

# Clinical Protocol for SABR Lung Tumours

## 1. Introduction

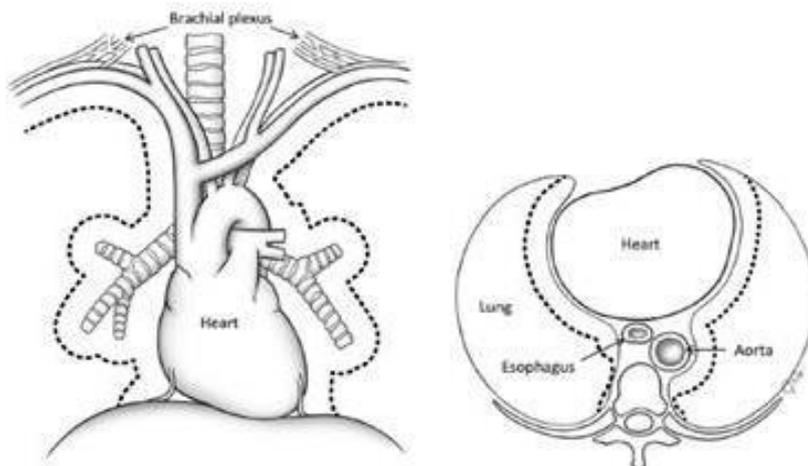
SABR (or SBRT) is the standard of care for patients with stage I (T1N0M0 and T2aN0M0) and IIA (T2bN0M0)<sup>1</sup> Non Small Cell Lung Cancer who are medically inoperable, or who decline surgery.

SABR is a treatment option for selected patients with oligometastatic disease involving the lung.

## 2. Peripheral, Central and Ultra-Central tumours

For the purposes of the treatment criteria below, lung tumours can be divided into peripheral, central and ultra-central lesions.

The IASLC defines central tumours as where the GTV is within 2cm of the bronchial tree, major vessels, heart, oesophagus, spinal cord, phrenic and recurrent laryngeal nerve or brachial plexus. Peripheral tumours lie outside of this.



There are a number of different definitions of ultra-central tumours in the literature, for example the Nordic Hilus trial defined this as where the GTV is  $\leq 1$  cm from the proximal bronchial tree.

## 3. Inclusion/Exclusion Criteria

### Inclusion criteria:

- Age  $\geq 18$  years, and
- Either: MDT diagnosis of NSCLC based on positive histology or radiological features (positive PET scan, or growth on serial CT scan). Clinical stage T1 or T2N0M0 (also selected

T3N0M0 where T stage due to chest wall invasion only). Not suitable for surgery due to medical co-morbidity, the lesion being technically inoperable or the patient having declined surgery.

- OR: Patients with up to 3 oligometastases, all suitable for focal therapy (eg surgery, RFA, SABR). The primary tumour should be under control, with an estimated life expectancy of > 6 months.

#### **Exclusion criteria:**

- Tumours not clinically definable on the planning CT scan, eg surrounded by consolidation or atelectasis.
- Any tumour larger than 5 cm diameter
- Ultra-central tumours
- Significant pulmonary fibrosis, or lung function insufficient for safe delivery of SABR
- Patient unable to give consent to treatment, or to comply with 4DCT scanning and/or lying in the treatment position

All potential SABR cases need to be reviewed in the GenesisCare SABR Advisory Team (SAT) eMDT before proceeding with treatment.

Cases meeting all of the criteria below are regarded as "routine" and are likely to be approved, allowing the treating clinician to take the case forward:

- All lung SABR targets are peripheral lesions
- No previous thoracic radiotherapy
- Case has been discussed in a lung cancer MDT
- The treating clinician is a GenesisCare recognised provider of SABR
- The patient will be treated in GenesisCare centre with SABR experience

Non-routine cases will also be discussed in the GenesisCare SABR eMDT, with recommendations on an individual case basis.

## 4. Oligoprogressive Disease

There is growing evidence for the use of SABR in this setting. Patients with  $\leq 2$  growing metastases and otherwise stable disease for at least 6 months are likely to be most suitable for treatment with SABR.

## 5. Immobilisation and Motion Management

### **Immobilisation:**

The patient is usually positioned supine resting on a wingboard, with arms raised above the head, and a Combifix used for knee and ankle immobilisation, as per Radical Thorax in [RT-WI-017 – Immobilisation and Set-Up Procedure](#).

Consideration should be given to tumour location for any adjustments to the above, for example in the use of abdominal compression.

### **Motion Management:**

Patient-specific tumour motion should usually be assessed and accounted for in treatment using 4DCT.

Methods to reduce, control or mitigate tumour motion will reduce the irradiated volume and should therefore be considered, especially if tumour motion is greater than 1 cm. Options available include:

- Abdominal compression
- Coached breathing, verified using CBCT
- Treating in mid-breath hold, using Vision RT software for gating, where available

If motion cannot be suitably restricted, planning may encompass the entire motion envelope providing all constraints, dose spillage and conformity is adhered to. However, if constraints and/or dose conformity cannot be met, the patient may be deemed ineligible for SABR.

## 6. Image Acquisition & Fusion

Pre-treatment imaging:

### 1. Full 4DCT scan.

In most cases, patients undergo a full 4DCT planning scan. The scan must include all potential organs at risk (OARs), and will be undertaken using axial slices of 2 mm. The scan limits are the upper c-spine (superiorly) and lower edge of the liver (inferiorly), including all the lung tissue.

Ten datasets are acquired through the breathing curve (0% to 100% in 10% iterations).

The Average Intensity Projection (AVIP) dataset is created from the 4DCT images, and is used for treatment planning/dose calculation.

For patients having a full 4DCT scan, a 3DCT with IV contrast can be considered in order to aid delineation of the OARs, but is not mandatory.

### 2. 3DCT scan (for breath hold treatment with Vision RT software).

This applies to centres with Vision RT technology commissioned, for the treatment of patients able to hold their breath for sufficient time to allow acquisition of a full 3DCT scan.

A 3DCT is performed in mid-breath hold (either mid-inspiration or mid-expiration), from the upper c-spine down to the lower edge of the liver, with 2 mm axial slices. If this is completed in comfortable breath hold, then an additional 4DCT is not required.

IV contrast can be considered, but is not mandatory

**Isocentre placement** must give consideration to the physical constraints of the treatment machine. If large lateral shifts are required that exceed the machine's limits for safe full rotation and XVI delivery, the isocentre may be placed away from the treatment volume, with a separate reference point used for calculation. If possible, depending on patient and machine availability, it may be advisable to identify the shifts required with an isocentre in the visible tumour, and perform a verification of positioning on the linear accelerator.

Image Fusion:

The AVIP images will be fused with the full 4DCT where this has been acquired. Any additional 3DCT images are also fused.

## 7. Target Volume and OAR delineation

All tumour and OAR contours should be reviewed by at least one consultant recognised by GenesisCare as a SABR provider.

### **Target Volumes:**

GTV is defined as the radiologically visible tumour in the lung, contoured using lung windowing.

CTV is the GTV, with no margin.

ITV is defined through contouring the tumour on 4DCT, usually by working through the 10 phases, and ensuring the tumour is contained within the contour in all phases/positions. Other methods include the use of the maximum intensity projection (MIP) scan, and combining contours from the maximum inspiratory (ITVins) and maximum expiratory (ITVexp) scans –

The ITV to PTV margin should be 5 mm, allowing for both daily motion variation and setup variation.

For breath hold treatment with Align RT, the GTV is contoured as above, with no margin added for the CTV. The CTV to PTV margin is 5mm.

### **Organs at Risk:**

The following OARs should be contoured, with guidance from the UK SABR Consortium guidelines and the UK consensus on normal tissue dose constraints for stereotactic radiotherapy (Hanna et al, Clin Oncol. 2018. 30(1):5-14)

- Whole lungs (right and left lung combined)
- Trachea
- Proximal Bronchial Tree (including distal 2 cm of trachea)
- Oesophagus
- Heart
- Spinal Cord/Canal
- Brachial plexus (on ipsilateral side, for upper lobe lesions)
- Chest wall (for selected peripheral tumours)

- Skin

Thoracic dose constraints

Description		3 fractions		5 fractions		8 fractions		Source	End point (and magnitude of risk where quantified)
		Optimal	Mandatory	Optimal	Mandatory	Optimal	Mandatory		
Brachial plexus	DMax (0.5 cm <sup>3</sup> )	<24 Gy	<26 Gy	<27 Gy	<29 Gy	<27 Gy	<38 Gy	3 and 5 fractions plus optimal constraints for 8 fractions: UK SABR Consortium [18]. 8 fractions mandatory constraints from LungTECH trial [24] (excluding heart and great vessels)	Grade 3+ neuropathy
Heart	DMax (0.5 cm <sup>3</sup> )	<24 Gy	<26 Gy	<27 Gy	<29 Gy	<50 Gy	<60 Gy	As above (8 fraction heart constraints from UK SABR Consortium [18])	Grade 3+ pericarditis
Trachea and bronchus	DMax (0.5 cm <sup>3</sup> )	<30 Gy	<32 Gy	<32 Gy	<35 Gy	<32 Gy	<44 Gy	As above	Grade 3+ stenosis/fistula
Normal lungs* (lungs – gross tumour volume)	V20 Gy	–	<10%	–	<10%	–	<10%	As above	Grade 3+ pneumonitis
Chest wall	DMax (0.5 cm <sup>3</sup> )	<37 Gy	–	<39 Gy	–	<39 Gy	–	As above	Grade 3+ fracture or pain
	D30 cm <sup>3</sup>	<30 Gy	–	<32 Gy	–	<35 Gy	–	As above	
Great vessels	DMax (0.5 cm <sup>3</sup> )	–	<45 Gy	–	<53 Gy	–	–	As above (8 fractions great vessels constraints from UK SABR Consortium [18])	Grade 3+ aneurysm

G.G. Hanna et al. / Clinical Oncology xxx (2017) 1–10

DMax is the near-point maximum dose, defined in this case as D0.5 cm<sup>3</sup>, which is the minimum dose to the 0.5 cm<sup>3</sup> volume of the organ receiving the highest doses.

V20 Gy is the percentage volume of the organ receiving a dose of 20 Gy or higher.

D30 cm<sup>3</sup> is the minimum dose to 30 cm<sup>3</sup> of the organ that receives the highest doses.

\* Normal lung (lungs – gross tumour volume) constraints for the treatment of two or three lung lesions in the same patient, should follow the guidelines in general point 9 above.

## 8. Dose, Fractionation and OAR constraints

Accepted dose and fractionation regimes are as per the national SABR Consortium guidelines.

- Peripheral tumours: Standard dose: 54 Gy/3#
- Conservative dose (eg consider for larger tumours) 60 Gy/5# or 55 Gy/5#
- Where PTV abuts or overlaps the chest wall: 60 Gy/5# or 55 Gy/5#
- Central tumours: 60 Gy/8#

Alternate day treatment is recommended, however a minimum of 24 hours is required between fractions, with a maximum interval between fractions of 4 days.

NB ultra-central tumours, as defined above, should currently not be treated with SABR outside of a clinical trial.

In the case of previous thoracic radiotherapy, doses may need to be lower than the above recommendations, and will need to be decided on an individual case basis.

### Previous Treatment

In the case of previous thoracic radiotherapy, OAR constraints will be decided on an individual case basis. Full details of the previous treatment (including DICOM RT files) will be needed to evaluate this safely.

### OAR Constraints

Figure 1 Thoracic dose constraints from G.G Hanna et al

## 9. Treatment Planning

It is assumed that before planning SABR Lung treatments the planner has full competence in planning single dose level IMRT/VMAT. The knowledge and understanding gained from this technique will be partially transferrable to the technique of SABR plans. It is also assumed that planners undertaking SABR lung plans have completed the required number of training plans and countersigned clinical plans and are defined as competent to plan SABR lung on the GenesisCare competency register.

A VMAT technique should be used when planning all SABR patients. Full or partial arcs can be employed but the trade-offs of limiting the number of angles control points can be delivered from should be considered during the planning process. A partial arc may minimise dose to the contralateral lung but at the expense of dose conformity of the high dose region and is therefore not clinically justified.

When clinically available within GCUK the use of FFF beams reduces the overall treatment beam delivery time and is therefore preferable to FF beams. The length of time patients are laying on the couch has been shown to have a direct impact on intra-fraction errors and thus any reduction in overall treatment slot time is beneficial.

When defining arc parameters for VMAT delivery it is imperative that the planner considers the following:

- Complexity of the target shape – how irregular it is
- Previous treatment or proximal OARs
- Location of tumour – Central or peripheral

### **Abdominal compression for Lung SABR**

If the Stradivarius board is used for patient Immobilisation or abdominal compression then separate couch density overrides from our standard 0.6, 0.08 should be used in Pinnacle. From measured data with the Stradivarius board the density values for couch inner and outer should be **0.21 and 0.6** respectively.

### **Prescribing the Dose in Pinnacle**

In general, the dose distribution should be normalised so that 95% of the target volume (PTV or PTV\_prescribe where appropriate) receives at least 100% of the quoted prescription dose (e.g. 54Gy/3#). In Pinnacle the prescription percentage is usually set to a value of around 80% (range of 70-90% acceptable). The optimal prescription isodose will be dictated somewhat by the dose distribution, the maximum dose, shape/size of the PTV, coverage of the PTV and OAR tolerances. Small changes of 1-2% can be changed to the prescription isodose being normalised to as a simple method of making minor adjustments to PTV coverage or max dose without having to recalculate the plan or re-optimize.

The dose distribution as a whole should be evaluated to check that dose to normal tissues far from the target (ilms, skin folds etc) is acceptable. Medium (~50% of prescription) isodose lines should exhibit a fairly isotropic distribution relative to the target volume, unless deliberately skewed to avoid dose to a particular OAR. If medium level isodoses extend away from the target, ensure the variation in patient setup or movement of OARs would not cause the OAR dose to exceed the constraints.

The maximum dose within the target volume should be between 110% to 140% of the prescription dose. Evidence suggests a benefit to dose conformity by planning with a greater dose inhomogeneity (130-140%), particularly for smaller volumes (<40cc).

**Multiple Targets**

Where multiple targets exist consideration should be given to the dose contribution between them as the proximity decreases. Where target volumes are within 2-3cm of each other the need to provide an accurate summed dose plan becomes of even greater importance. This is less of an issue where targets are geographically remote from each other but for targets in close proximity the need to plan with a common isocentre becomes necessary in order to have the capability to optimise and calculate both targets simultaneously. The "bridging" of high dose between target volumes although sometimes unavoidable should be minimised where possible and should be closely reviewed as part of the clinician assessment. The maximum dose should remain within the PTV.

SABR lung plans have a well-defined criteria for determining whether the resulting dose distribution and organs at risk doses are acceptable. The below tables define the values that should be achievable for roughly half of all patient 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

Figure 2 Prescription dose spillage requirements for lung and non-lung sites

Vol(PTV) (cc)	Vol(50%) / PTV V100%			Lung-GTV V20 (%)	Max dose >2cm	
	Target	Tolerance	Minor Dev		3 fractions	5-8 fractions
<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

Figure 3 Modified Gradient Index and other requirements for lung sites

The final plan should have a 2 degree gantry spacing which can be interpolated from an initial 4 degree spacing during optimisation. A 0.2cm dose grid should also be used for the final dose calculation.

10. References

1. UK SABR Consortium Version 6.1. Endorsed by the faculty of Clinical Oncology of the RCR

2. Hanna GG, et al, UK Consensus on Normal Tissue Dose Constraints for Stereotactic Radiotherapy, Clinical Oncology (2017)

## Revision History

<b>Version</b>	<b>Date Created</b>	<b>Created By</b>	<b>Description of change</b>
1.0	03/06/2019	Dr Alex Martin Mr Paul Laycock	Original