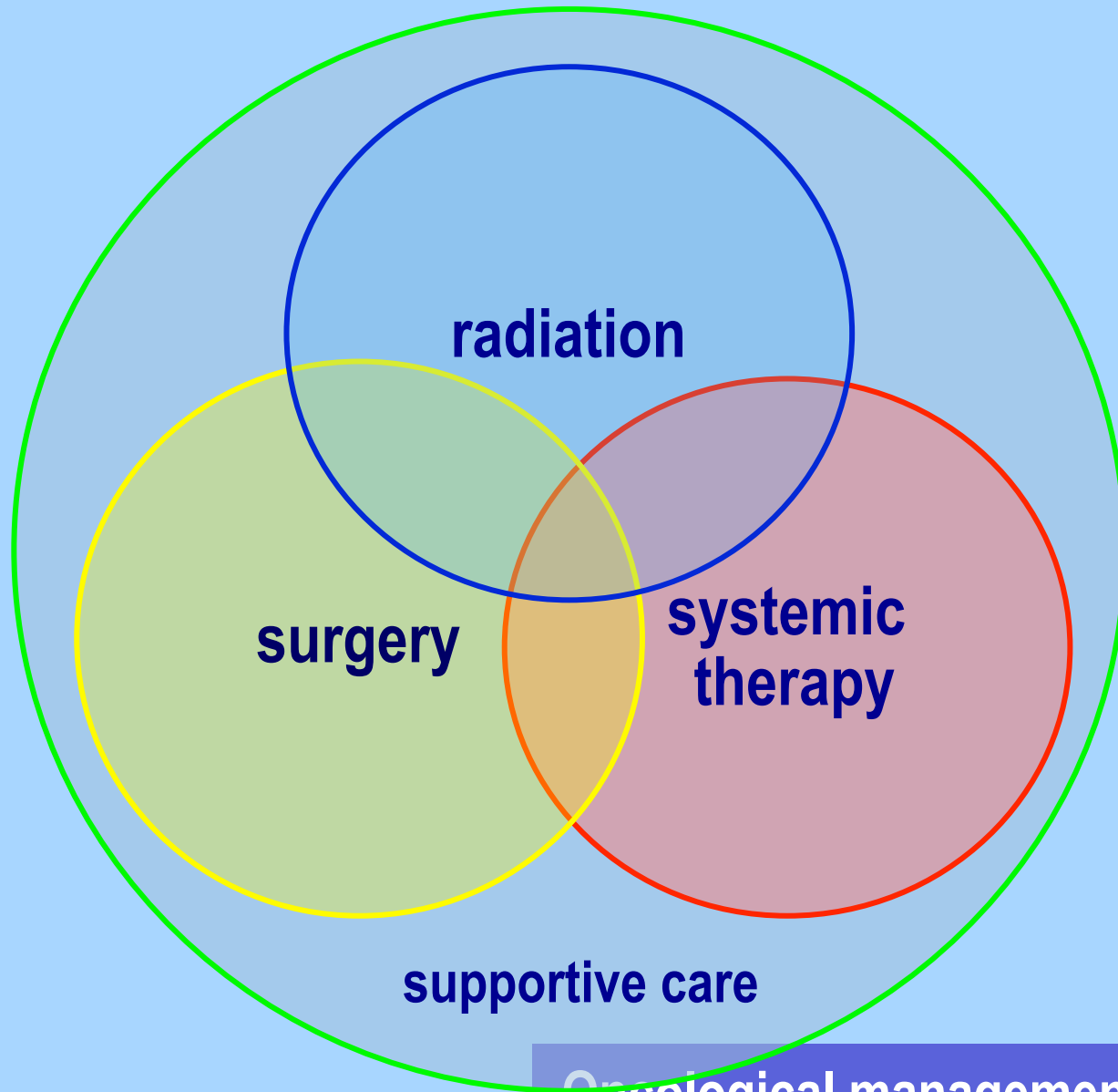
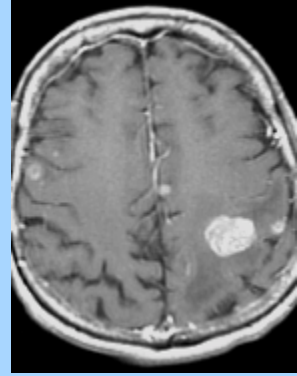


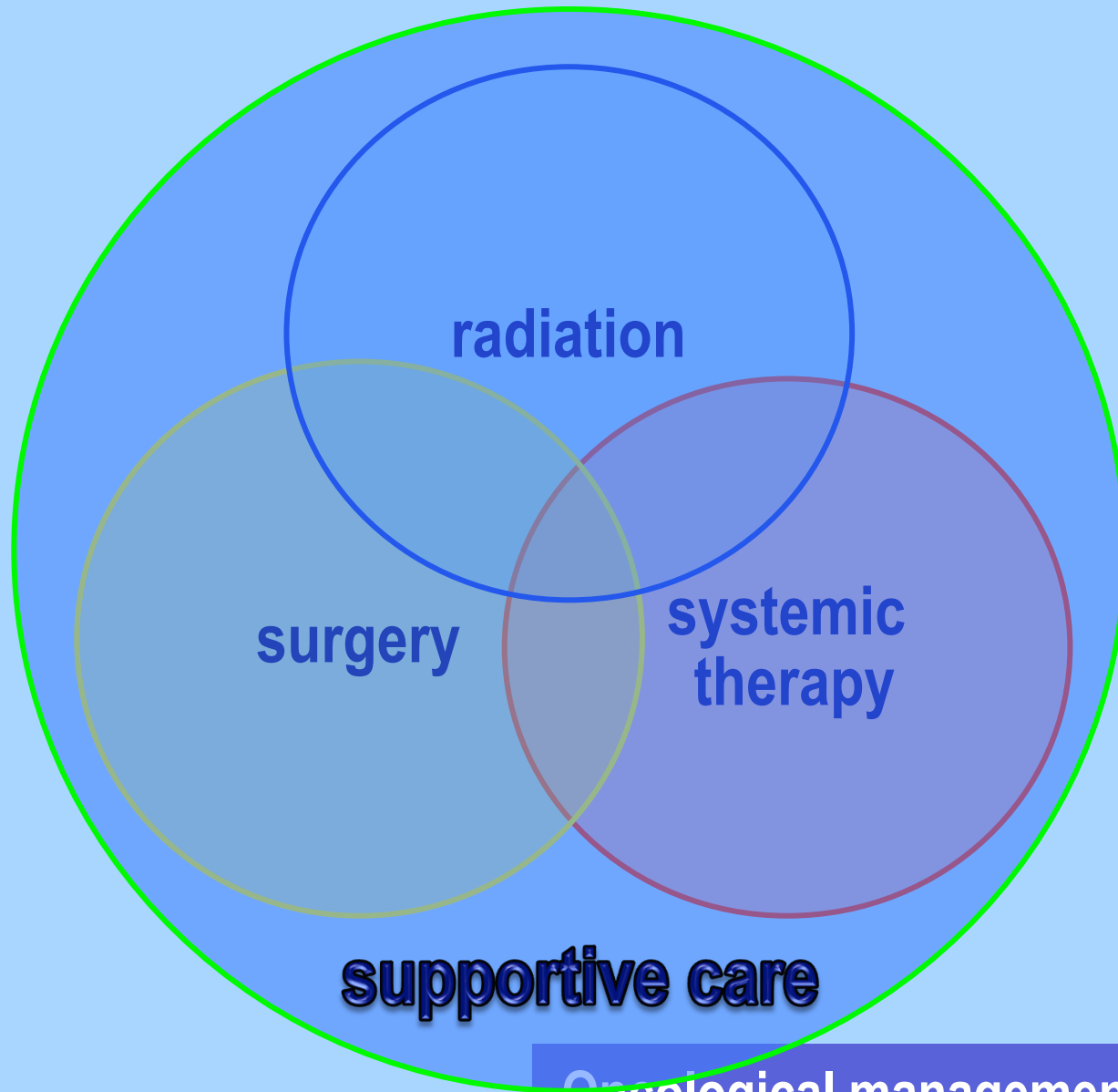
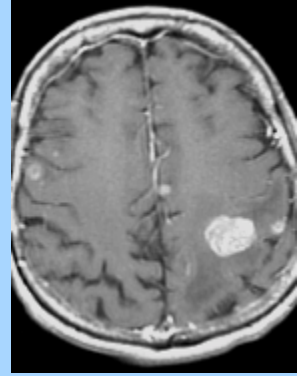


# **Radiosurgery in the management of brain metastases (1)**

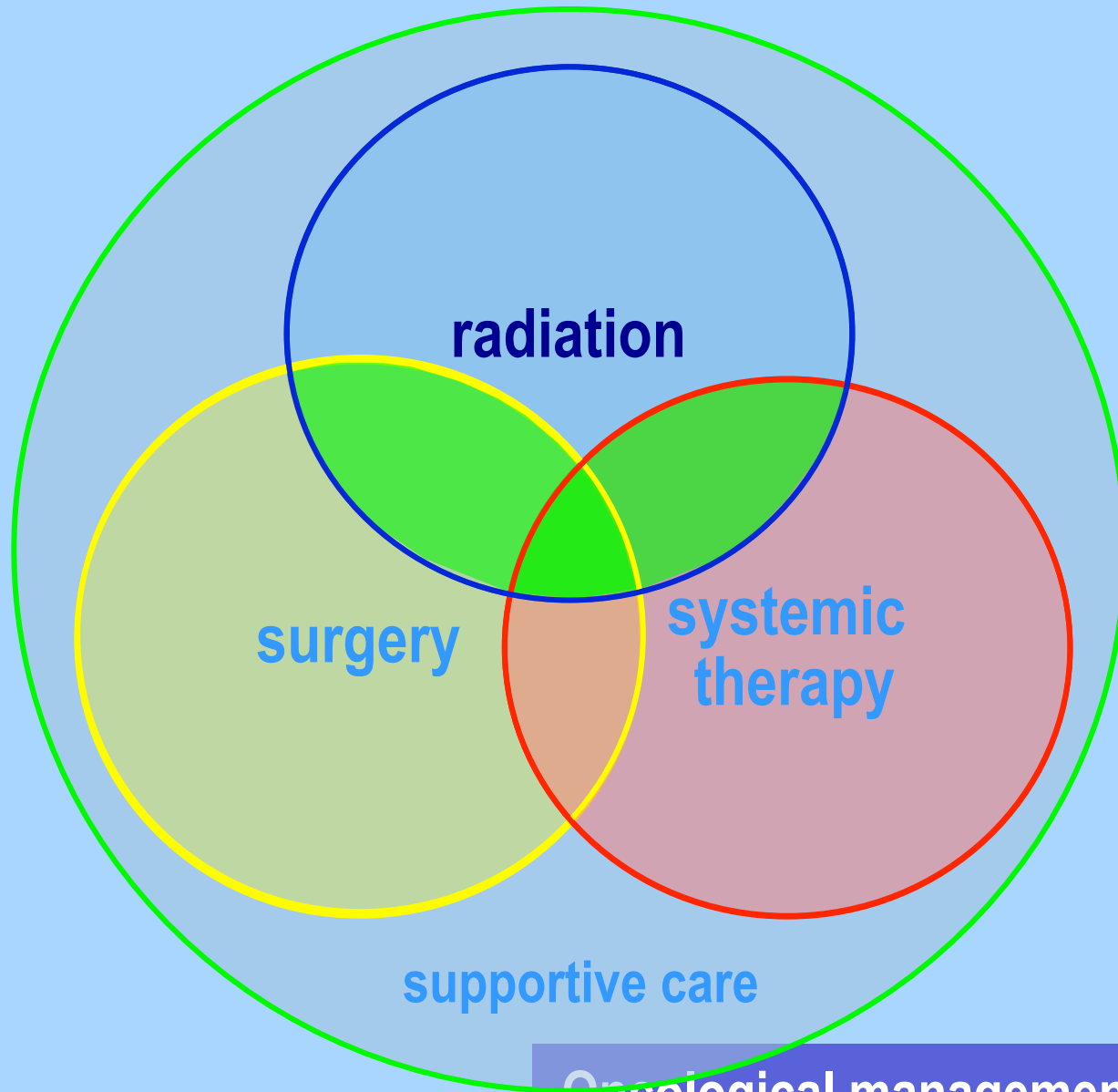
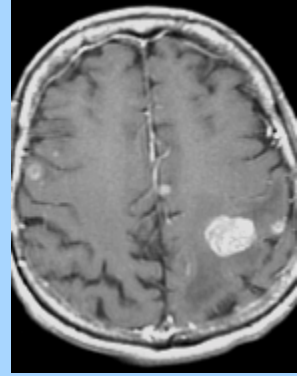
**Michael Brada**  
**IAEA NTC Bratislava**  
**21 March 2018**



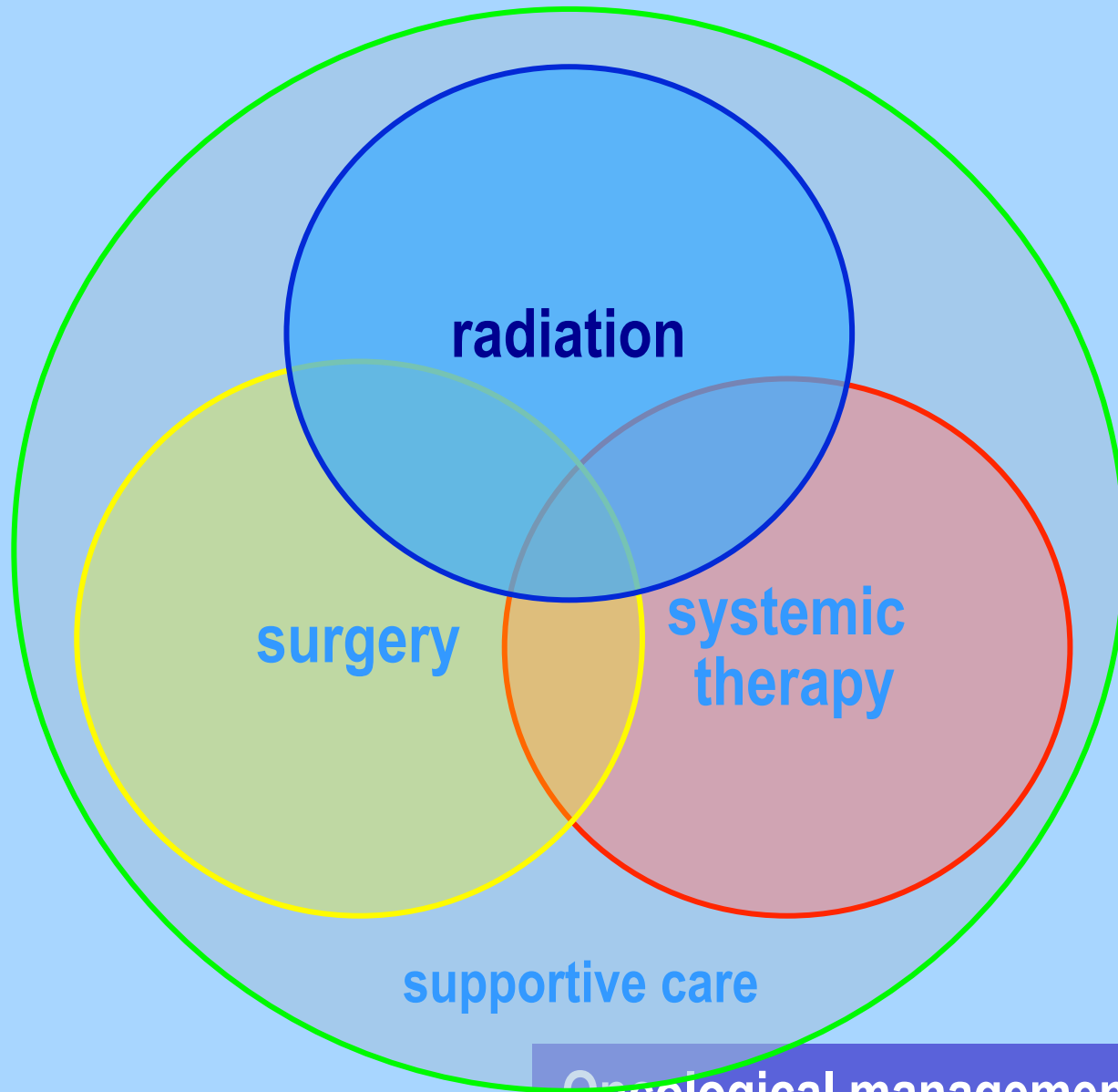
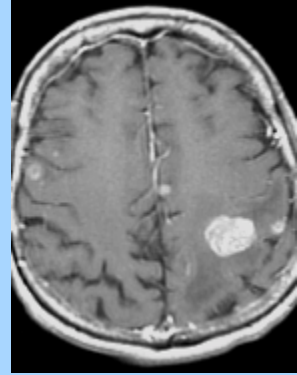
**Oncological management options**



**Oncological management options**



**Oncological management options**



**Oncological management options**

- **Radiotherapy technologies**
- **Context and endpoints**
- **Clinical issues - evidence base**

**Radiotherapy in the treatment of brain metastases**

- **Radiotherapy technologies**
- **Context and endpoints**
- **Clinical issues - evidence base**

**Radiotherapy in the treatment of brain metastases**

## **Extent of irradiation**

**whole brain radiotherapy (WBRT)**

**partial brain radiotherapy (PBRT)**

**focal radiotherapy (SRT) & radiosurgery (SRS)**

**Radiotherapy options**

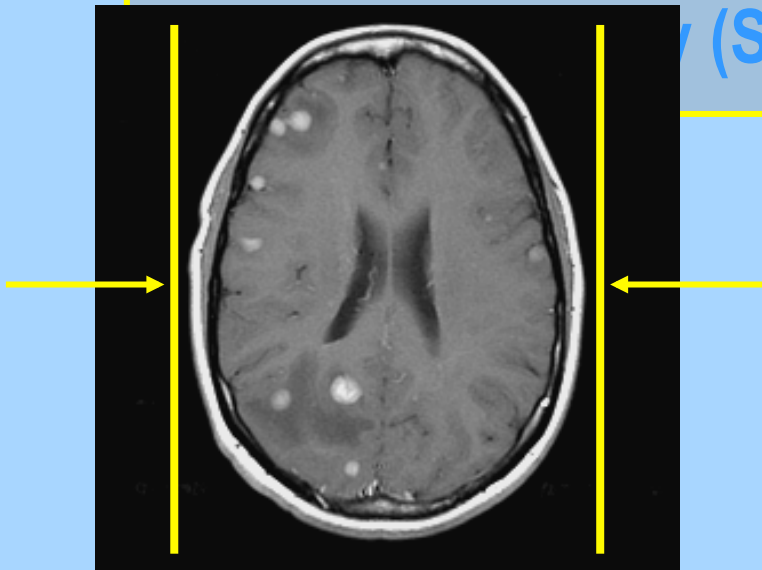


## Extent of irradiation

whole brain radiotherapy (WBRT)

partial brain radiotherapy (PBRT)

stereotactic radiotherapy (SRT) & radiosurgery (SRS)



Radiotherapy options

# Whole brain radiotherapy for multiple brain metastases

higher dose achieves  
better tumour control

30Gy in 10 fractions is  
the best regimen

more protracted  
fractionation is less toxic

causes somnolence and  
fatigue

all of these

## Extent of irradiation

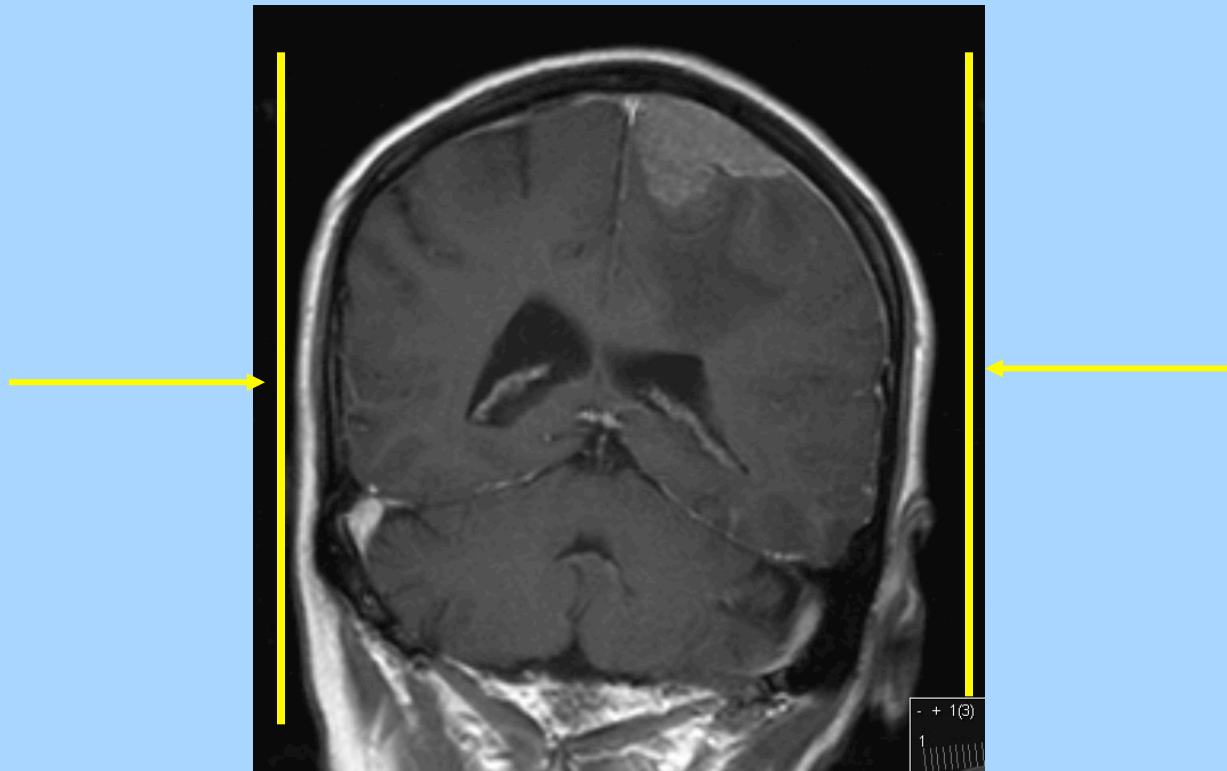
whole brain radiotherapy (WBRT)

partial brain radiotherapy (PBRT)

focal radiotherapy (SRT) & radiosurgery (SRS)

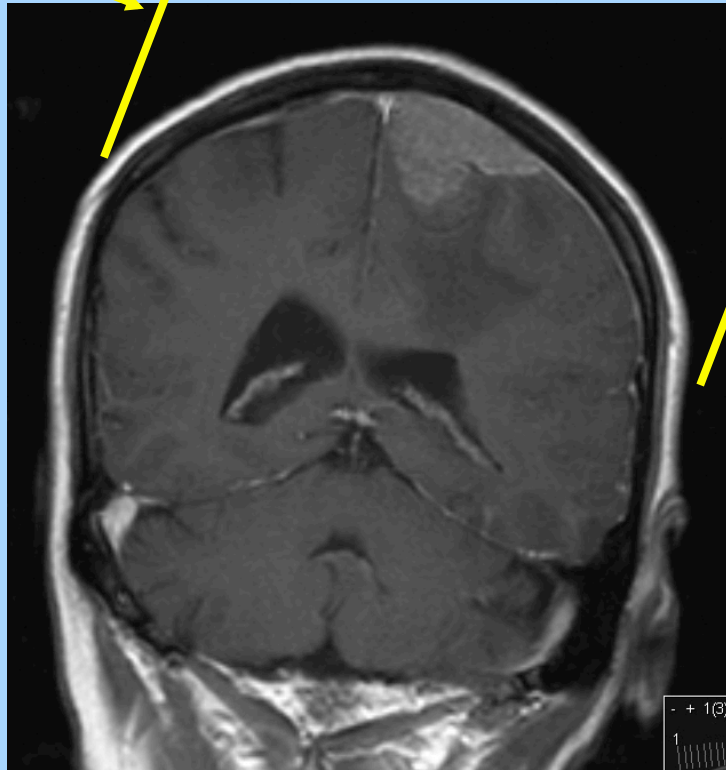
Radiotherapy options

# whole brain radiotherapy



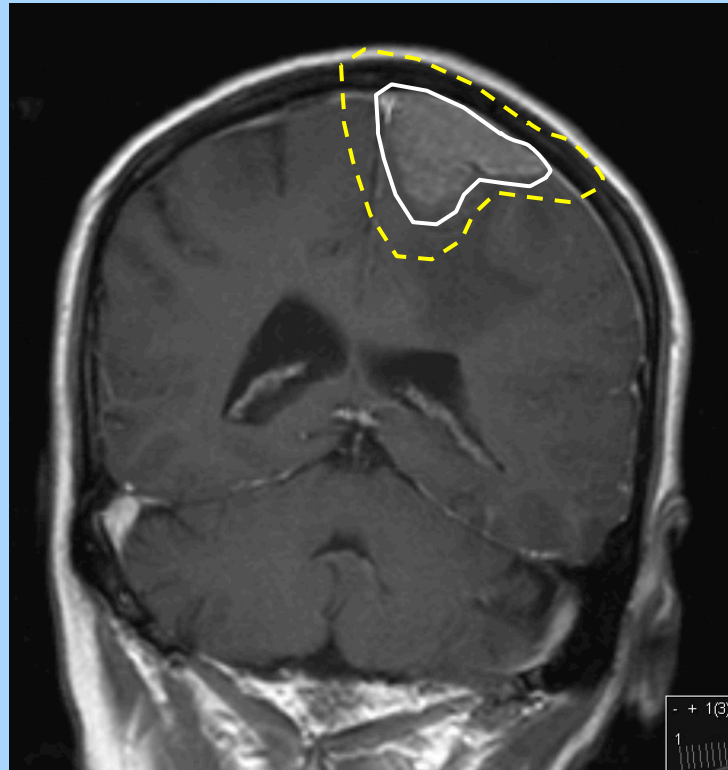
Radiotherapy options

## partial brain radiotherapy



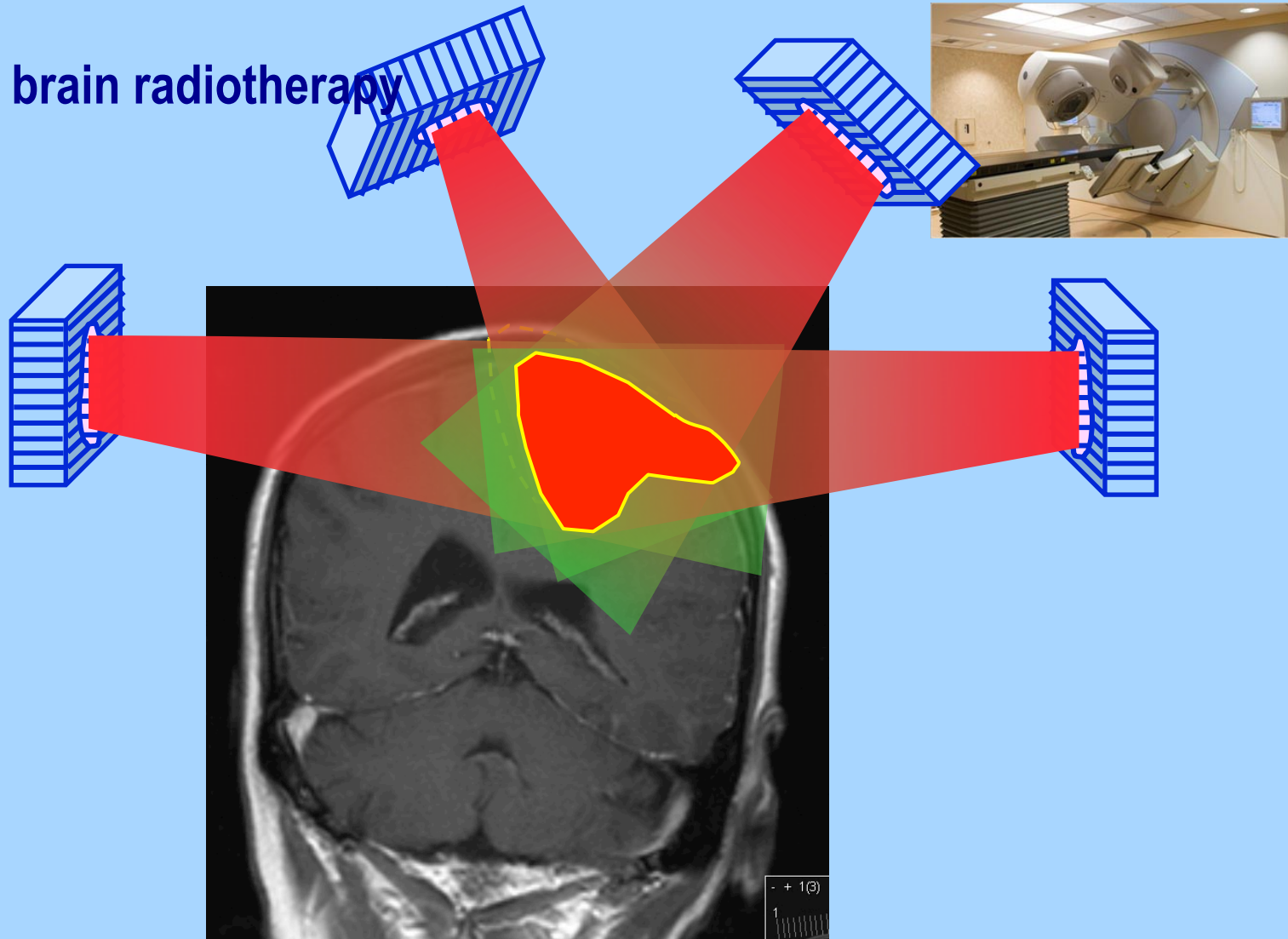
**Radiotherapy options**

## partial brain radiotherapy



**Radiotherapy options**

partial brain radiotherapy



Radiotherapy options

## Extent of irradiation

whole brain radiotherapy (WBRT)

**partial brain radiotherapy (PBRT)**

focal radiotherapy (SRT) & radiosurgery (SRS)

conformal RT  
IMRT  
tomotherapy  
VMAT/RapidArc

.....

**Radiotherapy options**



# whole brain vs partial brain radiotherapy



patients with brain metastases  
whole brain radiotherapy

Whole brain

Partial brain

Comparison of whole brain and partial brain RT

## Extent of irradiation

whole brain radiotherapy (WBRT)

partial brain radiotherapy (PBRT)

**focal radiotherapy (SRT) & radiosurgery (SRS)**

**Radiotherapy options**

## Extent of irradiation

whole brain radiotherapy (WBRT)

partial brain radiotherapy (PBRT)

focal radiotherapy (SRT) & radiosurgery (SRS)

single lesion  
multiple lesions

Radiotherapy options

# Preparation for treatment

- initial imaging
- staging
- immobilisation
- imaging for planning
- outlining
- delivery options

# Preparation for treatment

- initial imaging
- staging
- immobilisation
- imaging for planning
- outlining
- delivery options

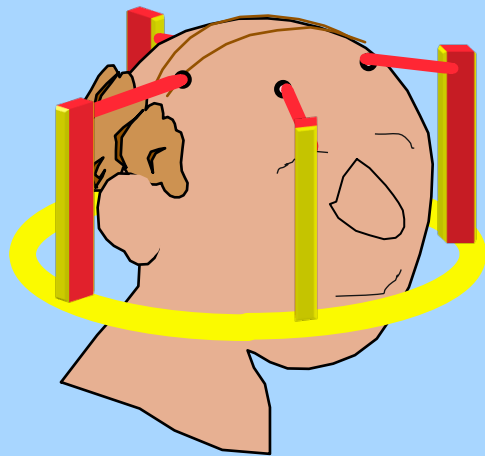
# Preparation for treatment

- initial imaging
- **staging**
- immobilisation
- imaging for planning
- outlining
- delivery options

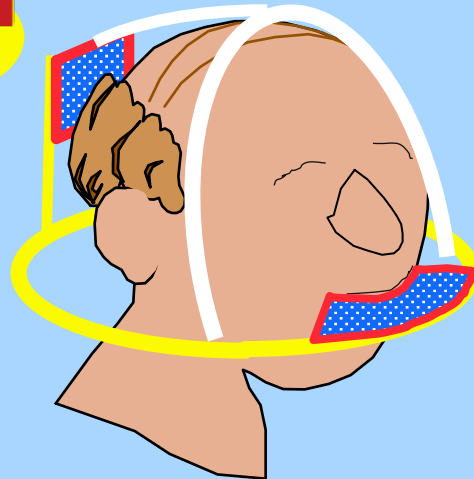
# Preparation for treatment

- initial imaging
- staging
- immobilisation
- imaging for planning
- outlining
- delivery options

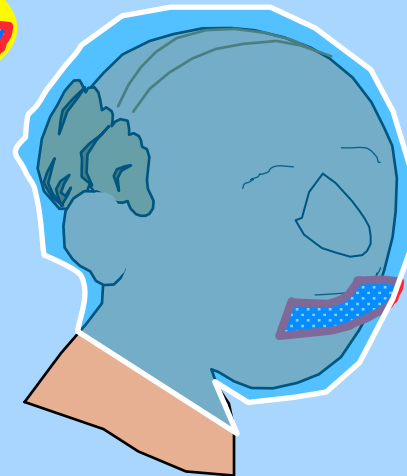
relocation accuracy



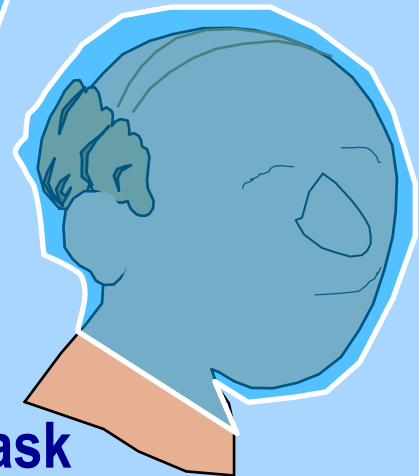
fixed frame



relocatable frame



precision mask



conventional mask

Methods of immobilisation



# Preparation for treatment

- initial imaging
- staging
- immobilisation
- **imaging for planning**
- delivery options

# Preparation for treatment

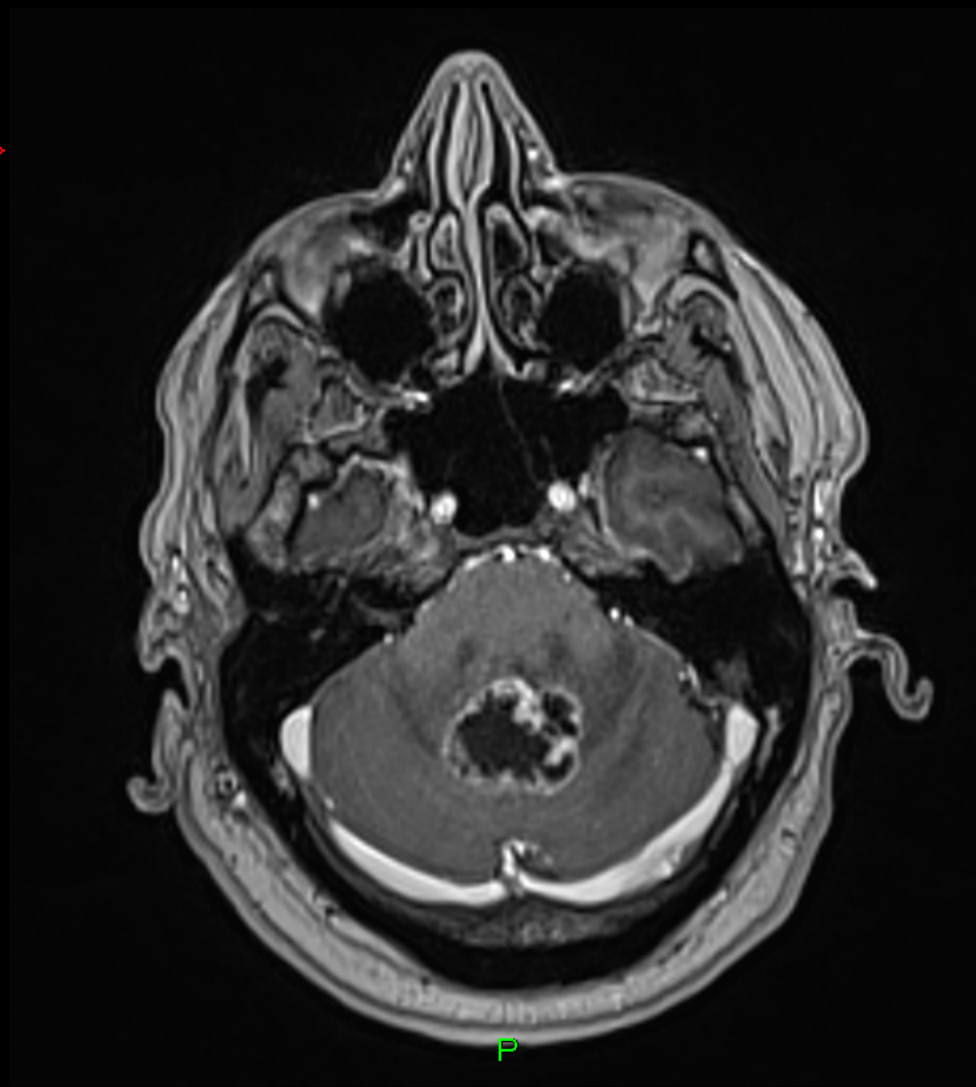
- initial imaging
- staging
- immobilisation
- imaging for planning - fusion
- delivery options

# Preparation for treatment

- initial imaging
- staging
- immobilisation
- imaging for planning
- **outlining**
- delivery options

< 7 - 49 >

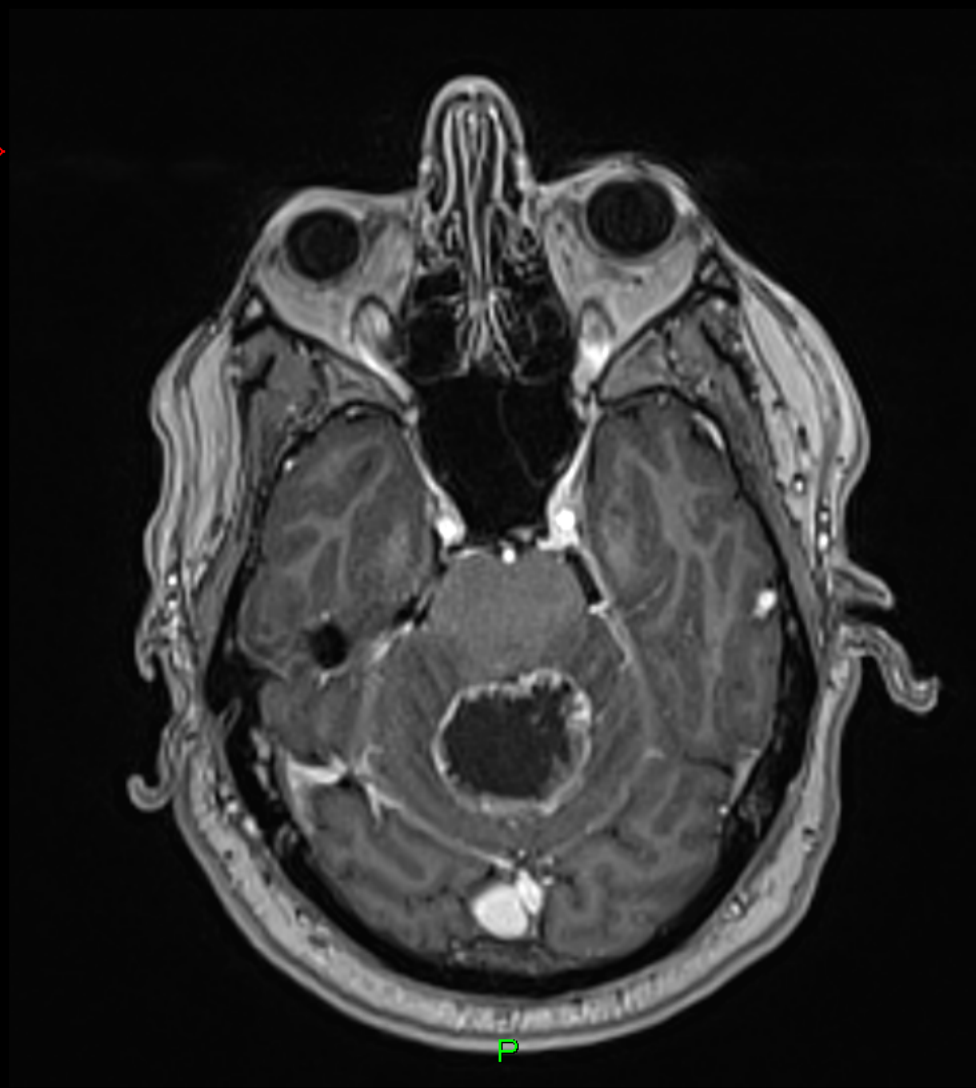
R



P

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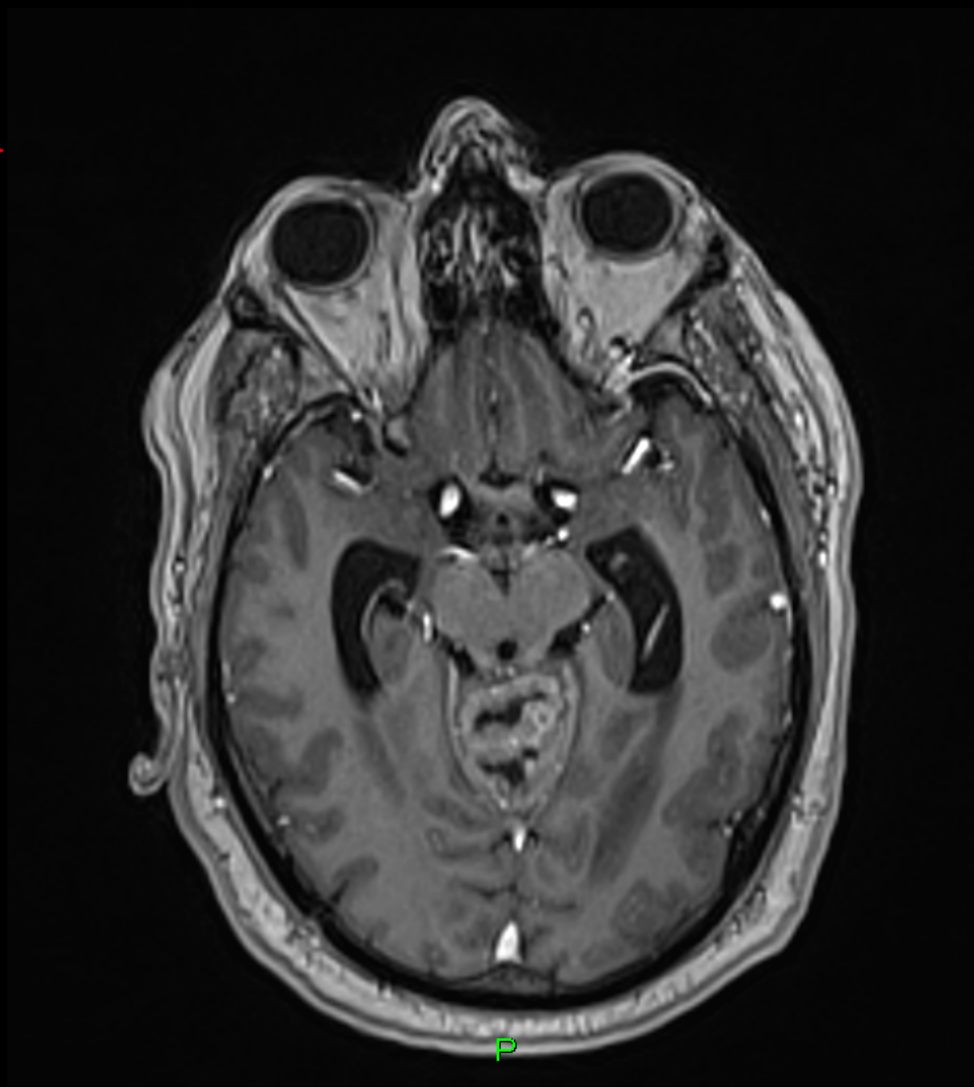
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P

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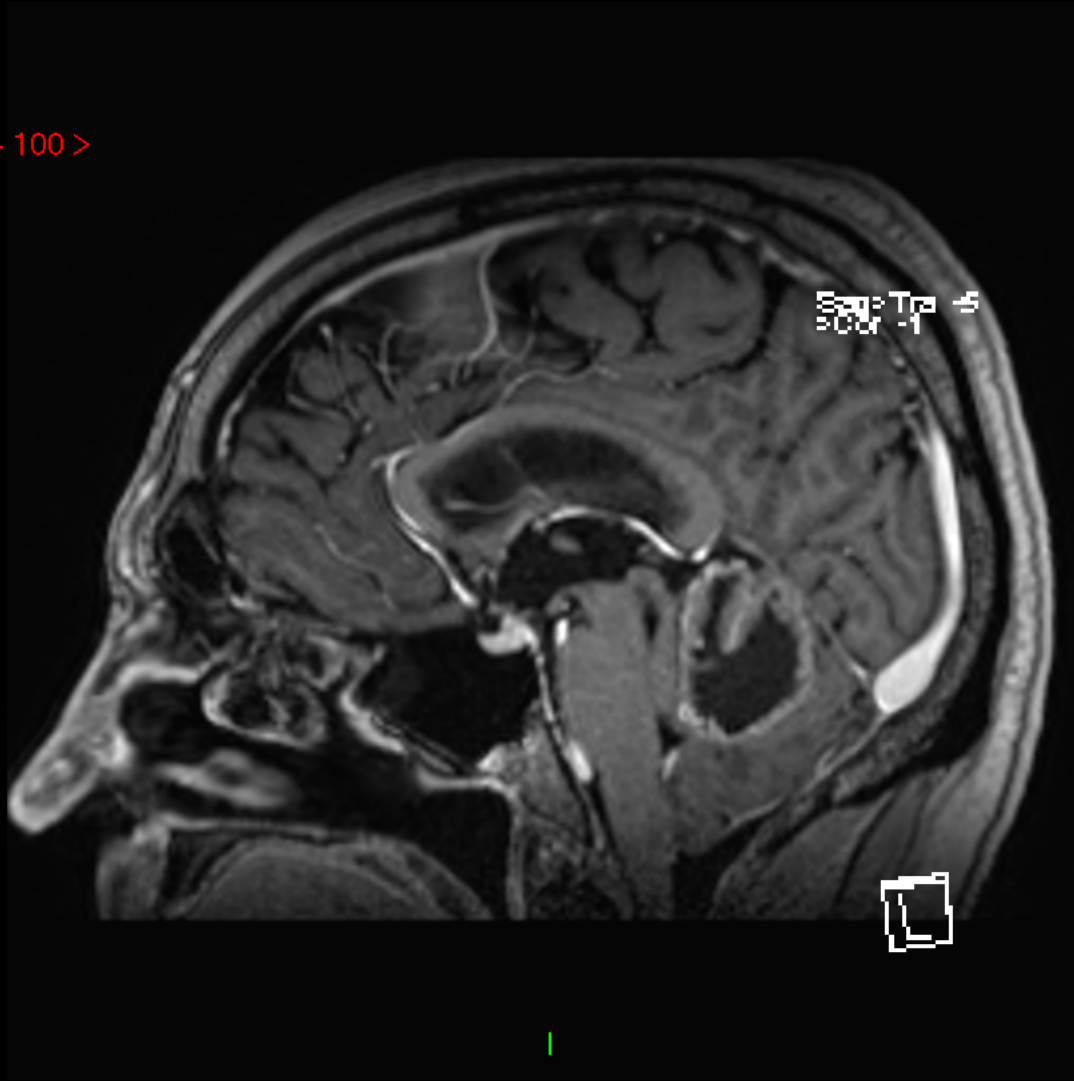
R



P

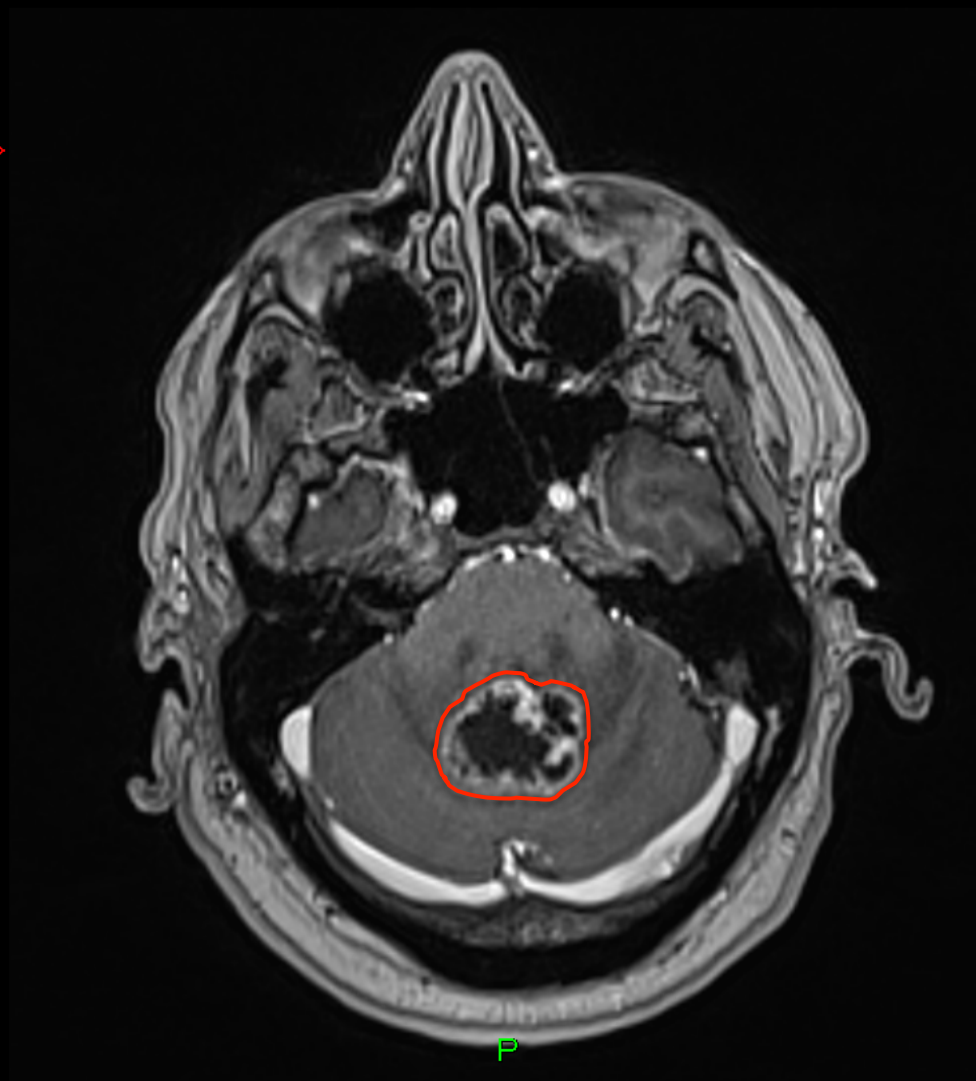
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A



< 7 - 49 >

R



P

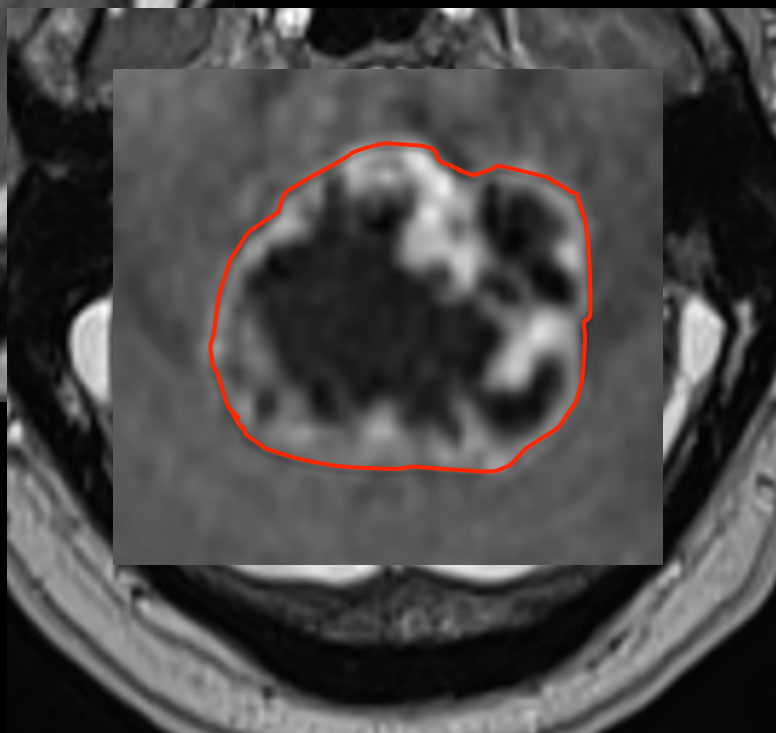
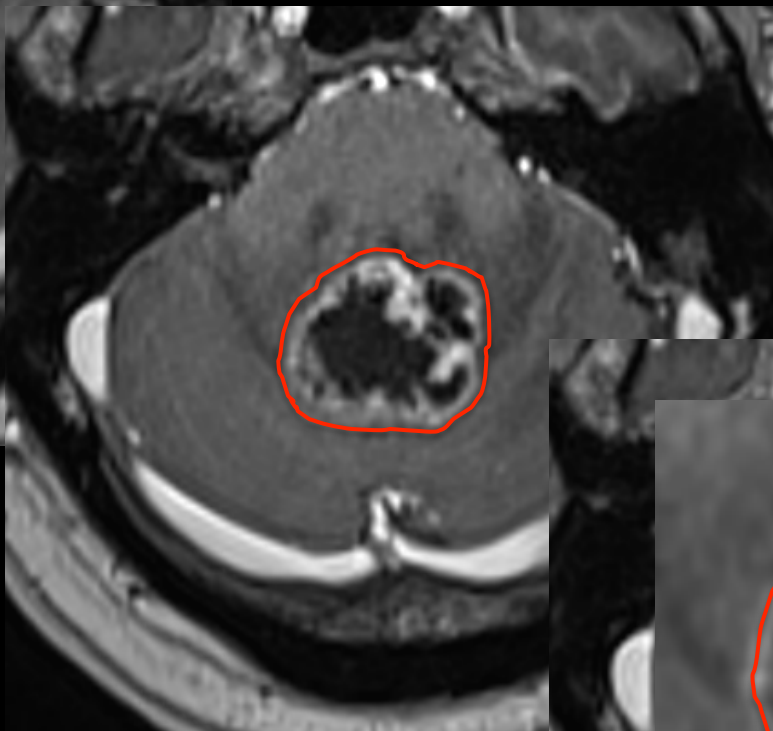
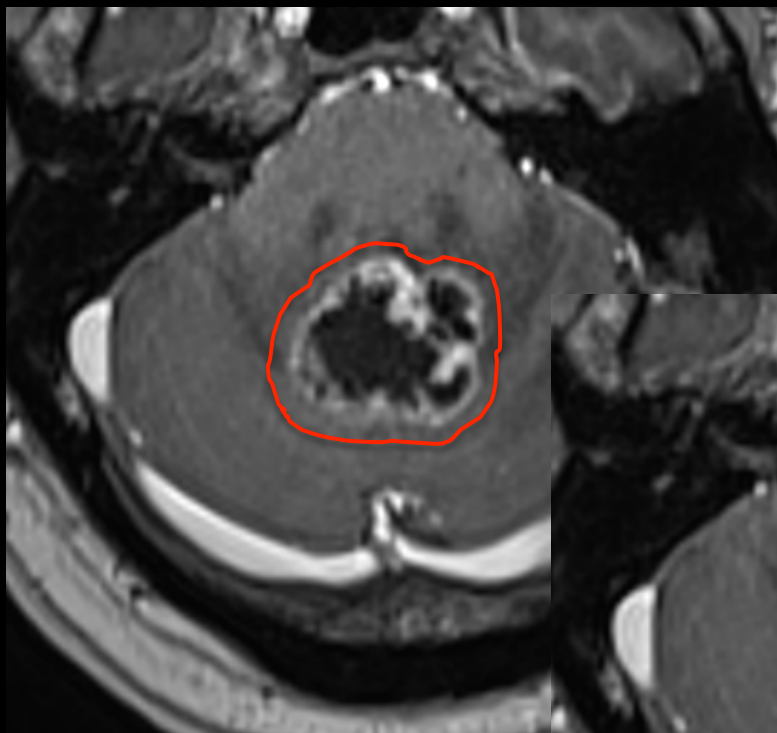


## critical normal structures (OAR)

< 10 - 100 >

A





# Preparation for treatment

- initial imaging
- staging
- immobilisation
- imaging for planning
- outlining
- **delivery options**

## *Delivery equipment*

**Extent of irradiation**

whole brain radiotherapy

partial brain radiotherapy (PBRT)

focal radiotherapy (SRT) & radiosurgery (SRS)

single lesion  
multiple lesions

**linac** - conventional/adapted

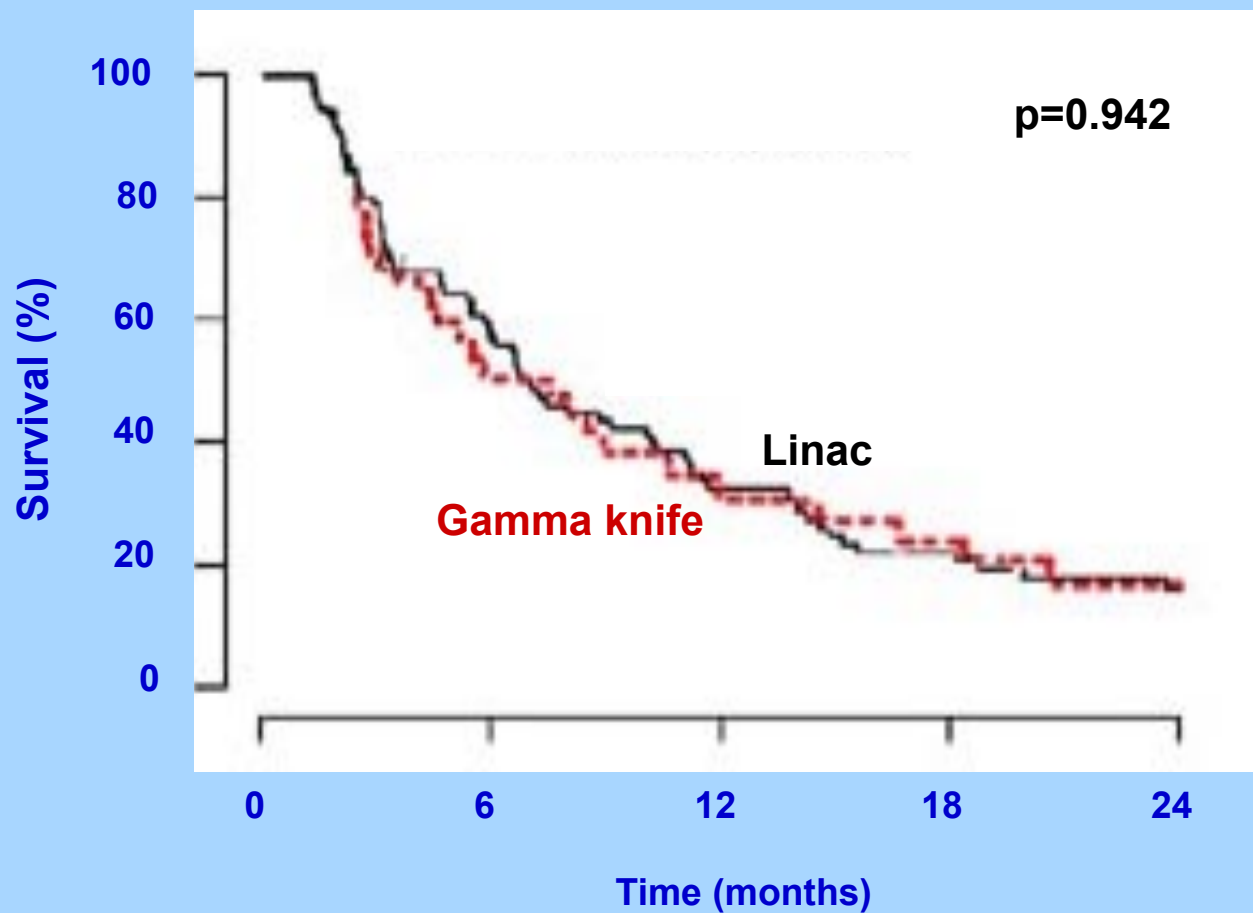
**small linac on robotic arm** (Cyberknife)

**helical rotating linac** (Tomotherapy)

**multiheaded Cobalt unit** (Gamma Knife)

**Radiotherapy options**

## survival – by treatment unit



**Radiosurgery for solitary brain metastases**



## *Delivery techniques*

**Extent of irradiation**

**whole brain**

**partial brain radiotherapy (PBRT)**

**focal radiotherapy (SRT) & radiosurgery (SRS)**

**single lesion  
multiple lesions**

**multiple conformal fixed fields  
single or multiple/dynamic arcs +/- IMRT  
single or multiple isocentres  
multiple sources & isocentres (GK)  
multiple small beams & isocentres (CK)**

**Radiotherapy options**

## *Delivery techniques*

**Extent of irradiation**

whole brain

partial brain radiotherapy (PBRT)

focal radiotherapy (SRT) & radiosurgery (SRS)

single lesion

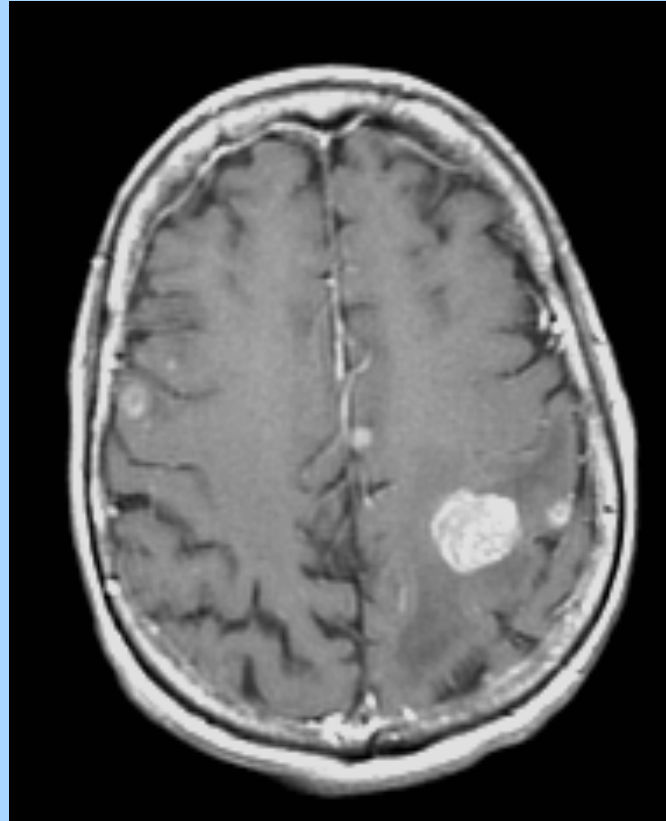
multiple lesions

multiple conformal fixed fields  
single or multiple/dynamic arcs +/- IMRT  
**single or multiple isocentres**  
multiple sources & isocentres (GK)  
multiple small beams & isocentres (CK)

Radiotherapy options

**whole brain RT**

**focal RT**



**Delivery techniques for multiple lesions**



# Techniques of RT for multiple lesions - focal vs whole brain



single isocentre dynamic conformal arc (SIDCA)  
multiple isocentre dynamic conformal arc (MIDCA)  
VMAT



*whole brain radiotherapy*



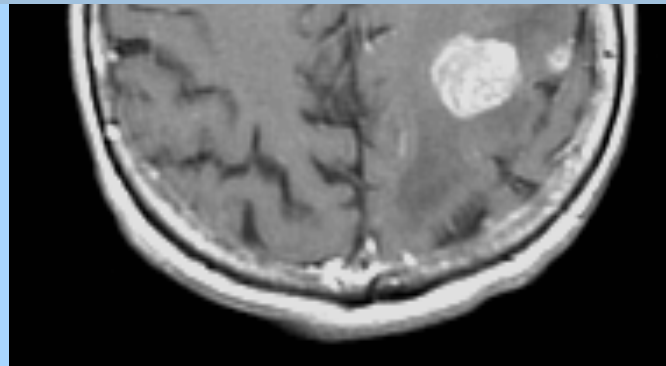
**Comparison of delivery techniques for multiple lesions**

# Techniques of RT for multiple lesions

## comparison of focal techniques



single isocentre dynamic conformal arc (SIDCA)  
multiple isocentre dynamic conformal arc (MIDCA)  
VMAT



**Comparison of delivery techniques for multiple lesions**

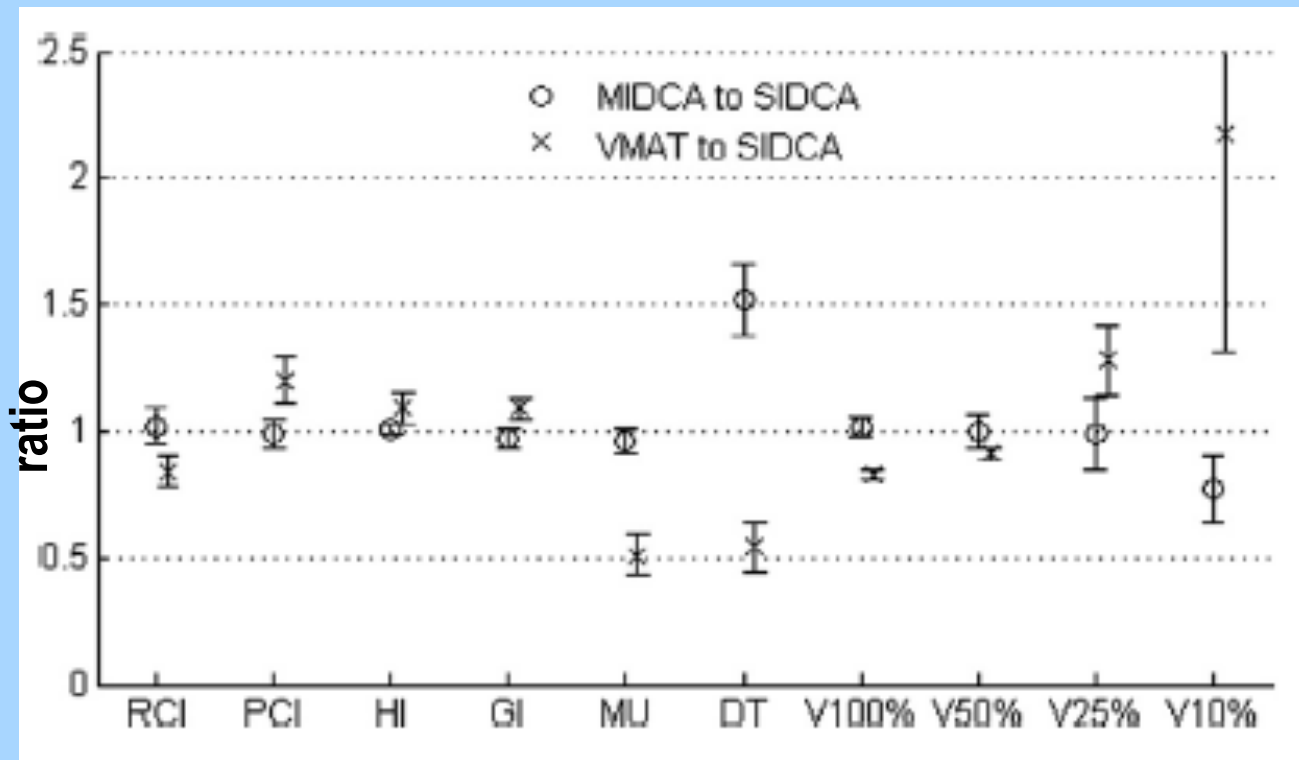
<i>Metric</i>		<i>calculation</i>
<b>conformity index</b> (RTOG)	<b>rCI</b>	$V_{Rx} / V_{PTV}$
<b>conformity index</b> (Paddick)	<b>target delivery</b>	
<b>homogeneity index</b>	<b>HI</b>	$D_{max} / D_{Rx}$
<b>gradient index</b>	<b>normal tissue avoidance</b> noncritical adjacent normal tissue	

- $V_{Rx}$  - volume covered by prescription isodose  
 $V_{PTV}$  - PTV volume  
 $V_{PTV,Rx}$  - overlapping volume  
 $D_{max}$  - maximum dose at the PTV  
 $D_{Rx}$  - prescription dose in the PTV

**Metrics for high precision RT**

# Techniques of RT for multiple lesions

## comparison of focal techniques



- RCI - RTOG conformity index
- PCI - Paddick conformity index
- HI - homogeneity index
- GI - gradient index
- DT - delivery time

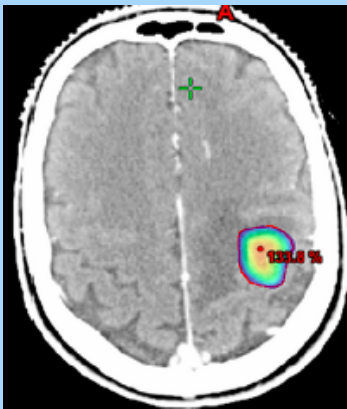
comparison of delivery techniques for multiple lesions

# Preparation for treatment

- initial imaging
- staging
- immobilisation
- imaging for planning
- outlining
- **delivery options - dose fractionation**

## *parameters*

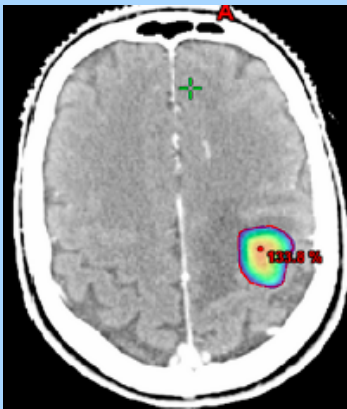
prescription isodose	50%	80-90%	100%
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**SRS dose fractionation for brain metastases**

## *parameters*

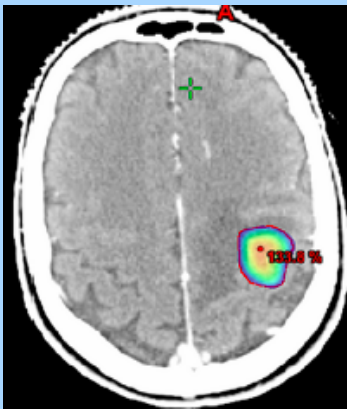
prescription isodose	50%	80-90%	100%
volume/dose limit	PTV volume	$V_{12\text{Gy}}$	diameter



**SRS dose fractionation for brain metastases**

## *parameters*

prescription isodose	50%	80-90%	100%
volume/dose limit	PTV volume	$V_{12\text{Gy}}$	diameter
dose	18Gy	20Gy	22Gy

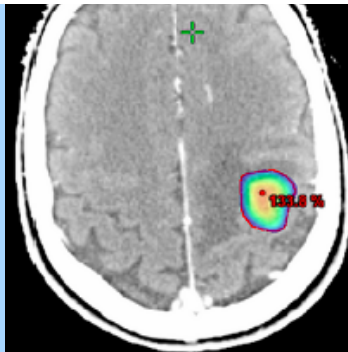


**SRS dose fractionation for brain metastases**



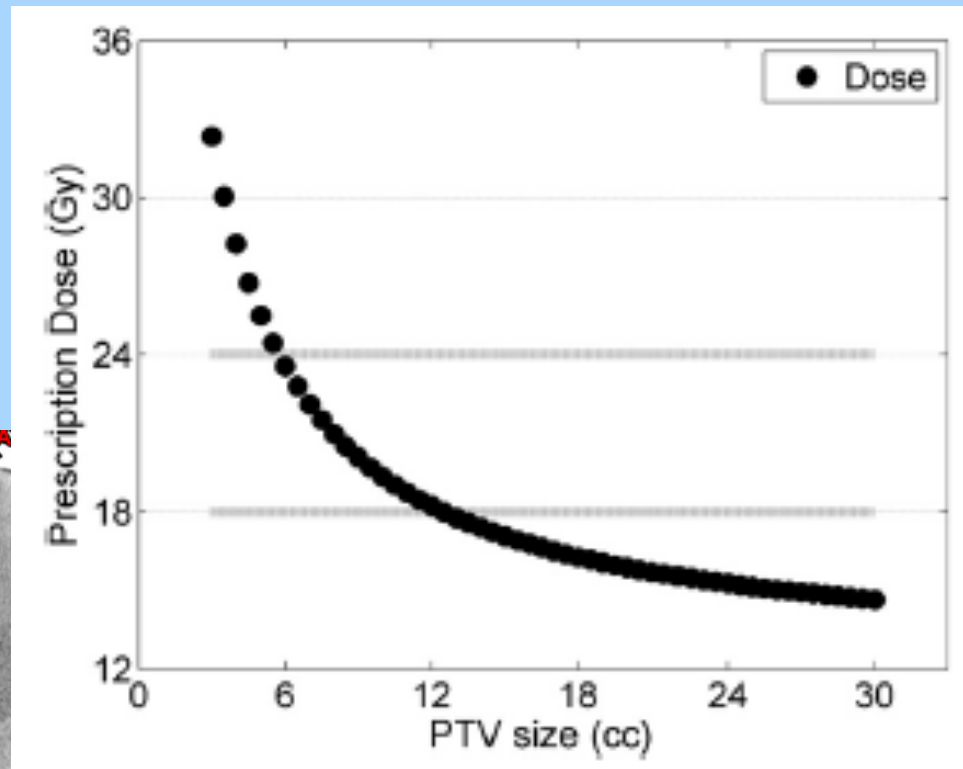
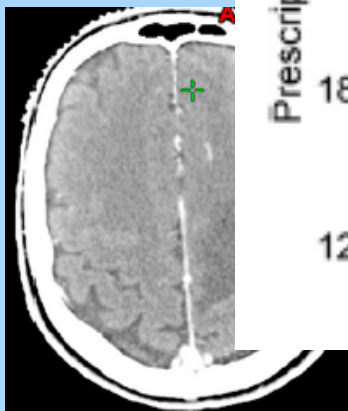
## Suggested doses in a study

PTV of the largest brain metastasis	Doses in each PTV	BM in brainstem (GTV = PTV)
$<1 \text{ cm}^3$	$1 \times 24 \text{ Gy}$	$1 \times 16 \text{ Gy}$
$1\text{--}10 \text{ cm}^3$	$1 \times 21 \text{ Gy}$	$1 \times 16 \text{ Gy}$
$10\text{--}20 \text{ cm}^3$	$1 \times 18 \text{ Gy}$	$1 \times 16 \text{ Gy}$
$20\text{--}65 \text{ cm}^3$	$1 \times 15 \text{ Gy}$	No SRS



**SRS dose fractionation for brain metastases**

# Potential calculated isotoxic doses



**SRS dose fractionation for brain metastases**

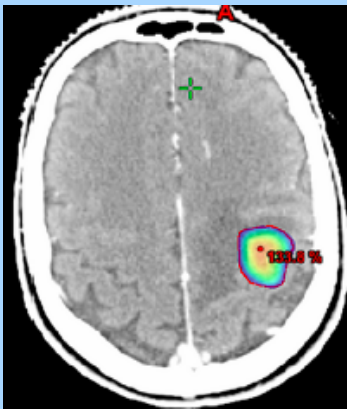
# OAR dose constraints for single fraction SRS

## OAR

brainstem  $\leq 16$  Gy ?

optic apparatus  $< 6 - 8$  Gy

.....



**SRS dose fractionation for brain metastases**

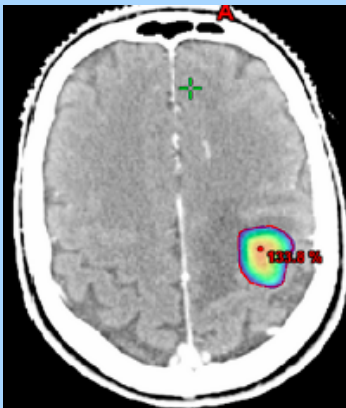
# OAR dose constraints for single fraction SRS

## OAR

brainstem  $\leq 16$  Gy ?

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.....



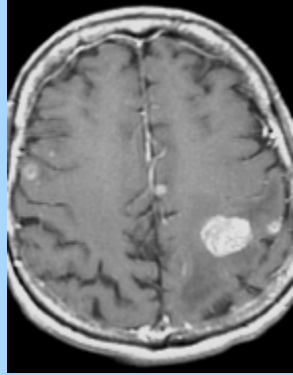
if dose constraint not met (or lesion too large)  
personal policy: fSRT 30 - 35 Gy in 5 fractions

**SRS dose fractionation for brain metastases**

- Radiotherapy technologies
- **Context and endpoints**
- Clinical issues - evidence base

**Radiotherapy in the treatment of brain metastases**

## Context



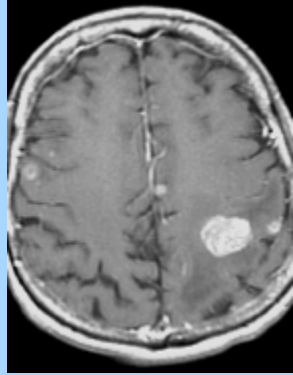
prognosis

primary tumour type

timing in the course of disease

**Oncological management options**

## Context



prognosis

primary tumour type

timing in the course of disease

**Oncological management options**

# Prognosis in patients with brain metastases

overall median survival is 6 months

age is an independent prognostic factor for survival

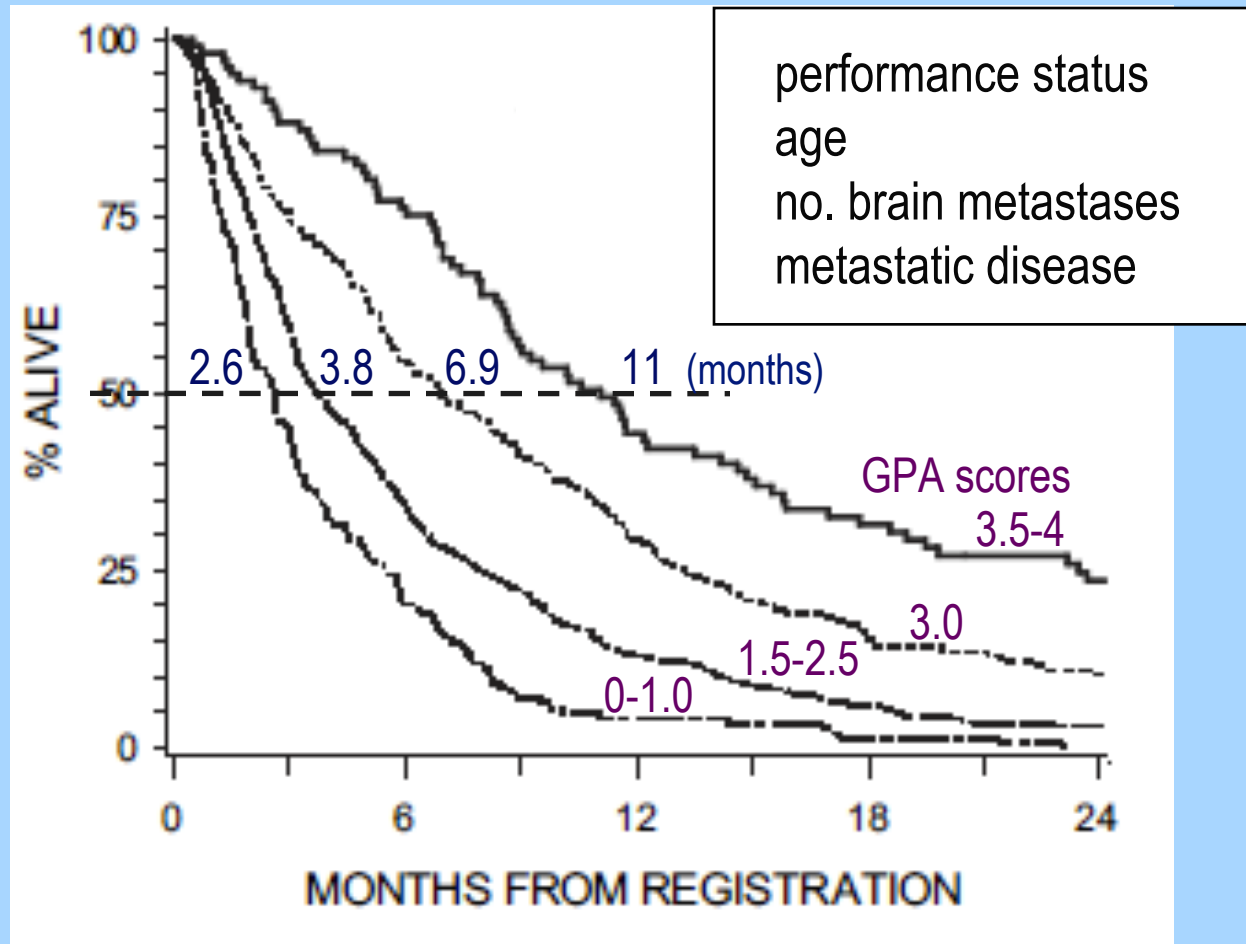
performance status is an independent factor for survival

the prognosis of patients with breast cancer and lung cancer with the worst GPA score (0-1) is very similar

the prognosis of patients with breast cancer and lung cancer with the best GPA score (3.5-4) is very similar

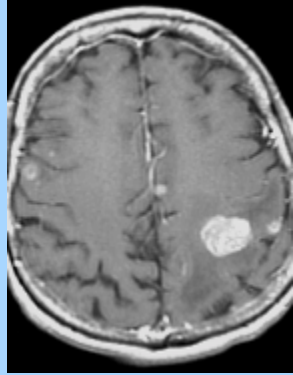


## Graded prognostic assessment (GPA)



**Prognosis in patients with brain metastases**

## Context



prognosis

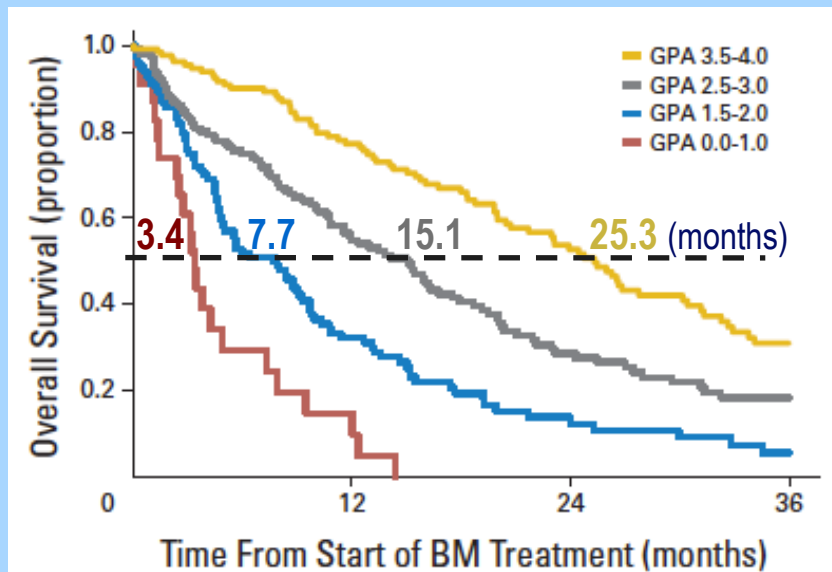
primary tumour type

timing in the course of disease

**Oncological management options**

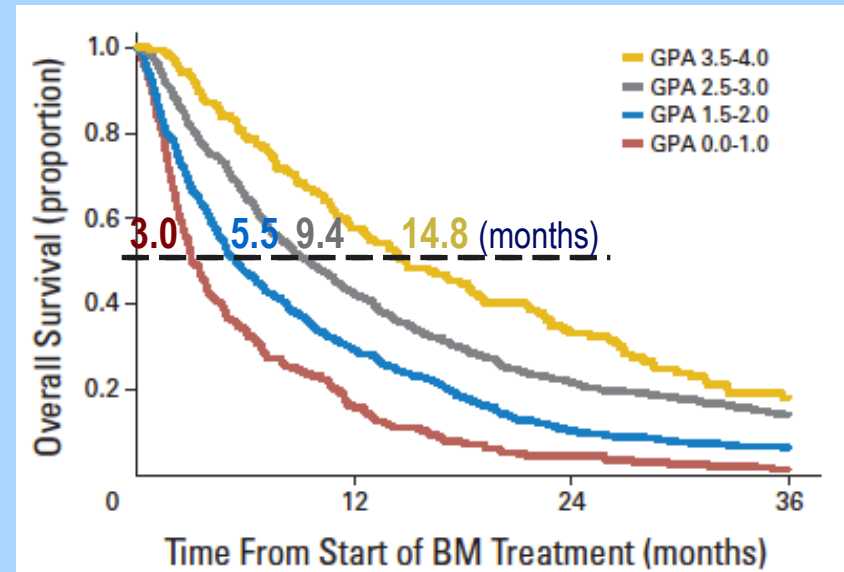
# Graded prognostic assessment (GPA)

## Breast



performance status  
age  
tumour subtype

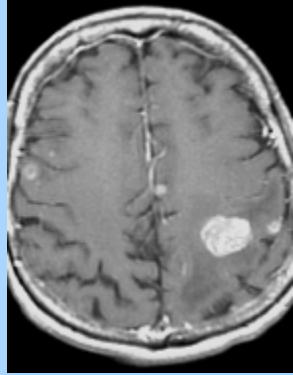
## NSCLC



performance status  
age  
no. brain mets  
metastatic disease

**Prognosis in patients with brain metastases**

## Context



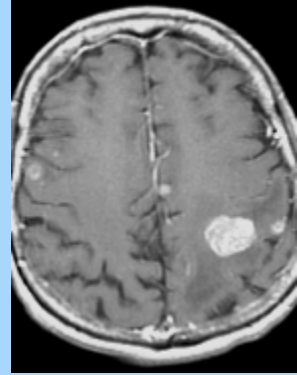
prognosis

primary tumour type

timing in the course of disease

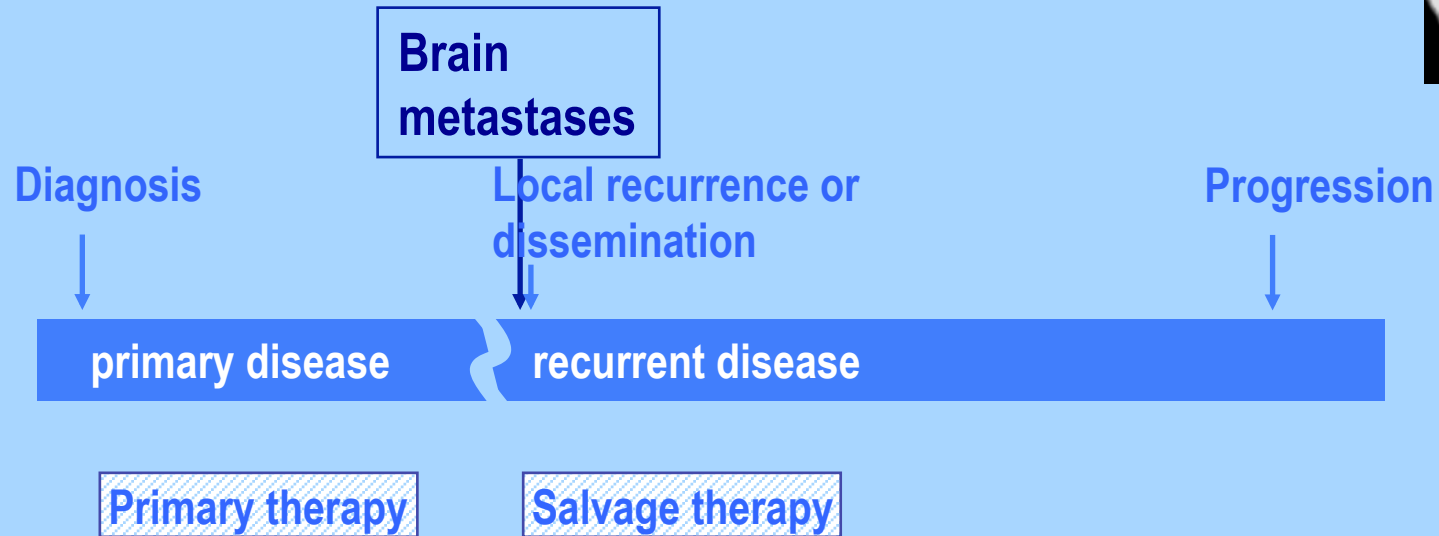
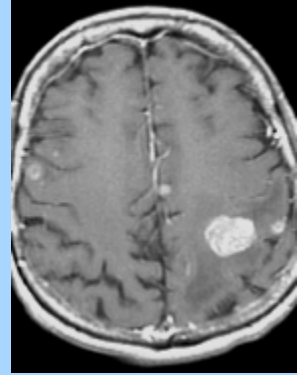
**Oncological management options**

# Course of malignant disease



**Brain metastases in malignancy**

# Course of malignant disease



**Brain metastases in malignancy**

# Course of malignant disease



**Brain metastases in malignancy**



# **Radiosurgery in the management of brain metastases (1)**

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& Department of Radiation Oncology

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