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**Case Report**

# The Importance of Radiation Planning Guidelines in Spinal Stereotactic Body Radiotherapy

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## Keywords

Stereotactic body radiotherapy · Oligometastatic disease · Spinal metastases · Colon cancer

## Abstract

***Introduction:*** Stereotactic body radiotherapy (SBRT) is a well-established treatment for spinal metastases. Official guidelines for radiation planning were published and revised by several groups. Here, we present real-world data about the importance of adhering to those guidelines. ***Case Report:*** A 42-year-old metastatic colon cancer patient presented with oligometastatic disease to L3 vertebra and underwent SBRT treatment. Due to lack of adhering to official guidelines both in dose regiment and in volume definition, he progressed locally and required re-treatment. ***Conclusions:*** SBRT is a well-known established choice for oligometastatic spinal lesions. Thorough evaluation of imaging and adherence to clinical guidelines are crucial for achieving a high local control rate and reducing the likelihood of re-irradiation and associated complications.



## Introduction

Stereotactic body radiotherapy (SBRT) employing intensity-modulated radiotherapy and image-guidance techniques has become the standard therapy for spinal metastases. SBRT for the spine attains a high local control (LC) rate (1 year: 90%) and has low toxicity (0.2% rate of neurologic injury) [1].

Current guidelines by the International Spine Radiosurgery Consortium recommend clinical target volume (CTV) expansion based on the gross tumor volume (GTV) location. The spine is divided into six sectors (vertebra, both pedicles, both transverse processes, and spinous process); the CTV encompasses the sectors housing the GTV, along with adjacent

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sectors, accounting for subclinical tumor spread in the marrow space. Enforcing this standardized approach is imperative to achieve high LC rate [2, 3].

Here, we present a case report of a patient treated at our institution with aim of emphasizing the importance of adhering to current guidelines. A 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/10.1159/000538770).

## Case Presentation

A 42-year-old man diagnosed with metastatic colon cancer in 2019 presented to the radiation oncology unit in September 2021. The patient exhibited an oligometastatic lesion in the body of L3 with some uptake in the left transverse process (Fig. 1).

Following a physical examination and imaging evaluation, a treatment plan was proposed for SBRT to L3, with a dose regimen of 21 Gy in 3 fractions for the CTV and 30 Gy integrated boost to GTV (Fig. 2, 3). Dose regiment was chosen based on ESTRO guidelines which recommend doses of 1 × 20 Gy, 1 × 24 Gy, 2 × 12 Gy, 3 × 10 Gy, and 5 × 7 Gy for achievement of LC >90% [2]. All volume delineation was done after registration of CT simulation with T2-MRI sagittal imaging for cord delineation and T1+G-MRI and position emission topography (PET)-CT imaging for GTV delineation. In our institution, we used mainly 30 Gy in 10 fractions for decreasing the odds for vertebral compression fracture which increase risk with single fraction above 20 Gy [4]. Dose constraints for spinal cord from Timmerman et al. [5] are 0.35 cc < 15.9 Gy and 0.0035 cc < 22.5 Gy and for cauda equine are 0.5 cc < 30 Gy and 0.0035 cc < 31.5 Gy. Dosimetry data for planning target volume (30) were D98% = 29 Gy, D50% = 30.3 Gy, conformity index of 0.89. Both cauda and cord max dose met dose constraints of 24.6 Gy and 0.19 Gy, respectively.

Follow-up examinations conducted during radiation treatment and 2 weeks post-completion of radiation therapy revealed no significant findings. In November 2021, the patient began to report escalating back pain radiating to the left leg, necessitating an escalation in narcotic use for analgesic treatment. A PET-CT scan conducted in December 2021 revealed progression at the left transverse process and body of vertebra, with a decreased uptake exactly at the GTV of the radiation plan (Fig. 4).

Due to concerns regarding radiation toxicity and following a multidisciplinary team discussion, the patient was reintroduced to systemic therapy comprising a combination of 5FU and oxaliplatin. As of April 2022, the patient continued to experience backache with no clinical improvement. A PET-CT scan conducted at that time revealed response in the isodose line of 95% for 30 Gy planning target volume with progression in the low-dose area of L3 and demonstrated disease progression in L2 and L4 (Fig. 5).

### *Re-Irradiation*

He was offered a second radiation treatment for palliative purposes. In May 2022, he received radiation totaling 30 Gy in 10 fractions, with an integrated boost up to 40 Gy encompassing all areas with high uptake observed in the PET-CT (Fig. 6).

Two weeks after the completion of radiation treatment, the pain decreased from 9 to 2 using Visual Analogue Scale (VAS) pain. Two months later, the patient was pain-free without any need for analgesic treatment. In November 2022, a PET-CT scan revealed decreased uptake at the L spine. The first radiological signs of the L3 vertebral fracture were observed (Fig. 7).

Unfortunately, there was progression in the lung and chest wall. The patient initiated immunotherapy and underwent palliative radiation treatment for a chest wall lesion. Subsequently, the same scan also showed progression in the chest wall, for which the patient underwent radiosurgery, resulting in a complete response. Unfortunately, in June 2023, progression in the lung and liver was observed, and the patient succumbed in August 2023.

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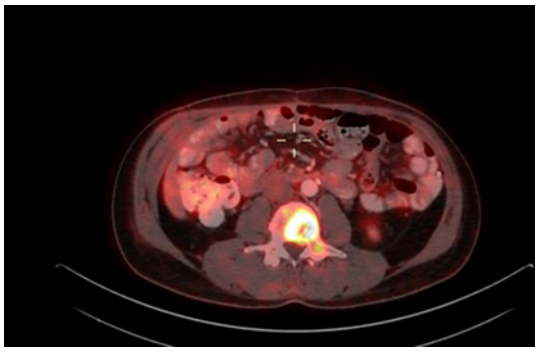

**Fig. 1.** September 2021, PET-CT axial view, L3.

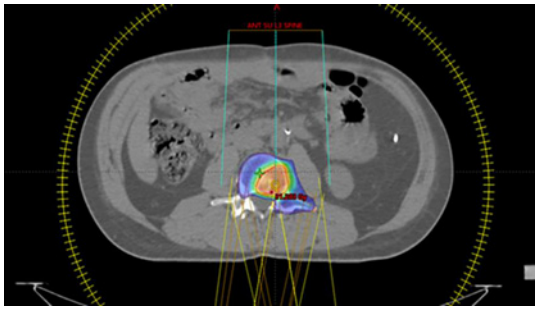

**Fig. 2.** Radiation planning, isodose line 95% from 21 Gy PTV. PTV, planning target volume.

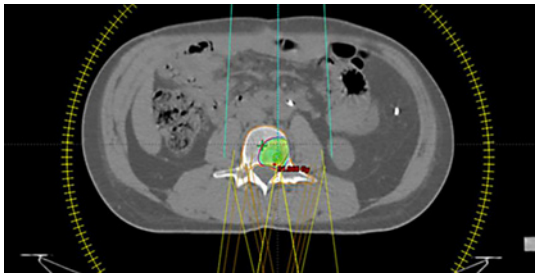

**Fig. 3.** Radiation planning, isodose line 95% from 30 Gy PTV. PTV, planning target volume.

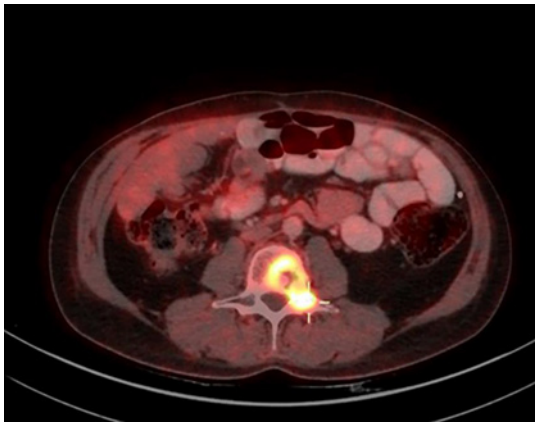

**Fig. 4.** December 2021, PET-CT axial view, L3 showing progressive disease in left transverse pedicle and left lamina.

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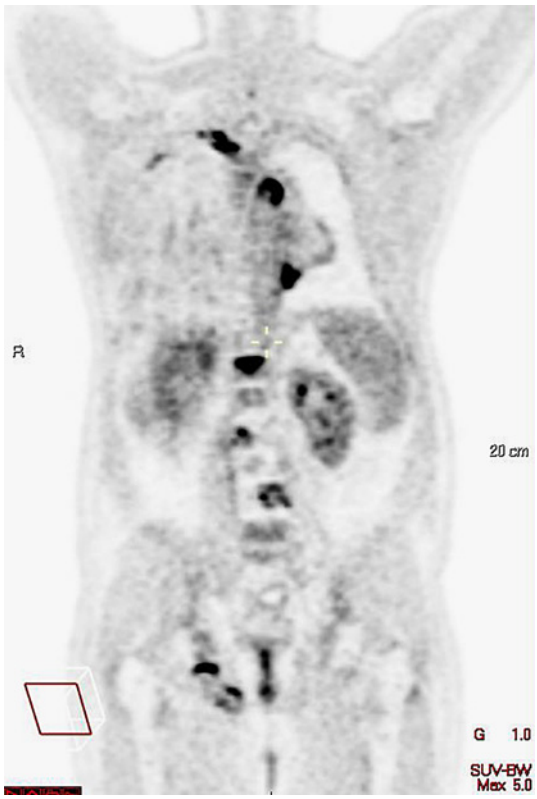


**Fig. 5.** December 2021, PET-CT coronal view, L2–L4 progression.

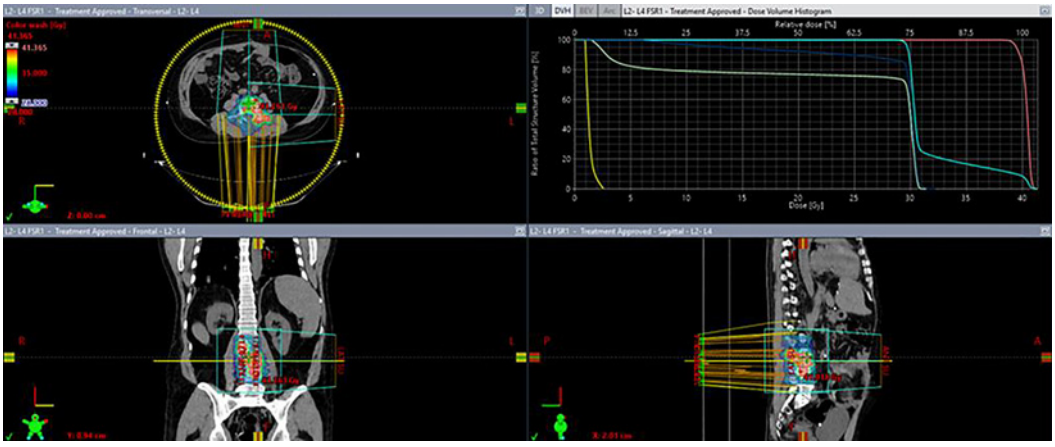

**Fig. 6.** May 2022, re-radiation treatment planning. Red color 40 Gy, blue −30 Gy treatment planning volumes.

## Discussion

Spinal SBRT is a favorable treatment modality for oligometastatic cases, particularly those limited to no more than three contiguous segments, provided the patients exhibit a good performance status and lack clinical or radiological signs of cord compression or spine instability [1]. Several studies have reported LC rates ranging between 85 and 90% [6].

The International Spine Radiosurgery Consortium has published consensus guidelines for delineating targets in spine SBRT, drawing upon expert opinions derived from ten representative cases. The GTV is advised to incorporate data from all available imaging

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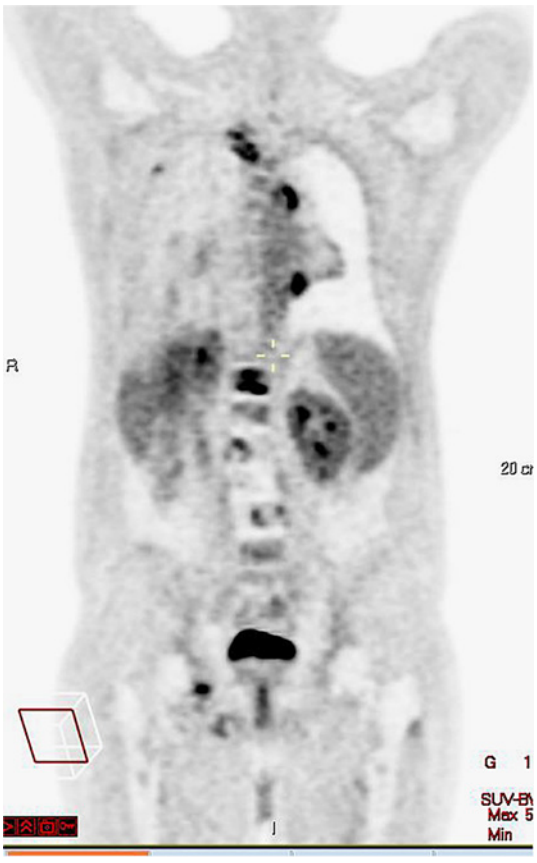


**Fig. 7.** November 2022, PET-CT coronal view, response in L2–L4.

modalities, encompassing epidural and paraspinal disease extensions. The CTV should include areas of potential microscopic extension. In general, where GTV is present within the vertebral body, pedicle, transverse process, lamina, or spinous process, the entirety of the respective region should be included. As a general principle, the adjacent potential bony region should be incorporated. For example, if the GTV involves the vertebral body and right pedicle, the CTV should expansively cover the entire vertebral body, right pedicle, right transverse process, and right lamina. In cases of bone-only disease, expansion of CTV volumes into extraosseous regions, such as the epidural space or paraspinal soft tissue spaces, is generally deemed unnecessary [2].

The total dose recommended to be delivered to the CTV is not well defined. Recent publications suggest different protocols, from 30 Gy in 3 fractions, 24 Gy in 2 fractions, to 16–18 Gy in a single fraction. The preferred regimen in most cases involves a biological effective dose greater than 50 Gy (alpha/beta-10). Notably, in all recent publications, the dose was delivered to the entire CTV without employing dose painting or differentiating the dose within the CTV [6–8].

In a recent publication by Chen et al. [9], it was demonstrated that, after adjusting for confounding factors, deviation from guidelines was the strongest predictor of inferior LC (HR: 3.52, 95% CI: 2.11–5.86, $p < 0.001$). Among guideline-compliant treatments, progressions were predominantly in the field (61%) and/or epidural (49%), whereas marginal (42%) and/or epidural progressions (58%) were most common for those with deviations [9].

Failure to adhere to published guidelines, as observed in our presented case, has resulted in progression at the low-dose volume. In our case, besides the lower than acceptable dose,

there was an omission of left lamina in the CTV, which is inconsistent with current guidelines. Those factors led to disease progression in the body of the vertebra, subsequently advancing to nearby vertebrae.

## Conclusion

SBRT is a well-known established choice for oligometastatic spinal lesions. Thorough evaluation of imaging and adherence to clinical guidelines, including CTV definitions and dose regimen of a least 50 Gy biological effective dose for all CTV definitions, are crucial for achieving a high LC rate and reducing the likelihood of re-irradiation and associated complications.

## Statement of Ethics

This retrospective review of patient data did not require ethical approval in accordance with local/national guidelines. Written informed consent was obtained from the patient and his family for publication of the details of his medical case and any accompanying images prior to his passing away.

## Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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No funding was used for this research.

## Author Contributions

O.H.: case report analysis and manuscript organization and writing. M.L.J.: editing. Y.L.: scientific supervision.

## Data Availability Statement

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

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