Advances in Radiation Oncology (2020) 5, 1380-1383

advances
in radiation oncology

www.advancesradonc.org

Teaching Case

Case Report: Adjuvant Breast Cancer Radiation Therapy in a Patient With an Implanted Deep Brain Stimulation Device

Muoi N. Tran, PhD,[a,*] Kyle E. Malkoske, MSc,[a] Patrick Quinn, MRT(T), HBSc,[a] Connie Ming, MRT(T), HBSc,[a] and Tiffany Tam, MD, FRCPC, DABR[a,b]

[a]*Royal Victoria Regional Health Centre, Ontario, Canada and* [b]*Department of Radiation Oncology, University of Toronto, Toronto, Ontario, Canada*

Received 5 March 2020; revised 28 April 2020; accepted 28 April 2020

Introduction

Deep brain stimulation (DBS) is used to treat movement disorders, such as Parkinson disease, essential tremor, and dystonia. The system consists of 1 or more electrode leads that are implanted in the brain and a wire or extension that is connected to an implanted pulse generator (IPG). The IPG is a battery-powered neurostimulator placed subcutaneously, typically just inferior to the clavicle. Unlike pacemakers and defibrillators, there are few publications in the literature reporting the effects of irradiating DBS systems.[1] The manufacturer's recommendation is to shield the device from direct radiation. However, this presents difficulty when the target to be treated is adjacent to the device. Borkenhagen et al[2] reported a case in which a patient received treatment to a target in the left lung that was within 3 mm of the device. Other authors have reported cases in which the electrode leads received full dose and the IPG received low dose due to scatter.[3-5] In this report, we present a case of a patient undergoing radiation therapy to her left chest wall and supraclavicular region with an implanted DBS within the target volume.

Sources of support: The authors would like to acknowledge the generous support of the RVH Foundation.

Disclosures: None.

Research data are stored in an institutional repository and will be shared upon request to the corresponding author.

* Corresponding author: Muoi N. Tran, PhD; E-mail: TranM@rvh.on.ca

Case Report

A 69-year-old female patient presented with node-positive left breast cancer treated with mastectomy and sentinel lymph node biopsy in early 2019. She subsequently was treated with adjuvant chemotherapy and planning proceeded for locoregional radiation to the left chest wall and regional lymph nodes. However, she had an IPG in her left chest wall, connected to an electrode in her left brain, to control an essential tremor (the device was implanted in January 2018).

The IPG was directly overlaying the treatment area. Relocation of the device involves surgical procedures and their associated risks.[6] Alternatively, exposing the device to direct radiation may result in patient injury as a result of electromagnetic interference (heating of components resulting in tissue damage) or device operational damage, according to manufacturer Medtronic's DBS Information for Prescribers. After discussion with the patient regarding the risks and benefits, radiation planning proceeded with a prescription dose of 42.56 Gy and 40 Gy in 16 fractions to her chest wall and the supraclavicular region, respectively. The neurostimulator device was turned off during computed tomography simulation and radiation treatment using the device's handheld remote control as per the manufacturer's recommendations.

The patient's chest wall and supraclavicular region were treated using a 4-field technique. The IPG was located in the

https://doi.org/10.1016/j.adro.2020.04.036

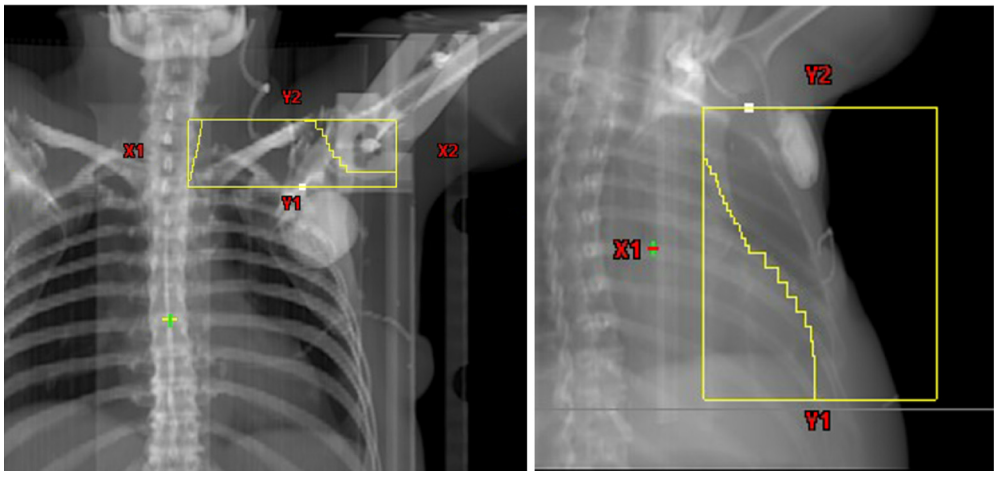

Figure 1 Open field portion of the hybrid intensity modulated radiation therapy (h-IMRT) 4-field technique. The implanted pulse generator (IPG) was not shielded in this portion.

superior portion of the tangent fields. Our institution has been using a hybrid intensity modulated radiation therapy technique, developed by Mayo et al,[7] for the tangent fields as a standard. Typically, the tangent fields consist of 2 opposing open fields, delivering 50% to 70% of the prescription dose, and 2 parallel IMRT fields, delivering the rest of the dose. In this case, approximately 50% of the dose was delivered with open fields in which the IPG was not shielded (Fig 1), and 6 fields were used for the IMRT portion of the treatment (2 of the 6 IMRT fields were parallel to the open tangent beams). The IPG (with a 1-cm margin) was completely shielded in all IMRT fields. This resulted in a plan with compromised dose coverage of the target in the vicinity of the IPG (Fig 2).

We restricted the energy to 6 MV to avoid neutron production, which has been shown to negatively affect the performance of implanted cardiac devices such as pacemakers.[1] Bolus was applied to the treatment area of the tangent fields.

To assess the dose delivered to the IPG, it was delineated in the radiation treatment planning system (TPS). Furthermore, optically stimulated luminescence dosimeters (OSLDs; Landauer, Inc) were used to perform in vivo dose measurements at various regions around the IPG during treatment (Fig 3). The measurements on top of the device (under the bolus) were in a region of low-dose gradient with respect to the IPG (locations C_1 and C_2 in Fig 3). These measurements were performed daily and showed excellent agreement with the TPS dose statistics of the IPG contoured structure (Table 1). Therefore, we were confident that the dose received by the IPG was approximately 27 Gy.

It should also be noted that 4 cm of the wire extension proximal to the IPG passed directly through the supraclavicular fields, at a depth of approximately 1.2 cm. This section of the wire extension would have received a dose of approximately 40 Gy based on the TPS estimates.

It was observed that the IPG was mobile under the skin. This underscores the importance of verifying the position of the device during daily treatment via setup imaging or other methods. In our case, in addition to checking the position of the device with pretreatment kV

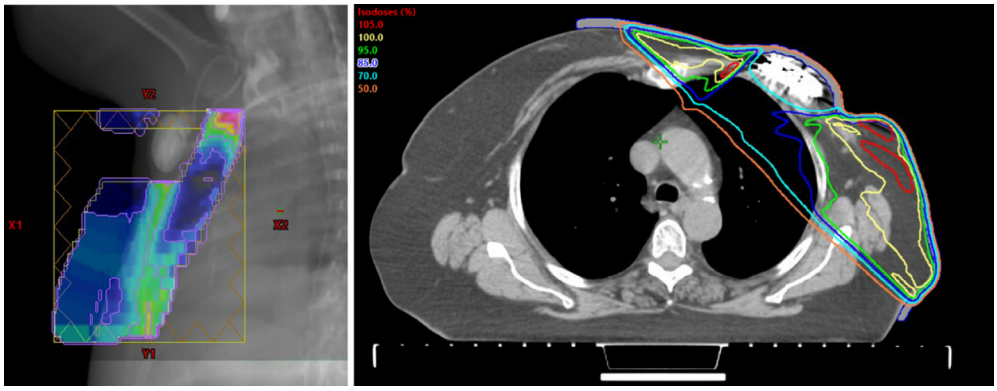

Figure 2 Intensity modulated radiation therapy (IMRT) portion of the hybrid intensity modulated radiation therapy (h-IMRT) 4-field technique. The implanted pulse generator (IPG) was shielded in this portion.

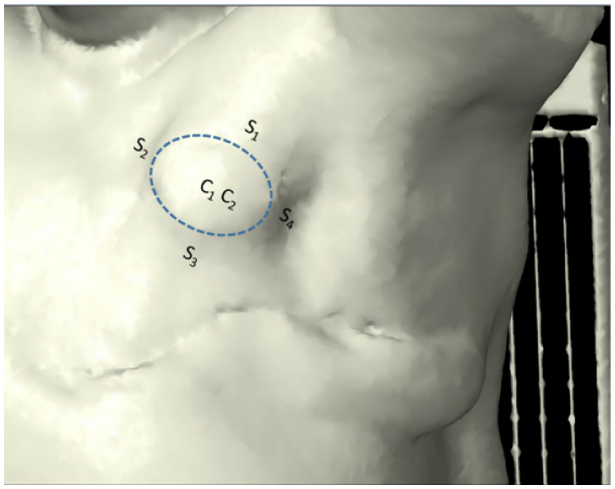

Figure 3 Skin rendering of the patient's chest wall showing the placement of the optically stimulated luminescence dosimeters (OSLDs).

imaging, we also placed 4 OSLDs (S_1-S_4 in Fig 3) at the periphery of the device to ensure the device had not moved into the high-dose region during treatment. This was done by palpating the edge of the IPG during setup. The total dose of S_1-S_4 ranged from 28.3 Gy to 37.5 Gy. Because the OSLDs were at least 5 mm away from the device, this confirmed that the IPG was never in the high dose of the 42.56 Gy region.

At fraction #10, the patient reported that she had noted an increase in tremors that she related to situational stress around her cancer diagnosis and treatment. However, this did not significantly affect her daily routine and she did not feel any intervention was needed. Based on the in vivo measurement, the device would have received approximately 17 Gy at this time.

Her radiation treatment was completed in September 2019. She was evaluated in January 2020 by her neurologist and she reported her hand tremor was quite bothersome. The device voltage was increased from 3.1 V to 3.8 V to help with her tremor and improvement was seen immediately during that visit. The electrode and therapy impedances were assessed and were within normal limits. A subjective assessment by the patient compared with her last visit in November 2018 was unchanged.

Table 1 Cumulative dose to the OSLDs over 16 fractions

	Mean (Gy)	Min (Gy)	Max (Gy)
TPS	27.3	26.4	29.5
OSLD measurements (C1, C2)	27.5	26.4	28.5

Abbreviations: OSLD = optically stimulated luminescence dosimeter; TPS = treatment planning system.

Discussion

Currently, there are no consensus guidelines on radiation exposure in patients with implanted DBS devices. Clinicians and patients are faced with balancing the need of irradiating the target volume and sparing the device. The American Association of Physicists in Medicine 1994 report set a threshold of 2 Gy, above which the pacemaker could be at an elevated risk of damage.[8] However, a recent report on cardiac implantable electronic devices (CIEDs) points to the stochastic nature of the CIED malfunction, unrelated to the cumulative dose. The predominant malfunction was recoverable resets to the device parameters that are not likely to cause permanent damage to the device.[1] The IPG is likely to behave in a similar manner as CIEDs under ionization radiation because it is similar in construction.

To our best knowledge, there were only 2 previous case reports in which the IPG received a dose exceeding 2 Gy. Mazdai and colleagues[5] reported a case in which a patient underwent radiation treatment to the head and neck, and they estimated that the IPG received a total dose of 7.5 Gy. In another report by Borkenhagen and colleagues,[2] a patient underwent treatment to the left lung and the mean dose to the device was determined to be 19.70 Gy. In both cases, the device was found to be fully functional during treatment and the setting was unchanged post radiation therapy. In our case, the mean dose to the neurostimulator device was 27 Gy, and the device's voltage was increased posttreatment. However, it is unclear whether the need for device voltage adjustment for symptom control was a result of the IPG receiving a high dose. For example, in a report by Page et al,[4] the dose to the device was estimated to be low at 2.9 Gy, and the device voltage required a slight increase in the last 3 of 30 fractions to improve the patient's Parkinson-related symptoms that worsened during his radiation therapy treatment.

In the face of a lack of evidence-based guidelines, clinicians will need to monitor the neurostimulator device behavior during and after radiation treatment. It is challenging to provide general clinical guidance based on limited data, but we hope that this and previous case reports highlight the need for a thorough systematic study of neurostimulator implants to help better understand the risks associated with irradiating these devices.

References

1. Indik JH, Gimbel JR, Abe H, et al. 2017 HRS expert consensus statement on magnetic resonance imaging and radiation exposure in patients with cardiovascular implantable electronic devices. *Heart Rhythm*. 2017;14:e97-e153.
2. Borkenhagen JF, Morris ZS, Horberg JR, et al. Delivery of definitive dose external beam radiation in close proximity to an implanted deep brain stimulator. *Prac Radiat Oncol*. 2014;4:294-297.

3. Kotecha R, Berriochoa CA, Murphy ES, et al. Report of whole-brain radiation therapy in a patient with an implanted deep brain stimulator: Important neurosurgical considerations and radiotherapy practice principles. *J Neurosurg*. 2016;124:966-970.
4. Page SM, Paris MI, Kelly L. Safe delivery of high-dose radiation therapy to an aggressive head and neck malignancy in a patient with deep brain stimulators. *J Clin Stud Med Case Rep*. 2019;6:060.
5. Mazdai G, Stewart DP, Hounsell AR. Radical radiation therapy in a patient with head and neck cancer and severe Parkinson's disease. *Clin Oncol*. 2006;18:82-84.
6. Umemura A, Jaggi JL, Hurtig HI, et al. Deep brain stimulation for movement disorders: Morbidity and mortality in 109 patients. *J Neurosurg*. 2003;98:779-784.
7. Mayo CS, Urie MM, Fitzgerald TJ. Hybrid IMRT plans—concurrently treating conventional and IMRT beams for improved breast irradiation and reduced planning time. *Int J Radiat Oncol Biol Phys*. 2005;61:922-932.
8. Marbach JR, Sontag MR, Van Dyk J, et al. Management of radiation oncology patients with implanted cardiac pacemakers: Report of AAPM Task Group No. 34. American Association of Physicists in Medicine. *Med Phys*. 1994;21:85-90.