Plan Evaluation & Dose Reporting

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Revolution in Radiation Oncology

1960’s

1970’s

1980’s & 1990’s
Aim Of Radiotherapy

- Deliver a sufficient dose to the tumor to provide a high probability of cure.
- To induce minimal damage in the surrounding normal tissues, leaving them architecturally intact and functionally competent.
Treatment Planning Process

• Step 1: Patient positioning and immobilization
• Step 2: Image acquisition and input
• Step 3: Anatomy definition (Define contours for target volume & OAR)
• Step 4: Dose prescription
• Step 5: Beam technique
• Step 6: Dose calculations

• Step 7: Plan evaluation
  • Step 8: Plan review and documentation
  • Step 9: Plan implementation and verification
Need For Plan Evaluation System

• Tumor coverage by the prescribed dose
• Sparing of critical structure
• Dose homogeneity in target volume
• Various dose parameters
Key Factors

• Provide relevant clinical, radiologic, geometric, dosimetric and radiobiologic information regarding target volumes, OAR’s, healthy tissues

• Visualization of the spatial arrangement of the tumor, critical organs, and isodoses in the form of a single three-dimensional representation that can be observed from all angles

• Detailed comparison between several treatment plans

• Technique allows an immediate appreciation of potential problems in the plan that could lead to adjustments of the treatment parameters

• Should provide quantitative information and be able to quantitatively assess the quality of a treatment option
NO PERFECT SYSTEM
Pre-requisite for Plan Evaluation

- Stage of the disease must be kept in mind.
- History, Clinical & HPE findings must be reviewed.
- Disease extension in relation to OAR’s.
- Patient Performance status.
- Careful assessment of the Contouring of the target volumes & critical organs at risk.
- Intent of treatment & objectives
- Dose levels
Factors Affecting Plan Evaluation

- Physician
- Patient
- Physicist & Radiographer
Definition of Volumes

(A) ICRU 29
(B) ICRU 50
(C) ICRU 62
ICRU 62 recommendations for marking various anatomical structures.

- GTV : dark red
- CTV : light red
- ITV : dark blue
- PTV : light blue
- OAR : dark green
- PRV : light green
- Landmarks : Black
GTV

- GTV can vary according to the diagnostic modality (clinical examination, anatomic imaging, functional imaging) used, a clear annotation is required.

- The GTV may consist of:
  - primary tumor (primary tumor GTV or GTV-T)
  - metastatic regional node(s) (nodal GTV or GTV-N), or
  - Distant metastasis (metastatic GTV, or GTV-M).

- Avoid potentially confusing terminology, e.g., biological target volume, proliferative target volume, hypoxic target volume.
CTV

• When several CTVs are used, it is recommended that an unambiguous terminology corresponding to the GTV denomination be used eg: Labelled by dose level

• Important: Biological volume
ITV

- The ITV is considered an optional tool in helping to delineate the PTV.
PTV

• In earlier ICRU documents, the possibility of compromising the margins of the PTV if they encroached on OAR was suggested.

[–NOT RECOMMENDED!–]

• To ensure accurate reporting of absorbed dose to the PTV in cases for which the PTV encroaches or overlaps another PTV, OAR, or PRV, it is now recommended that the delineation of the primary PTV margins should not be compromised.
# Tumor Volume Delineation And Doses

<table>
<thead>
<tr>
<th>Target Volumes</th>
<th>Doses</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTV (GTV primary + GTV Node)</td>
<td>70Gy/33# or 66Gy/30# or 70Gy/35#</td>
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<td>Low risk PTV 54/30 (CTV 59.4/33 or 54/30 with 5mm expansion)</td>
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</tbody>
</table>

![Image showing GTV, CTV, PTV volumes with doses](image-url)
PTV Sub volumes

• Subdivision of the PTV into regions with different prescribed absorbed doses (PTV: sub-volumes, PTV$_{SV}$).
• Same for overlapping PTVs.
• The dose reporting should, however, be done for the whole PTV.
• Concept of tissue organization is useful for the delineation of OARs.

• For instance, for the retina or tubular-type organs such as the rectum, it is preferred to delineate the wall or surface rather than the full organ.
• PTV and the PRV may overlap

• Recommended that the margins not be compromised for the PTV or PRV.

• PRV can be subdivided into regions with different absorbed dose constraints.

• The absorbed dose be reported in the full PRV.
Remaining Volume at Risk

• The imaged volume within the patient, excluding any delineated OAR and the CTV(s), should be identified as the RVR.

• RVR DVH may help to detect unsuspected regions of high absorbed dose within the patient that would otherwise go undetected.

• RVR might be useful in estimating the risk of late effects, such as carcinogenesis.
Isocentre Placement

• Preferably in PTV high risk

• Avoid slanting surface

• Ease of daily setup for treatment
Beam Placement

- No. of beams
- Placement
- Entry & Exit
- Relationship of OAR with beam
Beams Eye View

- A useful advantage of 3D computer system based planning system
- Gives instant beam direction
- conformation of the beam
Dose Volume Prescription

- According to ICRU 83 prescriptions in IMRT: specified and reported using dose–volume metrics i.e. coverage of the PTV by a specific absorbed dose

- The use of dose–volume reporting instead of reporting the absorbed dose at the ICRU Reference Point

- Dose-calculation algorithms, such as convolution/superposition method, provide accurate absorbed-dose calculations because they function well in inhomogeneous tissues.
Prescription

• The prescription is a description of the volumes of interest, the absorbed dose and/or dose–volume requirements for the PTV, the fractionation scheme, the normal-tissue constraints, and the absorbed-dose distribution(s) planned

• It is recommended here that the same metrics used for reporting be used for prescribing, e.g., to prescribe a given $D_{\text{median}}$ or a given $D_V$
DVH Reporting: Recommendations

- Ensure that TPS have the ability to compute the absorbed dose accurately for small fields, inhomogeneous tissues, and in regions in which there is electronic disequilibrium.

- The absorbed dose that covers a specified fractional volume $V$, $D_v$, should be reported:
  - For example, $D_{95\%}$ is the minimum absorbed dose that covers 95% of the volume of the PTV. The volume, $V$, that $D_v$ is based on should be reported textually or as a subscript value.
  - ($D_{95\%} = 50\text{ Gy}$, $D_{\text{median}} = 55\text{ Gy}$)
DVH Reporting: Prescription
Minimum Absorbed Dose

• $D_{100\%}$ (Minimum Absorbed Dose)
  – NOT RECOMMENDED!

• PTV cannot be determined with sufficient accuracy to warrant constraining the absorbed dose to every voxel on the PTV periphery.
Uncertainty in *Minimum Absorbed Dose*

- Often located in a high-gradient region at the edge of the PTV, making it highly sensitive to the resolution of the calculation and the accuracy of delineating the CTV or PTV.

0.5 L
Spherical Target

1% change in the volume of the PTV, if radius changes by 2mm
Near-minimum Absorbed Dose

- $D_{98\%}$, also designated as $D_{\text{near-min}}$

- Other dose volume values, such as $D_{95\%}$, may also be reported but should not replace the reporting of $D_{98\%}$.

- Do not rely solely on the DVH inspect the slice to make sure that the PTV is being covered.
Maximum Absorbed Dose

• “Maximum absorbed dose” the high absorbed dose in at least a given minimum volume of the tissue (ICRU 50, 1993).

– NOT RECOMMENDED!
Near-maximum Absorbed Dose

- $D_{2\%}$, also designated as $D_{\text{near-max}}$

- However, the radiation oncologist might judge that the “maximum absorbed dose” is clinically relevant, and this value may be reported.

- $D_{2\%}$ is simple to obtain and will add to consistency of reporting.
DVH values for the PTV and CTV

• True CTV DVH: representative if CTV did not change shape, did not move, and the treatment was always perfectly set up.

• PTV DVH: representative if the CTV moved evenly throughout the volume encompassed by the PTV.

• A large separation between the CTV and PTV DVH curves indicates that there is a steep gradient.

• Values of $D_v$ for the CTV should be included in addition to reporting the PTV prescription.
Median Absorbed Dose

- $D_{50\%}$ is likely to be a good measure of a typical absorbed dose in a relatively homogeneously irradiated tumor.

- Computed accurately by many TPS.

- Easy to determine from a cumulative DVH
Mean Absorbed Dose

• Often the median absorbed dose is close to the mean absorbed dose for a target volume.

• When deemed clinically relevant, the mean absorbed dose is recommended for Level 2 reporting.
DVH Reporting: OAR & PRV
Type of Normal Tissue Cell

• *Serial*: can lose their function if a small region of the tissue is damaged. Spinal cord, Optic Structure, Brainstem, Temporal Lobes, Mandible, Esophagus, TM Joint.

• *Parallel*: have sufficient reserve capacity so that a sizeable amount of damage can be tolerated without a complication occurring. Lung, Liver, Parotid, Inner/middle Ear, Tongue, Oral Cavity.

• *Mixed Serial and Parallel*
  kidney
Parallel Like Structure

- More than one dose–volume specification is recommended for reporting:
  - Mean absorbed dose, $D_{\text{mean}}$
  - $V_D$ : absolute value of D and V as a fraction (percent) of the volume of the organ.
    eg: $V_{20\text{ Gy}} = 30\%$.

- Entire organ be contoured so that meaningful values of $D_{\text{mean}}$ and $V_D$ can be determined
Serial Like Structure

- $D_{2\%}$

- Entire organ should be delineated

- High estimate of $D_{2\%}$ will result if only those portions of the organ that receive a high absorbed dose are delineated.
Serial or Parallel Like Structure?

- Most organs are not clearly a serial-like or parallel-like structure.

- At least three dose–volume specifications should be reported:
  - Mean absorbed dose, $D_{\text{mean}}$
  - $D_2\%$
  - $V_D$ : absolute value of D and V as a fraction (percent) of the volume of the organ.
Reporting of Treatment field, TPS version and delivery

• All fields be delivered on all days, but if not possible then the exact nature of the treatment delivery should be clearly reported.

• Make, model, and software version of TPS, optimizer software.

• Details of the treatment-delivery software.
Types Of Evaluation Models

• Physical models

• Biophysical models
Dose Homogeneity

• A perfectly homogeneous dose to the PTV would be characterized by a spike in the differential DVH

• Typically, the differential DVH for a PTV has a near Gaussian shape tightly distributed around the mean absorbed dose.

• $D_{\text{mean}}$ of PTV

• SD of Mean
Homogeneity Index

• Several definitions of a homogeneity index have been proposed:
  • ratio of the maximum absorbed dose to the prescription absorbed dose.
    • indicates only the magnitude of overdosing
    • does not indicate if there is under dosing within the target volume.

• $HI_{95\%/107\%}$ as the fraction of the CTV with an absorbed dose higher than 95 % and lower than 107 % of the ICRU-prescribed absorbed dose.
  • does not indicate the magnitude of under dosage or over dosage

• maximum-minus-minimum absorbed dose normalized to the ICRU prescription absorbed dose
  • minimum, the maximum, and ICRU Reference Point doses is no longer recommended

\[ HI = \frac{D_{2\%} - D_{98\%}}{D_{50\%}} \]

• An HI of zero indicates that the absorbed-dose distribution is almost homogeneous.
Dose Conformity

• Variety of indices have been proposed to characterize the degree of dose conformity of the treated volume (TV) to the PTV using a single parameter.
  
  • conformity index (ICRU),
  • index proposed by Paddick (2000)
  • Dice similarity coefficient (Dice, 1945; Zhang et al. 2007).

• Recommended that $D_{98\%}$ be used for delineating the TV.
• Limited applicability
Treated Volume

• Recommended that $D_{98\%}$ be used for delineating the TV.

• It is important to identify the shape, size, and position of the TV in relation to the PTV for several reasons.

• One reason is to provide information to evaluate causes for local recurrences (inside or outside the TV).
Conformity index (CI)

• Conformity index was developed as an extension of section-by-section dosimetric analysis and DVH.
• Defined as an absolute value resulting from the relationship between tumor volume or a fraction of this volume and the volume delineated by an isodose or a fraction of this volume.
• It can also be defined by the ratio of an isodose with another isodose (prescription isodose, reference isodose, minimum isodose, maximum isodose).
• 1993- proposed by RTOG
  Described in ICRU Report 62
Clinical and Biological Evaluation Metrics

• All biological models have uncertainties in the values of the parameters chosen.

• Use with caution

• Can be explored as evaluation metrics to provide additional quantitative tools.

• Assumptions used in the models, their parameters, and the model itself must be unambiguously specified.
Evaluation Tools

• Isodose Displays

• Dose Statistics
Colour Wash Display

- CT images are displayed on which various dose range regions are superimposed.

- Each dose range is assigned a specific colour. Colour wash dose displays may also be used for comparison of plans.
• Slice by slice dose coverage
Isodose Displays

**Isosurface on 3D Display**

- Can be used to assess target coverage, they do not convey a sense of distance between the isosurface and the anatomical volumes
Isodose Curves

**Disadvantages:**

- Ideal if number of CT slices are small
- Can not determine the volume of HotSpot/ Coldspot

**Advantages:**

- Location of HotSpot/ Coldspot
Dose Statistics

• Provide quantitative information on the volume of the target or critical structure, and on the dose received by that volume.

  • Minimum dose to the volume
  • Maximum dose to the volume
  • Mean dose to the volume
  • Dose received by at least 95% of the volume
  • Volume irradiated to at least 95% of the prescribed dose.
Types of DVH

- Differential (or Direct) DVH
- Cumulative (or Integral) DVH
Dose Statistics

Graphically summarizes 3D Dose distribution data in a single curve for each structure.

Competing plans can be plotted on the same graph for comparison.
Differential DVH

- The ideal DVH for a target volume would be a single column indicating that 100% of the volume receives the prescribed dose.

- For a critical structure, the DVH may contain several peaks indicating that different parts of the organ receive different doses.
Cumulative DVH

- Plot of entire volume of anatomical structure specified dose or higher dose.
- The computer calculates the volume of the target (or critical structure) that receives at least the given dose and plots this volume (or percentage volume) versus dose.
- All cumulative DVH plots start at 100% of the volume for 0 Gy, since all of the volume receives at least no dose.
Maximum dose (Dmax):

• Maximum dose to the PTV and to the tissues outside the PTV and to OAR should be identified.
• A volume is considered significant only if its minimum diameter exceeds 15mm.
• For smaller organs like eye, optic nerve and larynx smaller diameter should be considered.

Minimum dose (Dmin)

• It is the smallest dose in the defined clinical volume. There is no recommendation for volume limit for reporting minimum dose.
Drawbacks of DVH

- Loss of positional information in the volume(s) under consideration
- **DVH does not** replace isodose distribution
Disadvantages

- Exact location of dose in-homogeneity not displayed.

- Dose is only a surrogate of biological consequences.

Conclusion: Plan evaluation requires not only DVH analysis but it also include dose distribution analysis.
Avoid hot spots over critical structures to circumvent debilitating late toxicity.
Ensure target volume coverage and absence of hot spots in all 3 planes: Axial, Sagittal, and Coronal.
Average dose ($D_{\text{average}}$):
• It is the average of doses at lattice points distributed uniformly in the volume.

Median dose ($D_{\text{median}}$):
• Central value of doses at all lattice points, when arranged according to their magnitude

Modal dose ($D_{\text{modal}}$):
• Dose that occurs most frequently at the lattice points.
Hot spots:

• Volume outside the PTV receiving dose higher than 100% of the specified PTV dose.

• A volume is considered significant only if its minimum diameter exceeds 15mm.

• For smaller organs like eye, optic nerve and larynx smaller diameter should be considered.
Evaluation Tools: Summary

• Qualitative methods
  *Isodose Curves*

• Quantitative methods
  *Dose Statistics*
# OAR

## IMRT

<table>
<thead>
<tr>
<th>Site</th>
<th>Dose</th>
<th>OAR</th>
<th>Mean</th>
<th>Max</th>
<th>Median</th>
<th>Dose Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Head and Neck</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Fornix</td>
<td>26 Gy</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>50% Vol &lt; 20 Gy for 25% of combined vol of both fornix</td>
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<tr>
<td>Eyelid Retina</td>
<td>NA</td>
<td>50 Gy</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Optic nerves</td>
<td>NA</td>
<td>54 Gy</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Optic Chiasm</td>
<td>NA</td>
<td>54 Gy</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
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<tr>
<td>Mandible</td>
<td>NA</td>
<td>70 Gy</td>
<td>NA</td>
<td>&lt;1% vol &gt; 70 Gy</td>
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<tr>
<td>Brainstem</td>
<td>NA</td>
<td>54 Gy</td>
<td>NA</td>
<td>&lt;1% vol &gt; 54 Gy</td>
<td></td>
<td></td>
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<tr>
<td>PTV Brainstem</td>
<td>NA</td>
<td>50 Gy</td>
<td>NA</td>
<td>&lt;1% vol &gt; 50 Gy</td>
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<td></td>
</tr>
<tr>
<td>Spinal Cord</td>
<td>NA</td>
<td>45 Gy</td>
<td>NA</td>
<td>&lt;1% vol &gt; 45 Gy</td>
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<tr>
<td>PTV Spinal Cord</td>
<td>NA</td>
<td>30 Gy</td>
<td>NA</td>
<td>&lt;1% vol &gt; 30 Gy</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Brain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eyelid Retina</td>
<td>NA</td>
<td>45 Gy</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Lens</td>
<td>NA</td>
<td>510 Gy</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Optic nerves</td>
<td>NA</td>
<td>54 Gy</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<td>NA</td>
<td>54 Gy</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>L1 Temporal Lobe</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>&lt;15% volume &lt; 440 Gy, 20% volume &lt; 270 Gy</td>
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</tr>
</tbody>
</table>

## 3D-CRT

<table>
<thead>
<tr>
<th>Site</th>
<th>Dose</th>
<th>OAR</th>
<th>Mean</th>
<th>Max</th>
<th>Median</th>
<th>Dose Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pituitary</strong></td>
<td>450 Gy</td>
<td>NA</td>
<td>45 Gy</td>
<td>NA</td>
<td>NA</td>
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<td>Eyelid Retina</td>
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<tr>
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<td>NA</td>
<td>54 Gy</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>

<p>| <strong>Lung</strong>              | 660 Gy | NA   | 46 Gy| NA   | NA     |                                                        |
| Spinal Cord           | 66 Gy  | NA   | 66 Gy| NA   | NA     |                                                        |
| Total PTV             | NA     | NA   | NA   | V20 &lt; 35% (Index 30%)                             |
| Heart                 | NA     | NA   | NA   | &lt;33.3% of 60 Gy, 66.7% of 45 Gy, 100% of 40 Gy    |
| Spleen                | NA     | NA   | NA   | NA     | NA     |                                                        |
| Stomach               | 34 Gy  | NA   | 34 Gy| NA   | NA     |                                                        |</p>
<table>
<thead>
<tr>
<th>Target volume (OAR/PRV)</th>
<th>$D_{95}%$</th>
<th>$D_{\text{near-min}}\text{ or } D_{98}%$</th>
<th>$D_{\text{near-max}}\text{ or } D_{2}%$</th>
<th>Median absorbed dose or $D_{50}%$</th>
<th>Mean absorbed dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV-N and PTV-T1</td>
<td>≥95 % of planned absorbed dose</td>
<td>≥90 % of planned absorbed dose</td>
<td>≤107 % of planned absorbed dose</td>
<td>55.5 Gy</td>
<td>—</td>
</tr>
<tr>
<td>PTV-T2</td>
<td>≥95 % of planned absorbed dose</td>
<td>≥90 % of planned absorbed dose</td>
<td>≤107 % of planned absorbed dose</td>
<td>69 Gy</td>
<td>—</td>
</tr>
<tr>
<td>PRV spinal cord</td>
<td>—</td>
<td>—</td>
<td>≤50 Gy</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Spinal cord</td>
<td>—</td>
<td>—</td>
<td>≤48 Gy</td>
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<td>—</td>
</tr>
<tr>
<td>PRV contralateral parotid&lt;sup&gt;b&lt;/sup&gt;</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>≤26 Gy</td>
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<tr>
<td>PRV ipsilateral parotid&lt;sup&gt;b&lt;/sup&gt;</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>≤40 Gy</td>
</tr>
</tbody>
</table>
Plan Evaluation: Example

Plan1

Plan2
Plan Evaluation: Example
Plan Evaluation: Example
Plan Evaluation: Example

Eye Rt
Plan Evaluation: Example

Plan 1 vs Plan 2

Spinal Cord

Graph showing dose distribution with different plans.
Case scenario-1 (T1N0M0 Early NPC)

- 65yr/male, presented with one episode of epistaxis and right sided hearing loss.

- DNE- sub mucosal bulge in right lateral wall of nasopharynx.

- MRI showed:
  - Disease in the right lateral nasopharyngeal walls with bilateral Level IB nodes.

- PET/CT (outside):
  - Hyper metabolic disease confined to right lateral wall of NPX
  - No FDG avid neck nodes.
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![Diagram showing GTV, CTV, and PTV volumes with different dose levels]
# Planning Objectives

<table>
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<tr>
<th>Site</th>
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<th>Dose Constraints</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>Max (0.03cc)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Brainstem</td>
<td>NA</td>
<td>54 Gy</td>
</tr>
<tr>
<td></td>
<td>PRV Brainstem (Brainstem + 0.5cm)</td>
<td>NA</td>
<td>60 Gy</td>
</tr>
<tr>
<td></td>
<td>Spinal Cord</td>
<td>NA</td>
<td>45 Gy</td>
</tr>
<tr>
<td></td>
<td>PRV Spinal Cord (Cord + 0.5cm)</td>
<td>NA</td>
<td>50 Gy</td>
</tr>
<tr>
<td>Nasopharynx</td>
<td>Optic nerves L/R</td>
<td>NA</td>
<td>54 Gy</td>
</tr>
<tr>
<td></td>
<td>Optic Chiasm</td>
<td>NA</td>
<td>54 Gy</td>
</tr>
<tr>
<td></td>
<td>Parotid L/R</td>
<td>26 Gy</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Parotid L + R</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Mandible</td>
<td>NA</td>
<td>70 Gy</td>
</tr>
<tr>
<td></td>
<td>Temporal Lobe L/R</td>
<td>NA</td>
<td>70 Gy</td>
</tr>
<tr>
<td></td>
<td>Eye L/R</td>
<td>NA</td>
<td>35 Gy</td>
</tr>
<tr>
<td></td>
<td>Lens</td>
<td>NA</td>
<td>10 Gy</td>
</tr>
<tr>
<td></td>
<td>Oral Cavity - PTV</td>
<td>NA</td>
<td>40 Gy</td>
</tr>
<tr>
<td></td>
<td>Tongue</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Glottis</td>
<td>45 Gy</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Inner Ear</td>
<td>50 Gy</td>
<td>NA</td>
</tr>
</tbody>
</table>
## Evaluation Tools

| PTV | 1. $D_{98\%}$ (minimum dose)  
2. $D_{2\%}$ (maximum dose)  
3. $V_{95\%}$ (volume receiving at least 95% dose)  
4. $V_{107\%}$ (volume receiving at most 107%)  
5. HI: $D_{2\%}$-$D_{98\%}$ (difference between dose covering 5% & 95% PTV)  
6. CI: volume receiving at least 95% dose/volume of PTV |
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Spinal cord</td>
<td>Dmax ($\leq$45Gy)</td>
</tr>
<tr>
<td>Brainstem</td>
<td>Dmax ($\leq$54Gy)</td>
</tr>
<tr>
<td>Parotid</td>
<td>Dmean ($&lt;26$Gy for each gland)</td>
</tr>
</tbody>
</table>
| Healthy tissue | $V_{5Gy}$ (volume receiving 5Gy)  
$V_{10Gy}$ (volume receiving 5Gy) |

HI- Homogeneity Index; CI- Conformity Index
THANK YOU