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A Rational Informatics-enabled approach to the Standardised Naming of Contours and Volumes in Radiation Oncology Planning

Research Article

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Abstract: The standardising of nomenclature in the radiotherapy planning process has deep implications for the ability of the profession to examine the adequacy of construction of radiotherapy plans in outcomes research, particularly in relation to disease control and toxicity generation. After surveying the literature for similar attempts at Standardised Nomenclature, this paper proposes a logical standardised nomenclature which can be used by any individual or institution as a template for a mappable local standard.
The nomenclature is systematically constructed using the Foundational Model of Anatomy, ICRU Report 50 and ICRU report 62. The system foreshadows a XML metadata structure to detail the method of construction of volumes. Treatment Planning System vendors should build their software with the ability to use this systematic construction technique so that contours and volumes in a radiotherapy plan can be annotated. This metadata will allow the investigation of how a radiation plan's construction can affect the therapy outcome.
A Standardized Nomenclature is provided as an Appendix.

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1. Introduction

Nomenclatures are lists of words associated with meaning for use in particular circumstances. Standard nomenclatures are derived from local or regional efforts to achieve consistency of terms for application within that jurisdiction. More than this, a standardised nomenclature should have an logical and reproducible basis which is not subject to the whims of a local or regional group.

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1.1. What makes a good nomenclature?

Nomenclatures are built for a reason, which shapes their construction and ultimately determines their usefulness [1]. Determining the reasons for expending the effort should precede and adequately justify the effort. Furthermore, since construction requires effort, adequate solutions should not be superseded.

From an Informatics perspective, a nomenclature will be most useful if it corresponds to an ontology that reflects clinical care, supports information exchange with internal and external systems, reveals clinical decision making and accumulates structured information (such as occurs in a database) to assist in quality assurance measures and to aid research. A nomenclature is a device to benefit a profession, rather than the individual professional, but it does not substitute a well-formed ontology since nomenclatures do not exist outside the structure of the expert domain's knowledge base. Rather, it provides a list of instances of acceptable terms and definitions for pre-existing knowledge structures, e.g., Gross Tumour Volume (GTV) is the term given to the visible tumour defined by a ROI on a clinical image-set.

A comprehensive nomenclature would specify terms used by the radiation oncologist pertinent to the patient's characteristics and their assessment of the patient, as well as diagnosis, stage, the plan of care, therapies applied, the care actually delivered, the patient's responses to care, and the actual patient outcomes. In Radiation Oncology to date, the only standard nomenclatures reported have related to the names for contours and volumes assigned by the oncologist during the Simulation and Planning Processes. This report confines itself to the same nomenclature subset.

A standard nomenclature will permit synonymy, i.e., the expression the same concept in different ways depending on local preference. The point is that a local preference should be able to be mapped to the standard nomenclature [2]. The answer to lack of use of standards is not a Lord Of The Rings response ("one ring to rule them all") with a single defined nomenclature (such as SNOMED is purported to be), but rather local nomenclatures constructed to be interoperable with the standardised nomenclature, i.e., deliberately devised to fit well-constructed knowledge structures which have been formalised into an ontology. This deliberate construction would allow subsequent transfer of local names into a standardised common identifier. For radiation oncologists, it does not matter if the spherical anatomical item with which you see this page is called an *eye*, *eyeball*, *globe* or any other non-English term (ojo, oculus, occhio, oogappel, etc), so long as a colleague elsewhere using the term 'right eyeball' can translate this name into a standardised anatomical nomenclature (e.g., FMAID 12514). And when I use the term 'EYE_R' locally, that this too will translate into the same standardised anatomical nomenclature (i.e., FMAID 12514). However, the use of the term 'ball' to describe either an eye or a testis in a single department is problematic, as is the lack of a departmental conversion table that specifies that local use of 'ball' corresponds to the anatomical term 'testis'. Given that classifications enlarge over time, a translation table

will cater for these changes [3]

When used in a clinical process, a nomenclature should have sufficient granularity to describe differences in clinical care. Discussions between oncologists about recommended treatment can result in widely variable targets being defined, e.g., a recommendation to "treat the necks nodes" might result in ipsilateral or bilateral volumes, inclusion or exclusion of Levels 1A, 1B or 5 depending on the recipient's understanding of the recommendation. Similarly, when treating a Merkel Cell Carcinoma of the skin with radiotherapy, the recommendation to treat the primary site "with a wide margin" could result in margins of between 2 and 10cm. Since margin expansions are an important determinant of geographical miss probability, a standard nomenclature should seek to systematically quantify margins to allow analysis of variation and consequent outcomes.

The process of making a nomenclature useful requires synonymy which is clinical relevant, but also coding in a consistent manner that makes retrieved nomenclature consistent in structure and therefore able to be manipulated by the computer. The difference between 'EYE_R_PRV_3' and 'PRV_R_EYE_3' is non-trivial if they occur in a single institution.

2. Post-Nomenclature Radiotherapy Planning

Non-ambiguity in terms is ensured by clear, precise definition. However the tendency to impose a structure on the nomenclature to describe all processes used in normal clinical processes, even when precise and relevant, is counter-productive. Firstly the nomenclature becomes unwieldy when more than 2-3 additional processes are coded. Secondly, the names of volumes can become lengthy and highly codified. One schema could have a target volume titled 'SPINALCORD_PRV_3' where SPINALCORD is a defined anatomic structure, PRV corresponds to an expansion of the previous specified anatomic structure, and 3 meaning that a symmetric expansion of 3mm has occurred. While this example combines terms in a way that describes the clinical process, the problem of asymmetric expansion is not adequately addressed.

The concatenation of additional information into the nomenclature increases its expressiveness but also reduces its simplicity and legibility. The expanded nomenclature that includes domain specific knowledge is therefore a temporary solution.

Improving the semantic richness of a volume name to describe its construction requires a method to capture the details of the construction process as metadata. The capture of this information could be automated in current treatment planning software. The specification of metadata in a hierarchical markup language like XML

is common place, and could easily include details of the original contour/volume, the purpose of the volume and the expansion used. The advantage of this type of specification is that non-symmetrical expansion and excluded volumes could also be specified (Listing 1). As might be expected, the combination of multi-axial facets of a volume's construction enriches the information available for analysis.

The items utilised in plan construction including parent volumes, laterality, dose, and margins are all metadata items that derive from the knowledge structure of Radiation Oncology. While the names are identifiers, additional metadata that precisely detail the manner of construction makes analysis useful. Metadata makes explicit each oncologist's method of constructing volumes, providing a record for determining the accuracy of what I believe I am doing and laying bear the assumptions of my technique. Only when metadata is available and combined with my outcomes, will proper quality assurance be possible and enable us to objectively determine what methods of voluming are correct, too large and too small.

Properly constructed metadata will display the construction method of volumes, assuming that the logical patterns determined by the ICRU documents are followed [4]. This means that an organ at risk (OAR) will be contoured, and that that OAR will be used to derive a Planning Risk Volume (PRV) by expansion of a selected (and ideally measured) movement margin and then the optional exclusion of more important volumes. So the OAR has a single determinant (organ), and an OAR_PRV has three determinants - the OAR name, the expansion margin and the exclusion structure, e.g., for normal tissue sparing around a parotid gland, the following specifications would give an accurate view of their derivation. You will note that this specification presumes that the OAR is contoured AND the PTV6000 exists **before** the OAR_PRV can be constructed.

Listing 1. **XML-type structure for Contours**

```
<OrganAtRisk> OrganName = "PAROTID_R"
<OrganAtRisk>

<OrganAtRisk_PRV OrganName = "PAROTID_R">
    <Expansion ExpansionMarginAnterior = "3" ExpansionMarginPosterior =
       "4" ExpansionMarginLateralR = "3" ExpansionMarginLateralL = "4"
       ExpansionMarginSuperior = "10" ExpansionMarginInferior = "10">
    </Expansion>
    <PlanningtargetVolume Name ="PTV6000"
    </PlanningtargetVolume>
</OrganAtRisk_PRV>
\\
```

The situation for volumes is more complex (Listing 2). The process starts with specification of the GTV, which is a visualised tumour, i.e., anti-anatomy. A CTV, which is an anatomical volume, identifies the anatomical limit of the clinical risk, enclosing the entire GTV by definition. CTVs will extends to visible and named anatomic

boundaries that confine the risk, or occasionally may extend for some arbitrary distance from the GTV where the next anatomical boundary is obviously well away from any clinical risk. Once CTVs are complete, the PTVs can be constructed. As geometric structures, they cannot be drawn, only generated [4]. They define the movement envelope and also apply an indication of dose to be delivered. While a PTV may encompass several CTVs, each CTV will be derived from an identifiable GTV.

Listing 2. **XML-type structure for Volumes**

```
<PlanningTargetVolume>
    <RadiationDose TargetDose = "6000" Unit = "cGy">
    </RadiationDose>
    <ClinicalTargetVolume Name = "CTV">
        <GrossTumourVolume Name = "GTV">
        </GrossTumourVolume>
        <Expansion ExpansionBoundary = "anatomical boundary"
            ExpansionMargin = "mm">
        </Expansion>
    </ClinicalTargetVolume>
    <Expansion ExpansionMargin = "mm">
    </Expansion>
</PlanningTargetVolume>
```

The benefits of incorporating metadata relate to automation of assessment of a radiation oncologist's work in the areas of:

1. Audit of Practice
   (a) Quality Assurance of Volumes
      i. QA of Volumes is difficult because it involves estimation of risk. For any particular case, an anatomical area may be included or not as a matter of legitimate preference.
   (b) Quality Assurance of Contours
      i. Contours should display minimal variation because anatomy, while variable in size, is not variable in boundary
      ii. Planning risk Volumes, rather than contours, are subject to decisions of inclusion or exclusion.
2. Audit of Outcomes related to Volumes & Contours
   (a) The explicit delineation of areas designated as 'at risk' and specified within metadata allows for *post hoc* correlation of recurrence sites. Where risk levels of 2-10% are considered for non-included contours, many patients are required to determine whether the risk estimation is accurate.
   (b) A particularly problematic area is the overlap of PTV with a PRV. It is commonly a situation where oncologists, who wish to reduce dose to a PRV, will alter the PTV manually. Such a manual alteration obviously denies the ICRU50 & ICRU62 methodology and nomenclature.

(c) The issue of radiation plan quality has been highlighted as responsible for significant deficits in outcome [5]. However the boundaries for declaring a significant deviation were very loose [1]. One would hope that these criteria were rarely broached in the IMRT era, but automated assessment of this type is not possible without metadata specification. It is therefore not surprising that the authors have not closed the loop by voluming and contouring to define the exact deficits in the HEADSTART plan generation.

2.1. What makes something a standard?

Physicians have always been "knowledge workers", collaborating with other health care actors to provide patient care by applying published data to direct patient management. The process of evidence production, which is largely clinic-based, is now challenged by the paradigm of Informatics in the guise of Information Technology and electronic records. We have moved on from a time of independent components designed for specific but separate functions with data stored in proprietary formats in non-interacting silos. Despite a high degree of semantic homogeneity, data heterogeneity was imposed by the lack of domain standards which caused confusion. Standards were poorly implemented, training was insufficient and relied on sales people, and there was poor understanding and inadequate use of accumulated information because new paradigms of innovative data use could not be demonstrated. It may come as a surprise that this description comes from the recent paper by Gibaud [6] describing the problems of standards in Radiology!

Radiation Oncology has the same challenges, but unfortunately has a much smaller commercial base making the improvement of software more difficult. Given that most treatment planning systems can export to the DICOM-RT format, the issue of nomenclature has an elevated importance. As the DICOM-RT format is a standard, research by electronically accessing multiple files is supported. However looking inside the files will reveal many naming conventions and examples which will prevent collation. The Radiation Oncology Data Alliance (RODA), based on MOSAIQ use [7], found this problem of name proliferation to the detriment of analysis [8].

Making a nomenclature into a standard is a corporate task requiring recognition by a professional or governmental group. At present, none of the professional organisations in this region (TROG, RANZCR) have an approved

[1] *Table 1. Protocol-Specified Criteria for Significant Deviations (pp.2997)*
Tumor Dose at 200cGy/fraction delivered to target volumes.*
All gross disease (except nodes <2 cm) must receive at least 6650cGy
No more than 10% of the planning target volume (PTV) enclosing gross disease must receive <6650cGy (<5700cGy for small nodes) or >7500cGy, excluding volumes within the gross tumor volume or air cavities.
No more than 10% of PTV defining electively treated areas must receive <4000cGy

standardised nomenclature. The result is that the evolution of biomedical knowledge, which requires a necessary informatics articulation between care delivery and biomedical research [6] is stunted. In essence, the lack of standardised nomenclature results in a lack of openness, and the use of quasi-proprietary protocols (*I own my naming system, you own yours*, etc.) and so poor performance [6] in interoperability and collaboration which are the necessary infrastructure for research.

However, it is inevitable that nomenclatures managed by corporate agencies will be unwieldy and slow to change. It is possible to overcome this tendency by adopting an Open Source approach to nomenclature maintenance where any professional can commit an alteration, but a maintainer oversees and approves changes to maintain consistency of purpose. To aid in this task, the re-use of pre-existing nomenclatures and ontologies makes sense. In terms of anatomical names, radiation oncologists do not have any particular expertise. We only use the names. So an anatomy ontology or nomenclature should be used to derive names, if it is available and maintained. Such ontologies are available.

The development of standards and focus of interoperability have seen real benefits for the business of Radiation Oncology (e.g., IHE-RO [9]) so that we have the some ability to re-use data to perform different tasks [6]. However this interoperability does not translate into the clinical area since questions of re-use of data from tasks, letters, reports and literature to support outcomes research is not enabled. Interoperability requires the shared knowledge model behind the data [6] and the standard nomenclature to prevent data heterogeneity in the face of semantic homogeneity, thereby leading to ignorance while swimming in a sea of electronic data. This shared knowledge model is domain-specific and must represent an achievable standard for Radiation Oncology.

With the emergence of 'omics and the push for personalised medicine, radiation oncologists need to have and use their clinical data to overcome the present personalisation gap [10, 11]. The use of standardised protocols [8] in patient planning has benefits for the patient [5], it also has benefits for process efficiency [12].

As stated previously, the standardised nomenclature should only be seen as a stop gap measure. Nomenclatures are limited to simple concatenated terms with the same function as metadata, and should be specified within a formal description of the domain's specialist knowledge in the form of ontologies [13, 14] which include the vocabulary of terms defined in a formal language with the attributes of first-order logic to support reasoning. A common format is OWL and its variant, OWL-DL [15–17].

Not all standardised nomenclatures are useful in Radiation Oncology. The Systematised Nomenclature of Medicine (SNOMED) is not a true ontology having started life as a collection of terms. There is no formal analysis of its usefulness in Radiation Oncology, but the fact that it does not include the term 'RADIATION

ONCOLOGIST', and does not list 'MEDICAL ONCOLOGIST' among 'MEDICAL SPECIALIST' indicates some shortcomings.

2.2. What should be embedded in a nomenclature?

A nomenclature for use by radiation oncologists in Simulation and Planning should include several abilities which are listed below:

CONTOURS

Contours are ROIs drawn to define anatomical structures.

Organ - the name of the organ being contoured must be unambiguous and consistent, and should be derived from or locally correlated with an external anatomical source. The anatomical ontology is to be preferred over another nomenclature because of the added functionality of an ontology.

Laterality - the differentiation of right, left and combined total organs is required.

VOLUMES

Volumes are oncological ROIs based on the probability assessment that a moving area seen on an image set is or contains cancer, and therefore which need to be included in the daily radiation target.

Gross Tumour Volume - the GTV delineates all tumour visible on an image set, which is to say that its definition is 'anti-anatomical'. Differentiation of GTVs that exist in the primary site, multiple nodal deposits and/or multiple metastatic deposits is required.

Clinical Target Volume - the CTV defines the risk volume on the image set and is an anatomically defined volume, with each CTV being derived from one GTV by defining the surrounding risk area. It should be clear from the nomenclature which GTV resulted in a particular CTV.

Intermediate Target Volume - the ITV defines the physiological motion of an anatomically defined risk volume, i.e., a volume encompassing a moving CTV. It should be clear from the ITV nomenclature which CTVs have been combined to produce a particular ITV.

Planning Treatment Volume - the PTV is a volume is firstly defined by the total expected motion of the CTV while being treated. Secondly it is also defined by the dose which is expected to be delivered to the volume. The prescribed dose should be clear from the PTV nomenclature.

Planning Risk Volume - the PRV is a volume which defines a moving organ that is to be spared when constructing a radiation plan. This PRV will look like some portion of an expanded organ, and may encroach into a PTV. Overlap of PTV and PRV indicates an area of clinical decision making balancing tumour coverage and critical organ dosing. It should be clear from the nomenclature which organ forms the basis of the PRV, and what expansion has been used in its construction.

3. What Standardised Nomenclatures are available?

There are examples of departments and collaborative groups developing guidelines for consistent naming. However the term "standardised" could be a synonym for 'locally consistent' rather that being deliberately constructed or achieving the status of a standard. After the discussion below, Table 1 provides a comparison of the features of the nomenclatures.

- Princess Margaret Hospital Head & Neck Nomenclature

  In 2007, the Princess Margaret Hospital (PMH) in Toronto reported on a standardized Head & Neck voluming nomenclature that they had implemented in 2004 [18] to facilitate planning, quality assurance (QA) and future outcome audits of IMRT. It was designed to conform to ICRU 50 and 62. They used case-sensitive terminology for normal structures, gross disease and target volumes are which they described as unique and descriptive e.g. CORD (spinal cord), R facial (right facial node). Guidelines were developed to handle separate, multiple or combined targets.

  Physicians contour the primary disease with a GTV. For patients who have undergone surgery where there may be no gross tumour objects, the site(s) of preoperative tumour were considered high risk (CTV), as currently there is no ICRU terminology for this principle. Physicians contour all nodal gross disease and localized its anatomic position to specific surgical levels in the neck. A laterality prefix 'R' or 'L' is used for gross or elective neck nodal targets with the addition of nodal levels, e.g. R2A (right level IIa node). Dose was applied to CTVs as a suffix. The term CTV without prefix refers to a volume surrounding the GTV. In combination, their nomenclature specified RCTVs and LCTVs (right and left CTV) with corresponding PTVs, LPTVs and RPTVs. Increased specification produced these patterns - CTV50 (50 Gy CTV surrounding GTV), R2ACTV70 (70 Gy CTV encompassing a right level IIa node). All PTVs and PRVs are generated by planners [18].

  The authors felt that the voluming nomenclature had served the purpose of facilitating multidisciplinary communication, quality assurance review of H&N planning and had enabled the safe automation of complex programming tasks [18].

  There are some attractive principles espoused in this nomenclature, including the unambiguous use provided by capitalised names, a clear specification of laterality and specific surgically defined neck lymph nodes sites. However, the source of the anatomical names is not described, and is limited to H&N cases by original intent [1]. The positioning of the laterality as a prefix without separation from the volume's primary name makes reading difficult, and the lack of delimiter use affects legibility of more complex names, for example the name required for planning (CTV) may be disguised (R2ACTV70). While not specifically mandated in the ICRU reports, the use of dose in Gray is problematic for fractional doses (e.g., 50.4Gy). The use of an integer with centiGray (cGy), is preferred as it avoids the use of period in the name. Although supposedly based on ICRU 50/62, the nomenclature contravenes these standards by not identifying involved lymph

nodes as gross tumour volume ([4], Section 2.3.1 pg 6). In terms of aesthetics, one can compare R2ACTV70 with a rearranged and separated version, CTV_R_2A_7000, to decide on the legibility issue. While the PMH H&N nomenclature wraps dose with the CTV, in neither ICRU 50 [4] nor ICRU 63 [19] is there a CTV described with a juxtaposed dose. These reports only use dose when describing a PTV, and when specifying coverage of a PTV. Finally, in terms of workload, the nodal levels in the neck are defined separately while in fact the nodal groups are in continuity and might be defined differently in the future [3].

- Advanced Technology Consortium Nomenclature

  The second example of a nomenclature is one developed by a consortium, predominantly of physicists in USA and European cancer centres (Advanced Technology Consortium, ATC) [20]. This work indicates that nomenclatures are also useful to professions downstream from radiation oncologists who have responsibilities in differing facets of radiotherapy.

  Unfortunately radiation physicists are not the purveyors of knowledge structure of the medical domain of Radiation Oncology, only of the physics portion of the domain. The limited engagement of radiation oncologists has the potential to skew the nomenclature away from its general applicability in radiation oncology [1]. Failure to make the nomenclature relevant to radiation oncologists will result in under-use of the nomenclature.

  The group correctly identify that a nomenclature with consistent language and terminology is a key component of any effective process improvement and work flow management infrastructure [20]. The intra-departmental variability of free-text structure names prevents the reliable mapping of names by automated heuristic methods. The only solution is a great deal of manual quality assurance [20]. The pervasive nature of the Internet is moving attention onto inter-institutional data sharing and analyses. When this occurs, lack of standardisation will prevent sharing. Interoperability for analysis requires the profession to identify, adopt, and maintain a list of standardized structure names [20]. This nomenclature purports to be successfully implemented and in use [21].

  The ATC schema [20] is more complex and comprehensive than the PMH H&N nomenclature by attempting to address all circumstances, not just H&N, and divides structure names into target volumes (TV) and contours, which could be either Organs At Risk or Planning organ at Risk Volumes (PRV) derived from the OARs. The tenets of the schema are state that all radiation dose levels are specified in units of cGy with a maximum of five characters, and that margins are specified in units of millimeters with a maximum of two characters. The volume name is constructed using a capitalised TV base name, e.g., GTV, CTV, PTV, followed by a suffix associated with the target (p=primary, n=node) and target multiplicity (1, 2, ...) separated by an underscore (_) delimiter, but does not specify laterality. The inclusion of dose into CTV is not specified by any other standard [4, 19] and does not follow clinical reasoning. The CTV is an expression of risk, not dose. The oncologist defines the risk areas initially but only then specifies the dose

to the corresponding PTV [4, 19] based on the level of risk. This specification should be discussed with oncologists, the relevant users.

The order of suffixes may not reflect clinical importance. The volume GTVn1 when expanded by 15mm becomes CTVn1_15_5000. Irrespective of the inclusion of dose with CTV, a discussion should occur to see whether CTVn1_15_5000 or CTVn1_5000_15 is the preferred format.

They introduce the Tumour Bed Volume (TBV) and quantify respiratory motion in the respiratory cycle (EE (end expiration) or EI (end inspiration)) to allow the generation of an ITV. The source of the anatomic names used is not defined, nor how to add additional names. Base OAR names are constructed with more ambiguous and error prone *CamelCase* truncated at 16 characters. For repeating organs (ribs, cranial nerves, vertebral bodies) a laterality and suffix number is used inconsistently, e.g., (CN_I_R, CN_II_L, Rib1_L, Rib2_R, VB_C1_R (C=cervical, T=thoracic,L=lumber, S=sacral). Vasculature was named as A_name (artery) or V_name (vein), and combined bilateral organs were named simply as a plural organ (Lung_R + Lung_L = Lungs; Kidney_R + Kidney_L = Kidneys). Planning Risk Volumes as derived from the base OAR names with an underscore (_) delimiter for uniform expansion margins in millimetres (2 numerals maximum) (e.g., SpinalCord_05). Asymmetric PRV expansion uses the suffix _PRV (e.g., SpinalCord_PRV), but this could cause confusion (e.g., SpinalCord, SpinalCord_05, SpinalCord_PRV)

- TransTasman Radiation Oncology Group

  The TransTasman Radiation Oncology Group (TROG) has recently published their Standardised Nomenclature on their website[2] as the output of an XLS file without instructions on use. The document (from 14 May 2014) is a list of names with no instructions to describe use. Unconventional and general names are not provided with any definition to permit accurate delineation. The contour BaseOfTongue has no specification to assist an oncologist draw the contour. While the FMA does recognise the concept of regions, the lack of distinct boundaries prevents definition and so should be avoided in Planning Nomenclatures.

  The specification also contains some lateralised organs (Breast_L, Breast_R) but not others (CN_VII, Atrium). It also duplicates names without indication of how they differ (LargeBowel/Colon, Constrictors/PharynxConst, Eye/Globe, MainBronchus/BronchialTree/LobarBronchus_L). Some names are unusual (MassMuscle, GreatVessel, Vessels, A_Hypophyseal), while others are inconsistent (FemHead/FemoralJoint, Lung/BilatLung, A_subclavicular/V_SubClav).

  The lack of extensibility, duplications, undefined contours and inconsistencies indicate that this standard is not mature.

[2] *The document can be downloaded here - http://trog.com.au/SiteFiles/trogcomau/TROG_standardised_structure_names.pdf*

- Gregoiré Research Consortium Nomenclature

  A recent publication [3] provides consensus guidelines from several research groups, specifically DAHANCA, EORTC, HKNPCSG, NCIC CTG, NCRI, RTOG and TROG, on the nomenclature for neck lymphatic regions. The report focuses on this anatomical area alone, and as such provides no assistance in how to incorporate these names into a system to identify what has been contoured, or how to construct volumes in a way that describes their antecedents. Furthermore, it controversially suggests that the entire surgical nomenclature should be altered. It may be that such a proposal fails to gain widespread use outside of radiation oncology trials in H&N.

- Illawarra Cancer Care Centre Standardised Nomenclature

  This specification is provided in Appendix 1, and is an adaptable nomenclature based on the Foundational Model of Anatomy for OAR names, and a similar, though independently derived, TV construction to the ATC nomenclature. Being developed by an oncologist, it addresses the definition of lymphatic levels that are to be assigned to different risk levels, the ability to include new anatomy names, and the clinical use of the ICRU reports in generating TVs.

  The specification enshrines the logic of the ICRU process in moving from OARs to GTVs then through to PTVs. Using the GTVs, the definition of most CTVs occurs by combination of GTV expansion and OAR confinement. The generation of PTVs uses the aggregation of CTVs. This standardised nomenclature is also compared in Table 1. While the system does not use a meta-data definition for its construction method, as the next section demonstrates, the logic embedded in the metadata definition is identical to the logic described in this schema.

  The system also stipulates that PRVs and PTVs are not to be manually shaped, so that there is the possibility of assessing the outcome of assigning constraint priority to PRVs or PTVs can be detected.

Table 1: A Comparison of Standardised Nomenclatures

Standardised Nomenclature	PMH N&N	Gregoire, 2013	ATC	TROG	ICCC
Professional body	No, institution	Yes, research group	Yes, physicists	Yes, research group	No, institution
In use	Yes	No	Yes	No	Yes, individuals
Naming	CAPITALS	Numeric	CamelCase	CamelCase	CAPITALS
Applicability	H&N alone	H&N alone	All	All	All
Volumes					
Units (cGy)	No, Gy	Yes	Yes	No	Yes
Dose assigned to	CTV, PTV	CTV, PTV	PTV	No	PTV
Complies with ICRU50/62	No	No	Yes	No	Yes
Delineated GTV	Yes	GTVp*x*, GTVn*x*	GTVp*x*, GTVn*x*	No	GTVp*x*, GTVn*x*
Delineated CTV	Yes	CTVp*x*, CTVn*x*	CTVp*x*, CTVn*x*	No	CTV
Generated PTV	Yes	PTVp*x*_*dose*	PTV_*dose*	No	TROG_PTV_*dose*
Margins defined	No	Yes, suffix #1, mm	Yes, suffix #2, mm	No	No
Contours					
Anatomy Ontology	No	No	No	No	Yes, FMA
Add new OAR	No	No	No	No	Yes, refer to FMA
Delimiter	None	No	Underscore	Underscore	Underscore
OAR Laterality	Prefix	No	Yes	Yes, suffix #1	Yes, suffix #1
PRV definition	No	No	Yes	No	yes
PRV expansion	No	No	Yes, suffix #1	No	Yes, suffix #2
Respiratory motion	No	No	Yes	No	yes
Combined organs	--	No	Use plural	Use plural	Use _TOTAL
Tumour Bed Volume (TBV)	No	No	Yes	No	yes
Defines H&N Lymphatic volumes	Yes	Yes	No	No	yes
Identifies H&N Lymphatics volumed	Yes	Yes	No	No	yes
Defines & Identifies Pelvic lymphatics	No	No	No	No	yes
Defines & Identifies Mediastinal Lymphatics	No	No	No	No	yes

4. Standardised Anatomy Nomenclature

The use of a standardised framework is useful whenever trying to define and use expert domain knowledge. Anatomy is not the sole province of oncology and as its own expert domain has been subject to attempts at definition already.

The Foundational Model of Anatomy (FMA) was built to accommodate the knowledge of anatomy to be defined in a way that allows for machine argument. The ontology is built with terms (more than 110,000 [22]) that have a relationship (more than 170 types [22]). Examples of relationships that are well understood in the Radiation Oncology domain include:

- Tip of Tongue *drains_to* Level IA lymphatics.
- Level IA lymphatics *are_bounded_anteriorly_by* Mandible.
- Level IA lymphatics *drains_to* Level IB lymphatics.
- Level IB lymphatics *drains_to* Level II lymphatics.
- Level II lymphatics *drains_to* Level III lymphatics.
- Level III lymphatics *drains_to* Level IV lymphatics.
- Facial Artery *is_anterior_to* Masseter Muscle.

Once connected by one of the many relationships possible, logical arguments and searches can be built to answer questions. It is possible to ask the question, "What is the lymphatic drainage of the Tip of Tongue?" and establish that there is an anatomic link between the Tip of Tongue and the Level 4 lymphatics, which is what we teach our trainees to consider when drawing contours and volumes in the neck for radiotherapy. The benefit of the description logic in the FMA is seen where nodal drainage in the neck is described from the FMA and its relationships ('afferent', 'efferent') [23]. There is data demonstrating the use of an anatomy ontology in radiotherapy planning [24–26].

The use of a knowledge structure, such as the FMA, will permit easier outcomes research. It will allow faster and more accurate audit of practice, if practice definition allows the anatomical sites included to be defined retrospectively. Organ contouring can be compared between sites, even to the point of looking at CT numbers around the region of interest (ROI) boundary and adjudicating on conformality. It is likely that many ROIs will not be controversial (e.g., KIDNEY), but others such as CTVs and PTVs will be very variable [27].

5. What benefits accrue?

What can we do together if we use a standardised nomenclature? A standardised nomenclature for planning allows radiation oncologists to speak the same language, a language of intent and process relating to the construction of a plan. A logically constructed nomenclature allows for a limited description of actions undertaken in producing volumes from contours and GTVs.

The purpose of implementing a standardised nomenclature is to carry forward the original intent of the ICRU expressed in Reports 50 and 62 so that the construction of the radiation plan becomes logical and reveals the intent of the oncologist.

While there are international efforts to accumulate radiotherapy planning data [28], the lack of a nomenclature limits the effort by having mismatched ROI names, and by being unable to compare the actual method of construction of the ROIs. In fact, a later publication makes no mention at all of these nomenclature issues [29]. The comparison of variably named ROIs without any hint of the intent in construction cannot lead to useful conclusions to inform radiation oncologists.

6. Conclusion

The definition of contours and volumes in Radiation Oncology requires the use of names. These names have a use that lasts long after the development of an acceptable plan and can be used to define, or obscure, the voluming procedures and their consequence when developing new knowledge. At the heart of this ability is the need to combine data from many departments to discover explicit decisions and their consequences.

The realisation of this functionality is the problem of interoperability which Informatics addresses. It does this by applying knowledge modelling techniques to the development of standardised nomenclatures which embed components of knowledge and work flow. In its final state the components will be expressed in the metadata attached to a specific volume. The XML schema provides an excellent way of realising this level of metadata.

However while the application of Informatics to Radiation Oncology problems requires and assists in the production of nomenclatures for use, the realities of language and local use dictate that local instances of these nomenclatures must be permitted, and that a mechanism for translating locally developed nomenclatures into an ontologically sound and enabled schema should be in place.

This paper is followed by an appendix containing a clinically utilised specification where the correlation of organ

name with the Foundational Model of Anatomy provides the planning process with an structured ontology capable of machine manipulation. The appendix also displays that the logical development of target volume names also provides a specification of the knowledge flow and critical decision making undertaken by the radiation oncologist to assist with data mining of medical decisions. The nomenclature is superior to previous patterns, it is not completely expressive, because the granularity of metadata required cannot be specified in a single short name.

The development of such a granular process requires that commercial vendors approach the problem is a way that satisfies the Informatics needs of the expert domain.

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CENTRE FOR ONCOLOGY INFORMATICS
STANDARDISED NAMING FOR RADIOTEHRAPY PLANNING

COI Anatomical Naming

Version 2.0 **released 16 June 2014**

The use of unique names in individual cases of radiotherapy planning for contours of normal structures and the volumes of targets is routine. The naming strategies are the responsibility of the radiation oncologist and largely idiosyncratic to each individual radiation oncologist. The variability of names precludes automated comparison of plans and the correlation with important outcome measures such as rates of local and regional control and survival.

This standardised nomenclature, which is developed by a practicing radiation oncologist, addresses these shortcomings in a way that addresses the clinical knowledge structure of radiation oncology so that the logic of contour and volume construction during the planning process makes evident the clinical decisions of the radiation oncologist.

The peculiar feature of this schema is its use of the Foundational Model of Anatomy (FMA) to provide names. The FMA is a formal ontology which embodies anatomical definitions and relationships that exist between other anatomic structures. Relationships such as **`is_inferior_to`** and **`is_drained_by`** are catered for. The FMA can be manipulated by computers.

Although developed independently, this nomenclature incorporates and extends patterns proposed by the ATC and the TransTasman Oncology Group (TROG) to achieve Informatics-specific aims. The specific Informatics aims are the ability to accumulate DICOM-RT plans into a 'big data' repository and to embed the details of clinical decision making for collaborative outcomes research. Its use in research environments will assist with standardisation and analysis of data.

Sites who may prefer a different schema, can use this schema as a template. So long as the local schema correlates with the FMA number, translation between schemas is enabled. This schema is the Illawarra schema and it means that the hard work has been done already if implemented.

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HTTP://RADONC.WIKIDOT.COM/LOCAL--FILES/ONCOLOGY-INFORMATICS/COI_STANDARDISED_NOMENCLATURE.PDF

NSW GOVERNMENT Health
Illawarra Shoalhaven
Local Health District

Contents

1. Capitals & Lower Case

All non-standard names produced by RADIATION ONCOLOGISTS are to be in CAPITALS to denote their origin.

All non-standard names produced by radiation therapists/dosimetrists are to be lowercase to denote their origin. If a radiation therapist/dosimetrist produces a spinal cord, it should be labelled ‘SPINALCORD’, not ‘sc’.

2. Names for Contours of Anatomy

All OAR names are in capitals. Some OAR names may be truncated as there is a restriction on the length of names in the DICOM format. The names are specified so that the identifier is unique. Where a unique name can used to represent a single entity, a single word is preferred and substituted (e.g., the hyoid bone becomes 'HYOID'). Likewise, there are standardised additions for laterality (_R/L) and description.

The usefulness of this approach derives from the ability of a site to undertake DVH analysis of OARs by using a single report on the DICOM-RT file, and then being able to use that report anywhere without alteration when the OAR names are identical.

If the definition of the anatomical structure is in question, please consult the FMA Explorer on the website1 to adjudicate.

For the sake of interoperability later, the important part of this table is the FMAID and the definition of this FMA-described organ. The joining of several organ parts (e.g., upper femur) likewise can specify the FMAIDs used.

Should you substitute different words for the OAR names here then do three things:

i. record the alternate name
ii. use the same name for all oncologists within the same unit
iii. use the same name all the time within the same unit

Where organ contours are being produced, the use of auto-contouring based on CT numbers will result in a reproducible result, more so than free hand drawing. In the coming age of adaptive radiotherapy, this contouring technique is even more meaningful in trying to achieve reproducibility in contouring.

3. Planning Risk Volumes

The PRV is a construct which indicates how an organ at risk should be avoided during plan construction. The PRV is always constructed from a contoured organ. The organ is deemed to be ‘at risk’, and predicted to have an impact on plan appearance. Organs at Risk (OAR) can be sub-classified:

i. **Critical structures** which have a maximum dose allowable that may be achieved at the expense of PTV coverage.

   The normal examples are the SPINALCORD and BRAINSTEM. These organs will have their dose limited to a maximum, usually determined by documents such as those derived from QUANTEC.

ii. **Expendable structures** which have a desired dose but not at the expense of PTV coverage.

   The normal examples are PAROTID, LENS, KIDNEYS and OESOPHAGUS. These organs may be entirely expendable (e.g., LENS), or partially expendable (KIDNEYS).

   The PRVs for each are manufactured in different ways

iii. CRITICAL STRUCTURE_PRV

STRUCTURE_PRV = STRUCTURE + [MOTION EXPANSION]

This will mean that the STRUCTURE_PRV may overlap the PTV indicating that the STRUCTURE_PRV should be spared in preference to PTV coverage.

iv. EXPENDABLE STRUCTURE_PRV

STRUCTURE _PRV = STRUCTURE +[MOTION EXPANSION] – PTV

This will mean that the STRUCTURE_PRV will not overlap the PTV, indicating that PTV coverage is preferred. The DVH should be assessed to ensure that the STRUCTURE doses are not excessive (e.g., KIDNEY_TOTAL V18Gy>80%, LUNG_TOTAL V20Gy>60%)

4. Names for Volumes of Risk

There are three volumes that require specification. The logical naming of these volumes requires an understanding of definitions of the volumes.

a. **GTV**

Each gross tumour volume exists in one of three varieties – primary or Tumour, draining nodes or Nodes, and finally Metastases. The proposal is that these suffixes be added without spacer to the GTV, with numbers used to indicate individual masses if desired.

i. GTVp
the primary as visualised on the planning imaging scans

ii. GTVn
an involved node (single) or multiple involved nodes where no differentiation is required
- GTVn5
the fifth involved node volumed , if you wish to distinguish it from the first four

iii. GTVm
a single metastasis or multiple metastases where no differentiation is required
- GTVm2
the second metastasis volumed

b. **CTV**

Each GTV will have an associated CTV which related to a risk-estimated expansion trimmed to unbreached anatomical boundaries where the risk estimates approach zero. The use of CTV1, CTV2, etc is to be avoided on the basis that it does not define the reason for the CTV, nor its attendant risk.

i. CTVp
this volume is not a 0.5, 1 or 2 cm expansion of the GTVp, it should be drawn to match the anatomical boundaries distant to the GTVp boundary where the probability of tumour breach falls to zero.

ii. CTVn
this volume is an expansion which is clipped at anatomical boundaries, since the extent of extracapsular extension in in situ nodes is unknown unless there is obvious change in fat density, at present expansions of less than 0.5cm cannot be justified, but whether it is 0,5, 1 or 2cm is a matter of personal risk estimation. It is difficult to see how more than 2cm could be justified if intervening fat is normal on

imaging. The volumes should be produced in the same way as CTVp above (i.e., to produce CTVn1, CTVn2, etc.) with one addition.

iii. CTVn0
this is, the '***node negative***' neck, which is an anatomical volume in the neck volume which is devoid of any involved nodes and outside the risk assessed expansion on involved nodes. This volume should be drawn around and exclude the CTVn. Modern software allows for over-inclusive volumes to be automatically trimmed.

It is understood that some oncologists wish to define two CTVn0 areas of moderate and low risk and deliver different doses. In the case of three dose levels define the CTVp/CTVn (high dose), CTVn0a (medium dose) and CTVn0b (low dose). CTVn0a/b will relate to different contours (contour the nodal areas at risk separately).

iv. CTVm
this volume is not a 0.5, 1 or 2 cm expansion of the GTVm, it should be drawn to match the anatomical boundaries distant to the GTVp boundary where the probability of tumour breach falls to zero.

c. **PTV**

The definition of the PTV is a geometric expansion of the CTVs which can be grouped automatically in current software with isotropic or anisotropic expansions to form PTVs which are to receive a particular dose. For this reason, the PTV is annotated by a number representing the number of centiGray (cGy) desired in the prescription. The reason for using centiGray revolves around the possible ambiguity of the decimal point in the IT world.

i. PTV7000
this is a volume including all CTVs to which the radiation oncologist required a total dose of 70Gy.
- PTV7000_3
this is the same volume where an isotropic expansion margin of 3mm has been used. In the case of an anisotropic volume, no suffix should be used.

d. **ITV**

This volume is used in cases of MEASURED movement of a VISIBLE structure. It is produced by the combination of all GTVs or an anatomically defined CTV on a each image set in a 4D image set. The use of an expanded CTV will result in excessively large volumes.

e. **TBV**

Tumour Bed Volume is optional and a thing volume where the sides of the operative bed have joined or are separated by fluid collection.

Notes:

1. **** Under no circumstances is the PTV ever drawn or manipulated by hand.**

2. It should be possible to specify PTV construction based on the specified CTVs present in the plan. For example,

   PTV6000 = CTVp + CTVn1 + CTVn2 +CTVn0 + 3mm

   PTV7000 = CTVp + CTVn1 +CTVn2 + 3mm

   It is worth noting that this process will overlap PTV7000 on PTV6000. This has no implications for planning as success in covering the 7000 will also successfully cover the PTV6000. If separate, non-overlapping PTVs are preferred, it is easier to define the highest dose first and then use that PTV as an exclusion volume:

   #1 **PTV7000 = CTVp + CTVn1 +CTVn2 + 3mm**

   #2 **PTV6000 = CTVn0 + 3mm – (PTV7000)**

5. The List of Anatomical names standardised against the FMA

Standard Nomenclature	Root Name [alphabetical]	OAR Name	FMA number (FMAID)
Adrenal glands Left	ADRENAL	ADRENAL_L	15629
Adrenal glands Right	ADRENAL	ADRENAL_R	15630
Anal canal	ANUS	ANALCANAL	15703
Anal Sphincter	INTERNALANALSPHINCTER	ANALSPHINCT	15710
Aorta	AORTA	AORTA	3734
Arytenoid cartilage	ARYTENOID	ARYTENOIDs	55109
Arytenoid cartilage Left	ARYTENOID	ARYTENOID_L	55114
Arytenoid cartilage Right	ARYTENOID	ARYTENOID_R	55113
Azygos vein	AZYGOS VEIN	V_AZYGOS	4838
Base of Tongue	BASE OF TONGUE	BASEOFTONGUE	54645
Urinary Bladder	BLADDER	BLADDER	15900
Wall of the Urinary Bladder	BLADDERWALL	BLADDERWALL	15902
Small intestine	BOWEL	BOWEL	7200
Brachial Plexus	BRACHIALPLEXUS	BRACHIALPs	5906
Brachial Plexus Left	BRACHIALPLEXUS	BRACHIALP_L	65221
Brachial Plexus Right	BRACHIALPLEXUS	BRACHIALP_R	65222
Brachiocephalic artery	BRACHIOCEPHALICARTERY	A_BRACHIOCEPH	3932
Brachiocephalic vein left	BRACHIOCEPHALICVEIN	V_BRACHIOCEPH_L	4761
Brachiocephalic vein right	BRACHIOCEPHALICVEIN	V_BRACHIOCEPH_R	4751
Brain	BRAIN	BRAIN	50801
Brainstem	BRAINSTEM	BRAINSTEM	79876
Breasts	BREAST	BREASTS	9601
Breast Left	BREAST	BREAST_L	73125
Breast Right	BREAST	BREAST_R	73124
Bronchial tree	BRONCHUS	BRONCHUSs	26660
Bronchial tree Right	BRONCHUS	BRONCHUS_R	26661
Bronchial tree Left	BRONCHUS	BRONCHUS_L	26662
Atlas	C1	VB_C1	12519
Axis	C2	VB_C2	12520
Cervical Vertebra	C3	VB_C3	12521
Cervical Vertebra	C4	VB_C4	12522
Cervical Vertebra	C5	VB_C5	12523
Cervical Vertebra	C6	VB_C6	12524
Cervical Vertebra	C7	VB_C7	12525
Cervical Vertebra	C8	VB_C8	23892
Carina of trachea	CARINA	CARINA	7465
Atrium of the heart	CARDIACATRIUM	ATRIUMs	7099
Atrium of the heart left	CARDIACATRIUM	ATRIUM_L	7097
Atrium of the heart right	CARDIACATRIUM	ATRIUM_R	7096
Ventricle of the heart	CARDIACVENTRICLE	VENTRICLEs	7100
Ventricle of the heart left	CARDIACVENTRICLE	VENTRICLE_L	7101
Ventricle of the heart right	CARDIACVENTRICLE	VENTRICLE_R	7098
Carotid artery	CAROTID ARTERY	A_CAROTIDs	3939
Left Carotid Artery	CAROTID ARTERY	A_CAROTID_L	4058
Right Carotid Artery	CAROTID ARTERY	A_CAROTID_R	3941
Cauda Equina	CAURAEQUINA	CAUDAEQUINA	52590
Celiac artery	CELIACARTERY	A_CELIAC	50737
Cerebellum	CEREBELLUM	CEREBELLUM	67944
Cerebrum	CEREBRUM	CEREBRUM	62000
Cervix of uterus	CERVIX	CERVIX	17740
Chest Wall	CHEST WALL	CHESTWALL	50060
Optic chiasm	CHIASM	CHIASM	62045
Clavicle Left	CLAVICLE	CLAVICLE_L	13323

Clavicle Right	CLAVICLE	CLAVICLE_R	13322
Oculomotor nerve Left	CNIII	CN_III_L	50880
Oculomotor nerve Right	CNIII	CN_III_R	50879
Glossopharyngeal nerve Left	CNIX	CN_IX_L	50892
Glossopharyngeal nerve Right	CNIX	CN_IX_R	50870
Trigeminal nerve Left	CNV	CN_V_L	50885
Trigeminal nerve Right	CNV	CN_V_R	50884
Abducens nerve	CNVI	CN_VI	50867
Abducens nerve Left	CNVI	CN_VI_L	50887
Abducens nerve Right	CNVI	CN_VI_R	50886
Facial nerve Left	CNVII	CN_VII_L	50889
Facial nerve Right	CNVII	CN_VII_R	50888
Spinal accessory nerve Left	CNXI	CN_XI_L	50899
Spinal accessory nerve Right	CNXI	CN_XI_R	50897
Hypoglossal nerve Left	CNXII	CN_XII_L	50903
Hypoglossal nerve Right	CNXII	CN_XII_R	50901
Cochlea	COCHLEA	COCHLEAs	60201
Cochlea Left	COCHLEA	COCHLEA_L	60203
Cochlea Right	COCHLEA	COCHLEA_R	60202
Large intestine	COLON	COLON	7201
Constrictor Muscle of Pharynx	CONSTRICTOR	CONSTRICTORS	46620
Cornea	CORNEA	CORNEAs	58238
Cornea Left	CORNEA	CORNEA_L	58240
Cornea Right	CORNEA	CORNEA_R	58239
Penis	CORPUS CAVERNOSUM	CAVERNOSUM	75189
Penis	CORPUS SPONGIOSUM	SPONGIOSUM	19617
Cricoid cartilage	CRICOID	CRICOID	9615
Diaphragm	DIAPHRAGM	DIAPHRAGM	13295
Digastric muscle Left	DIGASTRIC	DIGASTRIC_L	46293
Digastric muscle Right	DIGASTRIC	DIGASTRIC_R	46292
Duodenum	DUODENUM	DUODENUM	7206
External Ear	EAR EXTERNAL	EAR_EXTERNALs	52781
External Ear	EAR EXTERNAL	EAR_EXTERNAL_L	53644
External Ear	EAR EXTERNAL	EAR_EXTERNAL_R	53643
Middle Ear	EAR MIDDLE	EAR_MIDDLEs	56513
Middle Ear	EAR MIDDLE	EAR_MIDDLE_L	56515
Middle Ear	EAR MIDDLE	EAR_MIDDLE_R	56514
Esophagus	ESOPHAGUS	OESOPHAGUS	7131
Esophagus	ESOPHAGUS	ESOPHAGUS	7131
Eyeball Left	EYE	EYE_L	12515
Eyeball Right	EYE	EYE_R	12514
Femur Left	FEMUR BASE	FEMBASE_L	32846
Femur Right	FEMUR BASE	FEMBASE_R	32845
Femur Left	FEMUR HEAD & NECK	FEMHEAD_L	32843
Femur Right	FEMUR HEAD & NECK	FEMHEAD_R	32842
Femur Left	FEMUR SHAFT	FEMSHAFT_L	32849
Femur Right	FEMUR SHAFT	FEMSHAFT_R	32848
Femur Left	FEMUR WHOLE	FEMUR_L	24475
Femur Right	FEMUR WHOLE	FEMUR_R	24474
Femur Left	FEMUR JOINT	FEMJOINT_L	35180
Femur Right	FEMUR JOINT	FEMJOINT_R	35179
Fibula	FIBULA	FIBULAs	24479
Fibula Left	FIBULA	FIBULA_L	24481
Fibula Right	FIBULA	FIBULA_R	24480
Frontal cerebral lobe left	FRONTALLOBE	FRONTALL_L	72970
Frontal cerebral lobe right	FRONTALLOBE	FRONTALL_R	72969
Gall bladder	GALLBLADDER	GALLB	7202
Hepatogastric ligament	GASTROHEPATICLIGAMENT	GHL	16520

Vocal cords	GLOTTIS	GLOTTIS	55414
Heart	HEART	HEART	7088
Hippocampus	HIPPOCAMPUS	HIPPOCAMPUSs	275020
Hippocampus Left	HIPPOCAMPUS	HIPPOCAMPUS_L	275024
Hippocampus Right	HIPPOCAMPUS	HIPPOCAMPUS_R	275022
Humerus Left	HUMERUS	HUMERUS_L	23131
Humerus Right	HUMERUS	HUMERUS_R	23130
Hyoid bone	HYOIDBONE	HYOID	52749
Hypophyseal artery	HYPOPHYSEALARTERY	A_HYPOPHYSEAL	49849
Hypothalamus	HYPOTHALAMUS	HYPOTHAMALUS	62008
Common iliac artery Left	ILIAC_CA	A_ILIAC_C_L	14766
Common iliac artery Right	ILIAC_CA	A_ILIAC_C_R	14765
Common iliac vein Left	ILIAC_CV	V_ILIAC_C_L	21388
Common iliac vein Right	ILIAC_CV	V_ILIAC_C_R	21387
External iliac artery Left	ILIAC_EA	A_ILIAC_E_L	18807
External iliac artery Right	ILIAC_EA	A_ILIAC_E_R	18806
External iliac vein Left	ILIAC_EV	V_ILIAC_E_L	18886
External iliac vein Right	ILIAC_EV	V_ILIAC_E_R	18885
Internal iliac artery Left	ILIAC_IC	A_ILIAC_I_L	18810
Internal iliac artery Right	ILIAC_IC	A_ILIAC_I_R	18809
Internal iliac vein Left	ILIAC_IV	V_ILIAC_I_L	18888
Internal iliac vein Right	ILIAC_IV	V_ILIAC_I_R	18887
Ilium Left	ILIUM	ILIUM_L	16591
Ilium Right	ILIUM	ILIUM_R	16590
Internal jugular vein	INTERNALJUGULARVEIN	V_INTERNALJUG_L	4762
Internal jugular vein	INTERNALJUGULARVEIN	V_INTERNALJUG_R	4754
Ischium Left	ISCHIUM	ISCHIUM_L	16594
Ischium Right	ISCHIUM	ISCHIUM_R	16593
Inferior vena cava	IVC	IVC	10951
Kidney	KIDNEY	KIDNEYs	264815
Kidney Left	KIDNEY	KIDNEY_L	7205
Kidney Right	KIDNEY	KIDNEY_R	7204
Renal pelvis Left	KIDNEYPELVIS	KPELVIS_L	15579
Renal pelvis Right	KIDNEYPELVIS	KPELVIS_R	15578
Lumbar Vertebra	L1	VB_L1	13072
Lumbar Vertebra	L2	VB_L2	13073
Lumbar Vertebra	L3	VB_L3	13074
Lumbar Vertebra	L4	VB_L4	13075
Lumbar Vertebra	L5	VB_L5	13076
Lacrimal gland Left	LACRIMAL	LACRIMAL_L	59103
Lacrimal gland Right	LACRIMAL	LACRIMAL_R	59102
Anterior interventricular branch of LCA	LAD	A_LAD	3862
Larynx	LARYNX	LARYNX	55097
Lens Left	LENS	LENS_L	58243
Lens Right	LENS	LENS_R	58242
Liver	LIVER	LIVER	7197
Lymph nodes			
– common iliac Left	LN_ILIAC_COM	LN_ILIAC_COM_L	224269
– common iliac Right	LN_ILIAC_COM	LN_ILIAC_COM_R	224269
– external iliac Left	LN_ILIAC_EXT	LN_ILIAC_EXT_L	229177
– external iliac Right	LN_ILIAC_EXT	LN_ILIAC_EXT_R	229177
– internal iliac Left	LN_ILIAC_INT	LN_ILIAC_INT_L	224275
– internal iliac Right	LN_ILIAC_INT	LN_ILIAC_INT_R	224275
– obturator Left	LN_OBT	LN_OBT_L	16676
– obturator Right	LN_OBT	LN_OBT_R	16676
– para-aortic	LN_PARAAORTIC_TxLx (upper T level – lower L level)	LN_P_AORTIC_TxLx	223899

– presacral	LN_PRESACRAL	LN_PRESACRAL	234280
– inguinofemoral	LN_INGUINAL	LN_INGUINOFEMs	236337
– inguinofemoral	LN_INGUINAL	LN_INGUINOFEM_R	236339
- inguinofemoral	LN_INGUINAL	LN_INGUINOFEM_L	236341
Axillary lymphatics			
Left	LN_Ax_L	LN_AX_L	73250
Right	LN_Ax_R	LN_AX_R	73249
Pectoral axillary lymphatics			
Left	LN_Ax1_L	LN_AX1_L	73253
Right	LN_Ax1_R	LN_AX1_R	73252
Central axillary lymphatics			
Left	LN_Ax2_L	LN_AX2_L	73263
Right	LN_Ax2_R	LN_AX2_R	73262
Apical axillary lymphatics			
Left	LN_Ax3_L	LN_AX3_L	73265
Right	LN_Ax3_R	LN_AX3_R	73264
Parasternal lymph nodes			
Left	LN_IMC	LN_IMC_L	5934
Right	LN_IMC	LN_IMC_R	5933
Lung	LUNG	LUNGs	68877
Lung Left	LUNG	LUNG_L	7310
Lung Right	LUNG	LUNG_R	7309
Lung - lower lobe of left	LUNG_LLL	LUNG_LLL	7371
Lung - upper lobe of left	LUNG_LUL	LUNG_LUL	7370
Lung - lower lobe of right	LUNG_RLL	LUNG_RLL	7337
Lung - middle lobe of right	LUNG_RML	LUNG_RML	7383
Lung - upper lobe of right	LUNG_RUL	LUNG_RUL	7333
Mandible	MANDIBLE	MANDIBLE	52748
Masseter Left	MASSETER	MASSETER_L	48998
Masseter Right	MASSETER	MASSETER_R	48997
Occipital cerebral lobe left	OCCIPITALLOBE	OCCIPITALL_L	72976
Occipital cerebral lobe right	OCCIPITALLOBE	OCCIPITALL_R	72975
Optic nerve Left	OPTICN	OPTICN_L	50878
Optic nerve Right	OPTICN	OPTICN_R	50875
Orbit Left	ORBIT	ORBIT_L	53083
Orbit Right	ORBIT	ORBIT_R	53082
Ovary Left	OVARY	OVARY_L	7214
Ovary Right	OVARY	OVARY_R	7213
Pancreas	PANCREAS	PANCREAS	7198
Parametrium	PARAMETRIUM	PARAMETRIUM	77061
Parietal cerebral lobe left	PARIETALLOBE	PARIETALLOBE_L	72974
Parietal cerebral lobe right	PARIETALLOBE	PARIETALLOBE_R	72973
Parotid gland Left	PAROTID	PAROTID_L	59798
Parotid gland Right	PAROTID	PAROTID_R	59797
Bony pelvis	PELVIS	PELVIS	16586
Bony pelvis Left	PELVIS	PELVIS_L	20227
Bony pelvis Right	PELVIS	PELVIS_R	20226
Penis	PENIS	PENIS	9707
Bulb of Penis	PENIS	PENISBULB	19614
Pericardium	PERICARDIUM	PERICARDIUM	9869
Perineum	PERINEUM	PERINEUM	9579
Peritoneal sac	PERITONEUM	PERITONEUM	9908
Pineal body	PINEALBODY	PINEAL	62033
Pituitary gland	PITUITARY	PITUITARY	13889
Platysma Left	PLATYSMA	PLATYSMA_L	45740
Platysma Right	PLATYSMA	PLATYSMA_R	45739
Pons	PONS	PONS	67943
Porta hepatis	PORTA	PORTA	15758

Prostate	PROSTATE	PROSTATE	9600
Pterygoid m. Left lateral	PTERYGOIDLATERAL	PTERYGOIDL_L	49017
Pterygoid m. Right lateral	PTERYGOIDLATERAL	PTERYGOIDL_R	49016
Pterygoid m. Left medial	PTERYGOIDMEDIAL	PTERYGOIDM _L	49013
Pterygoid m. Right medial	PTERYGOIDMEDIAL	PTERYGOIDM _R	49012
Pubic bone Left	PUBIS	PUBIS_L	16597
Pubic bone Right	PUBIS	PUBIS_R	16596
Pulmonary artery	PULMONARY ARTERY	A_PULMONARY	66326
Pulmonary vein	PULMONARY VEIN	V_PULMONARY	66643
Radius Left	RADIUS	RADIUS_L	23465
Radius Right	RADIUS	RADIUS_R	23464
Rectum	RECTUM	RECTUM	14544
Rectum	RECTUM	RECTUMWALL	14626
Retina Left	RETINA	RETINA_L	58303
Retina Right	RETINA	RETINA_R	58302
First Rib Left	RIB1	RIB1_L	7987
First Rib Right	RIB1	RIB1_R	7857
Tenth rib Left	RIB10	RIB10_L	8472
Tenth rib Right	RIB10	RIB10_R	8445
Eleventh rib Left	RIB11	RIB11_L	8532
Eleventh rib Right	RIB11	RIB11_R	8531
Twelfth rib Left	RIB12	RIB12_L	8534
Twelfth rib Right	RIB12	RIB12_R	8533
Second rib Left	RIB2	RIB2_L	8012
Second rib Right	RIB2	RIB2_R	7882
Third rib Left	RIB3	RIB3_L	8039
Third rib Right	RIB3	RIB3_R	7909
Fourth rib Left	RIB4	RIB4_L	8148
Fourth rib Right	RIB4	RIB4_R	7957
Fifth rib Left	RIB5	RIB5_L	8093
Fifth rib Right	RIB5	RIB5_R	8066
Sixth rib Left	RIB6	RIB6_L	8202
Sixth rib Right	RIB6	RIB6_R	8175
Seventh rib Left	RIB7	RIB7_L	8256
Seventh rib Right	RIB7	RIB7_R	8229
Eighth rib Left	RIB8	RIB8_L	8310
Eighth rib Right	RIB8	RIB8_R	8283
Ninth rib Left	RIB9	RIB9_L	8391
Ninth rib Right	RIB9	RIB9_R	8364
Sacral Vertebra	S1	VB_S1	13077
Sacral Vertebra	S2	VB_S2	13078
Sacral Vertebra	S3	VB_S3	13079
Sacral Vertebra	S4	VB_S4	13080
Sacral Vertebra	S5	VB_S5	13081
Sacrum	SACRUM	SACRUM	16202
Scapula Left	SCAPULA	SCAPULA_L	13396
Scapula Right	SCAPULA	SCAPULA_R	13395
Scrotum	SCROTUM	SCROTUM	18252
(skin & cremasteric fascia)			
Seminal vesicle	SEMINALVESICLE	SV	19387
Skin	SKIN	SKIN	7163
Small intestines	SMALLBOWEL	SMALLBOWEL	7200
Vertebral canal	SPINALCANAL	SPINALCANAL	9680
Spinal cord	SPINALCORD	SPINALCORD	7647
Spinal cord	SPINALCORD	SPINALCORD_C	71166
Spinal cord	SPINALCORD	SPINALCORD_T	71167
Spinal cord	SPINALCORD	SPINALCORD_L	71168
Spinal cord	SPINALCORD	SPINALCORD_S	256623

Spleen	SPLEEN	SPLEEN	7196
Splenic hilum	SPLEEN	SPLEENHILUM	15841
Sternocleidomastoid Left	STERNOMASTOID	SCM_L	13409
Sternocleidomastoid Right	STERNOMASTOID	SCM_R	13408
Stomach	STOMACH	STOMACH	7148
Subclavian artery left	SUBCLAVIAN ARTERY	A_SUBCLAV_L	4694
Subclavian artery right	SUBCLAVIAN ARTERY	A_SUBCLAV_R	3953
Subclavian vein right	SUBCLAVIAN VEIN	V_SUBCLAV_R	4755
Subclavian vein left	SUBCLAVIAN VEIN	V_SUBCLAV_L	4763
Sublingual gland	SUBLINGUALGLAND	SUBLINGs	59791
Sublingual gland Left	SUBLINGUALGLAND	SUBLING_L	59805
Sublingual gland Right	SUBLINGUALGLAND	SUBLING_R	59804
Submandibular gland Left	SUBMANDIBULARGLAND	SUBMAND_L	59803
Submandibular gland Right	SUBMANDIBULARGLAND	SUBMAND_R	59802
Superior mesenteric artery	SMA	A_SMA	14749
Superior vena cava	SVC	V_SVC	4720
Symphysis pubis	PUBICSYMPHYSIS	PUBICSYMPHYSIS	16950
Thoracic Vertebra	T1	VB_T1	9165
Thoracic Vertebra	T2	VB_T2	9187
Thoracic Vertebra	T3	VB_T3	9209
Thoracic Vertebra	T4	VB_T4	9248
Thoracic Vertebra	T5	VB_T5	9922
Thoracic Vertebra	T6	VB_T6	9945
Thoracic Vertebra	T7	VB_T7	9968
Thoracic Vertebra	T8	VB_T8	9991
Thoracic Vertebra	T9	VB_T9	10014
Thoracic Vertebra	T10	VB_T10	10037
Thoracic Vertebra	T11	VB_T11	10059
Thoracic Vertebra	T12	VB_T12	10081
Temporomandibular joint	TMJ	TMJs	54832
Temporomandibular joint left	TMJ	TMJ_L	54834
Temporomandibular joint right	TMJ	TMJ_R	54833
Temporal cerebral lobe Left	TEMPORAL LOBE	TEMPORALL_L	72972
Temporal cerebral lobe Right	TEMPORAL LOBE	TEMPORALL_R	72971
Testis Left	TESTIS	TESTIS_L	7212
Testis Right	TESTIS	TESTIS_R	7211
Thoracic Duct	THORACIC DUCT	THORACICDUCT	5031
Thyroid	THYROID	THYROID	9603
Thyroid cartilage	THYROIDCARTILAGE	THYROID_C	55099
Trachea	TRACHEA	TRACHEA	7394
Ureter Left	URETER	URETER_L	17888
Ureter Right	URETER	URETER_R	17887
Urethra	URETHRA	URETHRA	19667
Uterus	UTERUS	UTERUS	17558
Vagina	VAGINA	VAGINA	19949
Vulva (includes mons pubis)	VULVA	VULVA	20462

6. Pelvic & intra-abdominal lymph chains

This table describes the individual chains with radiological demarcation. Use this list if you wish to contour individual nodal groups. The suffix _R/L should be added to the end to designated laterality when the group is not central.

Lymphatic Chain	FMAID	Anatomy [all these entities exclude peritoneal space, mesorectum, muscles & bones]	
Thoracic duct			
THORACICDUCT	[5031]	*Top*: root of the neck *Right*: R crus of the diaphragm *Anterior*: aorta	*Bottom*: level of L2 *Left*: aorta *Posterior*: body of the L2
Lateral aortic lymphatics			
LN_P_AORTIC_TxLx	[223899]	*Top*: second lumbar vertebra *Right*: lateral psoas m. *Anterior*: peritoneum	*Bottom*: aortic bifurcation *Left*: lateral psoas m. *Posterior*: vertebra
Common iliac lymphatics			
LN_ILIAC_COM	[224269]	*Top*: aortic bifurcation *Medial*: no medial border *Anterior*: peritoneum	*Bottom*: common iliac bifurcation *Lateral*: medial edge of psoas muscle *Posterior*: pelvic bones (not nerve canal)
Sacral lymphatic chain			
LN_PRESACRAL	[234280]	*Top*: common iliac bifurcation *Medial*: continuous volume *Anterior*: peritoneum	*Bottom*: S1-2 junction *Posterior*: common iliac LC *Posterior*: sacral bones
External iliac lymphatics			
LN_ILIAC_EXT	[229177]	*Top*: common iliac bifurcation *Medial*: peritoneum *Anterior*: anterior border of artery/vein complex cease at ‘pelvic brim’ (line connecting anterior pelvic bones) *Posterior*: mid-distance to internal iliac artery [arbitrary], obturator LC	*Bottom*: superior level of mesorectum *Lateral*: pelvic muscle/bone
Inguinofemoral lymphatics			
LN_INGUINAL	[44226]	*Top*: superior level of pelvic brim *Bottom*: origin of profunda femoris	
Internal iliac lymphatics			
LN_ILIAC_INT	[224275]	*Top*: common iliac bifurcation *Medial*: peritoneum *Anterior*: mid-distance to external iliac artery, obturator LC *Posterior*: anterior aspect of piriformis muscle	*Bottom*: superior level of mesorectum *Posterior*: pelvic muscle/bone
Obturator lymphatics		[between internal & external iliac lymphatics inferiorly]	
LN_OBT	[16676]	*Top*: level near superior level of mesorectum posterior to the bladder where vessels start to move medially *Bottom*: base of seminal vesicles, cervix (will be in the span of the femoral head) *Medial*: seminal vesicles *Anterior*: vascular tissue	*Lateral*: pelvic side wall muscle/bone Posterior: mesorectum
Parametrium		[very thin posterior to bladder, encompasses vascular tissue]	
PARAMETRIUM	[77061]	*Top*: level near superior level of mesorectum posterior to the bladder where vessels start to move medially *Bottom*: base of seminal vesicles, cervix {will be in the span of the femoral head) *Medial*: posterior bladder with large vessels *Lateral*: obturator LC *Anterior*: posterior bladder wall	*Posterior*: mesorectum

Nodal Groups

Use this list if you wish to contour composite nodal groups. The suffix _R/L should be added to the end to designated laterality when the group is not central.

1. **LN_PAORTIC_TxLx**
   extent of para-aortic nodes
   Fill in 'x' according to the upper level (“Tx”) and lower level (“Lx”)
   superior: crura of the diaphragms
   inferior: bifurcation of the aorta (1st slice with common iliac vessels), may vary from L4 to S1

Since the pelvic nodes are in continuity rather than discrete, multiple areas may be contoured, but still need to be identified. The proposal for naming of combined pelvic lymph nodes is to reduce to 2 groups:

2. PELVIC NODES

   i. All nodes **LN_PELVIS_F_EI_ CI_II_O_PS**

   This contour includes ALL the nodes in the pelvis and down to the femoral nodes. This should only be used when the nodes volumed are bilaterally identical. The nodes are centred on the vessels, but do not extend into the muscle, bones or across the peritoneum into the peritoneal cavity which containing bowel (meaning that this contour should not contain any bowel loops).

   ii. One sided nodes **LN_PELVIS_ F_EI_ CI_II_O_PS_R/L**

   This contour names the lateralised nodes in the pelvis. Similar to the neck nodes, the regions NOT included should be deleted from the name, e.g., LN_ CI_II_O _R includes the common, internal iliac and obturator nodes on the right. The nodes are centred on the vessels, but do not extend into the muscle, bones or across the peritoneum into the peritoneal cavity which containing bowel (meaning that this contour should not contain any bowel loops).

3. **MESORECTUM**
   superior: anorectal junction with surrounding retroperitoneal fat
   inferior: pelvic floor (where fat around rectum is no longer visible)
   lateral: outer border of pelvic floor muscles (inner margin of ischiorectal fossa)

In all cases, areas that are NOT volumed have their name removed. The easiest and most sensible way to do this is to decide which nodal areas will be contoured before drawing anything and to adjust names to reflect the decision making. Then do the drawing.

The treatment of the external iliac & femoral nodal areas is only likely to occur with perineal malignancy (anus, vulva, lower vagina). Treatment of the mesorectum is only likely to occur with rectal cancer and extensive anal cancers.

7. Head & Neck Lymphatic Chains

This naming procedure is adopted to indicate the nodal areas that are being targeted for radiotherapy.

Lymphatic Chain	FMAID	Gregoire[6]	Anatomy
Level I			Divided by the anterior belly of the digastric muscle
Submental (IA)	L&R: 223846 L: 235616 R: 235614	1	Top: MANDIBLE (symphysis menti) Bottom: superior THYROID_C Medial: - Lateral: DIGASTRIC (Medial) Anterior: DIGASTRIC (Medial) Posterior: muscle anterior to HYOID
Submandibular (IB)	L: 224001 R: 223999	2	Top: MANDIBLE Bottom: lowest extent of SUBMAND Medial: STYLOHYOID, GENIOGLOSSUS Lateral: DEEP FASCIA Anterior: MANDIBLE Posterior: posterior SUBMAND, STYLOHYOID_M
SUPERFICIAL **Facial (IX)**	L: 223832 R: 223830	11	Top: MANDIBLE Bottom: SUBMAND Medial: DEEP FASCIA Lateral: MANDIBLE Anterior: FACIAL_A Posterior: anterior SCM
Buccal (IX)		11	Top: level of zygoma Bottom: bottom of MANDIBLE Medial: oral cavity Lateral: fascial plane under the subcutaneous fat (SMAS) Anterior: - Posterior: anterior MASSETER
Level II			a.k.a “upper deep cervical nodes”
Level IIa	L: 241975 R: 241973	3	Top: skull base Bottom: inferior border of the hyoid Medial: lateral neck muscles Lateral: medial SCM Anterior: posterior SUBMAND Posterior: posterior SCM
Level IIb	L: 241979 R: 241977	3	Top: skull base Bottom: inferior border of the hyoid Medial: lateral neck muscles Lateral: medial SCM Anterior: anterior SCM Posterior: posterior SCM
DEEP Retropharyngeal (VIIa)	L: 224033 R: 224031	9	retropharyngeal space between pharynx & vertebral bodies, drains nasopharynx and posterior pharynx
SUPERFICIAL Parotid (VIII)	L: 223806 R: 223804	10	predominately around the superficial lobe, draining lateral face, lateral eyelids, anterior/lateral scalp
SUPERFICIAL Mastoid (Xa)	L: 223794 R: 223792	12	posterior to mastoid process and ear, drains lateral scalp, drains to superficial & deep cervical nodes
Level III			
	L: 241953 R: 241951	4	Top: inferior border of the hyoid Bottom: inferior border of the cricoid Medial: medial vessels Lateral: neck muscles Anterior: medial SCM Posterior: posterior SCM

SUPERFICIAL			
Occipital (Xb)	L: 223788 R: 223786	12	
Level IV			
	L: R: 241957	5	Top: inferior border of the cricoid Bottom: brachiocephalic vein Medial: medial vessels Lateral: neck muscles Anterior: medial SCM Posterior: posterior SCM
Level V			
	L: R: 223786		
Va	L: 265617 R: 265626	6	Top: mastoid Bottom: inferior cricoid cartilage Medial: neck muscles Lateral: neck fascia Anterior: posterior SCM Posterior: anterior trapezius
Vb		6	Top: inferior border of the cricoid Bottom: level of sternoclavicular joint Medial: neck muscles Lateral: neck fascia Anterior: posterior SCM Posterior: anterior trapezius
Vc		7	Lateral supraclavicular fossa
Level VI			
		8	Top: inferior border of the hyoid Bottom: sternal notch Medial: centre of neck Lateral: medial vessels Anterior: fascia Posterior: aerodigestive tube

The naming schema has adopted the practice that a contour of the lymphatic areas being targetted be delineated as normal anatomy before volumes are constructed. The name for the H&N lymph nodes which will be contoured will start with the name, **LN_HN_1a1b2a2b3456_rp_fb_p_o_R/L**, and the radiation oncologist will then remove from this 'complete' name those parts that the radiation oncologist will NOT volume.

This follows the normal pattern of oncological thought in arriving with "at risk" areas. The anatomy at riskis decided BEFORE volumes are drawn. This point of decision is therefore the appropriate time to adjust names. As a workflow issue, if these nodal contours areas are defined initially, then the nodal contour can be used to define the at-risk boundaries for clipping of CTVs. Rather than drawing a CTV which is an anatomical risk boundary, this schema proposes that the oncologist EXPLICITLY define the nodal groups at risk by providing an name describing what has been contoured.

It stands to reason then that **LN_HN_2a2b34_R** represents a right neck node volume that does not include **Levels Ia, Ib, V, VI, retropharyngeal (VIIa), facial (IX), parotid (VIII)** or **occipital nodes (Xb)**. The anatomical boundaries of the volume should be consistent with the descriptive code provided.

If the oncologist desires to use 3 dose levels then during the contouring phase the oncologist would produce two contours with non-overlapping numbers, e.g., **LN_HN_1a1b2a2b3_R** and **LN_45_R**, The first should be used in the definition of **CTVn0a** and the second used to define **CTVn0b**. The equations to produce the PTVs would be :

```
PTV7000 = CTVp + CTVn1 +CTVn2 + 3mm

PTV6000 = CTVp + CTVn1 + CTVn2 +CTVn0a + 3mm

PTV5400 = CTVn0b + 3mm – PTV6000
```

8. Mediastinal Lymph Node Chains

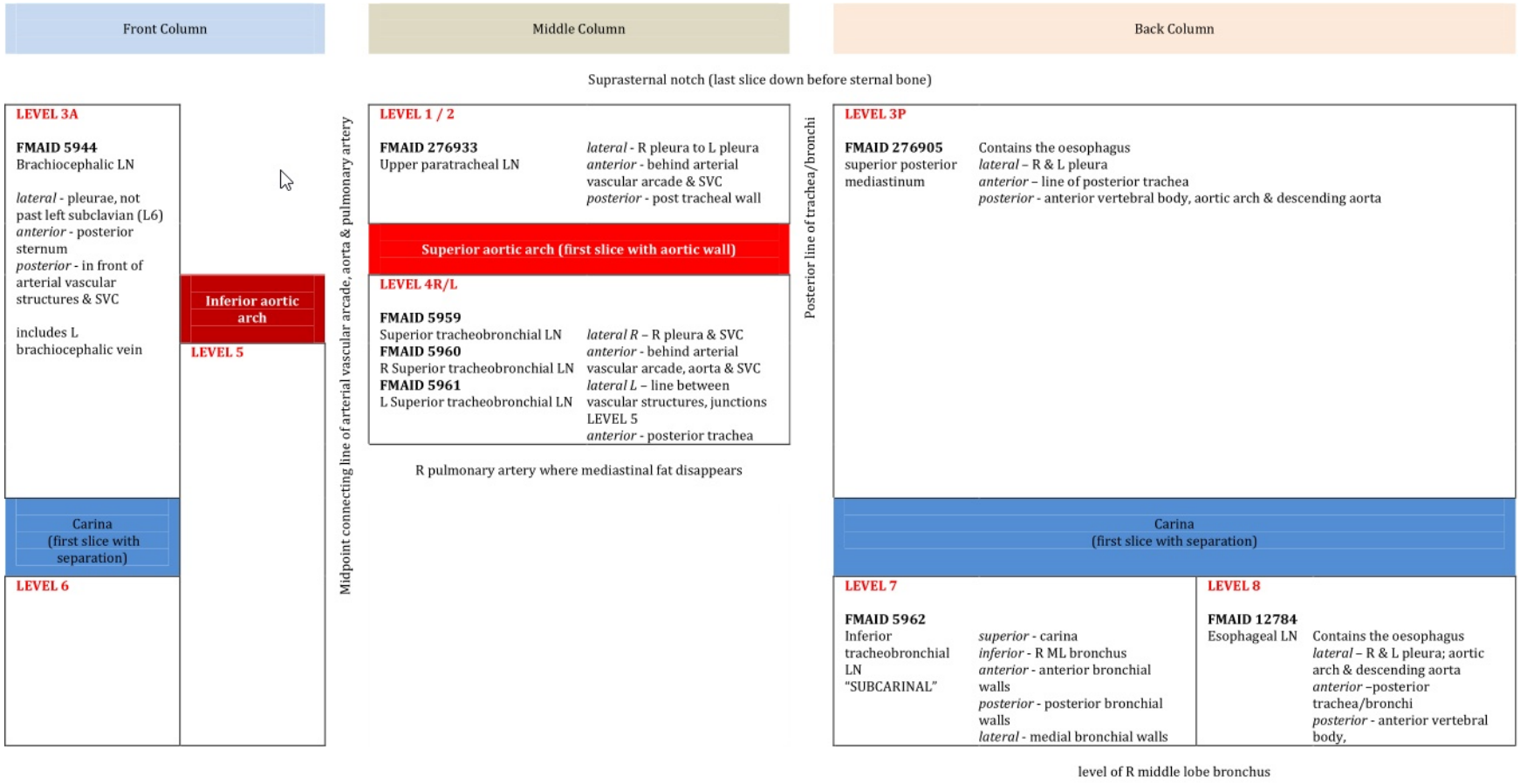
The delineation of nodal stations in the mediastinum is not, to my knowledge, a commonly undertaken task. Accurate delineation of the nodal regions requires a contrast scan as the appearance of pulmonary vasculature can be deceiving on a plain scan.

The thoracic nodal volumes are arranged in three columns – front, middle and back (these divisions are not necessarily reflective of the normal anatomical divisions of the mediastinum so I hesitate to use the proper anatomical terms like anterior). The naming confusingly is top down, i.e., the first nodal group – the hilar nodes – are **level 10/11**. The uppermost and presumably last involved node behind the upper sternum is **level 1**. The front column is a sheet wrapped around the anterior mediastinum in front of the vasculature, the middle and back columns form a central core divided along the line of the posterior trachea, and finally the middle column divides under the shadow of the carina.

The ***back column of nodes*** includes the oesophagus over its entire length, and is split into three levels at the *level of the carina* with **level 8** (below the carina inferiorly to the level of the *R middle lobe bronchus* and behind the line of the *posterior bronchial walls*), **level 7** (below the *carina* inferiorly to the level of the *R middle lobe bronchus* and behind the line of the *anterior & posterior bronchial walls*) and **level 3P** (up from the *carina* to the *suprasternal notch* where it sits behind the posterior *trachea*).

The ***middle column of nodes*** contains the *trachea* and the tissue around and in front, and is split at the level of the *arch of the aorta* into **level 4_R/L** (below the *arch of the aorta* inferiorly to the *R pulmonary artery* where mediastinal fat disappears, and in front of the posterior wall of the *trachea*) and **level 1/2** (up from the *arch of the aorta* to the *suprasternal notch* superiorly where it contains the *brachiocephalic vein* moving from behind the *left sternoclavicular joint* to the R second interspace [*angle of Louis*], and in behind of the arterial vascular arcade arising from the *aortic arch*).

The ***front column of nodes*** has two levels split at the level of the level of the *carina* into **level 6** (from the first slice showing the *carina* inferiorly to lowest image containing the *R pulmonary artery* but only around to the midpoint of the aortic ellipse where it junctions with **level 5** which occupies the posterior L lateral portion of the aortic ellipse around to the *descending aorta* and then *L pulmonary artery & vein* at the *hilum*) and **level 3A** (from first slice above the *carina* to *suprasternal notch* and anterior to the aortic vascular arcade arising from the *aortic arch* but not extending laterally past the *L subclavian artery*). On the left lateral side, **level 3A** junctions with **level 6** on the exposed anterolateral aortic wall behind the *L subclavian artery* which extends around to the mid-aortic wall, and moves around posteriorly to **level 5** (starts under the *aortic arch* and extends between the aortic limbs, the *left pleura* and the closest point between the aortic limbs inferiorly to lowest image containing the *R pulmonary artery*).


Front Column
Middle Column
Back Column
Suprasternal notch (last slice down before sternal bone)
LEVEL 3A
FMAID 5944
Brachiocephalic LN
lateral - pleurae, not past left subclavian (L6)
anterior - posterior sternum
posterior - in front of arterial vascular structures & SVC
includes L brachiocephalic vein
Inferior aortic arch
LEVEL 5
Carina (first slice with separation)
LEVEL 6
Midpoint connecting line of arterial vascular arcade, aorta & pulmonary artery
LEVEL 1 / 2
FMAID 276933
Upper paratracheal LN
lateral - R pleura to L pleura
anterior - behind arterial vascular arcade & SVC
posterior - post tracheal wall
Superior aortic arch (first slice with aortic wall)
LEVEL 4R/L
FMAID 5959
Superior tracheobronchial LN
FMAID 5960
R Superior tracheobronchial LN
FMAID 5961
L Superior tracheobronchial LN
lateral R – R pleura & SVC
anterior - behind arterial vascular arcade, aorta & SVC
lateral L – line between vascular structures, junctions LEVEL 5
anterior - posterior trachea
R pulmonary artery where mediastinal fat disappears
Posterior line of trachea/bronchi
LEVEL 3P
FMAID 276905
superior posterior mediastinum
Contains the oesophagus
lateral – R & L pleura
anterior – line of posterior trachea
posterior - anterior vertebral body, aortic arch & descending aorta
Carina (first slice with separation)
LEVEL 7
FMAID 5962
Inferior tracheobronchial LN "SUBCARINAL"
superior - carina
inferior - R ML bronchus
anterior - anterior bronchial walls
posterior - posterior bronchial walls
lateral - medial bronchial walls
LEVEL 8
FMAID 12784
Esophageal LN
Contains the oesophagus
lateral – R & L pleura; aortic arch & descending aorta
anterior –posterior trachea/bronchi
posterior - anterior vertebral body,
level of R middle lobe bronchus

9. APPENDIX 1 : Use of the Document

Departmental

The departmental group responsible for introduction of protocols should review the document and approve it. A governance radiation oncologist should be nominated to manage the present status of the document, or accept that the default document will be the default.

All scripting of names in the TPS should be reviewed and updated to the standard and verified by the Governance RO.

Personal

The most logical way to produce contours and volumes is to follow this pattern. Note that initially ROIs are freehanded, and then once the CTVp is complete, the rest are geometric manipulations:

1. Produce all of the contours first, including nodal groups
   For the nodal areas required, generate contours of nodal areas with anatomical names by freehand or segmentation. If 3 dose levels will be used, contour two nodal areas with non-overlapping names.

2. Produce these volumes in the order

[MANUAL CONTOURING]

a. Produce the GTVp &GTVn
   Usually achieved by freehand drawing on sim CT
b. Produce CTVp
   i. Transform GTVp into CTVp
      1. Expand with NO margin to create the CTVp, and then,
      2. Freehand modification of the CTVp to match appropriate radial anatomical planes (bone, air, lung, fascia, muscle)

[AUTOMATED CONTOURING]

c. Produce CTVn
   i. Expand GTVn to CTVn
      1. With margin (use departmental measure)
      2. excluding external to LN contours
      3. excluding internal of CTVp
d. Produce CTVn0
   i. Expand LN contour into CTVn0a/b
      1. With NO margin
      2. Excluding internal of CTVp
      3. Excluding internal of CTVn
e. Produce PTV_highdose
   i. Expand CTVp + CTVn
      1. With margin (use departmental measure)
      2. Rename to PTVxxxx
f. Produce PTV_middose
   i. Expand CTVp + CTVn + CTVn0a
      1. With margin (use departmental measure)
      2. Rename to PTVyyyy
g. Produce PTV lowdose
   i. Expand CTVn0b
      1. With margin (use departmental measure)
      2. Exclude PTVyyyy (middose)

10. APPENDIX 3 : Cheat Sheet

VOLUMES

GTV

GTVpx GTVnx
versions permitted (x=1,2,3)

CTV

CTVpx CTVnx
CTVn0
versions permitted (x=1,2,3)

PTV

Dose levels PTVxxxx_m
(x = cGy, m = mm)

CONTOURS

Endocrine

LACRIMAL_L LACRIMAL_R,
THYROID
BREAST_L BREAST_R,
ADRENAL_L ADRENAL_R,

Gynae

OVARY_L OVARY_R,
PARAMETRIUM CERVIX
UTERUS VAGINA
VULVA

H&N

BRACHIALP_L BRACHIALP_R,
LARYNX
PAROTID_L PAROTID_R,
SUBMAND_L SUBMAND_R,
PTERYGOIDL_L
PTERYGOIDL_R
PTERYGOIDM, _L
PTERYGOIDM, _R
THYROID_C
PLATYSMA_L PLATYSMA_R

Intestinal

OESOPHAGUS ESOPHAGUS
STOMACH DUODENUM
LIVER GALLB
PANCREAS PERITONEUM
BOWEL COLON
RECTUM ANUS

Lymphatic

LN_HN_1a1b2a2b3456_rp_fb_p_
o_R/L
THORACICDUCT
LN_AX123_L LN_AX123_R
LN_AX1_L LN_AX1_R
LN_AX2_L LN_AX2_R
LN_AX3_L LN_AX3_R
LN_IMC_R LN_IMC_L
LN_MED_3A56_124R4L_3P78_9
LN_PARAAORTIC_TxLx
LN_PELVIS_I_EI_CI_II_O_PS
LN_ILIAC_COM_L
LN_ILIAC_COM_R
LN_ILIAC_EXT_L
LN_ILIAC_EXT_R
LN_ILIAC_INT_L
LN_ILIAC_INT_R
LN_OBT_L LN_OBT_R
LN_PRESACRAL_L
LN_PRESACRAL_R
LN_INGUIN_R LN_INGUIN_L
MESORECTUM

Muscular

DIGASTRIC_L DIGASTRIC_R
MASSETER_L MASSETER_R
SCM_L SCM_R
DIAPHRAGM

Neural

BRAIN
CEREBRUM CEREBELLUM
BRAINSTEM PONS
SPINALCORD
OPTICN_L OPTICN_R
CHIASM
CNIII_L CNIII_R
CNIX_L CNIX_R
CNV_L CNV_R
CNVI_L CNVI_R
CNVII_L CNVII_R
CNXI_L CNXI_R
CNXII_L CNXII_R
COCHLEA_L COCHLEA_R
COCHLEAs
EYE_L EYE_R
LENS_L LENS_R
ORBIT_L ORBIT_R
HIPPOCAMPUS
HIPPOCAMPUS_L
HIPPOCAMPUS_R
PITUITARY PINEAL

Respiratory

ARYTENOID_L ARYTENOID_R
ARYTENOIDs
CRICOID TRACHEA
CARINA
BRONCHUS_L BRONCHUS_R
LUNG_L
LUNG_LUL LUNG_LLL
LUNG_R LUNG_RUL
LUNG_RML LUNG_RLL
LUNGs

Skeleton

MANDIBLE HYOID
CLAVICLE_L CLAVICLE_R
SCAPULA_L SCAPULA_R
HUMERUS_L HUMERUS_R
RADIUS_L RADIUS_R
PELVIS
PELVIS_L PELVIS_R
ILIUM_L ILIUM_R
ISCHIUM_L ISCHIUM_R
PUBIS_L PUBIS_R
SACRUM
FEMUR_L FEMUR_R
HOF_L HOF_R
SOF_L SOF_R
BOF_L BOF_R
FIBULAs
FIBULA_L FIBULA_R

RIB1_L RIB1_R RIB2_L RIB2_R
RIB3_L RIB3_R RIB4_L RIB4_R
RIB5_L RIB5_R RIB6_L RIB6_R
RIB7_L RIB7_R RIB8_L RIB8_R
RIB9_L RIB9_R
RIB10_L RIB10_R
RIB11_L RIB11_R
RIB12_L RIB12_R

VB_C1 VB_C2 VB_C3 VB_C4
VB_C5 VB_C6 VB_C7 VB_C8

VB_T1 VB_T2 VB_T3 VB_T4
VB_T5 VB_T6 VB_T7 VB_T8
VB_T9 VB_T10 VB_T11 VB_T12

VB_L1 VB_L2 VB_L3 VB_L4
VB_L5

VB_S1 VB_S2 VB_S3 VB_S4
VB_S5

SPINALCANAL

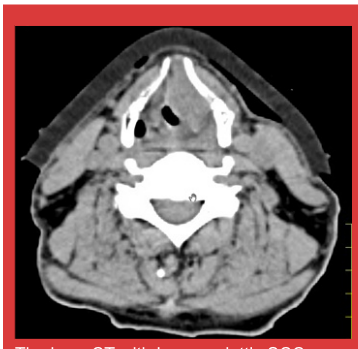
Urinary

BLADDER
KIDNEY_L KIDNEY_R
KIDNEYs
KPELVIS_L KPELVIS_R
URETER_L URETER_R
PROSTATE SV
PENIS
CAVERNOSUM SPONGIOSUM
SCROTUM
TESTIS_L TESTIS_R

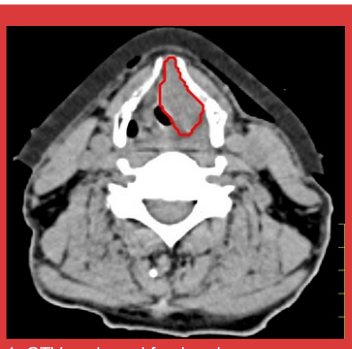
Vascular

A_LAD
A_PULM V_PULM
HEART AORTA
IVC SVC
V_ILIAC_C_L V_ILIAC_C_R
V_ILIAC_E_L V_ILIAC_E_R
V_ILIAC_I_L V_ILIAC_I_R
A_ILIAC_C_L A_ILIAC_C_R
A_ILIAC_E_L A_ILIAC_E_R
A_ILIAC_I_L A_ILIAC_I_R

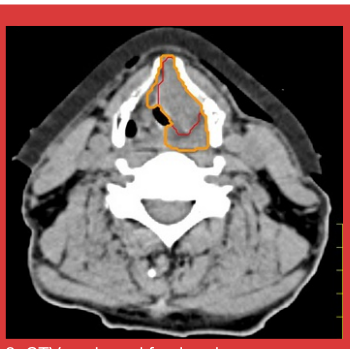
A second example of use of the Standardised Nomenclature



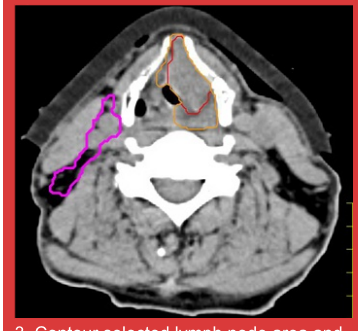
The bare CT with L supraglottic SCC [T2N0M0]



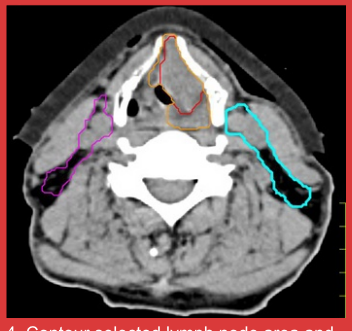
1. GTVp volumed freehand



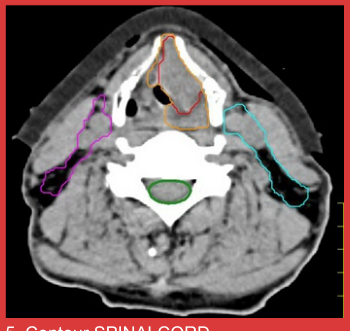
2. CTVp volumed freehand



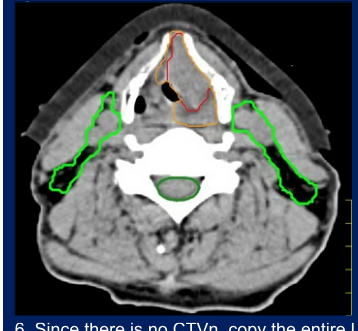
3. Contour selected lymph node area and adjust name – LN_HN_2a2b34_R



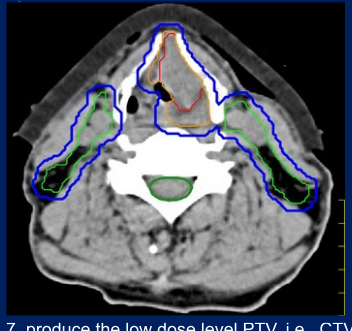
4. Contour selected lymph node area and adjust name – LN_HN_2a2b34_L



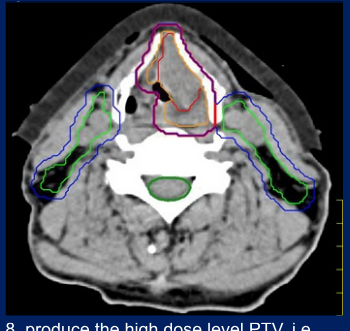
5. Contour SPINALCORD



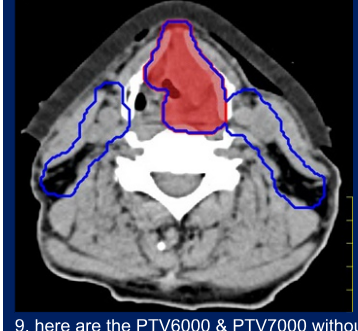
6. Since there is no CTVn, copy the entire LN volume to become CTVn0, i.e., LN_HN_2a2b34_R + LN_HN_2a2b34_L = CTVn0



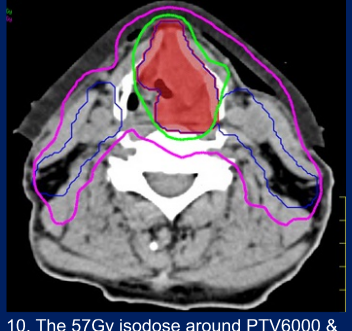
7. produce the low dose level PTV, i.e., CTVp + CTVn + CTVn0 = PTV6000



8. produce the high dose level PTV, i.e., CTVp + CTVn = PTV7000



9. here are the PTV6000 & PTV7000 without distractors



10. The 57Gy isodose around PTV6000 & 66.5Gy isodose around PTV7000 awaiting assessment

LEGEND

Contours and volumes for a iT2iN0iM0 supraglottic SCC where the aim is to deliver 70Gy/35Fx to the primary site and 60Gy/35Fx to the uninvolved neck.

This section includes all contours/volumes manipulation by freehand drawing.

This section includes only contour/volume manipulation by automated software.