Evaluation of Special Physics Consult for EBRT Re-Irradiation

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INTRODUCTION

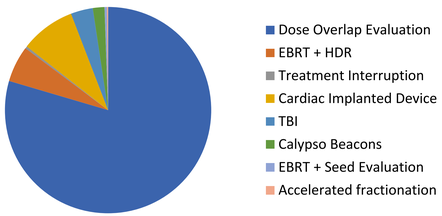
There will be an estimated 4.2 million 5-year cancer survivors previously treated with radiation by 2030 in the US, and many of these patients may return for external beam radiotherapy (EBRT) with recurrences or secondary cancers (1). This trend, paired with the stricter departmental policies and improved technical means to assess cumulative dose distributions, has caused a surge in special physics consults (SPCs) with some departments reporting a more than doubling number of SPCs within a year (2).
While other SPCs to evaluate dose distributions such as for cardiac implanted electronic devices (CIED) or combined EBRT-brachytherapy courses make use of clearly structured templates, predefined organs-at-risk (OARs) and consensus-based dose limits, guidelines for re-irradiation SPCs at NYU have been tailored to each case at the discretion of each physicist. The reason might be the varying forms of treatment records, the large number of treatment site-combinations and the physicist's familiarity to registration methods and dose metrics. Despite these various confounding factors, enough similarities exist between cases and systems to suggest a set of basis guidelines.

AIM

To assess the need for standardization of SPCs by doing a retrospective and systematic review of these consults and evaluating the dosimetric and clinical parameters utilized in these documents.

METHOD

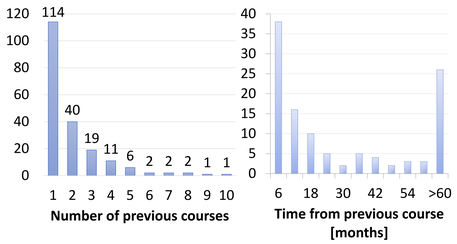
This project follows a two-step approach with two physics residents initially analyzing 15 months of SPCs under the supervision of a QMP to build a database and find exemplary SPC cases, and a subsequent committee of physicists and physicians to define OARs, biological weighting, and dose limits, similar as reported in (2). Here, we report the preliminary data from phase one of this study based on about 150 SPCs. The total number of SPCs within the 15 month period was 548 with about 80% of those analyzing dose overlap for re-irradiation.

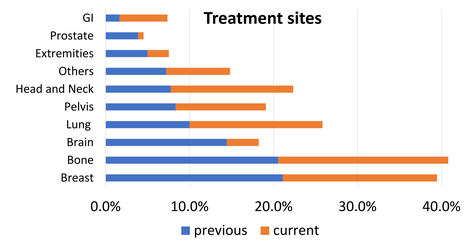


RESULTS AND DISCUSSION

Course statistics

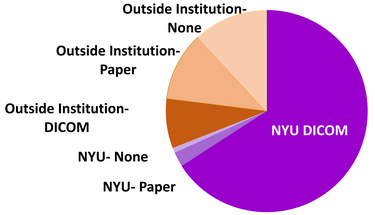
The figures below show the number of previous courses evaluated in the SPCs, the time between the current and the most recent course, and the available treatment records. Most patients came for irradiation after a single course with a median of 13 months between courses. Common treatment sites included sites typical for metastases such as bone, lung and brain, but also head and neck and breast which generally makes up almost half of all courses at NYU.





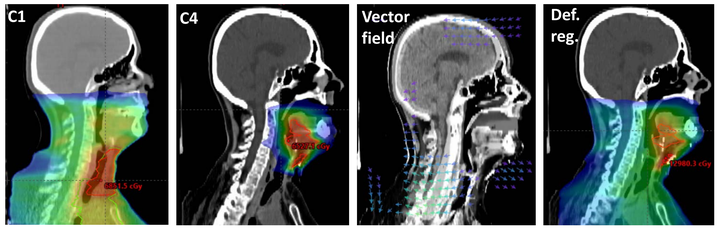
Treatment records

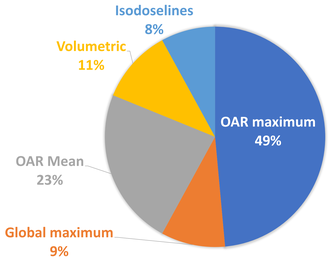
The majority (78%) of patients had prior radiation treatment at NYU with treatment plans available in DICOM format. For patients treated at outside institutions, records were available as DICOM-data for only 24%, in paper for 33% and not available for 36%.



Dose overlap evaluation: Plan registration and dose metrics

In half of the analyzed SPCs, no registration was performed because either there were no records available, or there was no dose overlap defined by a > 3 cm distance between the 50% isodose lines.
Rigid registration to bony anatomy or the PTV region was used for most overlapping dose distributions when DICOM data was available. Deformable registration was only performed in 2% of all cases. Figures on the right show two courses, C1 for thyroid bed and neck and C4 for the oropharynx. The head extension is only slightly different but PTV and OARs such as the brachial plexus (3) fall just into the region of highest deformation marked in the vector field. The registration of the RT-structure is mapped onto the RT-dose to calculate the sum dose distribution.





The commonly used dose metrics were:
- The global maximum dose (hotspot)
- The maximum dose in an organ at risk (OAR)
- The mean dose in an OAR
- Volumetric measures such as V20 for lung
- Isodose lines showing the distance between fields

$$BED = nd \cdot \left(1 + \frac{d}{\alpha/\beta}\right)$$

(excluding proliferation and repair)

$$EQD_2 = \frac{BED}{1 + \frac{2}{\alpha/\beta}}$$

To compare treatment courses of different fractionation schemes the maximum and/or mean dose to an OAR was used in the calculation of the biologically effective dose (BED) and equivalent dose in 2 Gy per fraction (EQD2). The tissue-specific α/β ratio was determined by the physician and generally between 2-3 for OARs and 10 for target volumes.
Adding the BED/EQD2 of each course, however, doesn't take the spatial distribution into account and may predict doses exceeding tolerances for serial organs even if their maxima are not overlapping.

CONCLUSION

The variation in SPCs performed to evaluate dose overlap in re-irradiation suggests a need for standardization. As a first step, an updated SPC template was created to make sure that all relevant parameters are included. In a second step, a team of physicists and physicians will define site specific OARs, biological weighting, and dose limits.

SPECIAL PHYSICS CONSULT

Location: NYULMC

<Primary Care Physician - Name (Default)>,

As per your request, an evaluation of dose overlap has been performed for the above listed patient.

Previous RT

Course #	Treatment Site	Treatment Dates	Dose Received (fractionation)	Facility	Potential Overlap with Current Course	Treatment record (DICOM/ Paper/ None)	Technique (3D/ IMRT/ HDR/ SBRT..)
					Y/N		
					Y/N		
					Y/N		
					Y/N		

Current RT

Course #	Treatment Site	Simulation Date	Dose Prescribed (cGy)	Technique

Scenario:

- ☐ No overlap, plan sum not required. There is a gap of ____cm between ____.
- ☐ Choose registration of CT data sets focused on anatomical region of interest: ____.
  There are anatomical changes that decrease the quality of image registration.
  Patient positioned very differently in courses. Therefore, cannot register CT data sets.
- ☐ Plan sum was created to evaluate overlap of Course # ____ / Treatment site ____ with Course # ____ / Treatment site ____.
- ☐ Re-creation of previous treatment fields +/- isodose levels onto CT data set of current course.
- ☐ The plan for the current course was adapted to decrease dose overlap.
- ☐ No RT details of previous dose distribution.

Findings: Consider time between re-irradiation to estimate risk for clinical endpoints

OAR	Max dose	Mean dose	3cc dose

Scenario: Overlap exists between current and prior courses. BED and EQD calculation for organs at risk and target is warranted.

All doses are in [Gy]

Structure	α/β	Course # / # of Fxs / Dose/Fx	BED	EQD2	Course # / # of Fxs / Dose/Fx	BED	EQD2	BED$_{Tmt}$	EQD$_{Tmt}$
				0.00			0.00	0.00	0.00
				0.00			0.00	0.00	0.00
				0.00			0.00	0.00	0.00
				0.00			0.00	0.00	0.00
				0.00			0.00	0.00	0.00
				0.00			0.00	0.00	0.00
				0.00			0.00	0.00	0.00
				0.00			0.00	0.00	0.00
				0.00			0.00	0.00	0.00

Findings: ____

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2 Paradis KC, et al. The Special Medical Physics Consult Process for Reirradiation Patients. Adv Radiat Oncol. 2019 Oct;4(4):559–65.
3 Chen, AM, et al. Tolerances of the Brachial Plexus to High-Dose Reirradiation, Int J Radiation Oncol Biol Phys, Vol. 98, No. 1, pp. 83e90, 2017

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