Standardizing Normal Tissue Contouring for Radiation Therapy Treatment Planning: An ASTRO Consensus Paper

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This document was prepared for the American Society for Radiation Oncology (ASTRO) Clinical Affairs and Quality Council as part of an ongoing quality initiative with the goal of enabling members to consistently deliver the highest quality and value care to cancer patients.

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This guidance is based on information available at the time the task force conducted its research and discussions on this topic. There may be new developments that are not reflected in this guidance and that may, over time, be a basis for ASTRO to revisit and update the paper.

Conflict of Interest:

Before initiation of this paper, all members of the Task Force and Review Panel completed disclosure statements. These statements are maintained at ASTRO Headquarters in Arlington, Virginia. ASTRO's Clinical Affairs and Quality Council reviewed these disclosures and determined they do not present a conflict with respect to the Task Force members' work on this consensus paper. **Jean Wright**: ASTRO (honoraria); **Sue S. Yom**: ASTRO (honoraria), Genentech, Merck, Bristol-Myers Squibb (research grants), UpToDate, Springer (royalty), American Radium Society (Executive Committee Treasurer,

Appropriate Use Criteria Committee Chair), American College of Radiology (Appropriate Use Criteria Committee Chair), International Journal of Radiation Oncology Biology Physics (deputy editor); **Raymond Mailhot Vega**: Varian (travel expenses), **George Rodrigues**: Demos Publishing Company (Royalty), George Rodrigues Medicine Professional Corporation (President, Stock).

Methods:

The Task Force formulated recommendations based on clinical practice and consensus. The draft manuscript was peer reviewed by 15 reviewers, ASTRO legal counsel, and ASTRO's Multidisciplinary Quality Assurance (MDQA) Subcommittee and revised accordingly.

The modified paper was posted on the ASTRO website for public comment in May 2018 for 6 weeks. The final document was approved by the ASTRO Board of Directors in 2018.

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1. Introduction

1.1. Background

Comprehensive identification and delineation of organs-at-risk (OAR) are vital to the quality of radiation therapy treatment planning and the safety of treatment delivery. A lack of standardization for normal tissue contouring allows variation in practice and potentially impacts the quality of the dosimetric plan.

Advances made in the field of radiation oncology over the past decades include increased dose conformality, particularly as the profession moved from two-dimensional (2-D) to three-dimensional (3-D) to intensity-modulated techniques. Improvements in the shaping and delivering of radiation have yielded two major outcomes: improved avoidance of critical structures and dose intensification. When targeting tumors, there may be adjacent structures for which potential toxicities are considered unacceptable. Additionally, there are structures for which clinical decision-making can be affected by toxicity risk depending on the disease site, patient age, treatment technique, prior radiation, and other variables. Achieving plan optimization and maximal organ-sparing ultimately depends on the accuracy of OAR definition and delineation.

This guidance aims to improve the consistency of contouring OARs by providing a single standardized resource for information regarding specific OARs to be contoured for each disease site.

1.2. Scope

The Task Force organized the recommendations into a user-friendly table format as a quality assurance tool for practices and a training resource for residents and other radiation oncology students.

- **Table 1** contains two designations for anatomic sites: (1) *Recommended* - those structures that are recommended for all cases based on consensus and (2) *Consider* - those structures that should be considered depending on the specific clinical scenario. Understanding that practices and patients need the best outcomes given possible resource constraints, the *recommended* list is focused on the essential organs needed for each primary site to provide a basic minimum standard of care. The organs listed in the *consider* category build on the *recommended* list and represent options relevant to specific clinical situations. In both categories, the focus on structures has centered around only those organs with recognized dose limits. These should be considered by the radiation oncology team depending on clinical factors such as anatomical location, treatment intent (palliative versus definitive), pediatric cases, use of stereotactic radiation therapy, and/or requirements for a clinical trial. It is recognized that for research or planning purposes, individual practices may wish to include other contours for which dose limits have not yet been clearly established.

- **Table 2** is a reference guide for accessing site-specific sources to assist with the delineation of the structures from Table 1. The list is not exhaustive, and other resources may be available in the medical literature and in clinical trial protocols to assist in OAR delineation for specific clinical scenarios.

Dose constraints for specific OARs are beyond the scope of this paper, but constraints are available using established guidelines published by Emami et al, American Association of Physicists in Medicine (AAPM) Task Group TG-101 report, [1] and most recently, the Quantitative Analysis of Normal Tissue

Effects in the Clinic (QUANTEC) guidelines.[2] Cooperative group protocols for clinical trials involving radiation therapy for different disease sites also provide additional resources for dose constraints.

The naming convention for tissue labels in Table 1 aligns with the AAPM TG-263 report, *Standardizing Nomenclatures in Radiation Oncology*,[3] which sought to standardize structure names.

2. Indications and Considerations

2.1. Standardization

While dose constraints are an integral part of treatment planning and a part of quality measurement in Medicare billing, there is a lack of standardization in how organs are selected and contoured across practices and providers. According to ASTRO's publication, *Safety Is No Accident*, "A review of target delineation and image segmentation prior to planning deserves more standardization."[4]

Multiple studies have shown variation in delineation of radiation therapy targets and OARs in such disease sites as the central nervous system (CNS),[5, 6] head and neck,[7, 8] thorax,[9-11] and pelvis.[12, 13] Differences in normal tissue contouring can affect dosimetric plan optimization, dose volume histogram (DVH) calculations, and potentially normal tissue complication probabilities (NTCP). For example, in a test case from a patient with oropharyngeal cancer, significant inter-clinician variation in contouring OARs was associated with differences ranging from -289% to 56% for mean dose and -22% to 35% for maximum dose.[8] Similar variability in normal structure delineation was observed for breast cancer radiation therapy planning in a Radiation Therapy Oncology Group (NRG Oncology) multi-institutional study; structure overlaps between radiation oncologists were as low as 10%, and volume variations had standard deviations up to 60%.[10]

Establishing standardized normal tissue contouring assists with dose assessment during radiation therapy planning and the accurate delivery of treatment, particularly in the era of advanced radiation therapy techniques.

2.2. Safety

In 2011, ASTRO partnered with the AAPM to develop RO-ILS: Radiation Oncology Incident Learning System®, the only medical specialty society-sponsored incident learning system for radiation oncology. Analysis of aggregated RO-ILS data indicates that, to date, 28% of all reported events occurred in treatment planning, with a featured theme being reported events relating to normal tissue definition.[14] These events include plans with critical structures not contoured and normal tissues incorrectly or incompletely delineated.

Similarly, reported data of radiation therapy patient events submitted to Public Health England between December 2013 and November 2015 identified that 27% of incidents occurred during the pre-treatment planning process.[15] Of those events recorded as "near-miss," target and OAR delineation was one of the most frequently reported processes (Figure 1).

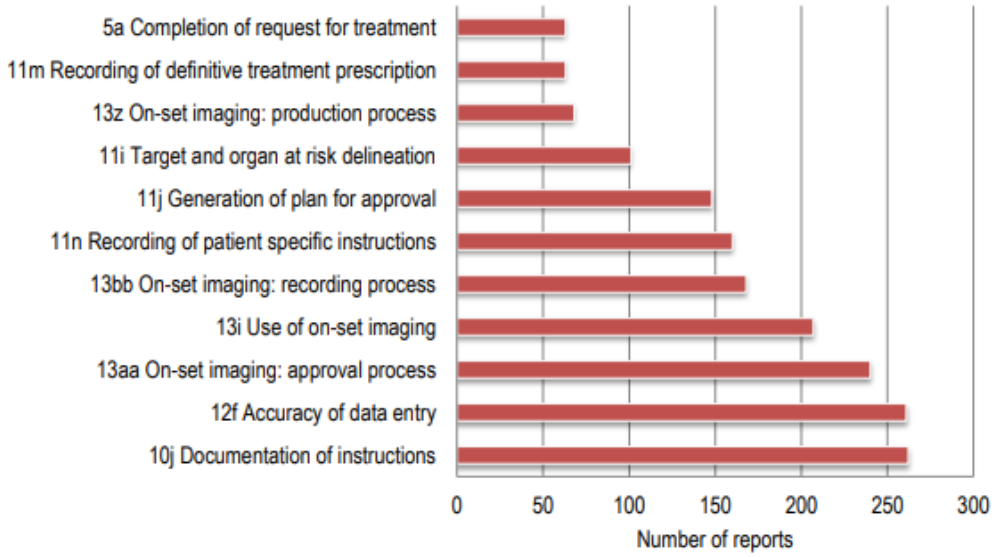

Figure 1. Public Health England, "*Radiotherapy Errors and Near Misses Data Report (December 2013 to November 2015)" [16] Reproduced with permission.*

Despite the importance of contouring and potential sources of variation, no recommended quality systems exist to ensure accuracy and consistency in normal anatomy contouring. Standardization may allow better quantification of DVH-toxicity relationships and assist in preventing avoidable toxicities to normal structures. Failure to include OARs in the planning process may lead to "dose-dumping," where unnecessary and potentially unsafe radiation doses are delivered to OARs that are not defined as part of the planning constraints. This concept extends to the palliative setting, where doses to OARs are generally considered less critical due to lower radiation doses and shorter patient life expectancy. Increasingly, re-irradiation is common, and if normal tissue doses are not tracked, inadvertent toxicity may occur.

3. Pre-treatment Preparation

3.1. Physician documentation

Constraining OARs is a fundamental component of the treatment planning process and should be included in the radiation oncologist's pre-treatment planning directive (order) documented prior to the initiation of treatment planning. The written planning directive must provide sufficient information to guide qualified personnel in carrying out the creation of a treatment plan. The ASTRO Accreditation Program for Excellence (APEx®) Standard 2.2.1 [17] requires practices to document defined patient-specific targets and normal tissues along with their respective dose goals and constraints as an essential evaluation component of the program.

3.2. Roles and responsibilities of treatment planning staff

ASTRO's *Safety is No Accident* publication highlights the need for all members of the radiation oncology team to maintain proper credentials, skills, and training, and to undergo clinical competency assessments [4] to assure standardization of contouring practices. It is ultimately the responsibility of the radiation oncologist to review the structures as part of the plan assessment and approval. (Figure 2)

	RADIATION ONCOLOGIST	MEDICAL PHYSICIST	MEDICAL DOSIMETRIST	RADIATION THERAPIST	NONPHYSICIAN PROVIDER (NP/PA)	ONCOLOGY NURSE
Clinical evaluation	x				x	x
Ongoing psycho/social evaluation	x				x	x
Decision to deliver external radiation therapy (XRT)	x					
Patient +/- family education	x			x	x	x
Interdisciplinary coordination of care	x			x	x	x
Patient positioning and image acquisition	x	x	x	x		
Fusion and registration	x	x	x			
Contouring/segmentation	x	x	x			
Dose-volume constraints	x	x	x			
Dose calculation	x	x	x			
Review of final treatment plan	x	x	x	x		
Patient-specific QA	x	x	x	x		
Treatment delivery	x	x	x	x		

Figure 2. Roles and responsibilities of the radiation oncology team [4].

4. Resources

4.1. Tools

Contouring guides, or atlases, are published for different anatomical sites to guide practitioners to define clinical target volumes (CTV) and should also be used for visualization of tissue parameters. Disease site-specific contouring atlases published by NRG Oncology are commonly utilized and are developed via consensus among cooperative groups and disease-site committees. Aside from the NRG Atlases, other prominent sources exist, as published in radiation oncology journals. These tools should be used to support consistency in practice procedures, for teaching resources, and in situations when planning treatment for an uncommon or infrequently treated disease site. Table 2 catalogs some of the references mentioned above, and this document seeks to further encourage use of these important tools to promote practice standardization.

4.2. Technology

Modern radiation oncology has experienced rapid changes in software and hardware technology. Knowledge and application of recent advances can impact the efficiency and quality of OAR delineation. Artificial intelligence and deep learning are currently being applied to develop more sophisticated predictive models and automatic contouring software, with an aim of improving the quality of treatment and the consistency of contours. These new tools use previously defined atlases to generate a structure set on a new patient image.

The ability to create and save templates of structure sets within the treatment-planning system (TPS) aids standardization and can be used to normalize practice between providers, within a health care system, or between institutions. Additionally, some TPSs have a built-in anatomical atlas where contours of normal structures are displayed on a scrollable computed tomography (CT) scan. Sagittal/coronal planes and a 3-D view can be used to review and adjust contours. Auto-contouring features in the TPS assist with multiple structures including the brain, lungs, spinal cord, and bony structures and can be accurate for certain structures (e.g., high-contrast organs such as femoral heads).

Reports have been published on the efficacy of auto-contouring technology and the differences between automated and manual contouring. [18, 19] In Aselmaa et al. the review focused on the quality of the delineation and the efficiency within the workflow. Their paper confirms expectation in most cases regarding the time-saving aspect of this technology. (Figure 3)

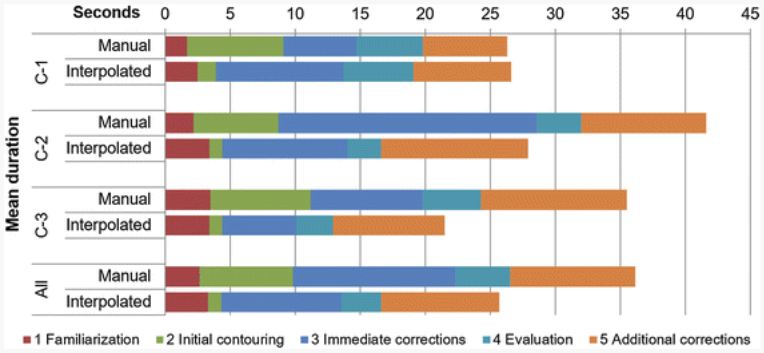

Fig. 6
Mean durations of different workflow steps in case C-1, C-2, and C-3. The type of workflow is labeled as manual or interpolated. In addition, the average of each step over all cases is shown as "All"

Figure 3. [18] *Reproduced with permission via the Creative commons license*

Additionally, according to the review, quality was more consistent between physicians when automatic contouring technology was utilized.

Skitka et al. evaluated the effects of automation bias on treatment planning, however, the review pointed to possible errors associated with automation, noting that "participants with an aid made errors of omission (missed events when not explicitly prompted about them by the aid) and commission (did what an automated aid recommended, even when it contradicted their training and other 100% valid and available indicators)." [19]

These contouring tools promise to reduce time, improve consistency, and increase quality; however, structures generated from computer-based tools should always be subject to a manual review and adjustment prior to initiating treatment planning.

5. Treatment Planning Processes

5.1. Registration

Changes in anatomy due to possible tumor extension mandate a basic understanding of normal anatomy. To assist with delineating normal tissues, imaging considerations are also important. Certain OARs are better visualized or defined on contrast-enhanced CT scans or magnetic resonance imaging (MRI) scans, compared to CT scans alone. For example, it is easier to delineate the parotid gland on a contrast CT due to the enhancing nature of the organ. Similarly, to accurately delineate the spinal cord, particularly for stereotactic planning, a high-resolution T2-weighted MRI or CT myelogram should be used. In the brain, it may be easier to delineate the optic chiasm and nerves using a fused high-resolution T1- or T2-weighted MRI than a typical treatment-planning CT. Contrast-enhanced CT scans or specific sequences in MRI scans for contouring facilitate delineation of normal tissues from adjacent tumor volumes and more adequately spare OARs compared with non-contrast treatment planning CT scans. Any registration should be verified before contouring commences.

5.2. Segmentation

Contouring appropriate OARs is essential for treatment planning, especially in the modern era of modulated techniques where specific details regarding tissue parameters are a necessary component. Each organ has its own best practice for appropriate contouring. For example, for lung constraints in the setting of definitive radiation therapy for lung cancer, tumor target volumes (e.g., GTV or CTV) are usually subtracted from the OAR volume to assess for dose constraints. Conversely, in the setting of CNS tumors, there is no such subtraction of tumor target volumes for brainstem dose constraints. There may also be a trade-off between adequate tissue sparing and optimal treatment of the target due to tumor location.

In developing guidance for appropriate organ contouring, the roles of artificial devices and surgical interventions in treatment planning also were reviewed. Recommendations for contouring cardiac implantable electronic device (CIED) [20] leads, ostomy bags, [21] and surgical hardware have been published. The presence of an implanted device may require additional consideration in treatment planning and a potential compromise between avoidance structures and optimal treatment plan design. This guidance includes these devices in the designation of “consider” where appropriate.

In other settings, a planning risk volume (PRV) margin around an OAR may further constrain particularly sensitive OARs or better shape dose distributions by intentionally constraining an area more purposefully than other planning techniques do. This use of PRVs is most common in treating tumors close to critical structures (e.g., spinal cord or optic structures) to prevent unintentional overdosing of these OARs due to setup errors, particularly with complex treatment planning techniques. [22]

Aside from anatomical region-specific examples, some universal suggestions are relevant regardless of disease site. This list is not meant to be exhaustive, but it represents some general guiding principles:

- Contour on appropriate density windows (i.e., bone, lung) for each tissue.
- Create structure set templates in the TPS to set standard practice procedures.
- Use contrast-enhanced scans when relevant to assist with delineation. Large areas of contrast need a density override or a registered non-contrast scan for planning purposes.
- Fuse relevant imaging (MRI, contrast-enhanced CT) to the planning CT to assist with tissue definition, and always review final contouring on the primary data set.

- Review structures in the coronal and sagittal planes when contouring on axial slices to verify completeness of coverage in all dimensions.

5.3. Treatment plan optimization and evaluation

Incorrect contours may result in difficulties with plan optimization for inverse planning or multileaf collimator (MLC) placement in forward-planned techniques. Ultimately, an error in any planning phase may have a downstream consequence resulting in a suboptimal plan producing suboptimal patient outcomes.

In accepting radiation therapy plans, a key step in the process is plan review and 3-D dose-volume-outcome analysis. Whether a more meaningful outcome for an OAR is the mean, maximum, or volumetric dose, inherent in the interpretation of that metric is the assumption that the contours represent the OAR. If not, the entire dosimetric treatment plan may be compromised, as treatment design aspects including beam angle, location of static beams, and avoidance regions in arcs may be affected. By using a standard set of tissues contoured based on disease site, evaluation of DVH data can be analyzed confidently.

6. Summary

Standardization improves patient safety, efficiency, and accuracy in radiation oncology treatment. This consensus guidance represents an ASTRO quality initiative to provide recommendations for the standardization of normal tissue contouring performed during treatment planning for each anatomical treatment site. Table 1 defines two sets of structures for anatomic sites: (1) those that are recommended in all cases and (2) those that should be considered on a case-by-case basis depending on the specific clinical scenario. Table 2 outlines the resources available for defined parameters for general organs-at-risk tissue delineation. Using this paper in conjunction with resources defining tissue parameters and published dose constraints will enable practices to develop a consistent approach to normal tissue evaluation.

7. Acknowledgements

The authors gratefully acknowledge the peer reviewers: Jennifer Bellon, MD, Nicolas DeNunzio, MD, MS, Avraham Eisbruch, MD, Supriya Jain, MD, Lori Kasuski, RT(R)(T), CMD, Aaron Kusano, MD, Lilie Lin, MD, Billy Loo, MD, Charles Mayo, PhD, Sasa Mutic, PhD, Tracey Schefter, MD, Abhishek Solanski, MD, Stephanie Weiss, MD, MS, Ying Xiao, PhD, Catheryn Yashar, MD, Sandra Zaky, MD, and Michael Zelefsky, MD.

8. Tables 1 and 2

Table 1 – Organs at Risk

Recommended = tissues for contouring in all cases
Consider = tissues dependent on patient-specific variables (anatomical location of target(s), palliative intent, pediatric, or stereotactic radiation therapy)

CNS		
Treated Organ	**Recommended**	**Consider**
Brain	Brainstem Eye_L/R Lens_L/R OpticChiasm OpticNrv_L/R SpinalCord Brain	A_Carotid Cochlea Hippocampus_L/R Glnd_Lacrimal Pituitary Scalp
Spine - Cervical	Brainstem Esophagus SpinalCord	BrachialPlex_L/R Bone_Mandible Cavity_Oral Glnd_Submandibular Glnd_Thyroid Larynx Oropharynx Parotids Trachea
Spine - Thoracic	Esophagus Heart Lungs SpinalCord	Bowel_Small Bowel_Large Liver Kidneys Stomach
Spine - Lumbar	CaudaEquina Kidneys SpinalCord	Bowel_Small Bowel_Large Liver Stomach
Spine - Sacral	CaudaEquina	Bladder Bowel_Large Bowel_Small Colon_Sigmoid Genitals Ovary Rectum SacralPlex Testis_L/R
Craniospinal	Brain Brainstem Cochlea Esophagus Eye_L/R Heart	Bladder Bowel_Large Bowel_Small Breasts Genitals Glnd_Thyroid

	Kidneys Lens_L/R Lungs OpticChiasm OpticNrv_L/R Pituitary SpinalCord	Liver Ovary Rectum Stomach Testis_L/R
H&N		
Treated Organ	**Recommended**	**Consider**
Face, Parotid	Brainstem Eye_L/R Lens_L/R Lips Parotid_L/R SpinalCord	Bone_Mandible Cavity_Oral Cochlea Glnd_Lacrimal_L/R Glnd_Submand_L/R Joint_TM_L/R Lobe_Temporal _L/R
Orbit	Brain Brainstem Eye_L/R Glnd_Lacrimal_L/R Lens_L/R OpticNrv_L/R OpticChiasm Parotid_L/R	Cochlea_L/R Lobe_Temporal _L/R Pituitary Retina
Sinonasal	Brain Brainstem Eye_L/R Lens_L/R Optic_Nrv_L/R OpticChiasm Parotid_L/R SpinalCord	Bone_Mandible Cavity_Oral Glnd_Lacrimal_L/R Glnd_Submand_L/R Lobe_Temporal _L/R Pituitary
Nasopharynx	Bone_Mandible Brain Brainstem Cavity_Oral Cochlea_L/R Eye_L/R Lens_L/R Lips Lobe_Temporal _L/R OpticNrv_L/R OpticChiasm Parotid_L/R SpinalCord Larynx	BrachialPlex_L/R Glnd_Submand_L/R Pituitary Glnd_Thyroid Musc_Constrict Esophagus

Oropharynx	Brainstem Cavity_Oral Larynx Lips Bone_Mandible Parotid_L/R SpinalCord	BrachialPlex_L/R Cochlea_L/R Eye_L/R Esophagus Glnd_Submand_L/R Glnd_Thyroid Lens_L/R Musc_Constrict OpticNrv_L/R OpticChiasm
Larynx, Hypopharynx, Thyroid or Cervical Esophagus	Bone_Mandible Brainstem Cavity_Oral Lips Parotid_L/R SpinalCord	A_Carotid_L/R BrachialPlex_L/R Esophagus Glnd_Submand_L/R Musc_Constrict Glnd_Thyroid Heart Lungs
Elective or Definitive Neck	Bone_Mandible Brainstem Cavity_Oral Glnd_Submand_L/R Glnd_Thyroid Parotid_L/R SpinalCord	BrachialPlex_L/R Cochlea_L/R Esophagus Larynx Lips Musc_Constrict
Thoracic		
Treated Organ	**Recommended**	**Consider**
Breast/Chestwall	Heart Lung_L/R	A_LAD Lungs Contralateral breast Ribs Pacemaker BrachialPlex_L/R
Supraclavicular fossa	SpinalCord	BrachialPlex_L/R Esophagus Glnd_Thyroid
Axilla	Heart Lung_L/R SpinalCord	BrachialPlex_L/R Esophagus Glnd_Thyroid Lungs
Lung	Esophagus Heart Lung_L/R Lungs SpinalCord	BrachialPlex_L/R Bronchus_Main Bronchus_L/R Chestwall_L/R GreatVes Liver Stomach Trachea Pacemaker

Mediastinum/Thymus	Esophagus Heart Lungs SpinalCord	Bronchus_Main Trachea Pacemaker
Esophagus	Esophagus Heart Lungs SpinalCord Stomach	Kidneys Larynx Liver Pacemaker
Abdominal		
Treated Organ	**Recommended**	**Consider**
Lower Esophagus/ Gastroesophageal Junction	Bowel_Small Esophagus Kidney_L/R Kidneys Heart Liver Lungs SpinalCord Stomach	Bowel_Large
Stomach	Bowel_Small Esophagus Kidney_L/R Kidneys Heart Liver Lungs SpinalCord	Spleen Bowel_Large
Spleen	Heart Lung_L Kidney_L SpinalCord Stomach	Bowel_Large Bowel_Small
Pancreas	Bowel_Small Duodenum Kidney_L/R Kidneys Liver SpinalCord Stomach	Bowel_Large
Liver	Liver Bowel_Large SpinalCord Bowel_Small Kidney_L/R	BileDuct_Common Chestwall Duodenum Esophagus GallBladder Heart Kidneys Lungs Stomach V_Venacava_I

Renal/Adrenal	Bowel_Large Bowel_Small CaudaEquina Kidney_L/R SpinalCord	Liver (Rt) Spleen (Lt) Stomach (Lt)
Paraaortic	Bowel_Small Kidney_L/R Kidneys SpinalCord	Bowel_Large CaudaEquina Duodenum Liver Stomach
Retroperitoneal Space	Bowel_Large Bowel_Small Kidney_L/R Kidneys Liver SpinalCord	Stomach
Pelvic		
Treated Organ	**Recommended**	**Consider**
Seminoma	Bladder Bowel_Large Bowel_Small Kidneys Rectum	SpinalCord Testis Bag_Ostomy
Bladder	Bowel_Small Colon_Sigmoid Femur_Head_L/R Rectum	Bag_Ostomy Bladder (partial) Bone_Pelvic Bowel_Large Prostate UreterDivert
Cervix/Uterus/Vagina /Vulva	Bladder Bowel_Small Colon_Sigmoid Femur_Head_L/R Rectum	Bone_Pelvic Bowel_Large Kidneys Ovaries Bag_Ostomy
Prostate	Bladder Femur_Head_L/R PenileBulb Rectum	Bowel_Large Bowel_Small Colon_Sigmoid Bag_Ostomy
Rectum	Bladder Bowel_Small Femur_Head_L/R	Bone_Pelvic Bowel (uninvolved) Genitals Vagina Bag_Ostomy
Anus	Bladder Bowel_Small Femur_Head_L/R Rectum	Bone_Pelvic Bowel (uninvolved) Genitals Vagina Bag_Ostomy

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Normal tissue	Resources
anorectum *bladder* *bowel bag* *colon* *femoral head* *penile bulb* *prostate* *rectum* *seminal vesicles* *sigmoid colon* *small bowel*	Pelvic normal tissue contouring guidelines for radiation therapy: A Radiation Therapy Oncology Group consensus panel atlas. [23]
brachial plexus	Development and Validation of a Standardized Method for Contouring the Brachial Plexus: Preliminary Dosimetric Analysis Among Patients Treated with IMRT for Head-and-Neck Cancer. [7]
brachial plexus *bronchus* *esophagus* *lung* *proximal bronchial tree* *ribs* *spinal cord (thoracic)*	Consideration of Dose Limits for Organs at Risk of Thoracic Radiotherapy: Atlas for Lung, Proximal Bronchial Tree, Esophagus, Spinal Cord, Ribs, and Brachial Plexus. [24]
brain *brainstem* *cochlea* *constrictor* *lips* *mandible* *optic chiasm* *optic nerve* *oral cavity* *parotid* *pituitary* *spinal cord (cervical)* *submandibular gland* *supraglottic larynx* *temporal lobe* *thyroid*	CT-based delineation of organs at risk in the head and neck region: DAHANCA, EORTC, GORTEC, HKNPCSG, NCIC CTG, NCRI, NRG Oncology and TROG consensus guidelines. [25]
breast *chestwall* *heart*	Delineation of target volumes and organs at risk in adjuvant radiotherapy of early breast cancer: National guidelines and contouring atlas by the Danish Breast Cancer Cooperative Group. [26] NRG Breast Cancer Atlas for Radiation Therapy Planning – Consensus Definition [27]

cauda equina	Stereotactic body radiotherapy for the treatment of spinal metastases. [28]
cochlea	Contouring the Middle and Inner Ear on Radiotherapy Planning Scans. [29]
common bile duct *duodenum* *esophagus* *gall bladder* *gastroesophageal junction* *kidney* *liver* *pancreas* *spinal cord (lumbar)* *spleen* *stomach*	Upper abdominal normal organ contouring guidelines and atlas: A Radiation Therapy Oncology Group consensus. [30]
constrictors *larynx*	Intensity-modulated radiotherapy of head and neck cancer aiming to reduce dysphagia: early dose-effect relationships for the swallowing structures. [31] Delineation of organs at risk involved in swallowing for radiotherapy treatment planning. [32]
cornea *cochlea* *eye/globe* *hippocampus* *lacrimal gland* *lens* *optic chiasm* *optic nerves* *pituitary* *retina*	Organs at risk in the brain and their dose-constrains in adults and in children: A radiation oncologist's guide for delineation in everyday practice. [33]
genitalia_men *genitalia_women*	Proposed genitalia contouring guidelines in anal cancer intensity-modulated radiotherapy. [34]
great vessels *heart*	Development and validation of a heart atlas to study cardiac exposure to radiation following treatment for breast cancer. [35]
hippocampus	Hippocampal Contouring: A Contouring Atlas for RTOG 0933 [36]
internal carotid artery	Simple carotid-sparing intensity-modulated radiotherapy technique and preliminary experience for T1-2 glottic cancer. [37]
parotid	A radiation oncologist's guide to contour the parotid gland. [38]
sacral plexus	Development of a Standardized Method for Contouring the Lumbosacral Plexus: A Preliminary Dosimetric Analysis of this Organ at Risk Among 15 Patients Treated with Intensity-Modulated Radiotherapy for Lower Gastrointestinal Cancers and the Incidence of Radiation-Induced Lumbosacral Plexopathy [39]

scalp	Tumor Directed, Scalp Sparing Intensity Modulated Whole Brain Radiotherapy for Brain Metastases. [40]

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