MAYO CLINIC

Collaborative Knowledge Modeling and Integration for Radiation Therapy Planning-

Challenges in standardizing treatment planning data for outcomes studies

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Knowledge Based Clinical Practice Improvement System

System we are building to routinely gather and analyze outcomes data for all patients





The basis of knowledge is information

Changing paradigms is not easy. It requires many phases of building consensus among stake holders.

• People believe in the vision, but act on the specifics of how the details impact their daily efforts.

 Real participation is driven by demonstration of ability to reduce effort or improve efficacy

• Physician partners, who champion the effort and are not daunted by iterating to evolve the solution, are essential



The barrier to routine analysis of data for all patients is largely the overhead of manual effort required



• Standardization underpins ability to create software tools that reduce need for manual effort.

• Standardization requires consensus – which takes time and effort.

Gather and analyze data to prove that the idea worked for a <u>smal</u>l sample set of patients

• Discussions about standardization are best carried out in the context of practice rather than theory.



Build faith in achieving the whole and nurture proponents by creating it in phases that target solving current problems in the clinic.

1st Objective: Gather a uniform data set of Dose Volume Histogram (DVH) metrics for all patients and disease sites.

Why this one first? Ties into physician led initiative to develop and define standards of practice for treatment plans.

- Variation in how structures are named undermines ability to inter-compare plans and build automation
- Variation in the what metrics are routinely gathered undermines ability to inter-compare plans
- Free text descriptions of DVH objectives for a plan are often ambiguous and vary greatly from one physician to another.

Demonstrate that of use of standardization enables creation of software to reduce manual effort and also add functionality: comparison of requested and obtained DVH metrics. Facilitates ability to publish on clinical experience.



Requirements for Structure Nomenclature

- Inconsistent naming complicates automation
- Need a schema that accomodates the limitations of vended systems used in the clinic
- Need a schema that meets requirements of institutional data governace committee
- Need a schema that may be consistently applied as new structures are added
- Need a schema that will meet technical requirements for multiple purposes: clinic, vended systems, database storage, web based exchange among federated databases.



Naming schema is left to right: general to specific with laterality at the end.

Character string length, use of capitals, spaces, etc are guided by vended systems used in the clinic (simulator, planning system, information system, etc)

Take an approach that allows a standard name plus an alias in the database e.g. ptv_high = PTV7200

Now coordinating with other institutions as part of data pooling efforts. Expect changes/refinements as we find consensus with other institutions.

Important to start with with something that works and plan for change

Partial list of our structure nomenclature

Mayo Clinic Radiation Oncology	Standard Structure Nomenclature	version-20130328
ptv_high	semi_cir_canal_l	parotid_total
ctv_high	semi_cir_canal_r	parotid-ptv_r
itv_high	ext_aud_canal_l	parotid-ptv_l
gtv_high	ext_aud_canal_r	parotid-ptv_total
ptv_intermediate	mastoid_l	sub_mandib_r
ctv_intermediate	mastoid_r	sub_mandib_l
itv_intermediate	cochlea_l	sub_mandib-ptv_r
gtv_intermediate	cochlea_r	sub_mandib-ptv_l
ptv_low	optic_nrv_r	oral_cavity
ctv_low	optic_nrv_l	nasal_cavity
itv_low	optic_nrv_prv_r	lips
gtv_low	optic_nrv_prv_l	mandible
body-ptv	optic_chiasm	carotid_artery
body-ptv2cm	optic_chiasm_prv	jugular_vein
brain	eye_r	constrictors_p
brain-ptv	eye_l	constrictors_p-ptv

Put the standard structures into the treatment planning system templates to make it easy to conform to the standard



Key to enableing automated DVH calculations

Define a DVH nomenclature schema that fully defines all parts of the curve and can be expanded upon to accommodate other DVH derived metrics as they evolve. endpoint name(calculation parameters)[output units]





Example of use for radiobiological metrics: V35EQ2Gy(4)[%]

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Build consensus with physician disease site groups define standard DVH metrics and objectives to use for all patient treatment plans ~ 18 months

- Supports physician led initiative to develop and define standards of practice for treatment plans.
- Replace free text word documents with standardized tabular templates
- Critical point in dialog for building consensus is distinction between agreement on what metrics we measure vs. the the constraint value and priority

lung_total V20Gy[%] < 25% Priority = 1

 While defining vanilla (standard), must take an approach that allows for chocolate (per patient changes)

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Building Consensus on the IT design and function.

Free text Word Physician driven

MAYO

TLINIC

Standardized formatted Word Physician + Physicist driven

Stand alone application that demonstrates automation and software driven templates

Physicist + Physician driven

Production application that uses database

IT driven with multidisciplinary committee: physicians, dosimetrists, therapists, physicists

ct(_high



Application becomes our standard prescription.

Also serves as documentation tool for image setup, notes, IMRT justification, etc.

Physician groups define consensus for DVH metrics for all treatment sites!

Clinic Number: Patient Name:		(100 M C	Birth Date: Age: Gender:				1	Physician:	<none selected<="" th=""><th>View How-To (</th><th><u>Guide</u> •</th></none>	View How-To (<u>Guide</u> •
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 ✓ ptv_low ✓ ctv_high ✓ ctv_low 		Head and Neck- BID Quad Shot Head and Neck-Melanoma-Hypofractionation Liver SBRT 5fx Lung - Conventional_QD Lung - SBRT 3fx Lung - SBRT 3fx Lung - SBRT ffx Lung - SmallCell_BID Lymphoma-Hodgkins-Favorable_Stage I-II Lymphoma-Hodgkins-Infavorable_Stage I-II Lymphoma-NHL-Aggresive Histology Lymphoma-NHL-Indolent Histology Multiple Myeloma-High Dose Multiple Myeloma-High Dose Multiple Myeloma-Single Fraction Osteosclerotic Myeloma Prostate - All Sarcoma Body Sarcoma Extremity SBRT - General Spine SBRT 3fx Solitary Plasmacytoma Solitary Plasmacytoma - High Dose Testis 3 Dose Level			 110 % 100 % 0.5 cc 0.5 cc 95 % of the presc 95 % of the presc 100 % 98 % 98 % 99 % 		2 Gi - Duodenum Gi - EHBD-GallBladder 1 Gi - Esophagus 1 Gi - Gastric Cancer Gi - Liver Primary 2 Gi - Liver SBRT 5fx Gi - Pancreas cribed dosGi - Rectal Adjuvant Gi - SBRT 3fx Head and Neck- Re Head and Neck-BID Quad Shot 2 Head and Neck-Melanoma-Hypofractionation		Shot	E	
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							Re Lymphoma-Hodgkins-Unfavorable Lymphoma-Hodgkins-Unfavorable Re Lymphoma-NHL-Aggresive Histole Lymphoma-NHL-Indolent Histolog 2 Lymphoma-NHL-Indolent Histolog Multiple Myeloma-Multifraction-Hig		orable_stage I-II-L(orable_Stage I-II-U Histology-Lower Histology-Upper stology-Lower stology-Upper on-High Dose-Lowe	pper	
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Users can

- add/remove constraints
- select which structures to use

 change constrain values and prioritization

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			V60Gy[cc]			2			•	
V brain_s	tem		Max[Gy]	<=	<= 50 Gy		2			•
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			V60Gy[cc]		< 0.1 cc		3		•	
		Mean[Gy]		< 30 Gy		3		•		
		V60Gy[cc]	<1	0.1 cc	3			•		



Now carry out comparisons of desired and achieved DVH metrics for all patients and for all disease sites ...

and save DVH metrics data for data mining in our outcomes database.

Clinic Number:	10.000	Patient		Gender:	DOB:	
Physician Signat	ture: The prescr	iption has been approved	by Franks, Robert or Th	1.3ac.2013.03.46 PM	1	
RTP Name: hyp	opharynx and ne	Ck Scan Location:	Eclipse	PROTOCOL #:		
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Target Volume	1990 1990 - 1990 - 1990 - 1990 - 1990 - 1990 - 1990 - 1990 - 1990 - 1990 - 1990 - 1990 - 1990 - 1990 - 1990 - 1990 -					
ptv high (ptv_hig	gh)	ctv high +	5 mm margin			
ptv low (ptv_low	()	ctv low +	5 mm margin			
Prescription						
Group	Number of Fractions	ptv high (ptv_high)		ptv	v low (ptv_low)	
Initial Volume	35	7000 (200 cGy per l	Fx)	6300 (180 cGy per Fx) 6300 cGy		
Total	35	7000 cGy				
Target DVH Obj	jectives			Priority	Achieved	
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Now carry out comparisons of desired and achieved DVH metrics for all patients and for all disease sites ...

and save DVH metrics data for data mining in our outcomes database.

brain	Max[Gy]	< 56 Gy	2	61.09 Gy
	V60Gy[cc]	< 1 cc	2	0.03 cc
brain_stem	Max[Gy]	<= 50 Gy	2	49.18 Gy
	V30Gy[%]	< 33 <mark>%</mark>	2	30.55 %
brain_stem_prv	V54Gy[cc]	<= 0.1 cc	2	0 cc
cord	Max[Gy]	<= 45 Gy	2	43.57 Gy
cord_prv	V50Gy[cc]	<= 0.1 cc	2	0.03 cc
cochlea_r	Mean[Gy]	< 45 Gy	2	10.91 Gy
cochlea_l	Mean[Gy]	< 45 Gy	2	15.45 Gy
ext_aud_canal_r	Mean[Gy]	< 30 Gy	3	11.18 Gy
	V60Gy[cc]	< 0.1 cc	3	0 cc
ext_aud_canal_l	Mean[Gy]	< 30 Gy	3	15.31 Gy
	V60Gy[cc]	< 0.1 cc	3	0 cc
masto <mark>i</mark> d_r	Mean[Gy]	< 30 Gy	3	20.88 Gy
	V60Gy[cc]	< 0.1 cc	3	0 cc
mastoid_I	Mean[Gy]	< 30 Gy	3	24.85 Gy
	V60Gy[cc]	< 0.1 cc	3	0.08 cc
semi_cir_canal_r	Mean[Gy]	< 30 Gy	3	12.08 Gy
	V60Gy[cc]	< 0.1 cc	3	0 cc
semi_cir_canal_l	Mean[Gy]	< 30 Gy	3	15.71 Gy
	V60Gy[cc]	< 0.1 cc	3	0 cc
eye_r	Mean[Gy]	<= 30 Gy	2	2.47 Gy
	V50Gy[cc]	<= 0.1 cc	2	0 cc
	V40Gy[%]	<= 50 %	2	0 %
eye_l	Mean[Gy]	<= 30 Gy	2	2.63 Gy
	V50Gy[cc]	<= 0.1 cc	2	0 cc
	V40Gy[%]	<= 50 %	2	0 %
parotid_r	Mean[Gy]	< 26 Gy	3	37.55 Gy
	V30Gy[%]	<= 50 %	3	51.84 %
	V40Gy[%]	< 33 %	3	42.8 %
parotid_I	Mean[Gy]	< 26 Gy	3	40.31 Gy
	V30Gy[%]	<= 50 %	3	57.1 %
	V40Gy[%]	< 33 %	3	48.87 %
parotid_total	Mean[Gy]	< 39 Gy	3	38.7 Gy
sub_mandib_r	Mean[Gy]		Report	71.38 Gy



We are now systematically gathering a wide set of DVH metrics for all patients and all disease sites (sample below shows some of the DVH metrics gathered during a 4 month period for head and neck patients). Compiling information allows examining practice patterns.

					Percent meeting
Structure	DVH Metric	Mean	Standard Deviation	nvalues	constraint
body-ptv	V100%[%]	0.22	0.29	145	100%
body-ptv	V110%[%]	0.00	0.00	147	100%
brachial_plex_l	Max[Gy]	59.42	11.86	91	59%
brachial_plex_r	Max[Gy]	57.59	14.64	99	67%
brain	Max[Gy]	45.33	18.85	130	61%
brain	V60Gy[cc]	0.75	4.19	115	94%
brain_stem	Max[Gy]	37.03	15.56	129	89%
brain_stem	V30Gy[%]	16.20	18.15	123	94%
brain_stem_prv	V54Gy[cc]	0.04	0.25	114	97%
cochlea_l	Mean[Gy]	16.54	11.88	112	96%
cochlea_r	Mean[Gy]	17.92	13.71	113	92%
constrictors_p	Mean[Gy]	47.75	14.86	106	54%
constrictors_p	V55Gy[%]	48.41	32.10	101	87%
constrictors_p	V65Gy[%]	17.90	27.12	104	74%
cord	Max[Gy]	37.32	12.41	150	87%
cord_prv	V50Gy[cc]	0.03	0.19	130	96%
esophagus	Mean[Gy]	28.81	12.17	129	81%
esophagus	V35Gy[%]	38.69	23.75	131	72%
esophagus	V55Gy[%]	10.99	19.15	123	92%
esophagus	V70Gy[%]	1.19	6.58	118	97%
ext_aud_canal_l	Mean[Gy]	17.86	13.23	96	88%
ext_aud_canal_l	V60Gy[cc]	0.06	0.30	91	96%
ext_aud_canal_r	Mean[Gy]	19.88	13.30	93	89%
ext_aud_canal_r	V60Gy[cc]	0.04	0.16	90	94%
eye_l	Mean[Gy]	6.78	11.67	102	96%
eye_l	V40Gy[%]	4.22	17.80	96	98%
eye_l	V50Gy[cc]	0.24	1.31	96	95%
eye_r	Mean[Gy]	4.90	5.59	105	100%
eye_r	V40Gy[%]	0.33	2.12	98	100%
eye_r	V50Gy[cc]	0.00	0.01	98	100%



We are now systematically gathering a wide set of DVH metrics for all patients and all disease sites.

- It now becomes easy to monitor the <u>distributions</u> of values of DVH metrics for all patients... and to watch the evolution over time.
- More meaningful evaluation of quality of practice.



The basis of knowledge is information

Standardization + Consensus + Software

We've moved from it being rare to complete the feed back loop toward it becoming routine.



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The work presented is the result of the work of a large group of collaborators

It takes a village to raise a child... and a lot of bright people to build an outcomes database

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