AAPM Taskgroup-263

Standardizing Nomenclatures in Radiation Oncology

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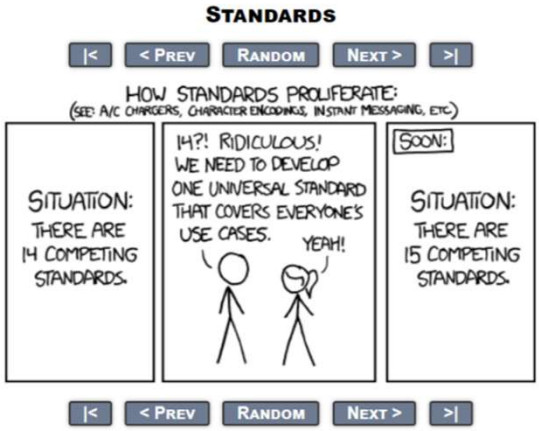
How do we not become this cartoon?



Disclosures

- Financially: None
- Emotionally: I'm an automation script-loving glass half full optimistic physicist.
- Professionally: I'm software ambivalent.
  - I'll reference radiation oncology software based only on my experiences
    - No endorsements
    - Similar features available in all software that I mention

Presentation Objectives and Goals

- Convince you that we have a problem
- Benefits of TG-263 adoption
  - Short term and long term
- Learn the history and how it confines our nomenclature
- Feel confident in knowing how to properly name:
  - Non-target structures
  - Target/PTV structures
  - Dose and DVH Metrics
- Game plan for how to implement in your clinic

What is TG-263?

- Task group
  - Largest ever author list for a Taskgroup/Published in the Red Journal

- Task group
  - Largest ever aut ed Journal

Standardizing Nomenclatures in Radiation Oncology

The Report of AAPM Task Group 263

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What is TG-263?

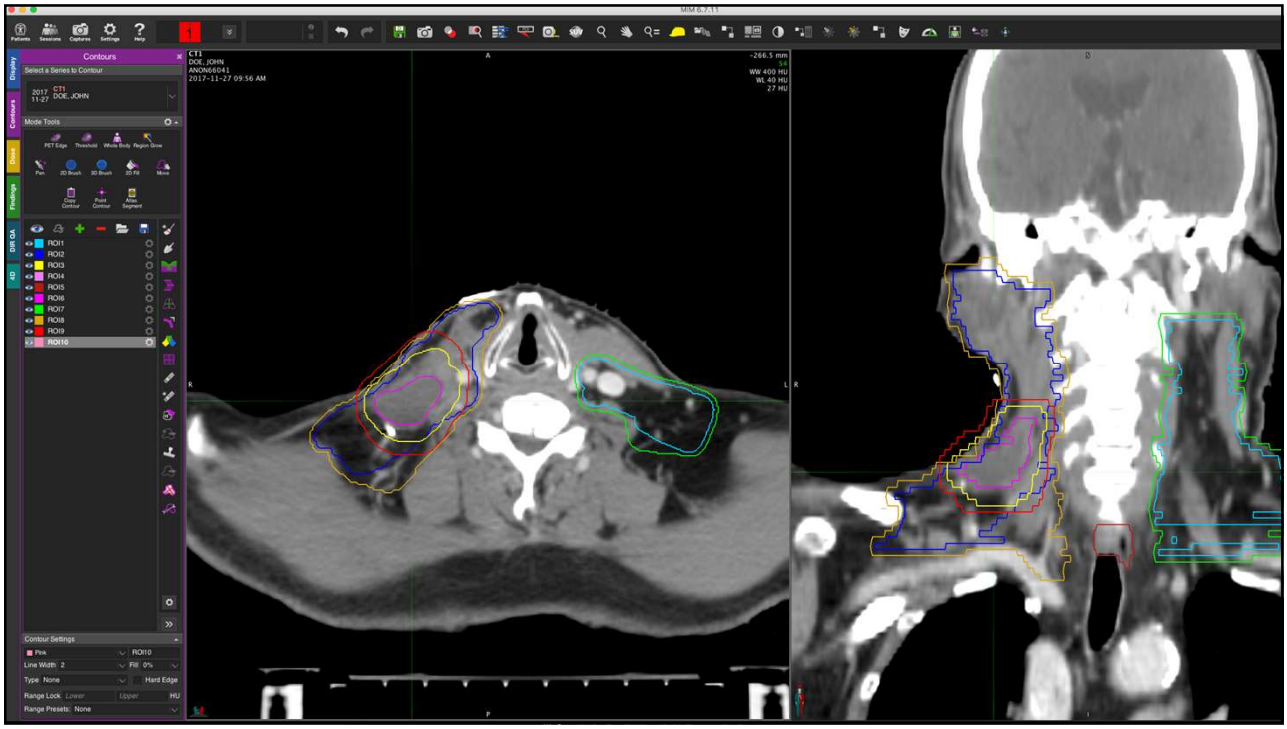
- Task group
  - Largest ever author list for a Taskgroup/Published in the Red Journal
  - Charges of TG-263
    - Provide nomenclature guidelines in radiation oncology for use in clinical trials, data-pooling initiatives, population-based studies, and routine clinical care by standardizing:
      - structure names across image processing and treatment planning system platforms;
      - nomenclature for dosimetric data (e.g., dose/volume histogram [DVH]-based metrics)
      - templates for clinical trial groups and users of an initial subset of software platforms to facilitate adoption of the standards;
      - formalism for nomenclature schema which can accommodate the addition of other structures defined in the future.

Outline

- Introduction
  - Do we have a problem?
  - Goals
  - History and challenges
- Rules and guiding structures
  - Non-Target Structure Nomenclature
  - Target Structure Nomenclature
  - Dose Volume Histogram Metrics
- Recommendations to Vendors
  - Wish list
  - Forward thinking
- Recommendations for Implementation
  - Change is hard
  - Clinical rollout
- Summary

Do we have problem?

- Clinical ambiguity
  - Targets/Structures



Do we have problem?

- Clinical ambiguity
  - Targets/Structures confusion
    - Communication of Intent
      - ROILS
        - https://www.astro.org/RO-ILS-Education.aspx
    - Imaging advances
    - Dose summations
    - Plans from other clinics
- Reporting ambiguity
  - RadOnc has great databases but poor sorting
  - Historical comparison
    - Ask yourself a question about your own data

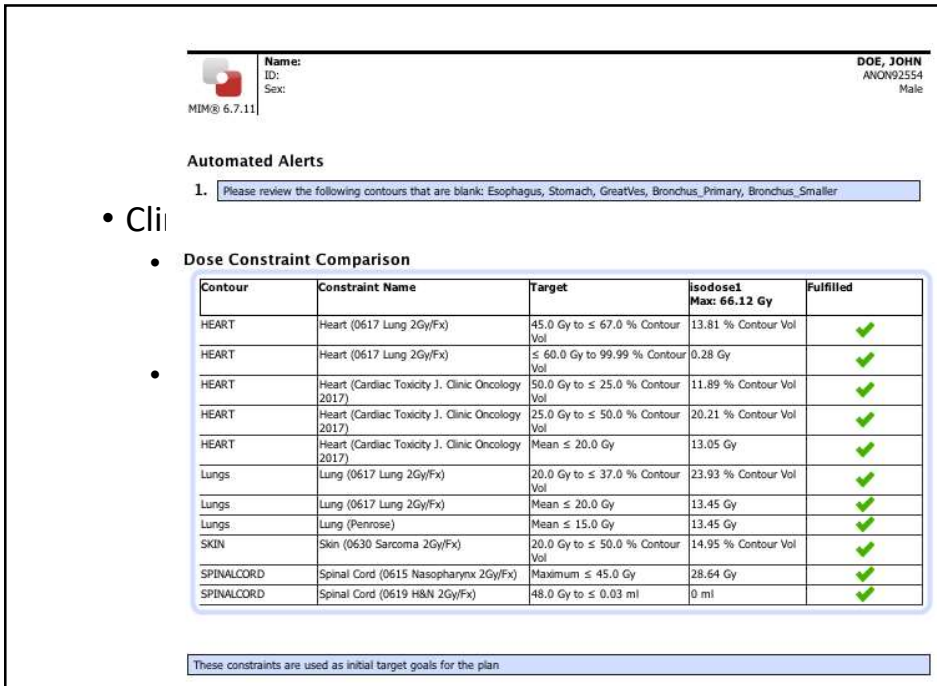
Variations in current standardization Naming

Table 1. Variations in standardized nomenclatures reported for non-target structures by 16 institutions. The number in () indicates the number of respondents using the same value if > 1.

Structure	Number of Institutions	Examples
Left Optic Nerve	12	Lt Optic Nerve, OPTICN_L, OPTNRV_L, optic_nrv_l, L_optic_nerve, OPTIC_NRV_L, OpticNerve_L, LOPTIC, OpticNerve_L (3), Lef Optic Nerve, ON_L
Left Lung	12	Lt Lung, Lung_L(4), LUNG_L(3), lung_l, L_lung, LLUNG, L Lung
Both Lungs	12	Lungs(2), LUNGs, LUNG_TOTAL, lung_total, combined_lung, LUNG, LUNGS(2), Lung,BilatLung, Lung_Both
8th Cranial Nerve	7	CN_VIII(5), cn_viii(2), CN8, CN_8
Right External Iliac Artery	2	A_ILIAC_E_R, a_iliac_e_r

Short-term Goals

- Clinical speed and consistency
  - Plan review
    - Faster
    - More systematic/historical comparisons
  - Scripting becomes easier
    - Automation
    - Missing organs check example
    - Protocols
    - Clinical improvement projects



Name:
ID:
Sex:

DOE, JOHN
ANON92554
Male

MIM® 6.7.11

Automated Alerts

1. Please review the following contours that are blank: Esophagus, Stomach, GreatVes, Bronchus_Primary, Bronchus_Smaller

- Cli
  - **Dose Constraint Comparison**

Contour	Constraint Name	Target	isodose1 Max: 66.12 Gy	Fulfilled
HEART	Heart (0617 Lung 2Gy/Fx)	45.0 Gy to ≤ 67.0 % Contour Vol	13.81 % Contour Vol	✔
HEART	Heart (0617 Lung 2Gy/Fx)	≤ 60.0 Gy to 99.99 % Contour Vol	0.28 Gy	✔
HEART	Heart (Cardiac Toxicity J. Clinic Oncology 2017)	50.0 Gy to ≤ 25.0 % Contour Vol	11.89 % Contour Vol	✔
HEART	Heart (Cardiac Toxicity J. Clinic Oncology 2017)	25.0 Gy to ≤ 50.0 % Contour Vol	20.21 % Contour Vol	✔
HEART	Heart (Cardiac Toxicity J. Clinic Oncology 2017)	Mean ≤ 20.0 Gy	13.05 Gy	✔
Lungs	Lung (0617 Lung 2Gy/Fx)	20.0 Gy to ≤ 37.0 % Contour Vol	23.93 % Contour Vol	✔
Lungs	Lung (0617 Lung 2Gy/Fx)	Mean ≤ 20.0 Gy	13.45 Gy	✔
Lungs	Lung (Penrose)	Mean ≤ 15.0 Gy	13.45 Gy	✔
SKIN	Skin (0630 Sarcoma 2Gy/Fx)	20.0 Gy to ≤ 50.0 % Contour Vol	14.95 % Contour Vol	✔
SPINALCORD	Spinal Cord (0615 Nasopharynx 2Gy/Fx)	Maximum ≤ 45.0 Gy	28.64 Gy	✔
SPINALCORD	Spinal Cord (0619 H&N 2Gy/Fx)	48.0 Gy to ≤ 0.03 ml	0 ml	✔

These constraints are used as initial target goals for the plan

Long-term Goals

ELSEVIER
doi:10.1016/j.ijrobp.2009.06.094

QUANTEC: VISION PAPER

IMPROVING NORMAL TISSUE COMPLICATION PROBABILITY MODELS: THE NEED TO ADOPT A "DATA-POOLING" CULTURE

- Big Data and Machine Learning
  - Quantec/Data sharing programs
    - Standard nomenclature is an essential enabling step for construction and use of tools to automatically extract pertinent data from medical records for data pooling initiatives and clinical practice improvements
    - Statistical power issues, as well as correct risk-factor identification issues, could potentially be reduced if we could pool data from much larger populations of patients
    - Biomarker
    - Machine learning target and contours works well on large databases
- But I'm not good at datamining/scripting/programming
  - Pooled data collection
  - Help large scale efforts by forming the foundations

History and Challenges

- Vendor challenges
  - Variations by the vendors in allowed naming
    - Length of names, capitalization, special characters, preset names in their modules
- Lack of Direction
  - No clear multi-institution oversight group
    - Variation even in naming between RTOG protocols
  - Variations in laterality, derived and planning structures
  - How to incorporate new elements

History and Challenges

- Standard
  - DICOM
  - Targets
    - ICRU-defined targets (GTV, CTV, PTV, ITV, etc)
  - Structures
    - Previous publications, NRG naming used as part of TRIAD system
      - FMA-open source ontology with numeric coding schema
        - http://bioportal.bioontology.org/ontologies/FMA
        - http://xiphoid.biostr.washington.edu/fma/index.html
        - Great but has some issues with radiation oncology specifics

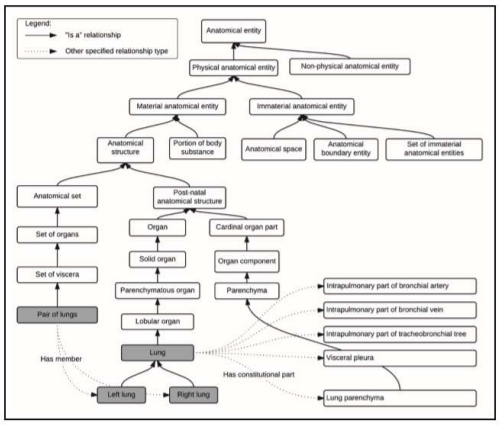
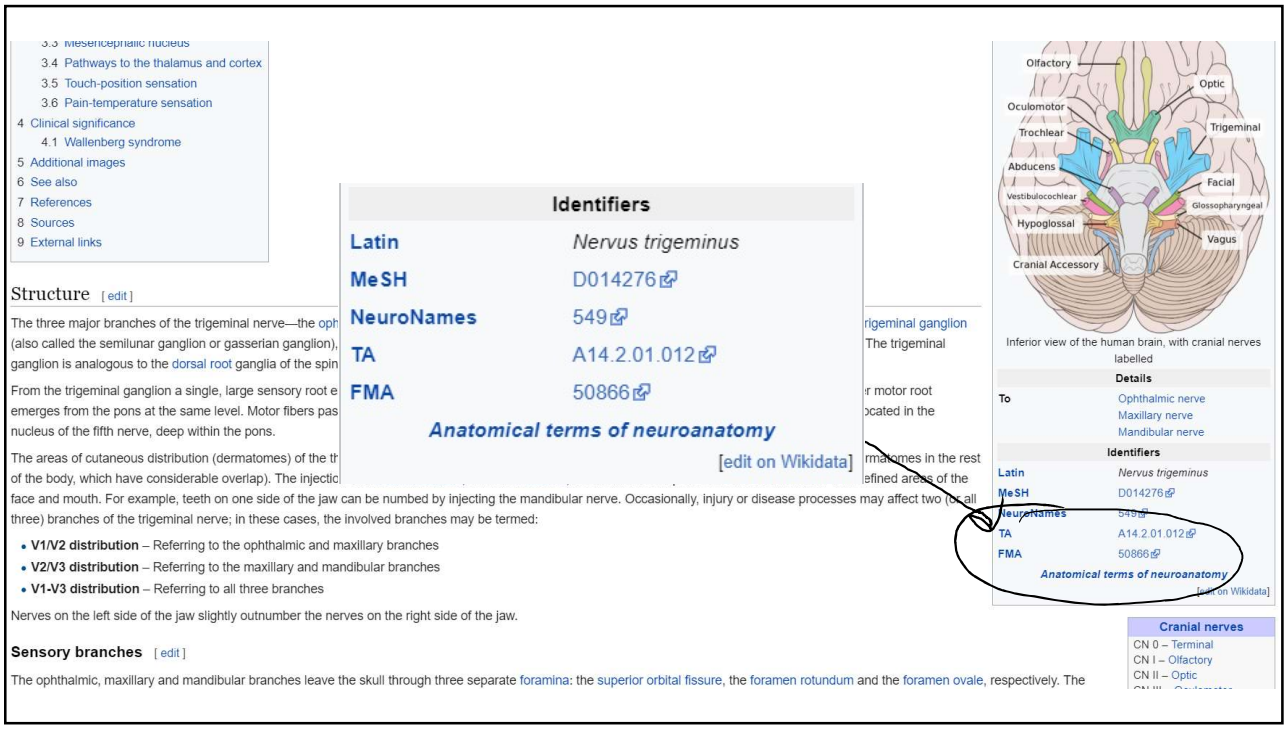


Figure 1. Illustration of the Foundational Model of Anatomy Ontology applied to lung volumes. The focus of the ontology is defining concepts and relationships in a format consumable by programs used in machine learning. The ontology is widely used in informatics but omits some concepts used in routine clinical care and does not address practical clinical issues for target and non-target structures that are addressed by the task group recommendations. Where there are common structures, the task group nomenclature identifies the ID of the corresponding FMA structure.



SNOMED

- Systematized Nomenclature of Medicine-Clinical Terms
  - From the UK
  - Framework for defining health care concepts and interrelationships
  - Linkages can very complicated and go well beyond physical anatomy
  - Each concept is associated with unique numerical code
- Useful for linking to EMR going forward
- Equivalent SNOMED CT codes may be derived from thesauri that maintain mappings between terminologies

SNOMED

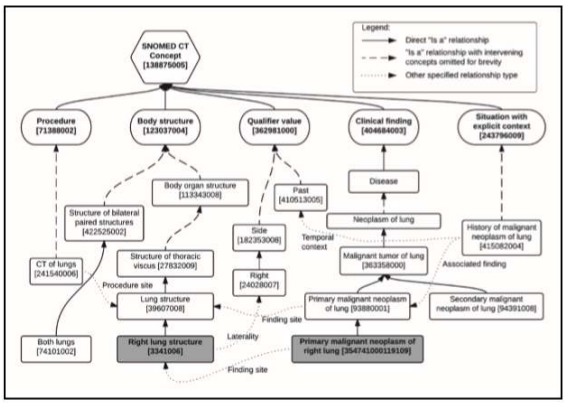


Figure 2. Illustration of a SNOMED CT concepts applied to lung cancer. SNOMED CT encompasses health care concepts beyond the purely anatomic goals of FMA. SNOMED CT is widely referenced in healthcare informatics. It has similar limitations as FMA for direct use as a nomenclature.

DICOM

- Key technology standard in Radiation Oncology
  - DICOM RT structure set
    - ROI name (3006,0026) object with 64 character
    - ROI Interpreter (3006,00A6) Name of person performing the interpretation
    - ROI Interpreted Type (3006,00A4) What type of contour is it?
    - ROI Observation Label (3006,0085) Record ref images, etc
  - Not an ontology unlike FMA and SNOMED
    - Mostly syntactic standard to transfer and store information

ftp://medical.nema.org/medical/dicom/final/sup11_ft.pdf

DICOM

Table 4. Defined terms for interpreted types from DICOM.

Interpreted Type	Term	Definition
Regions of Interest (ROI)	AVOIDANCE	Region in which dose is minimized
	BOLUS	Material layered onto the patient to increase high dose provided by external beam therapy to the patient's skin surface
	CAVITY	Patient anatomical cavity
	CONTRAST_AGENT	Volume into which a contrast agent has been injected
	CTV	Clinical Target Volume (as defined in ICRU 50/62)
	EXTERNAL	External patient contour
	GTV	Gross Tumor Volume (as defined in ICRU 50/62)
	IRRAD_VOLUME	Irradiated Volume (as defined in ICRU 50/62)
	ORGAN	Patient organ
	PTV	Planning Target Volume (as defined in ICRU 50/62)
	REGISTRATION	Registration ROI
	TREATED_VOLUME	Treated volume (as defined in ICRU 50/62)
Point of Interest (POI)	MARKER	Patient marker
	ISOCENTER	Treatment isocenter to be used for external beam therapy
Brachytherapy	BRACH_CHANNEL	Brachytherapy channel
	BRACHY_ACCESSORY	Brachytherapy accessory device
	BRACHY_SRC_APP	Brachytherapy source applicator
	BRACHY_CHNL_SHLD	Brachytherapy channel shield
Other Type	SUPPORT	External patient support device
	FIXATION	External patient fixation or immobilization device
	DOSE_REGION	ROI to be used as a dose reference
	CONTROL	ROI to be used in control of dose optimization

Keeping the Character Choices Simple

Table 3: Examples of compatible and incompatible special characters. Unicode values corresponding to the Universal Coded Character Set Standard UTF-8 hexadecimal values are listed.

Compatible Characters			Incompatible Characters		
Character		Unicode	Character		Unicode
_	underscore	U-005F	<	less than	U+003C
-	dash - minus	U-002D	>	greater than	U+003E
^	caret	U-005E	:	colon	U+003A
+	plus sign	U-002B	"	double quote	U+0022
=	equals sign	U-003D	'	single quote	U+0027
!	exclamation point	U+0021	/	forward slash	U+002F
~	tilde	U-0073	\	backward slash	U+005C
			|	pipe	U+007C
			?	question mark	U+003F
			*	asterisk	U+002A
			.	period	U+002E
			(	left parenthesis	U+0028
			)	right parenthesis	U+0029
			&	ampersand	U+0026
			#	octothorpe	U+0023
			$	dollar sign	U+0024

Recommendations for Non-Target Structures

- Guiding principles
  - 16 Characters or fewer
    - Compatibility with nearly all systems
  - Unique names independent of capitalization
  - Plurality of compound structures given with an ‘s’ or ‘i’
    - E.g., Lungs, Hippocampi
  - First letter of each structure category is capitalized
    - E.g., Femur_Head
  - No spaces

Recommendations for Non-Target Structures

- Guiding principles
  - Underscore to separate categorization
    - E.g., Bowel_Bag
  - PRV (planning organ at risk) following main structure
    - E.g, Brainstem_PRV03
    - Uniform expansion given in 2 digits in mm
  - Partial structures are designated by ~ after the root (e.g., Brain~)
    - Useful for parallel structures
  - Custom qualifier string at the end ‘^’
    - Catch-all for anything abnormal

Recommendations for Non-Target Structures

- Guiding principles
  - Standard category roots are used for structures distributed throughout the body
    - A for artery (e.g., A_Aorta, A_Carotid)
    - V for vein (e.g., V_Portal, V_Pulmonary)
    - LN for lymph node (e.g., LN_Ax_L1, LN_IMN)
    - CN for cranial nerve (e.g., CN_IX_L, CN_XII_R)
    - Glnd for glandular structure (e.g., Glnd_Submand)
    - Bone (e.g., Bone_Hyoid, Bone_Pelvic)
    - Musc for muscle (e.g., Musc_Masseter, Musc_Sclmast_L)
    - Spc for Space (e.g., Spc_Bowel, Spc_Retrophar_L)
    - VB for vertebral body
    - Sinus for sinus (e.g., Sinus_Frontal, Sinus_Maxillary)

Recommendations for Non-Target Structures

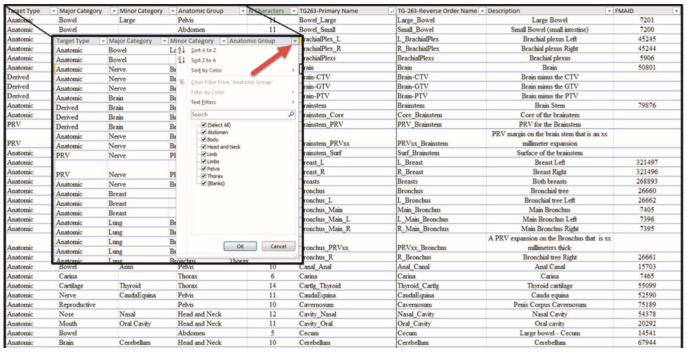
- Guiding principles
  - Spatial categorization located at the end of the string with an underscore
    - L for left
    - R for Right
    - A for Anterior
    - P for Posterior
    - I for Inferior
    - S for Superior
    - RUL, RLL, RML for right upper, lower and middle lobe
    - LUL, LLL for left upper and lower lobe
    - NAdj for non-adjacent
    - Dist for distal
    - Prox for proximal

Recommendations for Non-Target Structures

- Guiding principles
  - Consistent root structure is used for all substructures
    - SeminalVes and SeminalVes_Dist vs SeminalVesicle and SemVes_Dist
  - Camel case
    - A compound word where each word starts with a capital letter and there is no space between words such as CamelCase)
    - only used when a structure name implies two concepts, but the concepts do not appear as distinct categories in common usage (e.g., CaudaEquina instead of Cauda_Equina)
  - Structures that are not used for dose evaluation use 'z' at the prefix.
    - e.g., optimization structures, high/low dose regions
    - zPTVopt
    - No recommendations but be consistent!
    - Rings: zDistanceRingThickness (e.g., zRing05, z10Ring03)

Recommendations for Non-Target Structures

- The TG-263 spreadsheet
  - http://www.aapm.org/pubs/reports/RPT_263_Supplemental/
  - Living document
    - Currently 717 structures



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- Medical Physics Practice Guidelines
- ACR-AAPM Practice Parameters and Technical Standards
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- Online NCRP

PUBLICATIONS

Radiation Oncology Nomenclature Resource Page

American Association of Physicists in Medicine (AAPM) formed a task group (TG-263) to develop a consensus position on nomenclature for use in clinical trials, data-pooling initiatives, population-based studies, and routine clinical care. The task group was composed of a diverse international group of stake holders: hospital-based physicists and physicians, vendor representatives and dosimetrists. The task group included AAPM, American Society for Radiation Oncology (ASTRO) , European Society for Therapeutic Radiation Oncology (ESTRO) members, large academic centers, community clinics, vendors, and leaders from NRG, IHE-RO and the DICOM Working Group - 7. Many TG members were also members of clinical trial groups including NRG, Radiation Therapy Oncology Group (RTOG), Children's Oncology Group (COG), and IROC and had been involved in creating standardization templates within those groups.

The report is complete, this page provides links to documents and resources to assist end users in application and implementation of the nomenclature.

The work of the group will continue addressing a wider range elements and incorporating new and evolving needs from clinical, research and trails efforts. As needs and solutions for the nomenclature evolve, the resources on this page will be updated.

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Documents:

- Final Report
- Executive Summary
- Structure Spreadsheet

Templates:

-

Recommendations for Target Structures

- Combination of idea
- Could not come to consensus to define a single standard for all use cases and clinics
  - Numerous concepts for a target name
  - Character string constraints.
  - Guiding principles to specify where and how a concept should appear if it is represented in the target name.
  - Designed to be used in order of importance
- Not all ideas need to be used!

TARGET

1.) Needed, targets:

GTV, CTV ,PTV, ITV

GTV-gross disease with margin for motion

CTV-clinical disease with margin for motion

PTV!- for low dose PTV volumes that exclude overlapping high dose volumes

TARGET

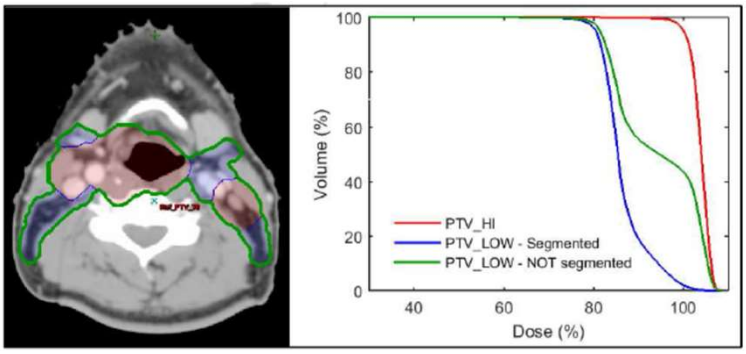
1.) Needed, targets:

GTV, CTV ,PTV, ITV

GTV-gross disease with margin for motion

CTV-clinical disease with margin for motion

PTV!- for low dose PTV volumes that exclude overlapping high dose volumes



TARGETclassifier

1.) Needed, targets:

- **GTV, CTV ,PTV, ITV**
- **GTV**-gross disease with margin for motion
- **CTV**-clinical disease with margin for motion
- **PTV**!- for low dose PTV volumes that exclude overlapping high dose volumes

2.) If needed, classifiers:

- **n**: nodal (e.g. PTVn)
- **p**: primary (e.g. GTVp)
- **sb**: surgical bed (e.g. CTVsb)
- **par**: parenchyma (e.g. GTVpar)
- **v**: venous thrombosis (e.g. CTVv)
- **vas**: vascular (e.g. CTVvas)

TARGETclassifier#

1.) Needed, targets:

- **GTV, CTV ,PTV, ITV**
- **GTV**-gross disease with margin for motion
- **CTV**-clinical disease with margin for motion
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- **par**: parenchyma (e.g. GTVpar)
- **v**: venous thrombosis (e.g. CTVv)
- **vas**: vascular (e.g. CTVvas)

3.) If needed, multiple spatially distinct targets:

- **#**: enumerated targets (e.g. PTV2, GTVp1, GTVp2)

TARGETclassifier#_imaging#

1.) Needed, targets:

- **GTV, CTV ,PTV, ITV**
- **GTV**-gross disease with margin for motion
- **CTV**-clinical disease with margin for motion
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- **n**: nodal (e.g. PTVn)
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- **par**: parenchyma (e.g. GTVpar)
- **v**: venous thrombosis (e.g. CTVv)
- **vas**: vascular (e.g. CTVvas)

3.) If needed, multiple spatially distinct targets:

- **#**: enumerated targets (e.g. PTV2, GTVp1, GTVp2)

4.) If needed, imaging and sequential order:

- **_imaging sequence: (**e.g. GTVsb_MR2, PTVp2_CT1PT1)

TARGETclassifier#_imaging#_structure

1.) Needed, targets:

- **GTV, CTV ,PTV, ITV**
- **GTV**-gross disease with margin for motion
- **CTV**-clinical disease with margin for motion
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2.) If needed, classifiers:

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- **sb**: surgical bed (e.g. CTVsb)
- **par**: parenchyma (e.g. GTVpar)
- **v**: venous thrombosis (e.g. CTVv)
- **vas**: vascular (e.g. CTVvas)

3.) If needed, multiple spatially distinct targets:

- **#**: enumerated targets (e.g. PTV2, GTVp1, GTVp2)

4.) If needed, imaging and sequential order:

- **_imaging sequence: (**e.g. GTVsb_MR2, PTVp2_CT1PT1)

5.) If needed, structure indicators:

- **_structure:** (e.g. GTV_MR1_CN_V_L, GTV_MR2_Preop, PTVn2_CT1PT1_Postop, PTV_LN_Pelvic_L)

TARGETclassifier#_imaging#_structure_DOSE

1.) Needed, targets:

- **GTV, CTV ,PTV, ITV**
- **GTV**-gross disease with margin for motion
- **CTV**-clinical disease with margin for motion
- **PTV!**- for low dose PTV volumes that exclude overlapping high dose volumes

2.) If needed, classifiers:

- **n**: nodal (e.g. PTVn)
- **p**: primary (e.g. GTVp)
- **sb**: surgical bed (e.g. CTVsb)
- **par**: parenchyma (e.g. GTVpar)
- **v**: venous thrombosis (e.g. CTVv)
- **vas**: vascular (e.g. CTVvas)

3.) If needed, multiple spatially distinct targets:

- **#**: enumerated targets (e.g. PTV2, GTVp1, GTVp2)

4.) If needed, imaging and sequential order:

- **_imaging sequence: (**e.g. GTVsb_MR2, PTVp2_CT1PT1)

5.) If needed, structure indicators:

- **_structure:** (e.g. GTV_MR1_CN_V_L, GTV_MR2_Preop, PTVn2_CT1PT1_Postop, PTV_LN_Pelvic_L)

6.) if needed, dose:

- **_dose level**: High, Mid, Low (e.g. PTV_High, CTV_Mid)
  if physical dose is needed use cGy (PTV_5040)

TARGETclassifier#_imaging#_structure_DOSEfx

1.) Needed, targets:

- **GTV, CTV ,PTV, ITV**
- **GTV**-gross disease with margin for motion
- **CTV**-clinical disease with margin for motion
- **PTV!**- for low dose PTV volumes that exclude overlapping high dose volumes

2.) If needed, classifiers:

- **n**: nodal (e.g. PTVn)
- **p**: primary (e.g. GTVp)
- **sb**: surgical bed (e.g. CTVsb)
- **par**: parenchyma (e.g. GTVpar)
- **v**: venous thrombosis (e.g. CTVv)
- **vas**: vascular (e.g. CTVvas)

3.) If needed, multiple spatially distinct targets:

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4.) If needed, imaging and sequential order:

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5.) If needed, structure indicators:

- **_structure:** (e.g. GTV_MR1_CN_V_L, GTV_MR2_Preop, PTVn2_CT1PT1_Postop, PTV_LN_Pelvic_L)

6.) if needed, dose:

- **_dose level**: High, Mid, Low (e.g. PTV_High, CTV_Mid)
  if physical dose is needed use cGy (PTV_5040)

7.) If needed, number of fractions:

- **Dose per fraction "x" fractions:** (e.g. PTV_Liver_2000x3)

TARGETclassifier#_imaging#_structure_DOSEfx-cropping

1.) Needed, targets:

- **GTV, CTV ,PTV, ITV**
- **GTV**-gross disease with margin for motion
- **CTV**-clinical disease with margin for motion
- **PTV!**- for low dose PTV volumes that exclude overlapping high dose volumes

2.) If needed, classifiers:

- **n**: nodal (e.g. PTVn)
- **p**: primary (e.g. GTVp)
- **sb**: surgical bed (e.g. CTVsb)
- **par**: parenchyma (e.g. GTVpar)
- **v**: venous thrombosis (e.g. CTVv)
- **vas**: vascular (e.g. CTVvas)

3.) If needed, multiple spatially distinct targets:

- **#**: enumerated targets (e.g. PTV2, GTVp1, GTVp2)

4.) If needed, imaging and sequential order:

- **_imaging sequence: (**e.g. GTVsb_MR2, PTVp2_CT1PT1)

5.) If needed, structure indicators:

- **_structure:** (e.g. GTV_MR1_CN_V_L, GTV_MR2_Preop, PTVn2_CT1PT1_Postop, PTV_LN_Pelvic_L)

6.) if needed, dose:

- **_dose level**: High, Mid, Low (e.g. PTV_High, CTV_Mid)
  - if physical dose is needed use cGy (PTV_5040)

7.) If needed, number of fractions:

- **Dose per fraction "x" fractions:** (e.g. PTV_Liver_2000x3)

8.) If needed, cropping from external contour:

- **"-xx" in millimeters**: (e.g. PTV-03, CTVp2-05)

TARGETclassifier#_imaging#_structure_DOSEfx-cropping^custom

1.) Needed, targets:

- **GTV, CTV ,PTV, ITV**
- **GTV**-gross disease with margin for motion
- **CTV**-clinical disease with margin for motion
- **PTV!**- for low dose PTV volumes that exclude overlapping high dose volumes

2.) If needed, classifiers:

- **n**: nodal (e.g. PTVn)
- **p**: primary (e.g. GTVp)
- **sb**: surgical bed (e.g. CTVsb)
- **par**: parenchyma (e.g. GTVpar)
- **v**: venous thrombosis (e.g. CTVv)
- **vas**: vascular (e.g. CTVvas)

3.) If needed, multiple spatially distinct targets:

- **#**: enumerated targets (e.g. PTV2, GTVp1, GTVp2)

4.) If needed, imaging and sequential order:

- **_imaging sequence: (**e.g. GTVsb_MR2, PTVp2_CT1PT1)

5.) If needed, structure indicators:

- **_structure:** (e.g. GTV_MR1_CN_V_L, GTV_MR2_Preop, PTVn2_CT1PT1_Postop, PTV_LN_Pelvic_L)

6.) if needed, dose:

- **_dose level**: High, Mid, Low (e.g. PTV_High, CTV_Mid)
  - if physical dose is needed use cGy (PTV_5040)

7.) If needed, number of fractions:

- **Dose per fraction "x" fractions:** (e.g. PTV_Liver_2000x3)

8.) If needed, cropping from external contour:

- **"-xx" in millimeters**: (e.g. PTV-03, CTVp2-05)

9.) If needed, custom string of text:

- **^text: (**e.g. PTV^Physician1, GTV^RadiologistReviewed)

DVH and Dose Constraints

- Guiding principles
  - Providing specificity on exactly what is measured, input parameters, units used for dose and volume
    - Format that can be parsed with regular expression operators
    - Improves the ability to use computer algorithms to automate calculation
    - The ability to incorporate radiobiological metrics and units is also important.

DVH and Dose Constraints

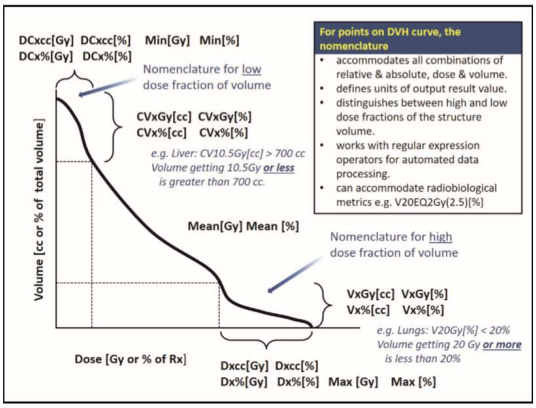


Figure 4. Illustration of standardized DVH nomenclature specifying input and output units. Approach is compatible with use of regular expressions.

DVH and Dose Constraints

- Measurement type is specified at the beginning of the string. Units or label for where on the curve the point is measured (input) are specified.
- Units or label for what is measured (output) are specified at the end of the string, enclosed in square brackets.
- Dose: Gy or % where percent (%) references dose prescribed to PTV_High structure type
- Volume: cc or % where percent (%) references volume of structure
- Equivalent 2 Gy: EQD2Gy

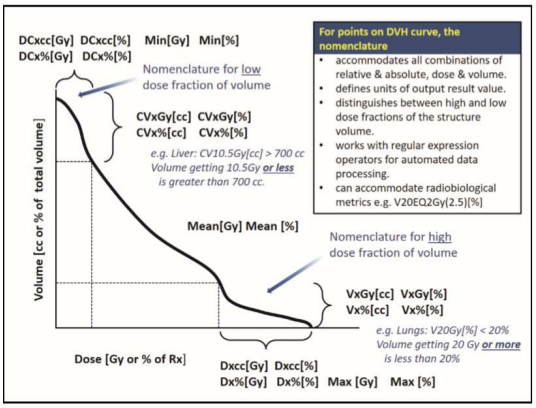


Figure 4. Illustration of standardized DVH nomenclature specifying input and output units. Approach is compatible with use of regular expressions.

Inputs

- Inputs:
- Vx: volume of sub volume receiving ≥ dose x. Dose units or label are specified (e.g., V20Gy[%], V95%[%], V20Gy[cc])
- Dx: minimum dose received by the hottest sub volume x. Volume units or label are specified (e.g., D0.1cc[Gy], D95%[%])
- CVx: volume of sub volume receiving ≤ dose x. Dose units or label are specified (e.g., CV10.5Gy[cc], CV95%[cc])
- DCx: maximum dose received by the coolest sub volume x. Volume units or label are specified (e.g., DC0.1cc[Gy], DC1%[Gy])
- calculation parameters are enclosed in parenthesis in front of the square brackets defining output units or label (e.g., V50EQD2Gy(2.5)[%])

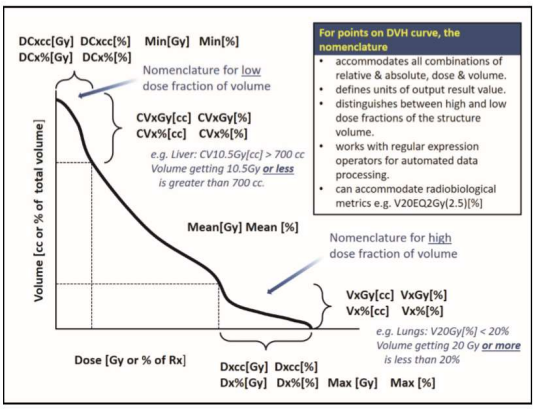


Figure 4. Illustration of standardized DVH nomenclature specifying input and output units. Approach is compatible with use of regular expressions.

Recommendations to Vendors

- Vendors are critical here.
- DICOM-RT is the standard for data communication across the radiation therapy process.
  - Don't restrict more than dicom!
- What we more of:
  - Relationships to imaging modalities
  - Motion assessments
  - Multiple versions of the same anatomical structure
  - Implement DICOM attributes to identify and categorize structures
    - FMAID and SNOMED

Recommendations to Vendors

- Make TG-263 Nomenclature available
  - Programming autocomplete/Natural language processing
  - Admin choice to restrict nomenclature to TG-263 standards and local standards
  - Allow definition of algorithms or scripts to define names of target structures
- Attribute identifiers
  - Versions
  - Linkage of target structure volumes to prescription elements (dose and fractionation)
  - Relationship of structures among data sets (e.g., PTV corresponds to the same target region in the structure set used for the first course and for a subsequent recurrence)

Recommendations to Vendors

- Attribute identifiers
  - Identification of the individual who created the structure
  - Full or partial volume (e.g., rectum near PTV vs full rectum)
  - Image data set (including phase on 4DCT) used to create the structure (e.g., created on registered MR scan and copied over to CT scan for planning)
  - Motion status (e.g., ITV created from 4DCT)
  - Linkages to standardized codes (e.g., diagnosis code (ICD9/10), oncology code (ICD-O), anatomical concept code (FMA and SNO-MED)

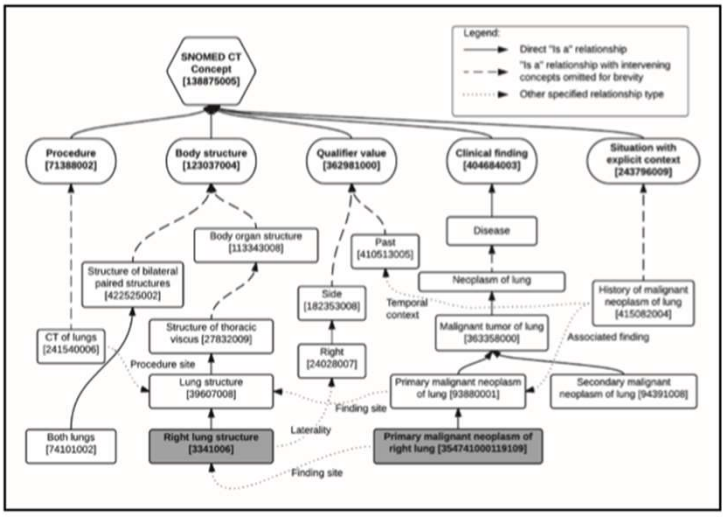


Figure 2. Illustration of a SNOMED CT concepts applied to lung cancer. SNOMED CT encompasses health care concepts beyond the purely anatomic goals of FMA. SNOMED CT is widely referenced in healthcare informatics. It has similar limitations as FMA for direct use as a nomenclature.

Recommendations to Vendors

- Attribute identifiers
  - Dose tag (e.g., name structure PTV_High and define dose tag = 7000 cGy)
  - Margins used to create the structure
  - Image modality characteristics
  - Visualization characteristics (e.g., window and level)
  - Factors and operations used to define derived structures (e.g., structure C is Boolean OR of structure A and structure B)

Recommendations to Vendors

- Systems should allow linkage of multiple structures
  - maintain a requirement that only one structure can be definitive per image set. For example, an anatomical entity may be identified in multiple longitudinal image sets that track changes in volume or shape over time.
  - Structures defined on multi-modality image sets should link the image features, such as PET affinity to density and perfusion to better characterize the anatomy and physiology in a comprehensive way
- Management of image segmentation for Adaptive radiotherapy
  - Preserve changes to contours over time
  - Maintain flexibility to compare with different imaging modalities, and allow for links between image sets for a given patient over time.
  - Multiple plans and multiple datasets

Recommendations to Vendors

- Systems should enable writable scripting
  - Creation of plans and structures adhering to standardizations
  - Writable scripts enable end users to create and share programs that design, edit, and optimize treatment plans consistent with standards as they are introduced.
    - It should be easy to import/export desired nomenclature, attributes, or identifiers in creation of treatment plans.

Recommendations for Implementation

- Gradual implementation
  - Allow time to develop an understanding of the guidelines, specific string values, and incorporation into their documentation.
  - Even basic effort to change to standardized structure naming is beneficial for the individual clinic, as well as the radiation oncology community as a whole.
- Long term process

Recommendations for Implementation

- Suggested work flow:
  1. Identify common treatment sites
     - (E.g., prostate, breast, head and neck)
     - Corresponding staffing groups (e.g., physicians, dosimetrists, physicists, therapists) affected by changes in nomenclature.
  2. Detail commonalities already in use
  3. Download the full list of non-target structure names recommended by the report.
  4. Save the full list, and make a separate copy for editing.

Recommendations for Implementation

- Suggested work flow:
  5. In that Excel sheet, delete rows from the spreadsheet containing structures that are not needed by your clinic. (An example might be: delete all cranial nerve structures, delete all individual heart-vessel structures, etc.)
  6. Discuss the final list, guidelines for target and non-target structures, and DVH metrics
  7. Identify local documentation templates that adjusted with changes to the nomenclature
     - (e.g., simulation and treatment directives, checklists used in plan review, etc.)
     - Review roadblocks in the contouring and TPS software

Recommendations for Implementation

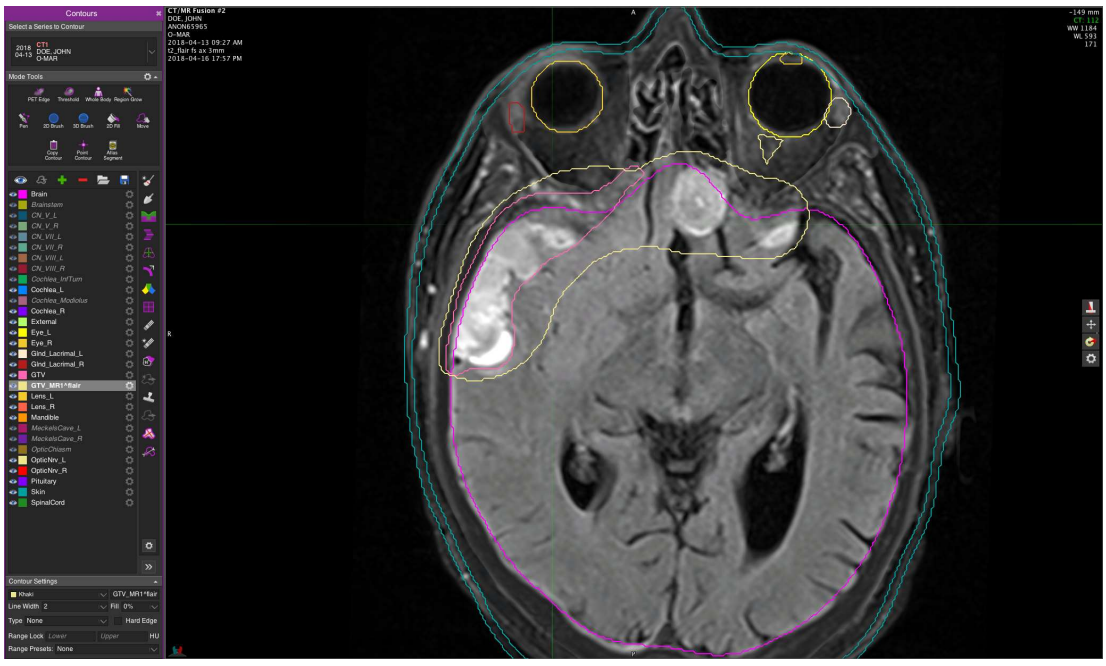
- Suggested work flow:
  8. Develop a plan for gradual rollout of the nomenclature into clinical practice:
     a. An example might be: implement non-target structure nomenclature and DVH metrics by disease site group over a defined period, and then implement clinic-wide target naming for all disease site groups.
     b. Include all stakeholders in the discussion (e.g., physicians, dosimetry, therapists, physicists).
     c. Consider where there are optimal break points in your clinical process for checking that correct values are used. Examples include plan review, plan check, and quality assurance rounds to review structures and doses.
     d. It may be easier for clinics which are large enough such that practices are broken up by disease site, to implement non-target nomenclatures first on a site-by-site basis and then later implement target nomenclature clinic-wide.

Recommendations for Implementation

- Suggested work flow:
  9. Develop a short list and create templates in your treatment planning system containing your new standard structures:
     a. One template that contains all of your standard structures.
     b. Or, individual templates for each treatment type that contain only structures needed for that treatment type.
  10. Retain the full list of structures as a reference for adding new structures to your templates as needed in the future.

Recommendations for Implementation

- Suggested work flow:
  - Here is what our templates look like



Benefits of implementation

- Benefits right now:
  - Review of plans
  - Building robust dose constraints review
  - Organ tracking reports
  - Scripting and quick plan building
- Future Benefits
  - Being able to compare your own data
    - See variations in techniques, planners, and over time
  - Being able to compare multiple clinic data
    - Focused registries
    - Anonymized vendor dicom repositories
  - Being able to compare large-scale radiation oncology data with other data sets

Thank you

- Important links:
  - https://www.aapm.org/pubs/reports/RPT_263_Supplemental/TG263_Nomenclature_Worksheet_20170815.xls
  - https://www.aapm.org/pubs/reports/RPT_263.pdf
- Acknowledgements:
  - Penrose dosimetrists/physicians/physicists
- Contact info: o.blasi@campphysics.com