

Adult & pediatric doses in CT

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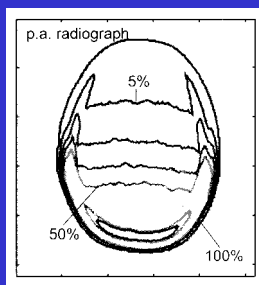
SUNY Upstate Medical
University, Syracuse NY

Introduction (Doses & risks)

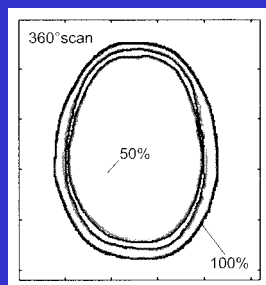
CT doses
(CTDI/E)

Head CT doses

Reducing CT doses



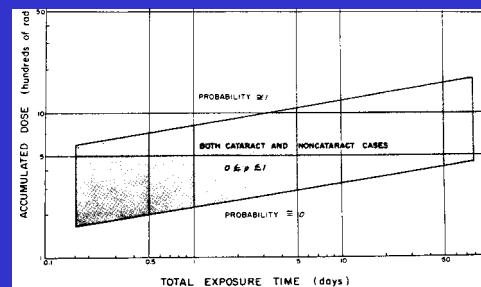
x-ray skin dose
2 mGy/0.2 rad



CT skin dose
40 mGy/4 rad

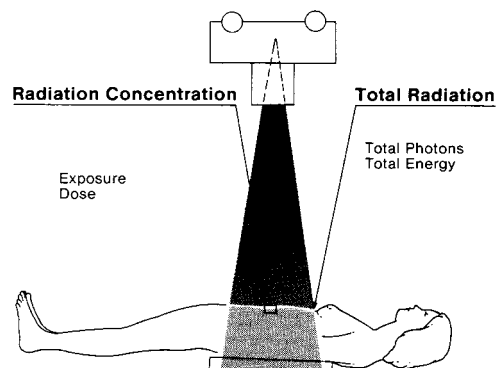
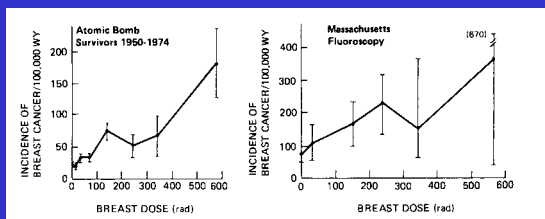
Cataracts

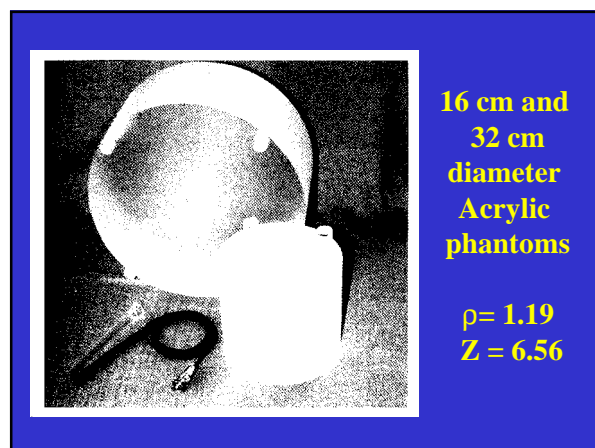
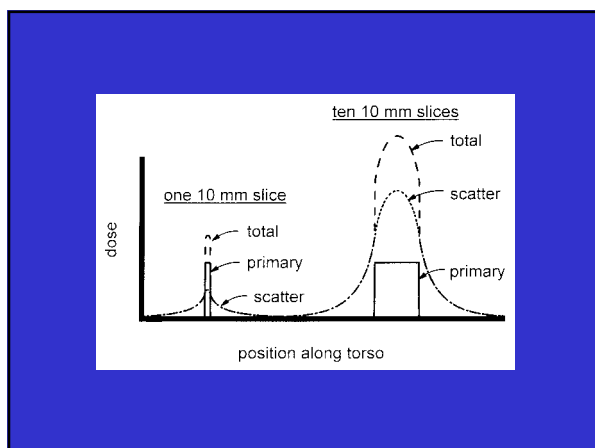
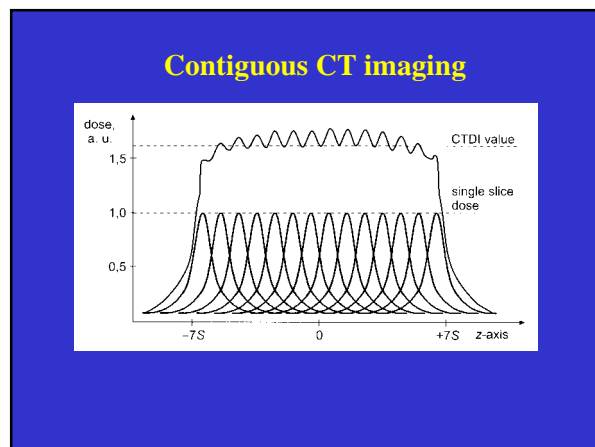
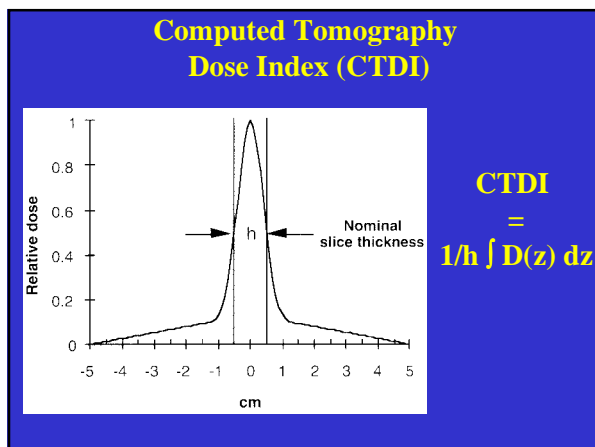
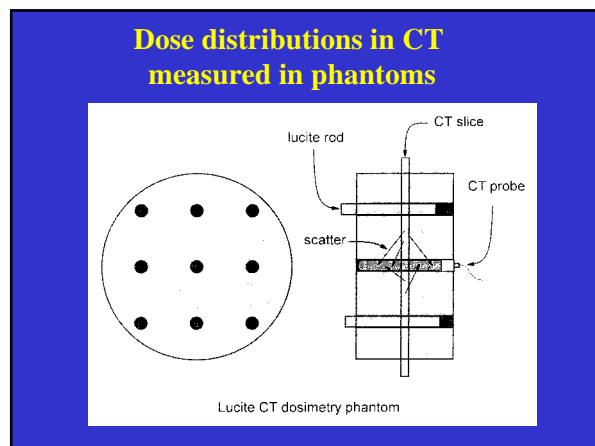
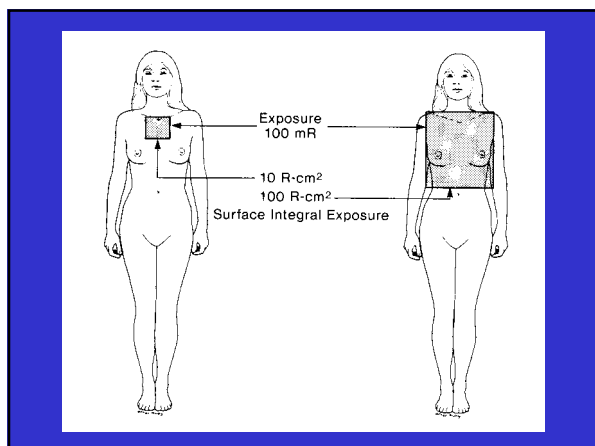
Deterministic effect



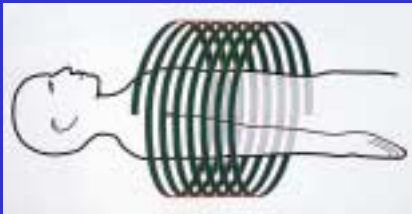
Carcinogenesis

Stochastic effect

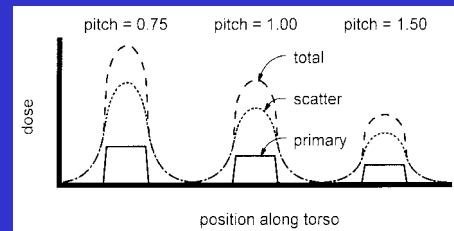




Helical scanning & dose



Pitch of 1.0 has dose \approx axial scan
Pitch of 0.75 has 33% more dose
Pitch of 1.5 has 66% less dose



CTDI is *independent* of
section thickness T
& number of sections N

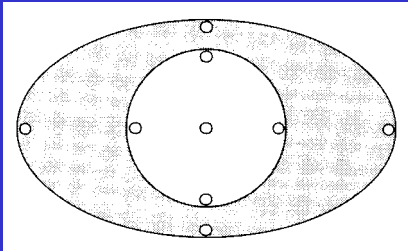
Patient risk *does* depend on section
thickness T & number of sections N

Dose (risk) in CT
is best measured by
effective dose (E)



$$E = \sum_i w_i \times D_i$$

Computing adult and pediatric
doses in head CT examinations

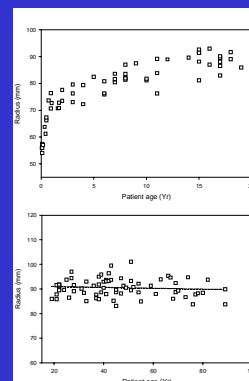
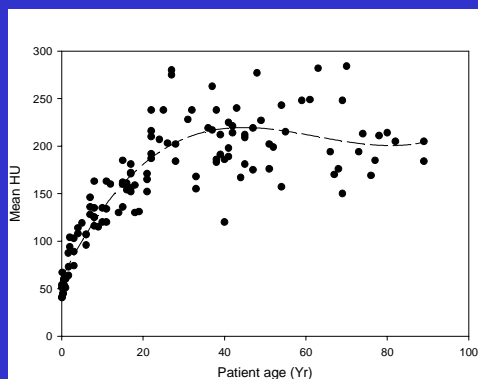


127 patients undergoing head
CT examinations



*Measurements
made at
level of the
basal ganglia*

*Dimensions
& average HU*

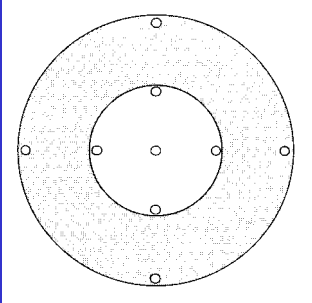


*Heads modeled
as water
equivalent
cylinders
with a radius r*

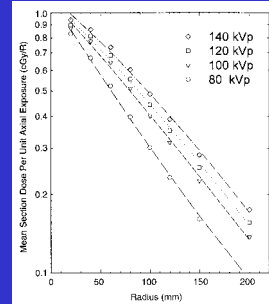
Infants ~60 mm

Adults ~90 mm

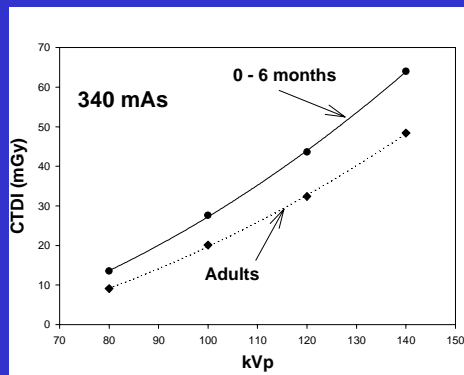
**CTDI is equal to:
Energy imparted/Section mass**



**“CTDI” for any sized radius
(Energy imparted/Section mass)**

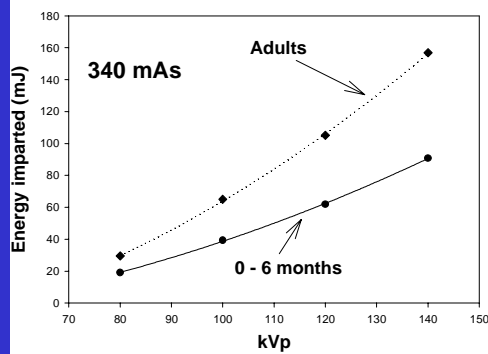


*Monte Carlo
modeling
Radiology
(1997)
203:417-422*



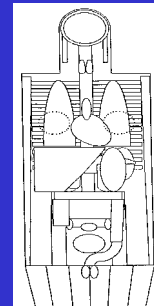
Energy imparted

**“CTDI”
x
Directly irradiated mass
(i.e., $\pi \cdot r^2 \cdot T \cdot N$)**



**For an anthropomorphic phantom
& head CT scan, compute :**

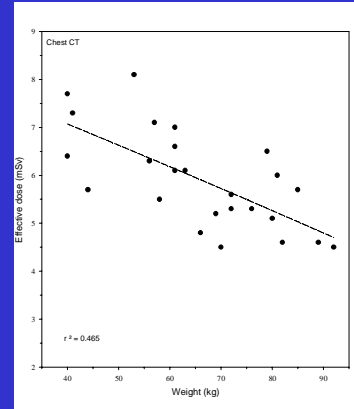
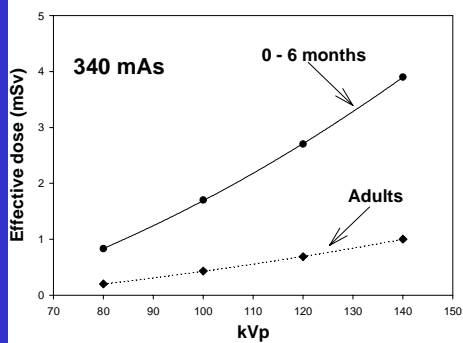
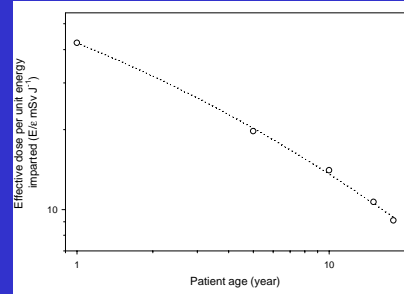
*Effective dose E
Energy imparted ϵ
E/ ϵ ratio*



Compute E/ϵ ratio for different sized patients (i.e., newborn to adults)



Effective dose per unit energy imparted for head x-ray examinations vs size



Patient dose:

is proportional to mAs

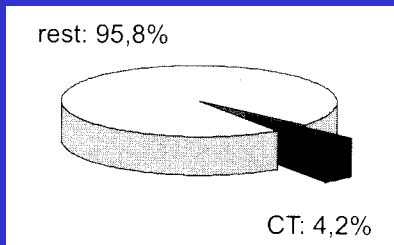
increases by factor of 5 when going from 80 to 140 kV (@ constant mAs)



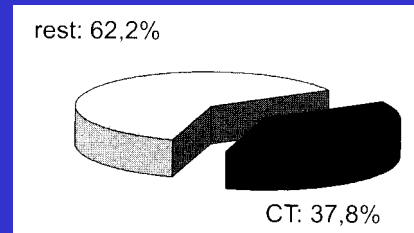
Doses from CT are a major concern



**Frequency of CT examinations
Germany 1994**



**CT contribution to collective medical dose
Germany 1994**



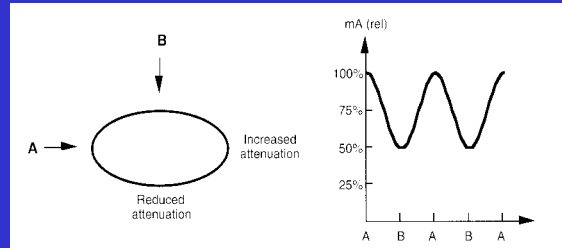
Dose reduction strategies

Technology (AEC)

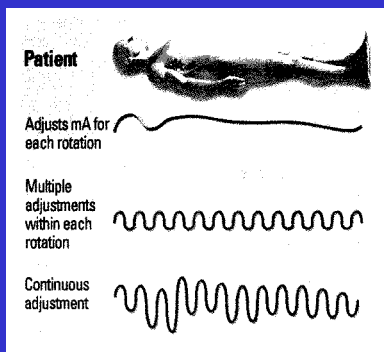
Dose reduction (ALARA)

Optimization

Tube current modulation for non-circular cross-sections of the body

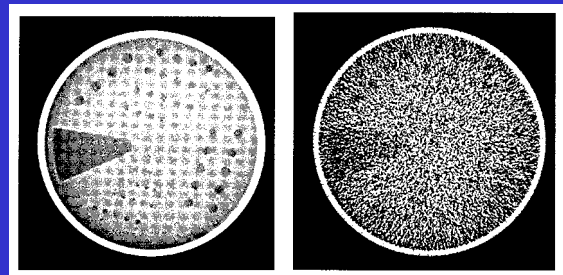


GE Smart mA (LightSpeed Ultra)



High dose scan

Low dose scan



120 kVp

5 mm

206 mAs



120 kVp

5 mm

43mAs

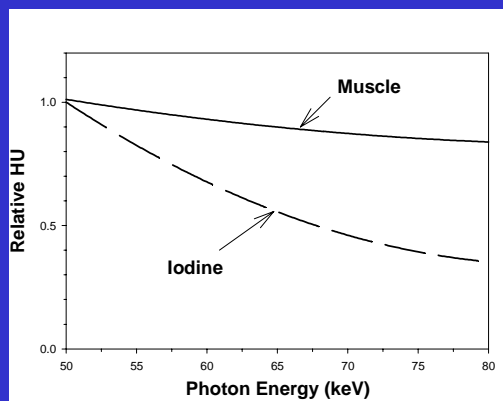
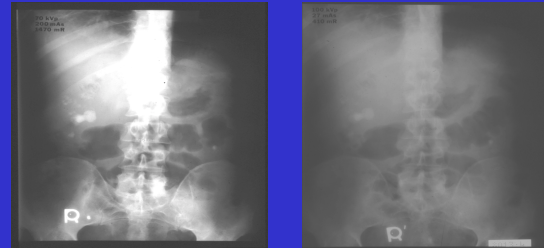
A Metastasis in vertebral body
B Subcutaneous gluteal metastasis

C Small gas inclusion
D ureter opacified c contrast

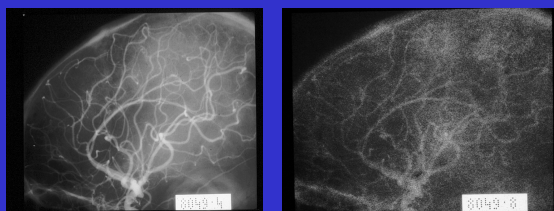
Optimizing CT with respect to dose



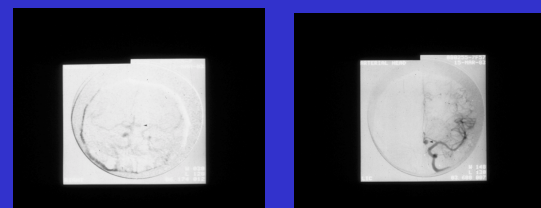
Increasing the x-ray photon energy (kVp) reduces image contrast



The mAs used to make a CT image is *very* important

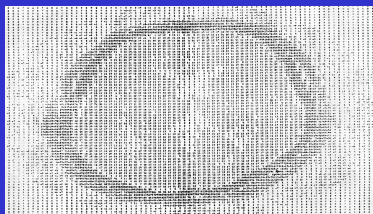


Contrast to noise ratio (CNR) defines CT image quality.

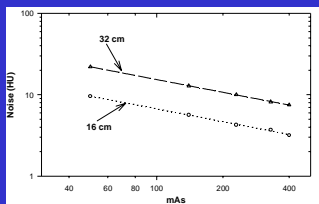


*Low
CNR*

*High
CNR*

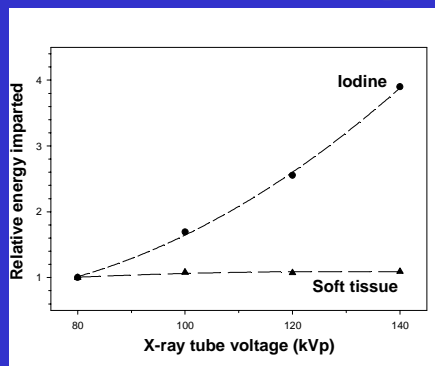


*First CT
image
(120 kVp)*



*CT CNR can be
changed via mAs;
CT is quantum
noise limited*

Constant CNR at each kVp



**Stochastic risks are
important in CT**

**Deterministic risk
should not occur**

Effective doses in CT

1 – 2 mSv for head

5 – 10 mSv for body

**CT doses “dominate”
medical exposures**

**ALARA principle
should be used to
minimize patient doses**

