Standardized Nomenclature from the MD perspective: Head and Neck Applications

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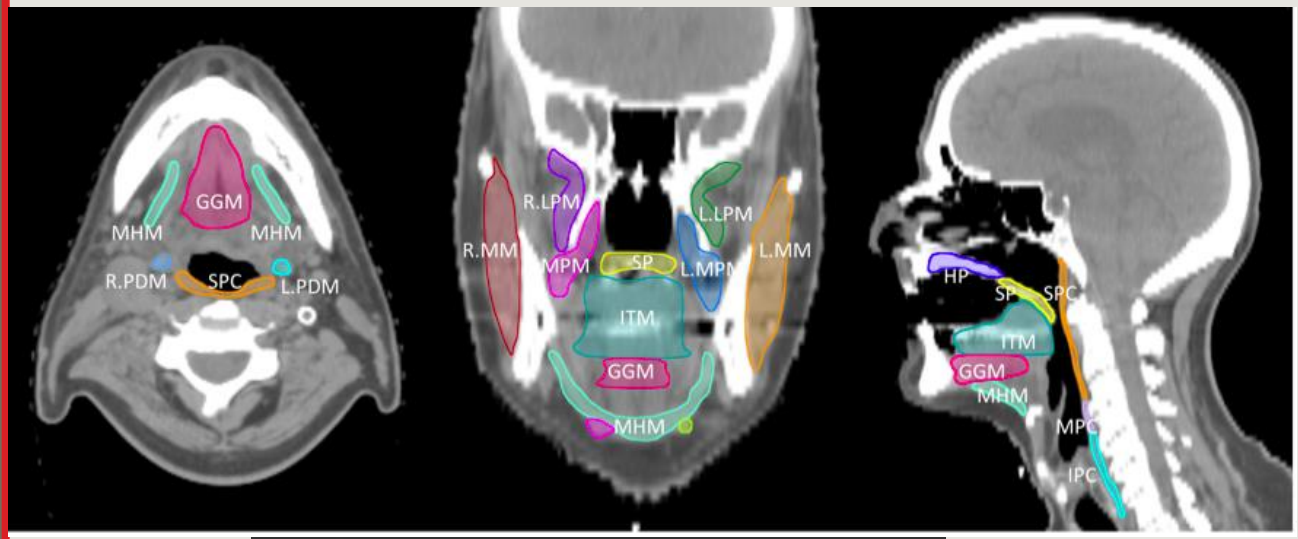
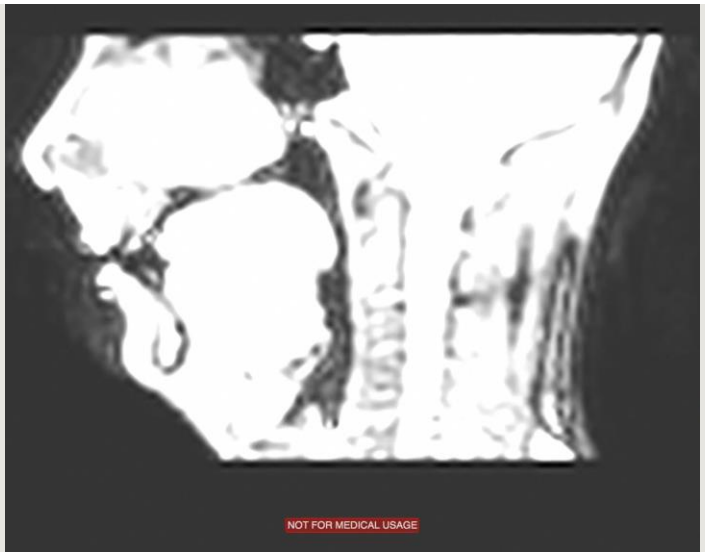
Assistant Professor

Head & Neck Section





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Overview

- Moving to a standardized nomenclature takes a team effort.
- A physician perspective will be presented including foundational information on how targets, organs-at-risk, and margins are defined.
- An example will be presented for how to modify clinical practice to standardize nomenclature for treatment of head and neck.
- Problems which arose during the transition will be shared along with information about the type and amount of effort required during the transition

C.D. Fuller Publication Acknowledgment/Disclosure

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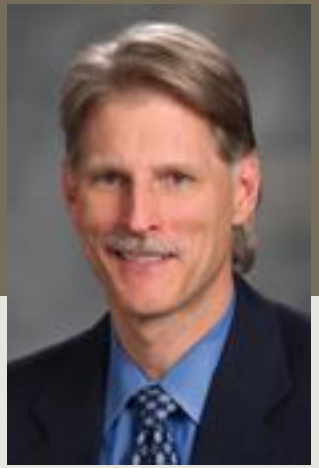
- Hope Foundation/Southwest Oncology Group
- ASCO Young Investigator Award

Radiation Oncology Head and Neck Section



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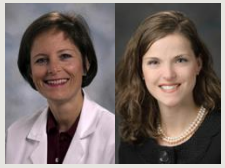

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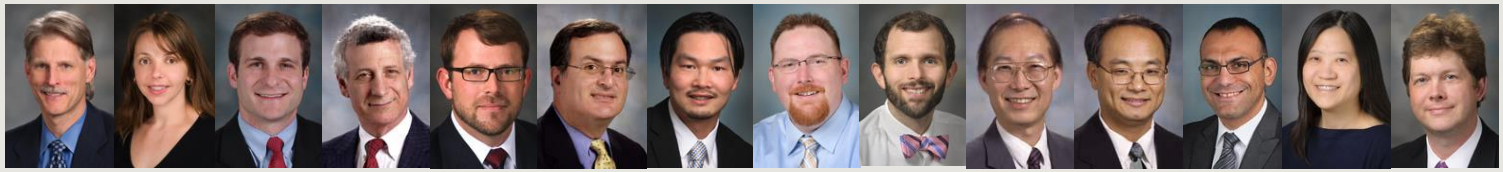

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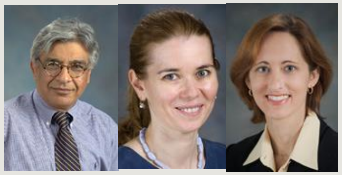

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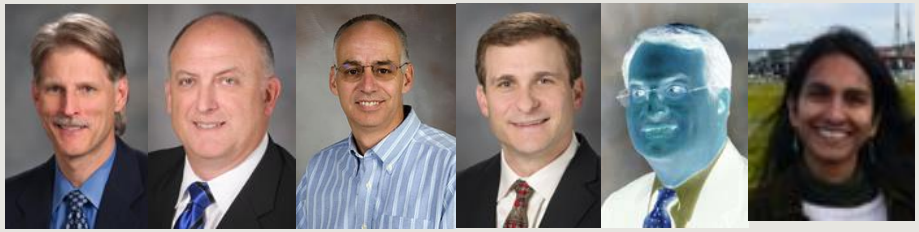

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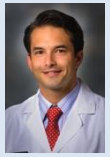
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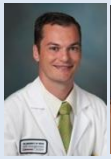
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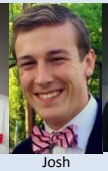
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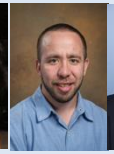
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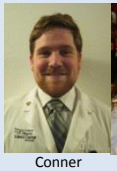
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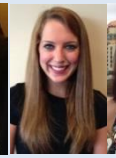
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The Home Team

Lack of standardization: An unmet need

Standardizing Naming Conventions in Radiation Oncology

Lakshmi Santanam, Ph.D.,* Coen Hurkmans, Ph.D.,† Sasa Mutic, Ph.D.,* Corine van Vliet-Vroegindeweij, Ph.D.,‡ Scott Brame, Ph.D.,* William Straube, M.S.,* James Galvin, D.Sc.,‡ Prabhakar Tripuraneni, M.D.,§ Jeff Michalski, M.D.,* and Walter Bosch, D.Sc.*,¶

Int J Radiation Oncol Biol Phys, Vol. 83, No. 4, pp. 1344–1349, 2012

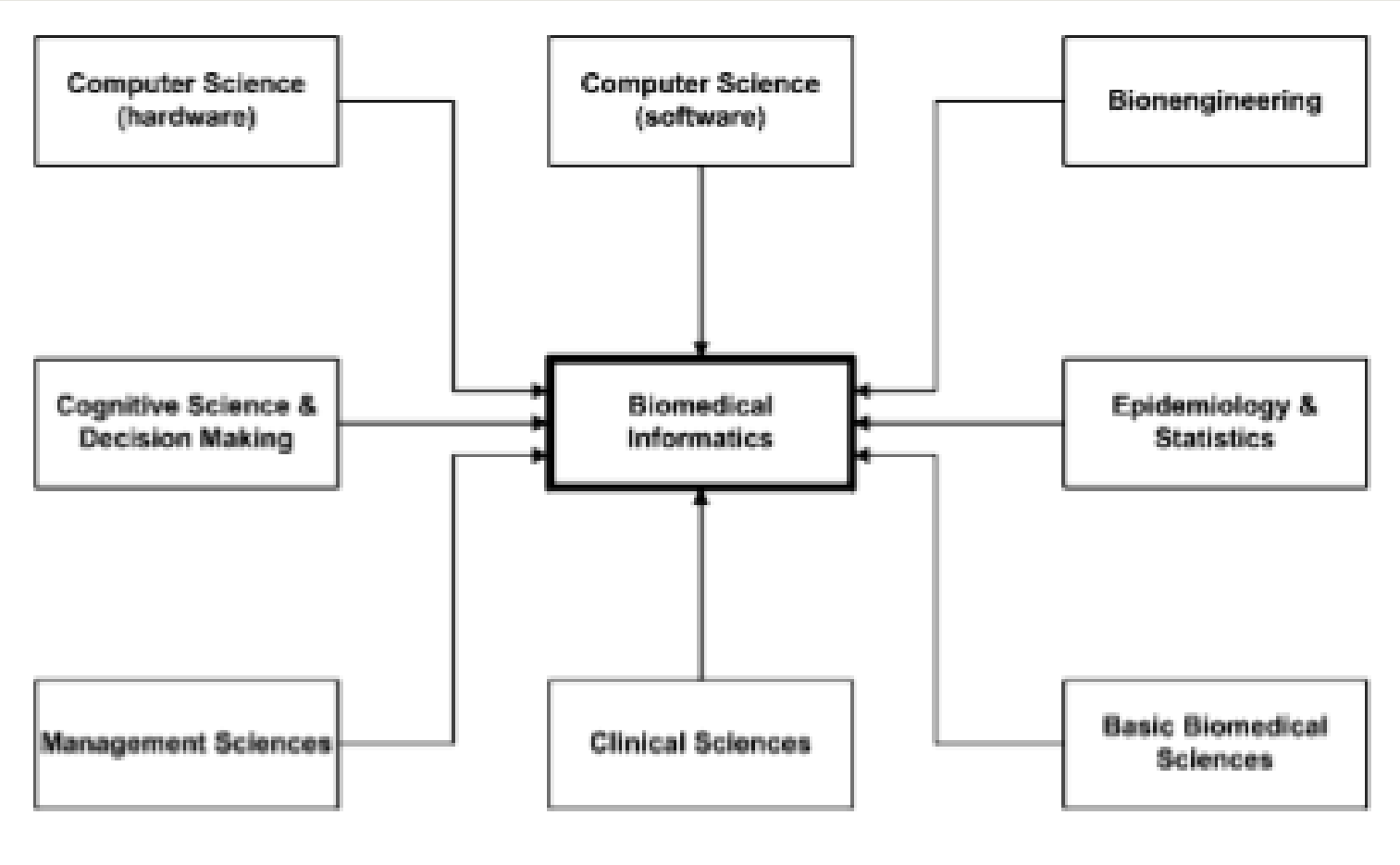
Several recent reports document the deleterious effects that inaccurate, incomplete communication can have in RO. An article published by the Pennsylvania Patient Safety Advisory in September 2009 found that 46% (17/37) of reported errors involved treatment to an incorrect site and 21% (8/37) to the wrong dosage (3). A similar error and near-miss reporting and learning system was implemented by Washington University (4). On the basis of the data collected from April 2008 to February 2010, 500 events due to miscommunication of intent were reported based on the treatment planning and simulation orders request. Of these 17% (84) were due to wrong contours or modifying or renaming (5). Although these events reported at Washington University did not result in patient mistreatments, each represents a process inefficiency that adds no value to the

Conceptual underpinnings for technical Head & Neck clinical QA efforts: QA is an information process

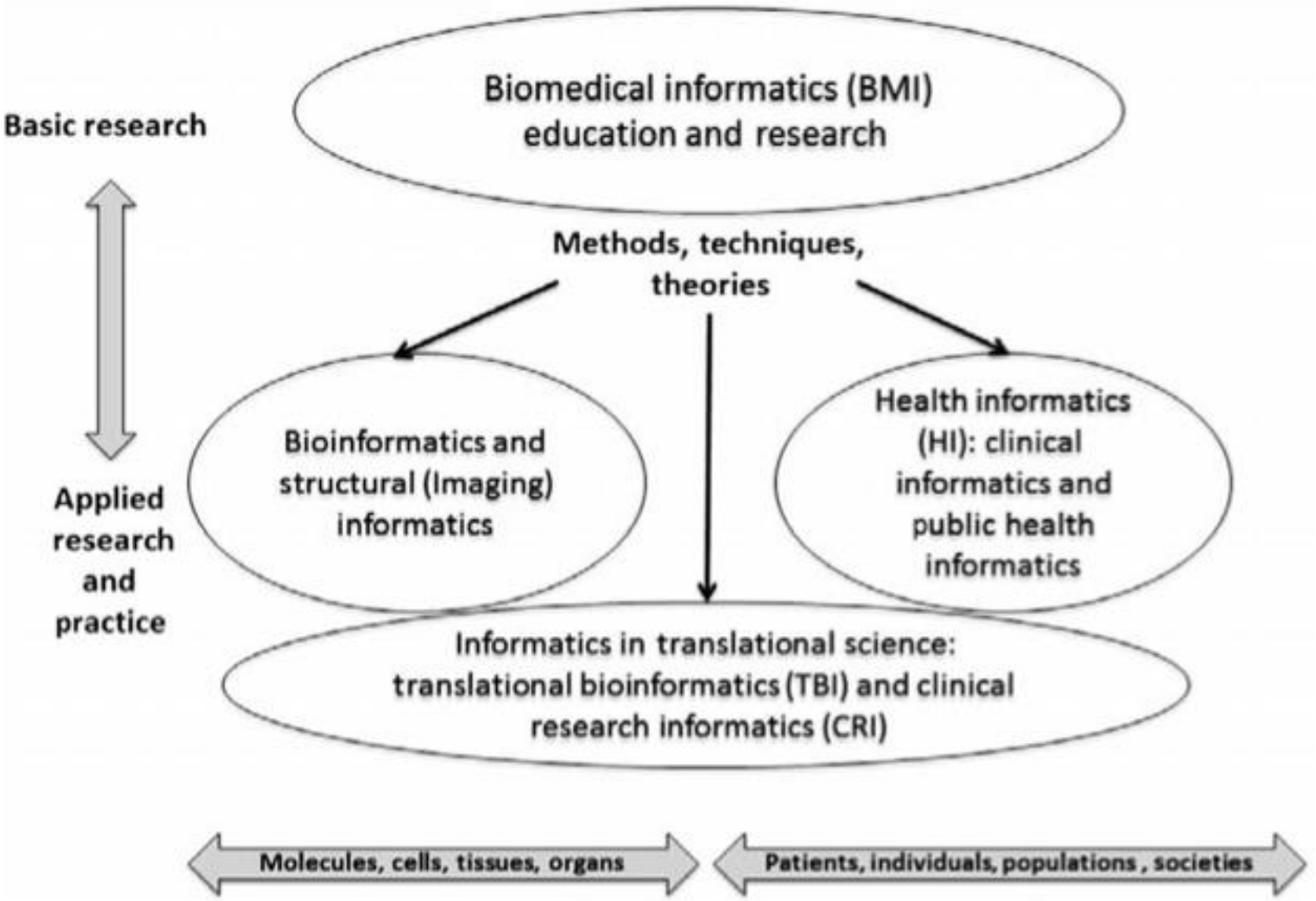
- All “error” is spatial (i.e. dose is or isn’t where it “should be”).
- In aggregate error (e.g. failure or toxicity) is an estimatable uncertainty with potentially knowable distributional probability
  - We can thus estimate, with enough priors, global or component uncertainty
- Spatial uncertainty is propagated through the treatment chain
  - Thus, primacy of inputs (i.e. target delineation, OAR nomenclature)
- Reducing systematic uncertainties decreases error proportionally greater than chasing random uncertainties
  - Thus systematic proactive efforts are more effective than serial reactive interventions

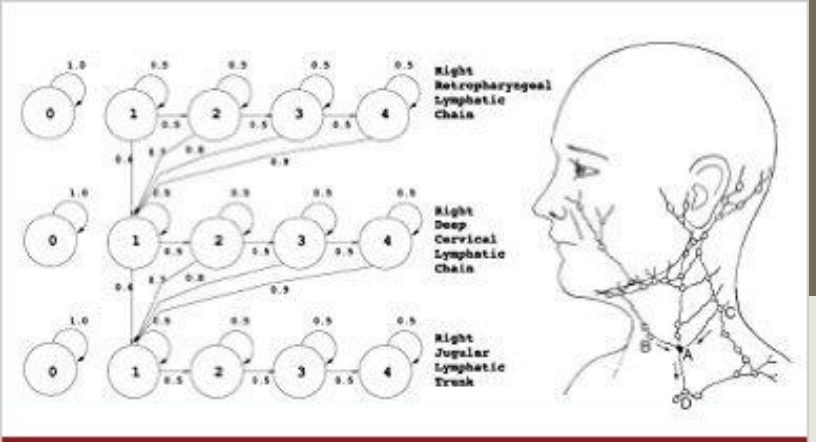
Serial links in treatment information chain

Position:
Medical physicists and radiation oncologists are obligate biomedical informaticists



Kagadis *et al.*: Medical physicists and health care applications of informatics


Biomedical informatics (BMI) education and research
Basic research
Methods, techniques, theories
Bioinformatics and structural (Imaging) informatics
Health informatics (HI): clinical informatics and public health informatics
Applied research and practice
Informatics in translational science: translational bioinformatics (TBI) and clinical research informatics (CRI)
Molecules, cells, tissues, organs
Patients, individuals, populations , societies



PRINCIPLES OF BIOMEDICAL INFORMATICS

SECOND EDITION

IRA J. KALET

Remembering Ira Kalet, 1944-2015

Retired CSE adjunct professor Ira Kalet passed away last night after a long battle with cancer.

Ira joined the University of Washington in 1978 in the then newly formed Department of Radiation Oncology. Subsequently he held adjunct appointments in Computer Science & Engineering, Bioengineering, and Biological Structure, and a joint appointment in Medical Education (now the Department of Biomedical Informatics and Medical Education).

Ira Kalet, PhD

Technology for Innovation in Radiation Oncology

Indrin J. Chetty, PhD,* Mary K. Martel, PhD,† David A. Jaffray, PhD,‡

1. Integrating radiation oncology databases across the discipline will facilitate science and elevate the quality of care (45). The creation of a Virtual Clinical Trials Group that enables federated databases at different institutions for conducting cooperative research is a consideration. Sharing practices and outcomes will permit high mean and tight variance in clinical practice and will improve quality (46).

2. Tools need to be created and made available for patients and physicians to discuss treatment options, as recommended by the Patient-Centered Outcome Research Institution. Such an approach will drive the development of metatreatment planning systems, in which one prescribes an outcome, not a treatment (eg specification of a 95% local control rate at 5 years with 5% grade 3 or more dyspnea) (6, 47). This could also be expanded beyond radiation oncology.

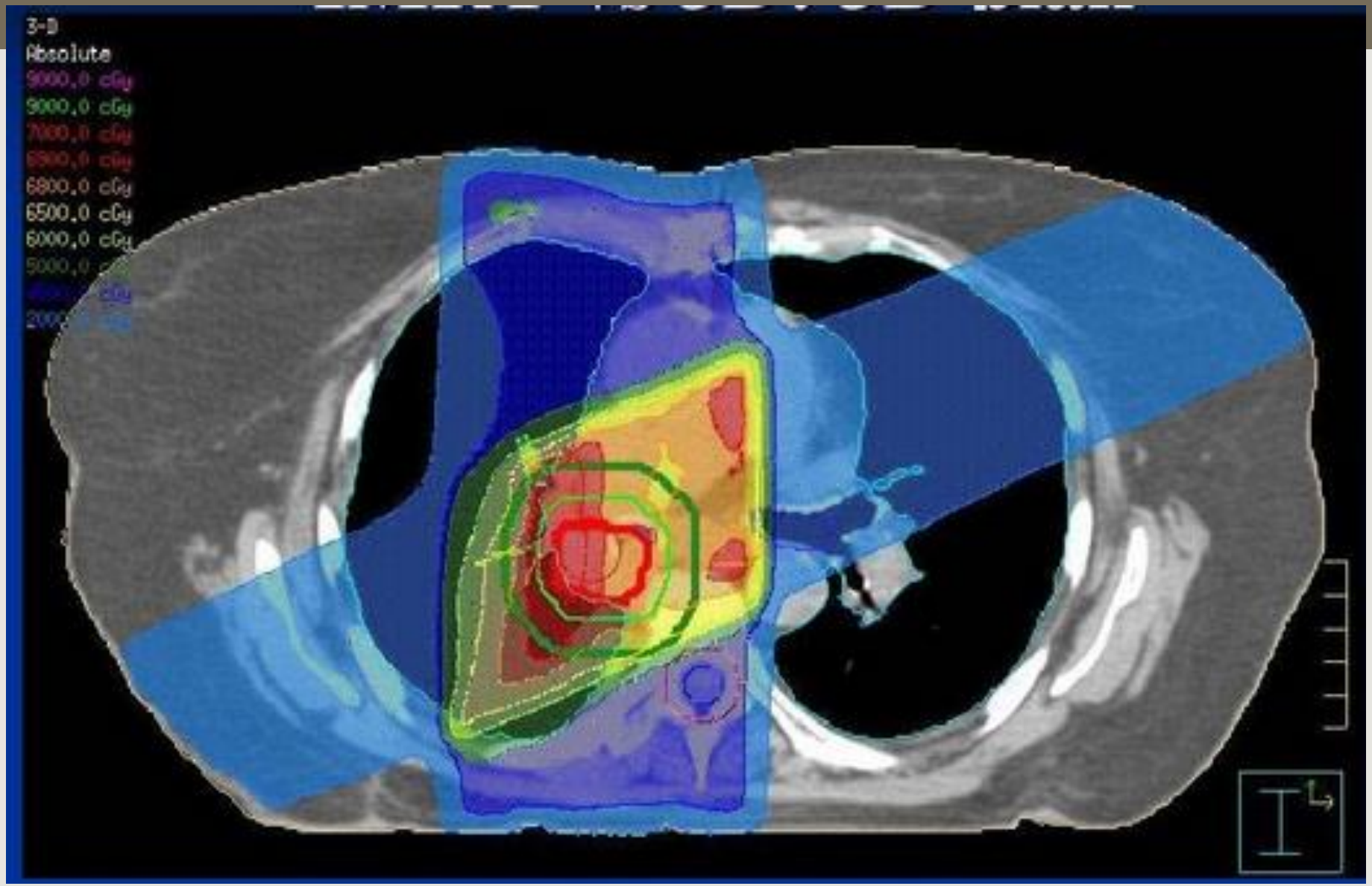
3. Expertise in the informatics domain among radiation oncology professionals needs to be developed (6). The most suitable candidates with the appropriate skill sets and multidisciplinary knowledge to succeed in this space are likely medical physicists or physicians with strong computational backgrounds. Training grants for developing programs for oncology informatics will provide these individuals with the knowledge needed to support informatics research initiatives.

4. Informatics tools need to be developed to support the monitoring of the quality of oncology care at the point(s) of delivery (48). Real world–based evidence approaches are emerging in other domains and will also benefit the field of radiation oncology. The often-quoted statements that 5% differences in dose result in significant changes in tumor control and normal tissue complication probabilities will be reinforced or challenged through collecting and sharing data from the entire clinical process.

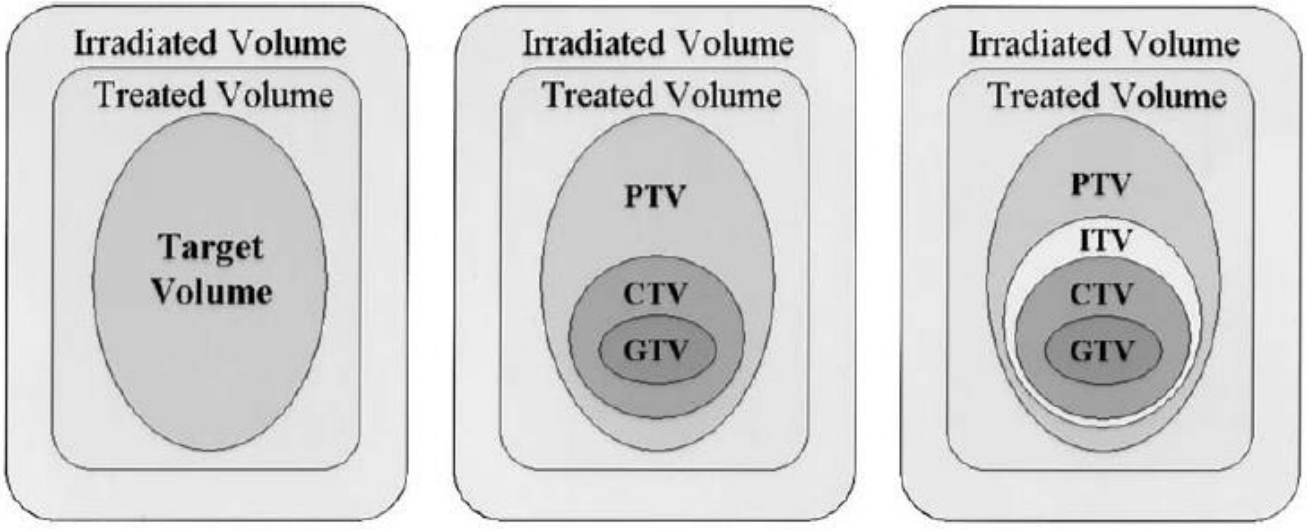
The problem

- Without common terminology, content is obscured…and we may not be aware of it!

Personal story



ICRU 29-62
Moving from RT to IMRT to IGRT



(A) ICRU 29 (B) ICRU 50 (C) ICRU 62

Figure 1. (A) Schematic illustration of the boundaries of the volumes defined by ICRU Report 29: target volume, treatment volume, and irradiated volume; (B) boundaries of the volumes defined by ICRU Report 50, GTV, CTV, PTV, treated volume, and irradiated volume; and (C) boundaries of the volumes defined by ICRU Report 62: GTV, CTV, internal target volume (ITC), PTV, treated volume, and irradiated volume.

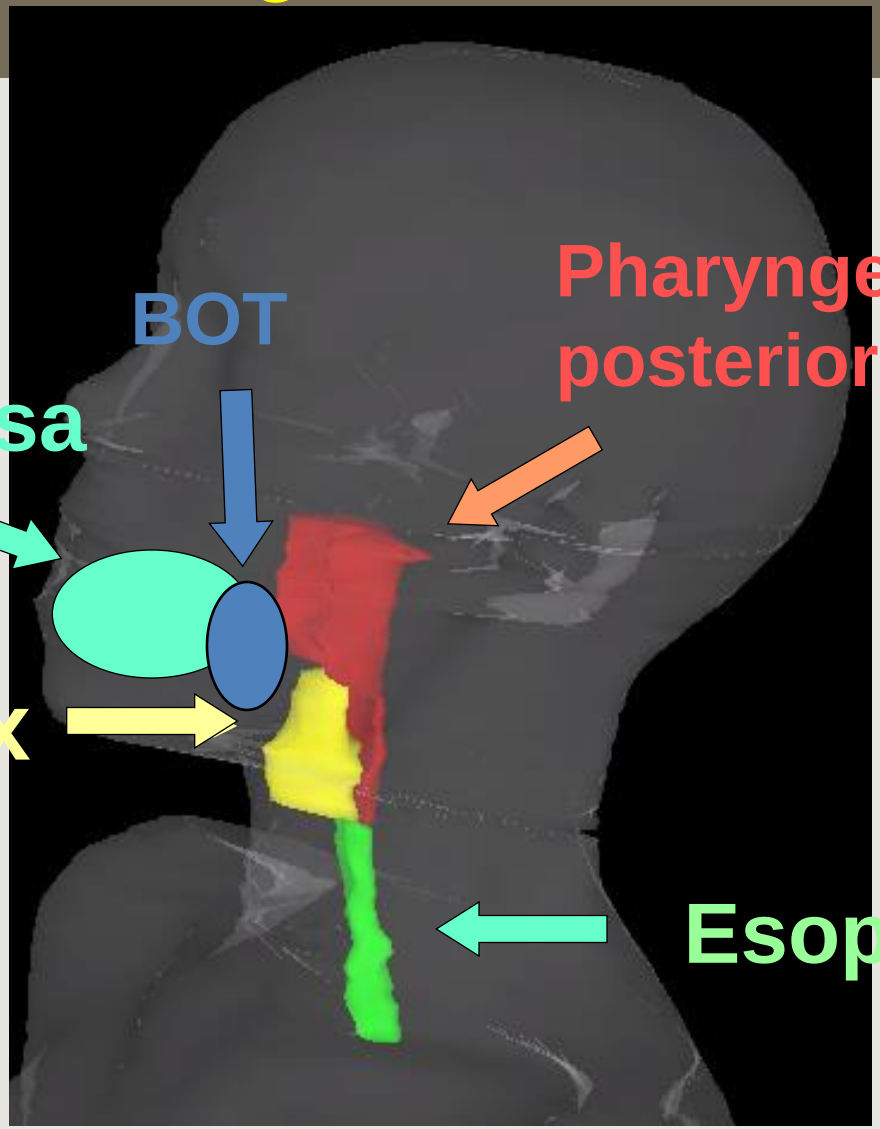
Prescribing, Recording, and Reporting Photon-Beam Intensity-Modulated Radiation Therapy (IMRT)

In IMRT, organs or structures that are not delineated can receive significant radiation absorbed doses. Contouring organs at risk (OAR) is the first step to control the dose in normal tissues, which might cause unacceptable complications. For so-called "parallel-like organs," the whole organ should be entirely delineated. For so-called "serial-like organs," those parts of the organ that could receive a high dose should be delineated in a consistent way. For tubular types of organ (*e.g.*, the rectum), delineation of the wall is preferred to whole-organ delineation. Especially for a serial-like organ, a planning organ at risk volume (PRV) should be delineated around the OAR. Tissues not included in the CTV or not delineated as dose-limiting OARs should still be specifically delineated and named the remaining volume at risk (RVR).

ICRU 83 specifies uncertainty margination, but does not guide regarding naming conventions nor not specify the rules for naming structures in treatment planning systems

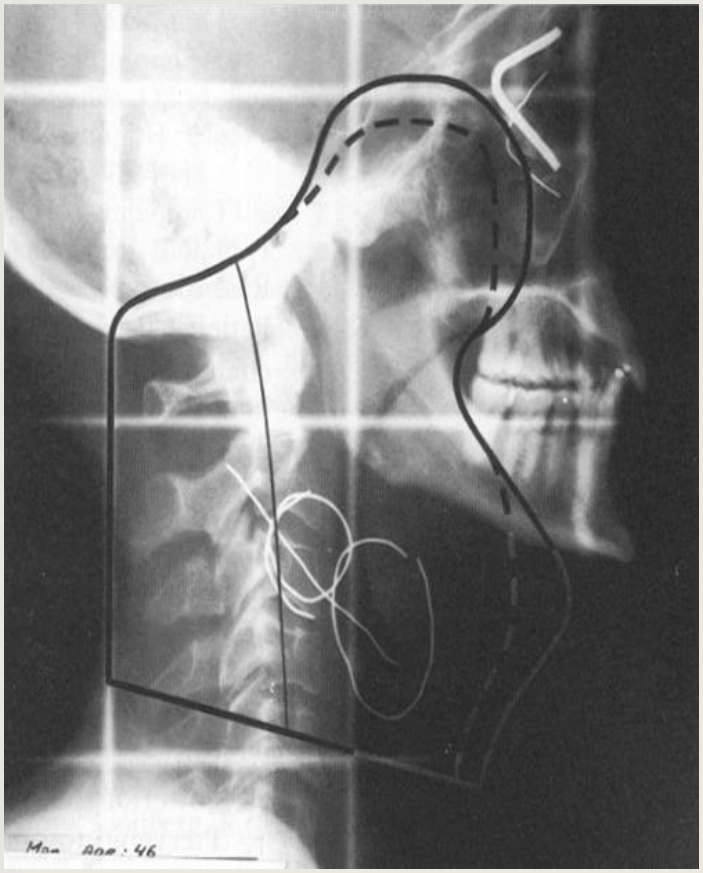
Journal of the ICRU Vol 10 No 1 (2010) Report 83

Head and neck:
A non-target rich environment

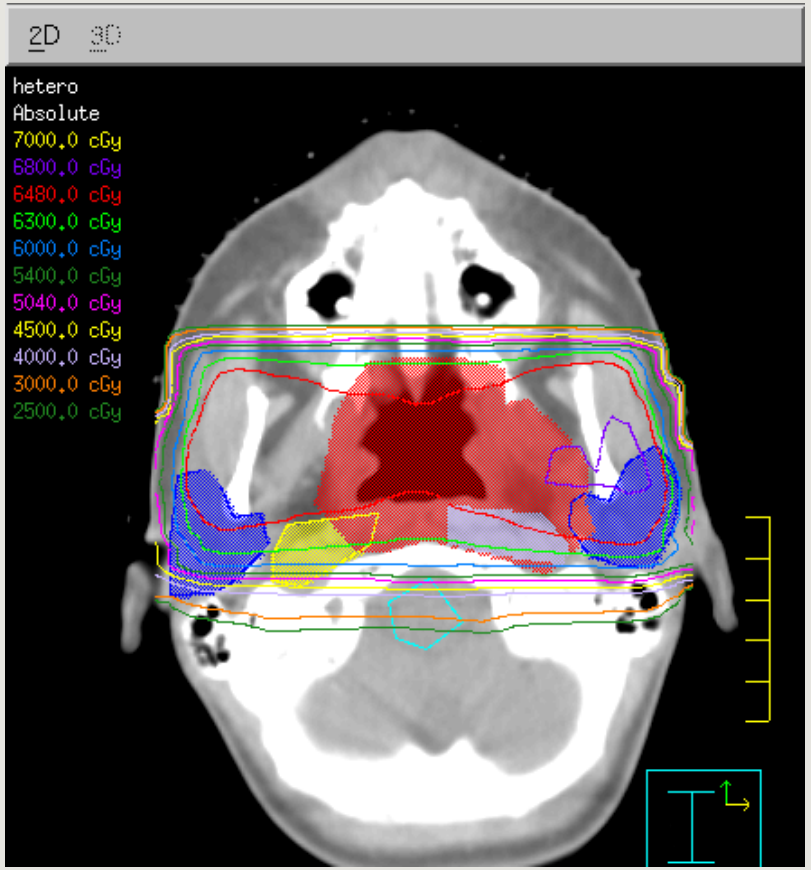


Conventional Nasopharynx

1990

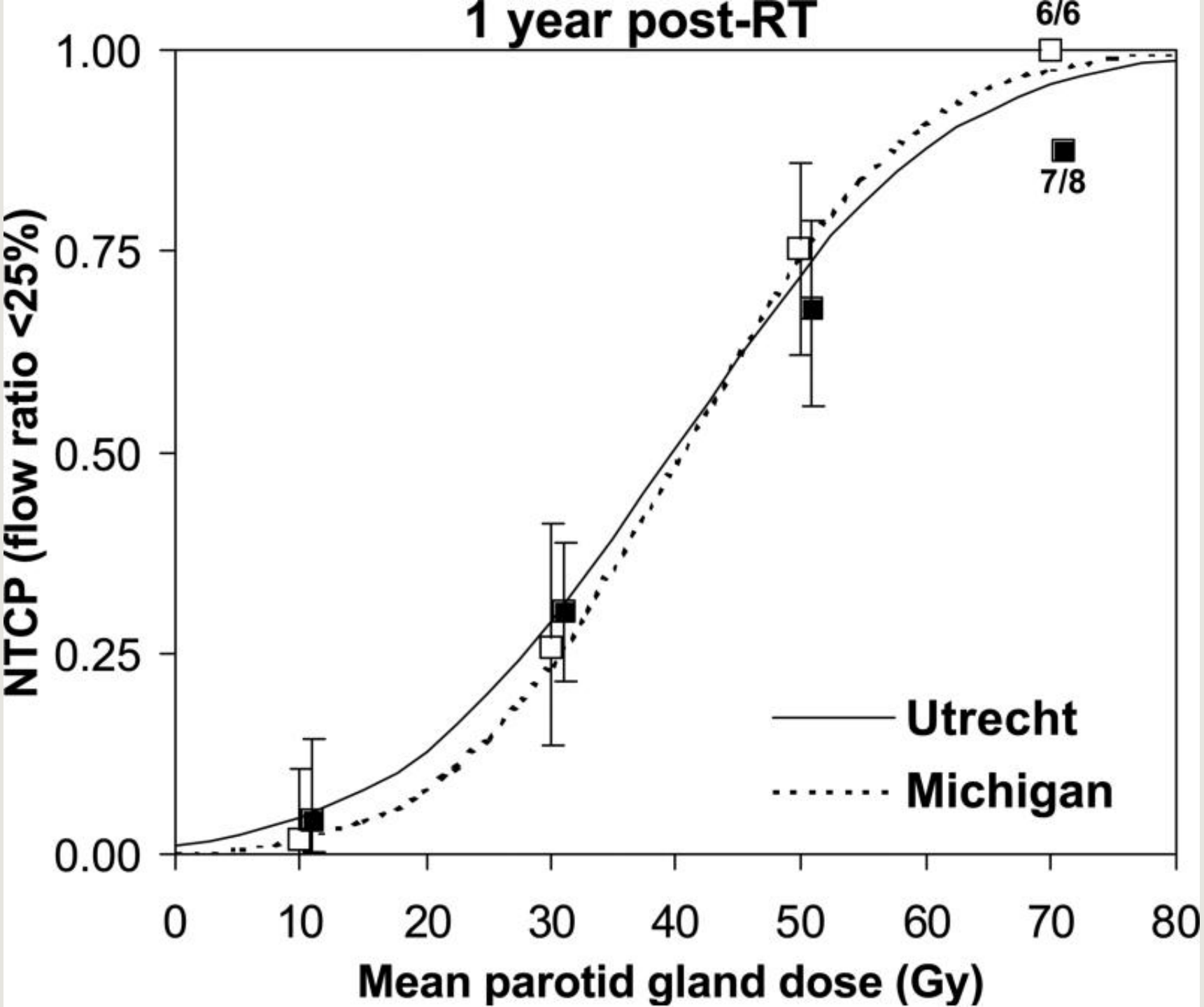


2000



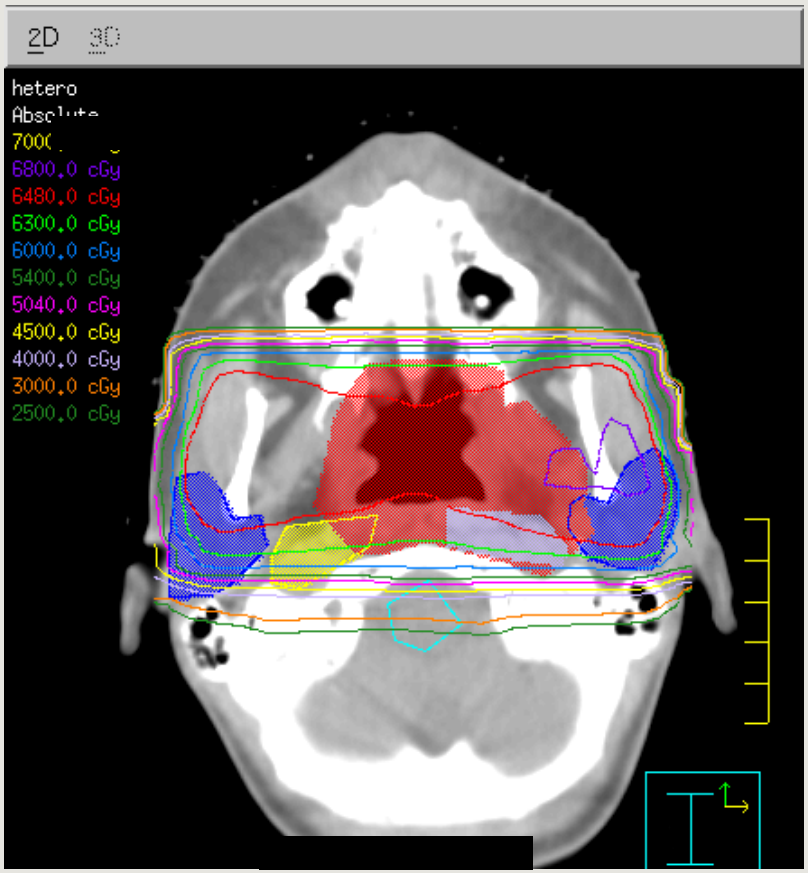
How have we been addressing morbidity?

- Xerostomia
- Dysphagia
- Swallowing dysfunction
- Odynophagia
- Anosmia
- Cranial neuropathy
- Motor/sensory function
- Memory loss
- Aphasia
- Vascular Sequelae

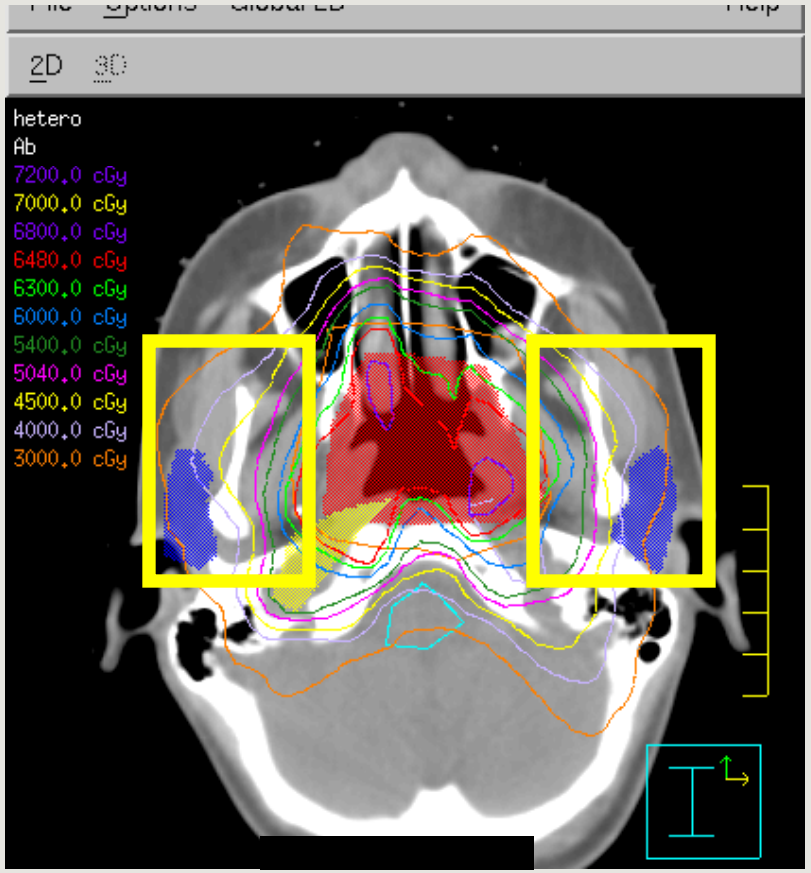

1 year post-RT
6/6
7/8
1.00
0.75
0.50
0.25
0.00
NTCP (flow ratio <25%)
Utrecht
Michigan
0
10
20
30
40
50
60
70
80
Mean parotid gland dose (Gy)

Benefit of IMRT: Parotid sparing

2000



2010



But IMRT does not remove dose to OARs, it just moves it around...

I. J. Radiation Oncology ● Biology ● Physics Volume 72, Number 3, 2008

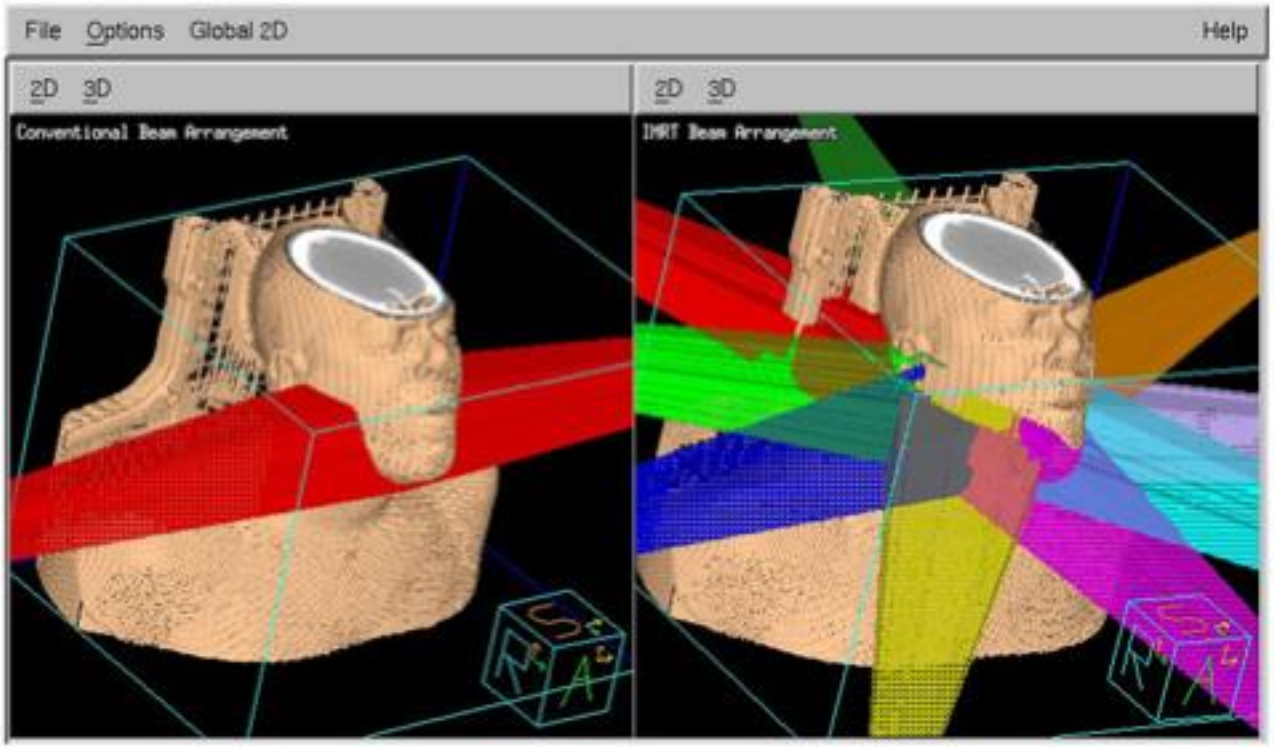


Fig. 1. Comparison of nontarget beam paths in intensity-modulated radiotherapy (top) vs. conventional three-dimensional technique (bottom).

IMRT toxicity profile

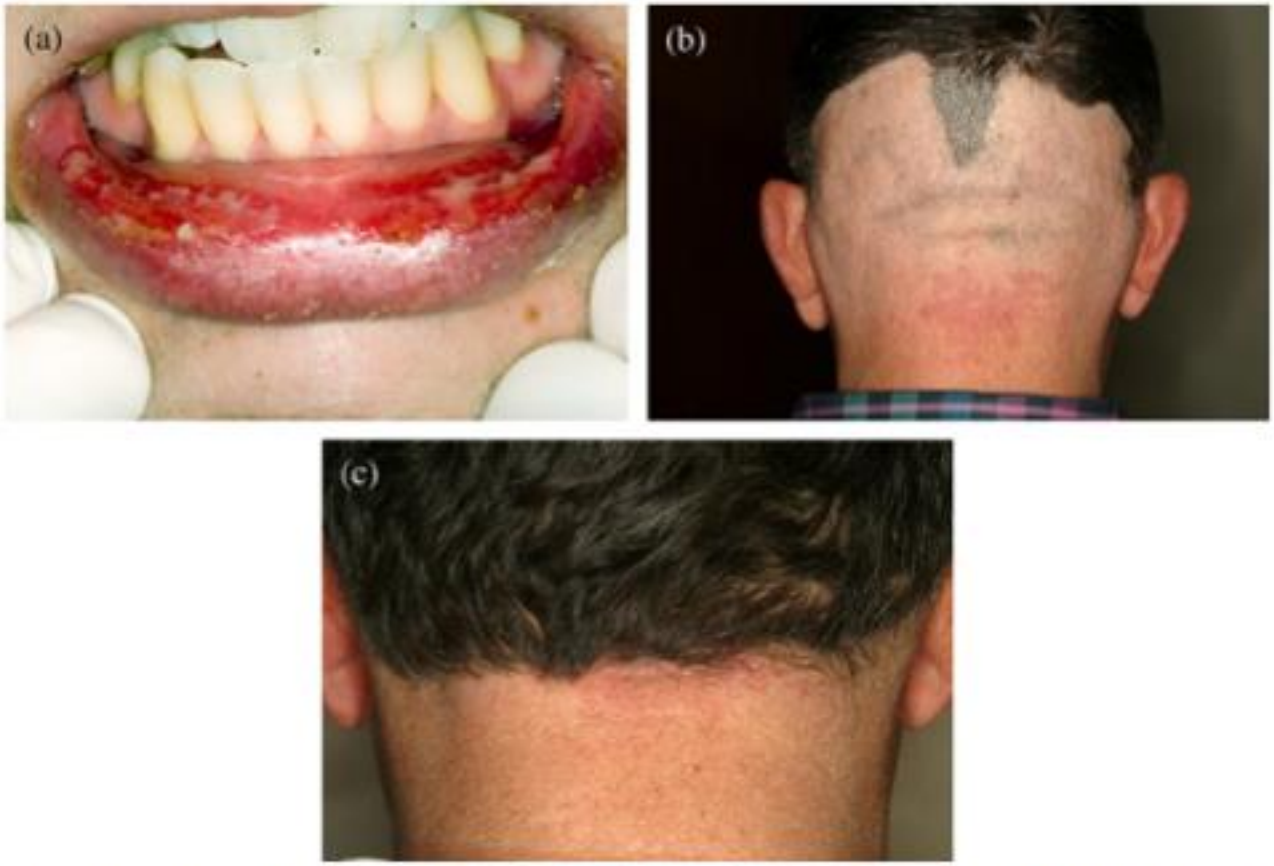


Fig. 3. (a) Anterior oral mucositis during intensity-modulated radiotherapy (IMRT). (b) Occipital scalp epilation after IMRT. (c) Scalp hair subsequent regrowth, same patient.

Table 6. Average of maximum voxel dose (in cGy) to noncontoured structures per patient, by treatment technique

Structure	Conventional	IMRT
Brain stem	3741.6	4590.4
Cochlea, left	426.4	3467.1
Cochlea, right	433.5	3372.3
Lower lip	226.7	3587.1
Mandible, anterior	752.4	3871.1
Mandible, middle	1124.3	4954.3
Mandible, posterior	4886.1	6149.3
Maxilla, anterior	264.7	3070.8
Maxilla, posterior	2894.0	4206.8
Middle ear, left	574.6	3557.3
Middle ear, right	642.3	3584.4
Occipital scalp	118.6	3453.6

Abbreviation: IMRT = intensity-modulated radiation therapy.

Table 4. Percentages of patients experiencing nausea and vomiting in the IMRT or IMRT-plus-concurrent-cisplatin groups

	Toxicity grade				
	0	1	2	3	4
Nausea*					
IMRT alone	24	33	38	5	0
Concurrent cisplatin	2	22	58	18	0
Vomiting**					
IMRT alone	63	16	18	3	0
Concurrent cisplatin	32	18	38	12	0

Abbreviation: IMRT = intensity-modulated radiation therapy.
* $p < 0.004$ based on Pearson Chi-Square test.
** $p < 0.04$ based on Pearson Chi-Square test.

EFFECT OF BRAIN STEM AND DORSAL VAGUS COMPLEX DOSIMETRY ON NAUSEA AND VOMITING IN HEAD AND NECK INTENSITY-MODULATED RADIATION THERAPY

doi:10.1016/j.meddos.2009.11.002

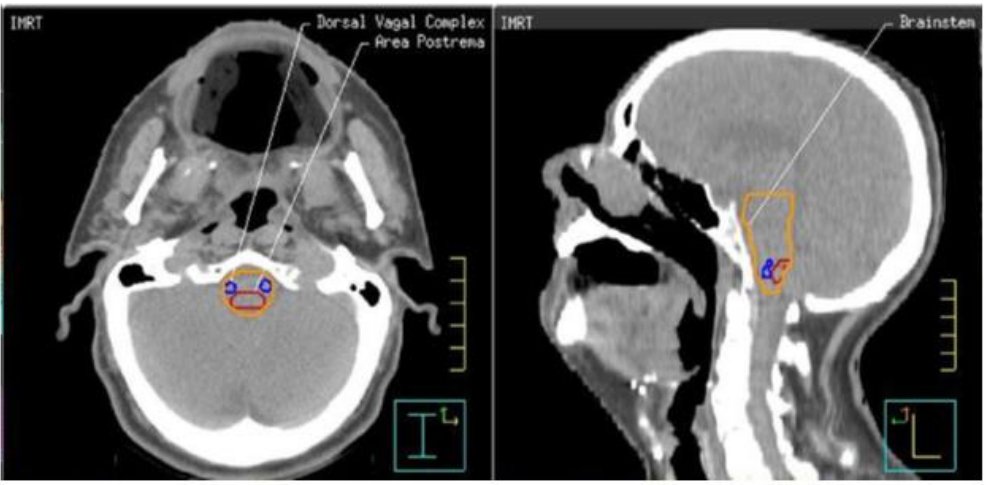


Fig. 2. Dorsal vagal complex, area postrema and brainstem delineation on CT.

Treatment type	
IMRT alone	49
Concurrent cisplatin	25
Other concurrent chemo	26

Table 5. Logistic regression

Structure	Parameter	p =	Sig.
a. Results of logistic regression evaluation of maximum toxicity distribution.			
Brainstem	Maximum	0.07	n.s.
	Mean	0.02	n.s.
	Median	0.02	n.s.
	EUD	0.5	n.s.
Dorsal vagal complex	Maximum	0.1	n.s.
	Mean	0.05	n.s.
	Median	0.06	n.s.
	EUD	0.3	n.s.
Area postrema	Maximum	0.08	n.s.
	Mean	0.3	n.s.
	Median	0.1	n.s.
	EUD	0.6	n.s.
b. Results of analysis of binary logistic regression (Grade 3 *vs.* < Grade 3 CTC-AE scores).			
Brainstem	Maximum	0.07	n.s.
	Mean	0.0006	*
	Median	0.004	n.s.
	EUD	0.3	n.s.
Dorsal vagal complex	Maximum	0.02	n.s.
	Mean	0.007	n.s.
	Median	0.009	n.s.
	EUD	0.4	n.s.
Area postrema	Maximum	0.01	n.s.
	Mean	0.001	*
	Median	0.01	n.s.
	EUD	0.7	n.s.

Beam path toxicity in candidate organs-at-risk: Assessment of radiation emetogenesis for patients receiving head and neck intensity modulated radiotherapy

Esengul Kocak-Uzel [a,c], G. Brandon Gunn [a], Rivka R. Colen [b], Micheal E. Kantor [a], Abdallah S.R. Mohamed [a,d], Sara Schoultz-Henley [e], Paniyotis Mavroidis [f], Steven J. Frank [a,j], Adam S. Garden [a], Beth M. Beadle [a], William H. Morrison [a], Jack Phan [a], David I. Rosenthal [a], Clifton D. Fuller [a,j,*]

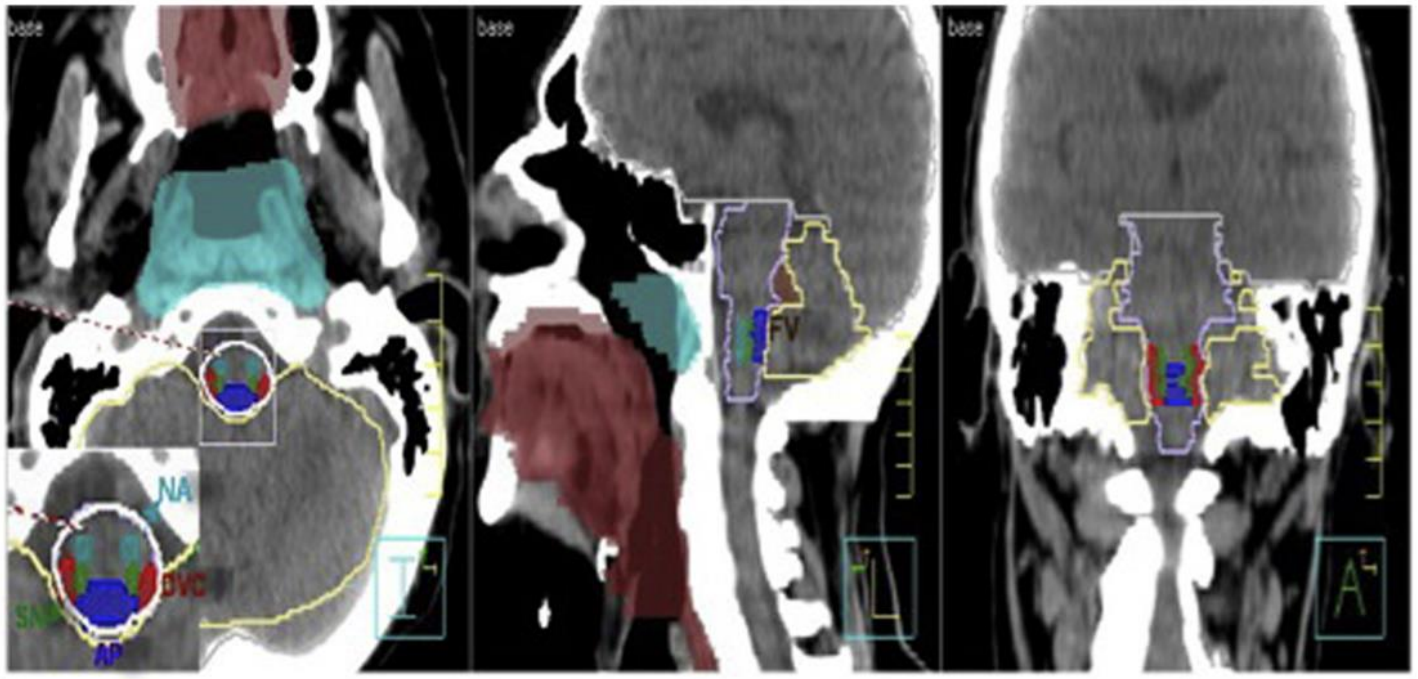
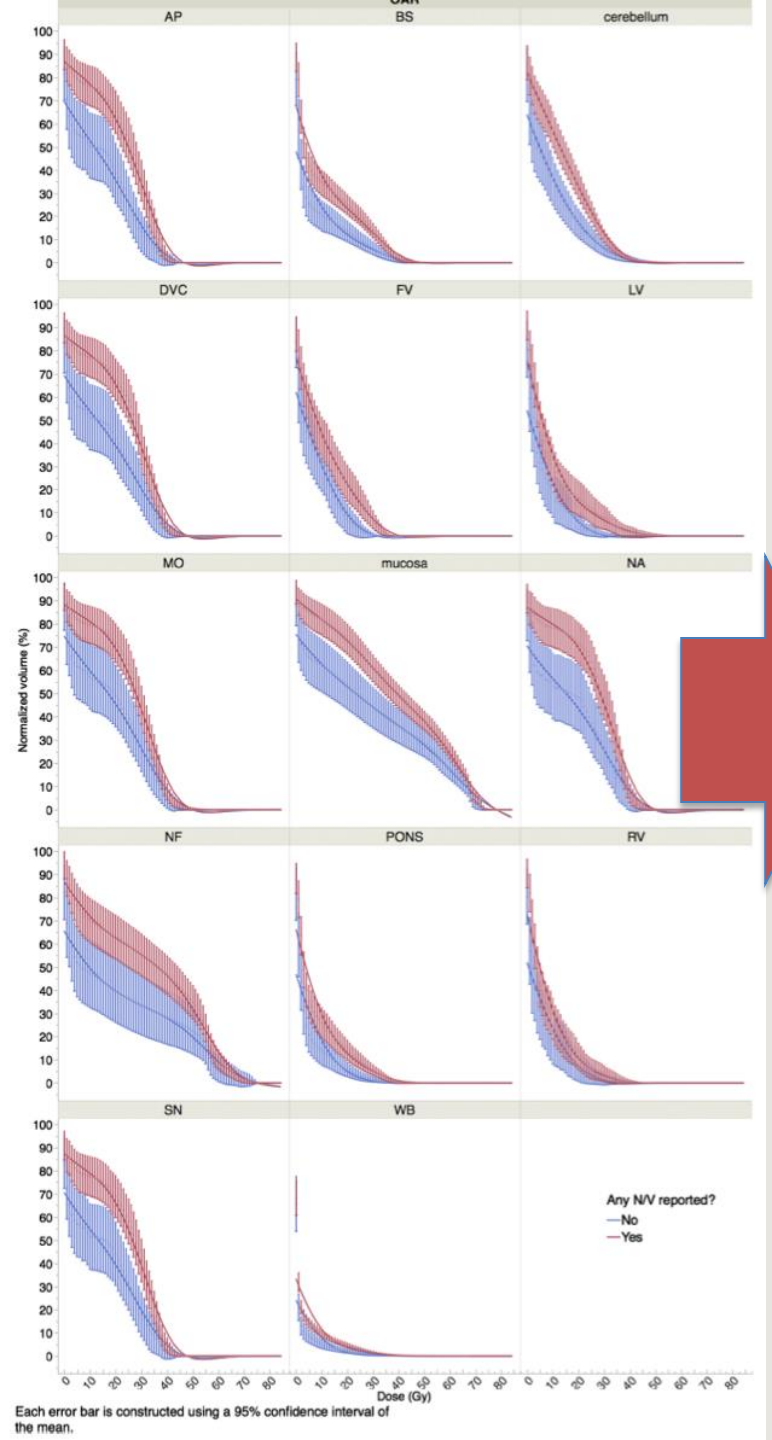


Fig. 1. Sagittal, coronal, axial view of the CNV-ROIs: DVC (Dorsal vagal complex), AP (Area postrema), NA (Nucleus ambiguus) SN (Solitary Nucleus), BS (Brainstem), FV (Forth Ventricle), NF (Nasopharyngeal mucosa), Cerebellum, Mucosa (Oropharyngeal mucosa), Pons (Pons), WB (Whole brain).



Bigger numbers= more powerful stats= Better patient care

Table 2
Four RPA-derived candidate OAR-dose–thresholds for univariate and multivariate assessment using comparison of *p*-values.

Source	MV	UV
DVC median ⩾ 26.9%	0.054121932	0.0014*
BS mean ⩾ 36 Gy	0.08	0.0022*
TV 40 > 80%	0.548212802	0.3504
Mucosa V70 > 0	0.081683735	0.0055*
AP V24 ⩾ 76%	0.021464091*	0.0001*
WB V16 > 5%	0.044658738	0.0001*
SN V20 > 99%	0.417539352	0.0001*

* Significant *p*-value.

Aspiration Pneumonia After Concurrent Chemoradiotherapy for Head and Neck Cancer

Beibei Xu, PhD[1]; Isabel J. Boero, BS[2]; Lindsay Hwang, BS[2]; Quynh-Thu Le, MD[3]; Vitali Moiseenko, PhD[2]; Parag R. Sanghvi, MD[2]; Ezra E. W. Cohen, MD[4]; Loren K. Mell, MD[2]; and James D. Murphy, MD, MS[2]

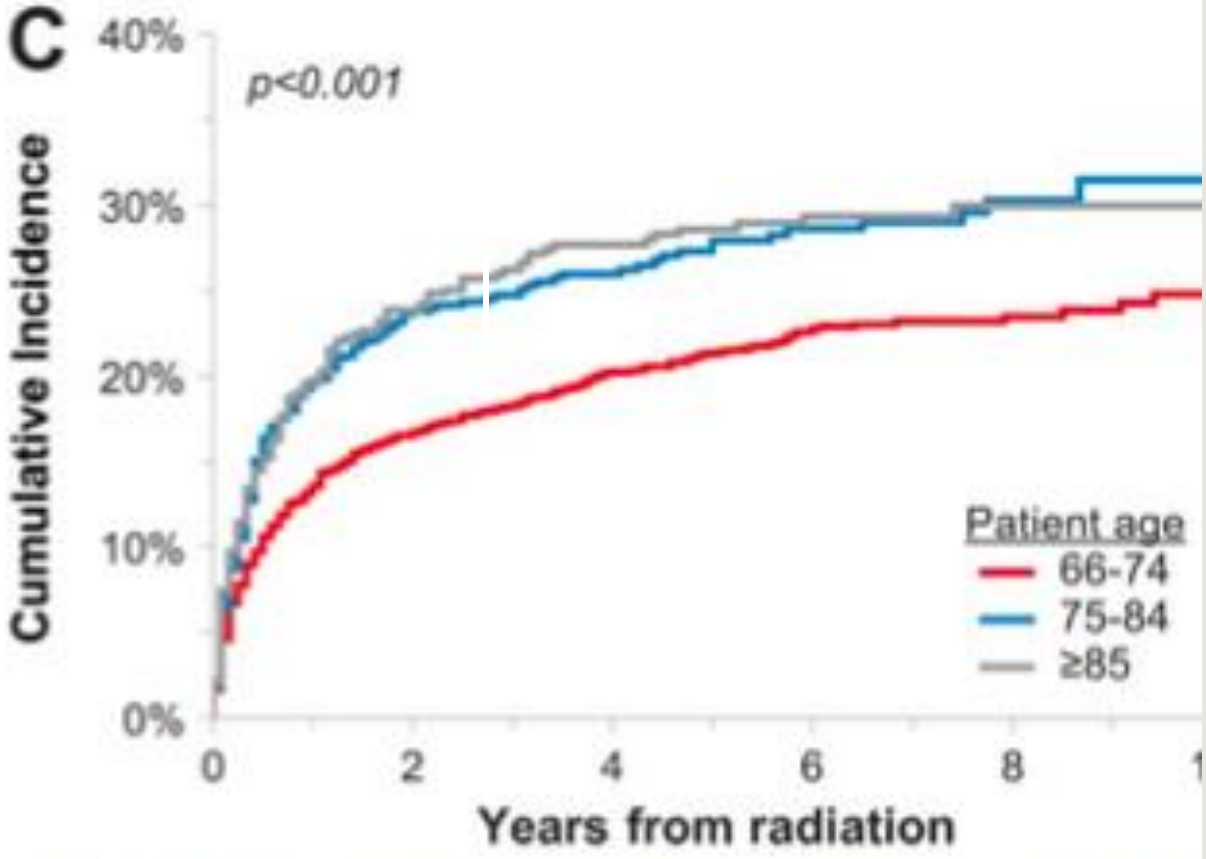


Figure 2. The cumulative incidence of aspiration pneumonia i

Prevention and Treatment of Dysphagia and Aspiration After Chemoradiation for Head and Neck Cancer

David I. Rosenthal, Jan S. Lewin, and Avraham Eisbruch

Table 2. Chemoradiation Trials: Therapeutic and Functional Outcomes

Trial	Radiation Therapy	Chemotherapy	Mucositis Grade 3 + 4	Swallowing Toxicity
RTOG 99-14[94]	72 Gy over 6 weeks; single arm; phase II	Cisplatin	67%	FT rate, 82.9%; 1 year, 40.9%; 2 years, 21.8%
Starr[95]	69.9 Gy over 38 days	Fluorouracil + carboplatin	68% *v* 52%; $P = .01$	2-year FT rates, 51% *v* 25%; $P = .02$
RTOG 91-11[6]	70 Gy over 7 weeks	Cisplatin	43% *v* 24%	1 year, softs or liquids only, 23% *v* 9%; 1 year, FT, 3% *v* none; 2 years, 14%-16% of both groups had "difficulty swallowing"
Intergroup 0126[5]	70 Gy over 7 weeks	Cisplatin	43% *v* 32%; $P = .08$	52% *v* 40%; $P = .08$; acute FT ratios
Abitbol[15]	74.4 Gy over 16 weeks	Cisplatin; fluorouracil + mitomycin-C	65%	5%, pharynx soft tissue necrosis; 6%, aspiration pneumonia chronic; 18% FT dependent chronic; 7%, liquids only
Eisbruch[60]	70 Gy; single arm; phase I	Gemcitabine	Grade 3 or higher for all	Acute FT rate, 82% all, 92% > 10 mg/m^2; chronic FT rate, 28% (associated with pharyngeal ulceration, aspiration, and obstruction not relieved by dilation
GORTEC 94-01[96]	70 Gy over 7 weeks	Carboplatin + fluorouracil	Grade 3/4; 71% *v* 39%	FT rates overall, 37% *v* 15%; $P = .02$; 15%; > 10% weight loss, 14% *v* 6%; $P = .04$
Kies[97]	75 Gy over 9 weeks; single arm; phase I	Paclitaxel; carboplatin; fluorouracil		1-year FT rate, 20%

*Abbreviations: RTOG, Radiation Therapy Oncology Group; GORTEC, Groupe Oncologie Radiothérapie Tête Et Cou; FT, feeding tube.

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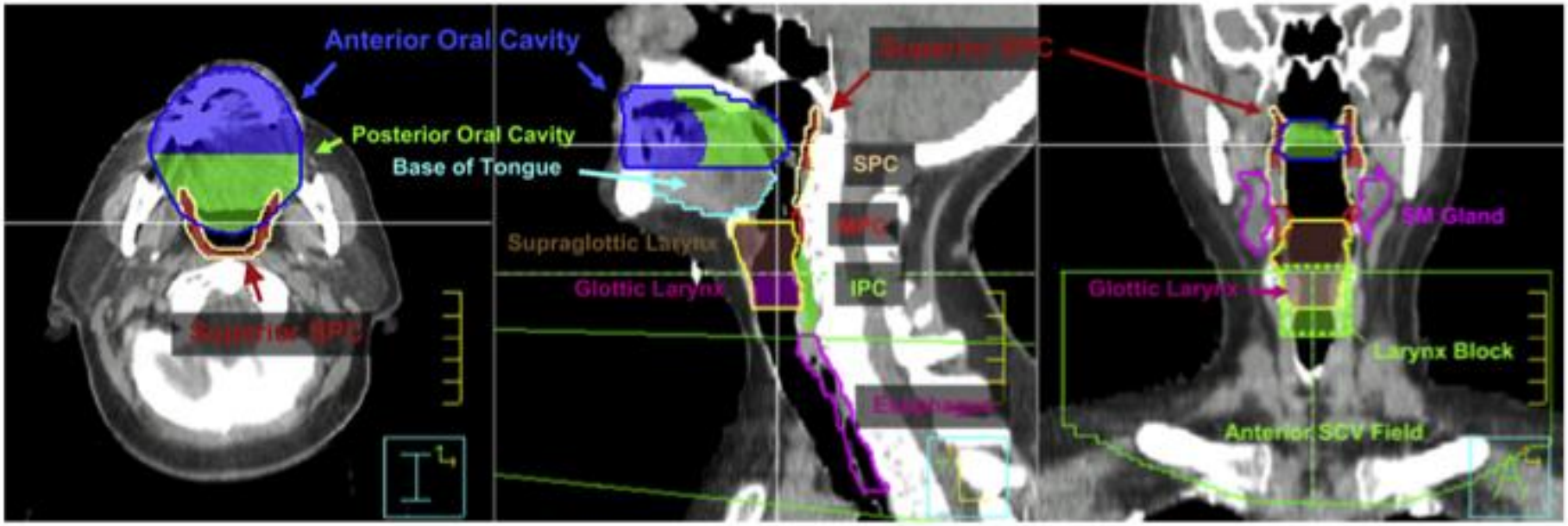
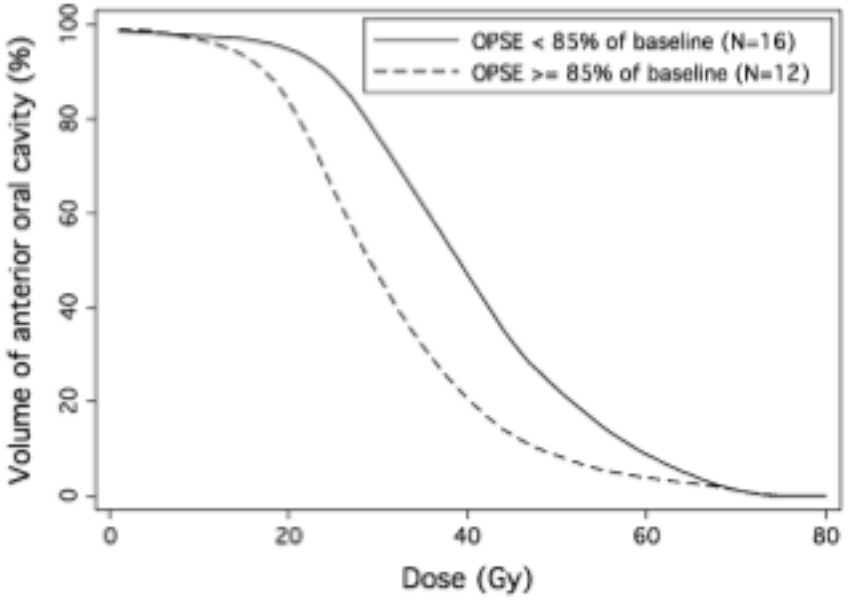
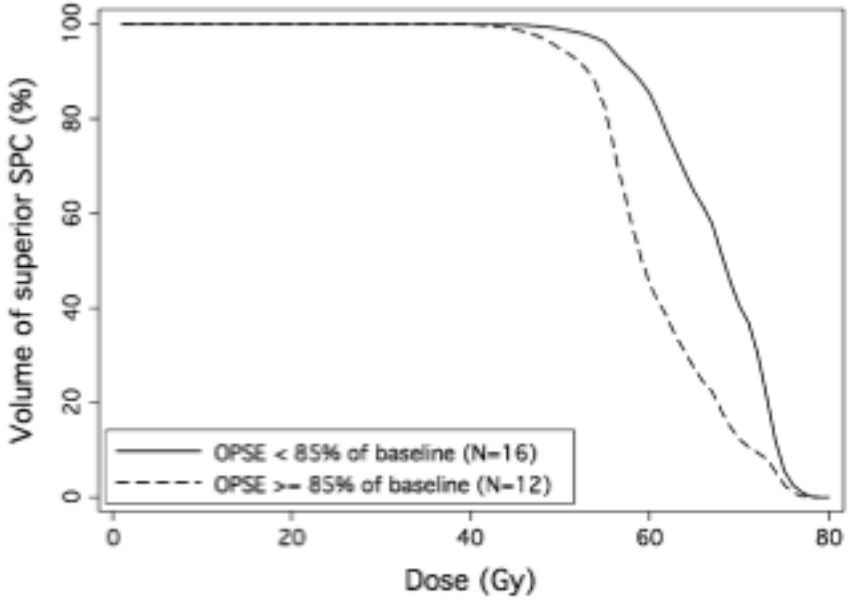
JOURNAL OF CLINICAL ONCOLOGY


Anterior Oral Cavity
Posterior Oral Cavity
Base of Tongue
Superior SPC
SPC
MPC
IPC
Supraglottic Larynx
Glottic Larynx
SM Gland
Glottic Larynx
Larynx Block
Anterior SCV Field


OPSE < 85% of baseline (N=16)
OPSE >= 85% of baseline (N=12)
Volume of anterior oral cavity (%)
0
20
40
60
80
100
Dose (Gy)
0
20
40
60
80


OPSE < 85% of baseline (N=16)
OPSE >= 85% of baseline (N=12)
Volume of superior SPC (%)
0
20
40
60
80
100
Dose (Gy)
0
20
40
60
80

Where to spare?

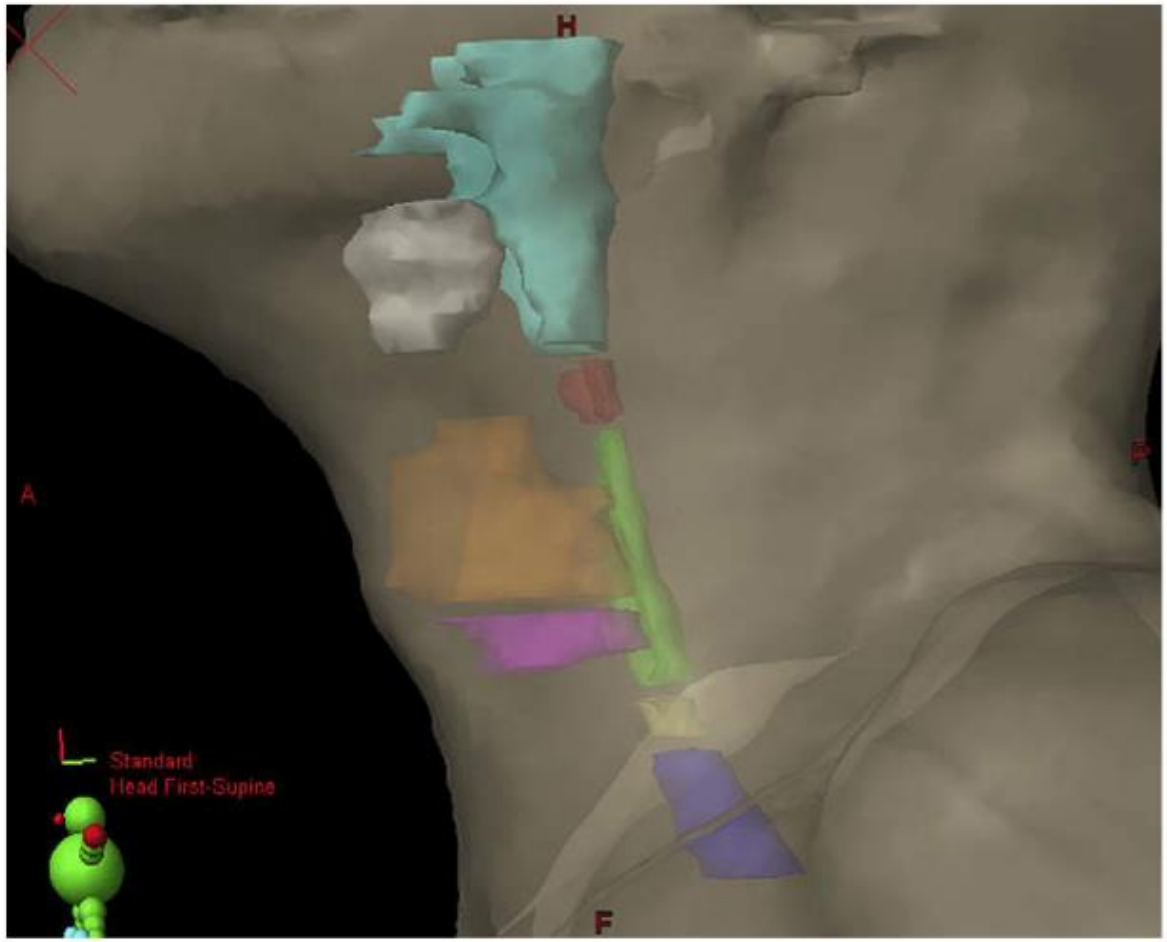


Fig. 1. Swallowing structures: superior pharyngeal constrictor muscle (cyan blue), middle pharyngeal constrictor muscle (red), inferior pharyngeal constrictor muscle (green), upper esophageal sphincter (yellow), esophagus (dark blue), base of tongue (white), supraglottic larynx (orange), and glottic larynx (magenta).

Int. J. Radiation Oncology Biol. Phys., Vol. 75, No. 2, pp. 385–392, 2009

0360-3016/09/$–see front matter

ELSEVIER

doi:10.1016/j.ijrobp.2008.11.041

CLINICAL INVESTIGATION **Head and Neck**

DYSPHAGIA AFTER CHEMORADIOTHERAPY FOR HEAD-AND-NECK SQUAMOUS CELL CARCINOMA: DOSE–EFFECT RELATIONSHIPS FOR THE SWALLOWING STRUCTURES

PIET DIRIX, M.D.,* SARAH ABBEEL, M.D.,* BIANCA VANSTRAELEN,* ROBERT HERMANS, M.D. PH.D.,† AND SANDRA NUYTS, M.D. PH.D.*

Departments of *Radiation Oncology, and †Radiology, Leuvens Kankerinstituut, University Hospitals Leuven, campus Gasthuisberg, Leuven, Belgium

Table 8. Overview of the literature

			Dosimetric parameter							
First author (Ref.)	No.	Site	Mean PC	Mean larynx	Mean ES	V50 PC	V60 PC	V50 larynx	V60 larynx	Endpoint
Feng (18)	36	OP/NP	0.008	0.032	NS	0.008	0.006	0.016	NS	VF
Levendag (19)	56	OP	0.02	–	NS	–	–	–	–	HNSW
Jensen (20)	25	HP/OP/NP	NS	0.048	NS	NS	NS	NS	0.035	HNSW
Caglar (21)	96	All	0.007	0.003	NS	0.05	NS	0.04	NS	VF
Present study	53	All	0.02	0.04	NS	0.04	NS	0.08	NS	HNSW

Abbreviations: ES = esophagus; HNSW = QLQ-H&N35 swallowing symptom score; HP = hypopharynx; No. = number of patients included in the analysis; NP = nasopharynx; OP = oropharynx; PC = pharyngeal constrictor muscles; VF = videofluoroscopy.

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journal homepage: www.thegreenjournal.com

Swallowing dysfunction

A predictive model for swallowing dysfunction after curative radiotherapy in head and neck cancer

Johannes A. Langendijk [a,b,*], Patricia Doornaert [a], Derek H.F. Rietveld [a], Irma M. Verdonck-de Leeuw [c], C. René Leemans [c], Ben J. Slotman [a]

[a] Department of Radiation Oncology, VU University Medical Center, Amsterdam, The Netherlands
[b] Department of Radiation Oncology, University Medical Center Groningen, The Netherlands
[c] Department of Otolaryngology/Head and Neck Surgery, VU University Medical Center, Amsterdam, The Netherlands

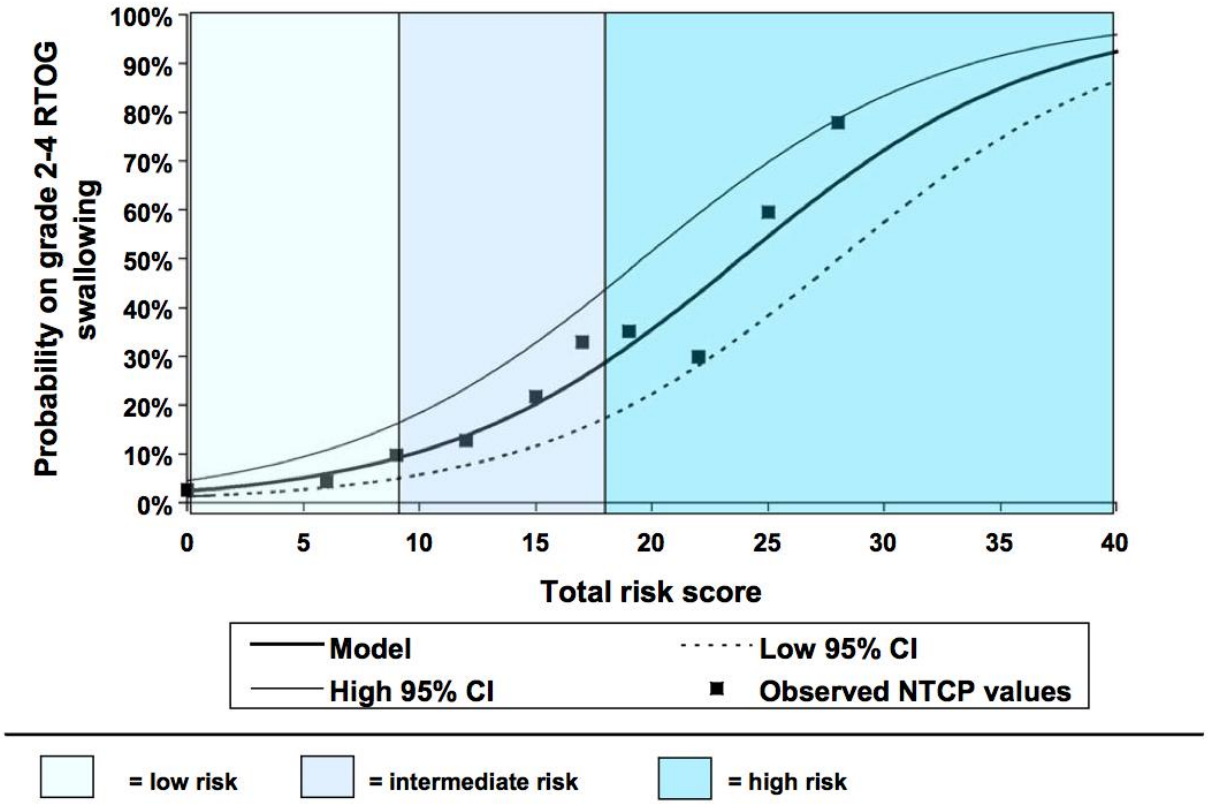


Fig. 1. Final model with probability on grade 2–4 RTOG swallowing dysfunction at 6 months as a function of the total risk score. The observed NTCP values all fall within the 95% confidence interval.

Int. J. Radiation Oncology Biol. Phys., Vol. 79, No. 1, pp. 52–59, 2011

0360-3016/$–see front matter

ELSEVIER

doi:10.1016/j.ijrobp.2009.10.057

CLINICAL INVESTIGATION **Head and Neck**

WEEKLY DOSE–VOLUME PARAMETERS OF MUCOSA AND CONSTRICTOR MUSCLES PREDICT THE USE OF PERCUTANEOUS ENDOSCOPIC GASTROSTOMY DURING EXCLUSIVE INTENSITY-MODULATED RADIOTHERAPY FOR OROPHARYNGEAL CANCER

Giuseppe Sanguineti, M.D.,*† G. Brandon Gunn, M.D.,* Brent C. Parker, Ph.D.,* Eugene J. Endres, C.M.D.,* Jing Zeng, M.D.,† and Claudio Fiorino, Ph.D.‡

*Department of Radiation Oncology, University of Texas Medical Branch, Galveston, TX; †Department of Radiation Oncology and Molecular Radiation Sciences, Johns Hopkins University, Baltimore, MD; and ‡Department of Medical Physics, San Raffaele Scientific Institute, Milano, Italy

Table 3. Summary of results of univariate logistic analysis (p values < 0.20)*

Variable	Structure	OR	95% CI	p
Dmean (cGy)	Oral mucosa	1.0016	1.0003–1.029	0.015
Dmeanw (cGy)	Oral mucosa	1.0073	1.0022–1.0124	0.005
V9.5 Gy/week (cm^3)	Oral mucosa	1.029	1.010–1.049	0.003
V10 Gy/week (cm^3)	Oral mucosa	1.024	1.008–1.041	0.003
Dmeanw (cGy)	Larynx	1.0033	0.9997–1.0070	0.07
Dmeanw (cGy)	Superior constrictor	1.0061	1.0018–1.0104	0.005
Dmeanw (cGy)	Middle constrictor	1.0072	1.0023–1.0121	0.004
Dmeanw (cGy)	Inferior constrictor	1.0051	1.0071–1.0095	0.02
Fractionation (no-HYPER vs HYPER)		0.17	0.05–0.63	0.008

Abbreviations as in Table 2.
* Endpoint: risk of ≥3-month percutaneous endoscopic gastrostomy dependence.

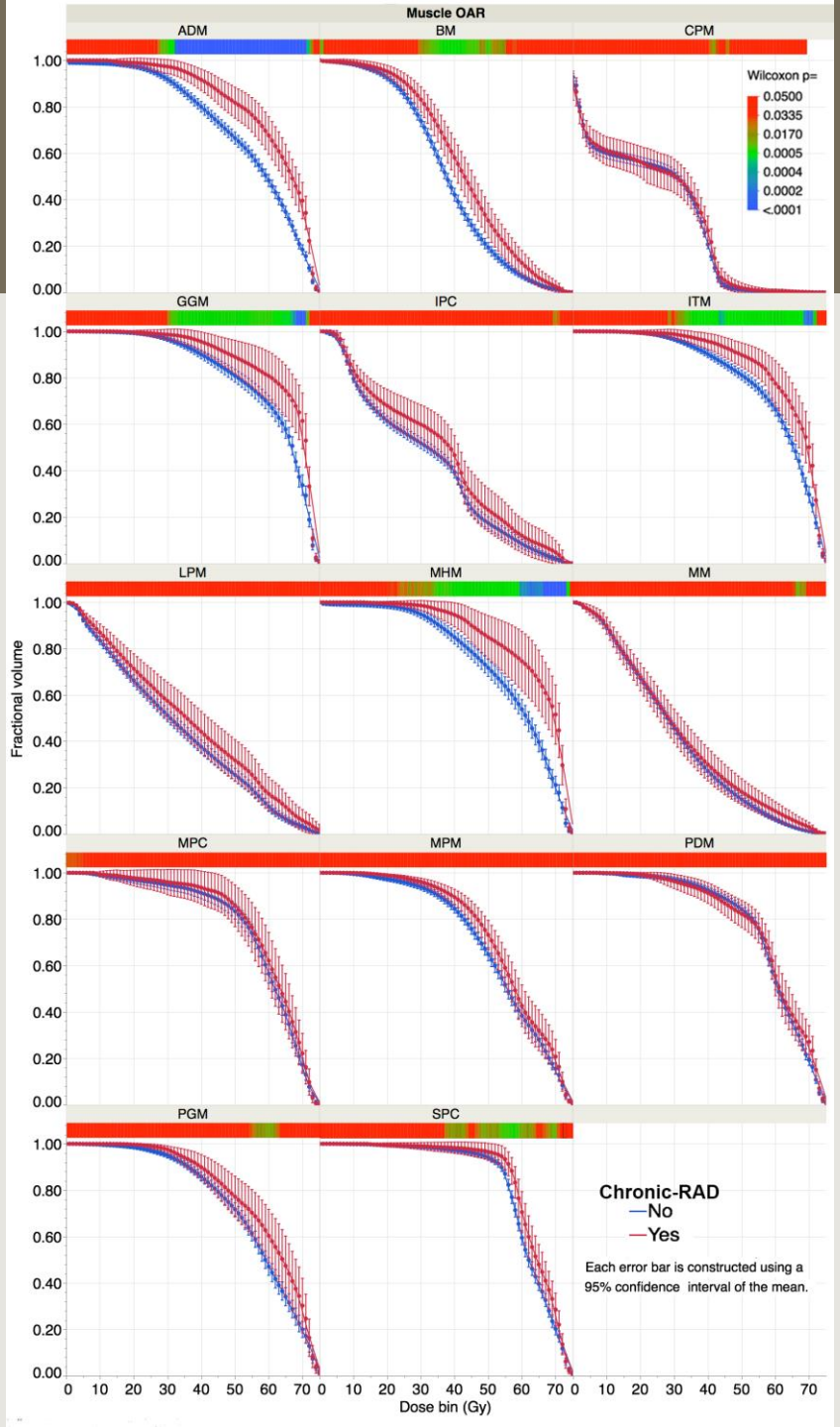
Beyond mean pharyngeal constrictor dose for beam path toxicity in non-target swallowing muscles: Dose–volume correlates of chronic radiation-associated dysphagia (RAD) after oropharyngeal intensity modulated radiotherapy ☆

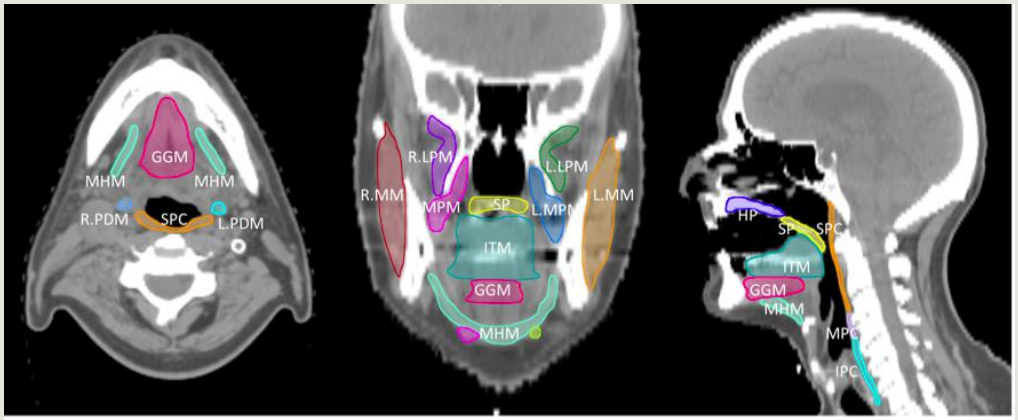
MD Anderson Head and Neck Cancer Symptom Working Group (

Recursive partitioning analysis								Confirmatory univariate nominal logistic regression				
Muscle OAR	V-level	Percent-threshold (%)	ROC AUC cohort (test)	ROC AUC holdback (verification)	LogWorth	*p*-Value	SS	Odds ratio (95% CI)	Relative risk (95% CI)	BIC	ΔBIC	Evidence grade §
ADM	60	79	0.68	0.60	5.95	<.0001	**	2.88 (1.32–6.12)	2.48 (1.32–4.65)	216.55	12.21	Very strong
BM	35	65.8	0.65	0.57	1.09	0.0815	n.s.	–				
CPM	45	0.35	0.64	0.51	1.00	0.0998	n.s.	–				
GGM	35	98.9	0.70	0.55	2.74	0.0018	**	3.65 (1.69–8.54)	3.17 (1.53–6.57)	212.08	7.73	Strong
IPC	70	98.2	0.60	0.51	1.08	0.0831	n.s.					
ITM	47	99.9	0.67	0.44	2.83	0.0015	*	2.66 (1.13–5.90)	2.30 (1.18–4.48)	218.48	14.14	Very strong
LPM	66	13.1	0.53	0.35	1.07	0.0860	n.s.	–				
LRX	63	1	0.61	0.47	0.89	0.1274	n.s.	–				
MHM	69	17.5	0.74	0.64	6.77	<.0001	**	4.54 (2.14–10.33)	3.81 (1.89–7.67)	204.34	0.00	$BIC_{minimum}$ (reference)
MM	66	4.4	0.61	0.53	0.88	0.1314	n.s.	–				
MPC	49	99.9	0.63	0.54	0.17	0.6825	n.s.	–				
MPM	70	1	0.59	0.45	3.31	0.0005	*	2.64 (1.27–5.72)	2.37 (1.22–4.60)	216.60	12.25	Very strong
PDM	69	13.5	0.60	0.48	0.15	0.7070	n.s.	–				
PGM	65	68.9	0.62	0.49	0.24	0.5732	n.s.	–				
SPC	70	6.35	0.68	0.47	5.09	<.0001	**	10.60 (3.12–45.16)	9.00 (2.20–36.83)	205.14	0.80	Weak

* Statistically significant at $P < 0.05$.
** Statistically significant after Bonferroni correction.

Reality: Everything matters!!





But need way to link dose to ROI and clinical outcomes in large datasets

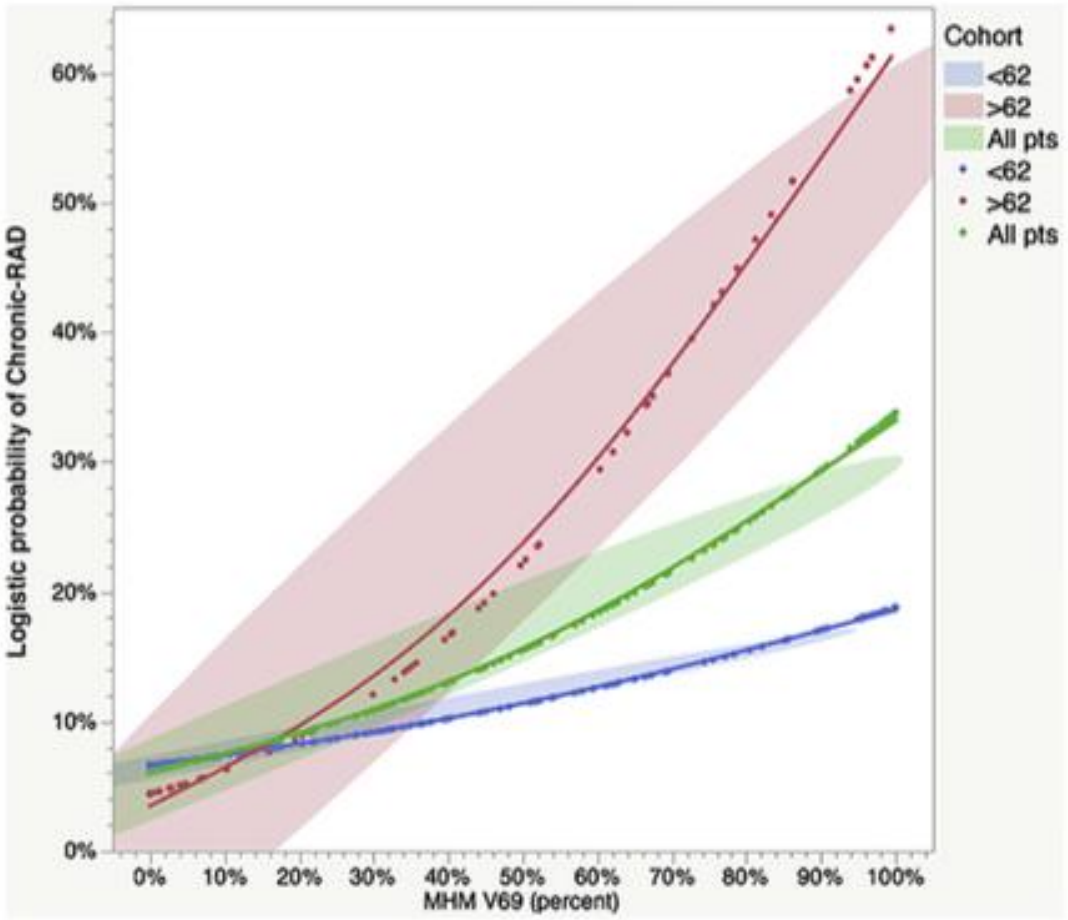


Fig. 4. Chronic RAD as a function MHM V69 by Age. Composite plot of MHM V69 (as a continuous variable) and age cohort (green shading denotes the observed whole population; red identifies patients over 62 years of age; blue indicates patients less than 62 years old). Smoothed fits are shown with color-specific ellipses covering 95% of observed values for each cohort as a visual uncertainty estimator.

MDACC is big…

- 8 Head and neck only Rad oncs
- Treat ~1,000 cases annually
- 6 distinct platforms used for portions of segmentation/optimization tasks (Monaco, Brain lab, Pinnacle, Eclipse, 2 internal custom platforms for MC)
- 4 additional software platforms used for dose calculation/DVH analysis (Velocity, MimVista, Slicer3D, CERR)
- But we couldn’t effectively aggregate data from DVHs!!

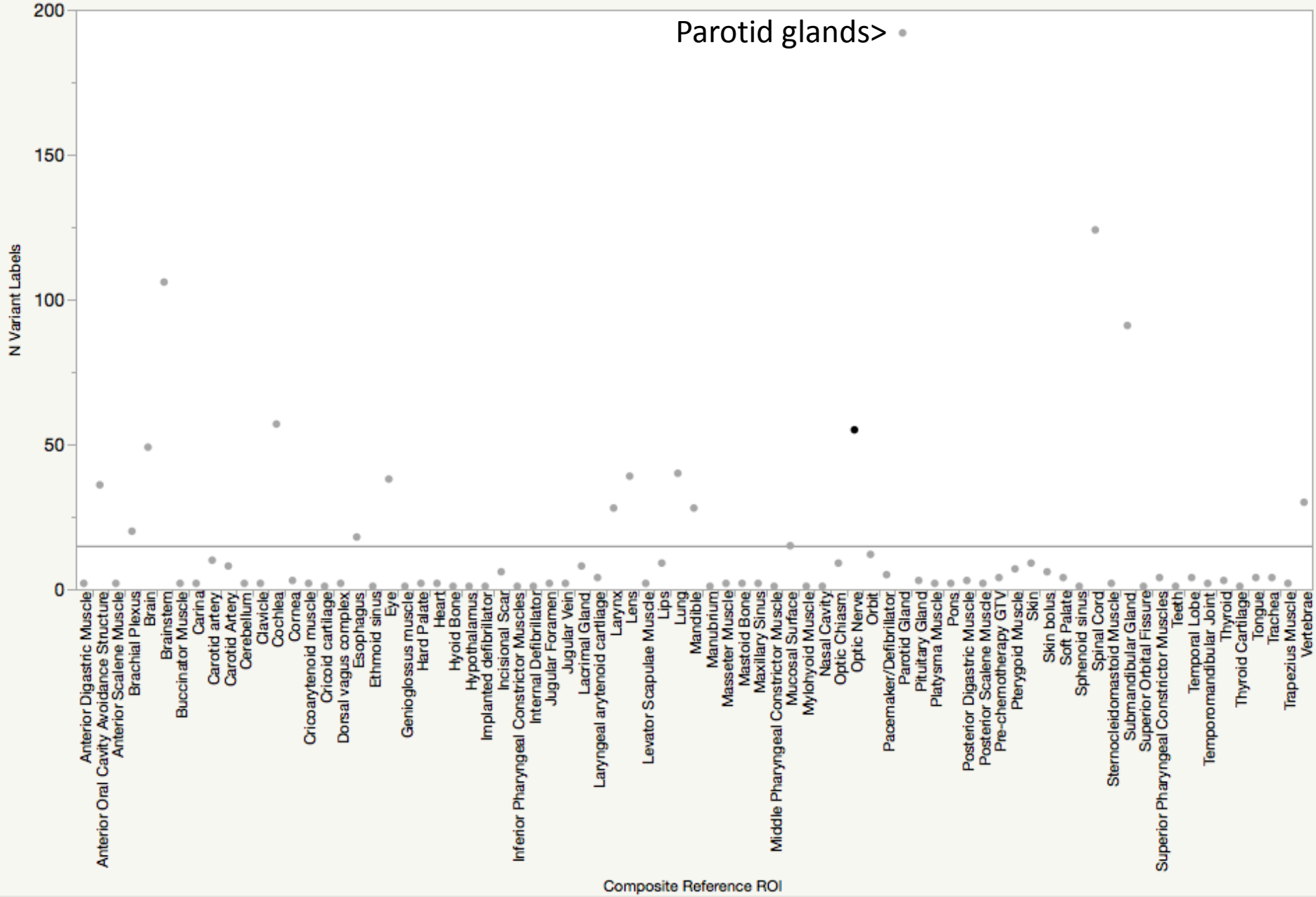
For head and neck and enormous amount of structures are being optimized/evaluated

- 2003-2011
  - Internal complexity check showed an average of 3 target volumes per MDACC head and neck patient (stable)…
  - *Average* number of OARs constrained for IMRT optimization increased from 3 >> 9 per patient; as many as 25+ ROIs for complex sinonasal cases
  - Routinely used include:
    - Cord
    - Parotids (L/R)
    - Brainstem
    - Cochleas (L/R)
    - Brain
    - Larynx
    - Mandible
    - Submandibular glands (L/R)

2014 internal survey

- Electronic data capture of 512 IMRT head and neck cases (bulk pull from DVH archives)
- Showed 78 identifiable TVs/OARs (concatenating intermediary ”ring” or “sub” structures
- Counted “name variants”
  - E.g. “tongue, oral tongue, tng”, all counted as variants of “Tongue”.
- Laterality ignored

- ”Target volume”>


Parotid glands>
N Variant Labels
200
150
100
50
0
Anterior Digastric Muscle
Anterior Oral Cavity Avoidance Structure
Anterior Scalene Muscle
Brachial Plexus
Brain
Brainstem
Buccinator Muscle
Carina
Carotid artery
Carotid Artery
Cerebellum
Clavicle
Cochlea
Cornea
Cricoarytenoid muscle
Cricoid cartilage
Dorsal vagus complex
Esophagus
Ethmoid sinus
Eye
Genioglossus muscle
Hard Palate
Heart
Hyoid Bone
Hypothalamus
Implanted defibrillator
Incisional Scar
Inferior Pharyngeal Constrictor Muscles
Internal Defibrillator
Jugular Foramen
Jugular Vein
Lacrimal Gland
Laryngeal arytenoid cartilage
Larynx
Lens
Levator Scapulae Muscle
Lips
Lung
Mandible
Manubrium
Masseter Muscle
Mastoid Bone
Maxillary Sinus
Middle Pharyngeal Constrictor Muscle
Mucosal Surface
Mylohyoid Muscle
Nasal Cavity
Optic Chiasm
Optic Nerve
Orbit
Pacemaker/Defibrillator
Parotid Gland
Pituitary Gland
Platysma Muscle
Pons
Posterior Digastric Muscle
Posterior Scalene Muscle
Pre-chemotherapy GTV
Pterygoid Muscle
Skin
Skin bolus
Soft Palate
Sphenoid sinus
Spinal Cord
Sternocleidomastoid Muscle
Submandibular Gland
Superior Orbital Fissure
Superior Pharyngeal Constrictor Muscles
Teeth
Temporal Lobe
Temporomandibular Joint
Thyroid
Thyroid Cartilage
Tongue
Trachea
Trapezius Muscle
Vertebrae
Composite Reference ROI

Example: Parotid Glands

- 192 “nominal variants”
  - Most common (“R_Parotid”) was used 68% of the time
  - Multiple structures on several patients (“R_parotid_sub”)
  - Unclear which was optimized
  - Unclear if manually or autosegmented

The Post-Hoc Nomenclature Solution: Fellows!

2011-2015

Esengul Kocak-Uzel MD, Sisli Eftal Univ., Turkey

Manee-Naad Ruangskul, MD Mahidol University, Thailand

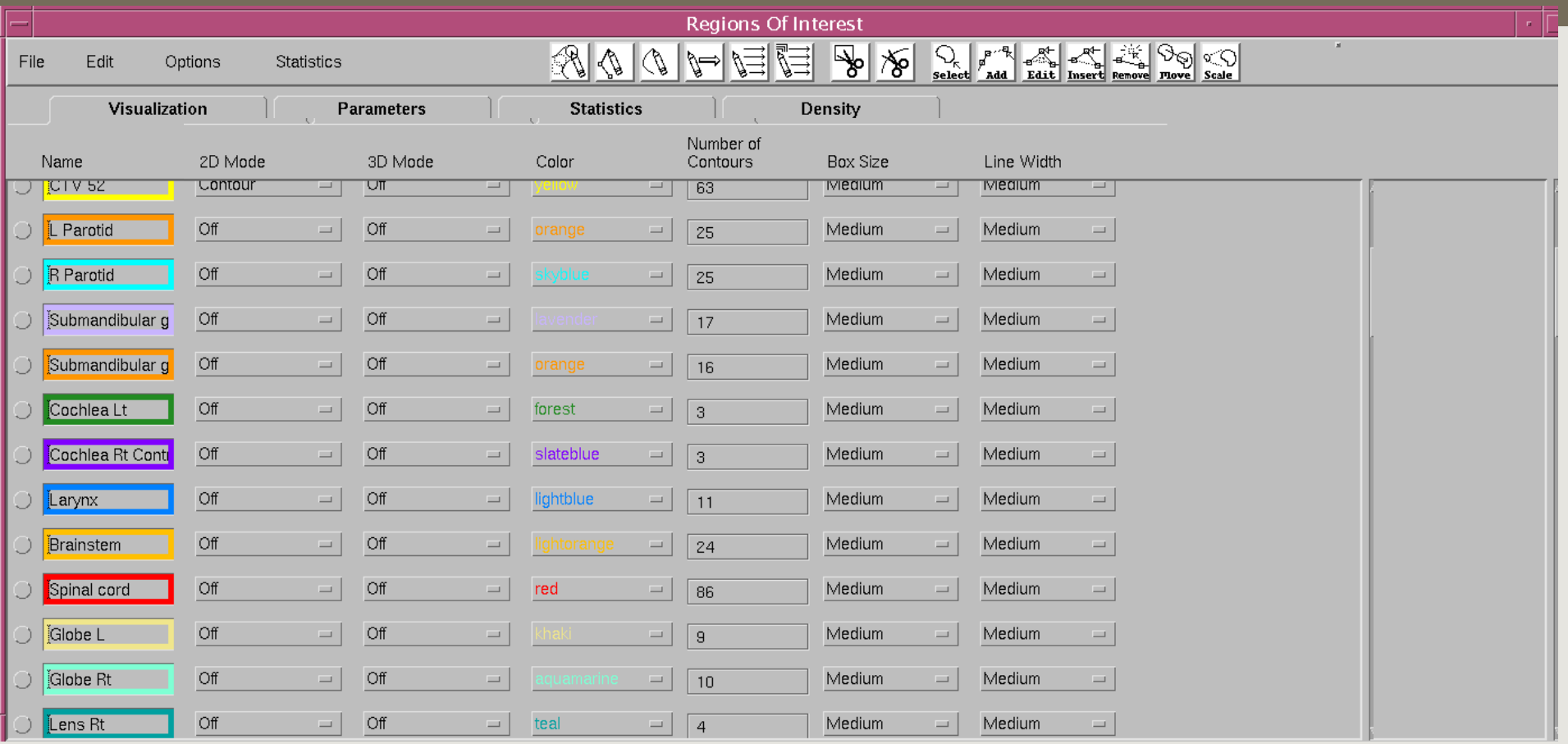
Jared Sturgeon MD, PhD MDACC

Sasikarn Chamchod MD Chulabhorn Hosp.. Thailand

ICRU 50/62-based TV contouring

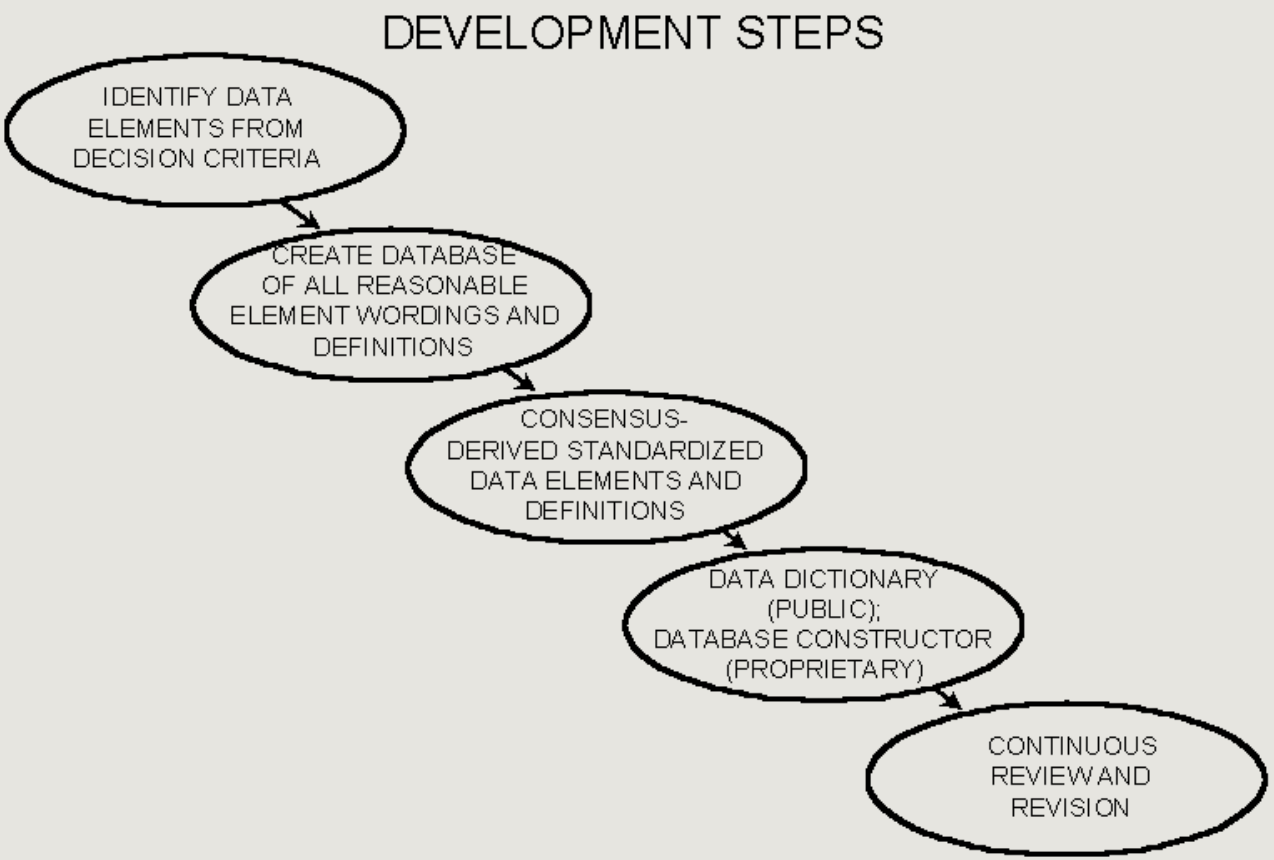
- GTV – Gross disease
- CTV1 - Gross disease + 8mm – 1cm margin
- CTV2 – “High Risk” nodal volumes and mucosal sites
  - A somewhat ambiguous volume that means different things to different individuals.
  - Optional volume in many RTOG protocols
    - i.e. uninvolved level II nodes in base of tongue cancer.
    - the right base of tongue in a left cancer of the glossopharyngeal sulcus
- CTV3 – Uninvolved nodal regions at risk for microscopic disease extension

Example case from 2013



The Core Process begins…

FIGURE 3. DATA STANDARDS/DICTIONARY



- **K. Hammermeister, MD (http://www.uni-mainz.de/FB/Medizin/Kardiologie/incis/Data/p4_1.htm)**

Enter RTOG/ATC/TG-263

Uniform Tissue Names for Use in RTOG Advanced Technology Clinical Trials

Walter R. Bosch, D.Sc.

Consistent naming of contoured structures used in radiotherapy treatment planning is essential to facilitate the comparison of dose-volume statistics across patients for quality assurance and outcomes analysis. Maintaining consistency in structure names is particularly important (and challenging) in multi-institutional clinical trials, in which treatment planning data are collected from many participating institutions. Differences in treatment planning techniques and local languages are among the factors that contribute to variations in the names used to identify structures.

The Image Guided Therapy QA Center (ITC) has developed a Digital Data Integrity QA process to examine submitted RT treatment planning data for completeness and consistency. This process involves resolving discrepancies between submitted and protocol-specified structure names. For some data sets, the mapping between submitted and protocol-specified structure names is obvious, and the process of assigning standard names using ITC tools is straightforward. Other cases, however, require visual inspection of images and contours to identify structures. For trials involving disease sites with many organs at risk, e.g., H/N IMRT, the effort required to correctly identify all structures can be substantial.

http://atc.wustl.edu/resources/RTOG-ATIC/ATIC-ATC_Uniform_Tissue_Names.pdf

Uniform Tissue Names for Use in RTOG Advanced Technology Clinical Trials

Walter R. Bosch, D.Sc.

A. Organs at Risk

1. A list of base names for organs at risk is given in **Table 1**, This list is not exhaustive. It is expected that it will be extended in a consistent manner as new protocols are written.

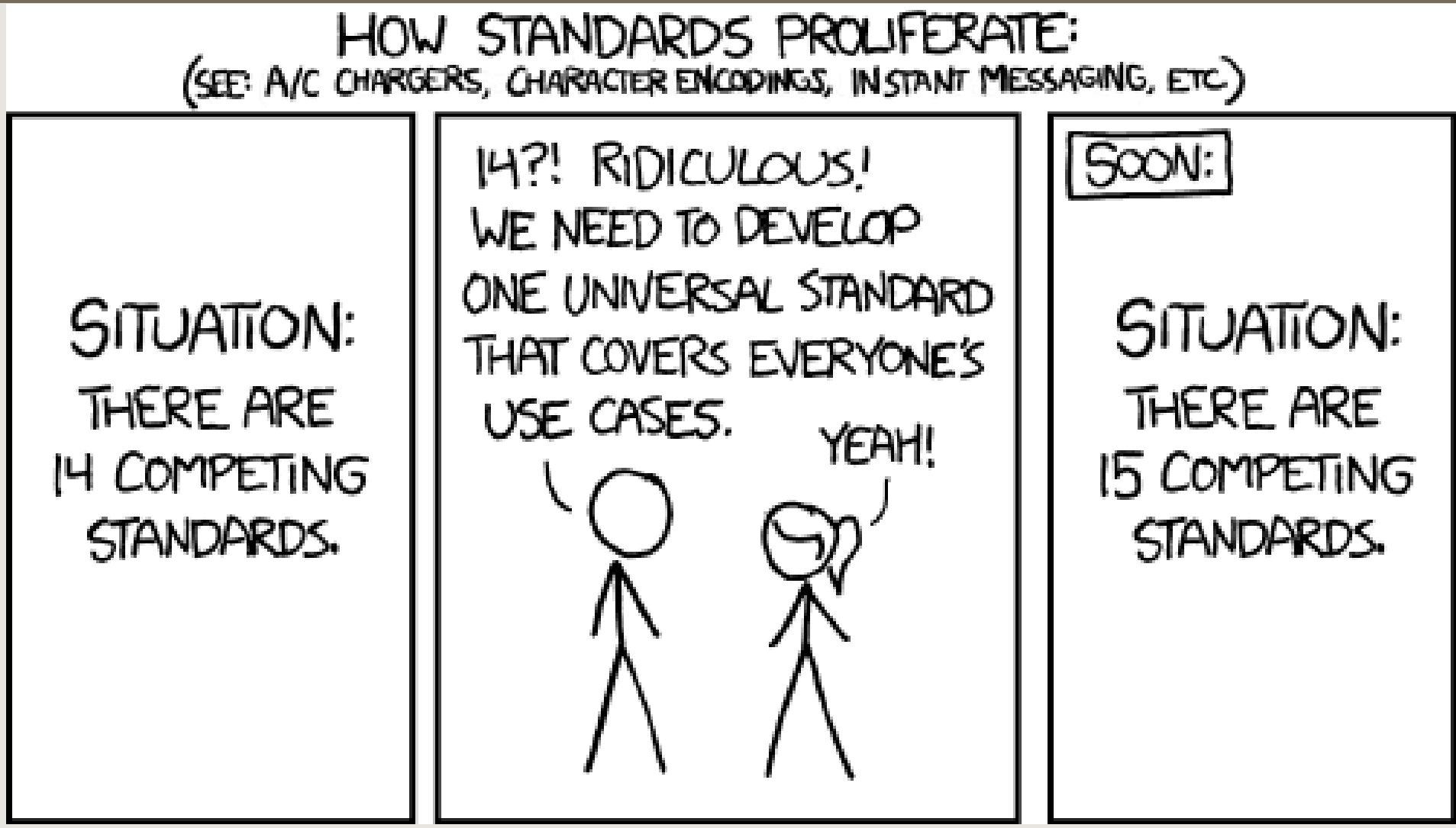
2. For paired organs, right or left organs are identified by appending "_R" or "_L" to the base name. E.g., LUNG_L

3. For geometric extensions of organs (PRVs) with *uniform margin,* a suffix of "_PRV*m*" is appended to the base name, where *m* is an integer indicating the size of the margin in mm, e.g., SPINAL_CORD_PRV5. *Non-uniform* PRVs are identified using the suffix "_PRV", i.e, *without margin size.*

Structure Name	Paired?
ANAL_CANAL	
BLADDER	
BRAC_PLX	_L / _R
BRAIN	
BRAINSTEM	
BREAST	_L / _R
BRONC_TREE	_L / _R
CARINA	
CAUDA_EQUINA	
CEREBELLUM	_L / _R
CEREBRUM	_L / _R
CHIASM	
CN_VII	_L / _R
CN_VIII	_L / _R
COCHLEA	_L / _R
CORNEA	_L / _R
DUODENUM	
EAR_MID	_L / _R
EAR_EXT	_L / _R
ESOPHAGUS	
FEMUR	_L / _R
GLOBE	_L / _R
GLOTTIS	
GREAT_VESS	
HEART	

Structure Name	Paired?
MAIN_BRONC	_L / _R
OPTIC_NRV	_L / _R
ORAL_CAVITY	
OVARY	_L / _R
PAROTID	_L / _R
PENILE_BULB	
PERINEUM	
PHARYNX	
PITUITARY	
PROSTATE	
RECTUM	
RETINA	_L / _R
RIB	
SACRUM	
SEM_VES	
SKIN	
SM_BOWEL	
SPINAL_CORD	
STOMACH	
SUBMND_SALV	_L / _R
TEMP_LOBE	_L / _R
TESTIS	_L / _R
THYROID	
TM_JOINT	_L / _R
TONGUE	

So….


HOW STANDARDS PROLIFERATE:
(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC)
SITUATION: THERE ARE 14 COMPETING STANDARDS.
14?! RIDICULOUS! WE NEED TO DEVELOP ONE UNIVERSAL STANDARD THAT COVERS EVERYONE'S USE CASES.
YEAH!
SOON:
SITUATION: THERE ARE 15 COMPETING STANDARDS.

Standardizing Naming Conventions in Radiation Oncology

Lakshmi Santanam, Ph.D.,* Coen Hurkmans, Ph.D.,† Sasa Mutic, Ph.D.,* Corine van Vliet-Vroegindeweij, Ph.D.,‡ Scott Brame, Ph.D.,* William Straube, M.S.,* James Galvin, D.Sc.,‡ Prabhakar Tripuraneni, M.D.,§ Jeff Michalski, M.D.,* and Walter Bosch, D.Sc.*,¶

Int J Radiation Oncol Biol Phys, Vol. 83, No. 4, pp. 1344–1349, 2012

Table 2 Planning organs at risk volumes

Organ at risk name	Left/right	Margin (mm)	Proposed name
SpinalCord	N/A	Nonuniform	SpinalCord_PRV
SpinalCord PRV	N/A	5	SpinalCord _05
Parotid	Left	0	Parotid_L
Parotid	Right	0	Parotid_R
Total parotid	Left+Right	0	Parotids
Kidney	Left	10	Kidney_L_10

Solution: TG-263

Charge Facilitate improvements in clinical trials and outcome studies by standardizing

1. Structure names across imaging and treatment planning system platforms. Nomenclature will be defined, at minimum, for all anatomic structures identified as by the group as relevant to radiation oncology. The nomenclature schema should be expandable as other structures are identified in future as relevant.
2. Nomenclature for elements of the dose volume histogram curve and related data.
3. Developing templates for clinical trial groups and users of specific software platforms.

Let's start by trying to fix the standardization problems for DVH data

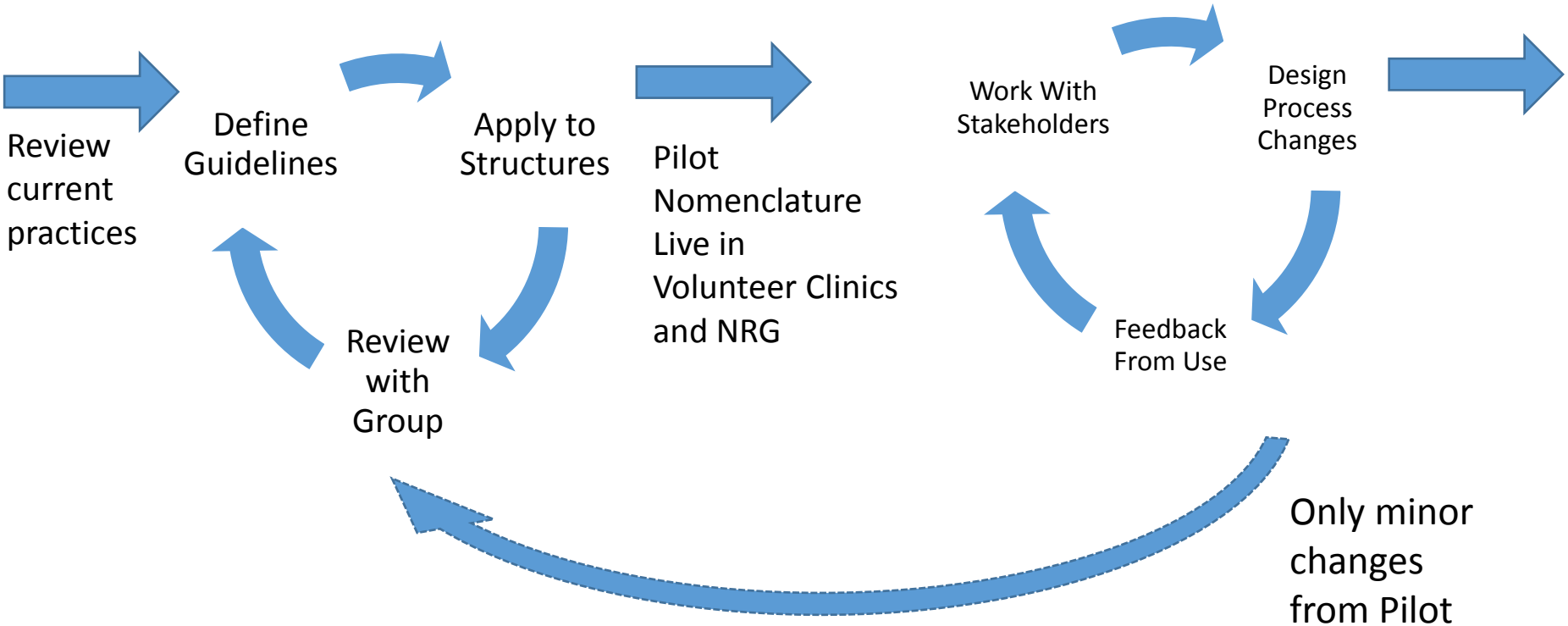
TG 263 - Standardizing Nomenclature for Radiation Therapy

- group of 57 stake holders
- domestic and international groups
- representing a broad range of perspectives

Roles	Professional Societies	Clinic Types	Specialty Groups
Physician	ASTRO	Academic	IHE-RO
Physicist	AAPM	Community	Dicom Working Group
Vendor	ESTRO	Large Practice	NRG
Dosimetry		Small Practice	IROC

Slide courtesy of Chuck Mayo (U. Mich.)

Development Process



Only minor changes from Pilot

Slide courtesy of Chuck Mayo (U. Mich.)

Task Group findings are in parent committee review process

- Guidelines
  - Target Structures
    - Standardized rule based approach (10)
    - Addresses primary issues and expandable
  - Non-Target Structures
    - Rule based approach (15) with a few concessions
    - Specific listing of 736 defined structures
- DVH Nomenclature

Slide courtesy of Chuck Mayo (U. Mich.)

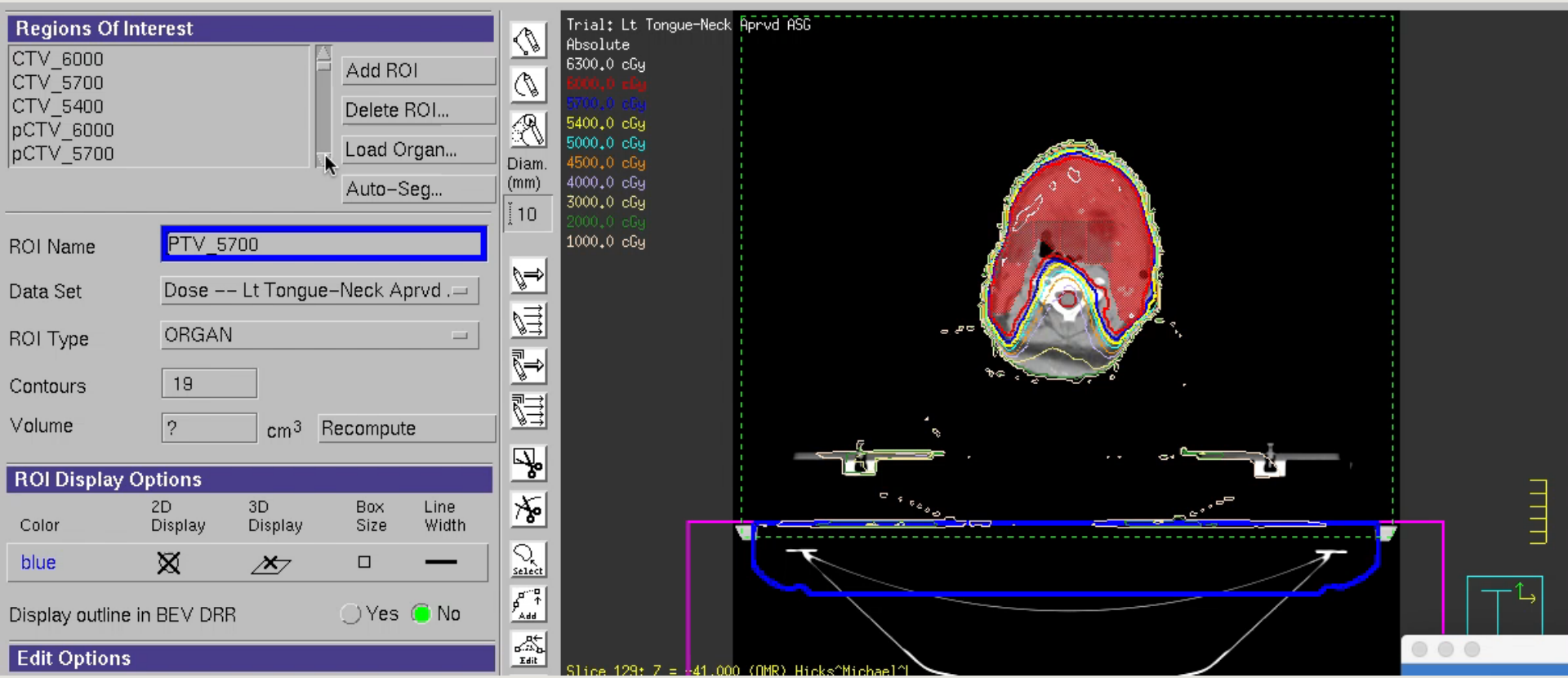
So, we implemented the new system

- V1.0
  - A designated “faculty champion” encouraged MDs to use the new nomenclature.
  - Result: Benign neglect
  - ☹

Insight: MDs hate to type

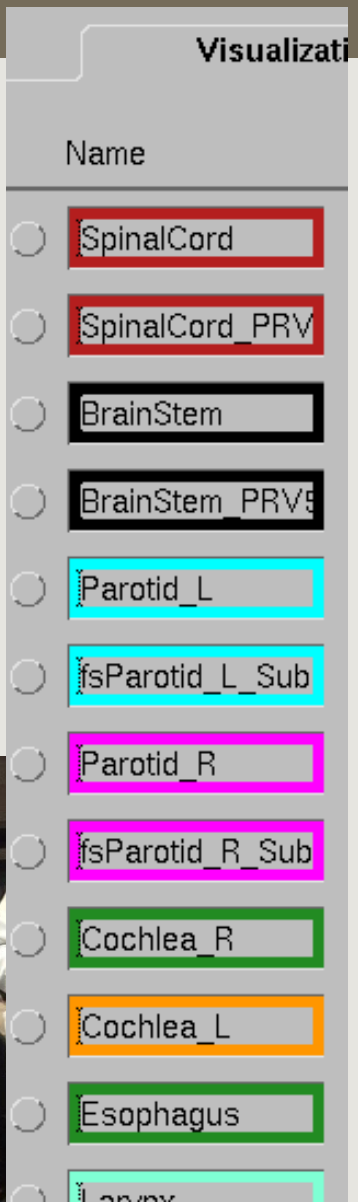
- V2.0
  - Script populated a standardized ROI list in random colors, in alphabetical order
  - Result: ~60% compliance
  - :|

2016 V3.0


Regions Of Interest
CTV_6000
CTV_5700
CTV_5400
pCTV_6000
pCTV_5700
Add ROI
Delete ROI...
Load Organ...
Auto-Seg...
ROI Name
PTV_5700
Data Set
Dose -- Lt Tongue-Neck Aprvd
ROI Type
ORGAN
Contours
19
Volume
?
cm3
Recompute
ROI Display Options
Color
2D Display
3D Display
Box Size
Line Width
blue
Display outline in BEV DRR
Yes
No
Edit Options
Diam. (mm)
10
Trial: Lt Tongue-Neck Aprvd ASG
Absolute
6300.0 cGy
6000.0 cGy
5700.0 cGy
5400.0 cGy
5000.0 cGy
4500.0 cGy
4000.0 cGy
3000.0 cGy
2000.0 cGy
1000.0 cGy
Select
Add
Edit

Insight: MDs like their “system”

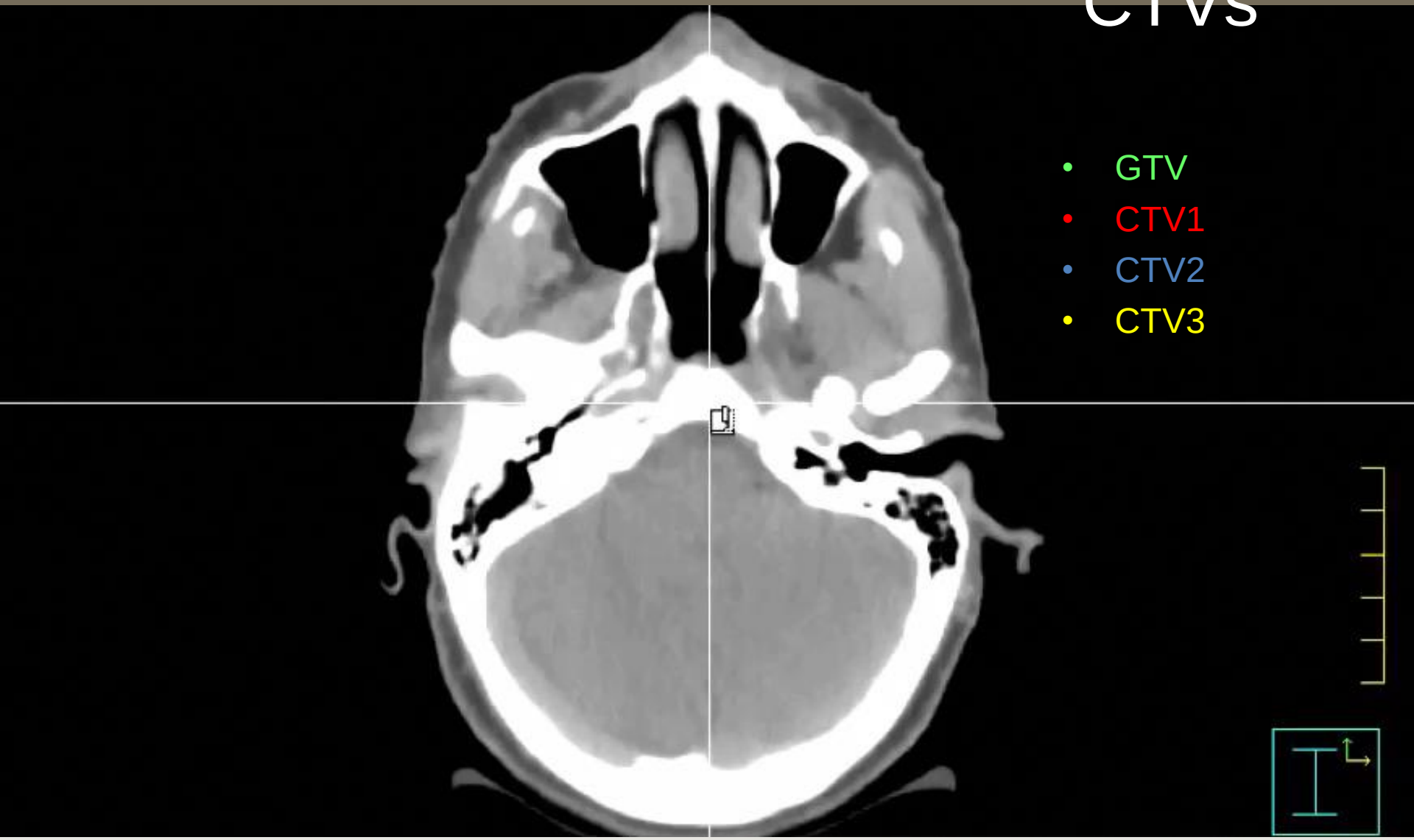
- V3.0
  - Script populated a standardized ROI list in standard colors, in order of use (GTV, CTV, commonly used OARs)
  - Result: >85% compliance
  - ☺



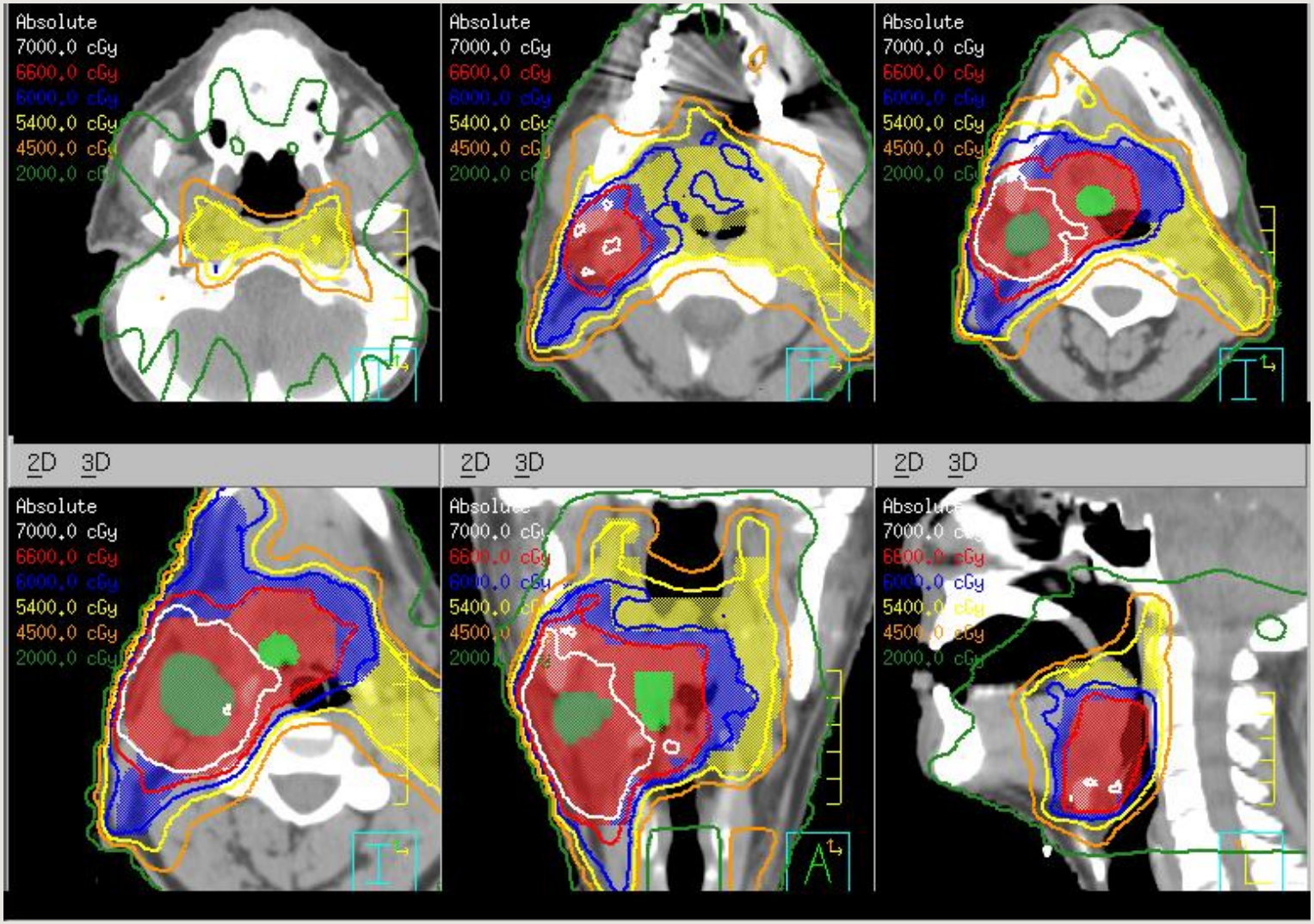
What made it work?

- Ease of use
  - MDs were saved effort by ROI auto-population
- Familiarity
  - Standardized color/polygon modes made direct interaction easier after
  - Intuitive ordering

CTVs



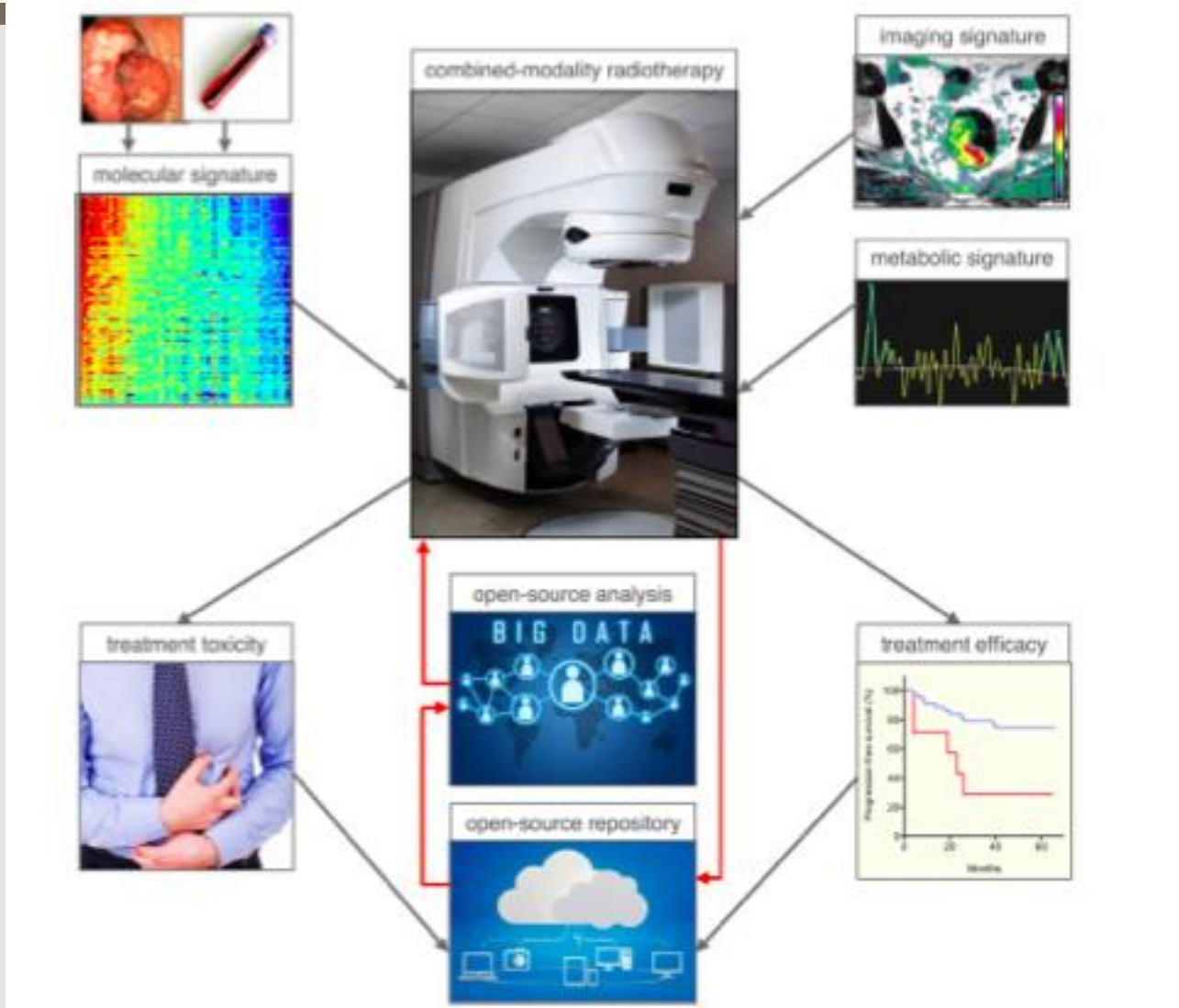
Base of Tongue isodose display



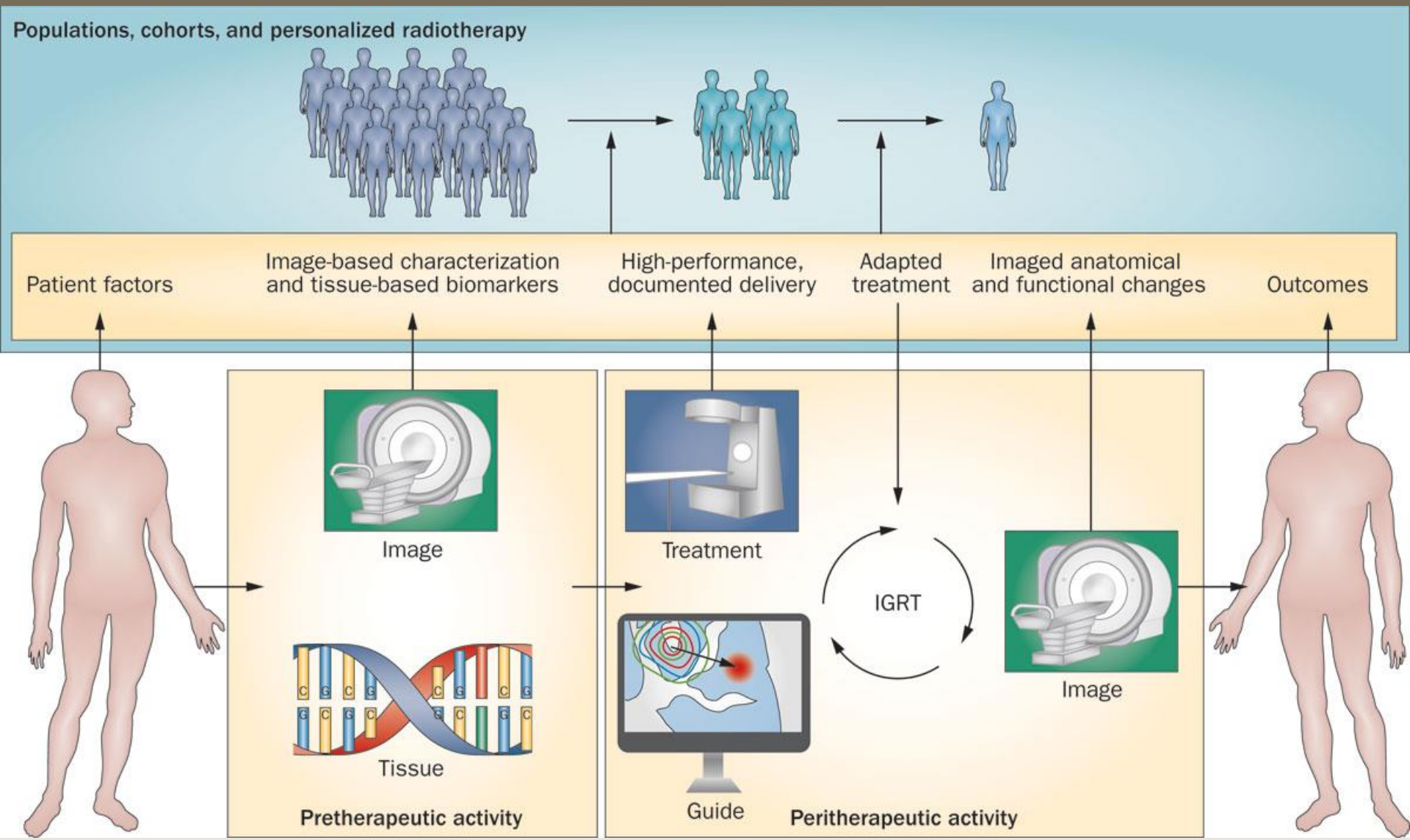
Slide courtesy Adam Garden

Personalized radiotherapy: concepts, biomarkers and trial design

[1,2]A H REE, MD, PhD and [1]K R REDALEN, PhD



Integration of imaging information in designing treatments



Jaffray, D. A. (2012) Image-guided radiotherapy: from current concept to future perspectives
Nat. Rev. Clin. Oncol. doi:10.1038/nrclinonc.2012.194

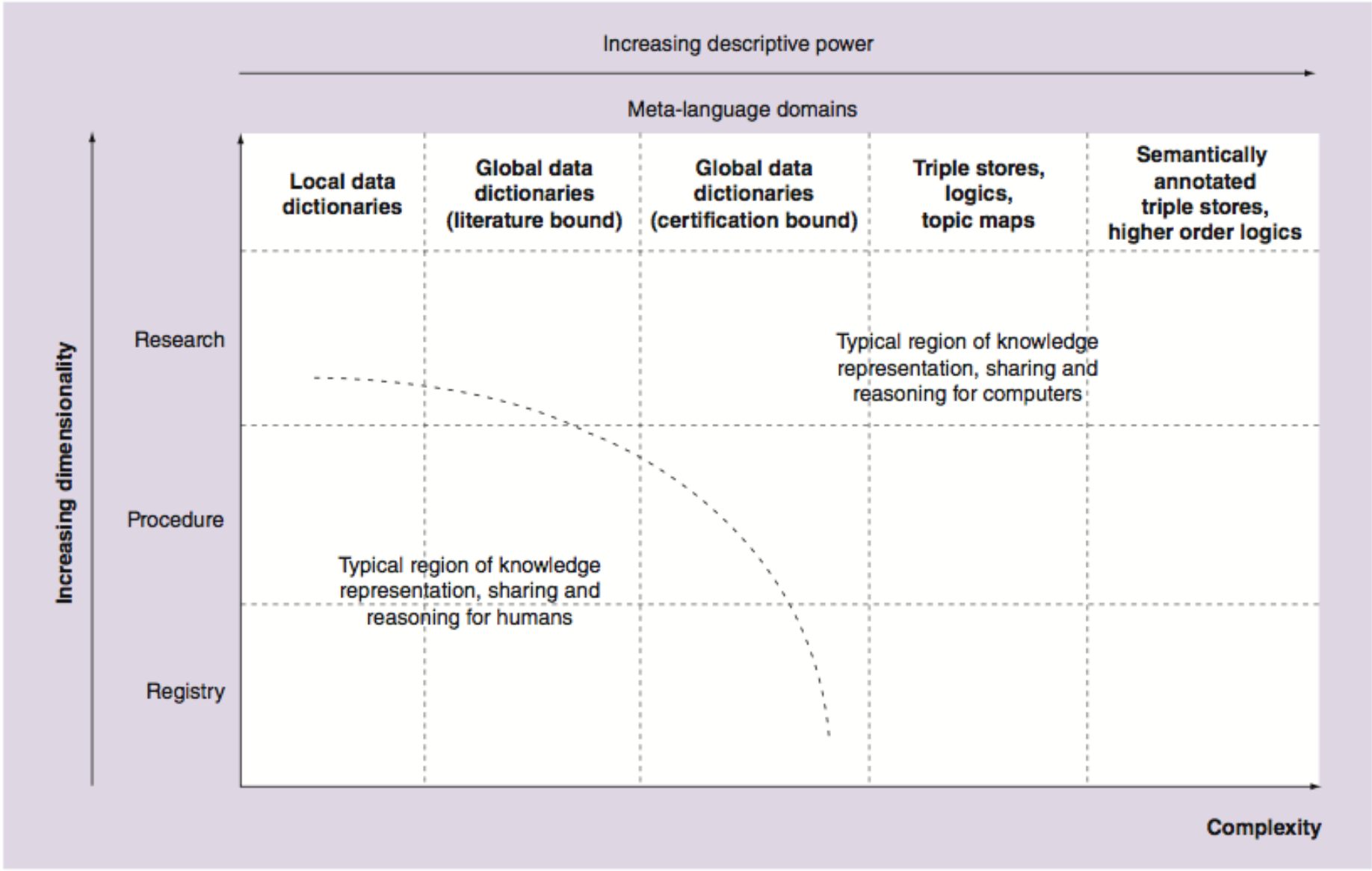


Figure 1. Possible evolution in knowledge representation, seen from the perspective of computer science, under a qualitative point of view.

Technology for Innovation in Radiation Oncology

Indrin J. Chetty, PhD,* Mary K. Martel, PhD,† David A. Jaffray, PhD,‡

1. Integrating radiation oncology databases across the discipline will facilitate science and elevate the quality of care (45). The creation of a Virtual Clinical Trials Group that enables federated databases at different institutions for conducting cooperative research is a consideration. Sharing practices and outcomes will permit high mean and tight variance in clinical practice and will improve quality (46).

2. Tools need to be created and made available for patients and physicians to discuss treatment options, as recommended by the Patient-Centered Outcome Research Institution. Such an approach will drive the development of metatreatment planning systems, in which one prescribes an outcome, not a treatment (eg specification of a 95% local control rate at 5 years with 5% grade 3 or more dyspnea) (6, 47). This could also be expanded beyond radiation oncology.

3. Expertise in the informatics domain among radiation oncology professionals needs to be developed (6). The most suitable candidates with the appropriate skill sets and multidisciplinary knowledge to succeed in this space are likely medical physicists or physicians with strong computational backgrounds. Training grants for developing programs for oncology informatics will provide these individuals with the knowledge needed to support informatics research initiatives.

4. Informatics tools need to be developed to support the monitoring of the quality of oncology care at the point(s) of delivery (48). Real world–based evidence approaches are emerging in other domains and will also benefit the field of radiation oncology. The often-quoted statements that 5% differences in dose result in significant changes in tumor control and normal tissue complication probabilities will be reinforced or challenged through collecting and sharing data from the entire clinical process.

“Where standards exist...use them!”

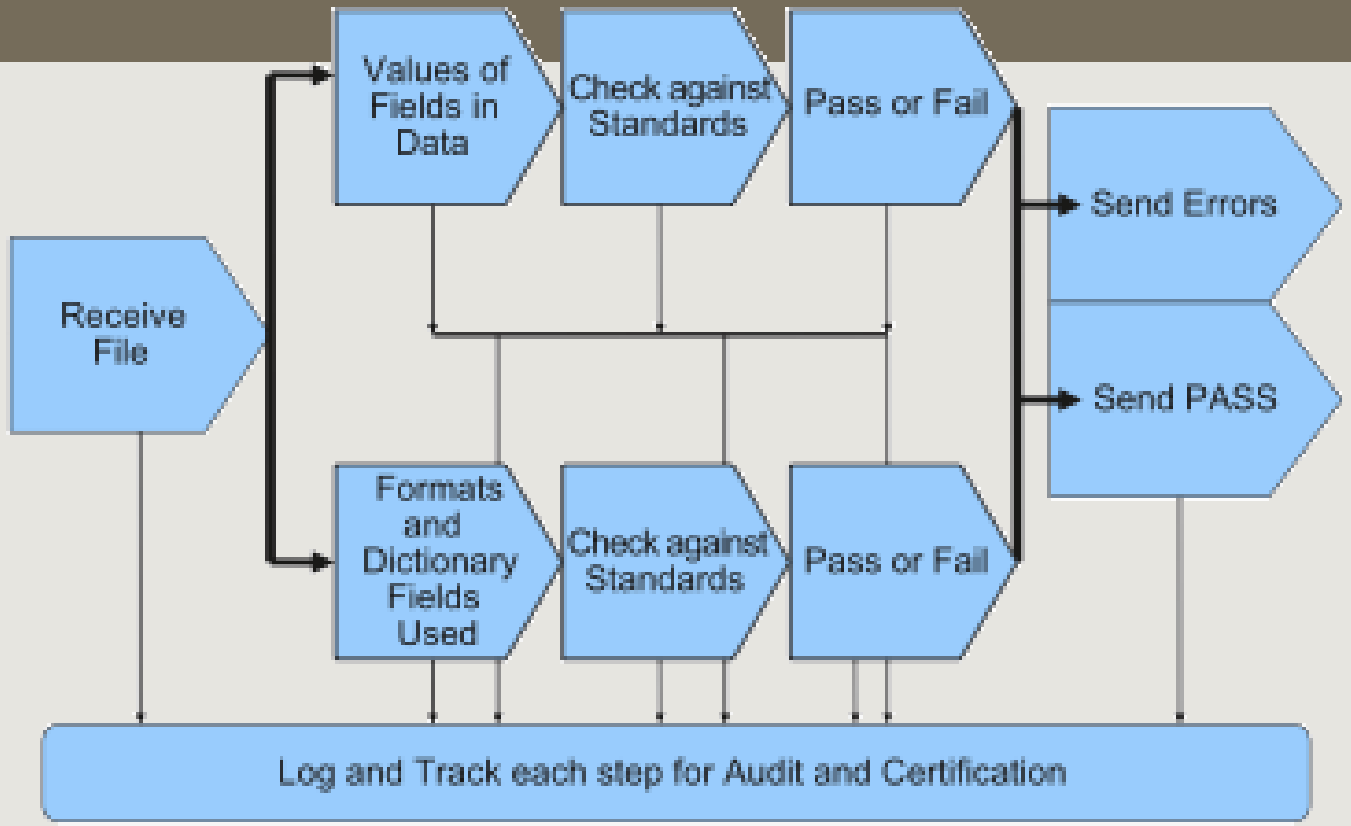


FIGURE 5. Validation for format, fields, and values against standards: a simple configuration for standards designers.

Informatics in Clinical Research in Oncology

Current State, Challenges, and a Future Perspective

Amar P.S. Chahal, MBBS, FRCS, MBA

DICOM-RT and Its Utilization in Radiation Therapy[1]

Maria Y. Y. Law, PhD • Brent Liu, PhD

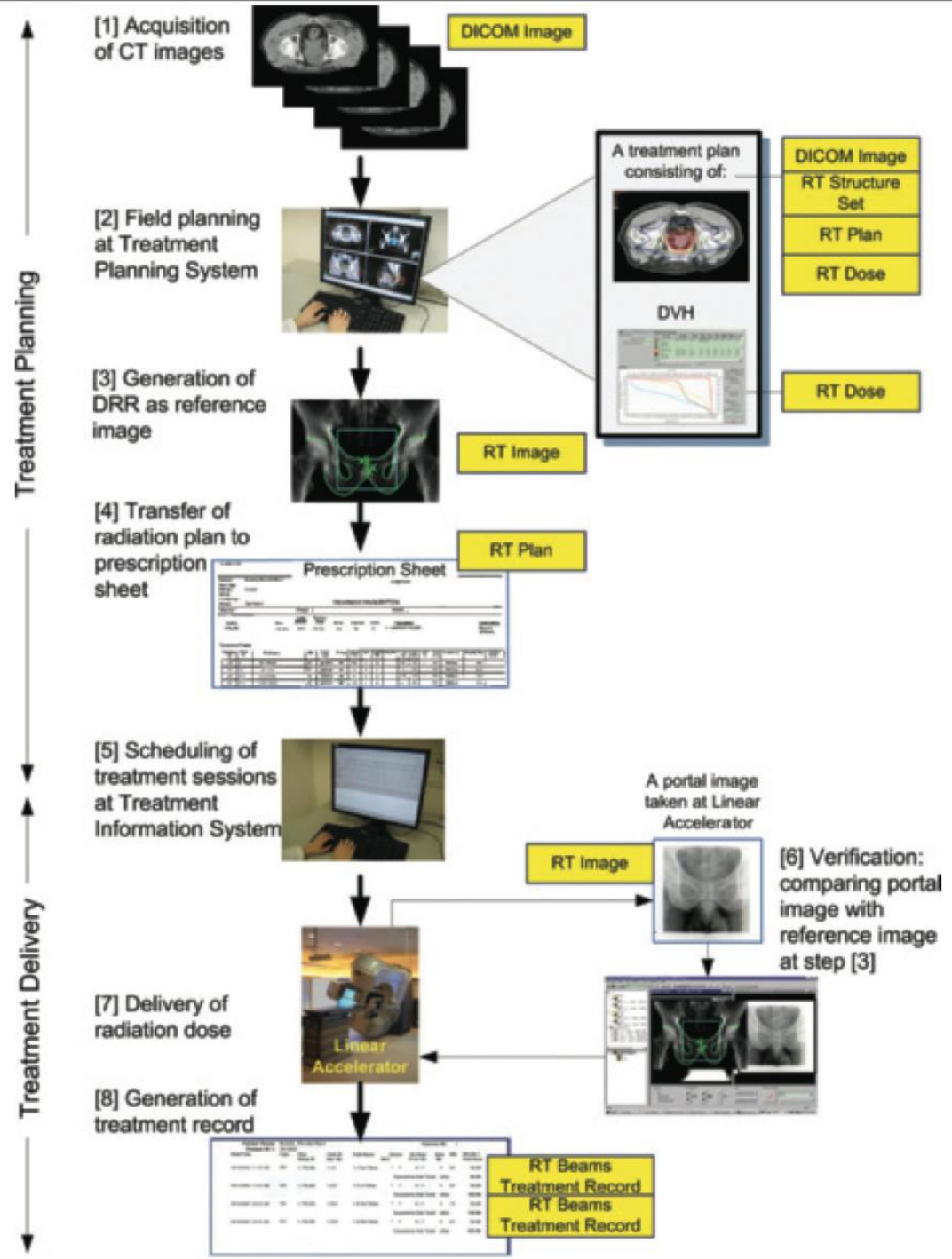


Figure 3. Chart illustrates radiation therapy work flow. Yellow boxes indicate the DICOM-RT objects that could be generated within the work flow. A radiation therapy treatment plan (step 2) with radiation dose distribution involves the superposition of the radiation therapy objects RT Plan, RT Structure Set, and RT Dose on the corresponding set of DICOM computed tomographic (CT) scans according to the coordinates in the DICOM-RT standard. Because the work flow is for external beam therapy, the RT Brachy Treatment Record information object is not shown. *DRR* = digitally reconstructed radiograph, *DVH* = dose-volume histogram.

TABLE 5.3 Base Names for Organs at Risk

Structure Name	Paired?	Structure Name	Paired?
ANAL_CANAL		MAIN_BRONC	
BLADDER		OPTIC_NRV	_L/_R
BRAC_PLX	_L/_R	ORAL_CAVITY	
BRAIN		OVARY	_L/_R
BRAINSTEM		PAROTID	_L/_R
BREAST	_L/_R	PENILE_BULB	
BRONC_TREE		PERINEUM	
CARINA		PHARYNX	
CAUDA_ EQUINA		PITUITARY	
CEREBELLUM	_L/_R	PROSTATE	
CEREBRUM	_L/_R	RECTUM	
CHIASM		RETINA	_L/_R
CN_VII	_L/_R	RIB	
CN_VIII	_L/_R	SACRUM	
COCHLEA	_L/_R	SEM_VES	
CORNEA	_L/_R	SKIN	
DUODENUM		SM_BOWEL	
EAR_MID	_L/_R	SPINAL_CORD	
EAR_EXT	_L/_R	STOMACH	
ESOPHAGUS		SUBMND_SALV	_L/_R
FEMUR	_L/_R	TEMP_LOBE	_L/_R
GLOBE	_L/_R	TESTIS	_L/_R
GLOTTIS		THYROID	
GREAT_VESS		TM_JOINT	_L/_R
HEART		TONGUE	
KIDNEY	_L/_R	TRACHEA	
LG_BOWEL		URETHRA	
LARYNX		VULVA	
LAC_GL	_L/_R		
LENS	_L/_R		
LIPS			
LIVER			
LUNG			
MANDIBLE			

Source: From Bosch, W. R., *Uniform Tissue Names for Use in RTOG Advanced Technology Clinical Trials*, August 19, 2009. Available at http://atc.wustl.edu. Accessed 1 December 2009.

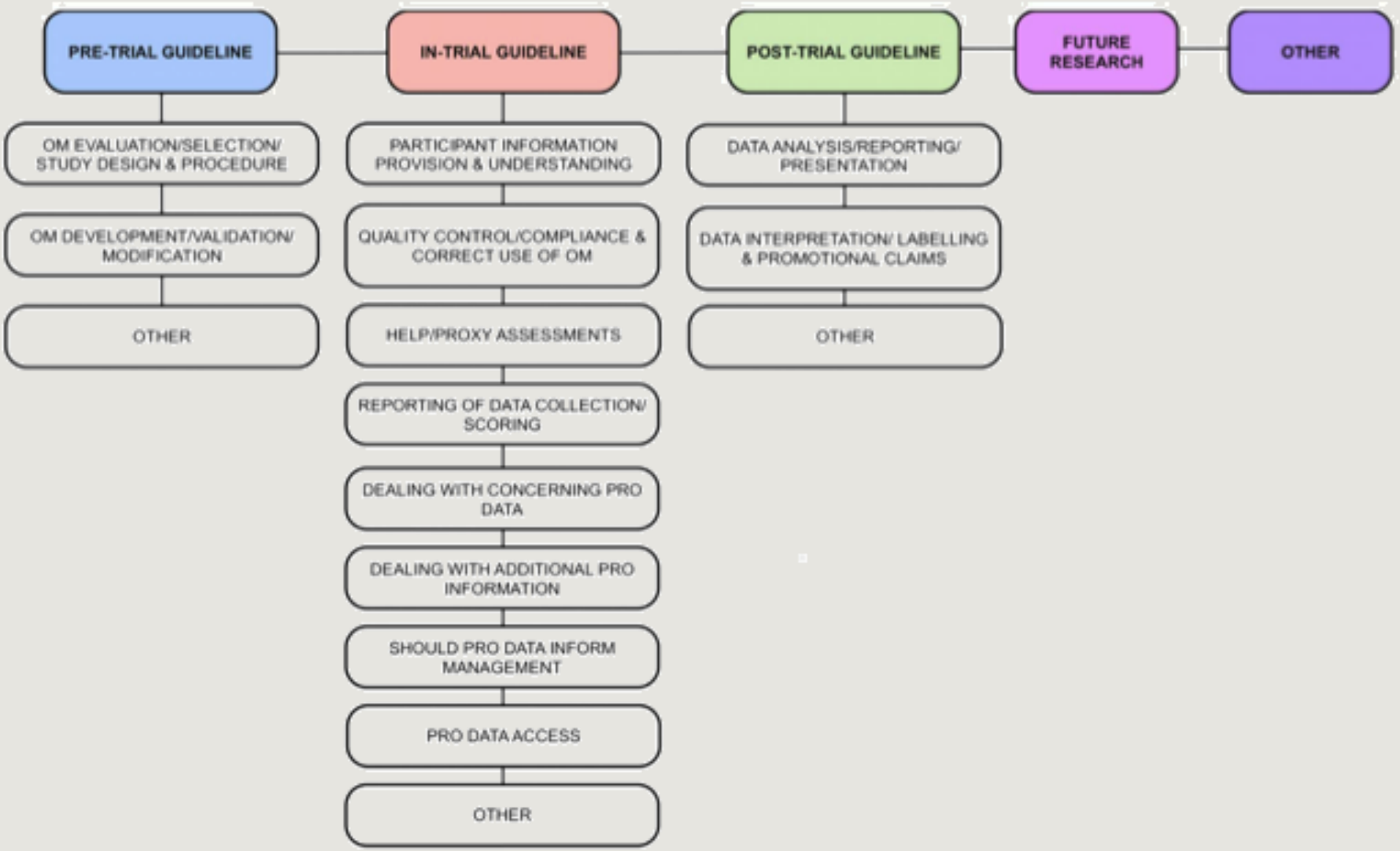
Note: Where paired organs are indicated, laterality is indicated by appending "_L" or "_R" to the base name. Geometric extensions of these structures are indicated by appending "_PRV*m*," where *m* is the nominal margin (mm) used to extend the structure.

We're just now agreeing on the ontology of structure names!!!

OPEN ACCESS Freely available online

Patient Reported Outcomes (PROs) in Clinical Trials: Is 'In-Trial' Guidance Lacking? A Systematic Review

Derek G. Kyte[1]*, Heather Draper[2], Jonathan Ives[2], Clive Liles[3], Adrian Gheorghe[1], Melanie Calvert[1,4]



Imaging Informatics: Challenges in Multi-site Imaging Trials

Steve Langer[1] and Brian Bartholmai[1]

Table 1
Radiotherapy research data types within their common IT systems.

Information type	Data examples	IT system
Baseline clinical data	Demographics (including co-morbidity and family history), TNM-stage, date of diagnosis, histopathology	HIS, TDS
Diagnostic imaging data	Diagnostic CT, MR and PET imaging	PACS
Radiotherapy treatment planning data	Delineation/structure sets, planning-CT, dose matrix, beam set-up, prescribed dose and fractions	PACS, RIS
Radiotherapy treatment delivery data	Cone beam CTs, orthogonal EPID imaging, delivered fractions	PACS, RIS
Non-radiotherapy treatment data	Surgery, chemotherapy	HIS, TDS
Outcome data	Survival, local control, distant failure, toxicity (including patient reported outcomes), quality of life	EDC, TDS
Follow-up imaging data	Follow-up CT, MR and PET imaging	PACS
Biological data	Sample storage, shipping, tracing and lab results	LIMS
Additional study conduct data	Study design, protocol, eligibility criteria	EDC, CTMS

Data collection

Benefits of a clinical data warehouse with data mining tools to collect data for a radiotherapy trial

Erik Roelofs [a,*,1], Lucas Persoon [a,1], Sebastiaan Nijsten [a], Wolfgang Wiessler [b], André Dekker [a,1], Philippe Lambin [a,1]

[a] Department of Radiation Oncology (MAASTRO Clinic), Maastricht University Medical Centre (MUMC+), The Netherlands; [b] Siemens Healthcare, Malvern, PA, USA

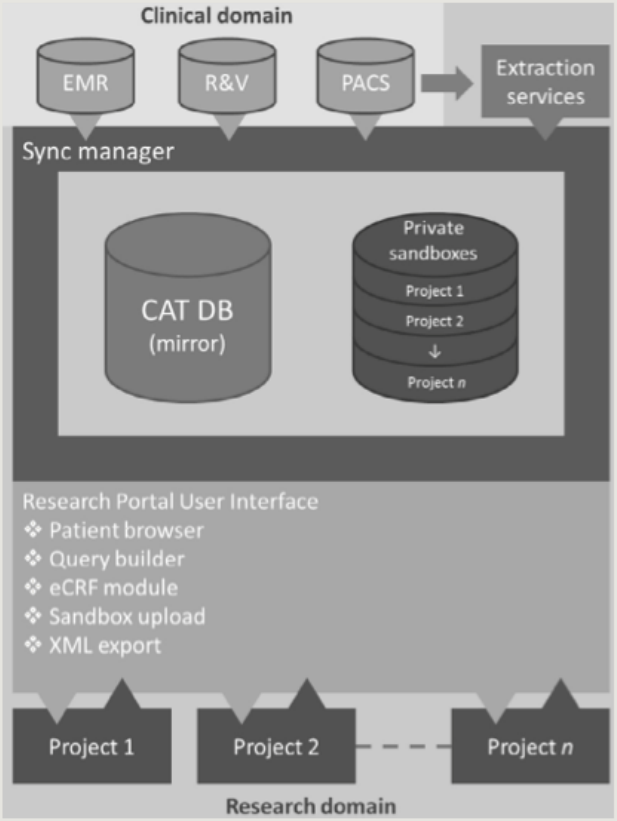


Fig. 1. Schematic overview of the CAT data warehouse/research portal. The system synchronizes data from clinical data sources and custom services. It is also capable of collecting data for trials and data collected for other research purposes. For data export, several modules exist in the system and are easily accessible by web-technology (i.e. the patient browser, query builder and an electronic case report form XML export).

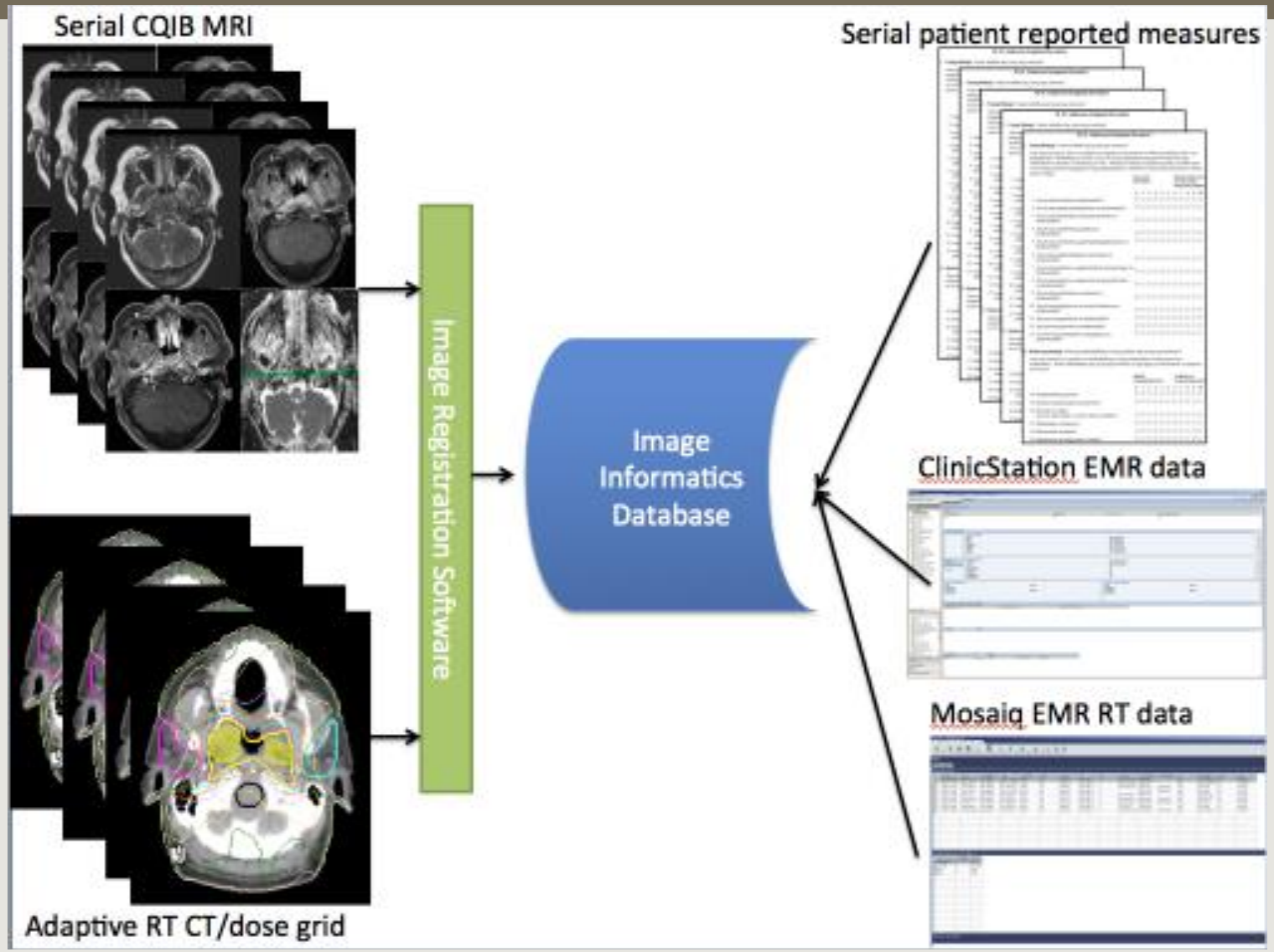
"Here's a list of 100,000 warehouses full of data. I'd like you to condense them down to one meaningful warehouse."

Table 1
Parameters collected for the NSCLC and rectal cancer groups. The last columns show which data were looked up where and from which source the data were recalculated.

Parameter	NSCLC	Rectum	Source		Action
			Manual	Automatic	
Gender	√	√	Chart	EMR	Looked up
WHO score	√	√	Chart	EMR	
TNM staging	√	√	Chart	EMR	
Chemo therapy	√	√	Chart	EMR	
Number of positive lymph nodes	√	√	Chart	EMR	
Tumour PA	√	√	Chart	EMR	
pCR		√	Chart	EMR	
Survival	√	√	Chart	EMR	
Total delivered dose	√	√	R&V	R&V	
Overall treatment time	√	√	R&V	R&V	
GTV volume	√	√	XiO	PACS	Recalculated
V_5	Lungs[a]		XiO	PACS	
V_{20}	Lungs		XiO	PACS	
V_{40}		Bladder	XiO	PACS	
MLD	√[b]		XiO	PACS	
SUV Max		Tumour	TrueD	PACS	
SUV Mean		Tumour	TrueD	PACS	

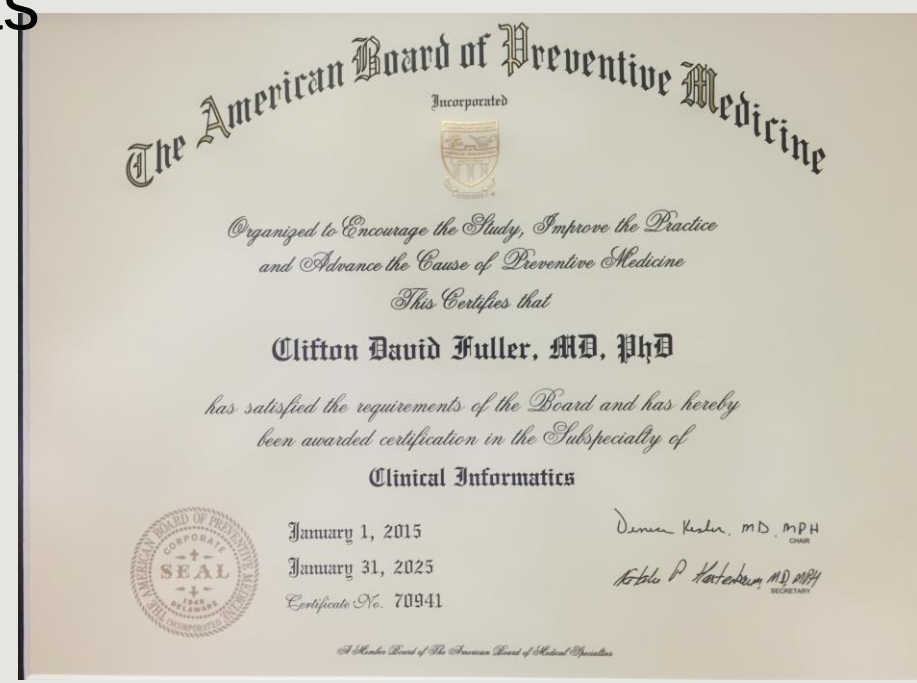
[a] V_5 and V_{20} data for the lungs were calculated with both lungs minus the PTV.
[b] MLD data for the lungs were calculated with both lungs minus the GTV.

Innovative technology requires innovative data structures



Digression: We need more radiation oncologists and informatics folks working with medical physicists!

- Growth of information has led to creation of a new medical subspecialty board certification…
- But few rad oncs.
- Most informaticists are EHR-oriented (AMIA)…
- And those that know DICOM are typically PACS-oriented (SIIM).


The American Board of Preventive Medicine

Incorporated

Organized to Encourage the Study, Improve the Practice and Advance the Cause of Preventive Medicine

This Certifies that

Clifton David Fuller, MD, PhD

has satisfied the requirements of the Board and has hereby been awarded certification in the Subspecialty of

Clinical Informatics

January 1, 2015

January 31, 2025

Certificate No. 70941

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A Member Board of The American Board of Medical Specialties

Next step: from Ontology to Mereology

A formal theory for spatial representation and reasoning in biomedical ontologies

Maureen Donnelly [a,*], Thomas Bittner [a,b], Cornelius Rosse [c]

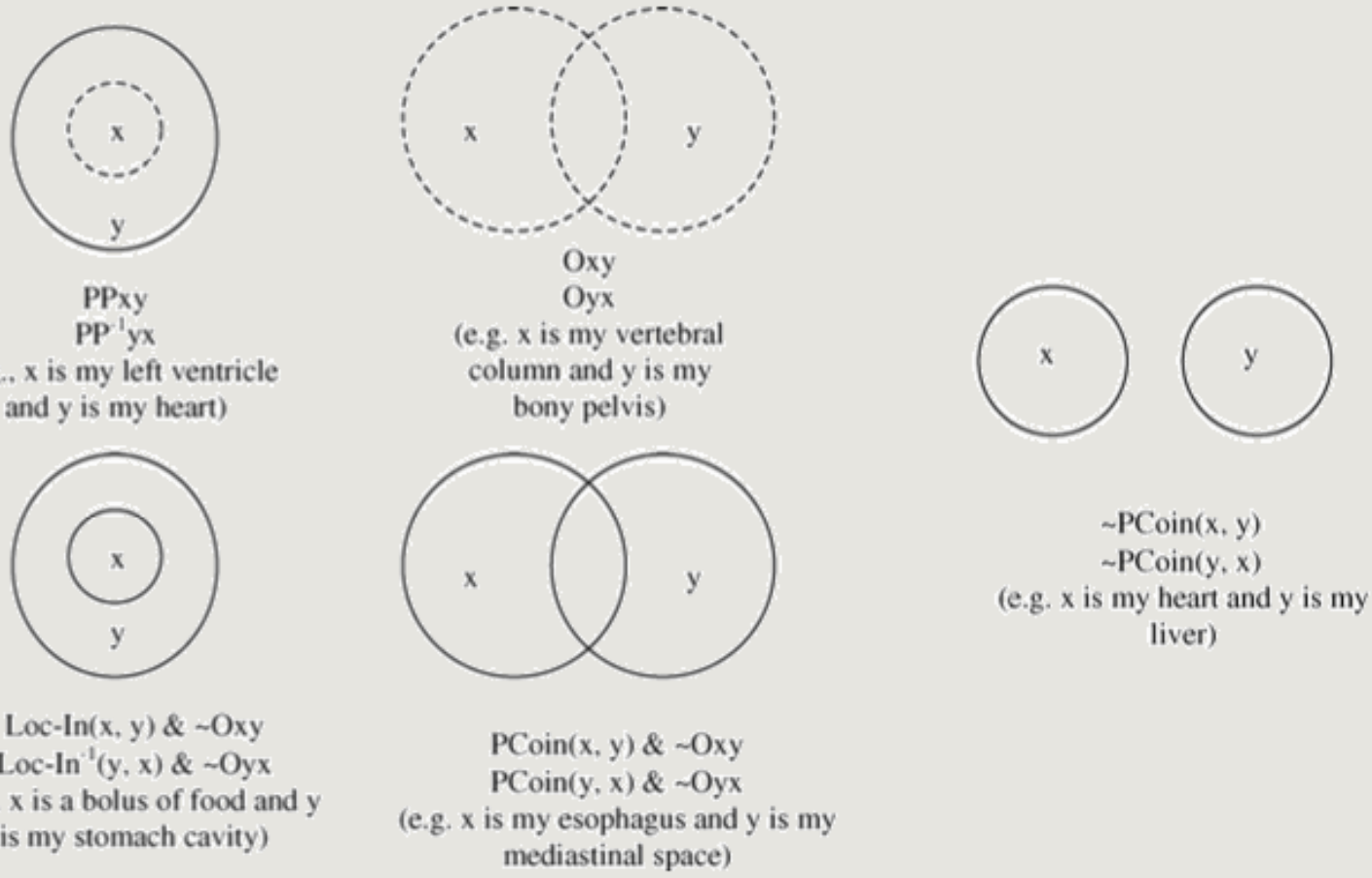


Figure 1 Basic spatial inclusion theory (BIT) relations.

Artificial Intelligence in Medicine (2006) 36, 1–27

What if the TPS already incorporated spatial classifiers for OARs (or TVs) based on TG-263?

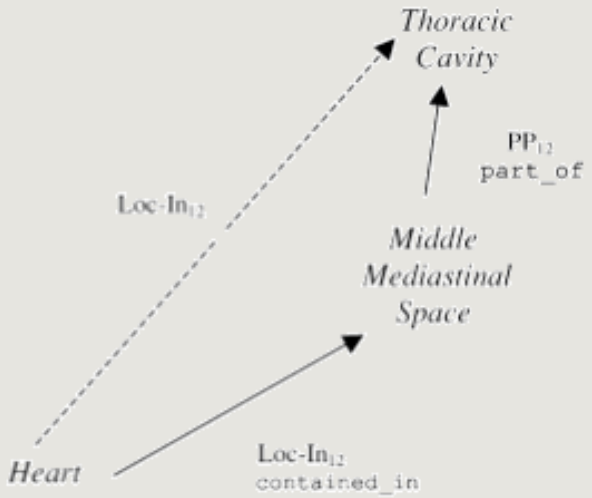


Figure 3 Potential for reasoning about parthood and containment in the FMA.

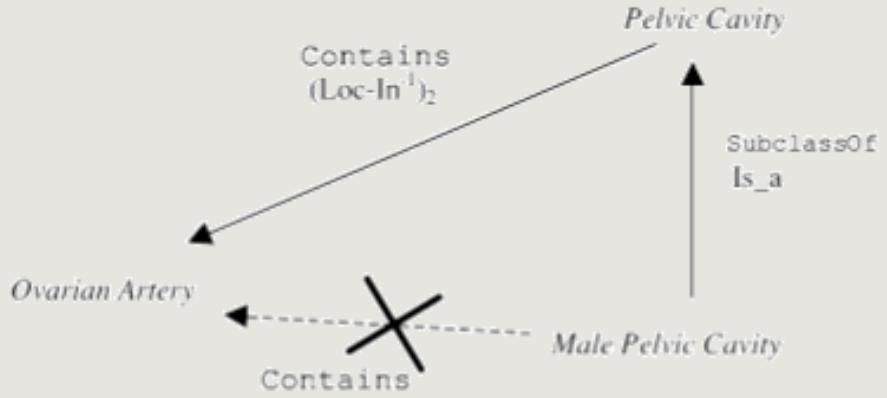


Figure 5 Reasoning about containment and subclass relations in GALEN.

Artificial Intelligence in Medicine (2006) 36, 1–27

“Where standards exist...use them!”

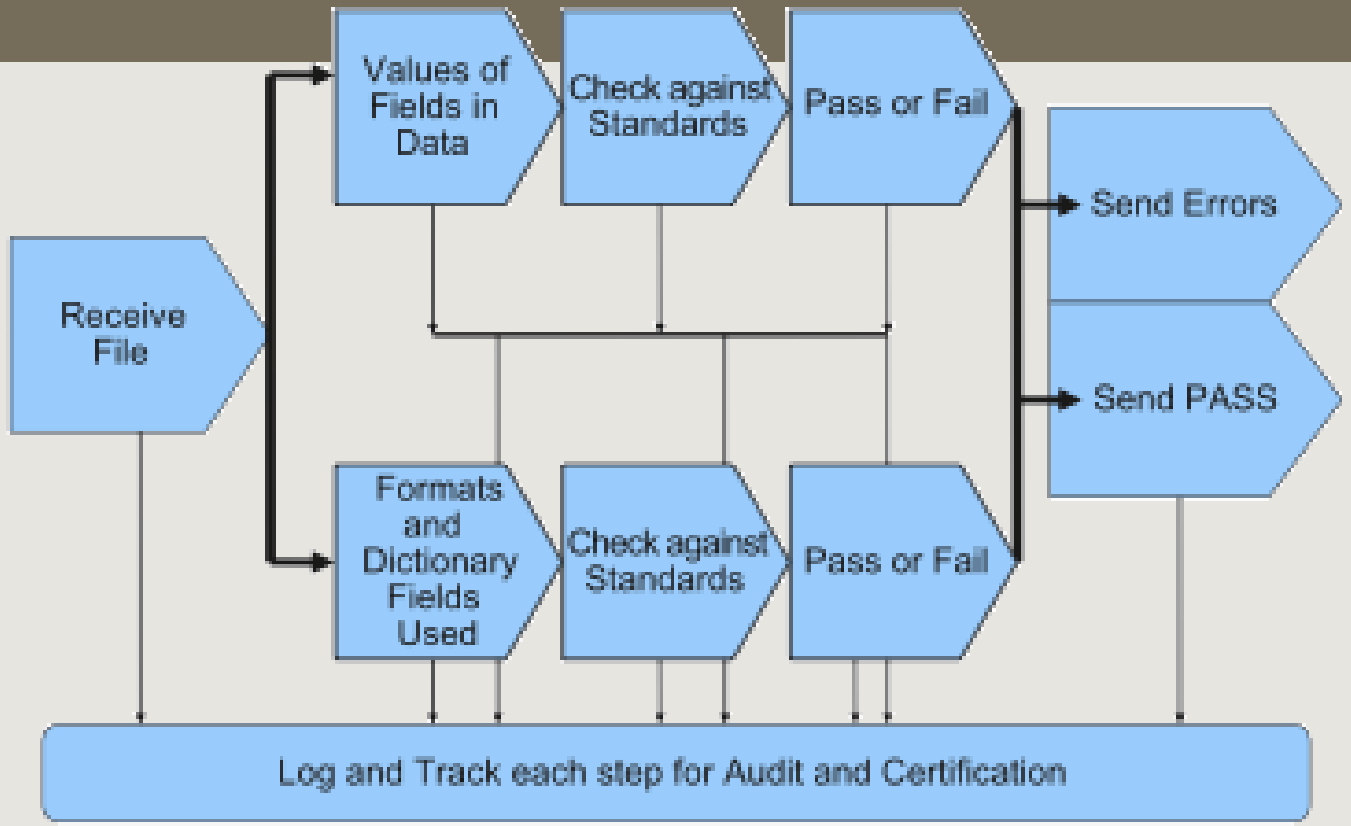


FIGURE 5. Validation for format, fields, and values against standards: a simple configuration for standards designers.

Informatics in Clinical Research in Oncology

Current State, Challenges, and a Future Perspective

Amar P.S. Chahal, MBBS, FRCS, MBA

Better prediction models?

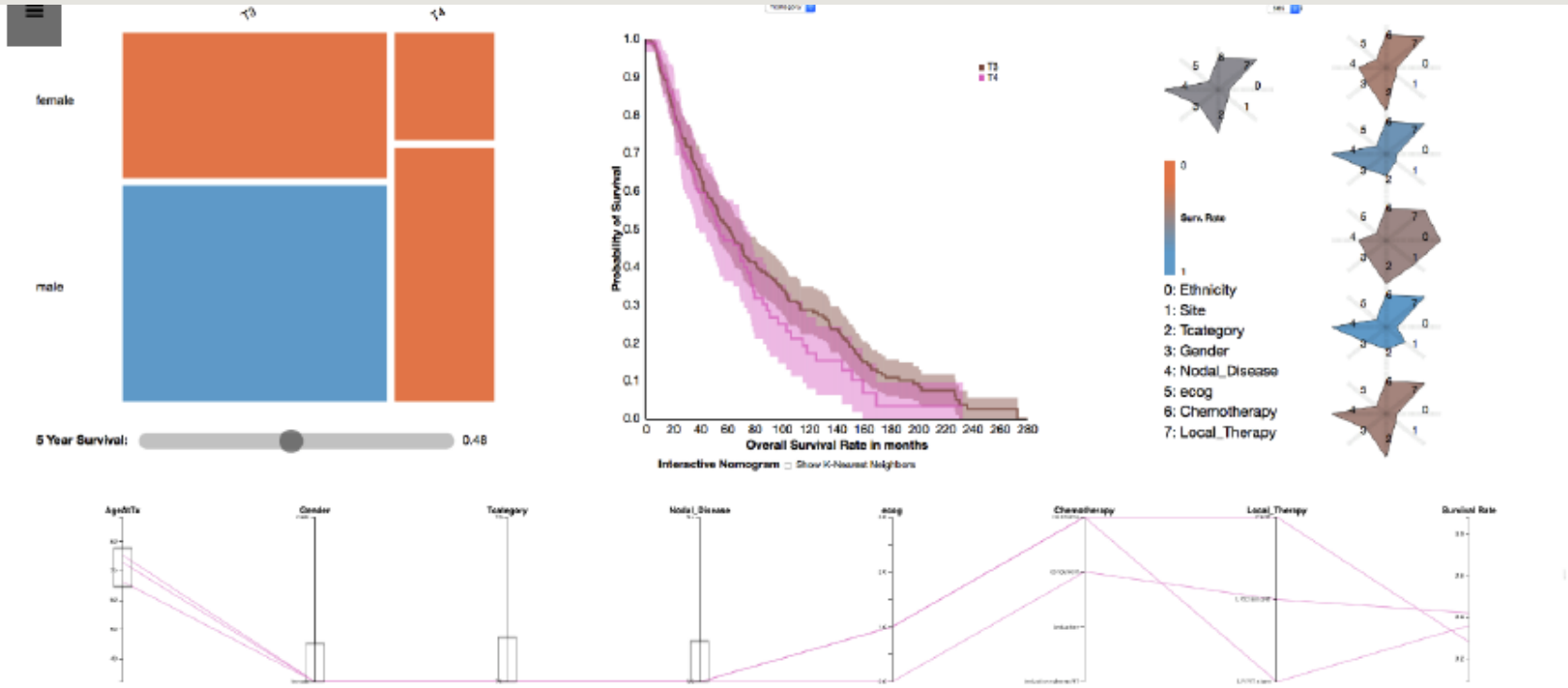


Figure 4. Web-based Therapy Explorer: Patient prognosis for a white female subject with T3 stage supraglottic cancer. The mosaic (top left) shows the T3 female subgroup has particularly low mean survival rates, close to those of the more severe T4 category. The Kaplan Meier chart (top middle) also predicts similar trajectories for T3 and T4 categories; the ribbon bands are std deviations. The star panel (top right) shows the patient along with the 5 most similar patients in the cohort repository; the varying color of the glyphs, from blue to orange, captures a notable variation of therapy outcomes. The interactive nomogram view (bottom) shows that despite the variation in the treatment course for two similar patients, the survival outcomes (rightmost axis) are very similar and fairly low. The four encodings are linked through interaction; 4 filters are currently applied along the first nomogram axes.

Spatial data?

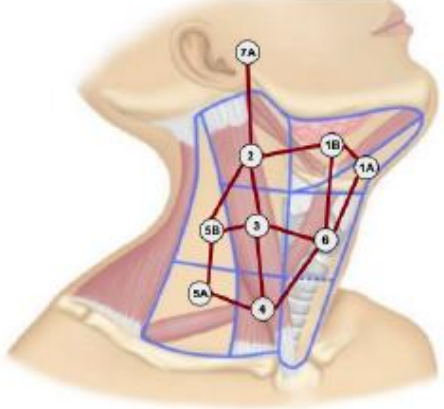


Figure 2. Topological map (blue) defined over lymph node regions, overlaid with a dual graph representation (red) of the map.

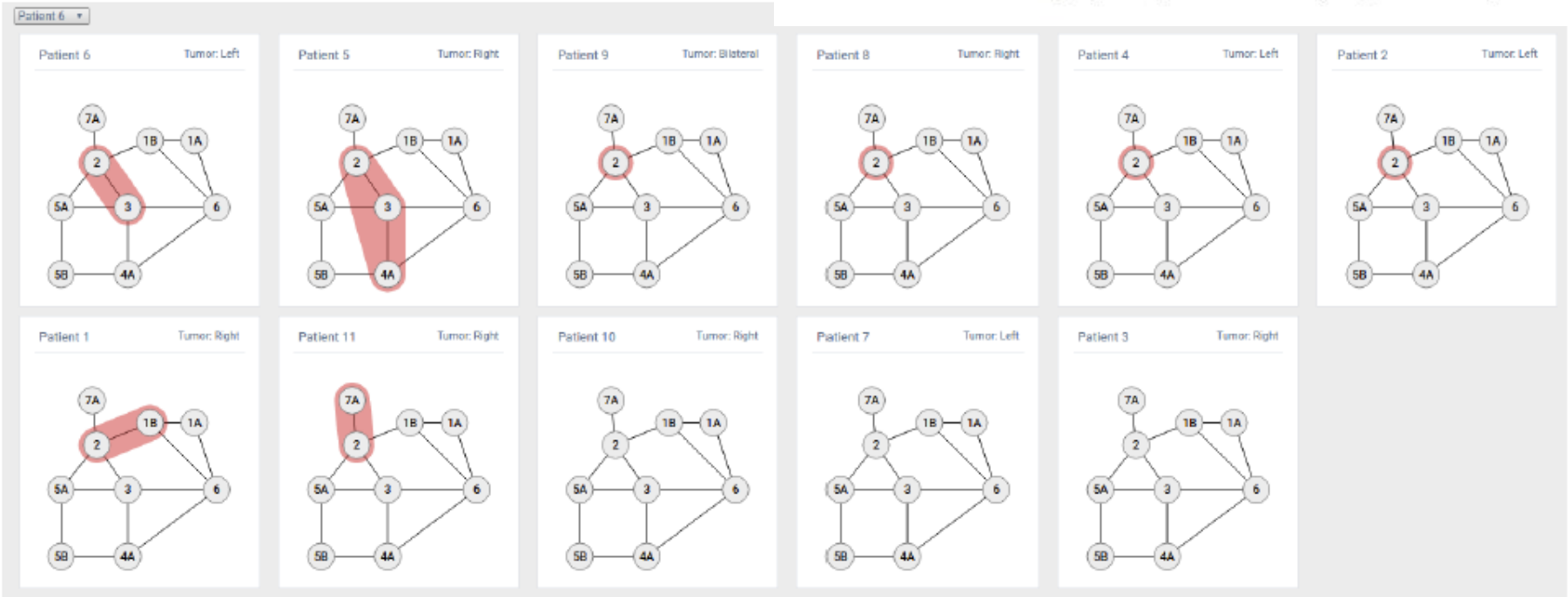
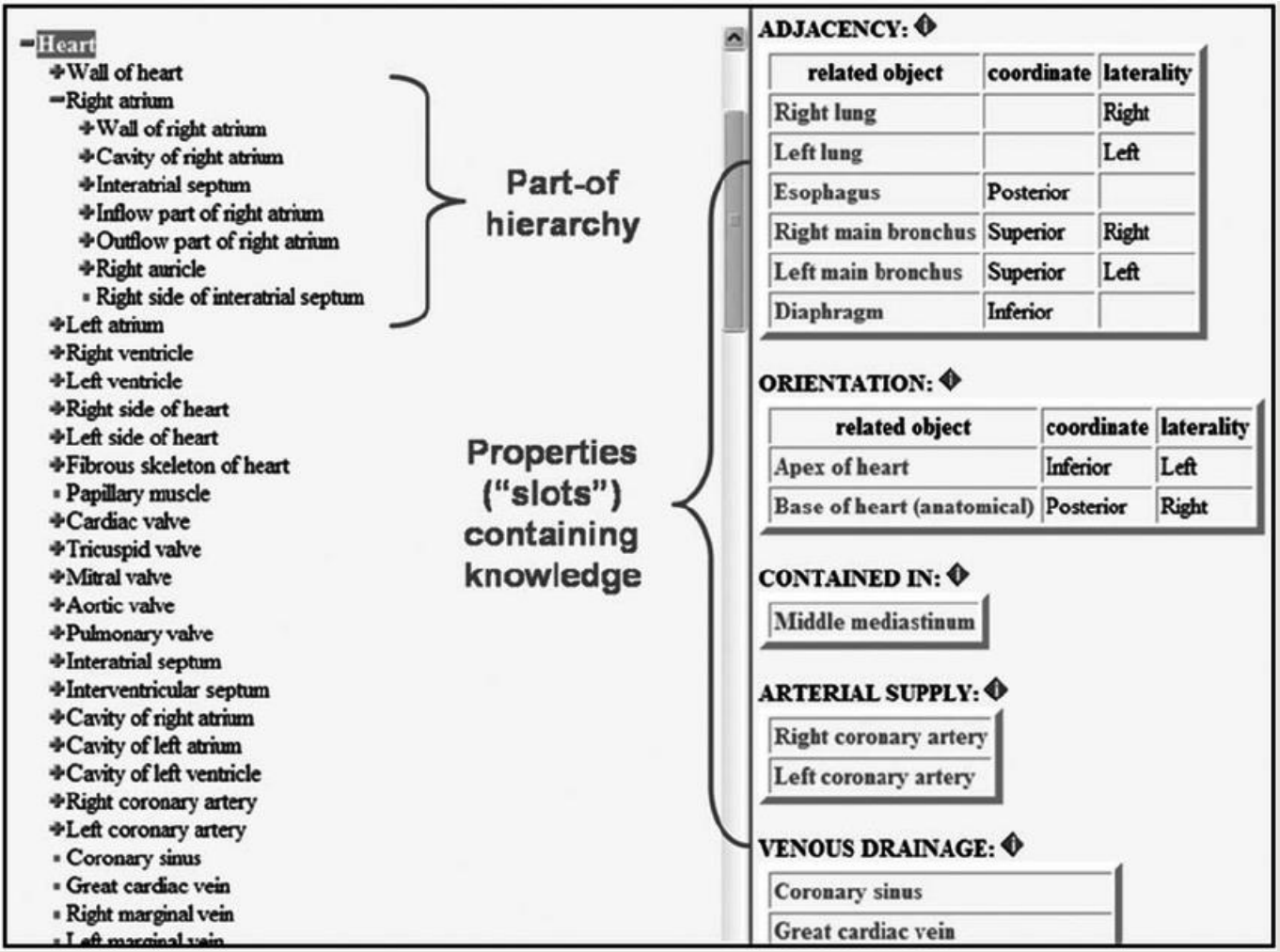


Figure 3. Lymph node distributions of 11 patients, ranked by their similarity to Patient #6. Patient #6 (shown top left) has two nodes affected along a chain, in regions 2 and 3, left side. The most similar case in this set has one more node along the same chain; the next 4 most similar cases have one node affected in region 2; the next two have combinations of node 2 with a node along another chain; while the 3 least similar ones have no nodes affected. This automated similarity technique detects seamlessly symmetric cases: in the top row, the last 4 cases have the one-node pattern bilaterally, on the right, on the left, and respectively on the left.

Example: FMA

The Foundational Model of Anatomy ontology contains approximately 75,000 classes and over 120,000 terms; over 2.1 million relationship instances from over 168 relationship types link the FMA's classes into a coherent symbolic model. The FMA is one of the largest computer-based knowledge sources in the biomedical sciences.



http://si.washington.edu/projects/fma

Content-specific auditing of a large scale anatomy ontology

Ira J. Kalet [a,b,c,d,*], Jose L.V. Mejino [d], Vania Wang [c], Mark Whipple [e], James F. Brinkley [b,d,c]

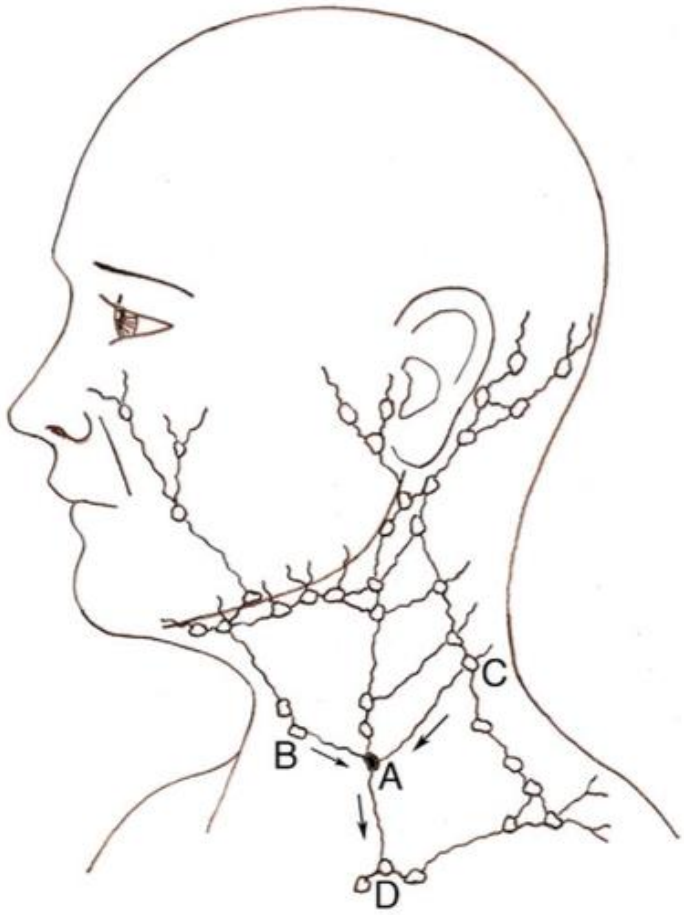


Fig. 2. A diagram showing some of the lymphatic chains and nodes in the head and neck region, illustrating the "efferent to" and "afferent to" relations. In this diagram, node A is efferent to node D, and is afferent to nodes B and C. The arrows just show the direction of flow of lymphatic fluid.

Table 1
Contents of "efferent to" slots of some lymphatic chains and lymphatic vessels.

Chain or vessel name	Contents of "efferent to" slot
Pulmonary lymphatic chain	Bronchopulmonary lymphatic chain
Subdivision of pulmonary lymphatic chain	NIL
Axillary lymphatic chain	Subclavian lymphatic trunk Subclavian lymphatic tree
Subdivision of axillary lymphatic tree	NIL
Posterior mediastinal lymphatic chain	Thoracic duct Tracheobronchial lymphatic chain
Tracheobronchial lymphatic chain	Bronchomediastinal lymphatic trunk Bronchomediastinal lymphatic tree
Tributary of tracheobronchial lymphatic chain	NIL
Left cardiac tributary of tracheobronchial lymphatic chain	NIL
Brachiocephalic lymphatic chain	Bronchomediastinal lymphatic trunk Bronchomediastinal lymphatic tree
Right cardiac tributary of brachiocephalic lymphatic chain	NIL
Lymphatic capillary	NIL
Tributary of lymphatic trunk	NIL
Superficial lymphatic vessel	NIL
Deep lymphatic vessel	NIL
Lymphatic trunk	NIL

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http://si.washington.edu/projects/fma

Anatomical Information in Radiation Treatment Planning

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Proc AMIA Symp
1999 pp. 291-295

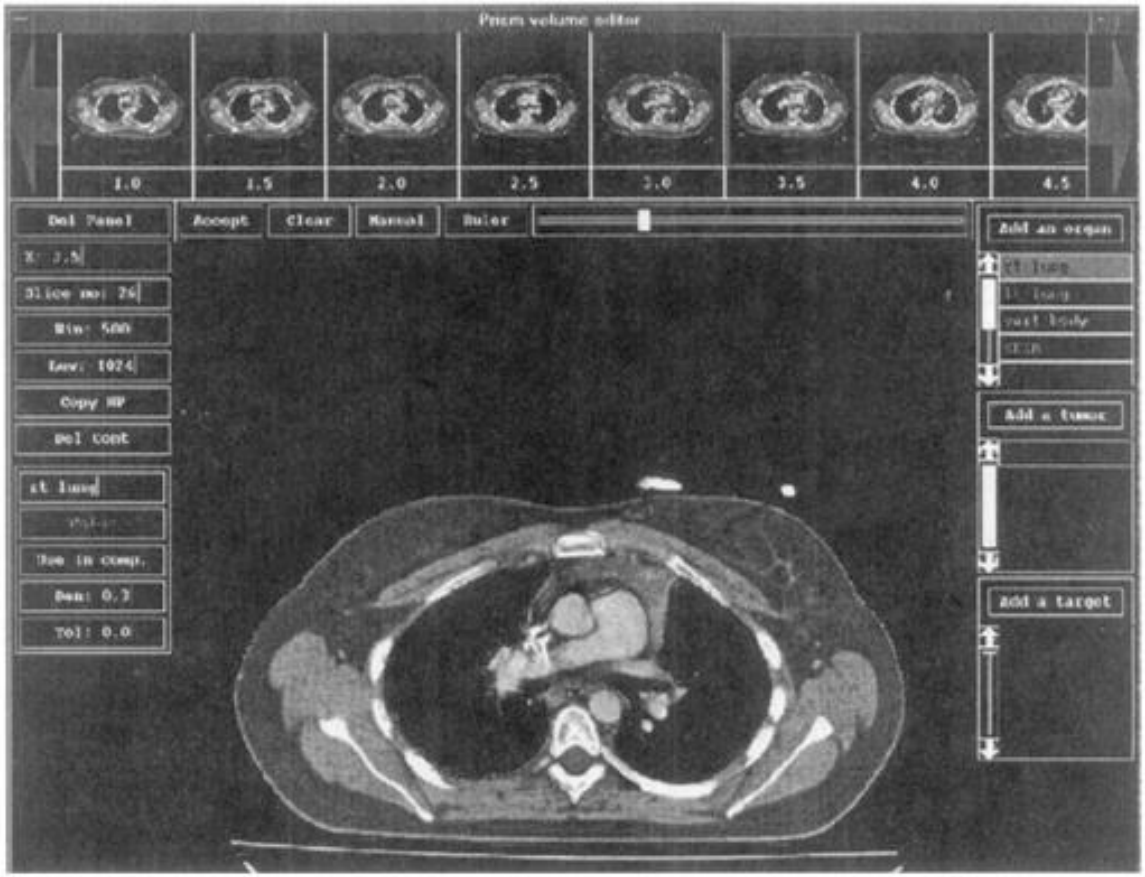

Figure 1: The Prism anatomy drawing panel showing a thorax cross section. Larger structures are easy to discern, but important smaller structures such as blood vessels, nerves and lymph nodes are impossible to see in these images.

The future: Centralized & automated segmentation/prescription

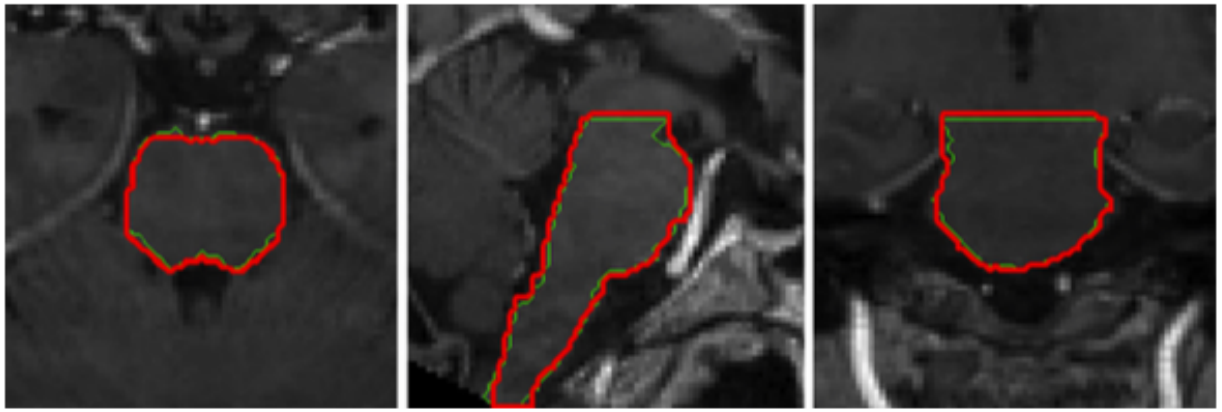

Fig. 7 Brainstem segmentation example. *Green* represents manual contouring, while *red bold* is the segmentation provided by the proposed approach

Table 5 Table that summarizes results of previous works which attempted to segment the brainstem on MRI images

References	Method	DSC	pVD(%)	Segmentation time
Babalola et al. [4]	Atlas-based	0.94	3.98	120–180 min (set of brain structures)
	Statistical-based (PAM)	0.88	6.80	1 min + 20 min[a]
	Statistical-based (BAM)	0.89	7.80	5 min + 3 min[a]
	Expectation–minimization	0.83	21.10	30 min (set of brain structures)
Bondiau et al. [5]	Atlas-based	–	−13.11	20 min (seven OARs and seven normal structures)
Isambert et al. [6]	Atlas-based	0.85	−14.8	7–8 min (six OARs)
Proposed approach	SVM	0.90	3.99	36.6 s

DSC and pVD are given as mean values

[a] These two approaches required registration steps which took 20 min in the first case and around 3 min for the second method

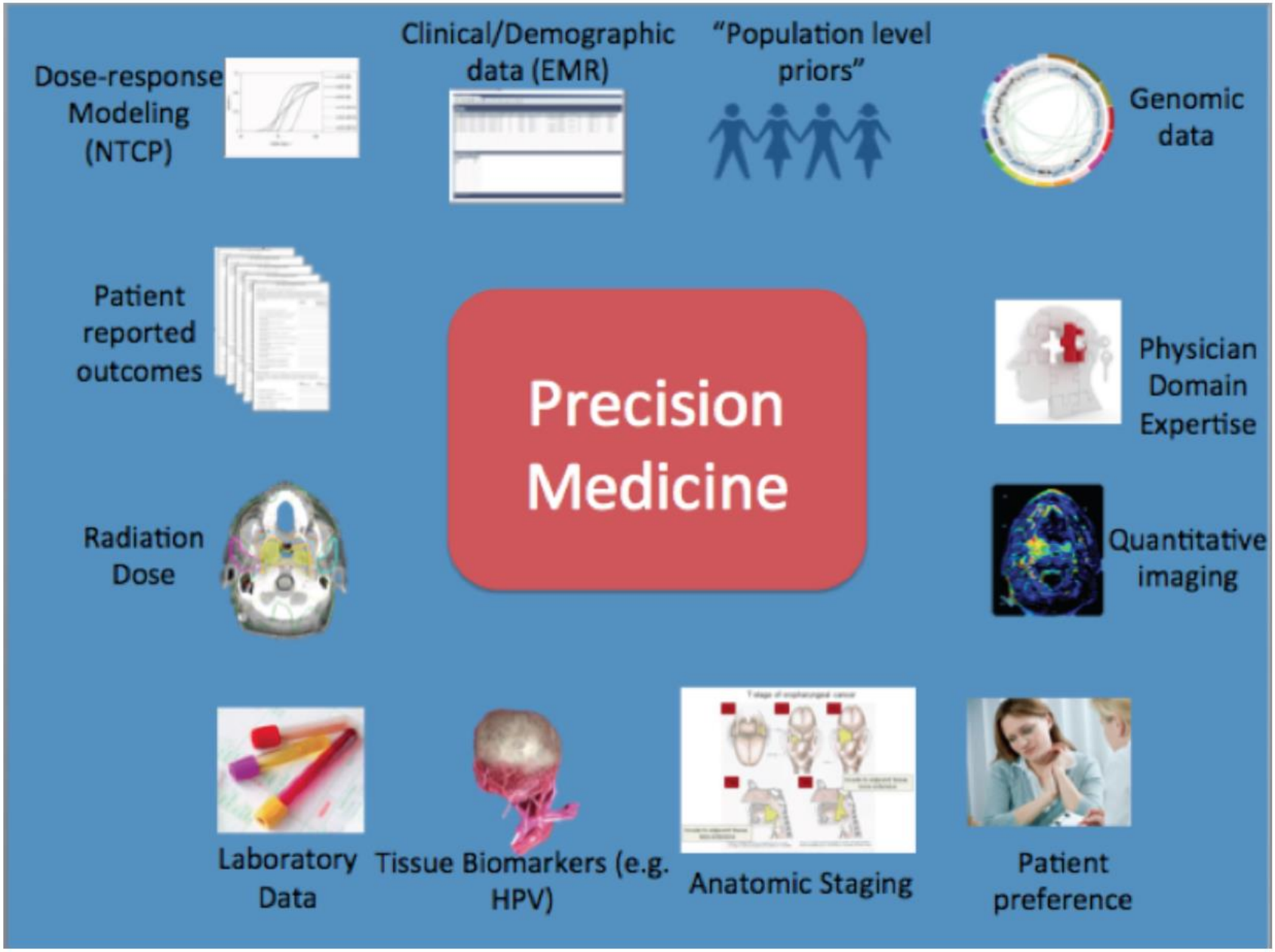

Figure 5: Overview of candidate data streams for potential incorporation into precision medicine models for decision improvement tools.

Predicting the future is not easy…

Thank You!!

- Questions?
- Please email me: cdfuller@mdanderson.org