7	55.3 ± 9.2	0.67**				
Male, <i>n</i> (%)	18 (52.9)	8 (44.4)	10 (55.6)	0.15*				
Female, <i>n</i> (%)	16 (47.1)	11 (68.7)	5 (31.3)					
Hypertension, n (%)	13 (38.2)	8 (42.1)	5 (33.3)	0.60*				
Diabetes mellitus, n (%)	10 (32.4)	6 (31.6)	5 (33.3)	0.91*				
Smoking, n (%)	18 (52.9)	12 (63.2)	6 (40.0)	0.18*				
Hyperlipidaemia, n (%)	13 (38.2)	9 (47.4)	4 (26.7)	0.22*				
BMI (kg/m ²) (mean \pm SD)	26.5 ± 1.8	26.7 ± 1.6	26.2 ± 2.1	0.43**				
Ejection fraction (%) (mean ± SD)	55.3 ± 7.8	53.7 ± 8.1	57.2 ± 7.1	0.20**				
Location of myxoma, n (%)								
Left atrium	25 (73.5)	13 (68.4)	12 (80.0)	0.45*				
Right atrium	9 (26.5)	6 (31.6)	3 (20.0)					
BMI: body mass index. *Pearson's chi-squared test, **Student's t-test.								

student's *t*-test was used for those with normal distribution, and Mann–Whitney *U*-test for those without normal distribution. Pearson's chi-squared test or Fisher's exact test was used in the analysis of categorical data. For all tests, p < 0.05 was considered to be statistically significant.

Results

The demographic characteristics and clinical data of the patients are summarised in Table 1. There was no statistically significant difference between symptomatic and asymptomatic patients. In our study, 25 (73.5%) of the myxomas completely removed surgically were localised in the left atrium, while nine (26.5%) were in the right atrium. There were no myxomas in any other cardiac cavities.

The pre-operative and early postoperative blood analysis and haematological parameters of the patients are summarised in Table 2. Pre-operative ESR levels were significantly different between the groups (p = 0.02).

Among the symptomatic patients, the most common symptoms were dyspnoea (8/19 patients, 42.1%), palpitations (4/19 patients, 21.1%), ischaemic stroke (3/19 patients, 15.8%), syncope (2/19 patients, 10.5%) and systemic symptoms (2/19 patients, 10.5%).

In our study, there was a total of 15 (44.1%) asymptomatic cardiac myxoma patients. The majority (13/15 patients) were diagnosed incidentally during imaging for reasons such as pre-operative cardiac evaluation for non-cardiac surgery and routine health screenings. Of these, eight patients were diagnosed by pre-operative echocardiography, three by CT scanning and two by chest X-ray.

Intra-operative and postoperative data of the patients are summarised in Table 3. There was no statistically significant difference between the groups in terms of summarised data. As

Table 2. Pre-operative blood results and haematological parameters of patients with symptomatic and asymptomatic cardiac myxomas							
	All cardiac myxomas	Group 1 symptomatic myxomas	Group 2 asymptomatic myxomas				
Blood results and haemato- logical parameters	(n = 34) $(mean \pm SD)$	(n = 19) $(mean \pm SD)$	(n = 15) $(mean \pm SD)$	p-value			
Pre-operative							
Haemoglobin (mg/dl)	12.92 ± 0.95	12.87 ± 0.84	12.99 ± 1.11	0.73*			
Creatinine (mg/dl)	0.76 ± 0.28	0.83 ± 0.29	0.68 ± 0.24	0.11*			
Urea (mg/dl)	40.53 ± 3.54	40.21 ± 3.10	40.93 ± 4.11	0.56*			
Leucocyte counts (× 10 ³ cells/µl)	8.28 ± 1.89	8.13 ± 1.92	8.46 ± 1.91	0.62*			
Thrombocyte counts (× 10 ³ cells/µl)	235 ± 48	228 ± 47	245 ± 49	0.30*			
CRP (mg/l)	0.87 ± 0.54	0.88 ± 0.52	0.85 ± 0.57	0.87*			
ESR (mm/h)	16.00 ± 7.30	18.47 ± 7.28	12.87 ± 6.23	0.02*			
Postoperative							
Haemoglobin (mg/dl)	8.91 ± 0.92	9.08 ± 1.03	8.69 ± 0.73	0.22*			
Creatinine (mg/dl)	0.95 ± 0.27	1.01 ± 0.32	0.88 ± 0.17	0.15*			
Urea (mg/dl)	43.29 ± 5.41	44.63 ± 6.38	41.60 ± 3.36	0.11*			
Leucocyte counts (× 10 ³ cells/µl)	12.23 ± 2.19	12.48 ± 2.07	11.91 ± 2.36	0.45*			
Thrombocyte counts (× 10 ³ cells/µl)	346 ± 57	354 ± 50	337 ± 64	0.39*			
CRP (mg/l)	40.84 ± 7.42	39.74 ± 8.44	42.23 ± 5.85	0.34*			
ESR (mm/h)	41.88 ± 7.16	42.84 ± 7.10	40.67 ± 7.30	0.39*			
CRP: C-reactive protein, ESR: erythrocyte sedimentation rate. *Student's t-test.							

Table 3. Intra-operative and postoperative data of the patients								
Patients' characteristics	All cardiac myxomas (n = 34)	Group 1 symptomatic myxomas (n = 19)	Group 2 asymptomatic myxomas (n = 15)	n-value				
Duration of surgical intervention (days) (mean ± SD)	31.79 ± 24.22	17.79 ± 6.36	49.53 ± 26.97	0.0001*				
ACC time (min) (mean ± SD)	37.97 ± 16.97	36.53 ± 11.80	39.80 ± 20.22	0.58*				
CPB time (min) (mean ± SD)	62.62 ± 22.93	60.74 ± 14.96	65.00 ± 30.67	0.60*				
Amount of drainage (ml) (mean ± SD)	349 ± 134	366 ± 114	340 ± 105	0.45*				
Intubation time (hours) (mean \pm SD)	5.85 ± 1.35	5.79 ± 1.48	5.93 ± 1.22	0.76*				
Stay in ICU (hours) (mean ± SD)	24.06 ± 6.26	25.00 ± 6.84	22.87 ± 5.42	0.33*				
Duration of hospital stay (days) (mean ± SD)	6.21 ± 1.72	6.47 ± 1.58	5.87 ± 1.89	0.31*				
Use of blood products, $n(\%)$	16 (47.1)	7 (43.8)	9 (56.3)	0.18**				
Use of inotropic support, <i>n</i> (%)	10 (29.4)	17 (9.3)	36 (5.9)	0.20**				
Follow-up times (months) (mean ± SD)	113.79 ± 44.11	109.84 ± 44.32	118.73 ± 44.87	0.57*				
ACC: aortic cross-clamp, CPB: cardiopulmonary bypass, ICU: intensive care unit. *Student's <i>t</i> -test, **Pearson's chi-squared test.								

a surgical approach, we performed a left atriotomy in 18 patients (52.9%), a right atriotomy in nine patients (26.5%), a transseptal approach with right atriotomy in four patients (11.8%), and the myxoma was resected by performing both right and left atriotomy in three patients (8.8%).

In 14 cases, the area of attachment of the myxoma was excised in full thickness. The defect formed in these patients who underwent full-thickness resection was repaired with a pericardial patch in five patients (Fig. 2). In the other nine patients, the defect was primarily sutured. Associated procedures consisted of coronary artery bypass grafting in two patients, coronary artery bypass grafting and the Bentall procedure in one patient, mitral valve replacement in two patients, and mitral valve replacement and tricuspid valve reconstruction in one patient.



with septal tissue in full thickness.

Arrhythmia was observed in seven patients (20.6%) in the early postoperative period. Of these, transient nodal rhythm was found in three patients (8.8%) and transient atrial fibrillation in four patients (11.8%) who successfully converted to sinus rhythm after intravenous infusion of amiodarone. None of these patients required permanent pacemaker implantation.

Neurological events (transient ischaemic event, speech disorder, hemiplegia or hemiparesis) in the first month postoperatively were seen in two patients (10.5%) in group 1 and in one (6.7%) in group 2. There was no statistically significant difference between the groups (p = 0.69).

There was no mortality in any patient in hospital and in the first month postoperatively. However, in our long-term follow up, one patient died due to an oncological disease in the 93rd month of follow up, and another died in the 118th month of follow up due to multiple organ failure. Other postoperative complications were sternum wound infection in two patients and pericardial effusion requiring re-sternotomy in two patients with tamponade findings.

Tumours resected from all patients were submitted for histological examination. The diagnosis of myxoma was confirmed by extensive fibrin deposits, proliferation of capillaries, and blood extravasations (Fig. 3).

Discussion

In this study, we present our 16-year experience of cardiac myxoma from two hospitals that provide tertiary care and are also cardiac centres. Autopsy studies have determined the incidence of primary cardiac neoplasms to be approximately two in 10 000 and the majority of them histologically benign.¹⁰ Cardiac myxomas are the most common primary benign tumour of the heart, most common between the fourth and sixth decades of life, and more common in women.¹¹

In our study, the mean age of the patients at the time of surgery was 54.5 ± 8.8 years, which is in line with that of the



Fig. 3. Histopathological image of the excised myxoma.

literature. The incidence of myxoma in our study was also similar to that of other studies.

Myxomas are usually solitary and originate from the left atrium (75%) or from the atrial septum close to the foramen ovale, but with decreasing frequency, they can also originate from the posterior atrial wall, anterior atrial wall and atrial appendage.¹² Myxomas are usually round or oval, broad-based, pedunculated tumours that grow at a rate of about 0.15 cm per month.¹³ In our study, myxoma localisation was in the left atrium in 25 patients (73.5%).

Cardiac myxomas are benign tumours but often result in serious complications due to their asymptomatic features.¹⁴ Because of the high blood flow, the ruptured tumour fragments can reach all parts of the body, and because they are asymptomatic, patients with undiagnosed cardiac myxomas are at risk of experiencing systemic and pulmonary embolism and even intracardiac obstruction.¹⁵ Embolism from myxomas may cause various complications such as myocardial infarction, stroke, heart failure, other organ infarction and limb ischaemia.¹⁴ In our study, three patients (15.8%) were diagnosed with ischaemic stroke.

Evaluation of other concomitant cardiac and non-cardiac health problems in patients with cardiac myxoma is important for management and treatment strategies.³ The use of echocardiography has greatly facilitated the diagnosis of structural heart pathologies and cardiac myxomas.¹ Echocardiography is the most commonly used diagnostic method for accurate and rapid pre-operative evaluation of myxoma patients.¹⁴ In previous studies, it was emphasised that the heart valves and chambers should be carefully examined with both TTE and TEE due to concomitant cardiac pathologies.¹⁶ TEE and three-dimensional echocardiography should be performed to clarify the shape, size and mobility of the cardiac myxoma.³ In addition, clinical features and histopathological type of the myxoma can be predicted and treatment strategies can be determined by echocardiography.¹

CT and MRI, which are other diagnostic methods, can distinguish between tumour and non-tumour mass, benign and malignant mass, and information about the characteristics and spread of the tumour can be obtained.¹³ Radiological imaging of these lesions, especially with CT or MRI, can provide an accurate assessment of the size, location and attachment point of these lesions and assist in surgical planning.¹⁷

In recent years, cardiac MRI has become an indispensable method for comprehensive evaluation, clinical diagnosis and treatment guidance of heart tumours due to its multi-plane image reconstruction capability, adequate spatial resolution, excellent soft tissue characterisation and capacity to distinguish different tissue features.⁸ In addition, cardiac MRI allows determination of the location, homogeneity, morphology, extent, margin, mobility and valve dysfunction of heart masses and can evaluate the relationship between tumour and lung, pericardium or mediastinum.¹⁸

Contrast-enhanced MRI is preferred to define further characterisation of cardiac myxomas, but CT coronary angiography may be more used for differential diagnosis of the myxoma and thrombus.¹⁹ In contrast-enhanced cardiac MRI, contrast enhancement describes the vascularity of the tumour and its relationship to the blood vessels, and further illustrates the impact of tumours on tissue characterisation, cardiac function and haemodynamics, and the relationship between cardiac tumours and extracardiac structures. This advantage of contrast-enhanced cardiac MRI is of great importance in tumour treatment and prognosis evaluation.²⁰

Cardiac MRI also has disadvantages, one of which is that, due to its lower temporal resolution, it cannot provide an advantage over echocardiography in the evaluation of heart or valve tumours that are less than 10 mm in diameter, nearly invisible, and highly mobile.⁸ Other limitations of cardiac MRI are its high cost, long acquisition time, and unavailability of use in patients with implanted cardiac devices such as pacemakers or intracardiac defibrillators, those with haemodynamic instability or those with breathlessness and claustrophobia.²¹

Cardiac CT has become a second-line diagnostic method, with increasing use in the evaluation of heart masses, especially in cases where other imaging methods are contra-indicated or under-evaluated.⁸ With the emergence and advancement of technologies such as cardiac CT, multidetector CT, helical CT and electrocardiographic-gated CT, cardiac masses have achieved submillimetre spatial resolution and shorter scanning time, minimising motion-related artifacts, with improved temporal resolution and imaging quality defined more accurately.²²

Cardiac CT has the ability to characterise tissue by evaluating density and perfusion, and the use of contrast-enhanced CT provides significant benefits, especially in determining the differential diagnosis of cardiac masses and evaluating the vascular distribution and fibrous component of tumours.²³ Cardiac CT is reported to be the most appropriate and preferred imaging technique for the evaluation of cardiac tumour calcification and other non-cardiac structures when compared to other imaging modalities.²² Limitations of cardiac CT are exposure to radiation, risk of adverse events from the contrast medium used, and lower soft tissue resolution compared to echocardiography or cardiac MRI.⁸

There is still no consensus on whether or not to perform pre-operative coronary artery angiography in patients with cardiac myxoma in the presence of ischaemic symptoms.²⁴ Because cardiac myxoma can easily be diagnosed by echocardiography, some authors have recommended that myxomas be resected as soon as the diagnosis is made.²⁵ Other authors have recommended that coronary artery angiography be performed only in patients with chest pain or over the age of 40 years.²⁶ Sometimes coronary angiography can also be useful to identify high-level vascular tumours such as angiosarcoma.²⁵

In clinical practice, echocardiography and cardiac MRI are the primary imaging modalities for the diagnosis and treatment of cardiac tumours, while cardiac CT is a powerful and valuable complementary tool. In our study, echocardiography was the most commonly used diagnostic method for pre-operative diagnosis of myxomas in both symptomatic and asymptomatic patients and for detecting the presence of residue of postoperative residual tumours and the recurrence of tumours.

In the follow up, if there was a suspicious appearance in the area where the myxoma was excised, the possibility of recurrence was followed up with cardiac CT or MRI. In addition, in our study, cardiac CT and MRI examinations were performed on myxoma patients whose location of anatomical attachment could not be determined by echocardiography and could not be clearly differentiated from thrombus. We also performed coronary artery angiography in all myxoma patients.

Although it is generally accepted that intracardiac masses require surgical intervention, there is no consensus on the timing of excisional surgery.¹ Surgical excision of cardiac myxomas is the only remedial treatment modality, except for a few recurrences in long follow up times in patients with low operative risk.²⁴ While debate continues about the timing of the surgery, it is commonplace for patients to die or experience a major complication while awaiting surgery due to the risk of sudden cardiac death.¹⁹ As a result, some studies suggest that emergency surgery is required when a patient has a myxoma large enough to cause complete intracardiac obstruction.²⁷

Pinede *et al.* reviewed 112 cases of left atrial myxoma from 1959 to 1998 and reported that the time interval between the onset of symptoms and surgical removal of the myxoma ranged from zero to 126 months, with a median of four months.⁹ In their 2017 study, Lee *et al.* reported that they performed elective surgery on 65 patients and emergency surgery on 28 patients with severe symptoms or embolic risk. However, they did not specify the time before elective surgery in this study.²⁸

There are no studies directly investigating the impact of surgical timing on patient prognosis in cardiac myxomas, but the general opinion is that speedy surgical excision should be performed after diagnosis because of the high risk of valve occlusion or systemic embolisation.¹⁹ In our study, the mean duration of time up to surgery for symptomatic patients was 17.79 ± 6.36 days, while it was 49.53 ± 26.97 days for asymptomatic patients. In addition, no emergency surgical excision was carried out in any patient in our study.

A surgical approach in cardiac myxomas should be chosen according to myxoma location and size, the surgeon's preference and experience, the presence of concomitant heart diseases and the genetic structure of the myxoma.²⁹ The basic principle of surgical treatment for cardiac myxomas is complete tumour removal to avoid intra-operative embolisation and the presence of tumour remnants.³⁰

Adequate resection with microscopically and macroscopically negative clean margins is the cornerstone of myxoma resection to prevent the risk of recurrence after surgery, and the tumour should be removed with a 0.5- to 1-cm tissue margin.²⁹ Due to the anatomical location of the myxoma, extensive resection may sometimes be required, and in such cases the resected part can be reconstructed with a patch.¹⁶ However, resection of myxomas on the atrioventricular valves or around the conduction tissue can be technically difficult and very risky, and limited resection at the subendocardial level may be inevitable, instead of extensive tissue removal. Very close follow up is required in these patients to exclude possible recurrence.²⁹

Cardiac myxomas are excised by open-heart surgery under CPB, and the surgical approach is to make an incision in the left atrium behind the interatrial groove to visualise the tumour in the left atrium.³¹ However, in cases where the left atrial myxoma is large and access to the left atrium is limited, and in right atrial myxomas, right atriotomy is the other surgical approach.¹⁹ If the myxoma is papillary or its base is sessile, the tumour can be reached with a bi-atrial approach.³¹ However, the ideal surgical approach in left atrial myxomas is controversial and no consensus has been reached on the best surgical approach.²⁹

In left atrial myxomas, the bi-atrial approach, which includes bi-atriotomy, right atrial trans-septal approach and superior trans-septal approach provide some advantages over the uni-atrial approach in the majority of patients.³⁰ Jones *et al.* defined the advantages of the bi-atrial approach in their study as follows: direct visual identification of the tumour pedicle, minimal manipulation of the tumour, adequate excision margins, examination of all heart chambers, and safe closure of the atrial septal defect.³² Siminelakis *et al.*, in their new and intriguing study, defined the ideal surgical approach for cardiac myxomas as right atrial or bi-atrial incisions, excision of the fossa ovalis and surrounding tissues, and closure of this area with a pericardial patch.³³

Although the bi-atrial approach offers excellent exposure, criticism remains against this approach as it is responsible for the high incidence of arrhythmias and conduction disorders after resection of left atrial myxomas.²⁹ Choosing the appropriate surgical approach for myxomas is very important for the patient's prognosis and tumour recurrence. The surgical approach to myxomas should allow examination of all four heart chambers and minimal manipulation of the tumour, provide adequate exposure for complete resection without residue, minimise the chance of recurrence, and be safe and effective.³⁴

In our study, 22 of 25 patients had excision of a left atrial myxoma with a left atrial approach and three with a bi-atrial approach. In all patients with right atrial myxomas, the myxoma was removed with a right atrial approach. In our study, no malignant arrhythmias were observed after surgery. In seven (18.9%) cases, only atrial fibrillation occurred as a postoperative rhythm disorder. The tumour was resected with a bi-atrial approach in two patients who developed postoperative atrial fibrillation, a left atrial approach in three patients, and a right atrial approach in two patients.

The outcome after cardiac myxoma resection is quite good, with a 20-year survival rate of around 85%, and a low atrial myxoma recurrence rate after surgical resection (5%).²⁴ Local recurrence of cardiac myxomas is very rare, but may be due to incomplete resection, multicentricity, origin outside the left atrium, familial tumours, or part of a disease complex such as Carney complex.³⁵ Elbardissi *et al.* reported in their study that myxoma recurrence rate after resection was 13%, but it was much more common in familial myxomas compared to sporadic myxomas (22 vs 3%).³⁶ In their study involving 98 patients who underwent surgery for cardiac myxoma, Garatti *et al.* reported that the recurrence rate was 1% in their 15-year follow up.¹

In another study, Jiang *et al.* reported that the recurrence rate was 1.5% in the long-term follow up of 403 patients who underwent myxoma resection.³⁷ In another study, Vroomen *et al.* reported that they did not see any recurrence after 20 years of follow up in patients with myxoma.³⁸ Yüksel *et al.*, in their study involving 43 patients who were operated on for cardiac myxoma, reported that they followed up the patients for an average of 102.3 \pm 66.5 months, and no recurrence was observed in any of their patients during this period. They also reported that these patients had 95, 92 and 78% survival rate at five, 10 and 15 years, respectively.²⁹ In our study, no recurrence occurred in any of our patients during their long-term follow up (follow-up times, median: 119.5, min–max: 10–172 months). None of our patients had Carney complex or a familial history of atrial myxoma.

The postoperative complication rate in cardiac myxoma resections is quite low and the postoperative period is generally uneventful, with minor complications.²⁶ Rhythm disturbances, especially atrial fibrillation, are the most common complications

after cardiac myxoma surgery, and they are rarely seen in neurological disorders, bleeding, myocardial infarction and other minor complications.¹

Previous studies reported that the 30-day mortality rate after excision of cardiac myxomas ranged from zero to 10%.²⁶ Shah *et al.* reported a 30-day mortality rate of 0.5% in their study involving 194 patients who underwent myxoma resection.³⁹ In another study, Cianciulli *et al.* reported that no 30-day mortality was observed in any of the 53 patients who underwent cardiac myxoma resection.⁴⁰ Lee *et al.* reported that the 30-day mortality rate after myxoma resection was 3.2%.²⁸ In our study, 30-day mortality was not observed in any patient.

Limitations

Our study has some limitations. The most important of these is that due to the retrospective nature of the study, not all necessary information could be accessed and the number of patients was low. In addition, our results may not be generalisable to all other centres since our study was a dual-centre study. Third, we may have missed recurrences in some asymptomatic patients, since echocardiography could not be routinely performed on all patients at regular intervals during the follow-up period.

Conclusion

We retrospectively analysed 34 patients with cardiac myxomas that were surgically removed over a 16-year period in two centres providing tertiary care and working as cardiac surgery centres. Myxomas are the most common benign tumours of the heart and most commonly originate from the fossa ovalis region of the left atrium.

A high index of suspicion is required for diagnosis as most patients are asymptomatic. Cardiac tumours should be considered in patients who frequently present with non-specific symptoms such as weight loss, fatigue, heart failure, arrhythmias and embolism. Echocardiography is an ideal diagnostic tool, as well as for follow up. Emergency surgical treatment is indicated in all diagnosed patients because of risk of sudden death due to intracardiac obstruction and systemic embolic events. Surgical excision of cardiac myxomas in suitable centres and with experienced surgeons carries low operative risk and provides excellent short- and long-term results.

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