

Stereotactic Body Radiotherapy for Adrenal Metastases: A Case Report

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Abstract—Background

Adrenal metastases are increasingly detected in patients with advanced malignancies, particularly lung, renal cell carcinoma, and melanoma. Stereotactic body radiotherapy (SBRT) has emerged as a non-invasive ablative treatment option for selected patients with oligometastatic disease.

Purpose

To describe a practical SBRT technique for adrenal metastases and illustrate its application in a representative patient treated at a LINAC-based cancer center.

Case Presentation and Procedure

A 60-year-old man with metastatic squamous cell carcinoma of the lung developed a progressive right adrenal metastasis after multiple lines of systemic therapy. The patient presented with severe flank pain and was considered suitable for local ablative treatment because of oligometastatic disease. Treatment planning was performed using four-dimensional computed tomography (4D-CT) to account for respiratory motion. An internal target volume (ITV) was generated, and a planning target volume (PTV) was created. SBRT was delivered to a dose of 45 Gy in 5 fractions using image-guided LINAC-based radiotherapy.

Results

Organ-at-risk constraints were maintained within acceptable limits according to AAPM TG-101 recommendations. Follow-up PET-CT performed six months after treatment demonstrated a marked reduction in lesion size with near-complete metabolic response. The patient experienced significant pain relief and remained clinically asymptomatic.

Conclusion

SBRT is a safe, feasible, and effective treatment option for adrenal metastases. Careful motion management, image guidance, and adherence to organ-at-risk constraints allow delivery of ablative doses with excellent local control and minimal toxicity.

Index Terms—Stereotactic body radiotherapy, SBRT, Adrenal metastasis, Oligometastatic disease, 4D-CT, Image-guided radiotherapy

I. Introduction

Owing to their abundant vascular supply and advancements in cancer treatment and imaging, patients with primary cancers of the lung, renal cell, colorectal, pancreas, stomach, and melanoma are increasingly diagnosed with adrenal metastases¹⁻². Adrenal metastases make up about 7.5% of all adrenal masses, and their prevalence in patients with metastatic disease ranges from 15% to 35%. Metastases account for about 85% of all malignant adrenal lesions³. In order to guide treatment, patients with adrenal tumors should have a diagnostic work-up to ascertain whether the lesion is hormonally active or malignant⁴. The majority of adrenal metastases are unilateral, and they are frequently discovered during imaging studies⁵.

Adrenal gland metastases can be treated with radiation therapy, surgery, and interventional radiology methods like chemoembolization and radiofrequency ablation⁶⁻⁷. However, one of the main treatments for

controlling adrenal metastases is now stereotactic body radiation therapy (SBRT), particularly for individuals with oligometastatic or oligoprogressive illness, which has a low metastatic disease burden⁸. Adrenal metastases treated with SBRT were significantly more common than those treated with surgery, according to a recent pattern of care review⁹. With careful treatment planning considerations (tumor size, motion management, dose/fractionation), SBRT is emphasized as a safe and efficient substitute for adrenalectomy¹⁰.

Large studies on adrenal metastases SBRT report 1-year local control of 80–85% with little toxicity. Stereotactic body radiation offers significant biological doses in a few fractions while sparing nearby organs¹¹. Early-career observers frequently look for practical, resource-adapted methods in India, where SBRT capability is growing but still mostly restricted to tertiary centers¹².

This case report offers clear and useful information about the application of SBRT in the treatment of adrenal metastases. Along with a discussion of potential difficulties, recommendations are given for treatment planning, dose and fractionation, mobility management, and follow-up. Lastly, we examine the few data on the use of SBRT in the treatment of primary adrenal tumors.

II. Case Presentation

A 60 year old male Farmer patient is a known case of carcinoma right lung stage III C (T4N3M0) poorly differentiated squamous cell carcinoma, diagnosed in February 2021 in his hometown. Underwent 6 cycles of chemotherapy with Paclitaxel+Carboplatin from March to July 2021. Follow up PETCT scan August 2021-interval increase in size of right lung lesion, suggestive of disease progression. Patient developed persistent chest pain and hemoptysis. He was started on concurrent chemoradiotherapy with weekly Paclitaxel+Carboplatin (4 cycles) and Radiotherapy using 10MV photons a total dose of 60Gy in 30 fractions to GTV P and CTV P was given to a dose of 54Gy in 30 fractions, by rapid arc technique from 29.09.2021 to 10.11.2021. Patient was asymptomatic, defaulted for Follow up.

Then Patient reviewed on August 2022 PETCT showed disease progression with adrenal metastasis. Patient underwent 4 cycles 2nd line immunotherapy with Nivolumab from September till October 2022. Follow up PET CT done on 09.11.2022 showed stable disease with no metabolically active adrenal lesions. Patient was not on any treatment until 2024.

CT thorax abdomen and pelvis done on May 2024 showed mild interval change in right upper lobe Lung mass, Left adrenal is mildly bulky. Patient underwent 4 cycles of 3rd line immunotherapy with pembrolizumab from July 2024 till October 2024. CECT scan of chest, abdomen and pelvis done on Nov 2024 showed small ill-defined mass lesion in right upper lung, large ill-defined poorly enhancing lesion in right suprarenal region with few enlarged retroperitoneal lymph nodes. Small sclerotic bony lesions. Patient has undergone 2 cycles of 4th line chemotherapy with tab. Capecitabine from 22.11.2024 till 28.12.2024.

Follow up whole body PET CT scan done on Feb 2025 showed mass at upper lobe of right lung, mediastinal and hilar lymph node appears stable. Hypo enhancing mass in the region of right adrenal with patchy metabolic activity with infiltration of adjacent liver. No other hypermetabolic lesions. Patient has undergone 4 cycles of 5th line chemotherapy-GEMCITABINE+NAB-PACLITAXEL.

The patient began to have excruciating flank discomfort. PET CT (August 2025): In comparison with prior PET CT there is mixed response to the therapy with, relatively stable, low grade FDG avid ill-defined partly spiculated nodular lesion in the medial aspects of right lung upper lobe abutting the mediastinal pleura with stable nodular lesions in rest of the lung parenchyma. Relatively stable mediastinal and hilar lymph nodes with persistent metabolic activity. Increase in size and metabolic activity of ill-defined nodular lesions in right adrenal.

III. Procedure

The patient was evaluated by a multidisciplinary tumor board and deemed suitable for SBRT because of oligometastatic disease status and symptomatic adrenal progression. After that patient was referred to radiation oncology Dept, SBRT was advised by considering the extent of the adrenal lesion and his oligometastatic condition.

Thin-slice 4-dimensional (4D) CT is used in treatment planning once the SBRT indication for treating an adrenal gland metastasis has been verified. Intrafraction motion control was taken into consideration because of the adrenal glands' movement and retroperitoneal placement in the upper abdomen. In order to account for target mobility and take into account all anatomic positions during the breathing cycle, an internal target volume (ITV) was developed. Ablative radiation doses can be safely applied through gating approach, which only administer radiation when the target is in a predetermined anatomic position.

Given the target's favorable position and size, as well as the distance to significant OARs, the patient had five-fraction LINAC based SBRT with a prescription dose of 45 Gy to the 90% isodose line, allowing all dose limitations for a five-fraction treatment to be met (Fig. 1). The GTV was 29.1cm³, ITV was 68.8cm³, and a 5-mm margin was added to form the PTV 131.91 cm³ was the final PTV. Daily image guidance was utilized to ensure accurate target localization.

IV. Results

Table 1. Target volume and dosimetric parameters.

Parameter	Value
D99%	99.7%
D95%	102.8%
Conformity Index (RTOG)	1.23
Gradient Index (Paddick)	3.39
R50	4.18

Table 2. Organ-at-risk dose constraints and delivered doses

Organ	Dose Parameter
Combined Kidneys	V15Gy = 81 cc; Mean Dose = 8.52 Gy
Bowel	D0.5cc = 48.06 Gy
Liver	D700cc = 2.19 Gy; Mean Dose = 8.37 Gy
Spinal Cord	Maximum Dose = 15.83 Gy
Right Renal Cortex	D200cc = 0.54 Gy
Right Renal Hilum	D25cc = 8 Gy

At six months following SBRT, PET-CT demonstrated a marked reduction in lesion size with SUVmax of 2.95. The patient reported complete resolution of flank pain and remained clinically asymptomatic.

V. Discussion

Stereotactic body radiotherapy (SBRT) has emerged as an effective local treatment modality for adrenal metastases, particularly in patients with oligometastatic or oligoprogressive disease who are unsuitable for surgery or prefer a noninvasive approach. In the present case, SBRT delivered to a dose of 45 Gy in 5 fractions achieved excellent local control with significant symptomatic relief and minimal toxicity.

The patient remained clinically asymptomatic on follow-up, with PET-CT demonstrating marked metabolic and radiological response.

The adrenal glands are challenging targets for radiotherapy because of respiratory motion and their close proximity to radiosensitive organs such as the kidneys, bowel, liver, stomach, and spinal cord. Therefore, appropriate motion management and image guidance are essential for safe dose delivery and to reduce intra fraction errors. In our patient, use of 4D-CT simulation, ITV-based target delineation, and daily image guidance enabled accurate treatment delivery while maintaining organ-at-risk doses within acceptable limits according to AAPM TG-101 recommendations.

Several studies have reported favorable outcomes with adrenal SBRT, with 1-year local control rates ranging from 80–90% and low incidence of grade 3 or higher toxicity¹³⁻¹⁴. According to Buerger et al. and other studies there was no difference in the probability of Local control based on GTV and PTV size¹⁵⁻¹⁶. This shows that large volume adrenal metastases should not be excluded from SBRT. Potential prognostic factors for local control with SBRT for adrenal metastases have been evaluated in a number of trials. A larger prescribed dose has been demonstrated to be one of the most significant predictive variables for local control¹⁵⁻¹⁸. The only cut-off with a lower probability of local control was one with a BED10 $\leq$ 50 Gy. Higher biologically effective doses (BED) have consistently been associated with improved local control. In the multicenter analysis by Buerger et al., both lesion size and radiation dose significantly influenced treatment outcomes, with smaller lesions and higher BED regimens demonstrating superior local progression-free survival¹⁵. Our patient received an ablative BED regimen, which may have contributed to the durable metabolic response observed on follow-up imaging.

An additional important outcome in this case was rapid pain relief following treatment. Symptom palliation is particularly relevant in adrenal metastases causing flank or abdominal pain, where SBRT can provide both local tumor control and improvement in quality of life. Furthermore, treatment was completed without interruption and with only minimal acute toxicities, supporting the feasibility of SBRT in routine clinical practice, even in resource-adapted Indian oncology centers.

However, the risk of relapse remains higher in patients with uncontrolled primary tumors or additional non-controlled metastatic sites¹⁶. Although, achieving durable local control with SBRT can delay the need for alteration of systemic therapy and may improve progression-free survival, Overall survival in selected patients. Therefore, careful patient selection, multidisciplinary evaluation, and strict adherence to dose constraints are essential to optimize treatment outcomes while minimizing toxicity.

VI. Conclusion

SBRT is a safe, feasible, and effective treatment option for adrenal metastases in patients with oligometastatic or oligoprogressive disease. The present case demonstrates that delivery of 45 Gy in 5 fractions using 4D-CT-based planning, ITV generation, and image-guided IMRT can achieve excellent local control, substantial symptom relief, and minimal toxicity. With appropriate motion management and organ-at-risk sparing, adrenal SBRT can be successfully implemented in routine radiotherapy practice and represents an important noninvasive alternative to surgery for selected patients.

VII. Figure Legends

Figure 1. Treatment planning CT demonstrating right adrenal metastasis and target volume delineation.

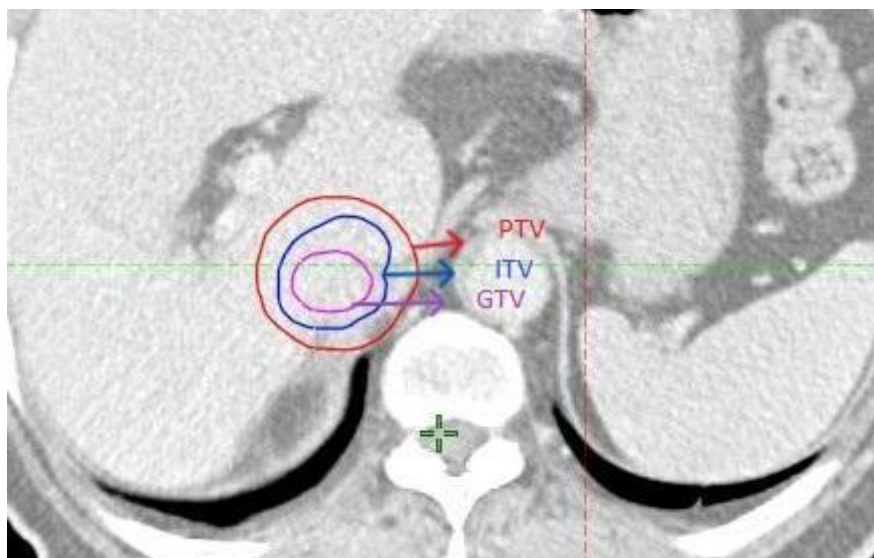


Figure 2. Dose distribution and isodose lines for SBRT plan delivering 45 Gy in 5 fractions.



Figure 3. Pre-treatment PET-CT demonstrating metabolically active right adrenal metastasis.

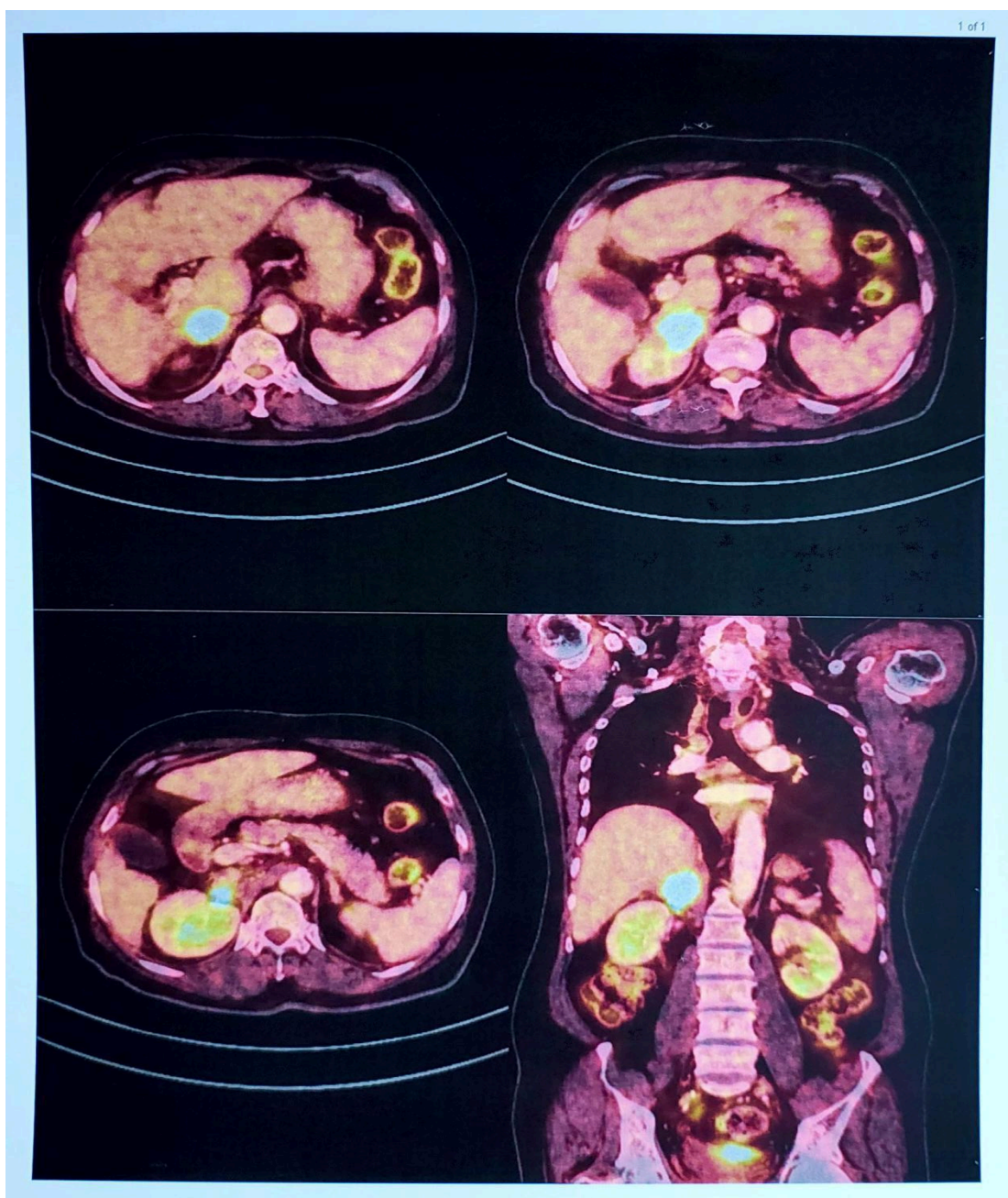
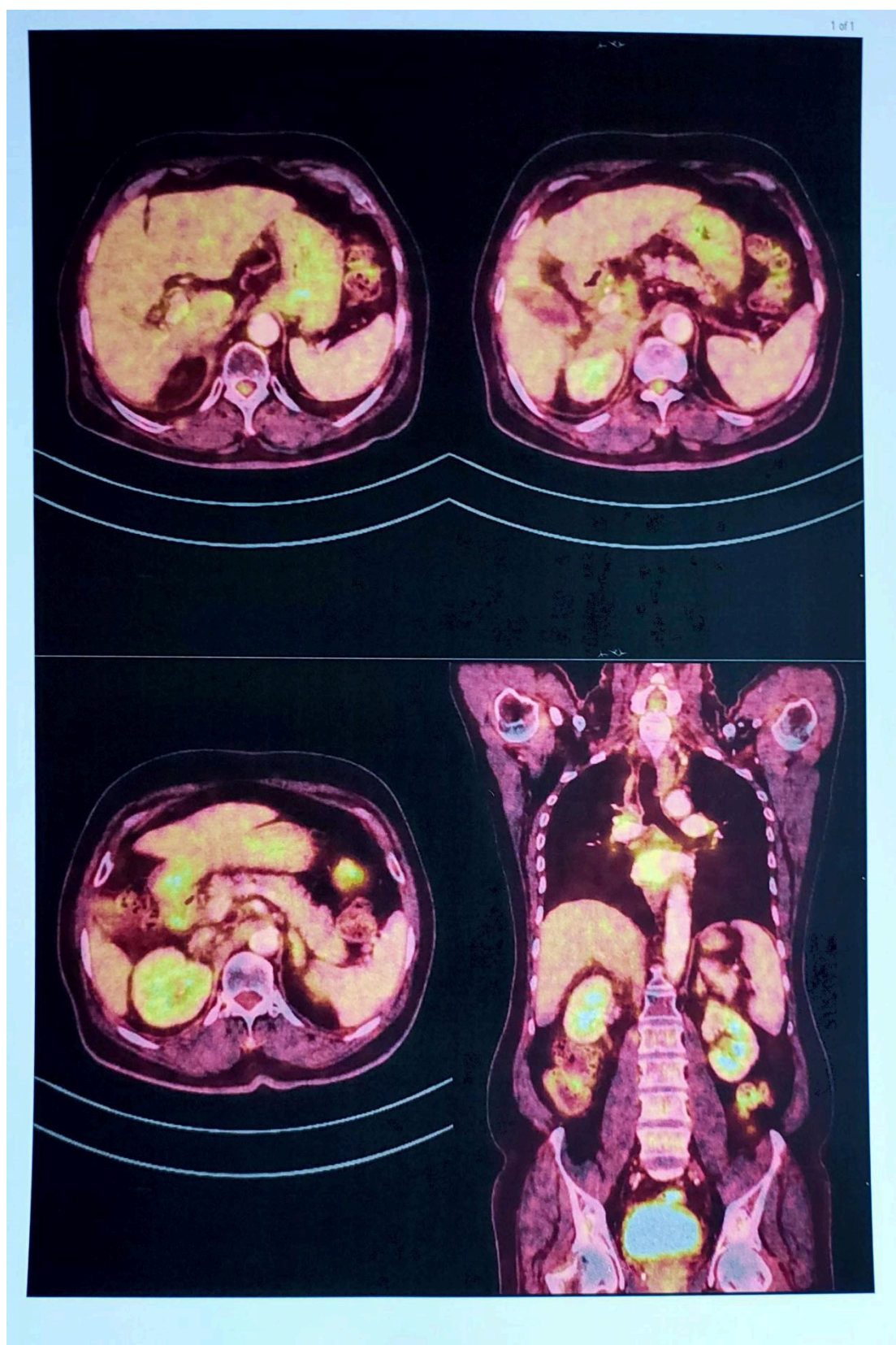


Figure 4. Post-treatment PET-CT at six months showing marked metabolic response and reduction in lesion size.



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