Foetal dose during radiotherapy treatment

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Introduction

- In USA: 4’000 cases per year
- In CHUV: ~ 1 case per year
- Documentation
  - Publications (van der Giessen)
  - Software (van der Giessen)
  - AAPM report 50

Introduction

	Preimplantation	Organogenesis	Early fetal	Mid-fetal	Late fetal
Postconception time, days	0 to 8	9 to 50	51 to 105	106 to 175	>175
Postconception time. weeks	1	2 to 7	8 to 15	16 to 25	>25
Effects					
Lethality	+ + +	+	+	-	-
Gross malformations	-	+ + +	+	+	-
Growth retardation	-	+ + +	+ +	+	+
Mental retardation	-	-	+ + +	+	-
Sterility	-	+	+ +	+	+
Cataracts	-	+	+	+	+
Other neuropathology	-	+ + +	+	+	+
Malignant disease	-	+	+	+	+

- No observed effect.
+ Demonstrated effect.
++ Readily apparent effect.
+++ Occurs in high incidence.

AAPM report 50

General recommendations

- Minimize field size
  - Problem of curative treatment
  - PTV is PTV !
- Do not use blocks
  - Problem of OAR
- Do not use wedges
  - Problem of dose homogeneity in PTV
- Patient shielding
  - Straightforward

Clinical data

- 24 year old patient
- Pregnancy: 17 weeks
- Grade 2 schwannoma H&N region
- Delivered dose: 60 Gy in 30 x 2 Gy

Physical data

- Localisation: C2, C3, C4
- Siemens Primus
- 6 MV energy
- Treatment plan
  - 2 AP-PA beams
  - 2 oblique beams
  - Dynamic wedge and MLC
- Field size: 15 x 15 cm^2
- Field to foetus distance : ~ 50 cm

What to do ?

- Use AAPM 50 report
- Phantom dosimetry
- In-vivo dosimetry
- Evaluate dose from radiographic exams

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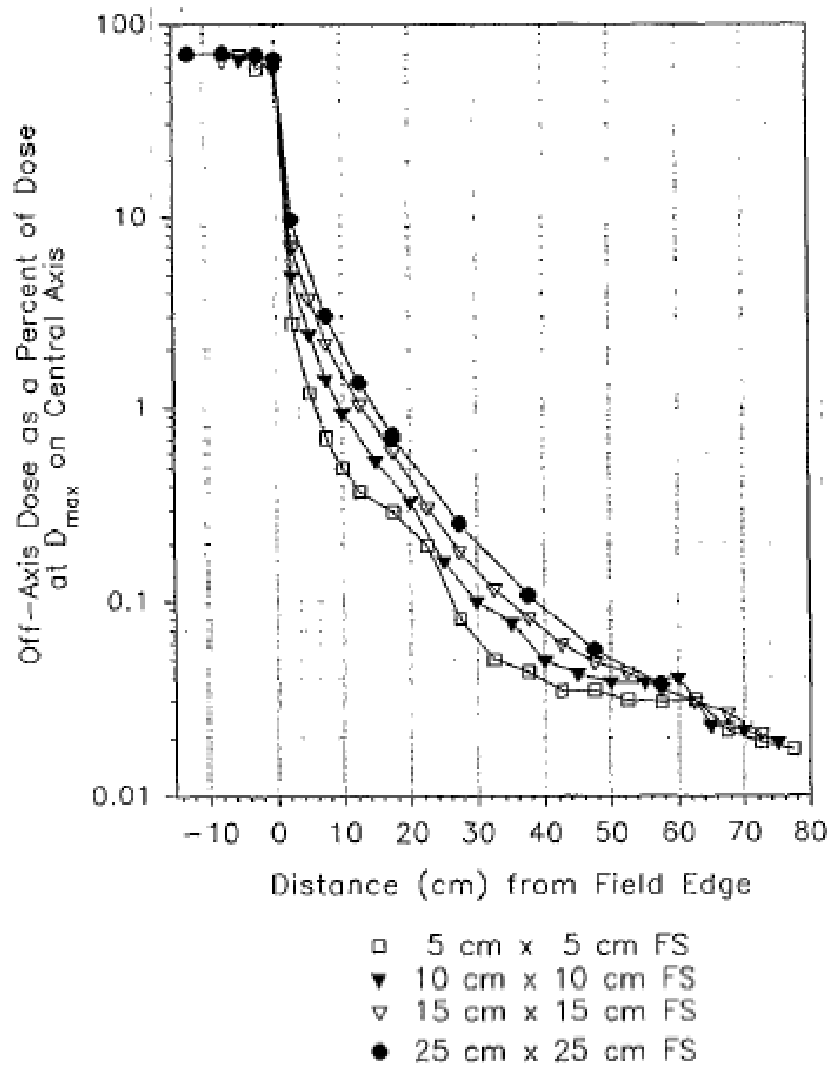
Use AAPM 50 report



- Shows graphs representing the dose versus distance, field size and energy
  - No shielding (factor 2)
  - No blocks, no wedges (factor 2 to 4)
- In our case
  - 0.04 % of the prescribed dose = 24 mGy
- With shielding: 12 mGy

Phantom dosimetry

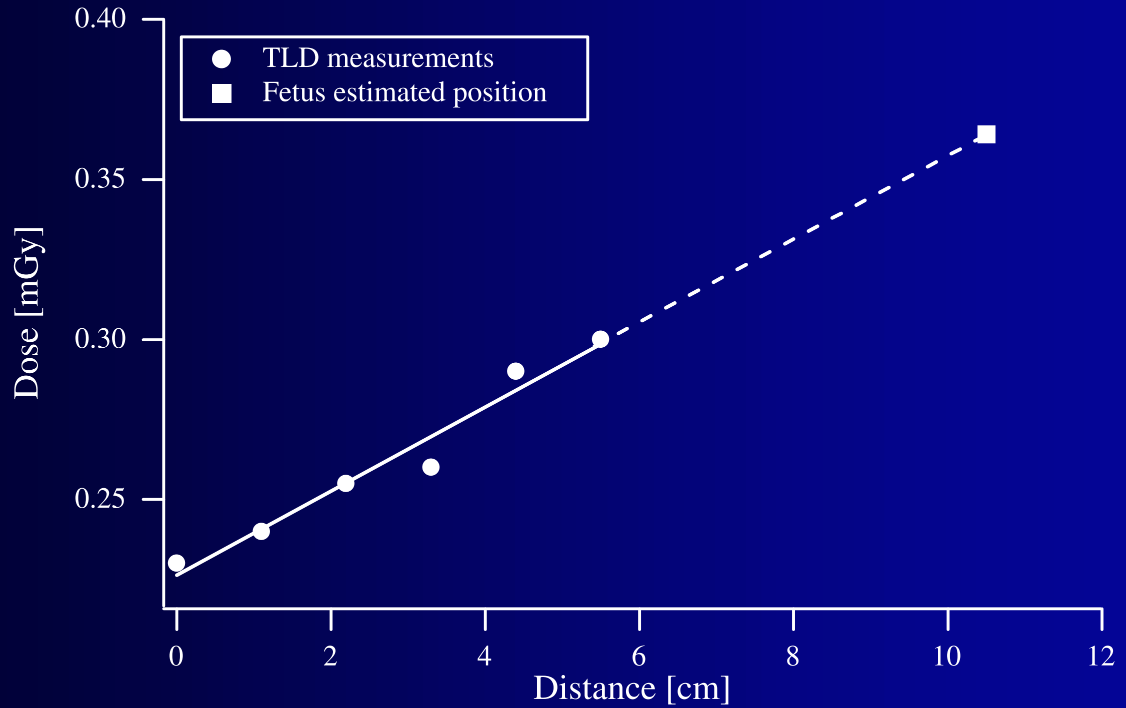
- Alderson phantom
- 0.6 cc ionisation chamber
- Each beam is measured and weighted
- No shielding
- Dose: 1.6 mGy / 500 MU ➜ D = 22 mGy
- With shielding (according to AAPM):
  D = 11 mGy

In-vivo dosimetry

- Skin dose
  - 3 series of 3 TLD
  - At foetal position (lateral and anterior)
  - TLD put under a 1 cm thick PMMA block
- Vaginal probe
  - 12 TLD over 5.5 cm
  - Dose extrapolated to the foetus

In-vivo dosimetry

- For 1 fraction
  - Skin dose : D = 0.34 mGy ; homogeneous
  - Vaginal probe: D = 0.36 mGy



Summary

• AAPM calculation:	12 mGy
• Phantom measurements:	11 mGy
• In-vivo dosimetry:	10.9 mGy

Radiology dose

- Whole body CT
  - Near the conception (yes / no process)
  - IRA procedure (based on CTDI)
  - Estimated dose: 20 mGy
  - CT dose included for risk estimation
- Bone scintigraphy
  - 544 MBq of Tc-99m
  - IRA procedure (based on ICRP 80)
  - Estimated dose: 5 mGy
  - Dose also included for risk estimation

Summary

• Radiology	25 mGy
• Radiotherapy	12 mGy
• Total	37 mGy

- Error estimate: 30 %

AAPM recommendation

• < 50 mGy	Little risk of damage
• 50-100 mGy	Risk uncertain
• 100-500 mGy	Significant risk of damage during 1st trimester
• > 500 mGy	High risk of damage during all trimester

Clinical outcome

- The patient was told that there was “Little risk of damage” for the baby
- She decided to accept radiation therapy
- She gave birth to a healthy baby 1 month after the end of the treatment
- 2 years later, she is in complete remission and the baby is healthy

Effect of wedges and blocs

	No shielding			Shielding	
Field	CB and PW	CB and VW	MLC and VW	CB and PW	MLC and VW
AP	30.9	9.9	6.2	19.0	4.0
PA	44.0	15.3	7.7	23.8	3.8
LOA	21.7	8.5	3.5	14.4	2.3
ROP	18.8	5.5	1.5	9.4	0.8
Total	115.4	39.2	18.9	66.6	10.9

Conclusions

- $D_{radiodiagnostic} > D_{radiotherapy}$
- Three methods gave the same result
  - Recommended to measure in phantom and in-vivo dosimetry
- Be careful with what is in the beam !
  - With a physical wedge: 4 x more dose
- Always shield the foetus

- Optimal: MLC et virtual wedges