



# **Radiation protection of patients in computed tomography Summary of contributed papers**

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# Content

21 papers from 14 countries

- Children protection (3 papers)
- Eye lens protection (3 papers)
- Angiography, cardiac & chest CT (4 papers)
- Head CT (2 papers)
- Multidetector CT (2 papers)
- Miscellaneous (7 papers)
- Conclusion

- Children are more sensitive to radiations (young tissues + longer life expectancy)
- CT is a high dose technique
- Children are not small adults = Specific CT protocols needed
- **DRLs in greater Korasan province (Barheyni Toussi - Iran)**
  - 7 randomly selected hospitals in 5 cities
  - 4 most common CT examinations (brain, chest, abdomen, pelvis)
  - Spiral protocol with head and trunk phantoms
  - 3 age groups (< 5, 5-10, 10-15 yo)
  - $CTDI_w$  and  $CTDI_{vol}$
  - DRL values smaller than UNSCEAR 2007 values
  - Satisfactory situation = qualified and RP trained technologists

### ➤ **Pediatric doses in Tehran (Khosravi - Iran)**

- 9 CT scans in 7 Tehran hospitals
- Standard head PMMA phantom
- 4 age groups (<1, 1-5, 5-10, 10-15 yo)
- CTDI<sub>w</sub> and DLP
- Results in the range of international values but CT and hospital dependent
- Optimisation needed

- **RP in pediatric CT in Buenos Aires (Rizzi – Argentina)**
  - Real Issue for children referred with a previous scan poorly realized
  - CT protocol designed for each child
  - 80kV reduces doses by 50% for same diagnostic quality
  - Scan delay time after contrast injection takes into account cardiac frequency = optimisation
  - Information and training of health teams on RP +++
  - Promotion of medical physics

- CT dose to eye lens increasing = risk of cataract
- ICRP threshold 0.5 Gy to avoid deterministic effects with occupational equivalent dose limit 20 mSv/year (average on 5 years, no single year > 50 mSv)
- **Reducing dose by adjusting beam path (Schmidt – Giessen - Germany)**
  - ICRP adult female phantom + Monte Carlo simulations
  - Dose change according to the eyes position within or close to the scan field
  - Effect of back of head with adapted spiral scan path to protect eyes
  - Direct eye exposure with standard head CT protocol = 35 mGy
  - Doses decrease by 3 in penumbra, by 10 when eyes outside the field and by 2.4 when back of head as protection (pitch 1.5)
  - No effect for pitch 1 or less

- **Eye and Thyroid dose from head CT (Curci Daros – Sao Paulo – Brasil)**
  - Standard head PMMA phantom + TLDs
  - Effect of gantry angulation  $-10^{\circ}$  and  $-20^{\circ}$  for single slice CT / Multidetector CT
  - Significant dose reduction for  $-20^{\circ}$  gantry angulations

### ➤ Eye dose with iterative reconstruction (Yoshimura – Sao Paulo – Brasil)

- Alderson head phantom + TLDs
- ASIR algorithm to reduce noise in acquired low dose imaging
- Comparison with Filtered back projection
- Evaluation with signal to noise ratio and contrast to noise ratio
- ASIR compensates the charge reduction from 310 to 100 mA.s
- Not as efficient with patient data



- High doses related to increased spatial and temporal resolution
- Increase use of CT
- **Image quality and dose in cardiac CT (Garcia-Pinto – Madrid - Spain)**
  - CT coronary angiography (2CT 64 and 320 slices)
  - Synchronization with patient's ECG and selection of best reconstruction cardiac phase (prospective or retrospective gating)
  - Evaluation on PMMA QRM thorax phantom simulating arteries : contrast to noise ratio, normalized area and structural similarity
  - Prospective gating dose less than retrospective gating (factor 2.6)
  - Complex results but useful method to analyze the influence of parameters (kV, contrast injection rate, heart rate, reconstruction filters ..) on the quality of images



#### ➤ **Coronary CT angiography (Sun – Perth - Australia)**

- Factors affecting dose : scan geometry, scan range, tube current and voltage, prospective vs retrospective gating, heart rate, slice thickness, noise and pitch
- Dose reduction from 10 mSv to 1 mSv is possible with
  - lower tube voltage from 120 kV to 100/80 kV (adapted to body mass index)
  - high pitch acquisition in 3D with dual source CT
  - prospective gating
  - Iterative reconstruction (better than filtered back projection)



#### ➤ **Doses from CT angiography in Sudan (Elnour – Khartoum - Sudan)**

- 2 CT in 2 hospitals
- DLP measurements in patients
- Evaluation by Sudan Atomic Energy Commission
- A factor 2.2 difference of mean values DLP between the 2 hospitals
- Optimisation to be achieved



- **Optimisation of dose in chest CT (Tamam – Khartoum - Sudan)**
  - Patient study
  - Comparison of standard protocol vs optimized protocol : increase pitch factor, patient related parameters and exposure related parameters
  - Dose reduction by a factor  $\approx 3$

- **CT Optimization in National Institute of Cancer (Kodlulovich – Rio de Janeiro – Brazil)**
  - Multidetector MDCT evaluation
  - CATPHAN model 504
  - Dose / noise level vs mAs for each pitch to establish the optimal technique
  - Determination of optimal technique and quantification by a factor of optimization
  - 56 % dose reduction in head CT with optimized protocols with no loss in image quality

- **Kernel selection in head CT optimization ( Silveira – Rio de Janeiro – Brazil)**
  - Head CT = highest collective dose for CT
  - Image quality phantom of ACR with MDCT (3 different manufacturers)
  - CTDI<sub>vol</sub> and CNR evaluation for different reconstruction filters
  - Decrease dose up to 40 % possible for same image quality

- **Comparison of 4 slice and 64 slice CT (Srivastava – Delhi – India)**
  - DLP and estimated effective doses in 4 slice and 64 slice CT of same manufacturer
  - Manufacturer's protocols for brain, chest and abdomen
  - Significant reduction of doses (50% on average) for brain CT with 64 slice CT/ 4 slice CT
  - No significant reduction of doses for chest and abdomino-pelvic studies

- **RP of patients with Multidetector CT (Chaturvedi – Mumbai – India)**
- Helical and multislice scanning (MDCT) allows a reduction of scanning time (e.g., whole body scanning time < 1 minute)... responsible for the increase in the number of procedures and the collective dose
- More examinations in a given time, extension of scope of examination before the patient leaves the room, introduction of new techniques
- Justification, optimization, quality assurance to be reinforced and controlled by regulators



- **Validation of Radiology Information System (RIS) dose / DICOM data (Couch – Liverpool – UK)**
  - Reliability of dose data in DICOM headers for audit purposes
  - High prevalence of impossible values: zero dose or extremely high doses
  - Manual entry of dose data in RIS / automatic registration in DICOM
  - Impossible to remove errors in RIS by statistical means
  - RIS is reliable if cleansed of unfeasibly large or small values

- **Dose of CT survey scans (Bohrer– Giessen – Germany)**
  - Tool to optimize patient positioning and scan range (scout view)
  - Often assumed to be negligible ( $< 1\%$  of CT dose)
  - Rando Alderson phantom and TLD measurements with MDCT
  - Up to 28% of CT dose in optimized sinusitis CT, 2-5% for chest, abdomen, pelvis

- **Risk of CT exposures : organ / effective doses (Ivanov – Obninsk – Russia)**
  - So far consensus on the use of effective dose for estimating risk
  - ICRP proposal (Brenner) for calculation of effective risk, i.e., summed of organ doses weighted with actual epidemiologically-based cancer risks
  - More emphasis on cancer incidence than cancer mortality
  - Life time risk evaluated by effective risk can be 3 times greater than effective dose risk

- **Body mass index influence on CT effective dose (Niiniviita–Turku – Finland)**
  - Target scanning areas: Thorax, abdomen and whole body with or without contrast
  - NRPB software to determine organ and effective doses
  - Significant increase of doses with BMI increase, up to 3.35mSv and 6 mGy for effective dose and absorbed dose for patients with BMI  $>30\text{kg/m}^2$  vs BMI  $<25\text{kg/m}^2$
  - Optimization needed essentially for whole body and abdomen scanning

- **Optimization study of CT doses in Cuba (Fernandez Herrera-Havana – Cuba)**
  - Evaluation in 3 CT in Havana as a preliminary study for Cuba (IAEA project RLA/9/607)
  - Air kerma index ( $C_{vol}$ ) and length product ( $P_{KL}$ ) estimated for each procedure
  - Analysis of results take also into account tube voltage & current, gantry rotation time, collimation and slice thickness, pitch and length, type of protocols (prerecorded or not)
  - Wide variation of air kerma values = Good basis for the evaluation of 80 new CT in Cuba

- **Optimization study of CT doses in Ankara (Bulur - Ankara – Turkey)**
  - Evaluation in 5 CT in Ankara for optimization
  - Head and body ACR phantoms + pencil type ionisation chambers and electrometers
  - 16 row MDCT with 5 different routine protocols
  - Tube current and voltage reduced until image quality was not significantly decreased
  - Reduction of  $CTDI_W$  by 46 % by reducing tube current from 240mA to 115mA
  - Main outcomes :
    - establishing DRL for Turkey
    - disseminate radiation protection culture and training

- **Personalized organ CT dose with Monte Carlo (Castra – Giessen – Germany)**
  - Evaluation of breast & lung CT dose in 21 female patients
  - Contouring of organs
  - Virtual CT scanner (Siemens volume zoom): 120kV, 135 mAs, collimation 10mm, 1.5 pitch
  - Personal dose calculation with homemade Monte Carlo software package
  - Significant decrease of organ doses with increasing breast volume
  - Comparison with simulations of female ICRP voxelized phantom : good on the average, but individual variation depending on patient geometry in the range of  $\pm 20\%$
  - Confirm ICRP 103 recommendation of individualization of phantoms