Radiological changes in renal cell carcinoma after extracorporeal CyberKnife® radiosurgical ablation: a case report

Alterações radiológicas no carcinoma de células renais após radiocirurgia estereotática com CyberKnife®: relato de caso

Fernando Korkes¹, Oseas de Castro-Neves Neto², Irving D. Kaplan³, Darren D. Brennan⁴, Andrew A. Wagner⁵

ABSTRACT
Small asymptomatic renal masses are more commonly discovered in elderly patients; however, multiple comorbidities in this population may preclude definitive surgical treatment. In this context, treatment options include active surveillance and ablative techniques. Stereotactic radiosurgery is a relatively innovative method of delivering ablative energy to abdominal organs, with very few human or animal experiences published. We describe our experience treating a patient with a large centrally located renal mass using CyberKnife® stereotactic radiosurgery.

Keywords: Radiosurgery/methods; Kidney neoplasms/radiotherapy; Humans; Case reports

INTRODUCTION
Small asymptomatic renal masses are more commonly found in elderly patients; however, multiple comorbidities in this population may preclude definitive surgical treatment. In such context, treatment options include active surveillance and ablative techniques. Stereotactic radiosurgery (SRS) is a relatively innovative method of delivering ablative energy to abdominal organs with very few human or animal experiences published. SRS systems are able to deliver high-dose radiation to extremely precise volumes of tissue while limiting dose to normal tissues. Moreover, hypofractionated SRS systems, such as the CyberKnife®, deliver the dose in few sessions. We describe our experience treating a patient with an enlarging, centrally located renal mass using CyberKnife® SRS.

CASE REPORT
A 58-year-old male patient with a history of bilateral partial nephrectomies, in separate settings, for bilateral complex cystic renal masses. The left tumor was an 8.5-cm papillary renal cell carcinoma, pT2, grade 3, with negative margins. Three tumors were excised from the right kidney; all of them grade 2 papillary renal cell carcinomas measuring 7.0, 3.0, and 2.2 cm, respectively, with negative margins. Follow-up revealed a fourth 11-mm enhancing mass centrally located in the lower pole of the right kidney.

Study carried out at Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA

¹ Assistant Professor at the Department of Urology of Faculdade de Medicina do ABC – FMABC, Santo André (SP), Brazil.
² Minimally Invasive Urology Fellow at Harvard Medical School of Boston, MA.
³ Radiation Oncology Department of the Beth Israel-Deaconess Medical Center of Harvard Medical School – Boston, MA.
⁴ Radiology Department of the Beth Israel-Deaconess Medical Center of Harvard Medical School – Boston, MA.
⁵ Urology Department of the Beth Israel-Deaconess Medical Center of Harvard Medical School – Boston, MA.

Corresponding author: Fernando Korkes – Rua Pirapora, 167 – Ibirapuera – CEP 04008-060 – São Paulo (SP), Brazil – Tel.: (11) 3884-2233 – e-mail: fkorkes@terra.com.br

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Serial magnetic resonance imaging (MRI) scans of the tumor revealed a growth rate of 3 mm/year. Basal creatinine level was of 1.5 mg/dL. The patient was offered continued surveillance, partial nephrectomy, percutaneous radiofrequency ablation, or SRS. Given his multiple prior surgeries, significant comorbidities, and the central location of the mass, SRS was chosen.

Initially, the patient underwent a computed-tomography-guided fine-needle aspiration of the tumor revealing papillary renal cell carcinoma. At that setting, four gold fiducials (CP Medical Inc., Portland, OR) were placed percutaneously: one seed inside the renal mass, one adjacent to the spinous process at L3 and two at the level of the transverse processes of L4.

Three weeks after the marker placement, a planning CT scan was carried out with the patient in the treatment position and the CT images were fused with the previous MRI images. The gross tumor volume was contoured, along with surrounding critical structures. Treatment plan was created using a three-dimensional image, with multiple pencil beams converging at the target to deliver the hypofractioned stereotactic radiation dose (Figure 1). Around the clinical target volume, a “safety margin” of 3 mm was added to obtain the planning target volume. All points more than 1 cm away from the target were to receive less than 50% of treatment dose (Figure 1). Treatment was given in 3 daily fractions of 1,000 cGy (total of 3,000 cGy in 158 beams) and radiosurgery was delivered through the CyberKnife® (Accuray Inc., Sunnyvale, CA) with the Synchrony® system (Accuray Inc.).

The patient had no adverse effects or toxicity after treatment, and creatinine levels remained unchanged. Three months after treatment, MRI revealed a slight increase in tumor size (from 1.7 to 2.0 cm), but the previously enhancing lesion became completely non-enhancing, suggesting complete tumor necrosis (Figure 2A and B). Seven months following treatment, the lesion continued to be non-enhancing and the maximum diameter of the treated area decreased to 1.6 cm (Figure 2C). After a 22-month follow-up, the lesion decreased to 9 mm and remained non-enhancing (Figure 2D).

**DISCUSSION**

Percutaneous radiofrequency ablation and cryoablation techniques are promising minimally invasive techniques which are most successful in exophytic tumors less than 3 cm in diameter\(^3\). Although these are safe techniques in experienced hands, the risks of bleeding, damage to surrounding organs or ureter, and neuropathy following percutaneous techniques are not insignificant. Our patient had a 1.7 cm centrally located mass in a previously operated kidney. Thus his situation was not ideal for percutaneous ablation. Instead, an extracorporeal ablation technique was found to be the safest treatment option for the patient, considering his comorbidities.

Although imaging criteria for tumor recurrence post SRS are not yet described, they are well established for...
other ablative techniques\(^{(3)}\). The most important imaging finding of tissue necrosis is the lack of enhancement, and MRI is particularly suited to this as confounding factors, like beam hardening, that are present on CT are absent. The present tumor showed a marked decrease in diameter after 22 months, and did not enhance on MRI. This is most consistent with complete tumor necrosis. Obviously, a long-term follow-up is necessary for this patient, and no further conclusions regarding efficacy and oncologic outcomes may be inferred.

Our experience with this patient and those with other intrabdominal tumors suggests that SRS using the CyberKnife\(^{®}\) is safe and has the potential to deliver extremely accurate, completely extracorporeal radiation to renal tumors. Further human and animal studies are needed to elucidate the radiobiological effects of hypofractioned SRS on normal renal tissue and renal cell carcinoma.

REFERENCES