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Case Report

Endocavitary Right Ventricular Cardiac Metastasis of a Lung Adenocarcinoma Treated by Surgery: A Case Report About a Novel Multimodal Therapeutic Approach

Serge Borne[a] Nicolas Benoit[b] Youcef Douadi[b] Olivier Carre[b] Stéphanie Thielen-Bethembos[b] Hortense Carette De Franssu[b] Gilles Touati[c] Anna-Laura Colta[d] David Patrao[b] Emilie Delattre[b] Julien Monconduit[a] Camille Piriou-Garoute[e] Bruno Chauffert[f] Charles Dayen[b]

[a]Medicine 1 Department, Clinique Victor Pauchet, Amiens, France; [b]Pneumology Department, Clinique de l'Europe, Amiens, France; [c]Cardiac Surgery Department, Centre Hospitalier Universitaire d'Amiens, Amiens, France; [d]Radiology Department, Centre Régional d'Imagerie Médicale, Amiens, France; [e]Pneumology Department, Centre Hospitalier de Saint Quentin, Saint-Quentin, France; [f]Oncology Department, Centre Hospitalier de Saint Quentin, Saint-Quentin, France

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Abstract
Introduction: Cardiac metastasis (CM) is a rare lung cancer location. It often remains clinically silent but may cause life-threatening complications. Better survival rates thanks to the immunotherapy revolution and the improving performance of imaging lead to an increasing number of CM diagnosis. ***Case Presentation:*** We report a case of a 54-year-old woman who was diagnosed with a stage IIIa non-small cell lung cancer. She developed a right ventricular CM without symptoms during treatment by immunotherapy after concurrent chemoradiotherapy. Cardiac magnetic resonance imaging confirmed the presence of an endocavitary lesion in the right ventricle apex. Complete surgical resection through a right ventriculotomy was performed. ***Conclusion:*** The diagnosis of similar cases has become more frequent due to immunotherapy and more advanced imaging technology. Our case report also highlights the fact that CM

Correspondence to:
Serge Borne, serge.borne@icloud.com

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surgery has to be considered as a successful therapeutic option in those oligo-progression situations. Guidelines on the management and treatment of lung cancer CM are needed as well as larger studies to evaluate the survival benefit from surgical treatment.

Introduction

While cardiac metastases (CMs) are 20–40 times more common than primary cardiac tumors, they remain rare. They are clinically silent in over 90% of cases and are often diagnosed postmortem [1]. Goldberg et al. [2] reported that the incidence of CM can be as high as 9.1% in patients with known malignancies. The reported incidence varies between 1.5% and 20% among autopsies of cancer patients. The most common causes are lung carcinoma (33–36%), breast cancer (10–12%), lymphomyeloproliferative neoplasms (10–12%), followed by melanoma and esophageal carcinoma [2, 3]. In the following case, we discuss the clinical presentation, diagnosis, and management of a patient with non-small cell lung cancer who developed a right ventricular CM.

Case Presentation

In June 2019, a 54-year-old woman with no prior medical history was referred to our department due to cachexia, dysphagia, and a weight loss of 12 kg. At the time of referral, her weight was 61 kg, her height was 171 cm, and her body mass index was 20.9 kg/m^2. She had a history of smoking since the age of fourteen, consuming 20 cigarettes daily, and had never ceased. Pulmonary and cardiac auscultation revealed normal findings. Pulmonary function tests indicated an impaired diffusing capacity of the lungs for carbon monoxide.

Due to severe dysphagia, a cervical and thoracic computed tomography scan (CTS) was performed, revealing emphysema, an 8-mm suspicious nodule in the right upper lobe, and a right paratracheal lymph node measuring 30 mm by 25 mm. The initial F-fluorodeoxyglucose positron emission tomography/computed tomography (18-FDG PET/CT) scan showed increased uptake in these two lesions (SUVmax of 2.2 for the right upper lobe nodule and SUVmax of 2.2 for the adenopathy). Endobronchial ultrasound-guided transbronchial needle aspiration yielded inconclusive results. Subsequent mediastinoscopy revealed lymph node metastases in the right paratracheal region (4R) and subcarinal region (7), consistent with a diagnosis of lung adenocarcinoma (TTF1+). P40 was negative, PDL1 was at 1%, and it was classified as cT1aN2M0, stage IIIa according to the eighth TNM classification.

Following a multidisciplinary clinical decision-making process, she initially underwent concurrent chemoradiotherapy in November 2019. This treatment regimen included four cycles of intravenous pemetrexed at 500 mg/m^2 and cisplatin at 75 mg/m^2 every 3 weeks. Concurrently, conformal intensity-modulated radiotherapy was delivered. Subsequent posttreatment imaging follow-up indicated a complete response. She then received an extended immunotherapy regimen using durvalumab.

In November 2020, a follow-up 18-FDG PET/CT scan showed a complete response in the right upper lobe and mediastinal adenopathy. However, it revealed a localized uptake with an SUVmax of 11.5 in the right ventricle (Fig. 1). Upon reevaluation, this CM was identified in the

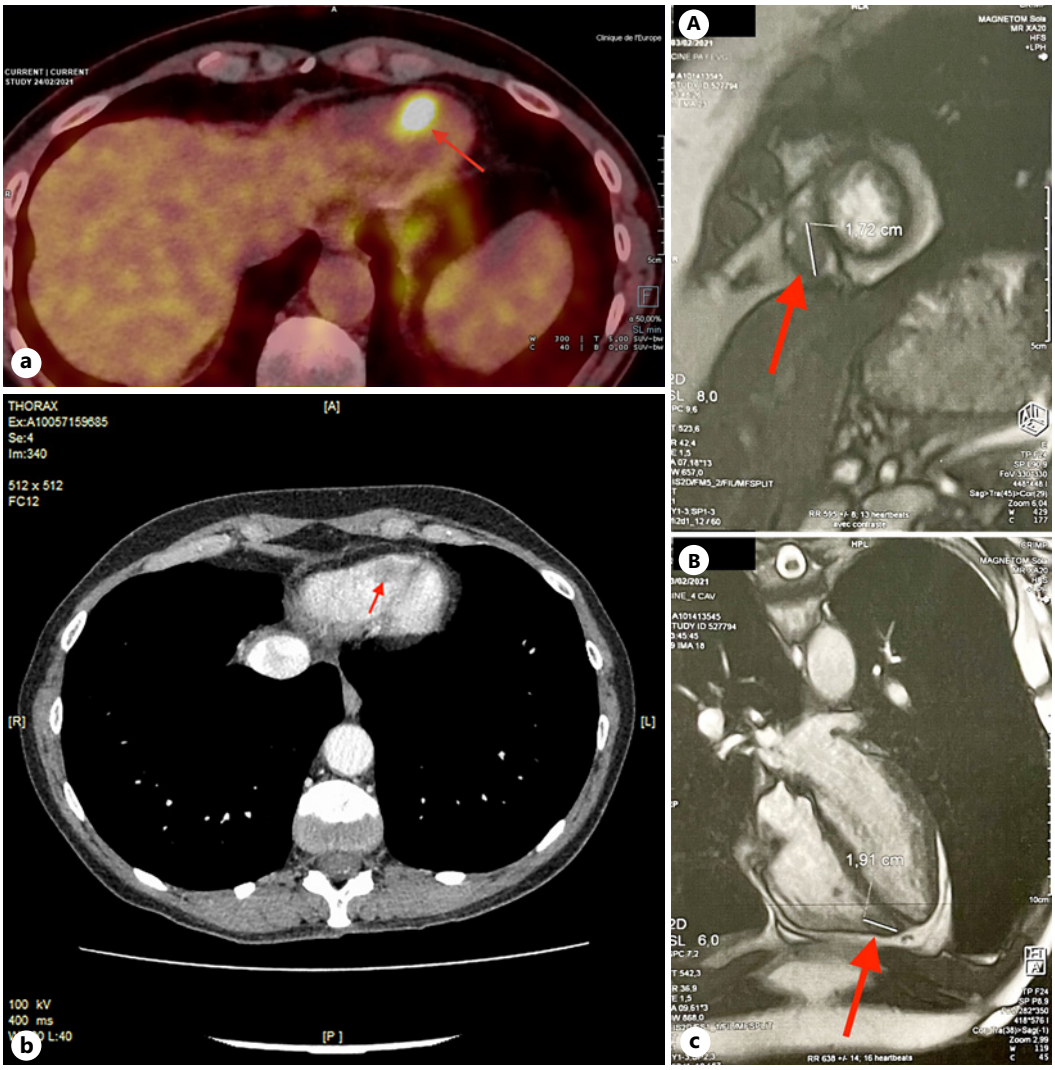

Fig. 1. a Transaxial image of FDG PET/CT showing high uptake (SUVmax 11.5) in the apex of the right ventricular. The four arrows show the same localization. **b** (A) Short-axis of the November 2021 thoracic CTS showing a defect in the right ventricular cavity, measured at 1.7 cm (red arrow). **c** (A) Short-axis view images of CMR in steady-state free precession sequence (SSFP) showing a low signal intensity at the endocavitary lesion measured at 1.7 cm (red arrow). (B) Four-chamber view images of CMR in SSFP showing the same lesion in low signal intensity measured at 1.9 cm (red arrow).

November 2020 CT scan (Fig. 1). Trans-thoracic echocardiography was inconclusive, and cardiac magnetic resonance (CMR) imaging confirmed an intracavitary tumor measuring 19 × 13 × 3 mm at the right ventricle apex with moderate and progressive enhancement (Fig. 1).

In March 2021, a decision was made to proceed with the surgical resection of the CM, following preoperative evaluation, including coronary angiography. Concurrently, she received her twenty-seventh durvalumab injection.

The surgical procedure involved a right ventriculotomy with reconstruction using a Dacron pericardial patch. Following a median sternotomy, a right ventriculotomy was performed, allowing for the complete removal of the tumor. Additionally, lymph node dissection was carried out. Pathological analysis confirmed the complete resection of the metastasis, affirming its origin as a lung adenocarcinoma (TTF1+).

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In December 2021, the 18-FDG PET/CT revealed disease progression, with new lesions in both adrenal glands and the liver. It also detected increased metabolic activity in the lower front section of the pericardium. However, there was no evidence of malignant recurrence in the lungs or mediastinal nodes. Subsequently, the patient received four cycles of carboplatin, pemetrexed, and pembrolizumab every 3 weeks.

In June 2022, the CDM team suggested a second-line chemotherapy using paclitaxel and bevacizumab due to the emergence of metabolic activity in the adrenal glands. The patient declined and opted for observation without further treatment.

In January 2023, a new CTS revealed isolated progression in the right adrenal gland node. They recommended localized radiotherapy targeting this node, which the patient has accepted.

Discussion

Solitary CMs are very rare. Common signs and symptoms may be nonspecific such as dyspnea, palpitations, and atrial arrhythmias. Intracavitary heart masses may cause cardiogenic shock due to outflow tract obstruction, pulmonary embolism (if originating from the right heart), and stroke (if originating from the left heart) [2]. In this case, the CM was symptomless. Even if CM remains rare, the increasing frequency is correlated to the extended survival of patients on immunotherapy. Even though recurrence had occurred, the patient remained well with good performance status and few symptoms. Oligo-progression and stabilization induced by the long-term immunotherapy gave the opportunity to propose curative treatment.

Treatment

We conducted surgery on the patient to prevent cardiac complications. The metastasis was solitary, and the performance status was satisfactory. The main goal was to maintain a long-lasting response after her extended survival with first-line therapy. It resulted in a complete tumor removal with no complications or cardiac issues. This resulted in 9 months of progression-free time and a sustained complete local response.

Managing cardiac tumors is a significant challenge for cardiothoracic surgeons, requiring versatility and extensive experience. The medical center must excel in various heart surgeries, including those for adults and children, rhythm surgery, transplantation, and artificial heart implantation. Due to limited published cases, determining the best treatment remains uncertain [4]. Debulking surgery may be required to prevent hemodynamic issues. In advanced cases affecting the right side of the heart, removing the entire right half is possible. Heart transplantation is extremely rare and considered a last option for specific cases [4].

Lung cancer treatment is much personalized. Advances like immunotherapy have improved survival rates. Surgical management of solitary metastases holds promise for curing cases with limited disease progression. Similarly, local treatments like radiotherapy and radiofrequency ablation may effectively manage metastases and complement systemic therapies [5].

There are no specific recommendations for treating CM. It is unclear if removing isolated CMs significantly improves overall survival or progression-free survival. Recent articles on CM removal and survival in non-small cell lung cancer are scarce. A few cases of CM removal in lung cancer and one in esophageal cancer suggest a potential survival benefit [6, 7]. Minimally invasive resection methods have shown promise. However, these studies mostly involve benign tumors [8]. New treatments like cryoablation or combined embolization-radiotherapy may provide less invasive curative options [9].

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Imagery

Cardiovascular anomalies remain a challenge to modern imaging. For our patient, we found that CMR and 18-FDG PET/CT were the most effective imaging techniques.

Echocardiography failed to detect the CM. Its sensitivity depends on factors like the patient's acoustic window, operator proficiency, and lesion location. However, echocardiography offers advantages such as accessibility, affordability, absence of radiation exposure, and quick results. It can assess cardiac function and plays a crucial role in detecting anomalies such as pericardial effusions, associated valvular stenosis or regurgitation, and outflow tract obstruction. It can also provide information about the tumor's size, attachment, mobility, and location [1]. However, its ability to evaluate extracardiac or deeper structures is limited.

In November 2020, the conventional CTS did not detect the cardiac lesion. More advanced, cardiac CTS is renowned for its excellent spatial resolution. It can identify direct tumor extensions into adjacent mediastinal structures, although with lower contrast resolution compared to CMR. The use of intravenous contrast is crucial for identifying intracardiac tumors, often discerned by filling defects. It also enables the visualization of coronary arteries.

The CM was identified through the 18-FDG PET/CT, which offers whole-body imaging capabilities. It excels at identifying sites with heightened metabolic activity (glucose consummation) as metastases. Rahbar et al. [10] have shown that 18F-FDG PET can determine tumor malignancy with 100% sensitivity using a cutoff SUVmax (maximum standardized uptake value) of 3.5. In this case, the CM exhibited a SUVmax of 13.2 a month before surgery. However, conditions like infection, inflammation, and non-metastatic processes can also result in increased 18-FDG uptake. They can reduce the specificity, making it crucial to consider the clinical context. Bilani et al. [11] reported a case of a false positive cardiac uptake, later confirmed by CMR. They also highlighted the challenge of pseudoprogression under immunotherapy, which can often manifest in the early months of treatment and, in some cases, even later. Surgery remains the definitive method for confirming such cases. Combining CMR with 18F-FDG PET appears to enhance specificity by providing superior resolution and anatomical detail.

In our case, CMR was the most sensitive and specific imaging method. It can also detect myocardial fibrosis (which may appear as increased uptake on 18-FDG PET/CT) and reveal intramyocardial masses not easily visible with echocardiography or CTS. Tissue characterization findings in CMR are not specific. The most common pattern involves low signal intensity on T1-weighted images and high signal intensity on T2-weighted images, with late gadolinium enhancement showing high signal intensity [12]. CMR can distinguish between malignant and benign cardiac masses using first-pass myocardial perfusion imaging and myocardial delayed enhancement after gadolinium administration. Late-enhancement techniques with long inversion recovery can aid in identifying thrombus. Its ability to visualize extracardiac structures helps detect direct tumor extensions from the mediastinum, identify pericardial adhesions, and assess mass mobility [13]. However, data on the sensitivity and specificity of CMR compared to other imaging modalities for diagnosing CM are limited. In a small study of 59 patients, CMR accurately differentiated between neoplastic and nonmalignant masses in all cases [14].

In summary, a combination of imaging modalities is often needed to confirm malignancy before considering surgery for CM. While 18-FDG PET/CT provides decent sensitivity, CMR and cardiac CTS offer superior resolution, and echocardiography is valuable for its accessibility, versatility, and cardiac function assessment.

Metastasis Pathways

Endocardial or intracavitary CM is a rare condition, accounting for only 3–5% of CM cases found postmortem, with a preference for the right side of the heart [3]. This infrequent occurrence can lead to severe complications, including cardiogenic shock due to right ventricular outflow tract obstruction or cardioembolic complications resulting from tumor embolism [1, 2].

Early detection of these complications is imperative and can be effectively accomplished using echocardiography. CM can extend to the pericardium, seen in 64–69% of all CM cases in extensive case series. This often results in pericardial effusion, cardiac tamponade (rapid pericardial fluid accumulation), and constrictive pericarditis. Epicardial involvement (25–34%) and myocardial involvement (29–32%) can lead to critical issues, including disruptions in cardiac conduction and acute coronary syndrome-like symptoms.

CM can disseminate through various pathways, including hematogenous spread (often associated with myocardial and endocardial metastases), lymphatic dissemination (leading to pericardial and epicardial involvement), transvenous routes (characteristic of cancer extending through the inferior vena cava into the right atrium), direct extension (occurring in locally aggressive tumors like mediastinal and pleural tumors), and propagation through the pulmonary veins into the left-side heart cavities [1–3]. The CARE Checklist has been completed by the authors for this case report, attached as online supplementary material (for all online suppl. material, see https://doi.org/10.1159/000534729).

Conclusion

Better survival rates, early detection, and the advantages of immunotherapy and TKI have led to more cases like ours. Oligo-progressions can now be treated with curative approaches like surgery.

Our case demonstrates that surgery can be a successful option in specific cases, especially when discussed within a specialized cardiac surgery center. Despite the generally poor prognosis associated with CM, we believe this case can contribute to better survival and disease control.

Today, routine imaging follow-ups are common practice. 18F-FDG PET and CMR are the most sensitive methods for CM detection. Echocardiography, while more accessible, quick, and cost-effective, remains a valuable tool. However, any patient with a history of cancer and cardiac symptoms should undergo further evaluation to rule out CM.

Clear recommendations are needed to guide decision-making in these cases. Larger studies are necessary to confirm significant survival benefits and explore less invasive alternatives like minimally invasive cardiac tumor resection, cryoablation, and combined embolization-radiotherapy.

Statement of Ethics

Ethical approval is not required for this study in accordance with local or national guidelines. Written informed consent was obtained from the patient for publication of this case report and any accompanying images. The authors have maintained the patient's anonymity for this publication.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

The authors confirm contribution to the manuscript as follows: Serge Borne: conceptualization, format analysis, investigation, methodology, validation, visualization, writing – original draft, and writing – review and editing; Nicolas Benoit and Charles Dayen: conceptualization, format analysis, investigation, methodology, validation, visualization, and supervision; Youcef Douadi, Olivier Carre, Stéphanie Bethembos, Hortense Carette, Anna-Laura Colta, David Patrao, Emilie Delattre, Julien Monconduit, and Camille Piriou-garoute: contributor, format analysis, methodology, validation, and supervision; Gilles Touati: reviewed the work critically about the cardiac surgery section, format analysis, methodology, validation, and supervision; and Bruno Chauffert: format analysis, methodology, validation, and supervision. All authors reviewed the results and approved the final version of the manuscript.

Data Availability Statement

All data generated or analyzed during this study are included in this article and online supplementary material files. Further inquiries can be directed to the corresponding author.

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