Radiotherapy Trials Quality Assurance
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NHS England and NHS Improvement

SABR Expansion Programme
QA review process guidelines - LUNG

1. QA review process

For the SABR expansion programme (SEP) QA approval will be per clinician and per centre. To treat lung primary and lung oligometastases, the following must be completed and approved:

- Facility Questionnaire, to provide details on equipment, processes, centre experience and timelines for SABR development.
- Lung benchmark cases, adhering to the UK SABR Consortium guidelines v6.1.
  - **Outlining Benchmark Case** (clinician specific) - each clinician must complete the Lung Outlining Benchmark case. Feedback will be provided through a written report. This process will be completed by a maximum of two clinicians for each centre. QA approved clinicians will be responsible for mentoring additional clinicians at their centre.
  - **Planning Benchmark Case** (technique specific) - each centre must complete the Lung Planning Benchmark case for their chosen SABR technique. Feedback will be provided through a written report. A single platform (e.g. VMAT or Tomotherapy) per anatomical site will undergo QA under the SABR Expansion Programme.

  Re-submission of cases will be requested where there are unacceptable variations from the required standard.
- UK SABR Consortium Lung Audit using the relevant treatment technique/beam energy and equipment to be used for SABR.

It is recommended that centres engage with their mentor centres, as required, prior to completing and submitting any QA.

The programme will cover review of the original benchmark and one resubmission. If centres are not QA approved after two attempts, they will be expected to undergo appropriate mentoring and will need to cover the costs of any subsequent QA.

Please contact the RTTQA Group at sabrctega.enh-tr@nhs.net if you have any questions.

2. Submission guidelines

Multiple files should be placed in a single folder, zipped and sent via the RTTQA secure transfer service (see instructions in document enclosed in this pack).

All data submitted should be suitably labelled, including the prefix "SEP". For clarity, the folder should be named in the following format: *SEP_centre_site_initials/technique*, referencing whether the included files relate to outlining or planning (by including either the clinician's initials or the planning technique). For example:

SEP_MVCC_spine_PO (clinician PO spine outlining benchmark)

SEP_MVCC_lung_VMAT (VMAT lung planning benchmark)

Please email sabrcteqa.enh-tr@nhs.net to notify the RTTQA Group that the data has been submitted.

2.1 Outlining Benchmark Case

The following will need to be submitted:

- Dicom CT and structure (RS) files containing clinician's contours
- Supporting information form

Contours for multiple clinicians can either be sent as separate (clearly labelled) structure files, or as a single structure file as long as these are clearly differentiated in the contour nomenclature using the clinician's initials.

2.2 Planning Benchmark Case

The following will need to be submitted:

- Dicom CT, plan (RP), structure (RS) and dose (RD) files. The RP file is not required for Cyberknife plans
- Supporting information form

3. Benchmark completion guidelines

3.1 Outlining Benchmark Case

Contouring will be reviewed for both target volumes and relevant organs at risk (OARs). OARs should be delineated in their entirety unless specified otherwise (Table 1). The submission will be reviewed once all required contours have been received by the RTTQA Group.

Case History

A 63-year-old ex-smoker presented to his GP with a 6-week history of a non-productive cough. He had no history of infective symptoms or weight loss. Dyspnoea limited his exercise tolerance to 400 metres.

Chest x-ray was reported as unremarkable. CT chest with contrast demonstrated a 16mm rounded lesion at the right lower lobe. CT guided biopsy confirmed TTF1 positive adenocarcinoma.

FDG PET-CT revealed a right lower lobe lung lesion measuring 18mm, SUV max 7.8. There was no evidence of FDG uptake in the mediastinum and no evidence of distant disease.

Pulmonary function tests reveal FEV1 0.9L (65% predicted) and TLCO 30%.

Social History	Retired council administrator 29 year pack smoking history 20 units of alcohol per week
Past Medical History	Chronic obstructive airways disease Osteoarthritis
Medication	Salbutamol inhaler prn Tiotropium Carbocysteine Lisinopril Doxazosin

Final stage is T1bN0M0 Adenocarcinoma of the right lower lobe. Lung function precludes surgical resection; the patient has been consented for stereotactic radiotherapy.

Instructions

A single outlining benchmark case is provided (SABR_Lung_C), comprising of the individual 12 phases of a 4DCT dataset (159 slices in each phase – except 80% IN, with 157 slices), along with an AVIP (159 slices), and a MIP (159 slices), all contained in different folders. A diagnostic PET-CT (494 slices) is also supplied.

1. The submitting clinician should contour all structures listed in Table 1 on the AVIP. To enable the review the nomenclature must be consistent with this list.
2. The ITV should be generated according to local practice. Centres performing breath-hold techniques should contour the GTV directly onto the AVIP scan and grow to a PTV as per local protocol. Centres using other techniques (such as contouring on the MIP or the individual breathing phases) should propagate the resulting ITV on the AVIP, and then grow to a PTV.
3. PTV expansions should be based on local margins for setup uncertainty.
4. Please complete the supporting information form with a summary of your contouring technique and the PTV margin used and include with your submission.
5. The benchmark planning CT extends from C7 to L1; please note the specific amendments to the standardised OAR descriptions below where structures are not contoured in their entirety.

Table 1: Structure nomenclature and descriptors

The OAR descriptions in this table have been adopted from Global Harmonization Group consensus guidelines by Mir et al (2020), available at: DOI:https://doi.org/10.1016/j.radonc.2020.05.038.

GTV	As per your departmental protocol
ITV	As per your departmental protocol
PTV	As per your departmental protocol
BrachialPlex_L **BrachialPlex_R**	Each brachial plexus should be contoured separately. The brachial plexus originates at the spinal nerve root foraminae C5, C6, C7, C8 and T1 and terminates at the medial limit of the second rib. Begin contouring with a 5mm diameter tool at the C5, C6, C7, C8 and T1 neural foramina and continue caudally, contouring the region from the lateral aspect of the spinal canal, to the small space between the anterior and middle scalene muscles. At the levels where no neural foramina are present, contour the space or soft tissue between the anterior and middle scalene muscles. The middle scalene muscle, and therefore brachial plexus structure, will terminate in the region of the subclavian neurovascular bundle one or two slices below the clavicular head. The first and second ribs serve as the medial limit of the brachial plexus contour. Co-registration with MRI and/or the use of intravenous contrast can help distinguish between nerves and vessels. Be aware that patient positioning may influence the position of the underlying anatomy and the brachial plexus. *As the cranial limit of the benchmark planning CT is at the C7 vertebral body contour the lower nerve roots only.*
Bronchus_Prox	The proximal bronchial tree is contoured using mediastinal windowing and includes the external aspect of the cartilage rings. The cranial border is 2cm cranial to the carina. Caudally, the proximal bronchial tree includes the bilateral proximal airways: the carina, right and left mainstem bronchi, right and left upper lobe bronchi, intermedius bronchus, right middle lobe bronchus, lingular bronchus, and the right and left lower lobe bronchi. Contouring of the lobar bronchi should end immediately at the site of a segmental bifurcation. Lung windowing may assist in identification of the segmental bifurcations.
Chestwall_L **Chestwall_R**	Each chest wall should be contoured separately.

	The chest wall is a 2 cm rind of the hemi-thorax outside of the thoracic cavity. The structure includes intercostal ribs, nerves and muscles and excludes vertebral bodies, sternum, and skin. The anterior-medial border is at the lateral edge of the sternum; the posterior-medial border is the lateral aspect of the vertebral body. *The chest wall should be contoured, as a minimum, from the top of T3 vertebra to the bottom of T11 vertebra*
GreatVes	The great vessels are contoured on mediastinal windowing to include the vascular wall and muscle layers out to the fatty adventitia. The structure abuts the Heart+A_Pulm contour. Intravenous contrast may be helpful in distinguishing the great vessels from adjacent structures. Contour the superior vena cava and the aorta (cranially up to the cranial aspect of the aortic arch). *For this submission, contour aorta caudally to bottom of T11 vertebra*. The inferior vena cava is included in the great vessels structure. The cranial aspect is where the inferior vena cava is clearly separate from the right atrium of the heart. *For this submission, contour IVC caudally to bottom of T11 vertebra*.
Heart+A_Pulm	The heart is contoured on mediastinal windowing to include the pericardial sac. The cranial border is at the cranial aspect of the pulmonary artery. The caudal extent is at the apex of the heart where the left ventricle blends with the diaphragm. Major vessels, including the inferior vena cava should be excluded. The pulmonary arteries are excluded below the main bronchi.
Lung_L **Lung_R** **Lungs**	Each lung should be contoured separately on lung windowing. Contour the whole lung, from the apex to the diaphragm including all inflated and collapsed lung. Small vessels less than 10mm in diameter and vessels beyond the hilar region are included. Exclude the proximal bronchial tree and trachea. Lungs is a summation of Lung_L and Lung_R, used for dose reporting purposes.
Oesophagus	The oesophagus is contoured on mediastinal windowing to include all muscle layers out to the fatty adventitia. Contour from the lower edge of the cricoid cartilage to the gastro-oesophageal junction.
Skin	The skin is the 5 mm inner rind of the external body contour. Please note actual skin thickness will vary dependent on region of interest.
SpinalCanal	The spinal canal is contoured according to the inner limits of the spinal canal using bone windowing.

	The cranial border is at the level of the tip of the dens of the C2 vertebra. The caudal border is the most caudal slice where the spinal canal is visualized, usually at the level of the L5-S1 vertebral bodies. *The spinal canal should be contoured from top of T3 vertebra to bottom of T11 vertebra.*
Trachea	The trachea should be contoured on mediastinal windowing. Contour from the caudal edge of the cricoid cartilage, continuing to 2cm cranial to the carina. Contour to the outer boundary of the cartilage, including the lumen, and trachealis muscle. The oesophagus lies posteriorly and should be excluded.

3.2 Planning Benchmark Case

Instructions

A single planning benchmark case is provided (SABR_Lung_P), containing a planning CT (170 slices) and a structure set. The contours included are listed in Table 2, alongside their respective volumes (as calculated in the Velocity review software, v4.1). Small variations in volume calculation between the centre's TPS and Velocity are expected; if there are significant differences from those listed below please contact the RTTQA Group for advice. Please **do not edit** any existing structures. Additional planning structures may be generated and should be clearly labelled.

1. The plan should be prescribed to **55 Gy in 5 fractions**.
2. PTVs have been provided. Nomenclature follows AAPM TG-263 as outlined below:
    a. PTV_1 denotes the more superior lesion (in this case the right)
    b. PTV_2 denotes the more inferior lesion (in this case the left)
    c. PTV_5500 is the sum of both PTVs
3. A structure named *Body-PTVExp20* has been created in order to check the maximum dose beyond 2 cm from the PTV. This is the body minus PTVExp20 (a direct 20 mm isotropic expansion of PTV_5500).
4. Dose grid resolution on the final dose calculation must be ≤2 mm. Please ensure the dose grid encompasses the whole patient for the final calculation (a pre-requisite for the RTTQA Group review platform).
5. The plan should aim to achieve a minimum of D95 of 100% and a D99 of 90% of the prescription dose to PTV_5500. The max dose (0.1cc) within the PTV should be kept between 110% and 140% of the prescription dose.
6. Planning technique, including dose conformity parameters and dose-volume constraints, should follow the latest version of the UK SABR consortium Guidelines (currently v6.1).

Table 2: Expected structure volumes

Target & OAR structures	Volume (cc)
GTV_1	2.89
GTV_2	0.76
ITV_1	3.66
ITV_2	1.56
PTV_1	16.21
PTV_2	8.14
PTV_5500	24.35
BODY	23050.50
Body-PTVExp20	22683.53
BrachialPlex_L	19.68
BrachialPlex_R	25.23
Bronchus_Prox	41.90
Chestwall_L	1707.76
Chestwall_R	1719.82
GreatVes	87.78
Heart+A_Pulm	849.71
Lungs	6275.74
Oesophagus	29.86
Skin	1644.22
SpinalCanal	76.75
Trachea	39.24