

Tumors of the right atrium and the inferior vena cava operated in deep hypothermic circulatory arrest

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ABSTRACT:

Introduction: Tumors which most frequently metastasize to the heart include: malignant melanoma, lung cancer, breast cancer, ovarian cancer, kidney cancer, leukemia, lymphomas and esophageal cancer.

Purpose: The purpose of this paper was clinical analysis of a group of patients operated in deep hypothermic circulatory arrest due to tumors of the right atrium and the inferior vena cava.

Material and method: The study covered 7 patients operated at the Cardiac Surgery Clinic with a cardiac tumor diagnosed on the basis of an echocardiographic assessment in the years 2012–2019. Before qualifying for surgical treatment, each patient underwent: thorough interview and physical examination, 12-lead ECG, laboratory tests and echocardiography. Patients additionally underwent: computed tomography of the chest or abdomen, magnetic resonance imaging and coronary angiography on the basis of which patients with significant coronary artery changes underwent simultaneous coronary artery bypass graft. After preparation, the tumor was excised from the vena cava and right atrium with simultaneous removal of the primary tumor, most often kidney cancer. Early and distant results of treatment were analyzed in the examined group of patients to determine the following endpoints: hospital mortality and survival after surgery: after 3 months and 12 months.

Results: Of all operated patients: 2 individuals died in the early postoperative period due to hemorrhagic complications (hospital mortality – 28.6%), and 5 patients (71.4%) were discharged from the Clinic in a good general condition. In total, 3-month survival was 71.4%, and 12-month survival amounted to 28.6%.

Conclusions: Surgeries are very complex and challenging, and usually take on average 8–10 hours. It can improve the outcomes of palliative oncological treatment, better physical function (cardiovascular fitness) and extend life from several months to several years in more than $\frac{2}{3}$ patients.

KEYWORDS:

inferior vena cava, right atrium, tumor

ABBREVIATIONS

ACC – adrenocortical carcinoma

CABG – coronary artery bypass graft

ECG – electrocardiogram

IVC – inferior vena cava

RA – right atrium

RCC – renal cell carcinoma

SFT – solitary fibrous tumor

INTRODUCTION

Among cardiac tumors we distinguish neoplastic changes, both primary – derived from the heart and secondary, metastasizing from other organs, as well as non-neoplastic lesions, most often thrombi. Primary heart tumors are diagnosed very rarely; their prevalence is estimated to be between 0.0017 and 0.28% of the total cancers. Of those cases 75% are benign, and their most common representative is myxoma. Sarcomas are the most commonly diagnosed of primary lesions. Still, most cardiac tumors are metastatic and occur 20–40 times more often than primary tumors. Neoplasms that spread to the heart most frequently are: malignant melanoma, lung cancer, breast cancer, ovarian cancer, kidney cancer, leukemia, lymphomas and esophageal cancer [1–4].

Cardiac tumors can be asymptomatic or present a variety of clinical symptoms depending on their location and morphology, such as features of systemic inflammation (fever, arthralgia, weight loss, fatigue), dyspnea, palpitations, fainting, rhythm/conduction disturbances and embolic incidents or hemodynamic disorders [2, 5, 6].

The basis for diagnosis of a cardiac tumor are the results of diagnostic imaging: echocardiography, computed tomography or magnetic resonance imaging. Echocardiographic examination allows to determine the morphology of a cancer, its location and extent, and to assess possible hemodynamic disorders caused by the tumor. Newer techniques such as contrast echocardiography and real-time 3D echocardiography can increase diagnostic accuracy by providing information about: blood supply to tumor, morphology, and relation to nearby organs. On the other hand, computed tomography and magnetic resonance imaging enable accurate assessment of tumor location and stage, and visualize the pericardium and large vessels better than echocardiography; in the case of metastatic tumors, they also allow to detect a primary outbreak in the chest or abdomen [7, 8].

The purpose of this paper was clinical analysis of a group of patients operated in deep hypothermic circulatory arrest due to tumors of the right atrium and the inferior vena cava.

MATERIAL AND METHODS

The study covered 7 patients operated at the Cardiac Surgery Clinic with a cardiac tumor diagnosed on the basis an echocardiographic assessment in the years 2012–2019. Prior to qualification for surgery, each patient underwent: thorough interview and physical examination, 12-lead ECG, laboratory tests (including blood count, electrolyte levels, glycemia, renal parameters, coagulation system) and echocardiography. Patients additionally underwent computed tomography of the chest or abdomen, magnetic resonance imaging and coronary angiography on the basis of which patients with significant coronary artery changes underwent simultaneous coronary artery bypass graft.

Patients had upper midline laparotomy. After assessing the stage and resectability of the kidney tumor or adrenal tumor, in case of the right kidney the right colic flexure was released, and Kocher maneuver was performed to expose the duodenum, revealing the superior vena cava from the diaphragm to the bifurcation on the common iliac veins. In cases of tumor of the left kidney, the left colic flexure and descending colon were released. A further step consisted in gradually releasing the kidney together with the tumor, and ligating the renal vein or renal veins and the renal artery. After excision of the right or left kidney, the right adrenal gland just below the diaphragm, the inferior vena cava was dissected. Vascular funnels were laid under the vein. The next stage was cardiac surgery in extracorporeal circulation. In the case of the left kidney tumor, the procedure was analogical, while for other tumors, resection was performed depending on the location (right adrenal tumor).

After removal of the kidney and exposure of the inferior vena cava in the diaphragmatic region, the chest was opened by means of a median sternotomy. Intravenous heparin was administered at a dose of 3 mg/kg bw. Extracorporeal circulation was set up: arterial cannulation - brachiocephalic trunk; venous cannulation - the auricle of the right atrium (until the patient is cooled and the right atrium is opened, and then to heat the two-stage venous cannula), for the time of circulation of the head only – cannulation of the superior vena cava. After starting extracorporeal circulation, the patient was cooled to 20–22°C and extracorporeal circulation was stopped. At that time, extracorporeal circulation affected only the head (brachiocephalic trunk + superior vena cava) for brain protection. Its effectiveness was monitored by cerebral oximetry. Prior to cardiac arrest, blood cardioplegia was administered to the ascending aorta after it had clumped. After cardiac arrest, blood from the patient was drained into the cardiotomy reservoir. The right atrium was opened and the tumor was enucleated: both from the right atrium and after opening the inferior vena cava in the area of the renal vein outlet, from its lumen on the abdominal side. Outlets of veins escaping to the vena cava in this area were monitored for the presence of cancerous tissues. Next, the inferior vena cava and right atrium were closed. A reperfusion period with patient warming followed. If the patient required an additional coronary artery bypass graft, the bridges were performed during cooling, after aortic occlusion and administration of Cardioplegin. Completion of the above procedures was followed by assessment of the condition of the peritoneal organs, hemostasis; a drainage was set up after the nephrectomy, and a layered suture was performed.

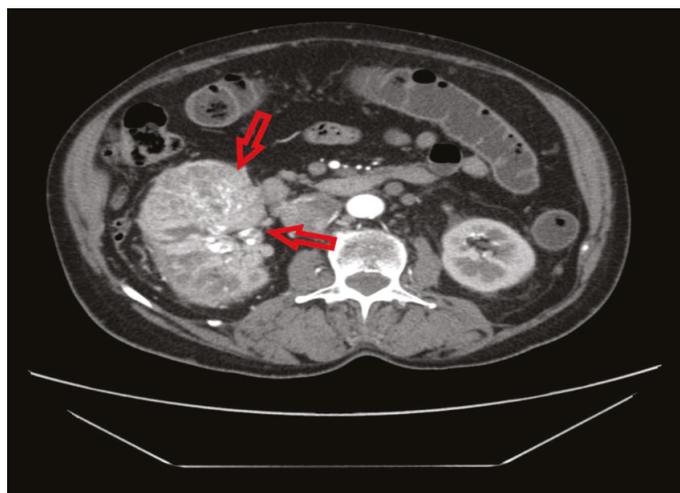


Fig. 1. Abdominal CT with contrast, cross-section – right kidney tumor (arrows).

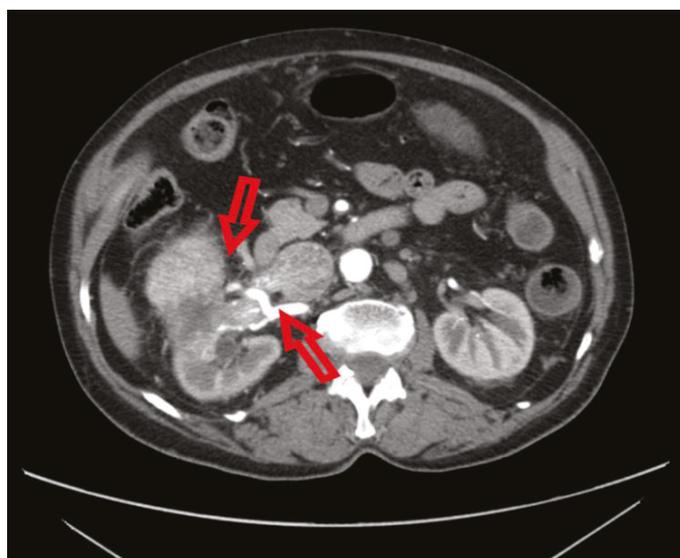


Fig. 2. Abdominal CT with contrast, cross-section – right kidney tumor, tumorous masses in the right renal vein and inferior vena cava (arrows).

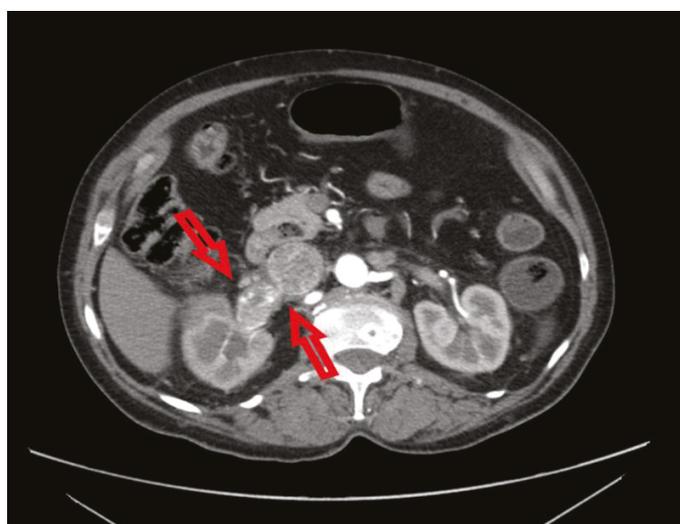


Fig. 3. Abdominal CT with contrast, cross-section – right kidney tumor, tumorous masses in the right renal vein and inferior vena cava (arrows).

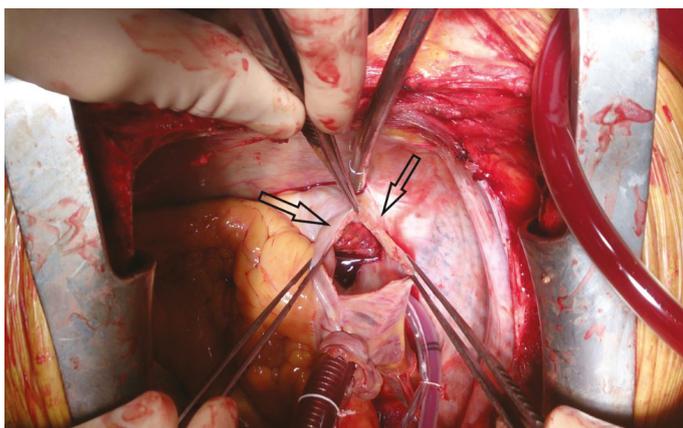


Fig. 4. Intraoperative image – inferior vena cava into the right atrium, visible tumorous masses within the inferior vena cava (arrows).

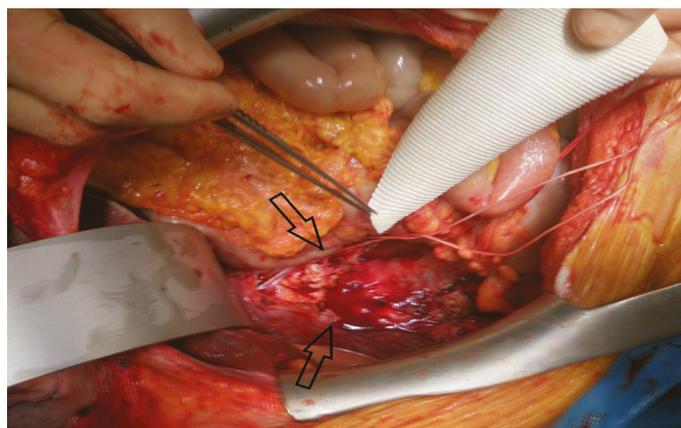


Fig. 5. Intraoperative image – fragment of opened inferior vena cava with visible tumorous masses (arrows).

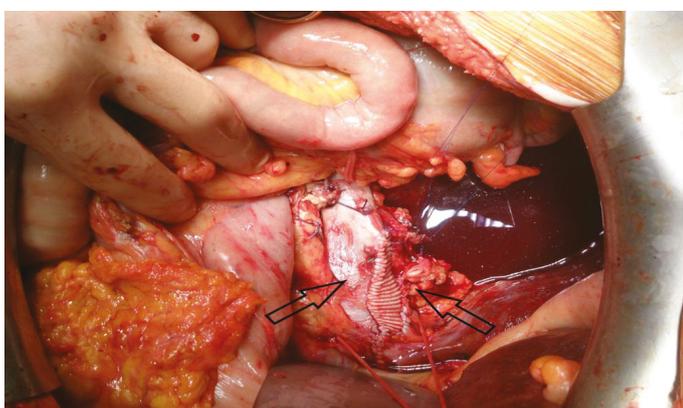


Fig. 6. Intraoperative image – fragment of the inferior vena cava after plastic surgery (arrows).



Fig. 7. Intraoperative image – tumorous masses from the right atrium and inferior vena cava.

Early and distant results of treatment were analyzed in the examined group of patients to determine the following endpoints: hospital mortality and survival after surgery: after 3 months and 12 months.

RESULTS

The studied group consisted of 7 people aged 47 to 78 (average 59.2 years). It comprised: 5 women (71.4%) and 2 men (29.6%). In the studied group of patients with diagnosed cardiac tumor, histopathological examination revealed that 5 people (71.4%) had a clear metastasis of renal cell carcinoma (in 4 cases of the right kidney, in 1 case of the left kidney), including one patient after right-sided nephrectomy who was found with local tumor recurrence. One patient (14.3%) who underwent right-sided adrenalectomy and reoperation due to local tumor recurrence was diagnosed with right adrenal metastasis. In all the described cases, the tumor spread into the right atrium through the inferior vena cava. One patient (14.3%) demonstrated a right atrial tumor infiltrating the atrial septum and protruding to the left atrial lumen, protruding into the inferior vena cava – a tumor of unspecified nature (in histopathological examination – solitary fibrous tumor). Two patients (28.6%) underwent isolated surgery to excise the tumor from the inferior vena cava and the right atrium. Other cases involved combined treatments: 4 operations (57%) – excision of

tumor from the inferior vena cava and the right atrium with nephrectomy and 1 operation (14.3%) – excision of tumor from the inferior vena cava and the right atrium with coronary artery bypass graft (CABG) (Tab. I).

Of all operated patients: 2 patients died in the early postoperative period due to hemorrhagic complications (hospital mortality – 28.6%), and 5 (71.4%) were discharged from the Clinic in a good general condition. In long-term observation: 2 patients (28.6%) died 4 and 5 months after surgery, and 1 of them underwent reoperation of the inferior vena cava. One patient (14.3%) still remains under cardiological and oncological observation: so far, she has not had any cardiovascular or other oncological events; one year after surgery, the patient underwent surgical treatment of the hernia in the postoperative scar. Another patient (14.3%) survived over 12 months after the surgery. The last patient (14.3%) is 3 months after surgery and in a domestic environment; she functions quite well overall. In total, 3-month survival was 71.4%, and 12-month survival – 28.6%.

DISCUSSION

Cardiac metastases are not a rare phenomenon. Although the exact frequency of their occurrence is unknown (data comes

Tab. I. Histopathological diagnosis, type of surgery and short- and long-term follow-up in patients operated for cardiac tumors.

	AGE	GENDER	HISTOPATHOLOGICAL DIAGNOSIS	TYPE OF PROCEDURE	SHORT-TERM OBSERVATION	LONG-TERM OBSERVATION
1.	64	M	clear cell renal cell carcinoma	tumor removal from RA and IVC and nephrectomy	death on the first day; hemorrhagic complications	-
2.	59	F	clear cell renal cell carcinoma	excision of tumor from RA and IVC and nephrectomy	-	death 4 months after surgery
3.	63	F	clear cell renal cell carcinoma	excision of tumor from RA and IVC and nephrectomy	death on the first day; hemorrhagic complications	-
4.	70	M	clear cell renal cell carcinoma	excision of tumor from RA and IVC and CABG	-	over 12 months
5.	52	F	right adrenal cancer	excision of tumor from RA and IVC	-	death 0.5 years after surgery – reoperation of ŻGD
6.	47	F	solitary fibrous tumor	excision of tumor from RA and IVC	-	one year after surgery, surgical management of hernia in postoperative scar
7.	78	F	clear cell carcinoma of right kidney	excision of tumor from RA and IVC and nephrectomy	-	Patient – 3 months after surgery, functions quite well

F – female, M – male, RA – right atrium, IVC – inferior vena cava, CABG – coronary artery bypass graft

mainly from large post-mortem examinations), it is recognized that they appear over 20 times more often than primary tumors. The clinical implications of cardiac metastases are varied and depend on the anatomical location of the tumor, however in 90% of cases they are asymptomatic, and the symptoms of the primary tumor may predominate in the clinical picture.

Arrhythmia, conduction disturbances, myocardial hypertrophy, signs of heart failure or embolic events in a cancer patient should raise suspicion of cardiac metastases. Some of the cancers, e.g. kidney, liver or uterine cancer, can spread to the right atrium through the inferior vena cava. However, metastases to the heart are often located in the pericardium, and the first manifestation may be large pericardial effusion. The basic diagnostic test is echocardiography, and deepening of diagnostic imaging (computed tomography, magnetic resonance imaging, positron emission tomography) enables further characterization and determination of the extent of both heart disease and primary tumor. Treatment of metastatic cardiac tumors depends on: their complications, clinical picture, prognosis and patient's condition [1, 5, 6, 8]. In our study, in the group of patients with a diagnosed heart tumor there were 4 individuals with a metastasis of clear cell renal cell carcinoma.

Kidney cancer is among the most common cancers – 90% of cases are renal cell carcinoma (RCC), and the most prevalent histological type is clear cell carcinoma (70–80%) [9–11]. RCC is almost twice as frequent in men than in women, and mortality is 56% for men and 39% for women. Intravascular tumor growth along the renal vein to the inferior vena cava, or IVC occurs in about 10% of all RCC patients, and a further spread of the tumor to the right atrium, or RA is found in about 1% of all patients. In kidney tumors, metastatic cardiac tumors with no communication with a primary lesion through the vena cava occur sporadically [9, 12]. In the examined group of patients, the tumor grew into the right atrium through the inferior vena cava, as in the cases presented by Shah et al. [10] and Oltean et al. [12]. There were no cases with

metastases to other organs. Surgical treatment of RCC with a tumor growing into IVC and RA is a major challenge and there is still some controversy regarding the safety of this therapeutic strategy. The guidelines of the European Association of Urology recommend an aggressive surgical approach with excision of kidney tumor and endovascular tumor in patients who were not found with distant metastases [12, 13]. In this paper, combined operations were performed in patients with metastatic renal cell carcinoma: 5 operations to excise the tumor from the inferior vena cava and the right atrium including nephrectomy and 1 operation to excise the tumor from the inferior vena cava and the right atrium with CABG in a patient after nephrectomy. One patient, who underwent right-sided adrenalectomy and reoperation due to local tumor recurrence, was diagnosed with right adrenal metastasis. ACC, or adrenocortical carcinoma is a rare malignant tumor with a poor prognosis.

Tumor growth is rapid – 82% of patients can be found to have metastases, mainly to the lungs, lymph nodes, liver and bones. However, in the few cases (with a frequency of 6 to 30%) ACC can spread to neighboring blood vessels, such as renal veins and IVC, up to the right atrium [14, 15].

In most cases of ACC spreading to RA described in the literature, it derives from the right adrenal gland, as in the works presented by Swan et al. [16], Sánchez et al. [14], Kim et al. [15]. The presented article also discussed metastasis of the right adrenal gland, and the tumor grew into the right atrium through the inferior vena cava. Surgical treatment was applied and isolated surgery was performed to remove the tumor from the inferior vena cava and the right atrium.

The last patient in the examined group was diagnosed with solitary fibrous tumor (SFT) on the basis of histopathological examination. This condition is a rare mesenchymal tumor, most commonly deriving from the pleura, but extrapulmonary locations

of the tumor, e.g. intra-abdominal, meningeal, have also been reported. Primary cardiac SFT is extremely rare; so far single cases have been described in the literature. In most cases SFT is benign, especially extrapulmonary tumor; recurrence is observed in 63% of all malignant SFTs and in 2% of benign tumors. The primary treatment option is surgical excision, and the prognosis depends on the total tumor resection [17–19]. In the presented work, the patient had a right atrial tumor infiltrating the atrial septum and protruding to the left atrial lumen, exiting from the inferior vena cava. Surgical treatment was applied and isolated surgery was performed to remove the tumor from the inferior vena cava and the right atrium. A similar description of SFT located in the right atrium was described by Zhao et al. [20].

CONCLUSION

This study describes the management of 7 patients operated for cardiac tumors. Due to the growing incidence of cancer, the diagnosis of cardiac tumors, especially metastatic, is not uncommon at present and begins a difficult diagnostic process, which is most often completed with surgical treatment. Optimal management in these patients is very challenging and bases upon the cooperation of many specialists. Surgeries are very complex and difficult, and usually last on average 8–10 hours. In over 2/3 patients, it is possible to improve the results of palliative oncological treatment and physical functioning (cardiovascular fitness) and extend life from a few months to several years.

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