



East of England Radiotherapy Network: Non-spine Bone Stereotactic Ablative Radiotherapy (SABR) Protocol V2.0

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1.0 Indications and patient population

This protocol covers treatment in the following situation: patients with metachronous oligometastatic disease meeting the NHSE criteria outlined below, and with at least one non-spine skeletal metastasis.

1.1 Treatment eligibility

1.1.a Inclusion criteria

As per NHS England commissioning document:

- Confirmed histological diagnosis of cancer (haematological malignancies excluded)
- Metachronous disease, with a disease-free interval between primary treatment and manifestation of metastases of at least 6 months
- 1-3 sites of extracranial metastatic disease only at the time of disease presentation, confined to one or two of the following organs: bone, spine, lymph nodes, liver, lungs, adrenals
- Maximum of 2 vertebral metastases
- Maximum size of 5 cm for any single metastasis
- Life expectancy of more than 6 months
- WHO Performance Status 0-2

1.1.b Exclusion criteria

As per NHS England commissioning document:

- Haematological malignancies
- Evidence of intracranial disease
- For spine metastases, evidence of spinal cord compression or spinal instability
- For lung metastases, evidence of severe interstitial lung disease
- For liver metastases, poor liver function/Child-Pugh score B
- More than 3 sites of metastatic disease, **or** development of new metastases post treatment of a maximum of 3 lesions
- Patients who require irradiation of a whole nodal field
- Previous SABR to the same site of metastatic disease

1.1.c Essential Pre-Radiotherapy investigations for patients

Patients should have whole body imaging within 6 weeks of MDT discussion, confirming eligibility for SABR.





2.0 Localisation

| Localisation | Notes |
|--|--|
| Position | Need for patient positioning and immobilisation methods will depend on the site being treated, and should be discussed prior to the CT localisation appointment, to ensure adequate equipment is available. |
| Arm/ leg/ head/ thorax position | As above |
| Immobilisation and supports | Abdominal compression can be considered for patients where breathing motion may affect the target (e.g. ribs or sternum). Consider patient preparation with additional analgesia as needed. |
| Organ pre-requisites | |
| Contrast | I.V. contrast will not usually be needed for non-spine bone SABR but may be helpful in selected cases to aid OAR delineation (e.g. brachial plexus). |
| CT acquisition | <p>Slice thickness: 1-2 mm for bones outside the thorax; 2-3 mm for bones inside the thorax.</p> <p>Scanning limits: At least 10cm superior and inferior to expected PTV.</p> <p>If part of the liver, kidney, spleen, or lung is likely to receive a clinically significant dose then the entire organ needs to be included in the scan.</p> <p>If multiple metastases that impact on the same organ at risk are being treated, then ONE scan should be taken that covers ALL areas in order that a composite plan can be created.</p> <p>For thoracic bone metastases (e.g. ribs, sternum) an additional reduced length 4D CT planning scan may be obtained.</p> |

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Author: Alex Martin

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| Localisation | Notes |
|---------------------------|---|
| | |
| Additional imaging | <p>A dedicated planning MRI will usually help with GTV delineation and should therefore be considered in many cases. This should then be fused with the planning CT.</p> <p>Fusion of diagnostic PET images may also help with GTV delineation, and therefore should also be considered, where available.</p> |





3.0 Dose prescription & chemotherapy

| Dose (Gy)/# | #/week | Chemo/ comments |
|-------------|--------|---|
| 30-40 | 3 | No prior irradiation |
| 30-40 | 5 | For selected patients e.g. where the target is very close to critical organs at risk, or there has been prior irradiation close to target. 5-fraction regimen should also be considered when treating metastases involving the femoral head or neck |

4.0 Target volumes

The volumes will be outlined according to local protocols and with reference to [The Global Harmonisation Group](#) descriptions.

4.1 3D scanned GTV/CTV/ PTV

- **GTV_3D** = all visible disease as defined on CT, and any additional imaging.
- **CTV_3D** = GTV_3D with a margin of 2-7mm, depending on the case, is usually recommended, and will be confirmed by the treating clinician after contouring the GTV. The CTV will then be “trimmed” back to the surface of the involved bone, unless there is clear soft tissue extension of the GTV outside the bone.
- **PTV** = CTV_3D + 0.5cm

4.2 4D Scanned GTV/ CTV/ PTV

- A 4D GTV is created using the 4DCT dataset (in cases of thoracic bone SABR if respiratory motion is expected)
- **GTV_4D** = all visible disease, covered in all phases of the breathing cycle.
- **CTV_4D** = GTV_4D with a margin of 2-7mm, depending on the case, is usually recommended, and will be confirmed by the treating clinician after contouring the GTV. The CTV will then be “trimmed” back to the surface of the involved bone, unless there is clear soft tissue extension of the GTV outside the bone. This is done most accurately by applying the CTV margin to the GTV on each bin of the 4DCT, and trimming back to bone, then combining all the bins together to produce the CTV_4D
- **PTV** = CTV_4D + 0.5cm

Note: These are the minimum allowable PTV margins. Larger margins may be used at the clinical oncologist's/local department's discretion, where there is more uncertainty in set-up, tumour motion etc.

5.0 Organs at risk

- Aim for the use of standard nomenclature as per Global Harmonization Group consensus guidelines (<https://www.thegreenjournal.com/action/showPdf?pii=S0167-8140%2820%2930294-2>) and the report of the AAPM TG 263.
- All organs at risk will be contoured on the 3D planning CT. The required organs at risk will depend on the site to be treated.
- Generally, any OARs within 3cm sup-inf from the maximum extent of the PTV will need to be outlined.
- Parallel organs such as lungs, liver and kidney lying within 3cm sup-inf of the PTV need to be outlined in their entirety. Spinal canal should be outlined in all cases.
- When treating bone metastases very close to the spinal canal then spinal cord/cauda equina should also be outlined using the fused MRI images if available.

5.1 Constraints

| | | 3 Fractions | | 5 Fractions | |
|--|-------------|-----------------------|------------|-----------------------|------------|
| | | Objective | Constraint | Objective | Constraint |
| PTV | V100% | ≥95% | - | ≥95% | - |
| | D95% | 100% | - | 100% | - |
| | D0.1cc | 130-140% | 110-140% | 130-140% | 110-140% |
| Conformity Index (V100% / PTV V100%) | PTV ≤ 20cc | ≤ 1.25 (ideal 1.2) | ≤ 1.40 | ≤ 1.25 (ideal 1.2) | ≤ 1.40 |
| | PTV 20-40cc | ≤ 1.20 (ideal 1.1) | ≤ 1.30 | ≤ 1.20 (ideal 1.1) | ≤ 1.30 |
| | PTV ≥ 40 cc | ≤ 1.15 (ideal 1.1) | ≤ 1.20 | ≤ 1.15 (ideal 1.1) | ≤ 1.20 |
| Modified Gradient Index (V50% / PTV V100%) | PTV ≤ 20cc | ≤ 7.5 (ideal 5.5) | ≤ 9.5 | ≤ 7.5 (ideal 5.5) | ≤ 9.5 |
| | PTV 20-40cc | ≤ 6.0 (ideal 4.5) | ≤ 7.5 | ≤ 6.0 (ideal 4.5) | ≤ 7.5 |





| | | 3 Fractions | | 5 Fractions | |
|--|------------|----------------------|------------|----------------------|------------|
| | | Objective | Constraint | Objective | Constraint |
| | | | | | |
| | PTV ≥ 40cc | ≤ 5.5 (ideal 4.5) | ≤ 6.5 | ≤ 5.5 (ideal 4.5) | ≤ 6.5 |
| BrachialPlex_L BrachialPlex_R | D0.1cc | - | ≤24Gy | ≤30.5Gy | ≤32Gy |
| Heart+A_Pulm | D0.1cc | ≤26Gy | ≤30Gy | ≤29Gy | ≤38Gy |
| Lungs (non-lung lesions) | V20Gy | ≤10% | ≤15% | ≤10% | ≤15% |
| | Dmean | ≤8Gy | - | ≤8Gy | - |
| Chestwall_L, Chestwall_R | D0.1cc | ≤36.9Gy | - | ≤43Gy | - |
| | D30cc | ≤30Gy | - | - | - |
| GreatVes (Great Vessels) | D0.1cc | - | ≤45Gy | - | ≤53Gy |
| Trachea and Proximal bronchial tree | D0.1cc | | ≤30Gy | ≤35Gy | ≤38Gy |
| SpinalCanal (inc. medulla) | D0.035cc | - | ≤20.3Gy | - | ≤25.3Gy |
| CaudaEquina | D0.035cc | - | ≤24Gy | - | ≤32Gy |
| | D5cc | - | ≤21.9Gy | - | ≤30Gy |
| LumbSacPlex_L, LumbSacPlex_R | D0.1cc | ≤24Gy | - | ≤32Gy | - |
| | D5cc | ≤22.5Gy | - | ≤30Gy | - |
| Duodenum | D0.1cc | - | ≤22.2Gy | ≤33Gy | ≤35Gy |
| | D10cc | - | ≤11.4Gy | ≤25Gy | - |
| Stomach | D0.1cc | - | ≤22.2Gy | ≤33Gy | ≤35Gy |
| | D10cc | - | ≤16.5Gy | ≤25Gy | - |
| | D50cc | - | - | ≤12Gy | - |
| Bowel_Small | D0.1cc | - | ≤25.2Gy | ≤30Gy | ≤35Gy |
| | D5cc | - | ≤17.7Gy | - | - |
| | D10cc | - | - | ≤25Gy | |
| Oesophagus | D0.1cc | - | ≤25.2Gy | - | ≤35Gy |
| Bowel_Large | D0.1cc | - | ≤28.2Gy | - | ≤38Gy |
| Rectum | D0.1cc | - | ≤28.2Gy | - | ≤38Gy |





| | | 3 Fractions | | 5 Fractions | |
|---|---|---|------------|-------------|------------|
| | | Objective | Constraint | Objective | Constraint |
| Liver (non-liver lesions) | Dmean | ≤13Gy | ≤15Gy | ≤13Gy | ≤15.2Gy |
| | V10Gy | - | - | ≤70% | - |
| | D(V _{TOT} -700cc) ⁺ | ≤15Gy | ≤17Gy | ≤15Gy | - |
| Kidney_Cortex_L, Kidney_Cortex_R, | Dmean | ≤8.5Gy | - | ≤10Gy | - |
| Kidney_Cortex (Combined kidney cortices) | D(V _{TOT} -200cc) ⁺ | | ≤16Gy | | ≤17.5Gy |
| If solitary Kidney_Cortex or if one Kidney_Cortex mean dose ≥optimal constraint | V10Gy [§] | - | ≤33% | ≤10% | ≤45% |
| Spleen * | Dmean | 10Gy | - | 10Gy | - |
| Bladder | D0.1cc | - | ≤28.2Gy | - | ≤38Gy |
| Ureter_L Ureter_R | D0.1cc | - | ≤40Gy | - | - |
| Urethra | D0.1cc | report | | | |
| Testes, Genitals | | Avoid beam entry; dose as low as possible | | | |
| SkinRind (the 5mm rind within Skin contour) | D0.1cc | ≤33Gy | - | ≤39.5Gy | - |
| | D10cc | ≤30Gy | - | ≤36.5Gy | - |
| Femur_HeadNeck_L, Femur_HeadNeck_R (Femoral Heads) | D10cc | ≤21.9Gy | - | ≤30Gy | - |

OAR dose constraints as per [UK 2022 Consensus](#) publication.

⁺ Cold constraint (V_{TOT} – xcc) is the total volume of organ minus a specified volume)

[§] Of the kidney receiving the lower dose

*Splenic constraint is based on recent RCR recommendation

6.0 Planning process/ technique

- All patients will be treated using Volumetric Modulated Arc Radiotherapy (VMAT).
- 100% of the dose will be prescribed to at least 95% of the PTV (i.e. DX%=100% where X is ≥95%). Aim to increase PTV coverage (with the prescribed dose) above 95%,



while still achieving OAR constraints AND conformity index/modified gradient index objectives.

- For patients with two or more sites for SABR whose dosimetry impacts on the same organs, the total combined doses to these organs must be within the constraints - a composite plan will be created. For retreatment or treatments near previously treated areas the dose given previously must be taken into account. For spinal cord tolerance the method described by Sahgal is recommended. This states that the maximum cumulative dose to the thecal sac should not exceed a BED of 140Gy ($\alpha/\beta=2\text{Gy}$).
- All plans will be approved by the clinical oncologist.

7.0 Peer Review/ Contour QA

- Prospective peer review of target and OARs by a second Oncologist with SABR experience is strongly recommended.
- A description of the contouring (planning note) and of the peer review process including changes made should be saved in the patient record.
- The peer review process and outcomes should be audited.

8.0 Target verification

| Modality | Frequency | Match point | Additional information |
|---------------------------------------|-----------|-------------|--|
| CBCT Stereoscopic kV/kV FBCT | Daily* | Bone | Consider 4DCBCT for intra-thoracic bone. Consider intra-fractional imaging to assess movement. **Pre and post treatment CBCTs may be taken as required |

9.0 Side effects

Please consult side effect information available relevant to the body site being treated.

| 9.1 Possible general early or short-term side-effects | |
|---|-------------------------------------|
| | Initial Management (if appropriate) |
| Fatigue | |
| Skin reaction | Standard post-radiotherapy skincare |

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9.1 Possible general early or short-term side-effects

| | Initial Management (if appropriate) |
|---|---|
| Pain flare | May need short term increase in analgesia |
| Bowel toxicity or sickness (for abdo/pelvic treatments) | |

9.2 Possible late or long-term side-effects

| | Initial Management (if appropriate) |
|---|---|
| Bowel toxicity (for abdo/pelvic treatments) | |
| Increased risk of insufficiency fracture | Analgesia where needed. Referral to orthopaedic team may be indicated |

10.0 References

Clinical Commissioning Policy Stereotactic ablative radiotherapy (SABR) for patients with metachronous extracranial oligometastatic cancer (all ages) (URN: 1908) [200205P]; March 2020. [1908-cc-policy-sbar-for-metachronous-extracranial-oligometastatic-cancer.pdf \(england.nhs.uk\)](#)

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Center for Innovation in Radiation Oncology; Contouring atlases, templates, and tools. [NRG > About Us > Center for Innovation in Radiation Oncology \(nrgoncology.org\)](#)

Diez P et al (May 2022). UK 2022 Consensus on normal tissue dose-volume constraints for oligometastatic, primary lung, and hepatocellular carcinoma Stereotactic Ablative Radiotherapy. *Clinical Oncology* **34** (2022), 288-300. [UK 2022 Consensus on Normal Tissue Dose-Volume Constraints for Oligometastatic, Primary Lung, and Hepatocellular Carcinoma Stereotactic Ablative Radiotherapy - Clinical Oncology \(clinicaloncologyonline.net\)](#)





[Incidental irradiation of the spleen - RCR guidance | The Royal College of Radiologists.](https://www.rcr.ac.uk/our-services/all-our-publications/clinical-oncology-publications/incidental-irradiation-of-the-spleen-rcr-guidance/)

<https://www.rcr.ac.uk/our-services/all-our-publications/clinical-oncology-publications/incidental-irradiation-of-the-spleen-rcr-guidance/>

11.0 Members of the protocol drafting committee

Cambridge University Hospital NHS Foundation Trust: Alex Martin (Chair), Donna Routsis, Lizzie Tait, Andrew Robinson, Rosanna Stott, Hannah Chantler, Jennifer Mehrer

East Suffolk and North Essex NHS Foundation Trust: Sadaf Usman, Dakshinamoorthy Muthukumar, Ram Venkitaraman, Alice Williams, Mark Porter, Matthew Ball, Nithya Kanakavelu, Helder Campos, Lindsey Sorroll

Norfolk and Norwich University Hospital NHS Foundation Trust: David Maskell, Ghafour Hallaji Zahmatkesh, Alex Martin, Sarah Betts

Mid and South Essex NHS Foundation Trust: Michael Barlow, Rafiqul Islam, Sarah Bull

North West Anglia NHS Foundation Trust: Abbie Hollingdale, Aristoula Papakostidi, Catherine Jephcott, Sarah Treece, Aquila Sharif, Jaak Joe, Stephanie Wagstaff

12.0 Amendment History

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