# An assessment of foetal dose due to CT pulmonary angiography for suspected maternal pulmonary embolism

Susan Doshi[1], Ian Negus[1], Jenny Oduko[2]

1. United Bristol Healthcare Trust
2. Royal Surrey County Hospital, Guildford

# Overview of presentation

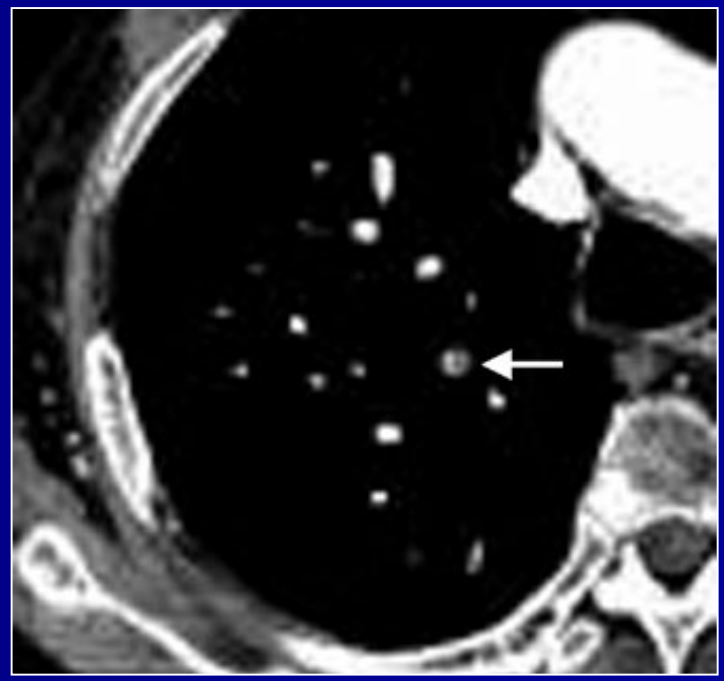
- Background
  - Aims of project
- Materials and Methods
  - Phantom & scanning protocols
- Results
  - Comparisons:
    - Literature - V/Q - Different scanners
  - Scan protocol
- Conclusions

# Venous thromboembolism (VTE)

- DVT/PE is ~5 times more common in pregnancy
- It affects ~1 in 1000-2000 pregnancies
- Symptoms generally non-specific
- Treatment has associated risk

# BTS Guidelines: Imaging

- Leg ultrasound
  - if DVT confirmed, begin treatment
- CTPA is recommended as initial lung imaging technique
- Ventilation/Perfusion (V/Q) may be used instead



*British Thoracic Society Guidelines for the Management of Suspected Acute Pulmonary Embolism*, Thorax 2003 **58:** 470-484

# BTS Guidelines: Pregnancy

- Current practice based on extrapolation from non-pregnant patients and observational studies
- Guidance on treatment in pregnancy is given

# Aim of project

- Diagnosis of VTE remains controversial, particularly in pregnancy
- Decision making could be further informed by greater certainty of foetal dose
- Estimates using Monte Carlo exist
- We want to add to this information with phantom measurements

# Description of phantom

# Description of phantom

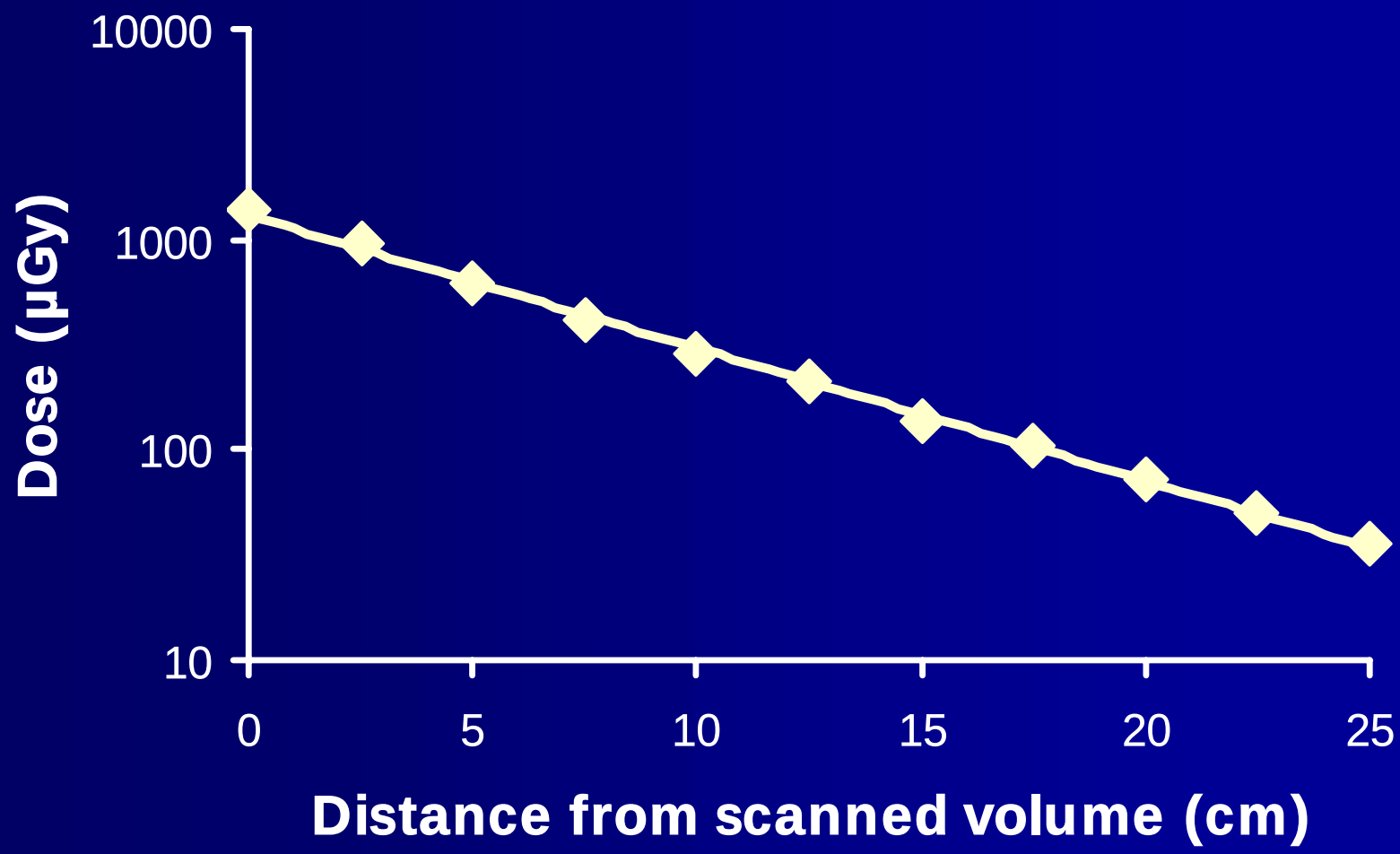
- St George's[1] pregnant pelvis phantom
  - Modelled on real patient at full term
  - Rigid water-filled container + Rando phantom pelvis
  - Chest of Bristol Rando phantom (male)
  - + water-filled balloons for other anatomy!

[1]Badr I et al. X-ray Pelvimetry – which is the Best Technique? *Clinical Radiology* 1997 52:136-141

# Scan Protocol

- Standard ‘Embolism’ protocol
  - 120kV
  - 100mAs (effective)
  - 16 × 0.75mm detectors
  - 15mm feed per rotation
  - 24.5cm scan length + 2cm overscan at each end

# Results


10000
1000
100
10
Dose (µGy)
0
5
10
15
20
25
Distance from scanned volume (cm)

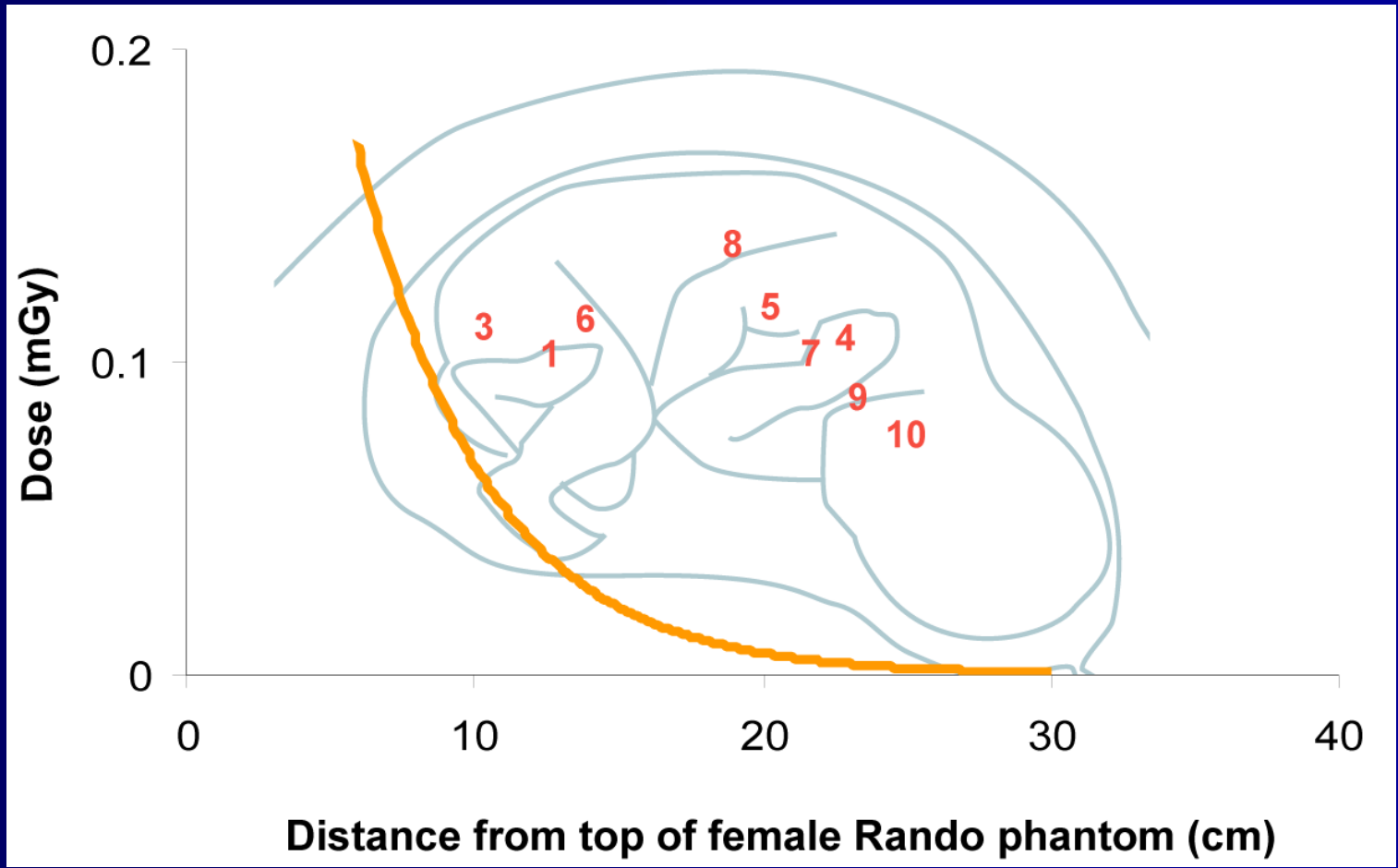
# Results

- Mean dose in water phantom = 390μGy
- Mean foetal dose ~ 100μGy

# Results

- Early pregnancy: use mean absorbed dose to assess risk (ICRP)
- Foetus at term – organs fully developed
- Scatter from CT is a heterogeneous dose distribution
- Need to consider radiosensitivies of organs
- Use ICRP60 tissue weighting factors

# Results


0.2
0.1
0
Dose (mGy)
0
10
20
30
40
Distance from top of female Rando phantom (cm)
8
5
3
6
1
7
4
9
10

# Results

| Organ | $H_T$ (μSv) | $w_T$ | $w_T H_T$ (μSv) |
|---|---|---|---|
| Gonads | 211 | 0.20 | 42 |
| Colon | 226 | 0.12 | 27 |
| Bone marrow (red) | 123 | 0.12 | 15 |
| Bladder | 182 | 0.05 | 9 |
| Stomach | 66 | 0.12 | 8 |
| Other organs + remainder | | | 24 |
| Effective dose = $\Sigma w_T H_T$ : | | | 125 μSv |

# Comparison with literature

| | Monte Carlo[1] (6 patients) | Phantom measurement |
|---|---|---|
| Max absorbed dose (µGy) | 330-860 | 300 |
| Mean absorbed dose (µGy) | 50-130 | 100 |

[1] Winer-Muram H T et al. Pulmonary Embolism in Pregnant Patients: Fetal Radiation Dose with Helical CT *Radiology* 2002; 224:487-492

# Comparison with V/Q

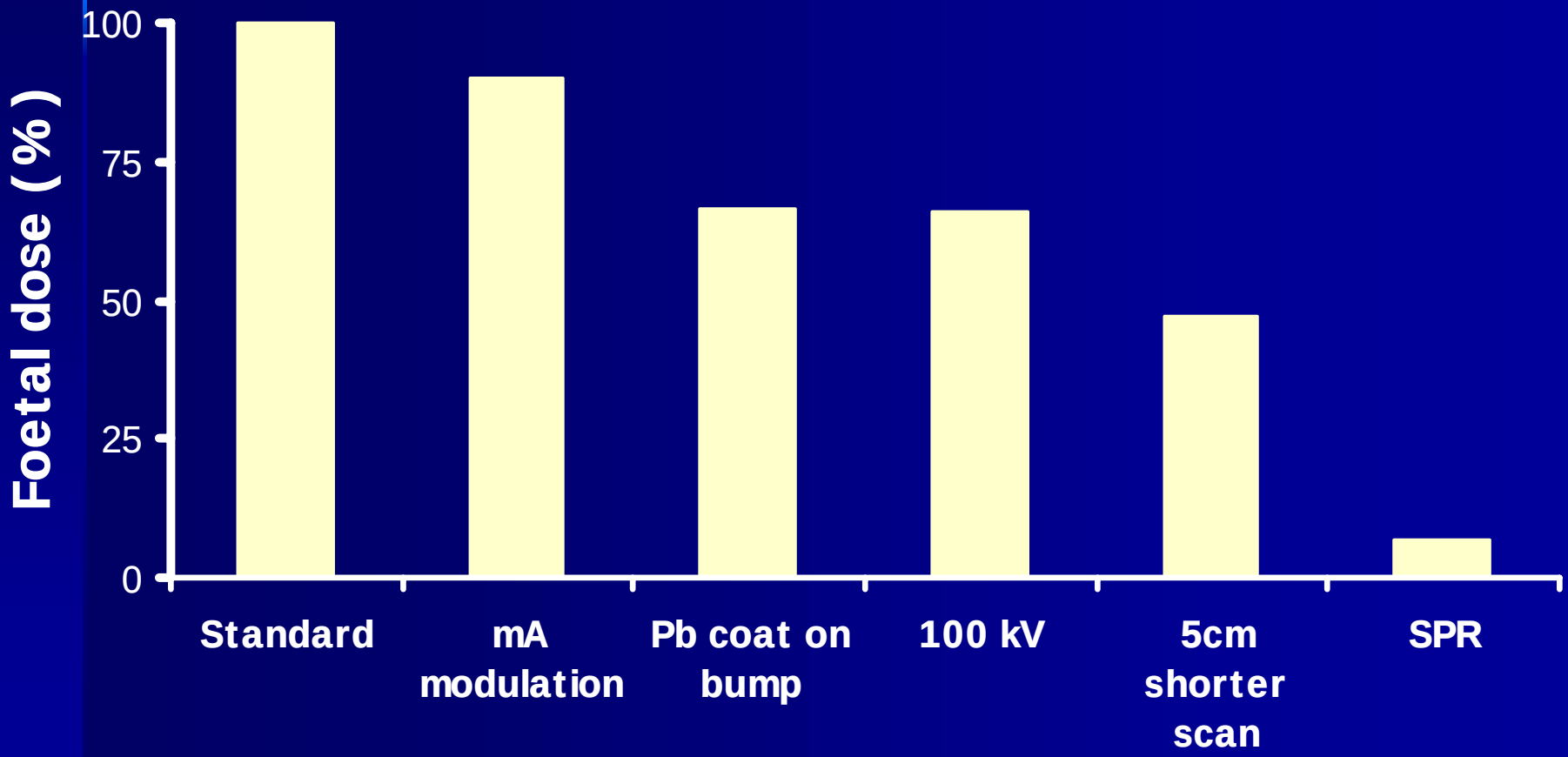
| | Dose to foetus (μSv) | Dose to mother (μSv) |
|---|---|---|
| $^{99m}$Tc perfusion[1] | 300 | 1000 |
| $^{81m}$Kr ventilation[1] | <0.1 | 200 |
| Total for V/Q | 300 | 1200 |
| CTPA | 125 | 4200 |

[1] From *Notes for Guidance on the Clinical Administration of Radiopharmaceuticals and Use of Sealed Radioactive Sources;* ARSAC 1998

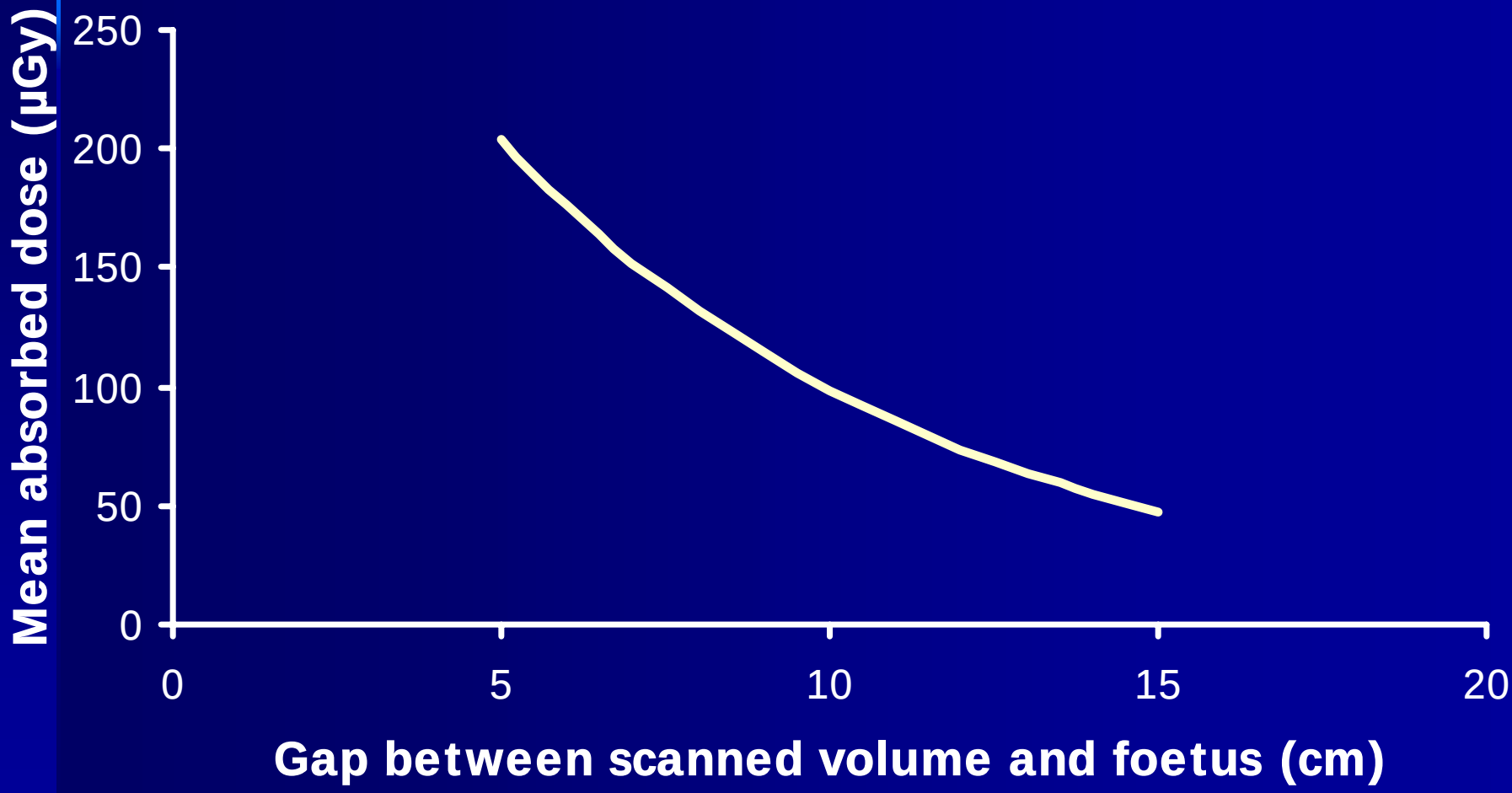
# Other Scanners

- Standard protocol depends on scanner capabilities
- $CTDI_w$ gives indication of dose for each protocol
- Some variation found in practice
- Each protocol requires optimisation

# Variation with scan parameters



# Geometry


Mean absorbed dose (µGy)
250
200
150
100
50
0
0
5
10
15
20
Gap between scanned volume and foetus (cm)

# Conclusions

- Foetal dose from CTPA measured as 100μGy
- Represents an excess risk of fatal cancer to age 15 of 1 in 300,000[1]
- Risk due to incorrect diagnosis is likely to be greater
- The radiation dose to the foetus does not preclude the use of CTPA

[1]Excess risk of fatal cancer = $3 \times 10^{-2} Gy^{-1}$ (from *Diagnostic Medical Exposure to Ionising Radiation of Pregnant Women,* NRPB 1993)