Effective Dose in Paediatric Computed Tomography

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- Why do we need to know?
- What have we got available?
- Produce some results.
- Test the method.
- Initiate a survey.

Why do we need to know?

- CT is generally considered a high dose procedure.
- 40% of annual medical radiation dose from only 5% of the examinations undertaken.
- Little dosimetry data available for paediatric CT due to great size variation.
- We have the means!

Aims of the project.

To establish a method for calculating effective dose.

- Use easily measured parameters

Parameters?

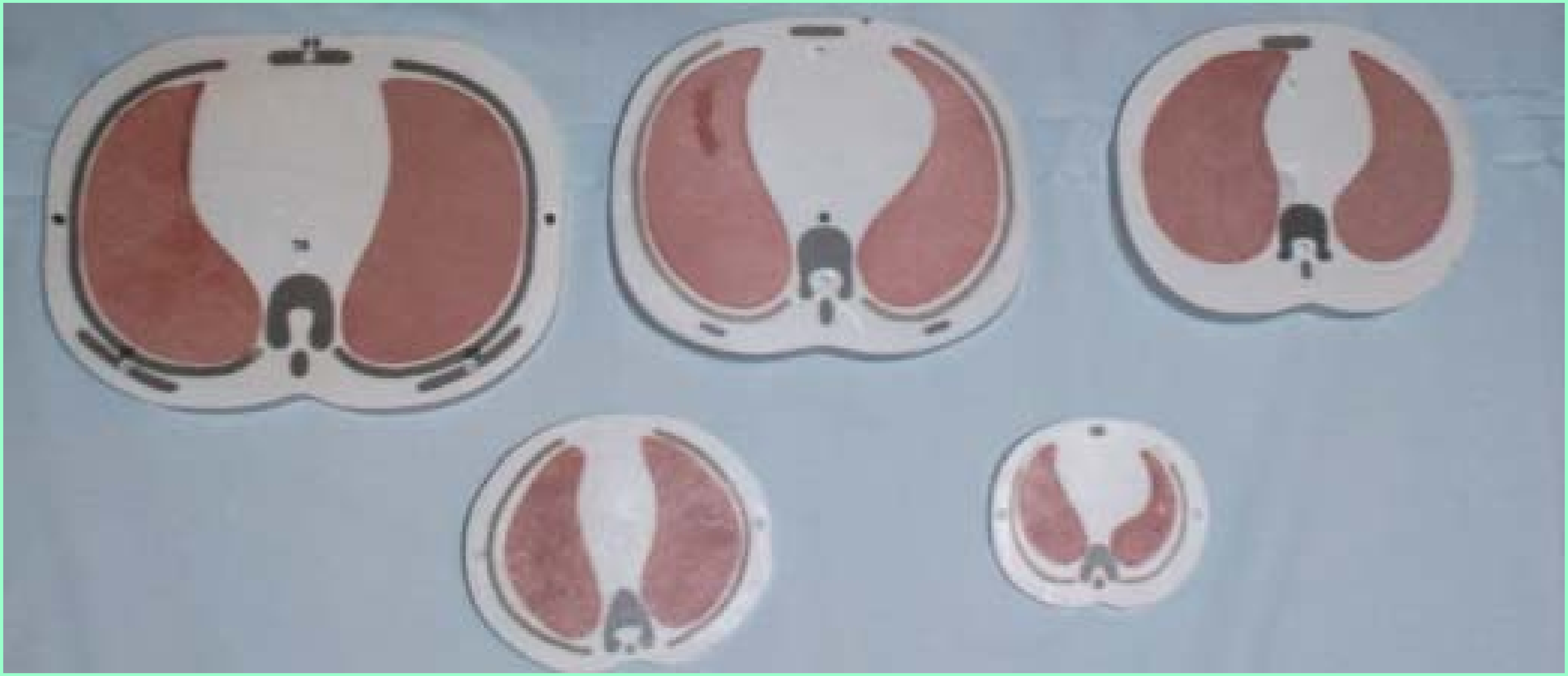
- Height & weight
- Equivalent diameter
- CTDIw
- Dose Length Product report
- Age only?
- Weight only ?
- DLP ?

$$E_{diameter} = \sqrt[2]{\frac{W(g)}{H(cm) \cdot \pi}}$$

What have we got available?

- A full set of paediatric dosimetry phantoms.
- Plenty of TLD.
- Access to several CT scanners.


1Y Abdo



Establish a method.

- **Fix areas of phantoms to be scanned.**
- Decide on some scanning parameters.
- Do CTDI measurements on scanner.
- TLD loaded into the phantoms.
- Scan areas of the phantoms repeatedly to accumulate a dose on the TLD.

Fix areas to be scanned

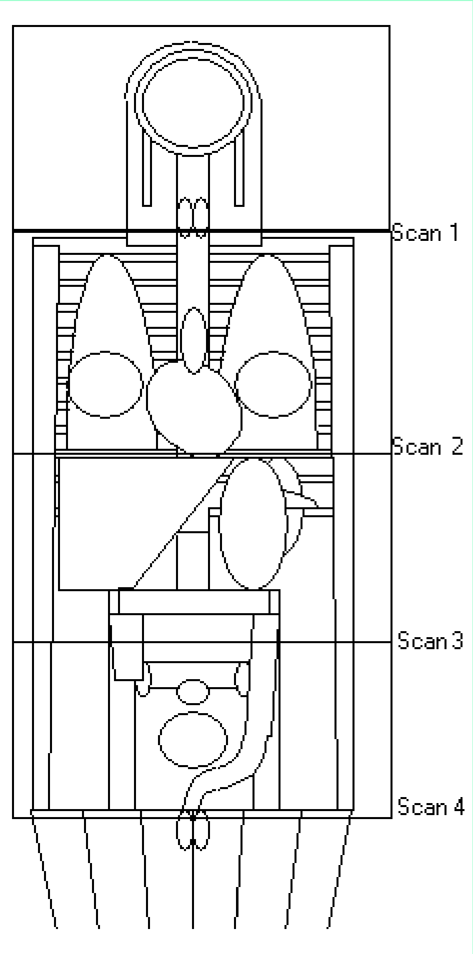
Head & Neck →

Chest →

Abdomen →

Pelvis →

Do not overlap areas



Establish a method.

- Fix areas of phantoms to be scanned.

- **Decide on some scanning parameters**.
  - Scan areas of the phantoms repeatedly to accumulate a dose on the TLD.

Establish a method.

- Fix areas of phantoms to be scanned.
- Decide on some scanning parameters.

- **Do CTDI measurements on scanner**.
  - Use weighted values from 16cm PMMA phantom
  - ‘Paediatric body’

Establish a method.

- Fix areas of phantoms to be scanned.
- Decide on some scanning parameters.
  - Scan areas of the phantoms repeatedly to accumulate a dose on the TLD.
- Do CTDI measurements on scanner.

- **TLD loaded into the phantoms**.

Phantoms & TLD

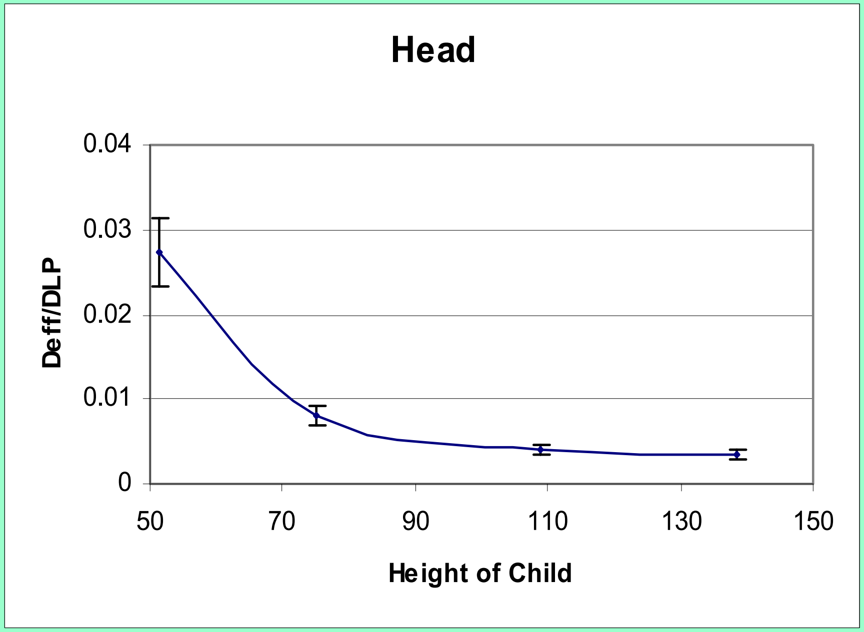
- All Organs containing a number of TLD.
- Most sections covered
- TLD 100
- Oven Annealing
- Calibration of TLD
- Neonate 135 TLD
- 15 year old 245 TLD
- 4 separate examinations
- Some repeats

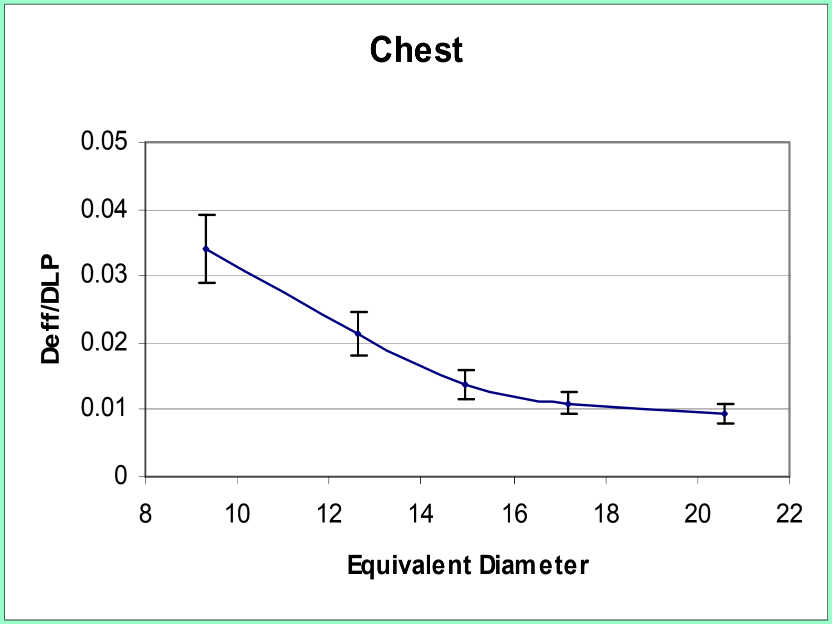
Establish a method.

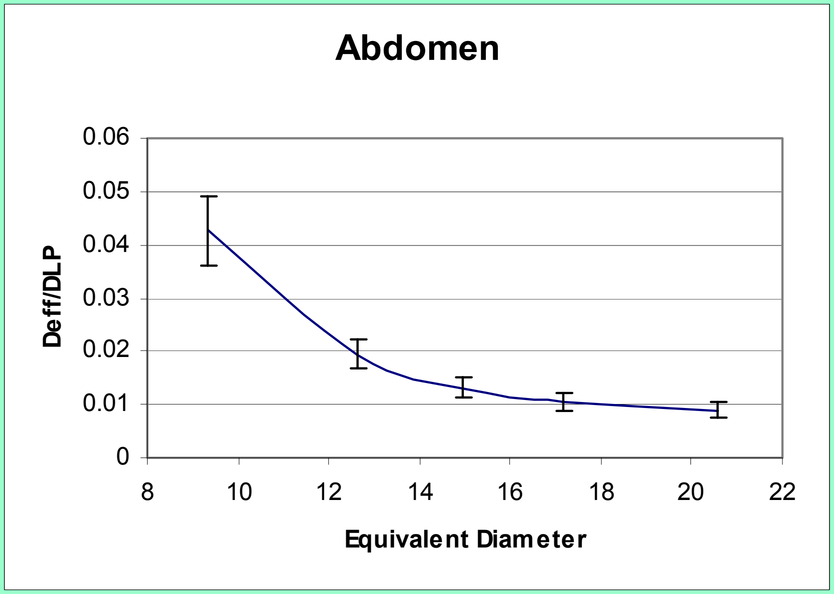
- Fix areas of phantoms to be scanned.
- Decide on some scanning parameters.
  - Scan areas of the phantoms repeatedly to accumulate a dose on the TLD.
- Do CTDI measurements on scanner.
- TLD loaded into the phantoms.
- **Scan the area of the Phantom.**

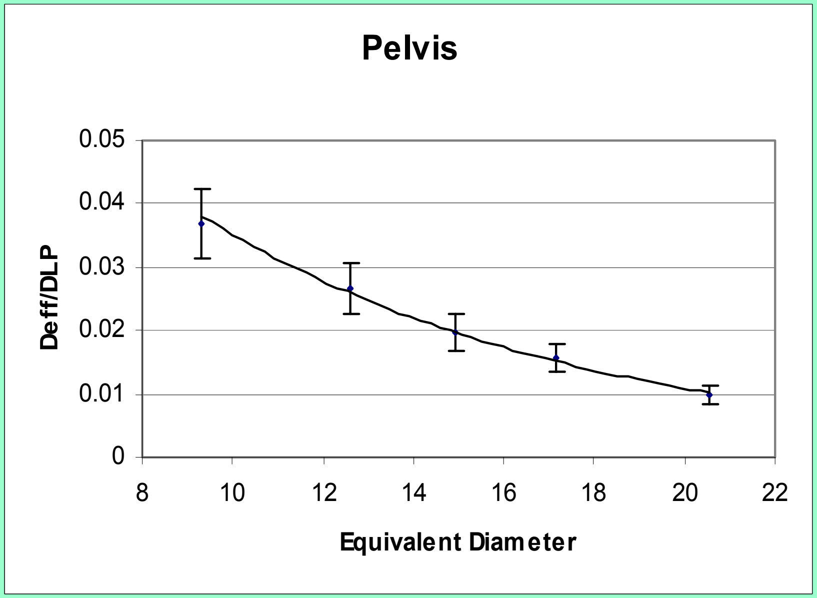
What next?

- Read TLD
- Calculate Effective Dose
- Calculate the Dose Length Product using the ‘paediatric body’ $CTDI_w$
- Plot graphs of effective dose / DLP against equivalent diameter of the phantom


Head
0.04
0.03
0.02
0.01
0
Deff/DLP
50
70
90
110
130
150
Height of Child


Chest
0.05
0.04
0.03
0.02
0.01
0
Deff/DLP
8
10
12
14
16
18
20
22
Equivalent Diameter


Abdomen
0.06
0.05
0.04
0.03
0.02
0.01
0
Deff/DLP
8
10
12
14
16
18
20
22
Equivalent Diameter


Pelvis
0.05
0.04
0.03
0.02
0.01
0
Deff/DLP
8
10
12
14
16
18
20
22
Equivalent Diameter

Effective Dose = DLP x Y_o+(A_1 x $e^{-(X/t_1)}$)

Look up Y_o , A_1 and t_1 from the table

X is the equivalent diameter of the child

Ref.

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Area	Y_0 (mSv mGy^{-1} cm^{-1})	A_1 (mSv mGy^{-1} cm^{-1})	t_1 (cm)
Head	0.00351	0.877	14.2
Chest	0.00736	0.272	4.07
Abdomen	0.00832	0.881	2.87
Pelvis	-0.0419	0.114	25.3

Test out the Theory

- Scan area to include parts of other areas
  - use some of the over-scanned phantom data
- Repeat some of the experiment on other scanners with different beam filtrations
- Get some protocols to calculate some doses

Calculation

- Example: ***Neonate Abdomen & Pelvis***
- *120kV, 200mAs, 10mm,13slices, Siemens Somatom Plus4*
- 0.3 scan in Abdomen & 0.7 scan in Pelvis

Neonate Abdomen-Pelvis

4.23mSv	**Abdomen**
8.5mSv	**Pelvis**

Total for full scan = 12.7 mSv

Neonate Abdomen-Pelvis

Siemens Somatom +4

- Predicted Dose $_{effective}$ = 12.7mSv
- Measured Dose $_{effective}$ = 12.9mSv

5 year old Chest with Abdomen
Toshiba Asteion

- Predicted Dose $_{effective}$ = 15.5mSv
- Measured Dose $_{effective}$ = 17.0mSv

Real Patients.

• Neonate Head	3-12 mSv
• 5 yr High Resolution Chest	0.4-1.2 mSv
• Neonate Abdomen	7.2 mSv
• 10 yr Abdomen	4.2 mSv
• Neonate Chest-Abdomen	7.5 mSv
• 10 yrs Chest-Abdomen	5.1 mSv

Conclusion.

- We have established a method for calculating Paediatric effective doses for CT examinations.
- Can be used for a range of CT scanner.
- Tested this method.
- Calculated some real doses for real patients.

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