West Midlands Radiotherapy Clinical Protocol

Paediatric Radiotherapy

Revision history

Version	Date	Summary of changes
6.6	February 2026	Updated by UHB
Review Date:	February 2029	

Paediatric Radiotherapy

Key Words:

Lead Clinicians:	Dr Daniel Ford; Dr Helen Benghiat
Lead Paediatric & TYA Specialist Therapeutic Radiographer:	Liam Herbert
Paediatric & TYA Specialist Therapeutic Radiographer	Sarah Tutill
Paediatric Radiotherapy co-ordinator	Helen Hewitt

Patients are seen and parents consented at Birmingham Children's Hospital after discussion at the relevant MDT. Consent needs to be obtained on a BCH form (Consent Form 2).

Some patients might require a general anaesthetic. Input from the Play Specialists may be helpful.

General Principles

- A number of indications are now routinely sent for proton beam radiotherapy and details of planning / treatment protocols will not be discussed here.
- Aim for fraction sizes no greater than 1.8Gy/#
- In growing children, late effects, including symmetrical growth is an important consideration when planning treatment.
- In children it is useful to consider the organs at risk (OARs) that need to be contoured and reported when selecting CT scan lengths.

Please see list of paediatric related protocols

Protocol / Treatment site	**Titles**	**Codes**
Abdomen	CT Localisation Protocol Paediatric Abdomen CT Localisation Protocol Paediatric Protocol for when Thorax, Abdomen and Pelvis are to be treated Paediatric Abdominal Radiotherapy	RAW60-P RAW122-3 *Draft v.*
Pelvis	CT Localisation Protocol Paediatric Pelvis CT Localisation Protocol Paediatric Protocol for when Thorax, Abdomen and Pelvis are to be treated	RAW61-P RAW122-3
Thorax	CT Localisation - 4D Lung CT Localisation Paediatric Thorax Whole Lungs Radiotherapy SGRT Protocol	RAW60-Lung RAW58-P RAW SGRT WLRT
Brain	CT Localisation Protocol Paediatric Brain and Head & Neck Treatment of open face masks	RAW52-P RAW06-Mask
Craniospinal Radiotherapy (Whole CNS)	Paediatric Whole CNS protocol – Tomotherapy CNS Trouble Shooting Whole CNS matching protocol CT Localisation - CNS	MTP34 TOW02-9 TOW03-0 RAW66-0

RAW60-PHead and Neck	CT Localisation Protocol Paediatric Brain and Head & Neck	RAW52-P
Limb	CT Localisation Protocol Paediatric Lower Limb	RAW65-P
Total Body Irradiation	TBI Measurement Form TBI Treatment including boosts and paediatrics under GA CT Localisation TBI boost scans CT localisation – Total Body Irradiation (TBI) Tomotherapy TBI matching protocol for patients 125cm or under Tomotherapy TBI matching protocol for patients over 125cm Planning and Co-ordination of Total Body Irradiation (TBI) for Allogeneic Transplant Patients	RAF08-2 RAW08-4 RAW8-55 RAW37-TBI TOW12-01 TOW12-02 SCTP/CP/019
Surface Guided Radiotherapy	Treatment of open face masks Radiotherapy SGRT protocol Non-Breast Mediastinal SGRT protocol AlignRT Trouble Shooting	RAW06-Mask RAW56-SGRT RAW80-02 RAG-ALIGNRT
Pregnancy	CT & Rooms – Pregnancy checking procedure Confirmation of pregnancy status under 16 form	RAW2.0 RAF24.0
Radiotherapy Procedure	Paediatric Radiotherapy Procedure	RAP04
Anaesthetics	Local Safety Standards for Invasive Procedures (LocSSIP): Radiotherapy - WHO checklist The Anaesthetic Practitioners Guide to Radiotherapy at UHB	DOC275 RAG09-02

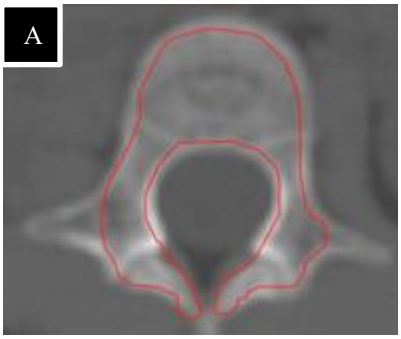
Contents:

- Vertebrae
- Extracranial Indications for Radiotherapy
  - Wilm's Tumour
  - Neuroblastoma
  - Hodgkin's Lymphoma
  - Sarcoma
  - TBI / TNI
- Whole Lung Radiotherapy
- Whole Abdominal Tomotherapy
- Intracranial Indications for Radiotherapy
  - Ependymoma
  - Low and High Grade Gliomas
  - Germ Cell Tumours
  - Diffuse Midline Tumours
- Craniospinal Radiotherapy
  - Medulloblastoma
  - Other indications

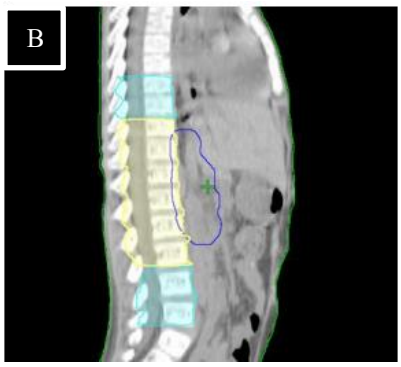
Vertebrae

Radiotherapy can impact vertebral body growth, and it is important to include the whole vertebral bodies when treating volumes that are proximity to the vertebrae to reduce uneven growth of the bones. Contouring guidelines use the SIOPE radiotherapy working group guidelines (2019).

Vertebral bodies within the PTV will be contoured to include the vertebral body and vertebral arch (see image A). This will be labelled as Vertebrae PTV. No additional margin is needed.



The vertebra adjacent to the Vertebrae PTV, superiorly and inferiorly, will be delineated to aid radiotherapy planning. They will be labelled as Superior Vertebra & Inferior Vertebra. (Image B).



The aim would be to deliver a homogeneous dose in the left-right and posterior-anterior vertebral dimensions. Dose to the adjacent vertebra should be based on the IMAT trial where the dose should be kept to V_{10}Gy < 5% where possible.

If not achievable then the following targets should be met:
21Gy in 4# - V_{20}Gy > 95%
36Gy in 24# - V_{25}Gy > 95%

Depending on patient geometry, e.g. the size of the intervertebral space, it may not be possible to meet the V10Gy < 5% criterion for the vertebrae immediately superior and inferior to the treatment field edge. The balance between dose to the adjacent vertebrae and these superior/inferior vertebrae is ultimately at the treating clinician's discretion, provided a rapid dose fall-off to less than 10Gy is produced in the superior-inferior direction.

Recommendations for prescription doses of less than 40Gy		
Organ	**Tolerance (Optimal)**	**Tolerance (Mandatory)**
Vertebrae PTV		< 5Gy Ant/Post, Left/Right gradient **children aged >2 years.** < 3Gy Ant/Post, Left/Right gradient **children aged <2 years**
Vertebra superior/inferior	D10% ≤ 15Gy **children aged >2 years.** D10% ≤ 10Gy **children aged <2 years**	

References

Hoeben, B. A., Carrie, C., Timmermann, B., Mandeville, H. C., Gandola, L., Dieckmann, K., ... & Janssens, G. O. (2019). Management of vertebral radiotherapy dose in paediatric patients with cancer: consensus recommendations from the SIOPE radiotherapy working group. *The Lancet Oncology*, *20*(3), e155-e166.
HR-NBL2 RTQA Guidelines
IMAT RTQA Guidelines

Extracranial Indications for Radiotherapy

Wilms Tumour

- The UMBRELLA protocol [SIOP-RTSG 2016] should be followed
- Children <3 years of age needing flank only volumes could be considered for proton beam therapy
- For children <2 years of age, consider lowering the dose per # to 1.5Gy for example:
    - 14.4Gy in 8# = 15Gy in 10#
    - 25.2Gy in 14# = 25.5Gy in 17#
- For Children <2 years of age requiring whole abdominal radiotherapy, consider lowering the dose per # to 1.25Gy.

Please see RAW60-P & RAW122-3 for patient set up and scanning protocols.

The following table can be used as a summary for the treatment of non-metastatic Wilms tumours:

17.4 Summary recommendation of radiation therapy treatment of abdominal disease

	Stage II	Stage III (except major rupture)	Stage III (major rupture)
Intermediate Risk	no indication	14.4 Gy in 8 fractions, +/- 10.8 Gy boost	Whole abdomen 15.0 Gy in 10 fractions +/- 10.8 Gy boost
High risk **Diffuse anaplasia**	25.2 Gy in 14 fractions +/- 10.8 Gy boost	25.2 Gy in 14 fractions +/- 10.8 Gy boost	Whole abdomen 19.5 Gy in 13 fractions +/- 10.8 Gy boost
High Risk **Blastemal type**	no indication	25.2Gy in 14 fractions +/- 10.8 Gy boost	Whole Abdomen 19.5 Gy in 13 fractions +/- 10.8 Gy boost

The following table can be used as a summary of recommendations for radiotherapy to metastatic sites:

17.8 Summary recommendations of radiation therapy treatment of metastatic sites

	Metastatic Site Lung	Liver (incomplete resection)	Brain	Bone
Intermediate Risk histology	Whole lung 12.0 Gy in 8 fractions	Whole liver/ local 14.4 Gy in 8 fractions (boost 10.8 Gy)	Whole brain 15.0 Gy in 10 fractions +/- 10.5 Gy boost	Local 30.6 Gy in 17 fractions or 30 Gy in 10 fractions
High Risk histology	Whole lung 15.0 Gy in 10 fractions	Whole liver/ local 20-25.2 Gy in 11 fractions (boost 16.2 Gy)	Whole brain 25.2 Gy in 14 fractions +/- 10.5 Gy boost	Local 30.6 Gy in 17 fractions or 30 Gy in 10 fractions

For detailed guidance the UMBRELLA Protocol should be referred to.

Parallel-opposed fields are traditionally used for Flank Volumes.

IMRT (tomotherapy) is used for whole lungs, abdominal and pelvic volume patients. See separate protocol for details of contouring / dose constraints.

Patient should be reviewed weekly with FBC assessment.

Neuroblastoma

- Children <3 years of age could be considered for proton beam therapy if they have no active metastatic disease at re-assessment
- Radiotherapy is indicated in high-risk disease. The post-induction chemo, pre-operative tumour volume is treated to a dose of 21Gy in 14 fractions.
- If there is significant residual disease, dose escalation to 36Gy in 24 fractions can be considered.
- **Please refer to the HR-NBL2 & IMAT trial protocol for detailed guidance.**
- Please see RAW60-P for patient set up and scanning protocols.

Contouring Guidelines:
Upper abdominal volumes might benefit from a 4D CT Planning scan.
Detailed information should be available for all patients pre-planning; including imaging reports, histopathology and operation notes.

GTV

- Reconstructed tumour volume (from post induction chemotherapy, pre-surgical imaging)
- Or, the gross residual tumour for inoperable cases
- With any immediately adjacent persistently enlarged nodes
- Trim the GTV from uninvolved organs that were displaced pre-operatively.

CTV

- GTV + 5mm (may be trimmed at natural barriers to spread e.g. bone / abdominal wall)

ITV

- CTV + a margin that encompasses anatomical movements as seen on the 4D CT planning scan.

PTV

- As per departmental protocol, typically = CTV+ 5mm.

The following OARs should be contoured:

Kidney_R, Kidney_L, Liver, Vertebrae (body and posterior arch) at least one vertebra above and below PTV, Heart, Lung_L, Lung_R, GI tract, SpinalCord.

Patient should be reviewed weekly with FBC assessment.

Neuroblastoma Dose Reporting Schedule – 21Gy/14#

MARK UP LOCATION : - PROSOMA ☐

TO BE PLANNED ON :- XIO ☐ MONACO ☐ TOMO ☐

SIM PLAN ID:-……

MARK UP APPROVED:- CONSULTANT 1…….…….. **CONSULTANT 2**……..…….…

		PTV 21		PTV 36	
% Volume	**% Dose**	**Dose Required**	**Dose Achieved**	**Dose Required**	**Dose Achieved**
99%	**>90%**	18.9		32.4	
95%	**>95%**	19.95		34.2	
50%	**=100%**	21		36	
5%	**<105%**	22.05		37.8	
2%	**<107%**	22.5		38.5	

ORGAN	CONSTRAINT (Gy)	CONCESSION	Dose Received
Contralateral Kidney (Kidney_L / Kidney_R)	V14Gy < 10% Mean (Lt/Rt)		
For Midline Tumours : Combined Kidney	V14Gy < 40%		
Liver	V19Gy < 100% V21Gy < 50% Mean		
Heart	Mean < 15Gy		
Combined Lungs	V15Gy < 10% V12Gy < 25% Mean (Lt/Rt)		
GI tract	V36Gy < 10% V30Gy < 50% V21Gy < 100 % Mean		
Vertebrae	D95% < 10Gy	V20 > 95% or V25Gy > 95%	
SpinalCanal	D0.1cc < 30Gy		
Spleen	Mean		
Pancreas	Mean		
Vertebrae PTV	< 5Gy Ant/Post, Left/Right gradient **children aged >2 years.** < 3Gy Ant/Post, Left/Right gradient **children aged <2 years**		

Vertebra superior/inferior		D10% ≤ 15Gy **children aged >2 years.** D10% ≤ 10Gy **children aged <2 years**	

PLANNED BY:- …… **CHECKED BY:-** …….

PLAN ID:-…….

PLAN ACCEPTED:- **CONSULTANT 1** ……..…….... **CONSULTANT 2** …..……...…..

Hodgkin's Disease

As per EuroNet PHL-C2 study.

The overall strategy is risk stratified (defining chemotherapy) and response adapted (defining radiotherapy) to tailor the amount of treatment to the individual patient and decrease long term complications.
Patients stratified into one of three groups.

- Low (Tl-1), Intermediate (TL-2) and advanced (TL-3) stage
- All patients receive two cycles of OEPA chemotherapy then PET scan (Early Response Assessment – ERA). Patients with a negative PET scan will not receive radiotherapy.
- All intermediate (TL-2) and advanced stage (TL-3) patients will either have respectively 2 or 4 standard COPDAC-28 or intensified DECOPDAC-21 consolidation chemotherapy cycles as determined by the paediatric oncology MDT.
- Those receiving DECOPDAC-21 have radiotherapy restricted to sites that remain FDG-PET positive at the end of all chemotherapy (Late response assessment – LRA)
- Those receiving COPDAC-28 have standard involved node radiotherapy as in the C1 trial.
- All RT is given on completion of chemotherapy

Patients with Inadequate Response (IR) at ERA

- TL-1 receives standard radiotherapy (19.8 Gy/11#) to all initially involved sites
- TL-2 and TL-3 Standard Chemotherapy Arm (COPDAC-28)
    - Standard involved node radiotherapy (19.8 Gy/11#). A 10 Gy boost will be delivered to Late Response Assessment (LRA) PET-positive sites
- TL-2 and TL-3 Intensified Chemotherapy Arm (DECOPDAC-21)
    - Radiotherapy (28.8 Gy/16#) only to LRA PET-positive sites. If the LRA FDG PET scan is negative, then RT is omitted completely

It should be noted that the majority of Hodgkins patients, if receiving RT, will be eligible for proton radiotherapy and so will be referred to The Christie in Manchester.

Sarcoma – Soft Tissue / Bone Tumours

See Chapter on Adult Sarcoma in Medical Treatment Portfolio. Consider Proton referral for appropriate cases.

Total Body Irradiation (TBI)

Total body irradiation is used as part of a conditioning regimen prior to an allogeneic stem cell transplant. The traditional method of delivering TBI is not CT- planned. It is therefore non-conformal and cannot spare individual organs at risk. Intensity modulated TBI (IMTBI) using Tomotherapy (TomoDirect) is advantageous as it allows image guided delivery, provides greater homogeneity within the target and will permit sparing of organs at risk.

IMTBI and non-conformal TBI are both permitted, however, the preferred method should always be IMTBI. Single fraction TBI will still be treated using the non-conformal technique.

Radiotherapy Principles

RCR Category 1.
Patients will receive TBI as part of their pre-SCT conditioning. Therefore patients must be referred in a timely fashion to allow appropriate scheduling of their radiotherapy.

TBI dose: 12Gy in 6 fractions over 3 days (Wednesday – Friday) – 14.4Gy in 8 fractions over 4 days (Tuesday – Friday).

+/- Pre-TBI: Testicular Boost: 4Gy in 1 fraction
Cranial Boost: 5.4Gy in 3 fractions over 2 days.

At present testicular boost will continue to be marked up clinically.

Contouring Guidelines
The entire patient is scanned supine with appropriate immobilisation device. For more information please see RAW37-TBI

- Contour the following OARs for dose reporting:
  - Kidney_R; Kidney_L (Kidneys_Combined)
  - Lung_R; Lung_L (Lungs Combined)
  - Lens_L, Lens_R
  - Eye_L, Eye_R
  - Thyroid
  - Heart
  - Liver
  - Spleen

- Planning team will generate:
  - Outer body contour (External)
  - PTV
  - Inner Lung_R; Inner Lung_L (Inner Lungs_Combined)

Assessment on Treatment:

- Patient will be an inpatient throughout TBI under the care of the haematologists via BCH.
- Ensure patient is prescribed regular anti-emetic.

Booking of IM-TBI

Patients who are taller than 125cm will need to be treated as two volumes. For patients who are awake for their CT planning scan and treatment will need to be invited to a prep session to make their immobilisation mask and immobilisation equipment. CT planning scans need to be booked after the results of the MRD assessment lumbar puncture but with a minimum of 1.5 weeks before treatment week. Please see the table below for schedule:

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Week 1		Prep session for awake patient		MRD results	CT planning scan option 1
Week 2	CT planning scan option 2				
Week 3 (Treatment week)			TBI 8.00 #1 16.00 #2	TBI 8.00 #3 16.00 #4	TBI 8.00 #5 16.00 #6

TBI Treatment – Bi-daily treatment
Patients are scheduled to have their bi-daily treatment at 8.00 and 16.00 (8 hours apart). Patients **must** be treated with a minimum of 6 hours apart. You must notify the clinician if treatment will be before 7 hours apart. The gap should always be kept extended to 7 hours apart where possible.

IMTBI Dose Reporting Schedule – 12Gy/6#

Univeristy Hospitals Birmigham NHS Foundation Trust

THE CANCER CENTRE at the QUEEN ELIZABETH HOSPITAL

TBI ASSESSMENT FORM

Patient Name: Plan ID:

Hospital ID:

Prescription Dose Gy: 12 Fractions 6

		PTV			Junction
Volume %	**Dose%**	Dose Required	Dose Achieved	Single #	Dose Achived
98	**>90**	10.8			
50	**100**	12			
2	**<110**	13.2			
0	**<120**	14.4			

OAR	Dose	Objective	Achieved
Inner Lungs	$D_{50\%}$	10Gy	
	V_{8Gy}	>90%	
Kidneys	$D2_{\%}$	<103%	
		Mean	
Homogeneity Index PTV	$\frac{D_2 - D_{98}}{D_{50}}$		
Lens RT/LT		Max	
Eyes RT/LT		Max	
Thyroid		Mean	
Heart		Mean	
Spleen		Mean	

Comments

Written By:	Agata Grudniewska	**Authorised By:**	Marie Tiffany	**Issue Date:**	03/08/2022
Document Code:	**TOF12-1**	**Page No.**	1 of 2	**Issue No:**	1.3

Whole Lung Radiotherapy

May be indicated in patients with metastatic Wilms tumour and Sarcomas. See individual treatment protocols for more detail regarding dose / fractionation and indications. Note dose / fractionation may change depending on age of the child.
Please see RAW58P and RAW60Lung for patient set up.
These patients should have a 4D CT planning scan to contour the Lung ITV volume.

Contouring Guidelines:

- CTV: Whole lungs. Not including major airways.
- ITV: Maximum lung volume using the 4D images.
- Vertebral bodies should be contoured (Body and posterior arch, not including the transverse or posterior spinal processes; at the level of the PTV and at least one vertebra above and below PTV)
- **(4D CT Planning scan) PTV**: ITV + 7mm all round, 1.0cm inf. If child has not completed growth, then the PTV should include vertebral bodies to ensure homogenous dose. Smaller margins could be used for younger children.
- **(3D CT planning scan only) PTV**: CTV + 10mm all round, 15mm sup / inf. If child has not completed growth, then the PTV should include the vertebral bodies to ensure homogenous dose.

OARs to be contoured: Heart, vertebrae, spinal canal, breasts, thyroid, liver, spleen and kidneys.

Patient should be reviewed weekly with FBC assessment.

Whole Abdominal Radiotherapy

May be indicated with Wilms Tumour / Sarcomas. See individual trial / treatment protocols for more detail. Doses may include 15Gy / 10 # - 30Gy in 20 #.

Please see RAW60-P for patient set up.

Contouring Guidelines:

- CTV: Whole abdominal-pelvic cavity and contents
- Vertebral bodies should be contoured (body and posterior arch, not including the transverse or posterior spinal processes at the level of the PTV).
- PTV = CTV + 10mm all around. If the child has not completed growth, the vertebral bodies should be included in the PTV to ensure dose homogeneity.

OARs to be contoured: Kidneys, vertebrae, spinal canal, liver, spleen, pancreas, GI tract, testicles.

Patient will require daily ondansetron prior to radiotherapy and weekly FBC assessment.

Whole Lung Dose Reporting Schedule

MARK UP LOCATION : - PROSOMA ☐

TO BE PLANNED ON :- MONACO ☐ TOMO ☐

SIM PLAN ID:-……

MARK UP APPROVED:- CONSULTANT 1…….…….. **CONSULTANT 2**……..……..…

		PTV	
% Volume	**% Dose**	**Dose Required**	**Dose Achieved**
99%	**>90%**		
95%	**>95%**		
50%	**=100%**		
5%	**<105%**		
2%	**<107%**		

ORGAN	CONSTRAINT (Gy)	CONCESSION	Dose Received
Heart	Mean < 15Gy DMax < 107%		
Spinal Canal	DMax < 107%		
Kidneys_Combined	Mean < 12Gy V14Gy < 40% Mean (Lt/Rt)		
Liver	Mean < 19Gy DMax < 107%		
Thyroid	Record mean dose		
Breasts	Record mean dose		

PLANNED BY:- …… **CHECKED BY:-** ……

PLAN ID:-…….

PLAN ACCEPTED:- CONSULTANT 1 ……..…….. **CONSULTANT 2** ……..……..…..

Whole Abdominal Dose Reporting Schedule

MARK UP LOCATION : - PROSOMA ☐

TO BE PLANNED ON :- MONACO ☐ TOMO ☐

SIM PLAN ID:-……

MARK UP APPROVED:- CONSULTANT 1…….…….. **CONSULTANT 2**……..……..…

		PTV	
% Volume	**% Dose**	**Dose Required**	**Dose Achieved**
99%	**>90%**		
95%	**>95%**		
50%	**=100%**		
5%	**<105%**		
2%	**<107%**		

ORGAN	CONSTRAINT (Gy)	CONCESSION	Dose Received
Kidneys_Combined	Aim mean dose < 12Gy V14Gy < 40% Mean (Lt/Rt)		
Liver	Mean < 19Gy V19Gy < 100% V21Gy < 50%		
Heart	Mean < 15Gy		
Lungs_Combined	V15Gy < 10% V12Gy < 25% Mean (Lt/Rt)		
Spinal Canal	DMax < 107%		
Testes	Record max dose		
Spleen	Record mean dose		
Bowel	Record mean dose		

PLANNED BY:- …… **CHECKED BY:-** ……

PLAN ID:-……

PLAN ACCEPTED:- CONSULTANT 1 ……..…….. **CONSULTANT 2** ……..……..…..

Intracranial Indications for Radiotherapy

A discussion will be had with the specialist paediatric radiographers and clinical oncologists around the use of open face masks for paediatric patients. This might influence the PTV margins used in cases and will be discussed on a case-by-case basis.

Ependymoma

- Referred for proton beam radiotherapy if complete excision achieved. Aim to start radiotherapy within 6 weeks of surgery.
- Dose ranges from 54Gy – 59.4Gy in 30-33 fractions
- See Adult Ependymoma and SIOP EPII trial protocol for detailed contouring guidance.

Low and High Grade Glioma

- Dose / contouring principles are the same as in adult population. See Adult CNS chapter in Medical Treatment Portfolio for details.

Germ Cell Tumours

- Intracranial Germinomas / Non- Germinomatous Germ Cell Tumours require meticulous staging.
- See SIOP GCT II trial for full details. Further guidance in Adult CNS chapter in Medical Treatment Portfolio.
- Consider proton beam radiotherapy referral for craniospinal / whole ventricular / focal radiotherapy.

Diffuse Midline Glioma (Diffuse Intrinsic Pontine Glioma)

- Radiotherapy should be started as soon as possible.
- Dose: 54Gy in 30fractions.
- 39Gy in 13 fractions can be considered for selected patients with poor performance status.
- Re-irradiation is an option if a good symptomatic benefit is achieved with the first course of radiotherapy.
- Dose should be calculated using radiobiological principles, including time elapsed since first course of radiotherapy (See Re-RT chapter in Adult CNS portfolio), but can range from 19.8Gy - 36Gy in 1.8Gy fractions.

Glioma Dose Reporting Schedule – 28#

MARK UP LOCATION : - PROSOMA ☐

TO BE PLANNED ON :- XIO ☐ MONACO ☐ TOMO ☐

SIM PLAN ID:-……

MARK UP APPROVED:- CONSULTANT 1…….…….. **CONSULTANT 2**……..……..…

		PTV50.4	
% Volume	**% Dose**	**Dose Required**	**Dose Achieved**
99%	**>90%**	45.4	
95%	**>95%**	47.9	
50%	**100%**	50.4	
5%	**<105%**	52.9	
2%	**<110%**	55.4	

All dose constraints are maximum point dose unless otherwise specified.

ORGAN	CONSTRAINT	CONCESSION	Dose Received
PRV cord (max/1cc) *Cord (max/1cc)*	46/45Gy		
Brainstem	50.4Gy		
PRV brainstem	52Gy		
Globes (Lt/Rt)	40Gy		
PRV Chiasm *Chiasm*	50Gy		
PRV Optic nerves (Lt/Rt) *Optic Nerves (Lt/Rt)*	50Gy		
Cornea (Lt/Rt)	30Gy		
Lacrimal gland (mean)	<24Gy		
Lens (Lt/Rt)	6Gy		
PRV Cochlear (Lt/Rt) (mean) *Cochlear (Lt/Rt)*	40Gy		
Pituitary (mean)	Record*		
Contralateral hippocampus (Lt/Rt) (mean)	<10 Gy		

PLANNED BY:- …… **CHECKED BY:-** ……

PLAN ID:-……

PLAN ACCEPTED:- CONSULTANT 1 ……..…….. **CONSULTANT 2** ……..……..…..

Glioma Dose Reporting Schedule – 30#

MARK UP LOCATION : - PROSOMA ☐

TO BE PLANNED ON :- MONACO ☐ TOMO ☐

SIM PLAN ID:-……

MARK UP APPROVED:- CONSULTANT 1…….…….. **CONSULTANT 2**……..……..…

		PTV60		**PTV54**		**PTV50.4**	
% Volume	**% Dose**	**Dose Required**	**Dose Achieved**	**Dose Required**	**Dose Achieved**	**Dose Required**	**Dose Achieved**
99%	**>90%**	54.0		48.6		45.4	
95%	**>95%**	57.0		51.3		47.9	
50%	**=100%**	60.0		54.0		50.4	
5%	**<105%**	63.0		56.7		52.9	
2%	**<110%**	66.0		59.4		55.4	

All dose constraints are maximum point dose unless otherwise specified.

ORGAN	**CONSTRAINT**	**CONCESSION**	**Dose Received**
PRV cord (max/1cc) *Cord (max)*	46/45Gy		
Brainstem	55Gy		
PRV brainstem (surface dose)	60Gy		
Brain (1cc)	64Gy		
Brain V54*	≤33%		
Globes (Lt/Rt)	40Gy		
PRV Chiasm *Chiasm*	55Gy		
PRV Optic nerves (Lt/Rt) *Optic nerves (Lt/Rt)*	55Gy		
Cornea (Lt/Rt)	30Gy		
Lacrimal gland (mean)	<24Gy		
Lens (Lt/Rt)	6Gy		
PRV Contralateral Cochlear (Lt/Rt) (mean) *Cochlear (Lt/Rt)*	40Gy		
Pituitary (mean)	Record		

*If V54 whole brain >33% to discuss with clinician.

PLANNED BY:- …… **CHECKED BY:-** ……

PLAN ID:-…… **1** ……..…….. **CONSULTANT 2** …..……...…..

Gliomas Dose Reporting Schedule – 59.4Gy/33#

MARK UP LOCATION : - PROSOMA ☐

TO BE PLANNED ON :- MONACO ☐ TOMO ☐

SIM PLAN ID:-……

MARK UP APPROVED:- CONSULTANT 1…….…….. **CONSULTANT 2**……..……..…

		PTV59.4		**PTV54.45**	
% Volume	**% Dose**	**Dose Required**	**Dose Achieved**	**Dose Required**	**Dose Achieved**
99%	**>90%**	53.5		49.0	
95%	**>95%**	56.4		51.7	
50%	**=100%**	59.4		54.5	
5%	**<105%**	62.4		57.2	
2%	**<107%**	64.1		58.8	

ORGAN	**CONSTRAINT (Gy)**	**CONCESSION**	**Dose Received**
PRV cord (max/1cc) *Cord*	46/45		
Brainstem	55		
PRV Brainstem (surface dose)	60		
Globes (Lt/Rt)	40		
PRV Chiasm *Chiasm*	55		
PRV Optic nerves (Lt/Rt) *Optic nerves (Lt/Rt)*	55		
Brain (1cc)	<64		
Brain (V54)*	<33%		
Cornea (Lt/Rt)	30		
Lacrimal gland (mean)	<24		
Lens (Lt/Rt)	6		
PRV Cochlear (Lt/Rt) (mean) *Cochlear (Lt/Rt)*	40		
Pituitary (mean)	Record		
Contralateral Hippocampus (Lt/Rt) (Mean)	<10		

*If V54 Brain > 33%, to discuss with clinician re margins / dose / concurrent boost.

PLANNED BY:- …… **CHECKED BY:-** ……

PLAN ID:-……

PLAN ACCEPTED:- CONSULTANT 1 ……..…….. **CONSULTANT 2** ……..……..…..

Glioma IMRT Dose Reporting Schedule – 15#

MARK UP LOCATION : - PROSOMA ☐

TO BE PLANNED ON :- MONACO ☐ TOMO ☐

SIM PLAN ID:-……

MARK UP APPROVED:- CONSULTANT 1…….…….. **CONSULTANT 2**……..……..…

		PTV40	
% Volume	**% Dose**	**Dose Required**	**Dose Achieved**
99%	**>90%**	36.0	
95%	**>95%**	38.0	
50%	**=100%**	40.0	
5%	**<105%**	42.0	
2%	**<110%**	44.0	

All dose constraints are maximum point dose unless otherwise specified.

ORGAN	**CONSTRAINT**	**CONCESSION**	**Dose Received**
PRV cord (max/1cc) *Cord*	40Gy		
Brainstem	40Gy		
PRV brainstem (surface dose)	41.2Gy		
Globes	26.5Gy		
PRV Chiasm *Chiasm*	40Gy		
PRV Optic nerves (Lt/Rt) *Optic nerves (Lt/Rt)*	40Gy		
Cornea (Lt/Rt)	30Gy		
Lacrimal gland (mean)	<24Gy		
Lens (Lt/Rt)	4.9Gy		
PRV Contralateral Cochlear (Lt/Rt) (mean) *Cochlear (Lt/Rt) (Mean)*	40Gy		
Pituitary (mean)	Record		

PLANNED BY:- …… **CHECKED BY:-** ……

PLAN ID:-…… **1** …….…….. **CONSULTANT 2** ….……...…..

Medulloblastoma & Paediatric Whole CNS

A detailed protocol is outlined in the document MTP34.

Introduction
Medulloblastoma (MB) is a primitive embryonal cerebellar tumour. It is the most common malignant brain tumour in childhood, accounting for between 15 and 20% of all childhood primary CNS neoplasms. The outcome for children with MB is most closely related to the age of the patient and extent of disease at diagnosis. MB is associated with CSF seeding / metastases.

Risk Stratification:

Risk Factor	Average Risk	High Risk
Age	>3 years	< 3 years
Residual Tumour	< 1.5cm^2	>1.5cm^2
Stage	M_0	M_{1-4}
Other factors		Amplification of MYC or MYC-N Large Cell / Anaplastic subtypes
5 year survival	>80%	30-60%

Principles of Management
Multi-disciplinary management including surgery, chemotherapy and radiotherapy.
The management of supratentorial embryonal tumours follows similar risk-adapted radiotherapy principles to MB.

3 years of age is the cut-off for craniospinal radiotherapy. Children under 3 are treated with chemotherapy alone (HeadStart Protocol) or together with radiotherapy to the posterior fossa only (Infant PNET Study).

Standard Risk Medulloblastoma and High Risk Medulloblastoma can be referred for proton beam therapy. Some patients and families might decline proton beam therapy and wish to have standard radiotherapy locally. Some patients might be too poorly to travel for proton beam therapy and need urgent craniospinal radiotherapy. Families must be appropriately consented and made aware of the possible disadvantages of having radiotherapy with photons.

All patients are to be treated using TomoTherapy

Dose and Fractionation Average Risk MB:

- Craniospinal Axis Irradiation: 23.4Gy in 13 fractions treating once daily. Concurrent vincristine is no longer given during craniospinal radiotherapy.
- Boost to tumour bed: 30.6Gy in 17 fractions, treating once daily (total dose 54Gy in 30 fractions to tumour bed)
    - Preliminary results of COG ACNS0331 have shown equivalent overall survival and event free survival using posterior fossa versus involved field (tumour bed) radiotherapy.
- Adjuvant 'Packer' Chemotherapy (Vincristine, CCNU, Cisplatin / Cyclophosphamide).
- See below for details on immobilisation / contouring.

Dose and Fractionation: High Risk / Metastatic (first presentation): CCLG Recommend use of St Judes Protocol for HR MB: Risk adapted CSI followed by high dose chemotherapy

- M_0 – M_1 : Craniospinal Axis Irradiation: 36.0 Gy in 20 fractions treating once daily
  Boost to primary tumour bed: 19.8Gy in 11 fractions. (Total dose 55.8Gy to primary tumour bed).
- M_2 – M_3 : Craniospinal Axis Irradiation: 36.0 - 39.6Gy in 20 - 22 fractions treating once daily
  Boost to primary tumour bed: 16.2 – 19.8 Gy in 9 – 11 fractions (Total dose 55.8Gy to primary tumour bed)

- Boost other sites of metastatic disease (if applicable) to total dose of 50.4Gy (spinal), or 54-55.8Gy (intracranial).
- E.g. for spinal metastatic disease:
  - If Whole CNS received 36Gy in 20 fractions, boost metastatic disease to 14.4Gy in 8 fractions
  - If Whole CNS received 39.6Gy in 22 fractions, boost metastatic disease to 10.8Gy in 6 fractions

Radiotherapy Principles
RCR Category 1
Patients will receive craniospinal radiotherapy as outlined above followed by a boost to the primary tumour bed and sites of all macroscopic residual disease >5mm based on post-operative MR imaging. Extensive areas of residual meningeal disease may not be amenable to a boost. No concomitant chemotherapy will be given with radiotherapy for high risk / metastatic disease. Radiotherapy will be delivered in two separate phases.
Radiotherapy should start as soon as practicably possible following definitive surgery (ideally within 28 days and no later than 40 days post operatively).

Other indications
Craniospinal radiotherapy can also be used for other indications other than medulloblastoma where there has been metastatic spread and decided by the paediatric neuro-oncology MDT.

CT Scanning
3mm slice CT images are obtained from the vertex to 5cm below the S5 vertebra and transferred into ProSoma. The appropriate work instruction (RAW4.0-0) for CT should be followed by the radiographers which gives greater detailed instructions. Appropriate MRI datasets are obtained from the referring hospital and fused to enable delineation of posterior fossa / sites of metastatic disease.

Contouring Guidelines
TomoTherapy Contouring Guidelines
Planning of Spinal CTV:

- **Outline the Spinal Volume:**
  The aim is to include the entire subarachnoid space including the extensions along the nerve roots as far laterally as the intervertebral foramina.
  Divide the spinal CTV and label as: C-Spine CTV, T-L2 Spine CTV and L3 – S -Spine CTV.
  An additional margin should be added for PTV§ [4]:
  - **C-Spine = 5mm**
  - **T-L2 Spine = 10mm**
  - **L-Spine = 12mm§, but 10mm inferior to thecal sac.**
- **§** Audit of first 8 cases show shifts at lumbar spine to be <10mm. Therefore safe to reduce PTV margin at L – S Spine to 12mm at clinician discretion.

Where these PTVs overlap, trim the overlap back to the same slices as the CTV

- **Inferior border of spinal volume**
  The inferior limit of the spinal CTV must be determined by imaging the lower limit of the thecal sac on a pre-operative MRI. This usually comes down to the bottom of S1 as an obvious CSF space, but there is often elongation extending to the bottom of S2 or further inferiorly. Neuroradiological advice should be obtained to confirm position. A further 10mm margin should be added to the inferior border for PTV, which should lie approximately in the S3-4 interspace.

- **Growing Vertebra***
  To ensure uniform irradiation in those who have not reached adolescence, growth plates must be covered symmetrically.
  Outline:
    - Whole of vertebral body
    - Posterior Arch
    - Facet Joints
    - Not lateral elements / transverse processes.

  This will be treated with no margin to PTV as the targets are the growth plates.

- With high risk disease no requirement to include whole vertebra within spinal PTV with prescription doses of 36-39.6Gy, as fall off of dose from spinal PTV will still ensure adequate coverage of vertebral body with dose (despite gradient) to stop growth uniformly, ie >20Gy. Therefore for high risk patients, clinician discretion as to whether whole vertebra needs to be covered.

  **If adolescent / young adult who has finished growth – the entire vertebra does not need to be covered.

- **Spinal Target**
  Spinal Target = Vertebrae (if required) + Spinal PTV. In practice the anterior body of the vertebra becomes part of the target.

Cranial CTV
Outline the following:

- Whole brain (outline on bony windows). At base of skull, cranial CTV should extend up to inner table of skull and cover exit foramina of cranial nerves for phase 1 (i.e. craniospinal).
    - Ensure internal auditory canal, jugular foramen and hypoglossal canal covered by the cranial CTV.
- Brainstem
- Lens_L, Lens_R
- Eye_L, Eye_R
- Cochlea_L, Cochlea_R
- OpticNrv_L, OpticNrv_R
- OpticChiasm
- Pituitary
- Cribriform plate
- Cornea_L, Cornea_R
- Lips
- Gland_Submand_L, Gland_Submand_R

- Parotid_L, Parotid_R
- Mandible
- SpinalCord (in upper cervical spine only) + 5mm margin = PRV Cord.

Create the Cranial CTV = Brain + Cribiform plate + full length of optic nerves to the back of the globes.
Cranial PTV = Cranial CTV + 5mm

- **Facial Structure should be outlined.** Includes submandibular and parotid glands, the body & ramus of the mandible, upper & lower teeth and the thyroid. This will serve as an avoidance structure.

Organs at Risk to be outlined
Contour the following normal structures:

- Stomach
- Oesophagus
- Kidney_L, Kidney_R, Kidneys
- Liver
- Heart (Include entire pericardial sac. The superior extent of the heart is the first slice at which the right and left pulmonary arteries have separated).
- Lung_L, Lung_R, Lungs
- Gonads
- Breast_L, Breast_R, Breasts
- Thyroid
- Pancreas
- Spleen

Primary Site Irradiation: Medulloblastoma
GTV: includes all gross residual tumour and/or the tumour bed at the primary site based on the initial pre-operative MRI that defines the tissues initially involved with disease anatomically and the post-operative and pre-irradiation MRI that identify residual disease and/or the tumour bed. The GTV in most cases will be a contracted or collapsed tumour bed. Tissue defects resulting from surgical approaches will not be included as part of the GTV when not previously involved by tumour.
CTV: = GTV + 1cm (limited to anatomic boundaries eg bony calvarium, falx and tentorium).

PTV: = CTV + 0.3 – 0.5cm.

If the GTV is not anterior to the posterior aspect of the brainstem, the anterior border of the CTV may be limited to the centre of the brainstem in axial extent. The primary site PTV will receive a cumulative dose of 55.8 Gy (in high risk disease). In patients with significant measurable residual tumour (>1.5 cm^2 or 1.4 cm in greatest diameter), an additional local boost to 59.4 Gy will be considered at the discretion of the consultant (respecting organ at risk tolerance) using a CTV of 0.5 cm and PTV of 0.3-0.5 cm.

Posterior Fossa Boost (when primary site irradiation not applicable).
Posterior fossa contents (CTV) should be outlined on the CT scan (bony windows for lateral margins) fused with the T1 weighted + gadolinium MRI (Pre + post op).
Posterior fossa PTV = Posterior fossa CTV + 5mm
Borders of posterior fossa to aid contouring:

- Anterior: posterior clinoid process
- Inferior: Foramen Magnum
- Superior: Tentorium (use sagittal reconstruction).

The cranial nerve exit foramina should not be covered in the boost/phase 2 volume to reduce cochlea dose.

Metastatic Target Volume (MTV)

Overt metastatic disease >5mm in maximal diameter will define a volume or volumes for potential boost irradiation. Intracranially, the aggregate MTV+PTV will not exceed 25% of the intracranial volume. Intraspinally, the MTV will not exceed 8 consecutive or 10 total spinal segments.

Boost to Spinal Metastases (if applicable):

GTV = gross disease on appropriate MRI sequence
CTV = GTV + 0.5cm
PTV = CTV + 0.5-1.5cm margin depending on location within spinal canal

Summary

Disease Status	CSI	Primary Site	Local Boost	Spinal/Cranial Boost
AR MB	23.4	54	NA	
HR Medulloblastoma				
M0-1	36	55.8	NA	NA 50.4 (spine)
M2-3	36.0- 39.6	55.8	NA	54-55.8 (cranial)

Plan sign off

- Each phase should be scrutinised along with final summative plan. Every effort should be made to ensure there are no hotspots from phase 1 in critical serial structures.
- All whole craniospinal tomotherapy plans should have dual consultant review and sign off prior to treatment. Summation plan (ie composite of phase 1 and 2) should be reviewed at time of sign off. All doses to serial structures should be reported from summation plan.

Treatment

The majority of patients receiving craniospinal radiotherapy (i.e. medulloblastoma) patients are Category 1. Therefore they require treatment on service days and Bank Holiday compensation needs to be discussed with Consultant.

Assessment during Radiotherapy

- Patients will be reviewed with weekly weights and blood results jointly by Consultant Oncologist and Paediatric Radiographer.

Anti-emetics

Ondansetron must be prescribed to all patients.

Modifications due to haematological toxicity

Weekly Full Blood Counts will be performed during radiotherapy. This may be done by the Anaesthetics team if the child has a GA for treatment or for children not requiring anaesthetic, at BCH or by the community nurses.
Consider platelet support / use of growth factors if required. Ideally treatment should not be interrupted. Haemaglobin should be maintained >100.

Supportive care during and following radiotherapy.

- Steroids should not be used routinely during RT. If symptoms of raised intra-cranial pressure develop during treatment the cause, e.g. hydrocephalus, should be actively sought. Dexamethasone may be used as a short-term measure for the treatment of symptoms of raised intracranial pressure or the treatment of nausea and vomiting which cannot be controlled by antiemetics such as 5HT3 antagonists. The lowest dose of dexamethasone consistent with control of symptoms should be used and steroid treatment should be carefully withdrawn as soon as possible.

Dose Constraints

See MTP 34 for dose constraints to be used. Anticipated difficulties should be discussed with dosimetrists prior to planning.

Dose constraints have been modified from Addenbrookes protocol (for 39Gy in 30 fractions) / QUANTEC (assuming $\alpha/\beta = 3$ for late effects).

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6. Reiken S, Mohr A, Habermehl D et al. Outcome and prognostic factors of radiation therapy for medulloblastoma. Int J Radiat Oncol Biol Phys. 2011 81 (3), 7-13.
7. SCOPE 1 – Radiotherapy Guidance and Procedures 2008
8. CCLG Interim Guidance: High Risk Medulloblastoma and Supratentorial PNET.
9. COG ACNS0331 – Abstract – Neuro-oncology 2016.

Retinoblastoma

Plaque therapy – see protocol in document EYEP01 – paediatric only Dr Ford (ARSAC license holder)

Certain cases for EBRT (usually protons) – discuss with Dr Ford/Dr Benghiat on an individual basis