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Case Report

Percutaneous Radiofrequency Ablation of an Adrenal Metastasis From Non-Small Cell Lung Cancer: A Case Report

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ABSTRACT

Background: The adrenal glands are a recognized site of metastatic spread from non-small cell lung cancer (NSCLC). Distinguishing adrenal metastases from benign adrenal lesions requires integration of the oncological context, imaging characteristics, metabolic activity, temporal evolution and, when clinically relevant, histological findings. Image-guided percutaneous radiofrequency ablation (RFA) is a minimally invasive local treatment option for selected patients in whom surgery is declined, not feasible or adrenal-sparing surgery is unavailable.

Case presentation: A 37-year-old woman with stage IV poorly differentiated NSCLC and bone metastases, receiving atezolizumab plus bevacizumab, was referred for endocrine evaluation before percutaneous treatment of an enlarging adrenal lesion. Initial positron emission tomography/computed tomography showed a 10-mm hypermetabolic left adrenal nodule with a maximum standardized uptake value of 7. Subsequent imaging identified a new right adrenal lesion measuring 13 × 11 mm, which progressively enlarged to 23 × 25 × 23 mm. The lesion had an unenhanced attenuation of 41 Hounsfield units, an absolute contrast washout of 57% and a relative washout of 28%. Preprocedural hormonal assessment showed no evidence of cortisol or catecholamine excess and both plasma free metanephrines and urinary fractionated metanephrines were within the reference range. Computed tomography-guided core needle biopsy of the right adrenal lesion demonstrated a poorly differentiated malignant neoplasm, considered consistent with adrenal metastatic involvement in the context of the patient's known lung carcinoma and radiological evolution. Percutaneous RFA was subsequently performed under general anesthesia and continuous hemodynamic monitoring. During the procedure, the patient developed transient severe hypertension, with a maximum systolic blood pressure of 220 mmHg, which was successfully controlled without clinical sequelae. Initial post-ablation imaging showed enlargement and heterogeneous hemorrhagic changes in the treated adrenal gland. Subsequent follow-up demonstrated marked bilateral adrenal progression, with the right and left adrenal masses reaching 99 × 64 × 109 mm and 91 × 55 × 90 mm, respectively.

Conclusion: Adrenal lesions in patients with advanced lung cancer should be evaluated by integrating imaging findings, metabolic activity, temporal progression and pathological information when biopsy is clinically indicated. Endocrine assessment,

particularly exclusion of pheochromocytoma and continuous hemodynamic monitoring are essential before and during adrenal intervention. Percutaneous RFA is technically feasible and minimally invasive; however, clinically relevant intraprocedural hypertension may occur despite negative hormonal evaluation and durable local control cannot be assumed in patients with disseminated and actively progressive disease.

Keywords: Adrenal gland neoplasms; Lung neoplasms; Neoplasm metastasis; Radiofrequency ablation

Introduction

Lung cancer frequently presents with metastatic disease and the adrenal glands are a recognized site of distant spread, particularly in patients with non-small cell lung cancer (NSCLC). In an autopsy study of patients with non-resectable lung adenocarcinoma, Stenbygaard et al. found adrenal involvement in at least 40% of examined cases[1]. Adrenal metastases are generally asymptomatic and are most often detected during staging or surveillance imaging.

An adrenal lesion identified in a patient with an extra-adrenal malignancy should not automatically be considered metastatic. In a series of patients with potentially operable NSCLC, Oliver et al. showed that only a proportion of isolated adrenal masses were malignant[2]. Therefore, characterization requires integration of the oncological context, imaging features, metabolic activity and temporal evolution[3], together with hormonal evaluation. Histological confirmation should be considered selectively when the lesion cannot be confidently characterized by imaging and when the biopsy result is expected to influence clinical management[4,5].

Local treatment may be considered in appropriately selected patients. Surgical resection, including laparoscopic adrenalectomy, has traditionally been used mainly in patients with isolated adrenal metastases from NSCLC[6-11]. Lucchi, et al. reported the use of laparoscopic adrenalectomy in patients with suspected or confirmed solitary metachronous adrenal metastases following resection of NSCLC[6]. Stereotactic body radiotherapy represents another local treatment option[12], whereas image-guided percutaneous thermal ablation, including radiofrequency ablation, microwave ablation and cryoablation, provides a minimally invasive alternative when surgery is unsuitable or local treatment of a progressive adrenal lesion is considered clinically appropriate[13-18].

Before adrenal biopsy or thermal ablation, pheochromocytoma should be excluded because mechanical or thermal manipulation of adrenal tissue may precipitate severe hypertension, tachyarrhythmias or other potentially life-threatening hemodynamic complications[4,13,17,18]. This risk warrants appropriate anesthetic planning and continuous hemodynamic monitoring during adrenal ablation.

We report the case of a 37-year-old woman with metastatic NSCLC and a progressively enlarging adrenal lesion who underwent endocrine evaluation, percutaneous biopsy and radiofrequency ablation, complicated by transient severe intraprocedural hypertension and followed by subsequent bilateral adrenal progression.

Case

A 37-year-old woman with stage IV poorly differentiated non-small cell lung carcinoma and bone metastases, receiving systemic therapy with atezolizumab plus bevacizumab, was referred to the Endocrinology Unit for hormonal evaluation before percutaneous treatment of an enlarging adrenal lesion. She had no clinical manifestations suggestive of cortisol androgen or catecholamine excess and no history of hypertension. Physical examination and routine laboratory findings were unremarkable.

Preprocedural hormonal assessment showed no clinical or biochemical evidence of cortisol or catecholamine excess. Plasma free metanephrines and urinary fractionated metanephrines were within the reference range, making pheochromocytoma highly unlikely before the intervention.

Initial positron emission tomography/computed tomography (PET/CT) showed a 10-mm hypermetabolic nodule in the left adrenal gland, with a maximum standardized uptake value of 7 **(Figure 1)**. During subsequent imaging surveillance, a new, well-defined right adrenal lesion measuring 13 × 11 mm was identified **(Figure 2A)**. Serial computed tomography demonstrated progressive enlargement of the lesion, which ultimately evolved into a large heterogeneous right adrenal mass with areas of necrosis **(Figure 2B)**. The lesion showed an unenhanced attenuation of 41 Hounsfield units, an absolute contrast washout of 57% and a relative washout of 28%.

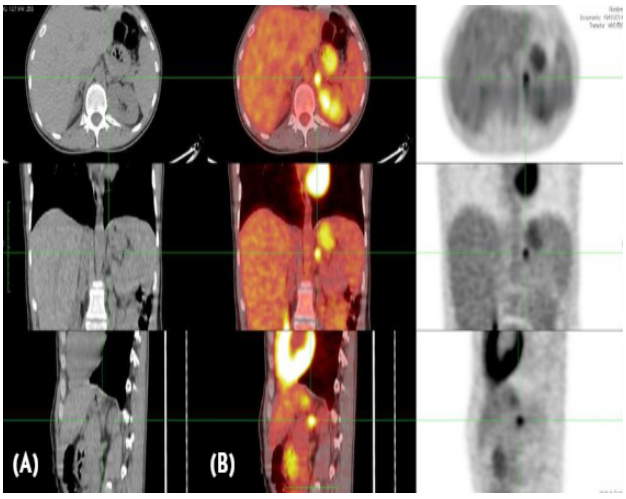

Figure 1: Initial PET/CT findings.
(A) Whole-body maximum-intensity-projection image showing hypermetabolic non-small cell lung carcinoma.
(B) Axial fused PET/CT image demonstrating a hypermetabolic adrenal nodule (SUVmax 7), suspicious for adrenal metastasis.

During the same admission, the patient underwent CT-guided percutaneous core needle biopsy of the right adrenal lesion **(Figure 3)**. Two tissue samples were obtained using a 16-gauge cutting needle. Immediate on-site cytological evaluation was positive for malignancy. Definitive histopathological examination demonstrated involvement by a poorly differentiated neoplasm. Despite immunohistochemical analysis, the tumor phenotype could not be conclusively established. In the context of the

patient's known advanced lung carcinoma and the radiological evolution of the lesion, the findings were considered consistent with adrenal metastatic involvement.

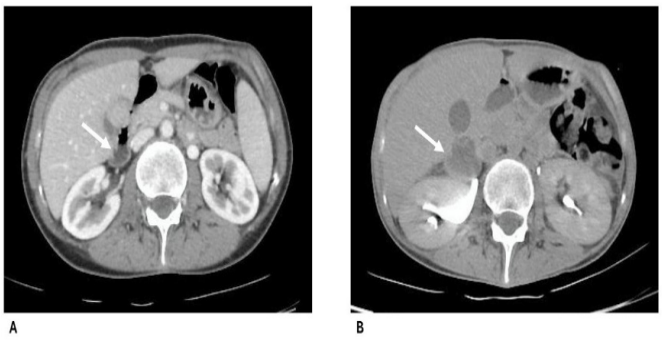

Figure 2: Radiological evolution of the right adrenal metastasis.
(A) Contrast-enhanced CT demonstrating a newly detected, well-defined 13 × 11 mm right adrenal lesion.
(B) Follow-up contrast-enhanced CT showing progression to a large heterogeneous right adrenal mass with areas of necrosis.

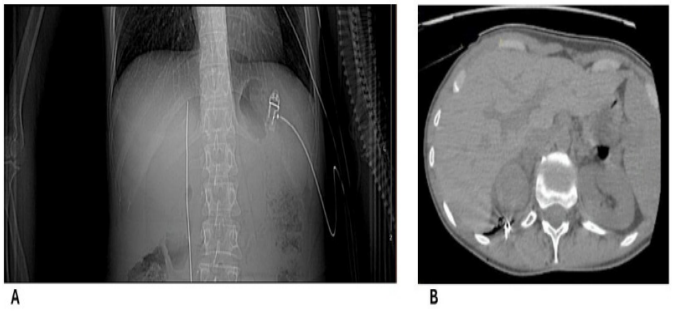

Figure 3: CT-guided percutaneous radiofrequency ablation of the right adrenal metastasis.
(A) CT scout image demonstrating planning of the percutaneous approach.
(B) Axial CT image confirming correct positioning of the radiofrequency electrode within the right adrenal metastasis immediately before radiofrequency energy delivery.

Given the presence of disseminated bone metastatic disease, local treatment was intended for disease control rather than cure. Adrenal-sparing surgery was not available in our setting and conventional surgical treatment would have required adrenalectomy. As the patient wished to avoid surgery, percutaneous radiofrequency ablation was selected after multidisciplinary evaluation as a minimally invasive local treatment option.

CT-guided percutaneous radiofrequency ablation of the right adrenal lesion was subsequently performed during the same procedural session under general anesthesia and continuous hemodynamic monitoring.

A 17-gauge Cool-tip™ Cluster Electrode with a 3-cm active tip was positioned within the lesion and radiofrequency energy was applied for 13 minutes. Immediate post-procedural CT showed no hemorrhage or other acute complications. During the procedure, the patient developed transient severe hypertension, with a maximum systolic blood pressure of 220 mmHg, which was successfully controlled by the anesthesia team. She remained clinically stable after the intervention and showed no evidence of acute adrenal insufficiency during the post-procedural observation period.

Early follow-up imaging demonstrated enlargement and heterogeneous changes in the right adrenal gland, including hemorrhagic components, which were initially interpreted as post-ablation changes. The left adrenal lesion also progressively increased in size, supporting bilateral adrenal metastatic involvement. Subsequent imaging demonstrated marked bilateral adrenal progression, with the right adrenal mass measuring 99 × 64 × 109 mm and the left adrenal mass measuring 91 × 55 × 90 mm.

Discussion

The adrenal glands are a recognized site of metastatic spread from non-small cell lung cancer (NSCLC). In an autopsy study of patients with non-resectable lung adenocarcinoma, Stenbygaard et al. reported adrenal involvement in at least 40% of examined cases[1]. Clinically detected adrenal metastases are frequently asymptomatic and are most commonly identified during staging or surveillance imaging. Symptoms such as abdominal or back pain may occur when lesions are large, rapidly enlarging, hemorrhagic or exert a mass effect.

An adrenal lesion detected in a patient with a known extra-adrenal malignancy should not automatically be considered metastatic. In a series of 330 patients with potentially operable NSCLC, Oliver et al. identified isolated adrenal masses in approximately 10% of patients, but only one-quarter of these lesions were malignant[2]. Therefore, adrenal findings must be interpreted by integrating the oncological context, imaging characteristics, metabolic activity and temporal evolution.

Computed tomography is generally the initial imaging modality. Adrenal metastases may exhibit high unenhanced attenuation, heterogeneous enhancement, irregular margins and progressive enlargement. Because adrenal metastases may show heterogeneous radiological features, diagnosis cannot rely on a single computed tomography criterion. Magnetic resonance imaging, particularly chemical-shift imaging, may provide additional characterization. In patients with bronchogenic carcinoma, Erasmus et al. demonstrated the usefulness of ^18F-fluorodeoxyglucose positron emission tomography for differentiating benign from metastatic adrenal lesions[3].

In the present case, the right adrenal lesion showed progressive enlargement on serial imaging and had an unenhanced attenuation of 41 Hounsfield units. Its absolute contrast washout was 57%, whereas its relative washout was 28%. Although contrast washout measurements may contribute to adrenal lesion characterization, isolated threshold values should not outweigh progressive growth, high baseline attenuation, metabolic activity and the presence of advanced lung malignancy. The subsequent enlargement of the contralateral adrenal nodule further supported the diagnosis of bilateral adrenal metastatic involvement.

Histological confirmation may be considered when the nature of an adrenal lesion remains uncertain and the result would alter clinical management. According to the European Society of Endocrinology, biopsy should be limited to hormonally inactive lesions that cannot be confidently characterized as benign on imaging and for which histology would influence treatment decisions[4].

Adrenal biopsy also has limitations, including non-diagnostic sampling, false-negative results, bleeding and other procedural

complications. Mazzaglia and Monchik found that adrenal biopsy had limited value in the general evaluation of adrenal neoplasms and emphasized that it should be used selectively[5]. Concern regarding needle-track dissemination is particularly relevant when adrenocortical carcinoma is suspected rather than constituting the principal argument against biopsy of a probable metastasis.

In the present patient, CT-guided core needle biopsy of the progressively enlarging right adrenal lesion demonstrated a poorly differentiated malignant neoplasm. Although immunohistochemical analysis did not conclusively establish the tumor phenotype, the pathological findings, together with the patient's known advanced lung carcinoma and the radiological evolution of the lesion, supported the diagnosis of adrenal metastatic involvement. This case illustrates that adrenal biopsy may confirm malignancy without always identifying the precise tumor lineage and that its findings should be interpreted within the broader clinical and radiological context.

Adrenal metastases usually do not compromise adrenal function when involvement is unilateral. However, bilateral metastatic replacement can result in primary adrenal insufficiency when a substantial proportion of the functional adrenal cortex has been destroyed. Clinical manifestations may include fatigue, weakness, anorexia, weight loss, nausea, abdominal discomfort, hypotension, hyponatremia and hyperkalemia. These manifestations may be nonspecific and difficult to distinguish from symptoms caused by advanced malignancy or systemic treatment.

Assessment of residual adrenal function is therefore particularly relevant in patients with large bilateral adrenal metastases. Current European guidelines recommend clinical assessment and measurement of morning serum cortisol and plasma adrenocorticotropic hormone, followed by dynamic testing when basal findings are inconclusive[4]. Continued endocrine surveillance became particularly relevant in our patient after progression to bilateral adrenal involvement.

Hormonal evaluation is also essential before adrenal biopsy or thermal ablation. Pheochromocytoma must be excluded because mechanical or thermal stimulation of a catecholamine-secreting lesion may precipitate severe hypertension, tachyarrhythmias or other potentially life-threatening hemodynamic complications[4]. Importantly, the absence of typical symptoms or a history of hypertension does not reliably exclude catecholamine secretion.

Although the patient had no history of hypertension or symptoms suggestive of catecholamine excess and both plasma free metanephrines and urinary fractionated metanephrines were within the reference range, she developed transient severe intraprocedural hypertension, with a maximum systolic blood pressure of 220 mmHg. This hemodynamic response may have resulted from mechanical and thermal stimulation of adrenal tissue, which can trigger acute catecholamine release even in lesions without demonstrable preprocedural hormonal secretion. Negative biochemical testing substantially reduces the likelihood of pheochromocytoma but does not eliminate the risk of an acute hypertensive response during adrenal ablation. Continuous hemodynamic monitoring and immediate anesthetic readiness remain necessary despite normal preprocedural metanephrine levels.

Local treatment options for adrenal metastases include surgical resection, stereotactic body radiotherapy (SBRT) and image-guided percutaneous thermal ablation. Treatment selection should be individualized according to the extent and control of extra-adrenal disease, the size and location of the adrenal lesion, the patient's performance status, expected survival, technical accessibility and institutional expertise.

Adrenalectomy has traditionally been considered for carefully selected patients with an isolated adrenal metastasis from NSCLC, especially when complete resection is feasible and the primary tumor and other disease sites are absent or controlled. Lucchi et al. evaluated laparoscopic adrenalectomy in patients with metachronous adrenal masses after resection of NSCLC[6]. Notably, some lesions initially suspected of being metastases were ultimately diagnosed as cortical adenomas, reinforcing the importance of appropriate diagnostic characterization before surgery.

Several retrospective series have reported prolonged survival following adrenalectomy for isolated adrenal metastasis from NSCLC[7-9]. Luketich and Burt suggested that resection may confer a survival benefit in selected patients[7], whereas Mercier et al. reported favorable outcomes after surgery for solitary adrenal metastases[8]. Raz, et al. also observed a survival advantage among selected surgical patients, although long-term survival was not observed in patients with contralateral adrenal metastases or mediastinal nodal disease[9].

A systematic review and pooled analysis by Tanvetyanon et al. found that patients undergoing adrenalectomy for metachronous isolated adrenal metastases had longer median survival than those with synchronous metastases, although five-year survival estimates were not significantly different[10]. Other multicenter studies did not consistently identify synchronous versus metachronous presentation as an independent prognostic factor[11]. Favorable factors across surgical series included complete resection, absence or control of other metastatic sites, favorable performance status and a prolonged disease-free interval.

These results derive mainly from retrospective and highly selected surgical cohorts and cannot be directly extrapolated to patients with disseminated, bilateral or actively progressive metastatic disease. In these settings, local treatment may be considered for control of a dominant progressive lesion rather than with curative intent.

SBRT represents a non-invasive local treatment option for adrenal metastases. In a systematic review and pooled meta-analysis of 39 observational studies including 1006 patients, approximately two-thirds of whom had a primary lung malignancy, Chen et al. reported pooled local control rates of 82% at one year and 63% at two years. Corresponding overall survival rates were 66% and 42%, respectively[12]. Higher radiation doses were associated with improved local control and severe toxicity was uncommon. Interpretation of these pooled outcomes is limited by heterogeneity in patient selection, primary tumor type, radiation dose and extent of metastatic disease.

Image-guided percutaneous thermal ablation provides an additional local treatment option, particularly when surgical resection is contraindicated, declined or considered excessively invasive. Available modalities include radiofrequency ablation,

microwave ablation and cryoablation. These procedures enable direct treatment of the target lesion and are generally associated with less invasiveness and shorter recovery times than adrenalectomy.

Radiofrequency ablation delivers high-frequency alternating electrical current through an electrode positioned within the tumor. Ionic agitation generates tissue heating and coagulative necrosis. This mechanism differs from microwave ablation, which uses an electromagnetic field generated by an antenna to produce tissue heating.

The available evidence supporting adrenal thermal ablation is predominantly derived from retrospective series. Espinosa De Ycaza et al. evaluated 58 patients with 60 adrenal metastases treated during 62 thermal ablation sessions and specifically examined the endocrine and hemodynamic consequences of the procedure[13]. Their findings underscore that adrenal ablation differs from ablation in other organs because stimulation of adrenal tissue can provoke clinically relevant cardiovascular responses.

Hasegawa et al. evaluated radiofrequency ablation in 35 patients with unresectable adrenal metastases[14]. Disappearance of tumor enhancement after the initial procedure was achieved in approximately 94% of patients. Local progression occurred in approximately 23%, while local adrenal tumor control was maintained in approximately 77% at the end of follow-up. Major complications occurred in a minority of procedures and no procedure-related deaths were reported.

Frenk et al. also demonstrated that image-guided percutaneous ablation can provide clinically meaningful control of adrenal metastases, particularly for lesions smaller than 5 cm[15]. In their series, technical success was 96%, primary efficacy was 72% and secondary efficacy was 76%. The overall local progression rate was 25%, while local progression-free survival was 82%, 69% and 55% at one, three and five years, respectively.

Liu, et al. retrospectively compared percutaneous radiofrequency ablation with adrenalectomy in patients with adrenal metastases[16]. Initial technical success with RFA was lower than complete surgical resection, but repeat ablation increased technical success. The study suggested that, in appropriately selected patients, particularly those with smaller lesions or increased surgical risk, RFA may provide a less invasive alternative with acceptable oncological outcomes.

Available guidelines for adrenal tumor ablation emphasize careful patient selection, review of tumor size and location, protection of adjacent organs, appropriate anesthesia, preprocedural endocrine assessment and close hemodynamic monitoring[17]. Large lesions and tumors adjacent to critical structures may be more difficult to treat completely and may require overlapping ablations, hydrodissection or more than one treatment session.

A recent series specifically examining thermal ablation of adrenal metastases from NSCLC also supported the feasibility of this approach. Mendez et al. reported prolonged local control without major complications in a small group of patients treated with radiofrequency or microwave ablation[18]. The small sample size and retrospective design preclude definitive comparisons with surgery or SBRT.

Adrenal thermal ablation entails specific procedural risks. Thermal or mechanical stimulation of adrenal tissue may induce catecholamine release even when the treated lesion has not previously demonstrated clinical or biochemical evidence of hormonal secretion. Acute hypertension and tachycardia are the most commonly reported hemodynamic events, although arrhythmias, hypotension and cardiovascular instability may also occur[13,17,18]. Careful endocrine assessment, appropriate anesthetic planning and continuous intraoperative hemodynamic monitoring are therefore essential.

In our patient, the right adrenal lesion was selected for radiofrequency ablation because it showed the most marked progression and was considered the dominant adrenal target at the time of treatment. Given the presence of disseminated bone metastatic disease, the aim was local disease control rather than cure. As adrenal-sparing surgery was not available in our setting and the patient wished to avoid adrenalectomy, percutaneous ablation was selected after multidisciplinary evaluation as a minimally invasive alternative. Although the procedure was technically completed, subsequent imaging demonstrated marked progression of both adrenal metastases, indicating that durable local control was not achieved.

Progressively enlarging adrenal lesions in patients with metastatic lung cancer require coordinated interpretation of the oncological context, imaging evolution, endocrine findings and pathology. Before adrenal intervention, hormonal evaluation is necessary to exclude pheochromocytoma and, when bilateral involvement develops, to assess residual adrenal function. Radiofrequency ablation may provide a minimally invasive local treatment option, although significant intraprocedural hypertension and subsequent progression may occur in patients with disseminated and biologically aggressive disease.

As a single case report, these findings cannot be generalized to all patients with adrenal metastases. Nevertheless, the case highlights clinically relevant diagnostic, endocrine and hemodynamic considerations that may inform the multidisciplinary management of patients undergoing adrenal intervention.

Conclusion

Adrenal metastases in patients with advanced NSCLC require multidisciplinary evaluation integrating imaging, endocrine assessment and pathology when indicated. Percutaneous radiofrequency ablation is a feasible, minimally invasive option for selected patients. However, significant intraprocedural hypertension may occur despite negative hormonal testing and durable local control cannot be assumed in disseminated disease. Careful patient selection, anesthetic preparedness and close follow-up are therefore essential.

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