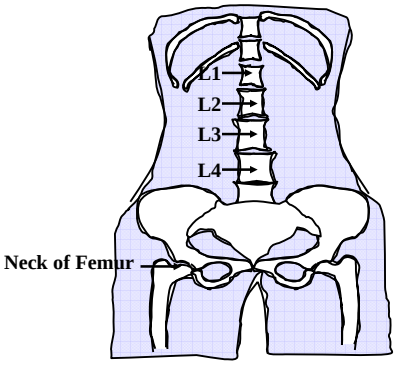
Patient Dose in DXA

Noirin Sheahan, PhD
Medical Physics and Bioengineering,
St. James's Hospital

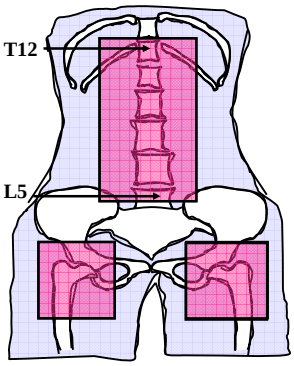
Outline of Presentation

1. **Relevant anatomical considerations**
2. **Dose and Risk in DXA**
   - **Adults**
   - **Paediatrics**
3. **Foetal Dose during Pregnancy**
4. **Summary**

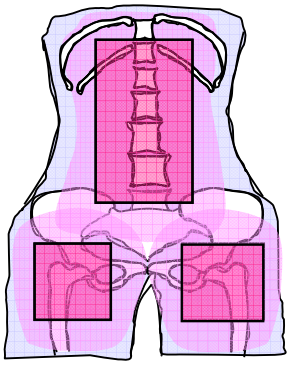
1. Relevant Anatomical Considerations



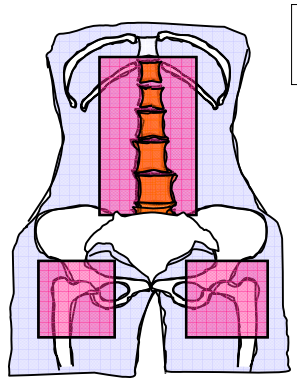
Irradiated Area



Radiation scattered outside of beam area contributes to dose:

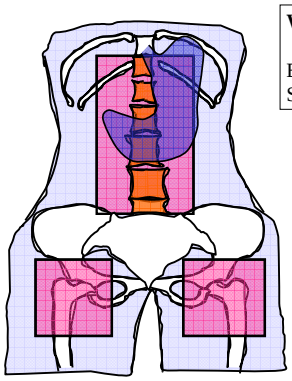


Radiosensitive Tissues in Irradiated Area



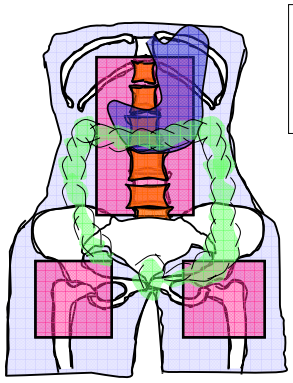
Weighting Factors	
Bone marrow	0.12

Radiosensitive Tissues in Irradiated Area



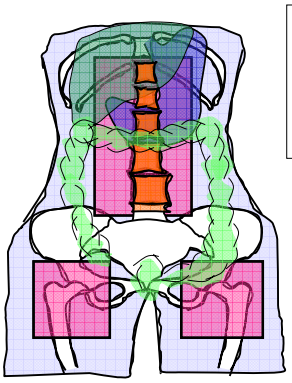
Weighting Factors	
Bone marrow	0.12
Stomach	0.12

Radiosensitive Tissues in Irradiated Area



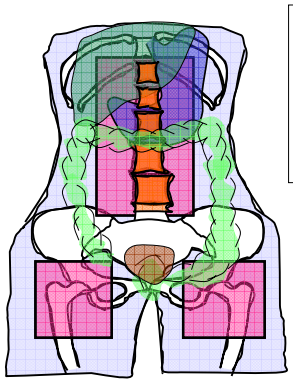
Weighting Factors	
Bone marrow	0.12
Stomach	0.12
Colon	0.12

Radiosensitive Tissues in Irradiated Area



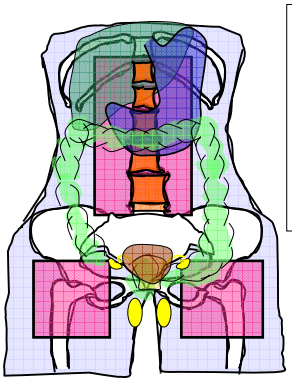
Weighting Factors	
Bone marrow	0.12
Stomach	0.12
Colon	0.12
Liver	0.05

Radiosensitive Tissues in Irradiated Area



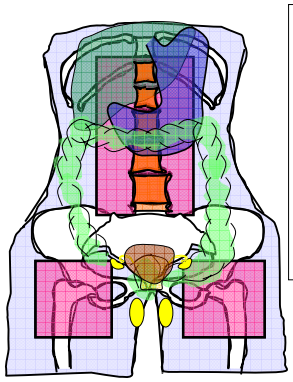
Weighting Factors	
Bone marrow	0.12
Stomach	0.12
Colon	0.12
Liver	0.05
Bladder	0.05

Radiosensitive Tissues in Irradiated Area



Weighting Factors	
Bone marrow	0.12
Stomach	0.12
Colon	0.12
Liver	0.05
Bladder	0.05
Gonads	0.20
	(.05)

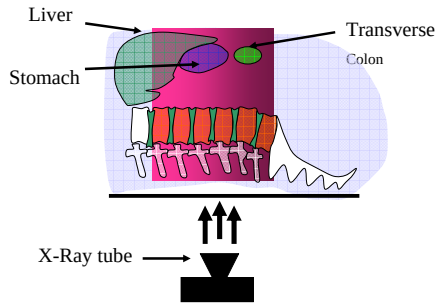
Radiosensitive Tissues in Irradiated Area



Weighting Factors	
Bone marrow	0.12
Stomach	0.12
Colon	0.12
Liver	0.05
Bladder	0.05
Gonads	0.20
	(.05)
Skin	0.01
Bone Surface	0.01

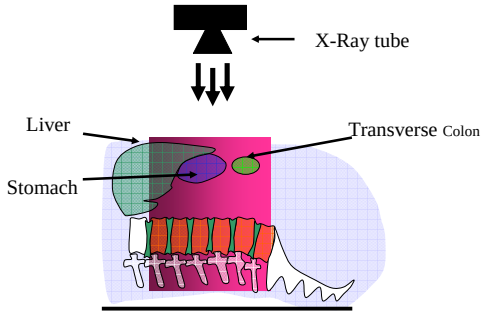
Variation of Dose with Depth –Under Couch Tube

e.g. Lunar DPX/Prodigy & Hologic



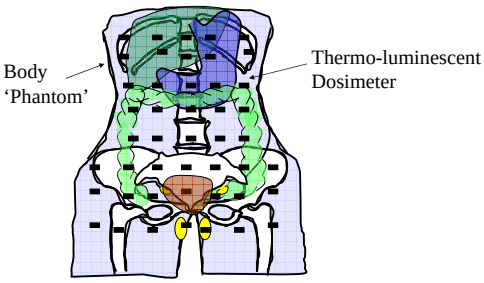
Variation of Dose with Depth – Over Couch Tube

e.g. Lexxos & Lunar Expert



2. Reported Dose Estimates in DXA

Estimation of Effective Dose:

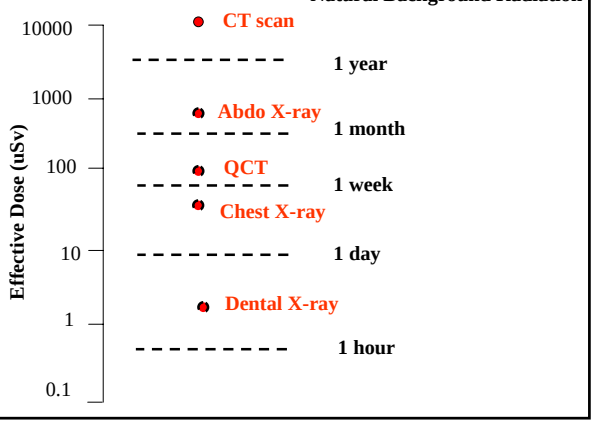


Effective Dose (uSv) – Adults
(Spine plus dual hip – Standard Patient)

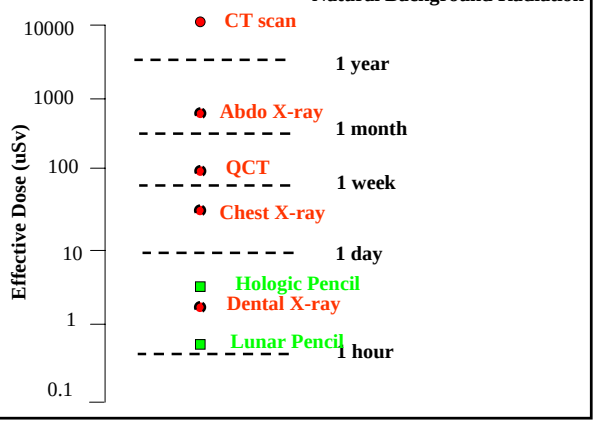
	Pencil	Fan	Cone
Lunar (DPX/Prodigy, std patient mode)	**0.5**	**2**	
Hologic (QDR1000/4500, Array mode)	**6**	**32**	
Lexxos (small/std patient)			**18**
Lunar Expert:		***170***	

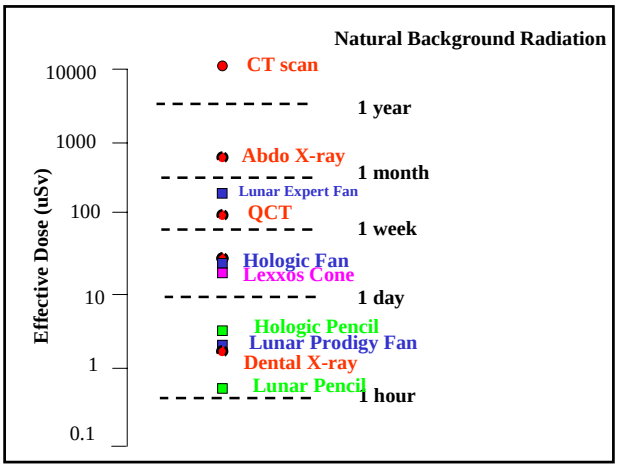
For comparison: ***Dental X-Ray 1 – 8uSv***
Chest XRay 30-50uSv

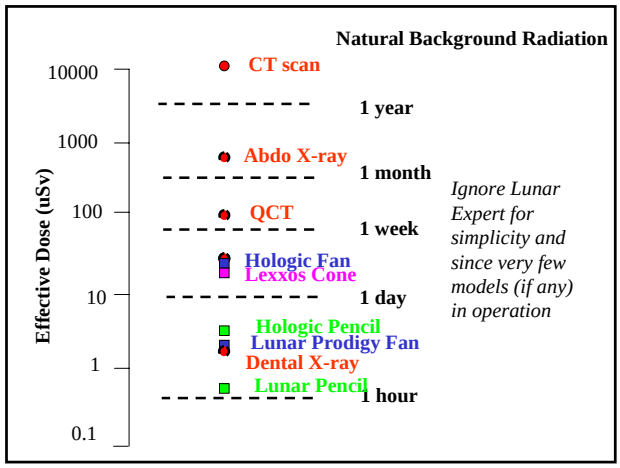
Natural Background Radiation

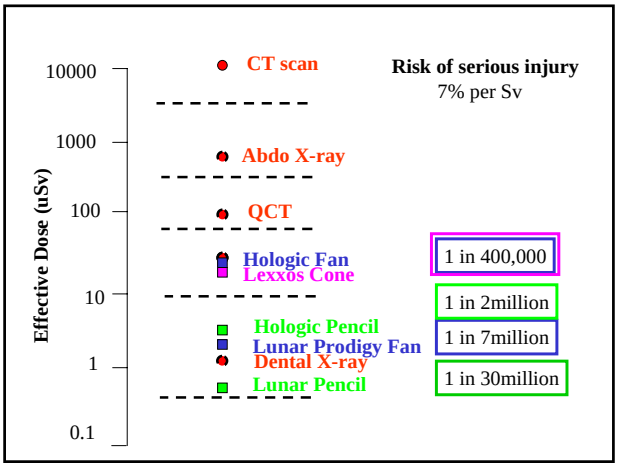


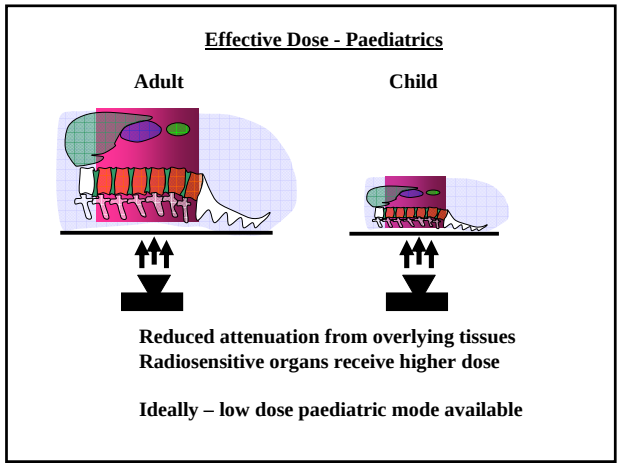
Natural Background Radiation

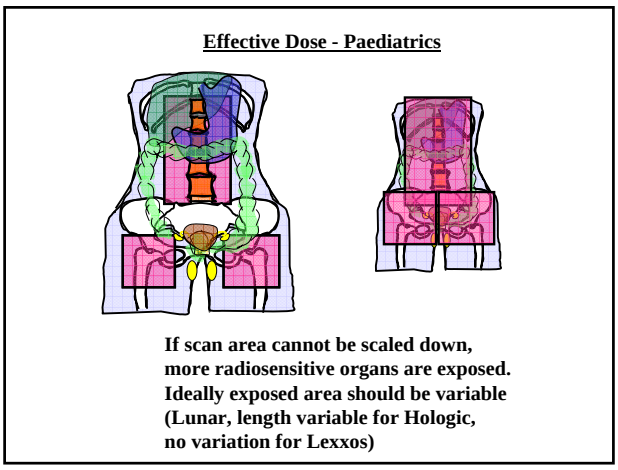












Effective Dose - Child compared to Adult

Hologic Fan Beam (QDR 4500A – Fast Array Mode)

	10 years Scaled	**5 years** Scaled
Spine	x1	x2
Hip (male)	x2	x3
Hip (female)	x1	x1

Thomas et al 2005

Hologic Fan Beam (QDR 4500A – same mode for adult & child)

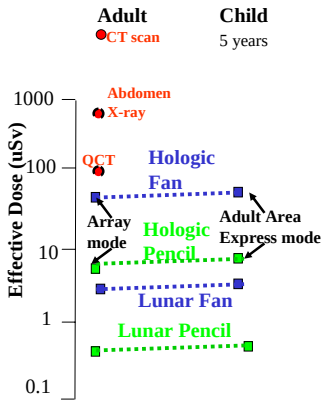
	10 years Scaled	Default	**5 years** Scaled	Default
Spine	x2	x3	x2	x4
Hip	x2	x2	x2	x3

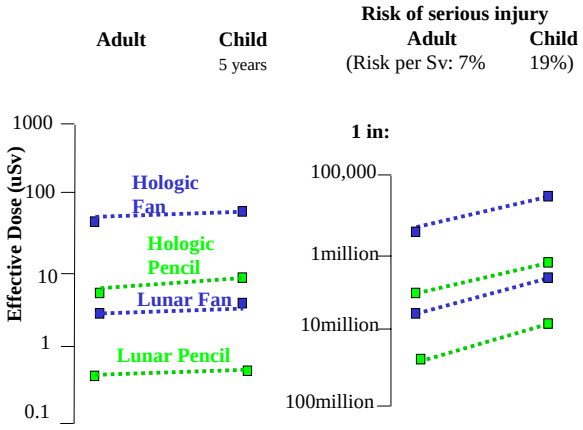
Blake et al 2006

Effective Dose - Child compared to Adult

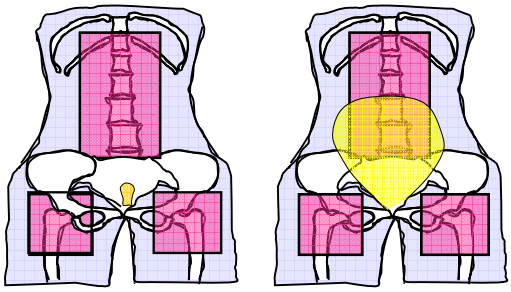
Lunar Pencil Beam	**10 years** Scaled	**5 years** Scaled
Spine	0.9	1.3

Njeh et al 1997



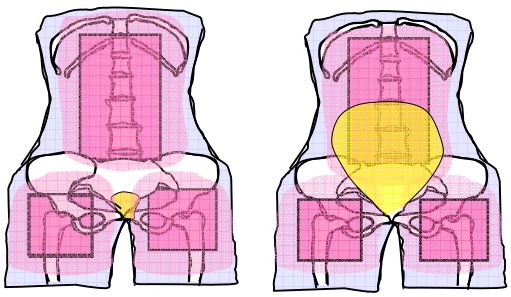


3. Foetal Dose during Pregnancy



Early Pregnancy | Later Pregnancy

Foetus receives scatter dose even in early pregnancy



Foetal Dose from Hologic QDR 1000 Pencil Beam Scanner

(Under-couch system)

	PA Spine (uSv)	**Femur** (uSv)	**Spine+Dual-femur** (uSv)
First trimester	2	3	7
Second trimester	3	1	6
Third trimester	5	1	7

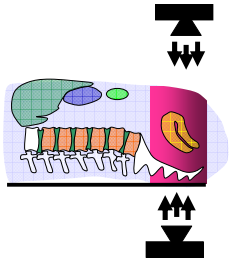
Damilakus et al 2002

Foetal Natural Background Dose about 3uSv / day
Foetal dose from AP Pelvis radiograph 800-1600uSv

No published reports but expect:
- **similar figures or less for Lunar DPX / Prodigy**
- **about 5 times higher for Hologic Fan Beam**

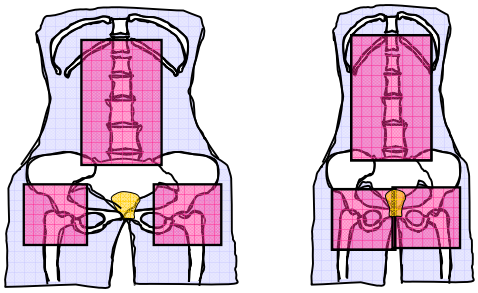
Foetal dose from over-couch tube systems not yet reported …

… expect higher dose to foetus



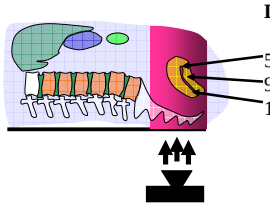
Under-couch systems – foetus protected by Sacrum

n.b. Damilakis et al assumed foetus outside main beam during first trimester. But … narrow-frame woman?



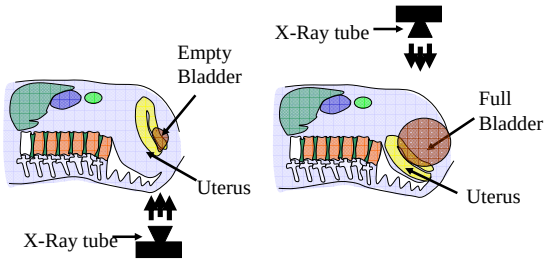
Scale field wherever possible to exclude uterus

Foetal Dose variation with Depth in Abdomen



Depth	Foetal Dose, uSv Femur DXA (First Trimester)
5.5cm	1.9
9.5cm	2.7
11.5cm	3.4

Foetal Dose variation with Depth in Abdomen



Empty bladder to reduce dose in under-couch system

Fill bladder to reduce dose in over-couch system

Patient Dose in DXA - Summary

- Factor of 60 variation in dose (0.5 – 30uSv) depending on technology, supplier, model, mode (excluding Lunar Expert – high dose model)
- Similar to Dental - Chest X-Ray dose range.
- Few days natural background at most.
- Dose in Children may be up to 3 times adult dose – depending on technology, supplier, mode etc
- Foetal dose about 7uSv (pencil beam) – few days natural background at most.

Keeping Patient Dose Low

- Many radiosensitive organs in or near scan area, so
  - **Choose model which allows user to vary scan area**
  - **Vary scan area according to patient size**
- For paediatric work, choose model which incorporates low-dose paediatric exposure mode
- Empty / fill bladder as appropriate before DXA in early pregnancy or possible pregnancy
- Scan femur only (not spine) in late pregnancy?