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 protection (3 papers) 1

- 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

Children protection (3 papers) 2

- **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)
  - CTDIw and DLP
  - Results in the range of international values but CT and hospital dependent
  - Optimisation needed

Children protection (3 papers) 3

- **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

Eye lens Protection (3 papers) 1

- 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 lens Protection (3 papers) 2

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

Eye lens Protection (3 papers) 3

- **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

Angiography, cardiac & chest CT (4 papers) 1

- 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

Angiography, cardiac & chest CT (4 papers) 2

➢ 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)

Angiography, cardiac & chest CT (4 papers) 3

- **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

Angiography, cardiac & chest CT (4 papers) 4

- **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 ≈ 3

Head CT 1

➢ **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

Head CT 2

➢ **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)
- CTDIvol and CNR evaluation for different reconstruction filters
- Decrease dose up to 40 % possible for same image quality

Multidetector CT 1

- **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

Multidetector CT 2

➢ **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

Miscellaneous 1

- **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

Miscellaneous 2

- **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

Miscellaneous 3

➢ **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

Miscellaneous 4

- **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 >30kg/m² vs BMI <25kg/m²

• Optimization needed essentially for whole body and abdomen scanning

Miscellaneous 5

- **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

Miscellaneous 6

➢ **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

Miscellaneous 7

➢ **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 ± 20%
- Confirm ICRP 103 recommendation of individualization of phantoms