STANDARDISATION OF CSI TREATMENT PLANNING AND EVALUATION USING A DVH REGISTRY

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ABSTRACT

Purpose: To develop standard dose-volume constraints for patients treated with intensity-modulated craniospinal irradiation (IMRT-CSI).

Introduction: CSI is a complex technique used less than 10 times per year in a radiation oncology department treating approximately 3000 patients/year. At our centre we have developed an IMRT-CSI technique that provides important sparing of organs at risk (OARs) from high dose exposure compared with our previous 3D technique. However, treatment planning is time consuming and we hypothesized could be greatly facilitated by defining ab initio an "optimal" IMRT-CSI plan with standard dose-volume constraints.

Methods: To determine the optimal IMRT-CSI plan we have employed a DVH registry developed at our centre. The registry records and summarizes data (age, sex, diagnosis, treatment site, etc) from the plans of previously-treated patients and allows for comparison of a present DVH with the appropriate historical average.

The backbone of the registry is a MySQL database that stores DVH data exported from the Eclipse treatment planning software (Varian Medical Systems, Palo Alto); the front-end provides web pages via a web-server. Before submission to the database, each patient's data are anonymised and structures are renamed using a naming convention. The registry allows for addition of future plans as they are produced, such that the data set is always current.

Results and conclusion: We have used our DVH registry to derive standard (average) DVHs for an initial demonstrative cohort of six recently-treated IMRT-CSI patients treated to 36 Gy. Initial results demonstrate the usefulness of the registry for CSI treatment and highlight areas for improvement in the user-friendliness of the system.

Introduction

Craniospinal Irradiation

Craniospinal irradiation (CSI) is an important component of treatment for some types of CNS tumors in children, for example, medulloblastoma and germ cell tumors. Even so, few centres treat more than a few such patients each year. CSI is technically challenging, requiring great care in target volume definition as well as in treatment planning and delivery for optimal results.

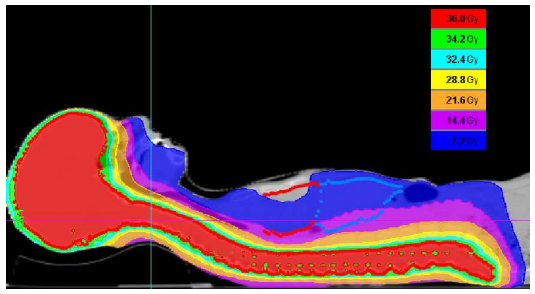

Figure 1. Dose-wash image of an example pediatric patient treated with IMRT-CSI at our centre.

At the McGill University Health Centre we have used IMRT for CSI that since 2008 has been delivered on a Tomotherapy unit (Parker *et al.* 2007). Figure 1 presents a dose-wash image of an example pediatric patient treated with IMRT-CSI at our centre.

Motivation

Patients who receive CSI as part of their treatment are at significant risk for long-term sequelae, some of which are due to exposure of non-target tissues. Inverse-planned IMRT requires determination of dose constraints prior to planning but in most centres the choice of dose constraints is rather arbitrary and even then may be applied differently by different planners.

In order to evaluate IMRT plans and to set benchmarks to guide IMRT planning we compiled a DVH registry using data from patients previously treated with CSI in our center.

Materials and Methods

Patient Cohort

The cohort of patients used in this work comprised six pediatric patients treated with IMRT-CSI. Four patients were treated for germ cell tumours and two for medulloblastoma. The following selection criteria were employed:

- Age: $\leq$ 17 years old
- Dose/fractionation: 36 Gy/20 fractions

Treatment Planning

Planning for treatment consisted of a CT scan, target/organ contouring and inverse IMRT optimization for helical Tomotherapy delivery.

Registry Infrastructure

Out DVH registry is a custom-developed software tool that is used to archive DVH data from the plans of patients previously treated at our centre. Figure 2 presents a schematic overview of the registry.

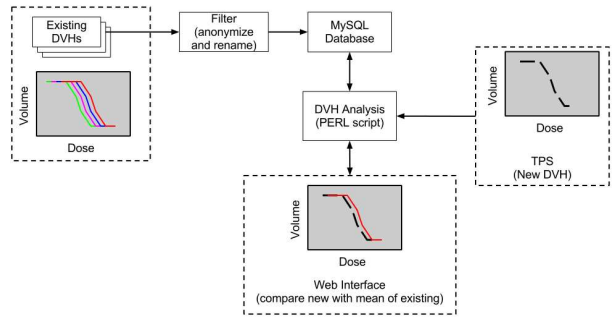

Figure 2. Schematic overview of the DVH registry developed and used at our centre.

Data from the DVH registry is provided upon specifying a patient cohort. DVH curves for the cohort are displayed in the form of mean DVH, DVH range, a composite of all DVHs in the cohort, and a plot of the standard uncertainly in the mean DVH. The planner may choose to overlay DVHs from the plan he/she is preparing for comparison.

Results

Dose-Volume Statistics

Using our DVH registry with the cohort of six patients treated with IMRT-CSI, we extracted mean dose-volume points for important OARs. Table 1 presents these results. These data provide a measure of the standard of practice in our centre pertaining to the cohort of six patients in the present study.

Organ	V5	V10	V20
Heart	86	28	1
Left Lung	53	15	2
Right Lung	69	25	5
Left Kidney	60	18	1
Right Kidney	68	19	2
Esophagus	100	100	45
Liver	71	24	0.5
Stomach	82	18	0.3
Trachea	100	95	33
Thyroid	100	94	17

Table 1. Mean dose-volume points for our study cohort as determined using the DVH registry. Abbreviations: V_5, V_{10}, V_{20} = volume of structure receiving more than 5, 10, 20 Gy, respectively.

References

Parker, *et al.* 2007 "IMRT radiotherapy for craniospinal irradiation: target volume considerations, dose constraints, and competing risks." International Journal of Radiation Oncology* Biology* Physics 69.1 (2007): 251-257.

Case Study

The usefulness of our DVH registry is demonstrated by a recent case. The registry allowed us to determine realistic initial planning constraints and to evaluate our new plan with reference to existing practice.

Figures 4 and 5 present the registry output for the heart and trachea. By comparing the trachea DVH with the existing average DVH we were alerted that significant improvement at low dose was possible. Upon adjusting the planning constraints the expected improvement was achieved.

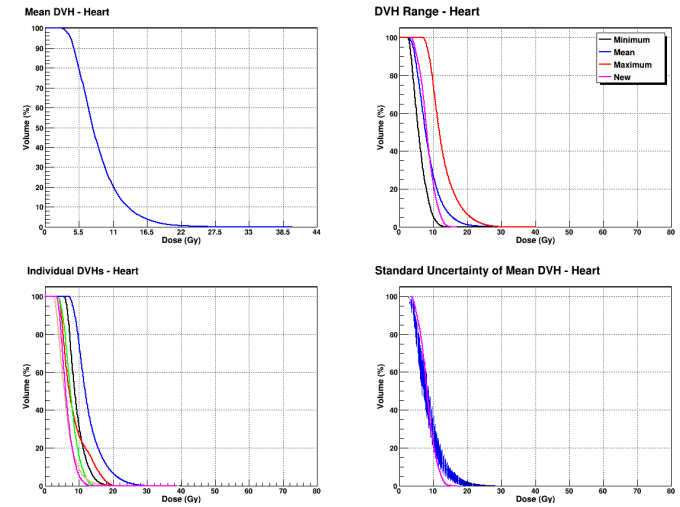

Figure 4. DVH registry output for the heart with the newly-planned DVH displayed for comparison.

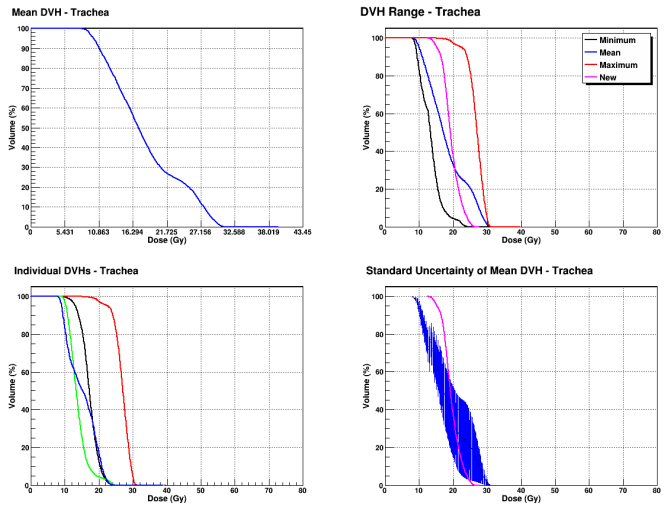

Figure 5. DVH registry output for the trachea with the newly-planned DVH displayed for comparison. The discrepancy between the mean and new DVHs at low dose alerted us to possible improvement to the plan. This improvement was subsequently achieved.

Conclusion and Future Work

We have developed a DVH registry to store DVH data for plans treated at our centre. The registry allows us to examine our standard of treatment and it provides realistic initial dose-volume constraints for treatment planning.

We expect our dose-volume statistics to improve as we add future patient data to the registry. We believe that our DVH registry will allow us to monitor and continuously improve the standard of IMRT-CSI treatment at our centre.