West Midlands Radiotherapy Clinical Protocol

Stereotactic Ablative Radiotherapy (SABR)

Primary Lung (NSCLC)

Revision history

Version	Date	Summary of changes
1.0	February 2023	Sent to EAG for Ratification but not ratified
2.0	April 14th 2023	Ratified at the EAG
3.0	14.2.25	Ratified by EAG
3.1- 3.3	20.5.25	Clarification of Timmerman 'central zone' vs RTOG in section 2.1 (inclusion criteria) to align with SABR Consortium guidance. Also clarification of wording in section 7 (dose fractionation)
4.0	July 2025	Ratified by EAG at June 2025 meeting pending final comments
Review Date:	July 2027	

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Purpose

To provide a standardised protocol for planning and delivery of external beam radiotherapy for patients undergoing Stereotactic Ablative Radiotherapy treatment within the West Midlands for Primary Lung cancer (NSCLC)

This document describes the procedures involved in the image acquisition, structure delineation, treatment planning, verification and treatment of patients for lung SABR. It has been written in accordance with the UK SABR consortium guidelines

SABR is delivered in partnership across the West Midlands, with Oncologists supported by cross regional specialist MDT's.

Information & Consent

- Each patient should be consented with individualised information of planned treatment, risks / benefits and toxicities
- Patients should be consented by a clinical oncologist specialising in SABR. Patients should be asked to give consent for the anonymised data to be collected for use in audit and service development.
- Booking form and consent completed by IR(ME)R practitioner
- Patients should also receive a local patient information sheet or MacMillan information booklets.

Responsibility

- To comply with the Ionising Radiation (Medical Exposure) Regulations 2017 the following roles are defined:
- Referrer & Practitioner: The consultant clinical oncologist is responsible for the care of the patient including correct referral for treatment, consent, justification, prescription and treatment authorization as defined in departmental protocol but in accordance with this regional protocol. See local protocols for departments with Advanced Practice Practitioners.
- Operators: Radiographers, physicists, technologists, consultant clinical oncologists and other medical staff are responsible for individual tasks associated with the plan production, verification and treatment delivery as per departmental protocols but in accordance with this regional protocol and are undertaken on the auspices of the practitioner.

- It is the responsibility of department management teams to ensure departmental protocols are consistent with this regional protocol and that any disagreement with the content of this protocol is raised through the West Midlands EAG.

1. Clinical Indications for Radiotherapy

Stereotactic Ablative Radiotherapy (SABR) has emerged as a new treatment option for patients with Primary Lung Cancer Non Small Cell Lung Cancer (NSCLC).

SABR is a recognised standard of care in early stage inoperable non-small cell lung cancer (NSCLC). This is due to its ability to produce local control rates similar to surgery, its low toxicity and patient convenience as a result of reduced number of visits required for treatment when compared to conventionally fractionated Radiotherapy. For peripherally located lesions, there is strong evidence that SABR is superior to conventional Radiotherapy for efficacy and safety with substantial clinical benefit.

All potential SABR patients to be reviewed within an appropriate specialist lung MDT and technical SABR MDT to ensure suitability for SABR and medically optimised from a respiratory point of view before commencing treatment.

Patients will receive a SABR information leaflet detailing the procedure and including the acute and long-term side effects and contact for a named SABR specialist radiographer.

Patients will be consented by a clinical oncologist specialising in SABR lungs. Patients should be asked to give consent for the anonymised data to be collected for use in audit and service development.

2. Lung Primary:

2.1. Inclusion Criteria

• MDT diagnosis of NSCLC based on findings of positive histology or a positive PET scan when predictive models (e.g. Herder, Brock) indicate a > 70% risk of malignancy and/or serial growth on imaging.

• Clinical stages of T1 N0 M0 or T2 (≤5cm) N0 M0 or a subset of T3 (by virtue of chest wall invasion only) (≤5 cm)

• Not suitable for surgery because of medical co-morbidity, lesion is technically inoperable or patient declines surgery after surgical assessment (or option of assessment)

• WHO performance status 0-2

• Peripheral lesions defined as outside the IASLC 'central' zone or Timmerman 'central zone' and moderately central lesions defined as abutting or within the IASLC 'central' zone but outside the ultra-central zone which is defined as 1cm around the proximal bronchial tree. (see figure 1 below)

• Age ≥ 18 years

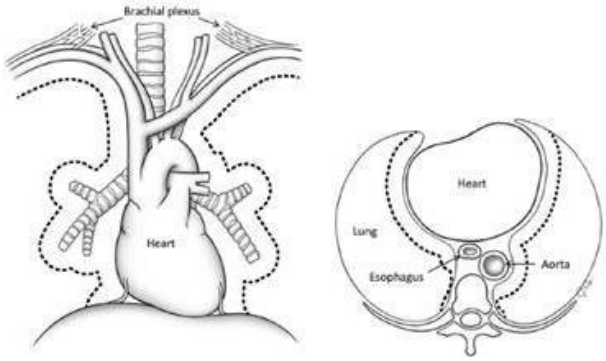

Figure 1. IASLC Central Zone which is defined as the 2cm zone around the bronchial tree, major vessels, heart, oesophagus, spinal cord, phrenic and recurrent laryngeal nerve and brachial plexus.

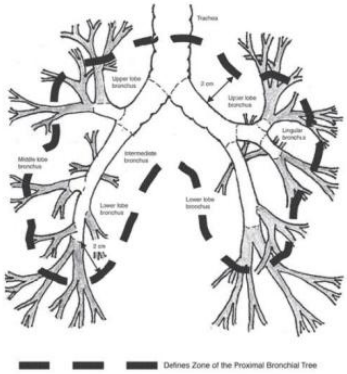

Figure 2. Timmerman 'central' zone definition: Any GTV within the 2cm zone surrounding the proximal bronchial tree (PBT).

2.2. Exclusion Criteria

- Any tumour that is not clinically definable on the treatment planning CT scan e.g. surrounded by consolidation or atelectasis.
- Previous radiotherapy within the planned treatment volume
- Pregnant or lactating females
- Inability to obtain informed consent or comply with treatment requirements

2.3. Relative Contra-Indications*

- Target motion due to respiration ≥ 1cm despite using techniques to reduce tumour motion: all OAR doses must be under tolerance to continue with SABR."
- Presence of pulmonary fibrosis (consider and consent for the increased risk of significant toxicity

*Some trusts operate under the principle that they attempt to reduce motion, they measure it with a 4D scan, but they still treat with motion >1 cm if all the dose statistics meet the consortium tolerances, as the patient is still benefitting compared to conventional radiotherapy.

3. Pre-treatment Assessment

All patients will be discussed at the sub regional SABR MDT with review of the following:

- CT of chest and abdomen.
- PET/CT.
- Predictive models, i.e. Herder/Brock
- Pulmonary function tests (FEV1) including DLCO.
- FBC (aim for Hb≥10), U&E, LFT, corrected calcium.
- Clinical history, including examination and PS.

4. Patient Immobilisation

Patient positioned supine with arms out of the treatment beams (or immobilised where patient has limited mobility) with patient-specific indexed immobilisation equipment, as per local

protocols. Ensure that the patient is comfortable in the chosen position and can maintain the position for at least 20 minutes.

For patients with apical lesions, immobilisation using a Head and Neck BDS with arms by the side should be considered.

5. Imaging for Planning

Imaging should be performed to account for the full range of tumour motion. Ideally this will be using 4DCT but alternative techniques such as inhale and exhale 3DCT may also be appropriate. An additional 3DCT may also be acquired to include the full extent of surrounding organs at risk. Slice thickness should be ≤3mm.

For tumours with significant respiratory motion, the use of further motion management, organ at risk doses and the appropriateness of treatment should be carefully considered.

6. Volume Delineation

All contours must be reviewed by another SABR lung oncologist and if necessary, a lung radiologist.

6.1. Targets

Peer review can be undertaken in the SABR MDT meetings or off-line outside of the meeting with recording of the outcome or any recommendations.

- **Gross Tumour Volume** – The motion adapted GTV is to be defined as the radiologically visible tumour in the lung contoured using lung settings and encompassing the full extent of tumour motion from the 4DCT. Mediastinal windows may be suitable for defining tumours close to the chest wall. Where available, information from PET-CT or other staging will be incorporated into delineating the GTV.

  Practically, the motion adapted GTV should be delineated using all phases of the respiratory cycle or considering the maximum inhalation phase (0%), maximum expiration phase (50%) and maximum intensity projection (MIP) as per locally agreed practice.

- **Clinical Target Volume** – No margin is applied and the clinical target volume is equal to the motion adapted gross tumour volume.

- **Planning Target Volume** = CTV + 5mm isotropically (or as per local margin). An anisotropic margin can be considered according to local policy.

6.2. Organs at Risk

Guidance on contouring these structures is based on [1].

Patient should be deemed ineligible for SABR if uncontrollable cough or patient cannot manage symptoms, or if dose conformity, dose spillage and OAR constraints cannot be met.

For coplanar planning outline OAR's within 5cm from PTV.

For non-coplanar planning include all OAR's within the path of the beams.

Name	Contouring guidance
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. Volumes can be more generous to account for imaging uncertainty. 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.

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	The chest wall is a 2cm 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.
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). 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.

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 (as seen in a coronal reconstruction of the CT scan). 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** **Lungs - GTV**	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 and is used for dose reporting purposes. Lungs – GTV is lungs minus the motion adapted GTV and is used for 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 visualised, usually at the level of the L5-S1 vertebral bodies.

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.
Liver	The whole liver should be outlined, excluding the gall bladder and hepatic vessels. Care should be taken not to inadvertently include the liver vasculature and/or gall bladder.

7. Fractionation and Prescription

A clinical oncologist specialising in lung SABR prescribes the treatment.

Dose Fractionation:

54Gy (18Gy x 3 fractions)	For peripheral lesions where the motion adapted GTV is outside of the IASLC/Timerman 'central' zone and the PTV is not abutting or overlapping the chest wall.
60Gy (12Gy x 5 fractions) 55Gy (11Gy x 5 fractions)	For peripheral lesions where the motion adapted GTV is outside of the IASLC/Timmerman 'central' zone and the PTV is abutting or overlapping the chest wall.
60Gy (7.5Gy x 8 fractions)	For lesions where the motion-adapted GTV is abutting or within the IASLC/Timmerman 'central' zone, but outside the ultra-central zone which is defined as 1cm around the proximal bronchial tree

For all fractionations, the dose should be prescribed such that ≥95% of the planning target volume receives the prescribed dose. Additionally, 99% of the planning target volume should receive a minimum of 90% of the prescription dose.

8. Treatment Planning

Efforts should be made to ensure that isocentre positioning is optimal for on-treatment imaging and that treatment plans are robust considering patient set-up and target motion.

8.1. Prescription Dose Spillage, MGI and Other Requirements

The maximum dose within the planning target volume should optimally be between 110% and 140% of the prescribed dose.

CtE data indicates that there is a benefit to dose conformity by planning with greater dose inhomogeneity (130-140%), particularly for smaller volumes (<40cc). In larger volumes targets (>40cc) there is no correlation between dose inhomogeneity and dose conformity, however individual cases when re-planned with greater dose inhomogeneity may benefit.

If this cannot be achieved, it is mandatory for the maximum dose to be between 105% and 145% of the prescribed dose.

The prescription dose spillage, modified gradient index and other requirements given in Table 1 and Table 2 should be met for all plans.

Vol(PTV) (cc)	Vol(100%) / PTV V100%		
	Target	Tolerance	Minor Dev
<20	1.20*	<1.25	1.25 - 1.40
20-40	1.10*	<1.20	1.20 - 1.30
>40	1.10*	<1.15	1.15 – 1.20

Table 1: Prescription Dose Spillage Requirements

Vol(PTV) (cc)	Vol(50%) / PTV V100%			Lung-GTV V20 (%)	Max dose >2cm	
					3 fractions	5-8 fractions
	Target	Tolerance	Minor Dev	Tolerance	Tolerance	Minor deviation
<20	7*	9*	9 – 11*	<5	<35.1Gy	<35.8Gy
20-40	5.5*	6.5*	6.5 - 7.5*	<6	<37.8Gy	<38.5Gy
40-60	5*	6*	6 – 7*	<10	<37.8Gy	<38.5Gy
60-90	4**	5	5 – 7	<10	<37.8Gy	<38.5Gy
>90	4**	4.5	4.5 – 6.5	<10	<37.8Gy	<38.5Gy

Table 2: Modified Gradient Index and Other Requirements

Where**:**

Vol(100%)/PTV V100%: the ratio of prescription isodose volume to the volume of the PTV receiving at least the prescription isodose.

Vol(50%)/PTV V100%: the ratio of 50% isodose volume to volume of the PTV receiving at least the 50% isodose.

Max dose >2cm: maximum dose at least 2cm from the PTV in any direction.

V20: the percentage of total lung volume – GTV receiving dose >20Gy.

8.2. OAR Dose Constraints

Guidance on dose constraints is from [5].

Description	Constraint	3 Fractions		5 Fractions		8 Fractions	
		Optimal	Mandatory	Optimal	Mandatory	Optimal	Mandatory
BrachialPlex	Dmax (0.1cc)	-	< 24Gy	< 30.5	< 32Gy	< 35Gy	< 39Gy
SpinalCanal*	Dmax (0.035cc)	-	< 20.3Gy	-	< 25.3Gy	-	< 32Gy
Heart+A_Pulm	Dmax (0.1cc)	< 26Gy	< 30Gy	< 29Gy	< 38Gy	< 40Gy	< 46Gy**

Bronchus_Prox	Dmax (0.1cc)	-	< 30Gy	< 35Gy	< 38Gy	-	< 40Gy
Trachea	Dmax (0.1cc)	-	< 30Gy	< 35Gy	< 38Gy	-	< 40Gy
Lungs-GTV	V20Gy	< 10%	< 15%	< 10%	< 15%	< 10%	< 15%
	DMean	< 8 Gy	-	< 8 Gy	-	< 8 Gy	-
ChestWall	Dmax (0.1cc)	< 36.9Gy	-	< 43Gy	-	-	-
	D30cc	< 30Gy	-	-	-	-	-
GreatVes	Dmax (0.1cc)	-	< 45Gy	-	< 53Gy	< 60Gy	< 65Gy
Oesophagus	Dmax (0.1cc)	-	< 25.2Gy	-	< 35Gy	-	<40Gy
Liver	D≥700cc	< 15Gy	< 17Gy	< 15Gy	-	-	-
	V10Gy	-	-	< 70%	-	-	-
	DMean	<13Gy	<15Gy	<13Gy	<15.2Gy	-	-
Skin	Dmax (0.1cc)	< 33Gy	-	< 39.5Gy	-	<48Gy	-
	D10cc	< 30Gy	-	< 36.5Gy	-	44Gy	-

*Whilst the dose constraint is strictly to the Spinal Canal, the use of a locally agreed PRV margin should be considered if appropriate. An alternative suitably small volume may also be used if it is not possible to report the dose to 0.035cc within the TPS used.

** If the eight-fraction cardiac mandatory constraint cannot be met, the prescription dose should be reduced from 60 to 50 Gy.

8.3. Patient specific QA

An independent monitor unit check and patient specific quality assurance should be carried out for all plans following locally agreed protocols.

9. Treatment Delivery

Treatment is delivered in fractions, one fraction per day, delivered alternate days with a minimum of 24 hours between fractions and a maximum interval of ideally 4 days.

Patient position as for CT planning scan.

On-set verification technique, process and action levels are defined within the local departmental protocols.

If the plan is not deliverable or there are issues with patient positioning or set-up, advice should be sought from SABR clinicians, physicists and radiographers as necessary.

4DCBCT and intrafraction imaging should be used as per local departmental protocols.

10. Treatment assessments

Patients will be reviewed by radiographers at planning CT and prior to each treatment fraction to review any symptoms, this will be recorded on a the SABR Toxicity assessment form in patients notes or R&V system.

11. Follow up

- Patients will be seen at 4-6 weeks post-treatment to assess acute toxicity, CTC v5, then 3 monthly visits for 1st year.
- Subsequent years up to 5 years will be 6 monthly.
- These will include history and physical examination (with prospective collection of quality of life data) with a repeat CT thorax done at 3 months and repeated at least every 3 – 12 months depending on the clinical scenario.
- Lung function tests can be considered annually

12. References

1. UK SABR Consortium. Stereotactic Ablative Body Radiation Therapy (SABR): A Resource, version 6.1, Jan 2019. (2022 update awaited)
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Review of lung SABR protocol (May- July 2025)

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