A 20-year experience in cardiac tumors: a single center surgical experience and a review of literature

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Introduction **Cardiac tumors are rare and heterogeneous entities which still remain a diagnostic and therapeutic challenge. The treatment for most cardiac tumors is prompt surgical resection. We sought to provide an overview of surgical results from a series of consecutive patients treated at our tertiary care center during almost a 20-year experience.**

Methods and Results **In this single center study, 55 consecutive patients with diagnosis of cardiac tumor underwent surgical treatment from January 2002 to April 2021. Of these, 23 (42%) were male and the mean age was 62 ± 12 years. Fifteen (27%) patients were symptomatic at the time of the diagnosis, mostly for dyspnea and palpitations. The most frequent benign cardiac tumor was myxoma (32; 58%), occurring mainly in the left atrium (31; 97%). Pleomorphic sarcoma was the most frequent primary malignant cardiac tumor (4; 7%), mainly located in the ventricles (1; 25% in the left ventricle; 2; 50% in the right ventricle). In all cases of benign tumors surgery was successful with no relapses. Two (50%) pleomorphic sarcomas showed subsequent relapses. After a median follow-up of 44 months, 15 (27%) patients died. Although malignant tumors presented a limited survival, benign tumors showed a very good prognosis.**

Conclusion **Cardiac tumors require a multidisciplinary approach to guarantee a prompt diagnosis and appropriate treatment. In our surgical experience, outcome after surgery of benign tumors was excellent, while malignant tumors had poor prognosis despite radical surgery.**

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Introduction

Cardiac tumors are rare and heterogeneous entities which still remain a diagnostic and therapeutic challenge. In most cases primary cardiac tumors are benign, whereas about 10% are malignant.[1,2] Myxomas account for approximately 50% of all benign cardiac tumors, while sarcomas are the most frequent malignant cardiac tumors.[3] Secondary tumors are more frequent than primary cardiac tumors, with still unknown incidence rate.[3] An involvement of the heart was reported in 9.1% of cases of all malignant tumors in an autopsy series.[4]

Cardiac masses can be effectively identified by multimodality imaging. Echocardiography remains the first diagnostic tool, allowing the evaluation of size, mobility, site of attachment and hemodynamic impact of the mass.[5,6] Computed tomography (CT), cardiac magnetic resonance (CMR) and positron emission tomography (PET) refine the diagnosis, describing anatomical relationships, extension to surrounding structures, tissue composition and metabolic activity.[7]

The treatment for most cardiac tumors is prompt and complete surgical resection, while the benefit of other therapeutic approaches such as chemotherapy and/or radiation therapy is still unknown.

In the present study we sought to describe the surgical experience and outcomes of a cohort of consecutive patients treated at our tertiary care center.

Methods

In this observational retrospective study, all consecutive patients with diagnosis of cardiac tumor and referred for cardiac surgery from January 2002 to April 2021 at University Hospital of Trieste were enrolled. All patients were >18 years old. Preoperative diagnosis was established using a multimodality imaging approach, including transthoracic echocardiography (TTE) and transesophageal

echocardiography (TOE). Cardiac CT, CMR and PET-CT were also considered, when available. Data regarding patient's baseline characteristics, symptoms, tumor location, surgical features, pathological findings and outcomes were collected. Standard operative technique was a median sternotomy and cardiopulmonary bypass (CBP), using aortic and bicaval cannulation, aortic cross clamp and cardioplegic arrest. In myxoma patients, *en bloc* excision of the septum around the base of the tumor pedicle was performed followed by atrial septal defect closure with a dacron or pericardial patch. In nonmyxoma tumors, operative strategy was individualized to obtain a curative resection. In case of endocavitary ventricular neoplasms, surgical exploration and exposition was through ipsilateral atriotomy and trans-mitral-valve visualization (if the tumor was located in the ventricular inflow) or through transaortic/transpulmonary-valve access (if it was located in the ventricular outflow). Partial ventriculotomy with mass enucleation was mandatory when the neoplasm was intramural, followed by LV reshaping by dacron patch interposition.

All survivors were contacted to assess tumor recurrence. Informed consent was obtained under the institutional review board policies of hospital administration. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Statistical analysis

Summary statistics of clinical and instrumental continuous variables were expressed as mean and standard deviation or median and interquartile range (IQR) as appropriate. Categorical data are presented as absolute numbers and percentages. Survival was estimated using the Kaplan–Meyer method and curves were compared using the log-rank test. Statistical analysis was performed using IBM SPSS Statistics software version 28.

Results

Patient population

Fifty-five patients with confirmed diagnosis of cardiac tumor underwent surgical treatment during the study period. Table 1 summarizes characteristics of the study population. Mean age was 62 ± 12 years and 23 (42%) patients were male. Median EuroSCORE 2 was 0.77 [IQR 0.76–0.78].

Clinical presentation

Fifteen (27%) patients were symptomatic at the time of the diagnosis. The most frequent symptoms were dyspnea (13; 24%) and palpitations (12; 22%). Other reported symptoms were chest pain (9; 16%), syncope (4; 7%) and stroke (1; 1%) (Table 2).

Types of cardiac tumors

A benign cardiac tumor was diagnosed in 45 (82%) patients. The most frequent benign cardiac tumor was myxoma (32; 58%), occurring mainly in the left atrium (LA; 31; 97%). Fibroelastoma was documented in 10 patients (18%), mostly at the level of mitral valve (6; 60%) and aortic valve (3; 30%) (Fig. 1, panel a). Ten (18%) patients presented a malignant cardiac tumor (Fig. 1, panels b and c). Pleomorphic sarcoma was the most frequent primary malignant cardiac tumor (4; 7%), mainly located in the ventricles (Table 3).

The overall ability of TTE and TOE in identifying cardiac masses properly as tumors, subsequently confirmed by the anatomopathological data, was 83%. Diagnostic accuracy of echocardiography was higher if contrast ultrasound was performed (86%).

Table 1 Baseline characteristics of the population

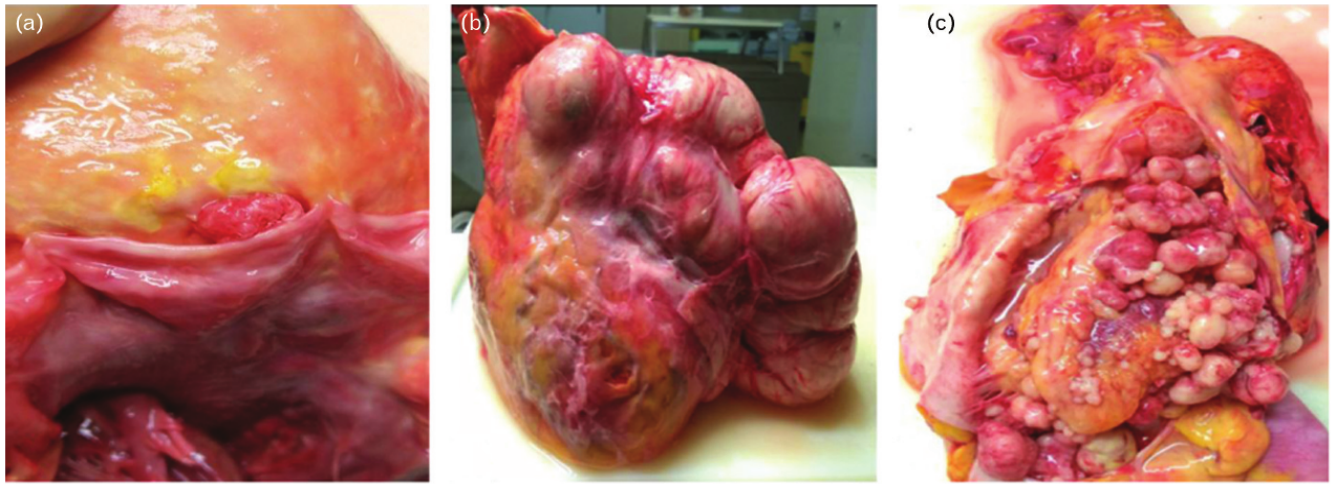
	Total ($n = 55$)
Age (years)	62 ± 12
Male, *n* (%)	23 (42)
BMI (kg/m^2)	26 ± 4
Follow-up duration (months)	44 [22-109]
LVEDV (ml)	77 ± 28
LVEF (%)	61 ± 9
EuroSCORE II	0.77 [0.76–0.78]
MR $\geq$2+	8 (15)
PAPs (mmHg)	43 ± 34
RV dysfunction, *n* (%)	4 (7)
Pericardial effusion, *n* (%)	8 (15)
Creatinine (mg/dl)	0.9 ± 0.3
GFR (ml/min/1.73 m^2)	87 [63–115]
Hemoglobin (g/dl)	12 ± 2
Previous cardiac surgery, *n* (%)	10 (18)
History of any tumor, *n* (%)	20 (37)
Diabetes, *n* (%)	13 (23)
Hypertension, *n* (%)	35(63)
COPD, *n* (%)	3 (5)
CKD, *n* (%)	13 (24)
Stroke, *n* (%)	6 (11)
CAD, *n* (%)	14 (25)
AF, *n* (%)	7 (13)
Warfarin, *n* (%)	12 (22)
DOAC, *n* (%)	2 (4)
ASA, *n* (%)	24 (44)
DAPT, *n* (%)	4 (7)
ACE-I, *n* (%)	16 (29)
ARB, *n* (%)	5 (9)
BB, *n* (%)	23 (42)
MRA, *n* (%)	1 (2)
Furosemide, *n* (%)	8 (15)
Statins, *n* (%)	19 (35)

AF, atrial fibrillation; ARB, angiotensin receptor blockers; ASA, acetylsalicylic acid; BB, beta blockers; BMI, body mass index; CAD, coronary artery diseases; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DAPT, dual antiplatelet therapy; DOAC, direct-acting oral anticoagulants; GFR, glomerular filtration rate; LVEDV, left ventricular end-diastolic volume; LVEF, left ventricular ejection fraction; MR, mitral regurgitation; MRA, mineralcorticoid receptor antagonists; NSVT, non-sustained ventricular tachycardia; PAD, peripheral artery disease; RV, right ventricle.

Table 2 Symptoms at presentation

	Total ($n = 55$)
Presence of symptoms, *n* (%)	15 (27)
Dyspnea, *n* (%)	13 (24)
Palpitations, *n* (%)	12 (22)
Chest pain, *n* (%)	9 (16)
Syncope, *n* (%)	4 (7)
Stroke, *n* (%)	1 (1)

Fig. 1



Macroscopic appearance of cardiac tumors. (Panel a) Giant papillary fibroelastoma. (Panel b) Fibrosarcoma. (Panel c) Liposarcoma.

Surgical approach and prognosis

Table 4 describes the surgical approach according to the histotype. Radical exeresis was achieved in all cases of benign tumors, with no further relapses. Complete macroscopic resection of malignant tumors was achieved in six (60%) patients. Surgical debulking was performed in two cases of pleomorphic sarcoma, one case of lymphoma and one case of metastatic tumor, with symptoms improvement in all cases. Postoperative complications occurred in six (10%) patients: atrial fibrillation after resection of LA myxomas (3; 50%), prolonged mechanical ventilation after radical exeresis of LV sarcoma (1; 17%), transient low cardiac output syndrome after extensive resection of LV sarcoma (1; 17%) and transient pericardial effusion without cardiac tamponade (1; 17%).

Adjuvant chemoradiotherapy was used in two cases of pleomorphic sarcoma (one case of RV sarcoma treated with radical exeresis and one case treated with surgical debulking and evidence of early recurrence).

During a median follow-up of 44 months (IQR 22–109), 15 (27%) patients died. Figure 2 and Table 5 show the overall survival after cardiac surgery according to tumor histotype. Patients with malignant tumors or metastases died from the underlying tumor. Five deaths were observed in the myxoma group (one natural death; two ischemic heart disease; one bacterial pneumonia; one respiratory insufficiency due to preexisting chronic obstructive pulmonary disease). Pleomorphic sarcoma (Fig. 3) showed the worst prognosis (median survival after surgery 10 months, IQR 6–16).

Discussion

Main findings

The results of the present study can be summarized as follows: benign tumors were the most frequent cardiac tumor, with myxoma the most prevalent histotype; most of the patients were asymptomatic at clinical presentation, whereas dyspnea and palpitation were the most frequent symptoms; complete resection was the most used surgical approach, whereas debulking was reserved for a few cases and associated with relapse during follow-up; benign tumors showed an excellent prognosis after surgery, while malignant tumors presented a limited survival.

Table 3 Histotype and location of cardiac tumors observed during study period

Histotype	Frequency	LA	RA	LV	RV	MV	AV	TV	PA
Myxoma, *n* (%)	32 (58)	31 (97)	1 (3)						
Fibroelastoma, *n* (%)	10 (18)					6 (60)	3 (30)	1 (10)	
Pleomorphic sarcoma, *n* (%)	4 (7)	1 (25)		1* (25)	2 (50)				1* (25)
Lipoma, *n* (%)	2 (4)		2 (100)						
Neoplastic thrombus, *n* (%)	2 (4)		2 (100)						
Liposarcoma, *n* (%)	1 (2)	1 (100)							
Fibro-leiomiosarcoma, *n* (%)	1 (2)				1 (100)				
Hamartoma, *n* (%)	1 (2)			1 (100)					
Lymphoma, *n* (%)	1 (2)		1 (100)						
Metastasis, *n* (%)	1 (2)		1 (10)						
Total, *n* (%)	55 (100)								

AV, aortic valve; LA, left atrium; LV, left ventricle; MV, mitral valve; PA, pulmonary artery; RA, right atrium; RV, right ventricle; TV, tricuspid valve. * Same tumor.

Table 4 Type of surgical approach to cardiac tumors according to histotype, associated surgical procedures and outcomes

Histotype	Type of surgery *n* (%)	Associated surgical procedures* *n* (%)	Macroscopical successful surgery *n* (%)	Relapses *n* (%)
Myxoma ($n=32$)	Radical exeresis 32 (100)	5 (16)	32 (100)	0 (0)
Fibroelastoma ($n=10$)	Radical exeresis 10 (100)	5 (50)	10 (100)	0 (0)
Pleomorphic sarcoma ($n=4$)	Radical exeresis 2 (50) Debulking 2 (50)	2 (50)	2 (50)	2 (50)
Lipoma ($n=2$)	Radical exeresis 2 (100)	0 (0)	2 (100)	0 (0)
Neoplastic thrombus ($n=2$)	Radical Exeresis 2(100)	0 (0)	2 (100)	1 (50)
Liposarcoma - (n=1)	Radical exeresis 1 (100)	0 (0)	1 (100)	0 (0)
Fibro-leiomiosarcoma ($n=1$)	Radical exeresis 1 (100)	0 (0)	1 (100)	0 (0)
Hamartoma ($n=1$)	Radical exeresis 1(100)	0 (0)	1(100)	0(0)
Lymphoma ($n=1$)	Debulking 1 (100)	0 (0)	1 (100)	0 (0)
Metastasis ($n=1$)	Debulking 1 (100)	0 (0)	1 (100)	0 (0)
Total ($n=55$)				

* Coronary bypass graft or valve surgery.

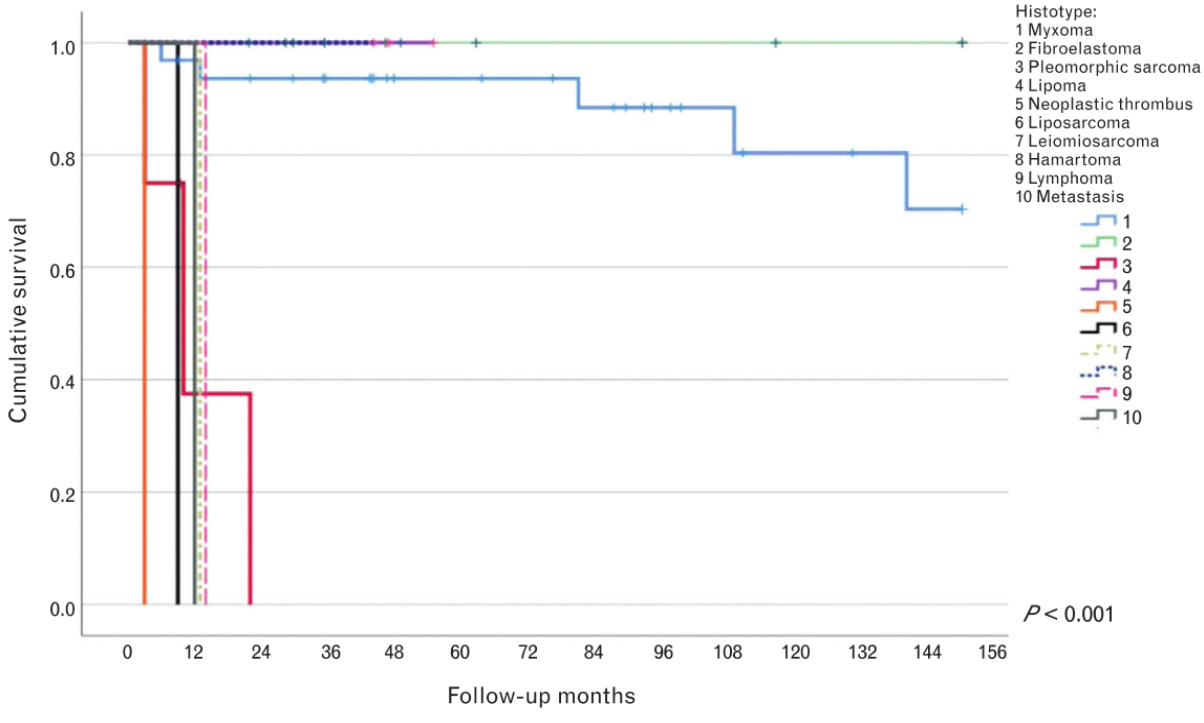
Prevalence, clinical presentation and diagnosis of cardiac tumors

The estimated prevalence of primary cardiac tumors is approximately 1:2000 in the autopsy series, while secondary tumors were reported in 1% of cases, with a secondary to primary ratio of 20:1.[1] Among primary cardiac tumors, almost 90% are benign and myxoma is the most common histotype.[1,2] Undifferentiated pleomorphic sarcomas are the most commonly encountered primary cardiac malignancies, accounting for approximately 10% of all primary cardiac tumors.[1] Consistently, in our series myxoma was the most common cardiac tumor, whereas a malignant cardiac tumor was found in 18% of cases.

Clinical presentation depends of size, location, propensity for embolization, invasiveness and relation with other cardiac structures.[2,3] In our series, only 27% of patients were symptomatic at the time of the diagnosis and the most frequent symptoms were dyspnea and palpitations. The presence of nonspecific symptoms in less than a third of cases is clinically relevant, because it is potentially associated with a delayed diagnosis.

Multimodality imaging is of paramount importance for a noninvasive diagnosis, in order to choose the most appropriate treatment. TTE and TOE are the first and largely available imaging modality, allowing the evaluation of size, mobility, site of attachment and hemodynamic impact of the mass.[8] Contrastechocardiography is useful to assess the perfusion of the mass, in order to differentiate tumors from thrombi.[9] Accordingly, echocardiography was our first diagnostic tool. The use and the choice of an

Fig. 2



Kaplan–Meier survival curves after surgery according to cardiac tumor histotype.

Table 5 Number and time of death after surgical resection according to histotype

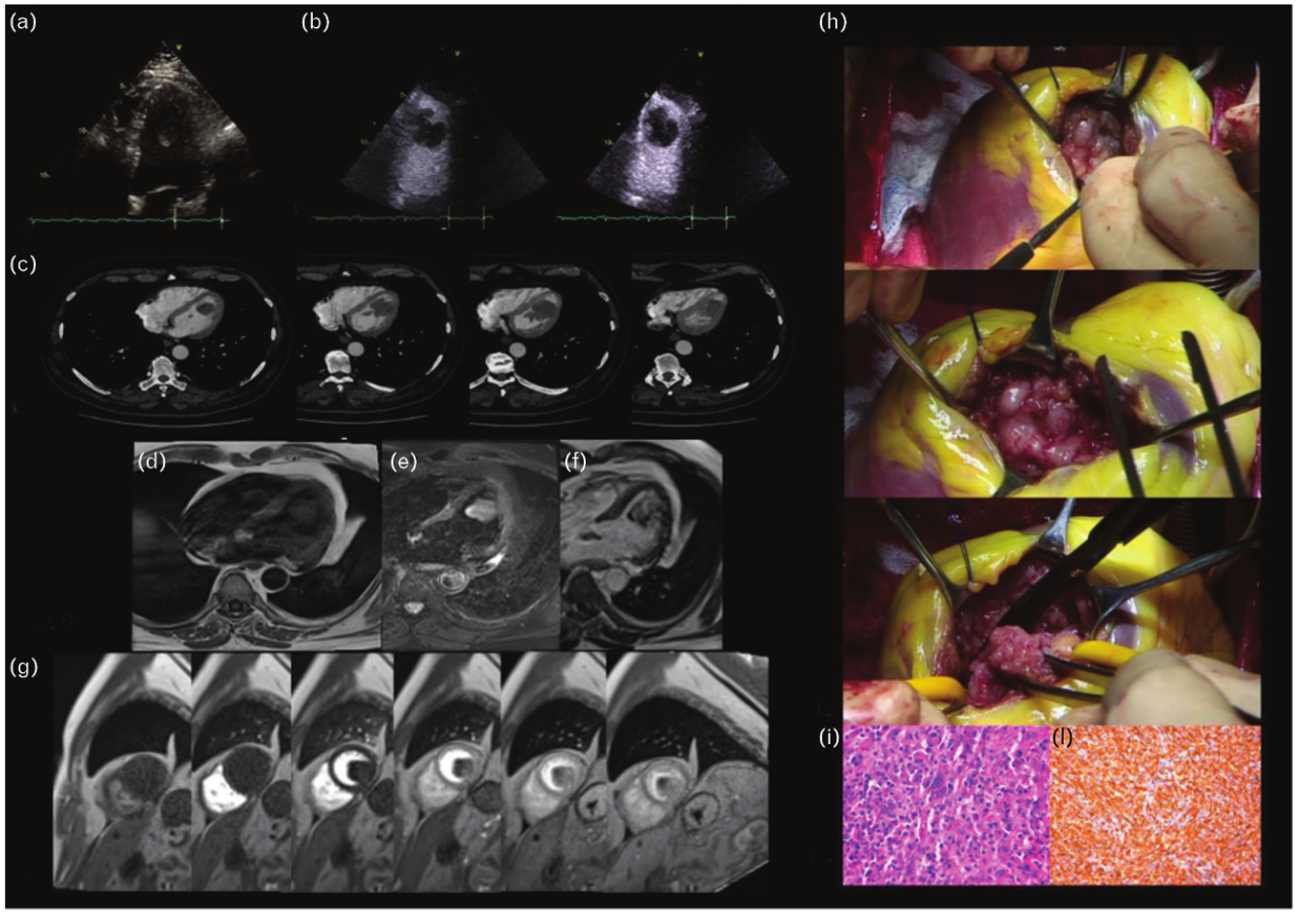
Histotype	Death *n* (%)	Months from surgery to death
Myxoma ($n=32$)	5 (16)	81 [13–109]
Fibroelastoma ($n=10$)	1 (10)	156
Pleomorphic sarcoma ($n=4$)	3 (75)	10 [6–16]
Lipoma ($n=2$)	0 (0)	–
Neoplastic thrombus ($n=2$)	2 (100)	3
Liposarcoma ($n=1$)	1 (100)	9
Fibro-leiomiosarcoma ($n=1$)	1 (100)	13
Hamartoma ($n=1$)	0 (0)	–
Lymphoma ($n=1$)	1 (100)	14
Metastasis ($n=1$)	1 (100)	12
Total ($n=55$)	15 (27)	

advanced imaging technique (CT, CMR, PET-CT) was based on clinical judgment. In our opinion, CMR is the best available noninvasive diagnostic tool, providing information about the mass (i.e. size, mobility, location, perfusion and tissue characterization), along with anatomical relations and extension to surrounding structures.[7] Histopathological characterization remains the diagnostic gold standard in any resected cardiac mass, defining the benign or malignant nature of the tumor and guiding further therapies.

Surgical approach to cardiac tumors

The gold-standard treatment for cardiac tumors is prompt surgical resection.[2,3] Surgical excision of benign cardiac tumors should always be considered when the lesion is found in left-sided chambers due to the embolic risk.[3] Complete resection is the treatment of choice in the presence of malignant tumors. However, surgical debulking can be considered when radical exeresis is not feasible due to the size and location of the mass or advanced stage of the disease, with the aim of improving patient's symptoms and quality of life.[10]

Fig. 3



(Panels a and b) Transthoracic echocardiography showing left ventricular mass with irregular margins and uneven echogenicity, attached to the inferior-lateral wall; the mass showed tardive inhomogeneous opacification after contrast agent administration. (Panel c) Computed tomography scan showing a single hypodense formation in the LV cavity indissociable from the ventricular wall. (Panels d–f) Cardiac magnetic resonance (CMR) scan: the mass appeared isointense in T1 (d) and hyperintense in T2 (e). The mass showed inhomogeneous late gadolinium enhancement (f). (Panel g) First pass perfusion CMR imaging: the mass showed significant contrast enhancement, consistent with vascularization. (Panel h) Macroscopic appearance of the mass during surgical inspection. (Panels i–l) Histological samples of the mass, consistent with pleomorphic sarcoma. (Panel i) Hematoxylin–eosin stain 10×. (Panel l) Vimentin 20×.

In our experience, radical exeresis was achieved in all cases of benign tumors, with no further relapses during follow-up. Complete macroscopic resection of malignant tumors was achieved in more than half of our patients. Surgical debulking was performed in a minority of patients, but associated with symptoms improvement.

Clinical outcomes and prognosis

The prognosis of cardiac tumors is related to several factors, including tumor histotype, surgical results and patient's condition. Outcome after surgery is excellent for benign cardiac tumors, with reported survival rates comparable to age-matched general population.[3–10] We found a median survival after radical resection of 81 and 156 months for myxoma and fibroelastoma, respectively.

The overall survival of malignant cardiac tumors remains poor. As reported in previous studies, the median survival was 12 months[11] after diagnosis and 6–18 months after surgery.[11–15] Although the optimal treatment strategy is still unclear, surgery – when feasible – remains the best therapeutic approach.[16,17] However, despite the radical resection of the mass, local recurrence and metastasis within 1 year are frequent and the median progression-free survival is approximately 6 months.[18–20] In our series, the median survival after surgery was 10 months. The benefit of adjuvant chemotherapy and/or radiation for primary cardiac malignancies is still unknown, but should be considered for patients with incomplete resections.[21,22] In our experience, the use of chemotherapy was limited. Further studies are needed to understand the benefit of additional therapies after surgery.

Conclusion

Cardiac tumors require a thorough workup to guarantee a prompt diagnosis and an appropriate treatment. Although multimodality imaging is useful, histopathological characterization remains the gold standard for a definite diagnosis. Surgical resection remains the treatment of choice, whereas debulking can be useful in improving symptoms and patient's quality of life. In our surgical experience, the prognosis of benign tumors was excellent, whereas malignant tumors showed poor outcome despite radical surgery.

Conflicts of interest

There are no conflicts of interest.

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