

X

A Study on Dose Difference between Newborn and Adult Phantoms for Diagnostic Chest X-ray

, , ,

X
6
MCNP4B
LAT
0.4, 0.8, 2, 8MeV
15
가
가
47% 가
가
X
X

ORNL
MIRD5
가
AP, PA,
54% 가
X
X

ABSTRACT

Mathematical phantoms representing newborn and adult were constructed, and organ dose and effective dose were calculated in chest x-ray examination. Newborn and female phantoms of ORNL and MIRD5 male phantom were constructed by MCNP4B, a general-purposed Monte Carlo code and esophagus model was added into newborn phantom. Firstly, organ doses and effective doses in standard irradiation environment, AP, PA and LAT directions and 0.4, 0.8, 2 and 8MeV gamma beam were calculated and compared. The effective dose of newborn phantom was 54% and 47% higher than those for adult phantom in standard irradiation situation and chest x-ray examination, respectively. The differences of doses are due to the difference of phantom size and corresponding difference of shielding effect. In this study, the difference of effective dose of newborn and adult in x-ray examination was evaluated quantitatively and need of study for dose difference in another irradiation conditions was suggested.

1.

X 가 X ,
 X . 가
 X 가
 [1].
 MCNP4B[2] X
 가 15 .

2.

[3] MIRD5 [4] ORNL
 1 2 1 y=0 .

Table 1. Comparison of whole body masses of three age phantoms.

| Phantom | Whole-body mass of phantom (kg) | | Whole-body mass of human (kg) ^e | |
|--------------------|---------------------------------|--------------------|--|------------------------|
| | Actual | Nominal | Female | Male |
| Newborn | 3.6 | 3.4 | 3.4 | 3.4 ^f |
| 15-AF ^a | 56.8 ^b | 55-58 ^d | 51.6 | 54.5 |
| Adult male | 73.7 ^c | 70 | 56.7 (58) ^g | 71.7 (70) ^g |

a) Age-15-male/adult female phantom b) 56.4 kg without the female breasts. c) 73.3 kg without the female breasts.

d) 55 kg for age 15 male and 58 kg for adult female. e) Data for ages newborn to 15 years are from Watson and Lowrey (1967).

f) 3.5 kg for newborn male is given in ICRP Publication 23

g) Reference whole-body masses were rounded to 58 and 70 kg for adult

Table 2. Trunk heights and total heights of phantoms

| Phantom | Trunk height (cm) | Total height (cm) |
|---------|-------------------|-------------------|
|---------|-------------------|-------------------|

| | | |
|------------|------|--------|
| Newborn | 21.6 | 51.49 |
| 15-AF | 63.1 | 163.99 |
| Adult male | 70.0 | 174.0 |

가
 ORNL . ICRP69[5] 가
 가 (thymus) 가
 Zankl Drexler가 가
 1992
 (1)[6].

$$\left(\frac{x-x_0}{a}\right)^2 + \left(\frac{y-y_0}{b}\right)^2 \leq 1 \dots\dots\dots (1)$$

$$z_1 \leq z \leq z_2$$

Table 3. Constants of esophagus model in newborn, adult female and male

| phantom | A | b | x_0 | y_0 | z_1 | z_2 |
|------------|-----|------|-------|--------|-------|-------|
| Adult-male | 1.0 | 0.4 | 0.5 | 2.5 | 43 | 75 |
| 15-AF | 1.0 | 0.4 | 0.5 | 2.4 | 41 | 70 |
| Newborn | 0.3 | 0.19 | 0.245 | 1.2273 | 13.14 | 24 |

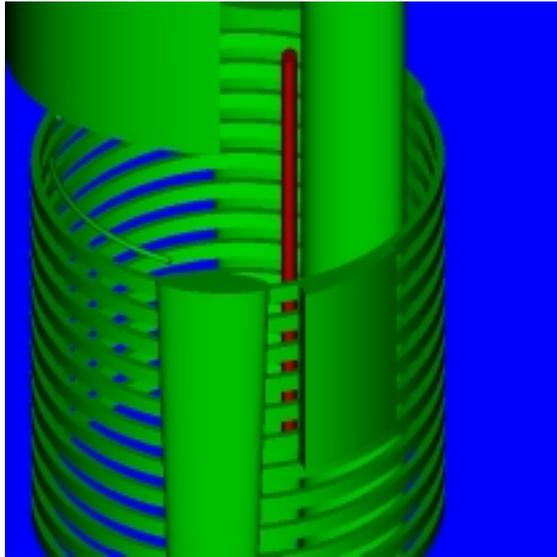
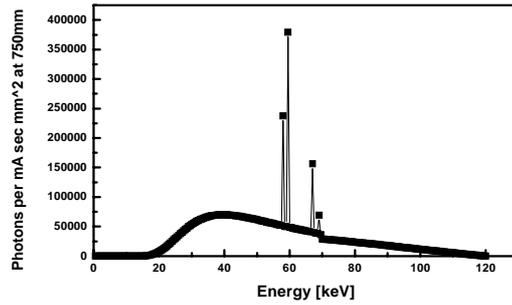
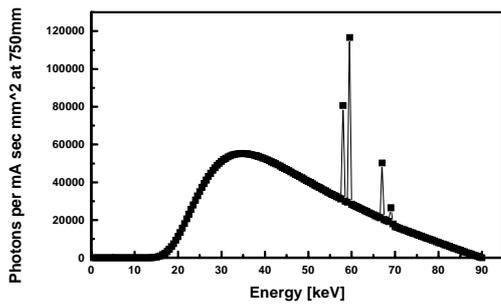


Figure 2. 3D images of newborn esophagus (rendered by Sabrina4.0)

0.4, 0.8, 2, 8 MeV
 AP, PA, LLAT, RLAT
 MIRD5
 15
 X
 IPEM(Institute of Physics and Engineering in Medicine)
 X
 X
 가 [7]. SPEC78 30 150kVp 6 22°
 0.5keV 75cm mAs
 3
 NRPB-R262[8] NRPB-R279[9]
 X . NRPB-R279 5
 X 0 1
 가 가 . PA X
 . 4 PA X



a) W target, 90kVp, 17 °; 2.5mm Al total filtration (b) W target, 120kVp, 13 °; 2.5mm Al total filtration

Figure 3. Example of x-ray spectra generated by SPEC78 code

Table 4. X-ray projections modeled in Monte Carlo simulation

| Age (years) | FSD* (cm) | Center (X,Y,Z) (cm) | Field size at midplane of phantom(cm) | Field size at image receptor width*length(cm) |
|-------------|-----------|---------------------|---------------------------------------|---|
| Adult male | 160 | (0,0,52) | 32*40 | 35*44 |
| 15-AF | 160 | (0,0,52) | 32*40 | 30*32 |
| Newborn | 160 | (0,0,16.69) | 12.62*12.62 | 13*13 |

*FSD = focus to surface distance.

3.

0.4, 0.8, 2, 8MeV

AP, PA, LLAT, RLAT

가

4~7

0.4MeV

8 4가

8

가

9

12.7cm

()

가 40cm

가

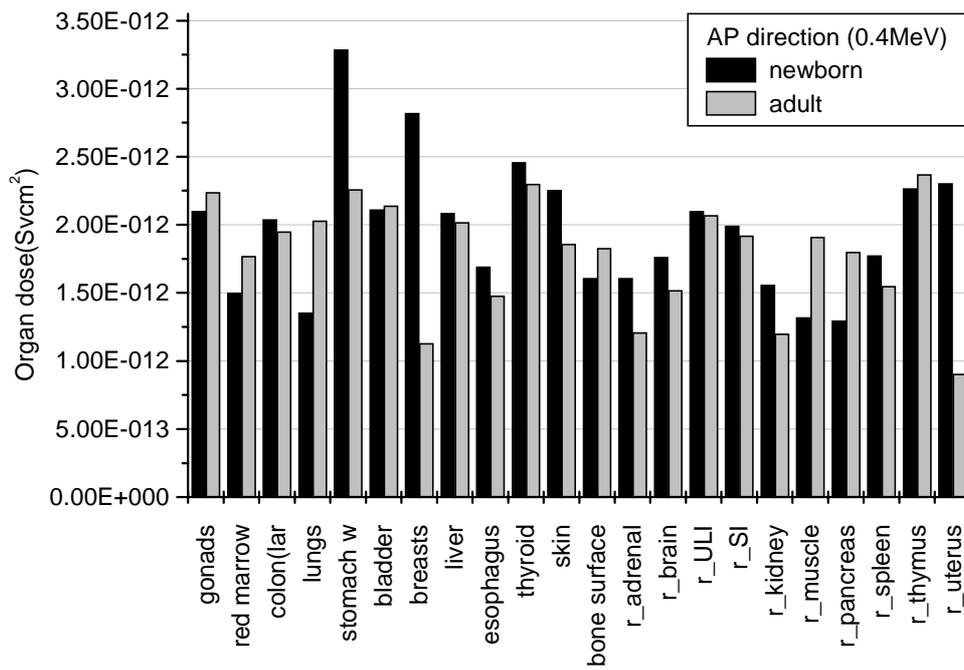


Figure 4. Organ dose of newborn and adult phantom irradiated by 0.4MeV gamma beam from AP direction

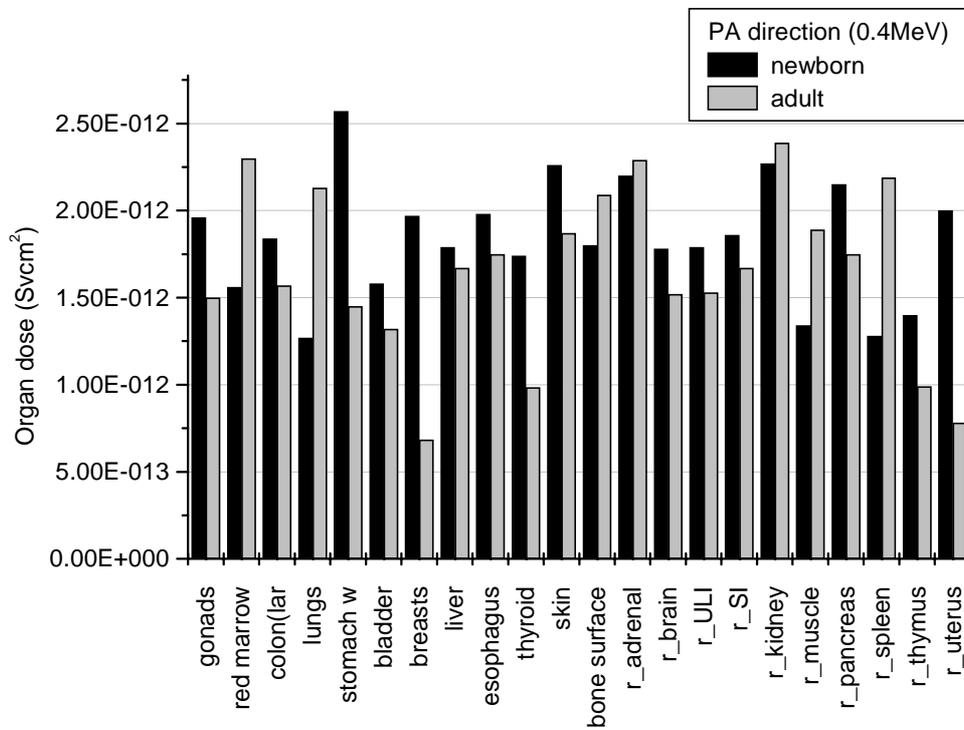


Figure 5. Organ dose of newborn and adult phantom irradiated by 0.4MeV gamma beam from PA direction

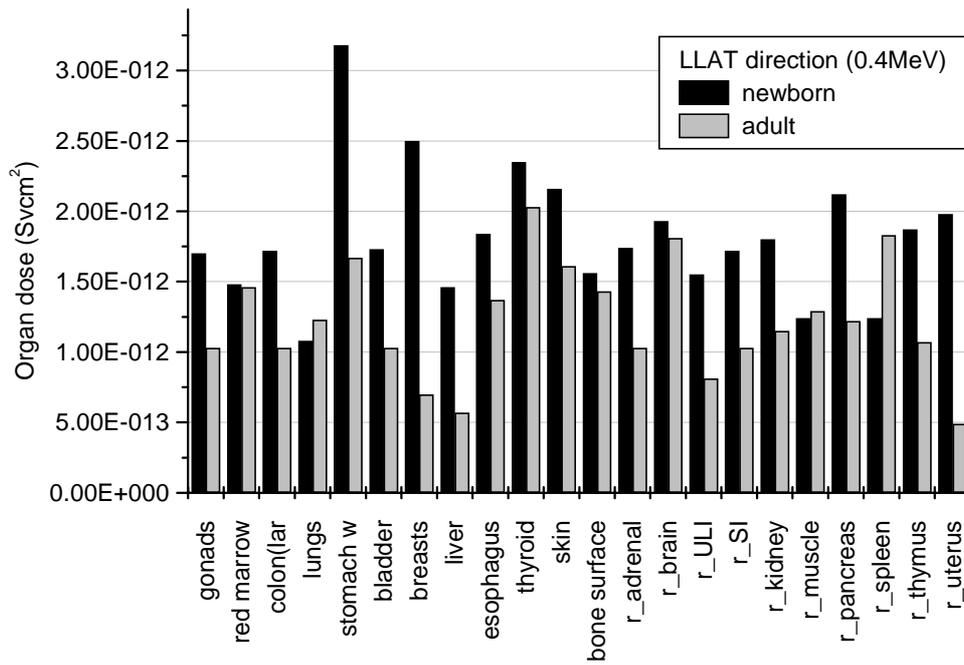


Figure 6. Organ dose of newborn and adult phantom irradiated by 0.4MeV gamma beam from LLAT direction

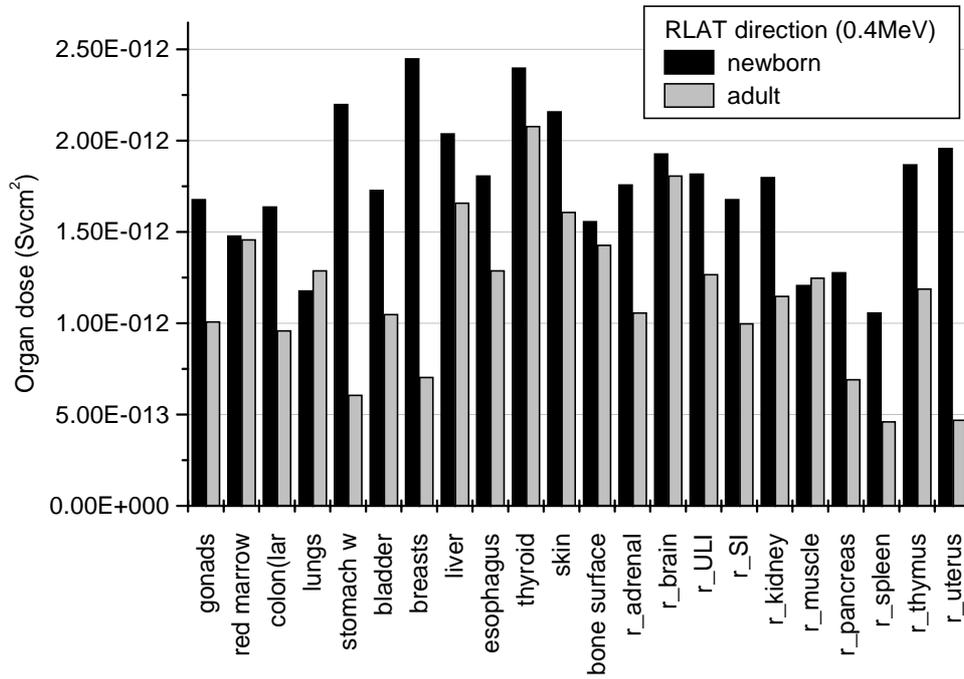


Figure 7. Organ dose of newborn and adult phantom irradiated by 0.4MeV gamma beam from RLAT direction

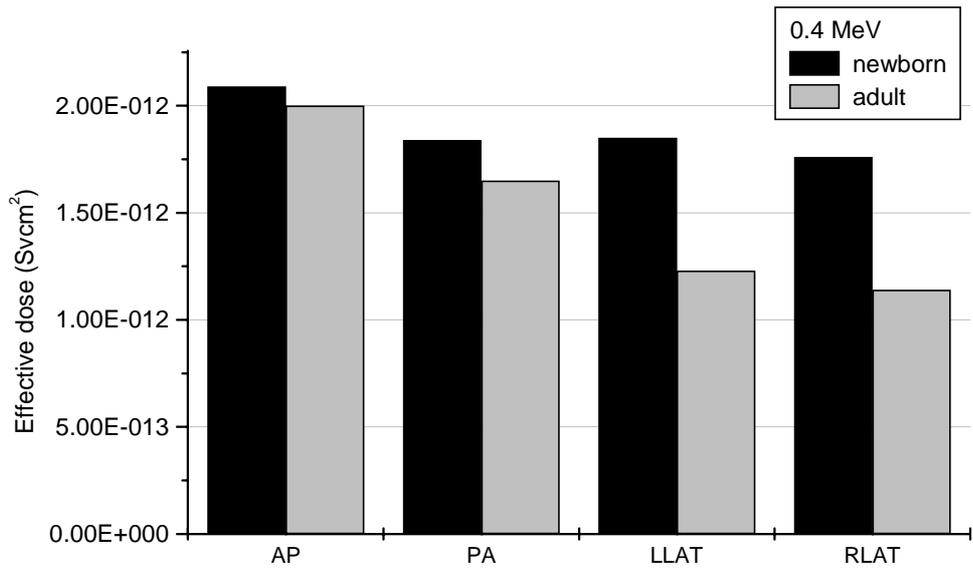
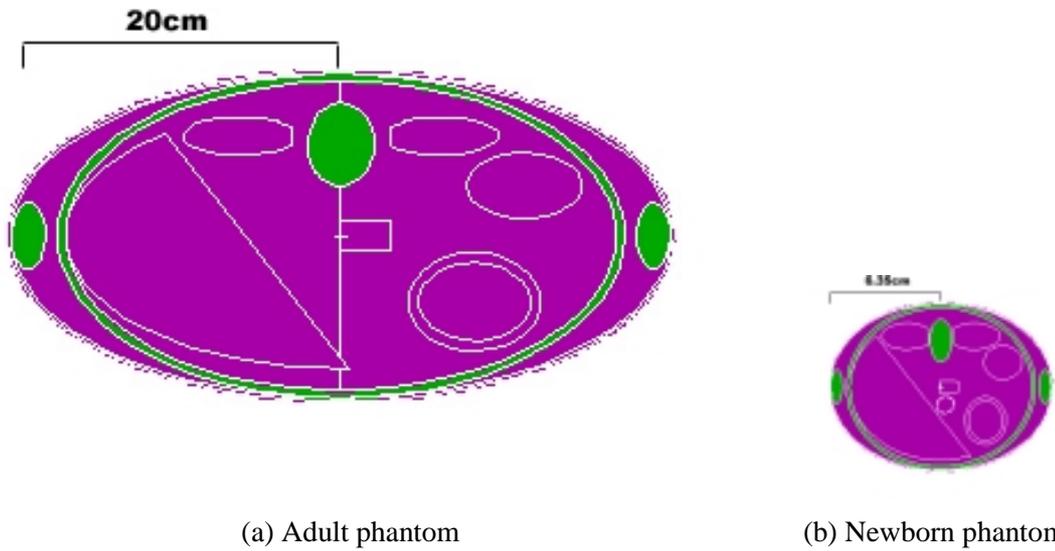


Figure 8. Comparison of effective dose between newborn and adult phantoms for 0.4MeV gamma beam in 4 directions(AP, PA, LLAT and RLAT).



(a) Adult phantom

(b) Newborn phantom

Figure 9. Comparison of depth of organs between (a) adult and (b) newborn phantoms

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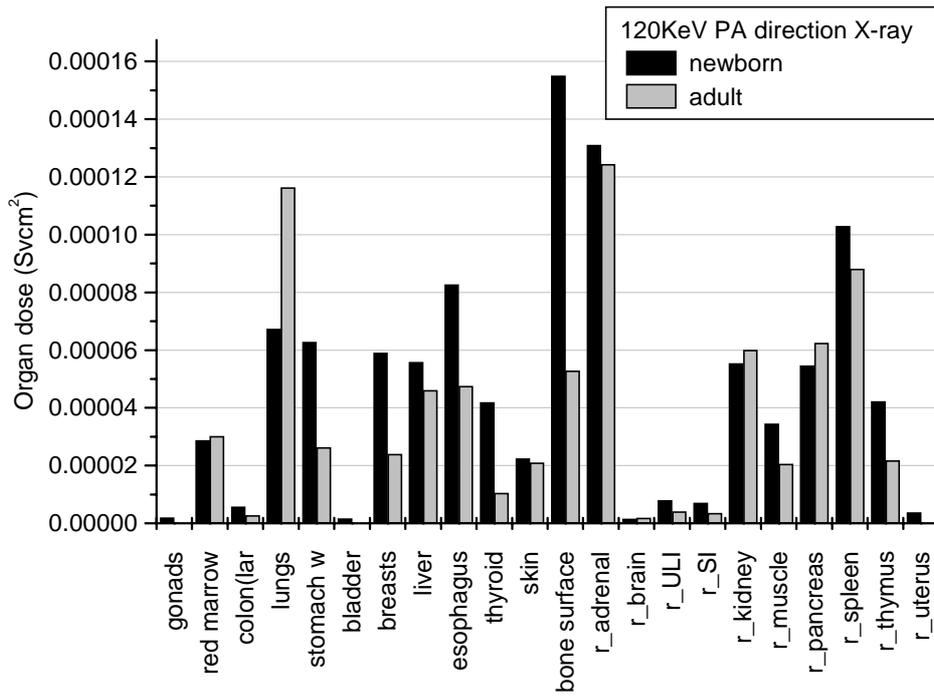


Figure 10. Comparison of organ doses between newborn and adult phantoms in chest PA x-ray examination

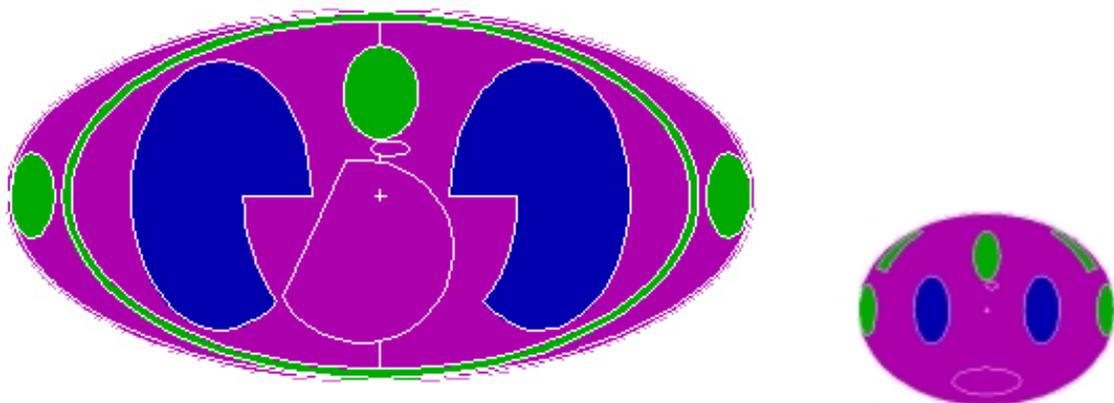


Figure 11. Comparison of lung shapes between newborn and adult phantoms

