Ontario Health

Radiation Treatment Quality Expectations by Disease Site 2020

September 28, 2020

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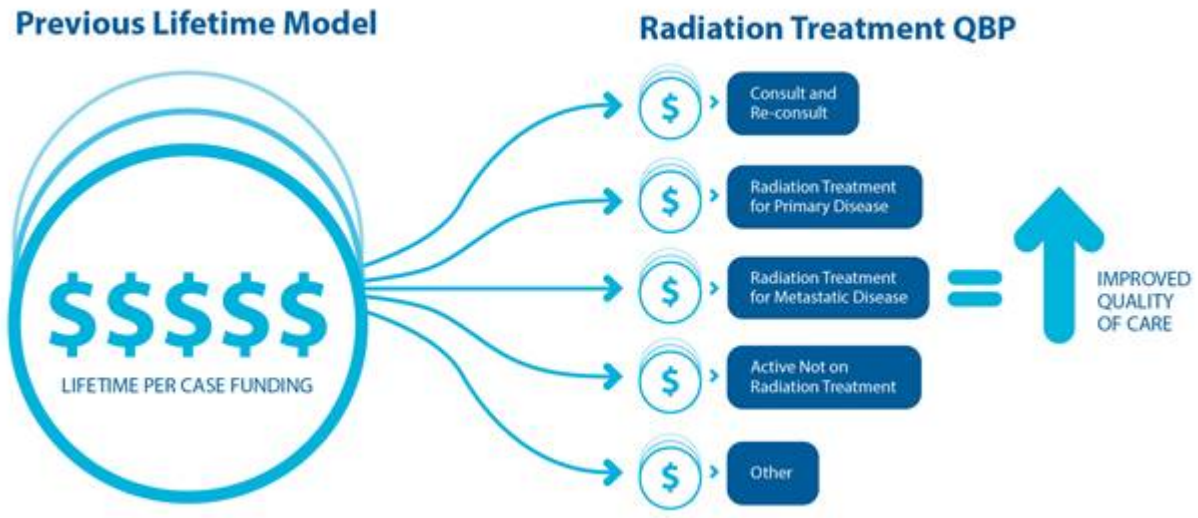
Introduction

Quality–Based Procedures (QBPs) are specific groups of patient services that offer opportunities for health care providers to share best practices that will allow the system to achieve even better quality and system efficiencies[i].

As part of this approach in cancer management, Ontario Health (Cancer Care Ontario) (OH-CCO), established expert advisory panels composed of a cross-sectoral, multi-geographic, and multidisciplinary membership including physicians, nurses, pharmacists, allied health professional, radiation therapists, medical physicists, clinical scientists and hospital administrative representatives. In Systemic Therapy and Cancer Surgery, these expert advisory panels have developed treatment protocols and quality of care expectations that define episodes of care for disease sites or procedures and provide best practice recommendations for patient care and indicators to monitor for ongoing quality improvement. Radiation services were approved by the Ministry of Health for a new QBP in 2018.

The use of best practices is intended to promote the standardization of care by reducing inappropriate or unexplained variation and thereby ensuring that patients get the right care, at the right place, and at the right time. This is an important part of the Patient's First: Action Plan for Health Care, the Ontario government's blueprint for the next phase of health care system transformation. Once a procedure is established as a QBP, funding for each specific grouping is provided on a "price times volume" basis and health care providers are funded using a standard rate (or price) adjusted for the types of patients they serve.

The figure below outlines how the funding model for radiation services in the province will change with this new approach – from lifetime per case funding to activity-based funding. These activities include consult, treatment of primary or metastatic disease, and management of patients not receiving radiation treatment but under the care of the radiation oncologist.



In the development of these quality of care expectations and clinical treatment protocols, we initially performed jurisdictional scans as well as an evidence-based review of current clinical guidelines and guidance documents. We then engaged, over an 18 month period, with over 200 clinicians including radiation oncologists, medical physicists, radiation therapists, nurses, as well as administrative representatives from each cancer center (22 expert panels, 9 working groups and 6 overarching advisory committee meetings) in the province and obtained consensus by disease site on best practices in terms of pre-treatment assessment, details of treatment procedures and follow-up care.

Quality of Care Expectations Common to All Disease Sites and Associated Treatment Protocols

To access the list of treatment protocols by disease site, please refer to the Clinical Handbook or Databook (Appendix 1.46).

Overall Institutional Policies

The Radiation treatment program in each cancer center should have written policies outlining (by disease site):

- Pre-treatment assessment and associated required documentation (e.g. imaging tests required for best practice care)
- CT Simulation (and MRI Simulation where appropriate) protocols
- Radiation planning protocols, including contouring guidelines and normal tissue dose constraints
- Management of patients with cardiac rhythm or implantable electronic devices
- Treatment protocols including frequency of imaging and image matching strategies and tolerances
- Post-treatment follow-up recommendations

Overall Quality Assurance

Quality Assurance (QA) in radiation treatment is defined by the World Health Organization (WHO) as, "all procedures that ensure consistency of the medical prescription, and safe fulfillment of that prescription, as regards to the dose to the target volume, together with minimal dose to normal tissue, minimal exposure of personnel and adequate patient monitoring aimed at determining the end result of treatment" (2). Each Radiation Program should adhere as much as possible to the Quality Assurance Guidelines for Canadian Radiation Treatment Programs outlined by the Canadian Partnership for Quality Radiotherapy (CPQR).

These QA procedures should include:

- QA of all treatment plans by a medical physicist and radiation therapist
- Radiation treatment physics plan checks as in OH-CCO guidance document developed by the Provincial Medical Physics Community of Practice
- Patient Specific QA measurement prior to treatment, as per OH-CCO guidance document developed by the Provincial Medical Physics Community of Practice
- Peer review of treatment plans as per OH-CCO peer review guidance documents

Quality of Care Expectations Specific to Disease Sites and Associated Treatment Protocols

Six-hundred and seventy one Quality of Care expectations were identified by the expert panels and working groups for all disease sites and protocols.
Wherever possible, the quality of care recommendations were derived from existing PEBC guideline documents (e.g. Organizational Guideline for the Delivery of Stereotactic Radiosurgery for Brain Metastasis in Ontario) and OH-CCO disease pathway documents[ii]. These expectations were divided into:

- General recommendations for consideration (e.g. suggested dose constraints when treating patients with stereotactic radiosurgery).
- Recommendations that should be followed/implemented unless there were specific circumstances or reasons not to. For instance, in the management of brain metastases cases with SRS "The clinical and imaging details each case must be discussed in an MCC. The MCC should be comprised ideally of a radiation oncologist, neurosurgeon, medical physicist, radiation therapist/medical dosimetrist, and a neuro-radiologist."

The recommendations were also divided into 5 groups:

1. Pre-treatment assessment
2. Treatment planning and associated imaging issues
3. Treatment delivery issues
4. QA steps specific to the disease site or protocol
5. Post- treatment follow-up

The following is a summary of the quality expectations by disease site/RT-protocol.

Lung Cancer

The OH-CCO Lung Cancer Pathway Map should be followed wherever possible.
Pre- Treatment phase:

Radiation oncology input as part of a multidisciplinary evaluation or discussion should be provided for the following groups of patients:

- All patients with stage III NSCLC
- Patients with early-stage disease who are medically inoperable
- Post-operative cases with suspicion of residual disease
- Patients who refuse surgery, or are high-risk surgical candidates

- Patients with stage IV disease that may benefit from local therapy

In addition, the following tests should be performed in patients being considered for curative Radiation Treatment (RT):

- An appropriately timed (</= 4 weeks before start of RT) and technically adequate PET/CT scan
- Pulmonary function tests (before start of treatment)

Treatment planning and associated imaging phase:

- Tumour and organ motion, especially due to breathing, should be assessed and accounted for at time of simulation. 4D-CT is considered the equipment of choice for patients who are receiving curative treatment.
- DVH for the following organs should be part of the published plan: lung, heart, esophagus, and spinal cord with consider to include liver, major vessels, stomach, brachial plexus, and proximal bronchial tree, where appropriate.
- Suggested normal tissue constraints for conventionally fractionated treatment with concurrent chemotherapy are outlined below:

Table 5. Normal Tissue Dose-Volume Constraints for Conventionally Fractionated RT with Concurrent Chemotherapy*

OAR	Constraints in 30–35 fractions
Spinal cord	Max ≤50 Gy
Lung	V20 ≤35%–40%†; MLD ≤20 Gy
Heart**	V50 ≤25%; Mean ≤20 Gy
Esophagus	Mean ≤34 Gy; Max ≤105% of prescription dose; V60 ≤17%; contralateral sparing is desirable
Brachial plexus	Median dose ≤69 Gy

Vxx = % of the whole OAR receiving ≥xx Gy.

*These constraints represent doses that generally should not be exceeded. Because the risk of toxicity increases progressively with dose to normal tissues, a key principle of radiation treatment planning is to keep normal tissue doses "as low as reasonably achievable" while adequately covering the target. The doses to any given organ at risk should typically be lower than these constraints, approaching them only when there is close proximity to the target volume.

†Use V20 <35%, especially for the following: elderly ≥70 years, taxane chemotherapy, and poor PFTs (such as FEV1 or DLCO <50% normal). Use more conservative limits with a diagnosis or radiologic evidence of idiopathic pulmonary fibrosis (IDP)/usual interstitial pneumonia (UIP) (the tolerance of these patients is lower though not well characterized).

Example table taken from NCCN guidelines
https://www.nccn.org/professionals/physician_gls/pdf/nscl.pdf

Treatment Delivery Phase:

- Adaptive re-planning should be considered if there is significant change during treatment in lung volume, pleural effusion, tumour size, or in patient's breathing pattern.
- Daily image guidance procedures should be performed. E.g. daily cone-beam CT

Post- treatment follow-up Phase:

As per OH-CCO Lung Cancer Disease Pathway Follow-Up Care Map

Breast Cancer

The OH-CCO Breast Cancer Pathway Map should be followed wherever possible

Pre-Treatment phase:

- Bilateral diagnostic mammography should be performed prior to treatment
- Patients with locally advanced disease who are candidates for neo-adjuvant therapy should have a consultation with a radiation oncologist prior to start of treatment in accordance with the OH-CCO Breast Cancer Pathway Map
- There should be discussion of breast reconstruction (if applicable)

Treatment planning and associated imaging phase:

- Dose Homogeneity:
  - Where possible, the volume of breast tissue receiving greater than 105% of the prescription dose should be minimized. To achieve this, an appropriate treatment planning technique should be used.
- Target Delineation and Coverage:
  - ASTRO guidelines "Radiation therapy for the whole breast: Executive summary of an American Society for Radiation Oncology (ASTRO) evidence-based guidelines" should be followed wherever possible.
  - The tumour bed should be contoured with a goal of achieving coverage of the tumour bed with at least 95% of the prescription dose. The breast volume may be contoured or defined clinically, with a goal of covering at least 95% of the breast volume with 95% of the breast prescription dose. Contouring of appropriate lymph nodes is recommended, especially in cases with locally advanced disease.
- Cardiac Delineation and Avoidance:
  - The heart should be contoured on the treatment planning computed tomography scan in accordance with Radiation Therapy Oncology Group guidelines. Tangent beams should be delineated to minimize the dose to the heart. The mean heart dose should be as low as reasonably achievable. Active Breath Control techniques/Deep inspiration breath hold, prone positioning, and/or heart blocks should be used as appropriate to minimize normal tissue exposure.

- For patients unable to tolerate breath-hold (including voluntary), the reverse semi-decubitus technique is an alternative approach to reduce cardiac dose (for left breast and internal mammary chain irradiation).
- Cardiac DVH should be part of the published plan.

- Other Normal Tissue Doses:
  - Treatment techniques should also minimize dose to the contralateral breast, lung, and other normal tissues.
    - Lung DVH should be part of the published plan.

Treatment Delivery Phase:

- Imaging at day 1 is required for all treatment fields. Imaging during treatment (after day 1), should be done at the radiation therapist's discretion. If a boost is part of the treatment plan, daily imaging is recommended.

Post-Treatment follow-up Phase:

As per OH-CCO's Position Statement on Guidelines for Breast Well Follow-up Care, which endorses the Canadian Steering Committee on Clinical Practice Guidelines for the Care and Treatment of Breast Cancer

In addition:

- The health care provider responsible for follow-up/surveillance should be identified and a Primary care physician could be one of them
- Eligibility for breast reconstruction (for patients treated with mastectomy) should be discussed
- At least one mammogram within the first year post-radiation therapy should be performed

Gastro-intestinal Cancers

Gastro-Intestinal malignancies include many sub-sites with different treatment protocols and quality of care expectations. The OH-CCO disease pathway maps (links below) should be followed wherever possible. The quality of care expectation are common to all disease sub-sites is:

- Daily Image guidance is required for patients receiving high dose treatment
- Suggested Dose Constraints for normal tissues

Volume of interest	Criteria

Lung	• V 40Gy ≤ 10% • V 30Gy ≤ 15% • V 20 Gy ≤ 20% • V 10 Gy ≤ 40% • V 05 Gy ≤ 50% • Mean < 20 Gy
Cord	• Max ≤ 45 Gy
Small Bowel	• Max bowel dose < Max PTV dose • D05 ≤ 45 Gy
Large Bowel	• Max bowel dose < Max PTV dose • D05 ≤ 45 Gy
Heart	• V 30Gy ≤ 30% (closer to 20% preferred) Mean < 30 Gy
Left Kidney, Right Kidney	• Evaluate each separately • No more than 33% of the volume can receive 18 Gy • Mean dose <18 Gy
Volume of interest	Criteria
Liver	V 20Gy ≤ 30% V 30 Gy ≤ 20% Mean < 25 Gy
Stomach, duodenum, jejunum	Max dose ≤ 55 Gy; not more than 30% of the volume can be between 45 and 55 Gy Mean < 30 Gy (if not within PTV) Max dose < 54 Gy

Specific Quality of Care Expectations by sub-site

Esophagus

Pre- Treatment phase:

- Metastatic work-up should include a PET scan
- Dietary assessment and appropriate nutritional support for patients receiving treatment is necessary
- Endoscopic ultrasound should be available when required

Treatment planning and associated imaging phase:

- 4DCT and/or organ motion management required when treating lower esophageal lesions with radical intent and optional for other esophageal sites

Pancreas

Imaging and Treatment Planning:

- Fiducial markers or appropriate surrogate recommended when SBRT used

Liver

Imaging and Treatment Planning:

- Planning CT scan (with contrast and/or MRI when possible) required

Rectum and Recto-sigmoid Junction

Pre-Treatment phase:

- Pre-treatment MRI unless contraindicated
- Sigmoidoscopy and/or colonoscopy

Post-Treatment follow-up Phase:
Follow-up care should follow the OH-CCO Colorectal Cancer Pathway Map

Anal Canal
Treatment Delivery Phase:

- Treatment with IMRT/VMAT is required

Post-Treatment follow-up Phase:

- Patient should be followed by a radiation oncologist and other members of the multi-disciplinary team as appropriate

Gynecological Cancers

Gynecological cancers include endometrial, cervix, vaginal and vulvar cancers and there are different treatment protocols and quality of care expectations for each sub-site. The OH-CCO Cervical and Endometrial Cancer Pathway Maps should be followed wherever possible.

The quality of care expectations identified by the expert panels and working groups were influenced by the following guideline and guidance documents:

Organizational Guideline for Gynecologic Oncology Services in Ontario
Imaging Strategies for Definitive Intracavitary Brachytherapy of Cervical Cancer - Recommendation Report

The Role of IMRT in Gynecological Cancer

IMRT Guidance Document for Intact Cervix

Radiation therapy quality-of-care indicators for locally advanced cervical cancer: A consensus guideline

Quality of care expectations identified across all sub-sites include:
Pre- Treatment phase:

- Multidisciplinary assessment with gynecologic oncologist and presentation wherever possible at MCC before treatment
- Reproductive status and fertility options if desired should be documented
- Imaging:
  - CXR and thoracic CT if indicated
  - MRI pelvis
  - CT imaging of the abdomen and pelvis and if findings on CT warrant, PET scan should be performed

Cervix Cancer

(and Endometrial cancer when treated with definitive RT)
Pre- Treatment phase:

- The minimum number of new cervix cancer patients treated within a radiation therapy program should exceed 10 per year and he minimum number of brachytherapy procedures per radiation oncologist should exceed 10 per year

Treatment planning and associated imaging phase:

- MR based planning for non-emergency cases with delineation of primary target volumes and organs at risk as per GEC-ESTRO
- 3D CRT or IMRT based on clinical and patient factors. With IMRT, volumetric imaging is essential with the ability for re-planning without delay to overall treatment time.
- Plan optimization should be performed as per GEC-ESTRO/EMBRACE II Guidelines (this is specific to cervix cancer but can be applied other gyne sub-sites when they are being treated with definitive RT)
- Example – EMBRACE II

Target	D90 CTV_{HR} $EQD2_{10}$	D98 CTV_{HR} $EQD2_{10}$	D98 GTV_{res} $EQD2_{10}$	D98 CTV_{IR} $EQD2_{10}$	Point A $EQD2_{10}$
Planning Aims	> 90 Gy < 95 Gy	> 75 Gy	>95 Gy	> 60 Gy	> 65 Gy
Limits for Prescribed Dose	> 85 Gy	-	>90 Gy	-	-
OAR	Bladder D_{2cm^3} $EQD2_3$	Rectum D_{2cm^3} $EQD2_3$	Recto-vaginal point $EQD2_3$	Sigmoid D_{2cm^3} $EQD2_3$	Bowel D_{2cm^3} $EQD2_3$
Planning Aims	< 80 Gy	< 65 Gy	< 65 Gy	< 70 Gy*	< 70 Gy*
Limits for Prescribed Dose	< 90 Gy	< 75 Gy	< 75 Gy	< 75 Gy*	< 75 Gy*

Brachytherapy:

- Intra-operative imaging for placement of applicators in a uterus (MR/CT/ultrasound)
- As a routine, the MR should be acquired as close to BT, at a minimum 1 week prior to brachytherapy is strong encouraged (MR-Informed). It is recommended that an MR be acquired with applicators in place and used for planning (MR-Adaptive).
- There is accumulating evidence of the benefits of MR guided/adaptive cervix brachytherapy over that of CT. Making the transition to move away from MR informed brachytherapy is strongly encouraged as it will be the standard of care in the near future.

Treatment Delivery Phase:

- Prescribed external beam radiation therapy dose should be ≥45 Gy in 1.8-2 Gy per fraction
- Coordination with delivery of concurrent platinum-based chemotherapy when chemo is given
- Overall BT treatment time (Day 1 EBRT) should be as short as reasonably achievable, preferably within 49 days and no more than 56 days
- Image-based treatment verification (2D or volumetric) should be used at least weekly with patient in the treatment position

- Intracavitary vault brachytherapy is incorporated in treatment for postoperative gynecological cancers when indicated

Post-Treatment follow-up Phase:

- As per Program in Evidence Based Care (PEBC) Follow-Up for Cervical Cancer Guideline
- Use of a vaginal dilator should be discussed with the patient
- Hormone replacement therapy should be considered for patients who were pre-menopausal prior to treatment

Cases treated after definitive surgery – additional quality expectations

- Intracavitary vault brachytherapy should be incorporated in treatment when indicated
- Applicator position should be verified by physician at first fraction

Head and Neck Cancers

The management of patients with head and neck cancers should follow the organizational guidelines noted below as well the various OH-CCO Disease Pathway maps and guidance documents:

- Oropharyngeal Squamous Cell Cancer Diagnosis Pathway Map
- Organizational Guidance for the Care of Patients with Head and Neck Cancer in Ontario
- The Role of IMRT in Head and Neck Cancer
- Best Practice Guidance for Patient-Specific Quality Assurance for IMRT and VMAT Plan Delivery Verification

Quality of care expectations identified across all sub-sites include:

Pre- Treatment phase:

- Head and neck CT or MRI should be performed for loco-regional staging. An MRI is strongly recommended in all cases except in early glottic larynx, hypopharynx and cervical esophagus, and is essential with nasopharynx patients prior to treatment (unless contraindicated).
- PET-CT scan should be considered and eligibility includes:
    - Cervical esophagus cancer
    - Unknown primary
    - Nasopharynx cancer
- Dental evaluation is essential for all cases where the oral cavity is part of the treatment program
- HPV status should be documented, whenever possible

- An audiogram (especially if cisplatin-based, chemotherapy planned) is considered essential
- Timely access to psychosocial oncology (PSO) **MUST** be available
    - Pre-treatment dietician assessment is essential in all cases, except those with early disease
    - Speech language pathology and social work services are essential for any patient undergoing large volume radiation treatment and especially those for whom tube feedings have been required
    - Please refer to the Organizational Guidance for the Care of Patients with Head and Neck Cancer in Ontario for information on roles and scopes within psychosocial oncology in head and neck cancer

Treatment planning and associated imaging phase:

- The planning CT scan should include all tissues to be irradiated. The slice thickness should be ≤ 0.3 cm in the region containing and in the vicinity of the primary target volumes. Regions above and below the treated volume may be scanned with 0.5 cm slice thickness (as NRG-HN001).
- Contouring should follow the OH-CCO Head & Neck CoP guidance document
- For MRI, it is important to ensure that geometric fidelity is maintained for all images. Distortions due to field inhomogeneities and gradient nonlinearities should be minimized. MR sequences should be validated to minimize the likelihood of susceptibility artefacts.
- Dose Constraints should follow the OH-CCO Head & Neck CoP dose constraints guidance document

Treatment Delivery Phase:

- Daily Image guidance using CBCT is recommended as per the IMRT guidance document created by the head and neck CoP (Please refer to "Reference" page)
- Dietetic support **MUST** be provided to head and neck patients during treatment
- Speech language pathology and audiology to be provided, as appropriate
- It is recommended that a nurse practitioner/clinical nurse specialist be involved in all head and neck cases, particularly in symptom management, as outlined in the Management of H&N Cancers PEBC document

- General nursing care **MUST** be available for in-the-moment nursing evaluation and supportive care of head and neck patients on treatment
- It is recommended that a CSRT be involved in the treatment of head & neck patients

- Local tolerances should be established based on patient anatomical changes from 3D IGRT imaging that could initiate a dosimetric investigation by physics and dosimetry. The results of this investigation should be reported to the responsible radiation oncologist and a re-plan initiated at their discretion.

Post-Treatment follow-up Phase:

- It is essential that all H&N patients are followed by an RO
- PSO support (dietician and speech-language pathology) **MUST** be provided to patients post-treatment, particularly in survivorship
- Ongoing dental support is essential for all cases where the oral cavity is part of the treatment program

Genitourinary Cancers:

Genitourinary cancers include kidney, ureter, bladder, prostate and testis cancers and there are different treatment protocols and quality of care expectations for each sub-site. The OH-CCO cancer Prostate and Bladder Cancer Pathway Maps should be followed wherever possible.

Quality of care expectations identified across all sub-sites include

Pre- Treatment phase:

- Baseline bowel, urinary and sexual functional status should be documented

Treatment Delivery Phase:

- Daily Image guidance (using CBCT soft-tissue matching or fiducial markers) must be used

Prostate Cancer EBRT

Pre- Treatment phase:

- Multiparametric MRI (< 6 months of treatment decision, before ADT) recommended if considering SABR
- Documentation of consideration of ADT for high-intermediate and high-risk cases

Treatment planning and associated imaging phase:

- Contouring of prostate (and SVs as indicated) and all relevant normal tissues should be performed to include bladder, rectum, femoral heads, relevant bowel at a minimum
- If pelvic lymph nodes are to be treated, they must be contoured
- Fiducial marker insertion optional unless SABR planned (consider trans-perineal approach)
- Institutionally defined dose constraints should be documented and DVHs obtained specific to each dose/fractionation protocol used

Suggested dose constraints:

Hypofractionation - PROFIT Study

Volume of interest	Metric	Dose criteria (Gy)
CTV60	D99	≥ 6000
PTV60	D99	≥ 5700
	Max dose to 1cc	≤ 6300
Rectum wall	D50	≤ 3700
	D70	≤ 4600
Bladder wall	D50	≤ 3700
	D70	≤ 4600
LFEMUR/RFEMUR	D5	≤ 4300

Conventional fractionation - PROFIT Study

Volume of interest	Metric	Dose criteria (Gy)
CTV	D99	≥ 7800
PTV	D99	≥ 74100 (-5%)
	Max dose to 1cc (+5%)	≤ 8190
Rectum wall	D50	≤ 5300
	D70	≤ 7100
Bladder wall	D50	≤ 5300
	D70	≤ 7100
LFEMUR/RFEMUR	D5	≤ 5300

SABR - Odette

Volume of interest	Criteria
CTV-PTV	3-5 mm margins
Prostate	40 Gy/5 fx EOD or weekly
PTV	36.5 Gy/5 Fx, CI<1.2
Rectum	V36<1.0cc Minor dev V36 < 1.5cc
Bladder	37 Gy <10cc Minor dev V37 <20cc
Bowel	V30 Gy< 1.0cc

Treatment Delivery Phase:

- Use of Six DOF Couch suggested if SABR used

Prostate Cancer Brachytherapy:

American Society of Clinical Oncology/Cancer Care Ontario Joint Guideline Update should be followed wherever possible

Pre- Treatment phase:

- Appropriate HR support (i.e. nursing, anesthesia, radiation therapy, medical physics) must be available to allow for intra-operative brachytherapy planning

Treatment planning and associated imaging phase:
Low-Dose Rate – LDR

- Volume study (TRUS/MR) with urethra visualization strategy essential
    - MRI strongly encouraged
- Suggested Dosimetric Targets
    - Prostate D90 > 100%
    - Prostate V100> 90%
    - Rectum D1cc < 100%

High-Dose Rate – HDR

- Suggested Dosimetric Targets
    - Prostate D90 > 100%
    - Prostate V100> 95%
    - Rectum D1cc < 100%
    - Urethra D10 < 118%

Treatment Delivery Phase:

- Time under Anesthesia should be less than 4 hours

Post-Treatment follow-up Phase (EBRT and Brachytherapy):

- As per OH-CCO Prostate Cancer Follow-up Care Pathway Map
- In LDR Brachytherapy cases, one-month volumetric post-implant peer review QA recommended involving CT or MR

Bladder Cancer

Pre- Treatment phase:

- A complete TUR of the bladder cancer should be performed, if possible
- Pelvic MRI to assess tumour extent is recommended, this is especially important if tumour boost is planned

Treatment planning and associated imaging phase:

- The bladder should be contoured along with the tumour volume, as appropriate. If pelvic lymph nodes are to be treated, they should also be contoured. If boost is being used, fiducial markers should be used, wherever possible.

Treatment Delivery Phase:

- The bladder/target volume must be monitored daily by soft tissue or 3D imaging techniques
- An adaptive approach using cone beam/soft tissue imaging, should be considered
    - References:
        - Foroudi, F., Pham, D., Bressel, M., Hardcastle, N., Gill, S., & Kron, T. (2014). Comparison of margins, integral dose and interfraction target coverage with image-guided radiotherapy compared with non-image-guided radiotherapy for bladder cancer. *Clinical Oncology*, *26*(8), 497-505.
        - Kong, V., Taylor, A., Chung, P., & Rosewall, T. (2018). Evaluation of resource burden for bladder adaptive strategies: A timing study. J Med Imaging Radiat Sci. 2018 Dec;49(4):420-427

Post-Treatment follow-up Phase:

Recommended follow-up interval as per:

Zuiverloon, T., van Kessel, K., Bivalacqua, T. J., Boormans, J. L., Ecke, T. H., Grivas, P. D., Kiltie, A. E., Liedberg, F., Necchi, A., van Rhijn, B. W., Roghmann, F., Sanchez-Carbayo, M., Schmitz-Dräger, B. J., Wezel, F., & Kamat, A. M. (2018). Recommendations for follow-up of muscle-invasive bladder cancer patients: A consensus by the international bladder cancer network. *Urologic oncology*, *36*(9), 423–431. https://doi.org/10.1016/j.urolonc.2018.01.014

Months	3	6	9	12	15	18	21	24	30	36	42	48	54	60
Laboratory test[a]	Laboratory testing should be done as clinically indicated													
Imaging[b]		X		X		X		X		X		X		X
Cytoscopy	X	X	X	X		X		X	X	X	X	X		X
Cytology[c]		X		X		X		X		X		X		X

[a]Laboratory testing should be done as clinically indicated.

[b]Imaging is defined as chest X-ray + CT abdomen, or preferable CT of the thorax and abdomen.

[c]Cytology is only recommended in centres with sufficient experience and trained staff, also taking into consideration that radiotherapy increases the number of atypical cells in a cytology specimen.

Testis Cancer

Refer to Management of Stage I Nonseminomatous Testicular Cancer

Pre- Treatment phase:

- Discussion of sperm-banking should take place

Treatment planning and associated imaging phase:

- Nodal regions to be treated, should be contoured. In IIA/IIB, GTV should be outlined.
- Kidneys, heart, and bladder should be contoured. If testicular shield is to be used, this should be taken into account at the time of simulation.

Treatment Delivery Phase:

- Testicular shield should be used if fertility is a concern

CNS Tumours

There are different treatment protocols and quality of care expectations for primary CNS tumours and for patients presenting with brain metastases. The following OH-CCO Guidelines should be followed wherever possible:
Diagnosis and Treatment of Adult Astrocytic and Oligodendroglial Gliomas
Organizational Guideline for the Delivery of Stereotactic Radiosurgery for Brain Metastasis in Ontario

The quality of care expectations common to both groups of patients include:

Pre- Treatment phase:

- Documentation of neurological status
- Discussion of cases in multidisciplinary tumour conference
- Specifications for equipment QA tolerances must be set for SRS treatments and verified daily (e.g. Imaging and treatment coordinate coincidence <1 mm)

- Positional accuracy of the SRS delivery system must be verified on each day of treatment

Treatment planning and associated imaging phase:

- Unless contraindicated, it is recommended to use a planning MRI. Geometric distortion of MR images is of primary concern for radiosurgery as, if left unaccounted for there may be a geographic miss of the target with treatment.

  For more information:
  Organizational Guideline for the Delivery of Stereotactic Radiosurgery for Brain Metastasis in Ontario
  Acceptance Testing and Quality Assurance Procedures for Magnetic Resonance Imaging Facilities

Treatment Delivery Phase:

- Daily image guidance is essential for fractionated treatment
- For SRS cases daily image guidance needed for frameless treatments

Primary CNS Tumours:

Treatment planning and associated imaging phase:

- IMRT, VMAT, or gamma knife should be used in standard or conventional hypo-fractionation cases to minimize dose to normal tissues
- Appropriate SRS immobilization to minimize intra-fraction motion must be used
- Contouring should be performed and dose volume constraints followed as per ASTRO/ESTRO recommendations

Examples

Table 1
Guidelines for target delineation of glioblastoma, according to the European Organisation for Research and Treatment of Cancer (EORTC) and the Radiation Therapy Oncology Group (RTOG).

EORTC treatment volumes (EORTC 22981/22961, 26071/22072 (Centric), 26981–22981, and AVAglio trials)	RTOG treatment volumes (RTOG 0525, 0825, 0913, and AVAglio trials)
Phase 1 (to 60 Gy in 30 fractions) GTV = surgical resection cavity plus any residual enhancing tumour (postcontrast T1 weighted MRI scans). CTV = GTV plus a margin of 2 cm* PTV = CTV plus a margin of 3–5 mm	Phase 1 (to 46 Gy in 23 fractions) GTV1 = surgical resection cavity plus any residual enhancing tumour (postcontrast T1 weighted MRI scans) plus surrounding oedema (hyperintensity on T2 or FLAIR MRI scans). CTV1 = GTV1 plus a margin of 2 cm (if no surrounding oedema is present, the CTV is the contrast enhancing tumour plus 2.5 cm. PTV1 = CTV1 plus a margin of 3–5 mm Phase 2 (14 Gy boost in 7 fractions) GTV2 = surgical resection cavity plus any residual enhancing tumour (postcontrast T1 weighted MRI scans) CTV2 = GTV2 plus a margin of 2 cm PTV2 = CTV2 plus a margin of 3–5 mm

GTV = gross tumour volume; CTV = clinical target volumes; PTV = planning target volume.
MRI = magnetic resonance imaging.
* Margins up to 3 cm were allowed in 22981/22961 trial, and 1.5 cm in 26981–22981 trial.

ESTRO Contouring Guidelines

Table 2
OAR definitions and dose limits in GBM patients - individual adaptation necessary according to the clinical situation. *Most protocols allow ipsilateral cochlea to receive 60 Gy rather than compromise dose.

OAR	If contouring on MRI always double check on CT in case of misalignment	Objective(s)
Brainstem	The foramen magnum to the point where the optic tract passes lateral to the midbrain (this upper limit is arbitrary but easy to define and ensures consistency). Again, for consistency, the quadrigeminal (tectal) plate should be included	$D \leqslant 54$ Gy [28] 1–10 cc < 59 Gy (periphery) [28]
Chiasm	Sits above and behind the anterior clinoids and runs backwards above the sella turcica. For consistency, the anterior and posterior 'limbs' should extend 5 mm to include the start of the optic nerves anteriorly and optic tracts posteriorly. The chiasm can sometimes only be seen on a single slice as it is about 3 mm thick in cranio-caudal direction. It is often easiest to identify in the coronal plane	D_{max} <55 Gy [28]
Cochlea	Sit just anterior to the lateral aspect of the internal auditory canal. They are most easily identified on the CT bone windows as small caves in the bone measuring 4–6 mm. Contour on 3 slices otherwise too small for dose calculation algorithms	Ideally one side mean <45 Gy [33]
Eyes	The whole of the outside of the globe should be contoured to include sclera and cornea. The macula lies opposite the lens	Macula <45 Gy [34]
Lacrimal glands	These can be difficult (sometimes impossible!) to see – but they lie on the superior and lateral aspect of the globe with the inferior border at the (axial) equator of the globe and wrap around superiorly about 30 degrees (i.e. face on – left eye from 1 to 3 o'clock and right eye 9 to 11 o'clock). They sit anterior to the (coronal) equator of the globe. Dose limits should not be used to compromise PTV dose	D_{max} <40 Gy [21]
Lens	Usually easy to see on the CT scan. However as cataracts are easily treatable the dose limits should never compromise PTV dose	Ideally <6 Gy Max 10 Gy [21]
Optic nerves	From the back of the globe to the optic chiasm passing through the optic canal to enter the skull anterior and inferior to the anterior clinoid. To help identify the exact path through the orbit change to CT bone windows. Ensure they join up with optic chiasm. It may be useful to check the structure in the sagittal plane to ensure the outlined structure is not an extra-ocular muscle	$D_{max} \leqslant 54$ Gy [19] D_{max} <55 Gy [28]
Pituitary	Within the sella turcica with chiasm lying superior and anterior to the stalk. As hypopituitarism is easily treatable the dose limits should never compromise PTV dose	D_{max} <50 Gy [32]

Post-Treatment follow-up Phase:

- 3-6 months with MRI brain for first 5 years (or 1 year for pituitary)
- If stable disease, yearly with MRI brain between 5-10 years
- Yearly with MRI beyond 10 years
- Pituitary patient follow up shared with endocrinology

- Supportive care should outline issues related to driving, seizures, raised intracranial pressure, steroids use, symptom management, nutrition, palliative care, and rehabilitation
  - Ford, E., Catt, S., Chalmers, A., & Fallowfield, L. (2012). Systematic review of supportive care needs in patients with primary malignant brain tumors. *Neuro-oncology*, *14*(4), 392-404.

Brain Metastases

Pre- Treatment phase:

- Review in MDT is encouraged and the multidisciplinary team treating this group of patients should be composed of (as per the OH-CCO Organizational Guideline for the Delivery of Stereotactic Radiosurgery for Brain Metastasis in Ontario)
  - Radiation oncologist, neurosurgeon (In cases where a neurosurgeon is not available, and MDT sign off is sufficient), medical physicist, radiation therapist, medical dosimetrist, neuro-radiologist

Treatment planning and associated imaging phase:

- Each brain metastasis should be delineated for dose reporting purposes
- Reporting should include screen capture of at least one slice of each brain metastasis, preferably 3 orthogonal views, the prescribed dose, the prescription isodose, OAR, and target volume
- Suggested dose constraints for SRS:

Single fraction

Volume of Interest	Suggested Reporting Metrics	Suggested Criteria
Each brain metastasis	V100	>99%
PTV (if applicable)	V100	>98%
Brain*	V10Gy, V12Gy	e.g. <10cm³
OARS: brainstem, optic structures, etc	Maximum dose, or dose to finite volume	Quantec or other guidelines

Hypofractionated

Volume of Interest	Suggested Reporting Metrics	Suggested Criteria
Each brain metastasis	V100	>99%
PTV (if applicable)	V100	>98%
Brain*	E.g. V20	-
OARS: brainstem, optic structures, etc	Maximum dose, or dose to finite volume	Quantec or other guidelines

*Variation in definitions exist and are acceptable. I.e. the brain minus all the targets, or the brain including targets, the brain locally around each target or the total brain, or tissue beyond brain.

- For whole brain treatment, it is recommended to shield the lenses as display the maximum dose received by the lenses

Post-Treatment follow-up phase:

For patients treated with SRS:

- Routine clinical visits including MRI is recommended for the first year (every 2-3 months); second and third year (every 2-4 months) and thereafter as determined by the MDT

For patients treated with whole brain RT

- Routine clinical visits at discretion of treating physician with CT or MRI as clinically indicated

Sarcomas

Management of patients with Sarcoma should follow the OH-CCO Provincial Sarcoma Services Plan. Cases should be discussed in a host centre MCC.

Pre- Treatment phase:

- Appropriate cross-sectional imaging
  - CT or MRI
- Chest CT
- Consider whole body MRI in myxoid liposarcoma
- Consider CNS imaging for alveolar soft part sarcoma, angiosarcoma and rhabdomyosarcoma
- Consider CSF examination and bone marrow assessment in rhabdomyosarcoma
- Molecular diagnostics as needed

Treatment planning and associated imaging phase:

Suggested contouring approaches and suggested dose constraints, refer to Princess Margaret Sarcoma Clinical Practice Guidelines as an example.

Example: Sarcoma Dose Constraints for Lower Limb from Princess Margaret Cancer Centre

EVALUATION

Typical Evaluation criteria:

Structure	Metric	5000	6600
PTVp_XXXX	D95	> 4750 cGy	> 6270 cGy
PTV p_XXXX	2 cc Vol	< 5250 cGy	< 6930 cGy
PTVp_XXXX	Dmax	< 5500 cGy	< 7260 cGy
CTVp_XXXX	D98	> 4750 cGy	> 6270 cGy
GTVp	D99	> 4750 cGy	> 6270 cGy
Bone	Average	< 3700 cGy	< 3700 cGy
Bone	Dmax	< 5250 cGy	< 5900 cGy
Bone	V40	< 60 %	< 60 %
Contralateral Leg	Dmax	<1000 cGy	< 1000 cGy
Eval_IntegalDose	For statistic review only		

Note: the bone dose Dmax may increase for the 6600 case if the volume touches the bone (max 6270cGy)

Retroperiteoneum:

EVALUATION

Typical Evaluation criteria:

Structure	Metric	5040 cGy
PTVp/m_XXXX	D95	> 4788 cGy
PTVp/m_XXXX	Dmax	< 5544 cGy
CTVp/m_XXXX	D98	> 4788 cGy
GTVp/m	D99	> 4788 cGy
Kidney_Ipsi	Dmax	< 5292 cGy
Kidney_Contra	V10	< 15%
Kidney_Contra	Dmax	< 1000 cGy
Kidney_Contra	Mean	< 500 cGy
Liver	V30	< 30 %
Liver	Mean	< 1500 cGy or < 2500 cGy (depending on distance between target and liver)
SpinalCord/ Canal	D2	< 5000 cGy
Bowel	Dmax	< 5292 cGy
Heart *(for upper left abdomen case)*	Mean	< 4000 cGy

Upper Limb:

EVALUATION

Typical Evaluation criteria:

Structure	Metric	5000	6600
PTVp _XXXX	D95	> 4750 cGy	> 6270 cGy
PTVp _XXXX	2 cc Vol	< 5250 cGy	< 6930 cGy
PTVp _XXXX	Dmax	< 5500 cGy	< 7260 cGy
CTVp _XXXX	D98	> 4750 cGy	> 6270 cGy
GTVp	D99	> 4750 cGy	> 6270 cGy
Bone	Average	< 3700 cGy	< 3700 cGy
Bone	Dmax	< 5250 cGy	< 5900 cGy
Bone	V40	< 60%	< 60 %
Brachial Plexus	Dmax	< 5250 cGy	< 6800 cGy
Heart	Average	< 4000 cGy	< 4000 cGy
Heart	D40	< 4500 cGy	< 4500 cGy
Ipsilateral Lung	V20	< 50%	< 50 %
Lungs	Ave	< 1500 cGy	< 1500 cGy
Lungs	V20	< 37%	< 37 %
Lungs	V10	< 50%	< 50%
Lungs	V5	< 70%	< 70 %
SpinalCanal	D2	< 5000 cGy	< 5400 cGy

Chest wall:

EVALUATION

Typical Evaluation criteria:

Structure	Metric	3000 cGy	5000 cGy
PTVp/m_XXXX	D95	> 2850 cGy	> 4750 cGy
PTV p/m_XXXX	2 cc Vol	< 3150 cGy	< 5250 cGy
PTVp/m_XXXX	Dmax	< 3300 cGy	< 5500 cGy
CTVp/m_XXXX	D98	> 2850 cGy	> 4750 cGy
GTVp/m	D99	> 2850 cGy	> 4750 cGy
Lungs	Ave	< 1500 cGy	< 1500 cGy
Lungs	V20	< 37%	< 37%
Lungs	V10	< 50%	< 50%
Lungs	V5	< 70%	< 70%
Contralateral Kidney	V10	< 15%	< 15%
Contralateral Kidney	Ave	< 500 cGy	< 500 cGy
Ipsilateral Kidney	Dmax	< 3000 cGy	< 5000 cGy (or Rxn Dose)
Ipsilateral Kidney	V30	Customize to situation	Customize to situation
Liver	Dmax	< 3000 cGy	< 5000 cGy (or Rxn Dose)
Liver	V30	< 30%	< 30%
Heart	Ave	< 1000 cGy	< 4000 cGy
SpinalCord/ Canal	D2	< 3300 cGy	< 5000 cGy

Pelvis:

EVALUATION

Typical Evaluation criteria:

Structure	Metric	5000	6600
PTVp_XXXX	D95	> 4750 cGy	> 6270cGy
PTV p_XXXX	2 cc Vol	< 5250 cGy	< 6930cGy
PTVp_XXXX	Dmax	< 5500 cGy	< 7260cGy
CTVp_XXXX	D98	> 4750 cGy	> 6270cGy
GTVp	D99	> 4750 cGy	> 6270cGy
Bladder	Mean	< 5000 cGy	< 5000 cGy
Rectum	D30	< 5250 cGy	< 7000cGy
Genitalia (testes / ovary)	Dmax	< 100 cGy	< 100 cGy
Bone	Mean	< 3700 cGy	< 3700 cGy
Bone	V64	< 4000 cGy	< 4000 cGy
Bone	Dmax	< 5250 cGy	< 5900 cGy
FemoralHead_L/R	Dmax	< 5000 cGy	< 5000cGy
CaudaEquina	Dmax	< 5250 cGy	< 6000 cGy
Bowel	Dmax	< 4500 cGy	< 4500 cGy

Treatment planning and associated imaging phase:

- IMRT/TOMO/VMAT with image guidance is required for radical intent cases
- Immobilization is mandatory for extremity tumours

Post-Treatment follow-up phase:

- Patient should be followed by a radiation oncologist and other members of the multi-disciplinary team as appropriate
- For High-Risk patients
    - First F/U 4 to 6 weeks following primary treatment

- Every 3 to 4 months in first 2 years
- Every 6 months for years 3 to 5 and annually thereafter

Hematological Malignancies:

Pre- Treatment phase:

- FDG-PET scan should be obtained as per provincial eligibility criteria
- For patients receiving radiation after chemotherapy, PET-CT/CT scans before and after treatment should be used to determine the involved sites and residual disease. This is especially important in patients receiving ISRT.

Treatment planning and associated imaging phase:

- CT scan should be used for planning with slice thickness no thicker than 3mm. Contrast should be considered to improve identification of vasculature and assist in targeting nodal disease.
- Consider 4D imaging or deep inspiratory breath-hold technique for disease sites significantly affected by respiratory motion.

  Specht L, Yahalom J, Illidge T, Berthelsen AK, Constine LS, Eich HT, Girinsky T, Hoppe RT, Mauch P, Mikhaeel NG, Ng A (2014). Modern radiation therapy for Hodgkin lymphoma: field and dose guidelines from the international lymphoma radiation oncology group (ILROG). ILROG. *Int J Radiat Oncol Biol Phys*, 89(4):854-62.

- Consider ABC breathing control for patients with any thorax-related radiation therapy

  Charpentier, A. M., Conrad, T., Sykes, J., Ng, A., Zhou, R., Parent, A., ... & Hodgson, D. C (2014). Active breathing control for patients receiving mediastinal radiation therapy for lymphoma: Impact on normal tissue dose. *Practical radiation oncology*, *4*(3), 174-180.

- The heart and lung should be contoured for any thorax or any upper abdominal treatment planning in accordance with institutional guidelines. Beams should be delineated to minimize the dose to the heart and lung using the ALARA principle. Active Breath Control techniques/Deep inspiration breath hold, prone positioning, and/or heart blocks should be used as appropriate to minimize normal tissue exposure.
- Dose Constraints and contouring should follow ILROG guidelines:

  Illidge, T., Specht, L., Yahalom, J., Aleman, B., Berthelsen, A. K., Constine, L., ... & Wirth, A. (2014). Modern radiation therapy for nodal non-Hodgkin lymphoma—target definition and dose guidelines from the International Lymphoma Radiation Oncology Group. *International Journal of Radiation Oncology* Biology* Physics*, *89*(1), 49-58.

  Hoskin, P. J., Diez, P., Williams, M., Lucraft, H., & Bayne, M. (2013). Recommendations for the use of radiotherapy in nodal lymphoma. *Clinical oncology*, *25*(1), 49-58.

  For TBI dose rates and OARs, recommendations in Studinski et al should be considered

Studinski, R. C. N., Fraser, D. J., Samant, R. S., & MacPherson, M. S. (2017). Current practice in total-body irradiation: results of a Canada-wide survey. *Current Oncology*, *24*(3), 181

For more information on imaging practices in lymphoma, the guidelines by the International Lymphoma Radiation Oncology Group (ILROG) should be used:

Mikhaeel, N. G., Milgrom, S. A., Terezakis, S., Berthelsen, A. K., Hodgson, D., Eich, H. T., Dieckmann, K., Qi, S. N., Yahalom, J., & Specht, L. (2019). The Optimal Use of Imaging in Radiation Therapy for Lymphoma: Guidelines from the International Lymphoma Radiation Oncology Group (ILROG). *Int J Radiat Oncol Biol Phys, 1*(104), 501-512.

- Chin up position should be used for neck and SCF sites
- For head sites, clinician should indicate appropriate neck position
- Appropriate immobilization for the site being treated is required. In head and neck regions, this should include a customized immobilization shell.
- Users of MRI should ensure that geometric fidelity is maintained for all images. Distortions due to field inhomogeneities and gradient nonlinearities should be minimized. MR sequences should be validated to minimize the likelihood of susceptibility artefacts.

Treatment planning and associated imaging phase:

- Involved Site Radiotherapy (ISRT) is preferred treatment modality over Involved Field Radiotherapy (IFRT), when clinically appropriate
- Conformal plan with field arrangements devised according to treatment site
- Respiratory management should be considered:

Aznar, M. C., Maraldo, M. V., Schut, D. A., Lundemann, M., Brodin, N. P., Vogelius, I. R., ... & Petersen, P. M. (2015). Minimizing late effects for patients with mediastinal Hodgkin lymphoma: deep inspiration breath-hold, IMRT, or both?. *International Journal of Radiation Oncology* Biology* Physics*, *92*(1), 169-174.

- For TBI in lymphoma patients, the ASTRO guideline should be considered:

Wong, J. Y., Filippi, A. R., Dabaja, B. S., Yahalom, J., & Specht, L. (2018). Total body irradiation: guidelines from the international lymphoma radiation oncology group (ILROG). *International Journal of Radiation Oncology* Biology* Physics*, *101*(3), 521-529.

- For Early Hodgkin's lymphoma, the Early-Stage Hodgkin Lymphoma PEBC guide should be followed

Post-Treatment follow-up Phase:

- Follow-up can be shared between providers
    - First year – visits every 3 months
    - 2-3 years – visits every 4 months

- 4-5 years – visits every 6 months
- >5 years – annual follow-up

PSO support:

- PSO support (psychological counselling) should be provided to patients in post-treatment, particularly in survivorship. As an example, please see the OH-CCO Follow-up Care for Survivors of Lymphoma who have Received Curative-Intent Treatment.
- Secondary cancers are of concern – high risk breast screening and surveillance/monitoring where appropriate

Pediatric Malignancies

The SIOPE-ESTRO-PROS-CCI recommendations for the organization of care in pediatric radiation oncology should be followed wherever possible.

All curative cases should be considered for proton therapy.

Pre- Treatment phase:

- RT for children should be undertaken in specialized centres
- The pediatric RT team should have a: specialist pediatric RT, specialist nurse, and play specialist/child life specialist
- Patients should discussed in a multidisciplinary MCC
- All patients should be considered for clinical trial enrollment
- The use of corticosteroids to relieve obstruction symptoms or edema should be considered especially in diffuse intrinsic pontine gliomas
- Imaging should include CT and MRI (T1 gad, T2, and Flair of Brain where appropriate)
- Participation in clinical trials considered the standard of care for pediatric malignancies, and requires extensive time for documentation, radiotherapy data submission, QA and credentialing
- It is strongly recommended that treating RO and nurse attend the MCCs

Treatment planning and associated imaging phase:

- Access to MR fusion/MR Planning MRI should be available for CNS and sarcoma cases
- For cases involving RT to pelvis of females 12 years of age or older, MRI localization of ovaries should be attempted, with planning MRI (preferred) or fusion of diagnostic MRI, which should be used to estimate and document ovarian dose. This dose should be minimized where possible.
- For neuroblastoma cases, 4D planning CTs Should be employed to minimize PTV expansions
- For medulloblastoma cases for conformal boost treatment of the tumour bed, at least 95% of either target must be covered by at least 95% of the prescribed boost dose
- Care should be taken to avoid circumferential RT in an extremity

- For all CNS tumours, IMRT, VMAT or tomotherapy should be used and thermoplastic U/S frame should be considered
- For ependyomas, a 2-phase plan is recommended to protect organs at risk such as the brainstem, cervical spine or optic structures
    - CTV typically: GTV + 0.5 cm
    - PTV 0.3-0.5 cm (ASTRO 2017)
- <u>Craniopharyngioma</u>
    - GTV = residual disease including cysts
    - CTV = GTV + 0.5-1 cm
    - PTV = CTV + 0.3-0.5 cm
    - Dose limiting OARs include brainstem, optic nerves, hippocampi, and temporal lobes
- When conventional craniospinal techniques are used, couch should be rotated about 6 degrees to compensate for inferior divergence of lateral brain fields
- For medulloblastomas, a cavity boost is favoured over a posterior fossa boost to reduce toxicity of treatment
- For Ewing's Sarcoma
    - Consider whole lung RT if lung metastases present
    - MRI essential for defining initial extent of disease, including all T2/FLAIR changes
    - GTV1 includes pre-chemo extent of disease in soft tissue and bone
        - CTV1 = GTV1 + 1-1.5 cm, with high threshold to reduce the volume for pushing margin
        - GTV2 includes pre-chemo extent of disease in bone and post-chemo extent of disease in soft tissue
        - CTV2 = GTV2 + 1 cm
        - PTV expansion site and institution specific
        - Recommended doses are: PTV1 45 Gy in 25 fractions, PTV2 10.8 Gy in 6 fractions (0-5.4 Gy/3 fxs if vertebral body lesion), concurrent chemotherapy
- For Wilm's Tumour

    Flank RT:
    - Imaging: CT planning with clinical correlation to other imaging (pre-operative CT, MRI)
    - Planning: conventional field-based treatment should be used with an AP/PA parallel opposed pair. As required, 3DCRT or IMRT treatments should be used.

Whole abdominal irradiation:

- Imaging: CT planning with clinical correlation to operative report, CT/MR imaging, biopsies, cytology is recommended. The diaphragm should be included in the target volume, shield the femoral heads and inferiorly the fields should extend to at least the inferior pubic ramus.
- Planning: conventional field-based treatment should be used with a AP/PA parallel opposed pair

Whole Lung RT

- Planning: heterogeneity correction should be turned on

Boost RT

- CT simulation is required with correlation from diagnostic CT or MRI and 3DCRT or IMRT is recommended

- For Rhabdomyosarcoma
  - Immobilization: adapted to body site (may include thermoplastic frame, vacuum bag)
  - Confine orbital CTV to orbit unless tumour extended beyond the orbit
  - Boys ≥ 10 years old with paratesticular rhabdomyosarcoma should have "aggressive lymph node sampling" even if clinically negative, and boys of all ages should have LND if clinically involved regional lymph nodes
  - Treat only regionally-involved nodal basins
  - Have a low threshold for treating regionally involved nodal basins in patients with RMS of perineal and peri-anal regions

Suggested dose constraints:

Dose Volume Recommendations (ASTRO)

Neuroblastoma

Volume of interest	Dose criteria (Gy)
GTV1	extent of tumor at time of surgery, including involved lymph nodes
CTV1	GTV1 + 1.0-1.5 cm, anatomically-confined
PTV1	Treated to 21.6 Gy in 12 fractions

Things to consider

Suggested dose constraints

Neuroblastoma

- Suggested OAR constraints (in setting of prescriptions to 21.6 Gy) (ASTRO 2017):
  - Ipsilateral kidney: V19.8<33%
  - Contralateral kidney: V12<50%
  - Liver: V9 <25%
  - Lungs: V15
- As per ASTRO, suggested ANBL 1531 Proposed OAR/Target Volume:

Structure	Volume	Dose (Gy)
Ipsilateral Kidney	<75% Mean dose ≤ 18 Gy. <100%	18 14.4
Contralateral Kidney	<25%	18
Ipsilateral Lung	<30%	20
Contralateral Lung	<10%	20
B/L Lung	<30%	20
Liver	<15% Mean < 15 Gy	30
Vertebral Bodies	If vertebral body requires treatment, the entire vertebral body and posterior elements mean dose should be >18 Gy.	Mean dose >18 Gy
CTVs	>99% receives 95% of prescribed dose	
PTVs	>90% receives 95% of prescribed dose	

Hodgkin's Disease:

- Heart mean < 37%, mean lung dose < 12%, lung V20 <37%
- Thyroid dose should be kept below 15 Gy as doses beyond this are associated with 30% risk of thyroid insufficiency
- DVHs for heart, lungs, thyroid, breasts (if female), should be reported

Treatment Delivery Phase:

- Daily cone beam CT should be performed, and all displacements greater than 1 mm should be corrected prior to treatment delivery
- For all angular displacements greater than 3 degrees, a repeat set up should be considered
- Special pediatric lower dose presets should be considered for cone beam CT and CT sim
- In Wilm's tumour cases, RT should start no later than 10-14 days after surgery
- Timing of therapy
  - Ewing's Sarcoma
    - must be between 6-15 weeks as per Lin et al., 2019
  - Rhabdomysarcoma:
    - Recommended timing of RT: Low-risk – RT after 13 weeks of chemotherapy, Intermediate-risk – Between 4-13 weeks, and High-risk – RT after 20 weeks
  - Medulloblastoma
    - RT should start within 37 days after surgery
  - Ependyoma
    - RT should start within 90 days after surgery if no pre-RT chemotherapy

Post-Treatment follow-up Phase:
All patients should be referred to the closest late effects/aftercare clinic

For all Brain Tumours:

- Ongoing follow-up appointments must take place with neuro-oncology, neurosurgery, and radiation oncology and palliative care (if required)
- Regular MRI of brain and/or spine is recommended

For Wilms' Tumour:

- Patients must receive counselling around avoiding nephrotoxic exposures (non-steroidal analgesics) and disease states (diabetes, hypertension)

For Medulloblastoma:

- Rehabilitation should be considered for patients with neurological deficits such as posterior fossa syndrome

Bone Metastases

The quality of care expectations identified by the expert panels and working groups were influenced by the following guideline

- Palliative radiation therapy for bone metastases: Update of an ASTRO Evidence-Based Guideline
    - Prior XRT should be documented and previous RT records obtained
    - Non-RT options should be considered and documented
    - Patient logistics and distance from cancer centre should be considered
    - Patient's oncologic status, performance status and prognosis should be considered

Treatment planning and associated imaging phase:

Institutional policies should be developed that outline:

- Simulation strategies for conventional RT and SBRT
- Strategies for target volume delineation for conventional RT and SBRT
- Strategies for field placement for conventional RT
- Strategies for organs at risk delineation
- Dose constraints for organs at risk for SBRT

Post-Treatment follow-up Phase:

- Follow up with a radiation oncologist is required for patients that receive SBRT, unless the follow up has been delegated to another physician

Appendix

Expert Panel and Working Group Members

Breast Expert Panel

Name	Institution
Jean-Pierre Bissonnette	Cancer Care Ontario
Ryan Carlson	Health Sciences North
Conrad Falkson	Kingston Health Sciences Centre
Margaret Hart	Durham Regional Cancer Centre, Clinical Quality Lead
Anne Koch	Princess Margaret Cancer Centre
Justin Lee	Hamilton Health Sciences
Eileen Rakovitch	Sunnybrook Health Sciences Centre
Christiaan Stevens	Royal Victoria Regional Health Centre
Michael Brundage	Kingston Health Sciences Centre, Clinical Quality Lead

Breast Working Group

Name	Institution
Carol Agapito	Windsor Regional Hospital
Khalid Hirmiz	Windsor Regional Hospital
Francisco Perera	London Health Sciences Centre
Scott Karnas	London Health Sciences Centre
Sundeep Shahi	Grand River Hospital
Andre Fleck	Grand River Hospital
Karen Ellis	Jurvaniski Cancer Centre
Sara Zammit	Jurvaniski Cancer Centre
Joanna Wojcik	Trillium Health Partners
Michelle Nielsen	Trillium Health Partners
Matt Wronski	Sunnybrook Health Sciences Centre
Stephen Russell	Sunnybrook Health Sciences Centre
Anthony Fyles	Princess Margaret Hospital
Alana Pellizzari	Princess Margaret Hospital
Tatiana Conrad	Southlake Regional Health Centre
Linda Welham	Southlake Regional Health Centre
Lourdes Garcia	Lakeridge Health
Christine Black	Lakeridge Health
Chandra Joshi	Kingston Health Sciences Centre
Gary Bracken	Kingston Health Sciences Centre
Melissa Diffey	The Ottawa Hospital
Tiffany Tam	Royal Victoria Regional Health Centre
Keith Nakonechny	Royal Victoria Regional Health Centre
Laurie Stillwaugh	Health Sciences North
Shelley Mathews	Health Sciences North
Margaret Anthes	Thunder Bay Regional Health Sciences Centre
Kasey Etreni	Thunder Bay Regional Health Sciences Centre

CNS Expert Panel - Brain Metastases

Name	Institution
Arjun Sahgal	Odette Cancer Centre
Tatiana Conrad	Southlake Cancer Centre
Barbara-Ann Millar	Princess Margaret Cancer Centre
Luluel Khan	Trillium Health Partners
Jeffrey Greenspoon	Juravinski Cancer Centre
Mark Ruschin	Odette Cancer Centre
Julie Gratton	The Ottawa Hospital
Jean-Pierre Bissonnette	Princess Margaret Cancer Centre, Clinical Quality Lead
Margaret Hart	Durham Regional Cancer Centre, Clinical Quality Lead
Michael Brundage	Kingston Health Sciences Centre, Clinical Quality Lead

CNS Expert Panel - Primary CNS

Name	Institution
Norm Lapierre	Princess Margaret Cancer Centre
Sten Myrehaug	Odette Cancer Centre
Anthony Whitton	Juravinski Cancer Centre
Glenn Baumann	London Regional Cancer Program
Harald Keller	Princess Margaret Cancer Centre
Shawn Malone	The Ottawa Hospital Cancer Centre
Julie Chase	Juravinski Cancer Centre
Tom Chow	Juravinski Cancer Centre
Mark Ruschin	Odette Cancer Centre
Benoit Guibord	Princess Margaret Cancer Centre
Jean-Pierre Bissonnette	Princess Margaret Cancer Centre, Clinical Quality Lead
Margaret Hart	Durham Regional Cancer Centre, Clinical Quality Lead
Michael Brundage	Kingston Health Sciences Centre, Clinical Quality Lead

CNS Working Group - Primary & Bone Metastases CNS

Name	Institution
Kenneth Schneider	Windsor Regional Hospital
Karla Hodgins	Windsor Regional Hospital
Clare Ferguson	London Health Sciences Centre
Kinga Alliet	Grand River Hospital
Pierre Fortin	Grand River Hospital
Jeffrey Greenspoon	Hamilton Health Sciences Centre
Anthony Whitton	Hamilton Health Sciences Centre
Julia Giovinazzo	Trillium Health Partners
Theo Mutanga	Trillium Health Partners
Arjun Sahgal	Sunnybrook Health Sciences Centre
Lori Holden	Sunnybrook Health Sciences Centre
Barbara-Ann Millar	Princess Margaret Hospital
David Shultz	Princess Margaret Hospital
Tatiana Conrad	Southlake Regional Health Centre
Joel Broomfield	Lakeridge Health
Katharina Sixel	Lakeridge Health
Xiangyang Mei	Kingston Health Sciences Centre

Fabio Ynoe Moraes	Kingston Health Sciences Centre
Shawn Malone	The Ottawa Hospital
Robert Zohr	The Ottawa Hospital
Nevin Mc Vicar	Royal Victoria Regional Health Centre
Matt Follwell	Royal Victoria Regional Health Centre
Barb Ongarato	Health Sciences North
Michael Oliver	Health Sciences North
Medhat El-Mallah	Durham Regional Cancer Centre
Luluel Khan	Trillium Health Partners
Mark Ruschin	Odette Cancer Centre
Julie Gratton	The Ottawa Hospital
Jean-Pierre Bissonnette	Princess Margaret Cancer Centre, Clinical Quality Lead
Margaret Hart	Durham Regional Cancer Centre, Clinical Quality Lead
Michael Brundage	Kingston Health Sciences Centre, Clinical Quality Lead
Norm Lapierre	Princess Margaret Cancer Centre
Sten Myrehaug	Odette Cancer Centre
Glenn Baumann	London Regional Cancer Program
Harald Keller	Princess Margaret Cancer Centre
Julie Chase	Juravinski Cancer Centre
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Mark Ruschin	Odette Cancer Centre
Benoit Guibord	Princess Margaret Cancer Centre

Gastrointestinal Expert Panel

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Sten Myrehaug	Odette Cancer Centre
Anand Swaminath	Juravinski Cancer Centre
Jon Tsao	Carlo Fidani Peel Regional Cancer Centre
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Margaret Hart	Durham Regional Cancer Centre, Clinical Quality Lead
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Gastrointestinal Working Group

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Theo Mutanga	Trillium Health Partners
James Varghese	Trillium Health Partners
Vahab Atefy	Sunnybrook Health Sciences Centre
Shun Wong	Sunnybrook Health Sciences Centre

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Patricia Lindsay	Princess Margaret Hospital
Ahmar Abbas	Southlake Regional Health Centre
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Joel Broomfield	Lakeridge Health
Maria Kalyvas	Kingston Health Sciences Centre
Kit Tam	Kingston Health Sciences Centre
Kristopher Dennis	The Ottawa Hospital
Katie Lekx-Toniolo	The Ottawa Hospital
Jenna King	Royal Victoria Regional Health Centre
Adam Michalak	Royal Victoria Regional Health Centre
Gilles Dugas	Health Sciences North
Laurie Stillwaugh	Health Sciences North
Kevin Ramchandar	Thunder Bay Regional Health Sciences Centre
Patrick Rapley	Thunder Bay Regional Health Sciences Centre
Jim Brierley	Princess Margaret Cancer Centre
Sten Myrehaug	Odette Cancer Centre
Anand Swaminath	Hamilton Health Sciences
Jon Tsao	Carlo Fidani Peel Regional Cancer Centre
Conrad Falkson	Kingston Health Sciences Centre
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Margaret Hart	Durham Regional Cancer Centre, Clinical Quality Lead
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Genitourinary Expert Panel

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Genitourinary Working Group

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Kardi Kennedy	Kingston Health Sciences Centre

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Martin Korzenowski	Kingston Health Sciences Centre
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David McConnell	Thunder Bay Regional Health Sciences Centre
Mary Ann McGrath	Jurvaniski Cancer Centre
Scott Morgan	The Ottawa Hospital
Catherine Neath	Lakeridge Health
Michael Oliver	Health Sciences North
Sarah Rauth	Trillium Health Partners
Julie Renaud	The Ottawa Hospital
Jeffrey Richer	Windsor Regional Hospital
George Rodrigues	London Health Sciences Centre
Christie Wilcox	Lakeridge Health
Junaid Yousuf	Windsor Regional Hospital
Grace Zeng-Harpell	Trillium Health Partners
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Melanie Boyd	Royal Victoria Hospital
Michael Brundage	Kingston Health Sciences Centre, Clinical Quality Lead
Margaret Hart	Durham Regional Cancer Centre, Clinical Quality Lead
Jean-Pierre Bissonnette	Princess Margaret Cancer Centre, Clinical Quality Lead

Head & Neck Expert Panel

Name	Institution
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Ken Schneider	Erie St. Claire RCC
Nancy Read	London Regional Cancer Program
Lee Chin	Odette Cancer Centre
Andrew Pearce	Northeastern Ontario Regional Cancer Centre
Jean-Pierre Bissonnette	Princess Margaret Cancer Centre, Clinical Quality Lead
Margaret Hart	Durham Regional Cancer Centre, Clinical Quality Lead
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Head & Neck Working Group

Name	Institution
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Carol Agapito	Windsor Regional Hospital
Nancy Read	London Health Sciences Centre
Maureen Quinn	London Health Sciences Centre
Dani Scott	London Health Sciences Centre
Sylvia Mitchell	London Health Sciences Centre
Andre Fleck	Grand River Hospital
Katrina Fleming	Grand River Hospital
Orest Ostapiak	Jurvaniski Cancer Centre

Da-Hoon Kim	Jurvaniski Cancer Centre
Kathy Carothers	Sunnybrook Health Sciences Centre
Ian Poon	Sunnybrook Health Sciences Centre
Lee Chin	Sunnybrook Health Sciences Centre
John Waldron	Princess Margaret Hospital
Andrea McNiven	Princess Margaret Hospital
Jean-Pierre Bissonnette	Princess Margaret Hospital
John Kim	Princess Margaret Hospital
Margaret Hart	Lakeridge Health
Khaled Zaza	Kingston Health Sciences Centre
Michael Brundage	Kingston Health Sciences Centre
Ryan Studinski	The Ottawa Hospital
Jamie Bahm	The Ottawa Hospital
Angela Saunders	Royal Victoria Regional Health Centre
Laurie Stillwaugh	Health Sciences North
Andrew Pearce	Health Sciences North
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Lung Expert Panel

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Alison Ashworth	Kingston Health Sciences Centre
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Lung Working Group

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Daniel Glick	Grand River Hospital
Paule Charland	Grand River Hospital
Anand Swaminath	Hamilton Health Sciences Centre
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Brenda Schultz	Sunnybrook Health Sciences Centre
Andrea Shessel	Princess Margaret Hospital
Alex Sun	Princess Margaret Hospital
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Medhat El-Mallah	Lakeridge Health
Aaron Vandermeer	Lakeridge Health
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Andrew Kerr	Kingston Health Sciences Centre
Robert MacRae	The Ottawa Hospital
Dan La Russa	The Ottawa Hospital
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Madeline Ng	Royal Victoria Hospital
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Mellissa Linke	Thunder Bay Regional Health Sciences Centre
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Alison Ashworth	Kingston Health Sciences Centre
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Malti Patel	Hamilton Health Sciences
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Jean-Pierre Bissonnette	Princess Margaret Cancer Centre, Clinical Quality Lead
Margaret Hart	Durham Regional Cancer Centre, Clinical Quality Lead
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Skin Expert Panel

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Toni Barnes	Odette Cancer Centre
Steve Babic	Odette Cancer Centre
Emily Sinclair	Odette Cancer Centre
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Skin Working Group

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Emily Sinclair	Sunnybrook Health Sciences Centre
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James Loudon	Southlake Regional Health Centre
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Tanya Bigg	Lakeridge Health
Tim Hanna	Kingston Health Sciences Centre
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Bone Metastases Expert Panel

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Rebecca Wong	Princess Margaret Cancer Centre
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Daniel Glick	Grand River Cancer Centre
Carrie Lavergne	Durham Regional Cancer Centre

Anthony Brade	Peel Regional Cancer Centre
Danny Vesprini	Odette Cancer Centre
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Margaret Hart	Durham Regional Cancer Centre, Clinical Quality Lead
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Bone Metastases Working Group

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Anthony Brade	Trillum Health Partners
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Danny Vesprini	Sunnybrook Health Sciences Centre
Ian Poon	Sunnybrook Health Sciences Centre
Rebecca Wong	Princess Margaret Hospital
Jean-Pierre Bissonnette	Princess Margaret Hospital
Andrea Bezjak	Princess Margaret Hospital
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Margaret Hart	Lakeridge Health
Mark Niglas	Lakeridge Health
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Ananth Ravi	Odette Cancer Centre
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Gynecology Working Group

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Mackenzie Smith	Odette Cancer Centre
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Alexandra Rink	Princess Margaret Cancer Centre
Jennifer Croke	Princess Margaret Cancer Centre
Jean-Pierre Bissonnette	Princess Margaret Cancer Centre
Kathy Han	Princess Margaret Cancer Centre
Iwa Kong	Juravinski Cancer Centre
Rob Hunter	Juravinski Cancer Centre
Irene Papuga	Juravinski Cancer Centre
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Cheryl Burns	The Ottawa Hospital

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Julie Bowen	North Eastern Ontario Regional Cancer Centre
Andrew Pearce	North Eastern Ontario Regional Cancer Centre
Stacey Davidson	North Eastern Ontario Regional Cancer Centre
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Claire Copp	Windsor Regional Hospital
Ken Schneider	Windsor Regional Hospital
Laura D'Alimonte	Windsor Regional Hospital
Daxa Patel	Durham Regional Cancer Centre
Audrey Li	Durham Regional Cancer Centre
Margaret Hart	Durham Regional Cancer Centre
Ekaterina Borodina	Durham Regional Cancer Centre
Paule Charland	Grand River Hospital
Sofya Kobeleva	Grand River Hospital
Andrea Conrad	Grand River Hospital
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Margaret Anthes	Thunder Bay Regional Health Sciences Centre
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Kathleen Surry	London Regional Cancer Program
Quinn Sciberras	London Regional Cancer Program

Advisory Committee Members

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Ernest Osei	Grand River Hospital
Jim Wright	Juravinski Cancer Centre
Brenda Luscombe	Juravinski Cancer Centre
Sandy Garraway	Peel Regional Cancer Centre
Anthony Brade	Peel Regional Cancer Centre
Greg Czarnota	Odette Cancer Centre

Janice Stewart	Odette Cancer Centre
Mary Gospodarowicz	Princess Margaret Cancer Centre
Fei Fei Liu	Princess Margaret Cancer Centre
Woodrow Wells	Southlake Regional Health Centre
Rob Bull	Southlake Regional Health Centre
Katharina Sixel	Durham Regional Cancer Centre
Christie Wilcox	Durham Regional Cancer Centre
Conrad Falkson	Kingston Health Sciences Centre
Kit Tam Ho	Kingston Health Sciences Centre
Jason Pantarotto	The Ottawa Hospital
Julie Renaud	The Ottawa Hospital
Melody Boyd	North Simcoe Muskoka
Kyle Malkoske	North Simcoe Muskoka
Mark Hartman	North Eastern Ontario Regional Cancer Centre
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Margaret Anthes	North Western Ontario Regional Cancer Centre
Michael Del Nin	North Western Ontario Regional Cancer Centre
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Julia Monakova	Ontario Health (Cancer Care Ontario)
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