Necessity to Update Radiation Dose Calculation Programs of Computed Tomography

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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

- 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 programs
- To review limitations of the current CT dosimetry programs
- To suggest necessary future studies for CT dosimetry improvement

Material and Methods

- 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 CTDIw: Value = 8.8 mGy for CT Expo but 6.8 mGy for the others

- 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.