Necessity to Update Radiation Dose Calculation Programs of Computed Tomography

Jaekook Lee[1], Il Park[2], Kwang Pyo Kim[2]

[1] Korea Institute of Nuclear safety, Yuseong-gu, Daejeon, Korea

[2] Department of Nuclear Engineering, Kyung Hee University, Seocheon-dong, Giheung-gu, Yongin-si, Gyeonggi-do, Korea

Background

❖ **Concern of Radiation Exposure from CT scans**

- **Rapid increase of CT use**
- **High dose per scan:** ~ hundreds times of that from chest x-ray
- **Risk projection studies**

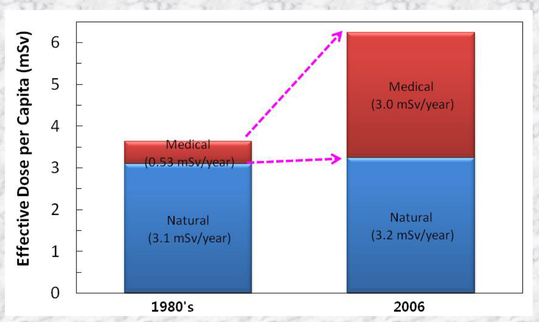


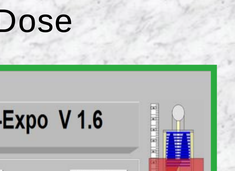
Figure . Effective dose per capital in the US (NCRP report 160)

❖ **CT Dosimetry Programs**

- **Programs:** CTDosimetry, CT-Expo, etc. → Used without consideration of the their difference and their limitations
- **User friendly programs:** easy to use
- **Data source:** NRPB or GSF databases → Old data generated in late 1980s

❖ **Time to Update under ICRP 103 and Improved Dosimetry technology**

- More organs and tissues in ICRP 103
- Recommend to use of image based male and female phantoms
- Pediatric phantoms
- Heterogeneous bone structure



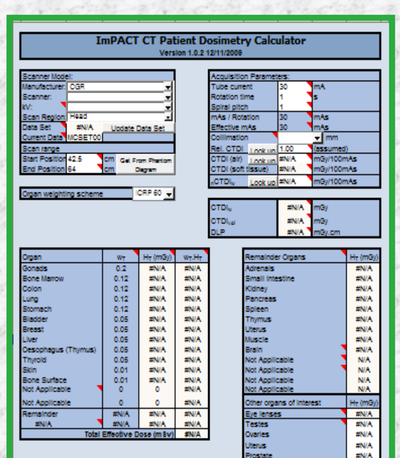
Objectives

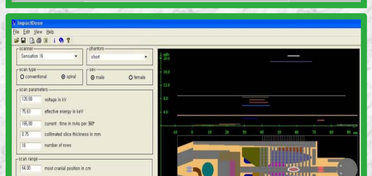
- ❖ **To compare radiation doses calculated by different CT dosimetry program**
- ❖ **To review limitations of the current CT dosimetry programs**
- ❖ **To suggest necessary future studies for CT dosimetry improvement**

Material and Methods

❖ **Dosimetry Programs**

- CTDosimetry, CT-Expo, ImpactDose





❖ **Dose comparison by computer programs**

- By scan type
- By scanner type

❖ **Dose comparison by sex and age**

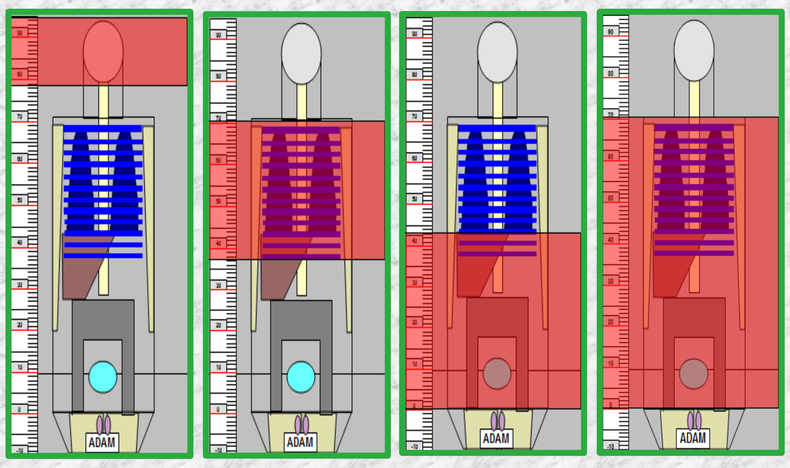
- CT EXPO
- Only program applicable to pediatrics

❖ **Calculation of Radiation Doses**

- **CT scanners:** Scanners more than 16 Slices from GE, Siemens, Philips, and Toshiba
- **Scan type:** head, chest, abdomen/pelvis, whole body
- **Technical settings:** 120 kVp, 100 mAs, Collimator width = 10 mm, Pitch = 1

❖ **Scan Regions**

- **Head scan:** Top of head to CV 2
- **Chest scan:** Shoulder to mid of liver
- **Abd/pel scan:** Top of liver to end of pelvis
- **Whole body scan:** Shoulder to end of pelvis



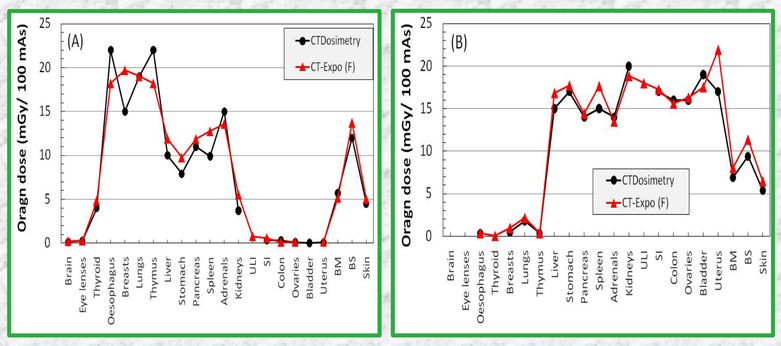
Results and Discussion

❖ **Organ dose by scan region**

- Organs in scan region: ~ > 10 mGy/100 mAs
- Organs partially within or close to scan region : 1 – 10 mGy/ 100 mAs
- Organs far from scan region: < 1 mGy/100 mAs

❖ **Radiation dose by CT Dosimetry Program**

- Generally similar, but relative large difference in some organs
- 40% higher dose in CT EXPO for Siemens scanners
- Due to higher $CTDI_w$: Value = 8.8 mGy for CT Expo but 6.8 mGy for the others



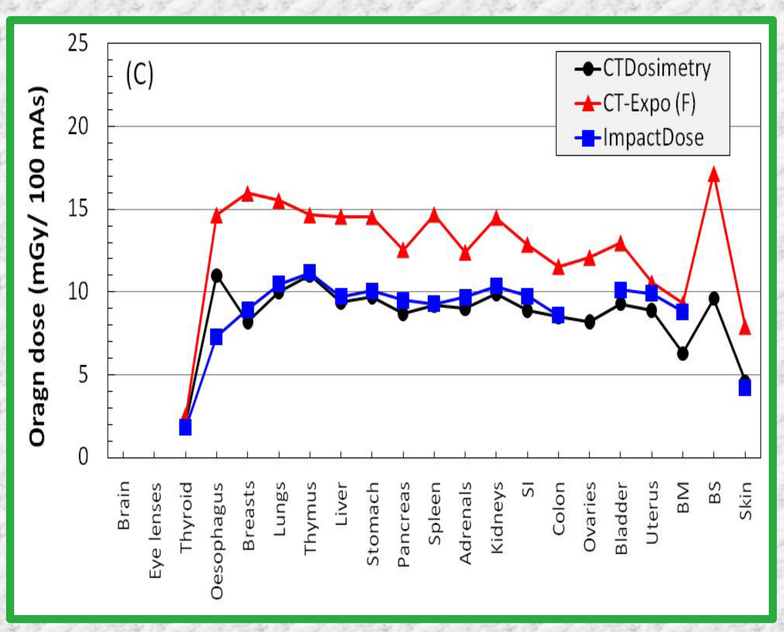
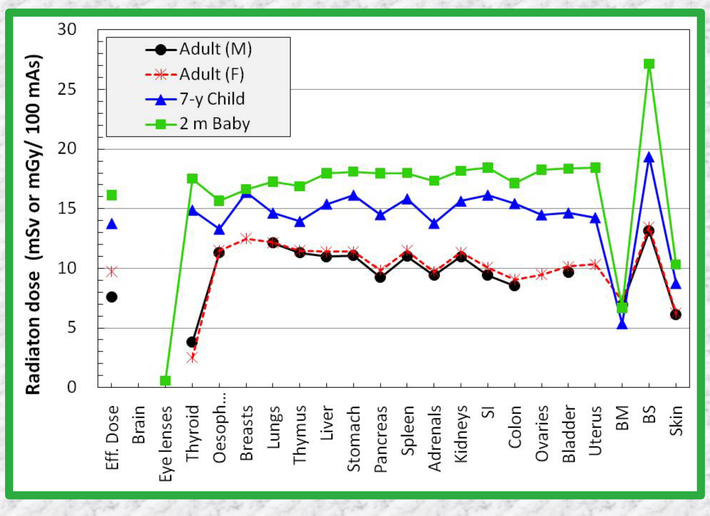


Figure . (A) Chest scan by LightSpeed VCT
(B) Abdomen/Pelvis scan by Aquilion
(C) whole body scan by Sensation 64

❖ **Radiation Doses by Sex and Age:**

- **Dose (Female) > Dose (Male):** About 5% due to small body size
- **Dose (pediatric) > Dose (Adult):** 40% higher for 7-year child and 70% higher for 2-month baby



❖ **Necessary Future Studies for CT Dosimetry and (← Limitations of CT dosimetry programs)**

- ➢ **Generation of dose database by sex** (← Radiation dose to hermaphrodite phantom)
- ➢ **Dose database by patient age** (← Radiation dose to adult or few pediatrics)
- ➢ **Dose to individual with different height and weight**
- ➢ **Dose database based on realistic anatomy** (← Database based on stylized phantom)
- ➢ **Inclusion of doses to organs in ICRP 103** (← organs in ICRP 60)
- ➢ **Improved bone marrow dosimetry considering heterogeneous skeletal tissue**
- ➢ **Application to various CT scanners**
- ➢ **Implementation of recent CT scan technologies (e.g., mA modulation, dual sources)**

Conclusion

- ❖ **Radiation doses from CT scans were calculated using different CT dosimetry programs.**
- ❖ **Radiation doses generally were comparable but large differences were observed for some specific organs or tissues.**
- ❖ **Relatively big difference was observed in Sensation CT scanners.**
- ❖ **There are a number of limitations of current CT dosimetry computer programs.**
- ❖ **It is necessary to use the programs with consideration of the potential dose difference and the limitations.**
- ❖ **Therefore, further studies are necessary to overcome the limitations and to improve CT dosimetry.**