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Preventable exposure in routine chest CT examinations: evaluation of effective dose beyond prescribed anatomical landmarks

A. Barbara, J. Ferreira, L. Lanca; *Lisboa/PT*

Objective

- Evaluate preventable exposure dose in routine chest CT examinations beyond prescribed anatomical landmarks and estimate extra dose delivered to the patient.

Background/rationale

- Recent technical advances have greatly increased the clinical applications of CT.
- Developments in multidetector-row CT (MDCT) technology have occurred.
- The major disadvantage with the increased use of MDCT is associated radiation exposure[1,2,3].

1 - McCollough C, Primak A, Braunc N, Kofler J, Yu L, Christner J. Strategies for Reducing Radiation Dose in CT. Radiol Clin North Am. 2009;47(1):27–40. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2743386/pdf/nihms131985.pdf

2 - Gray JE, Archer BR, Butler PF, Hobbs BB, Mettler F a, Pizzutiello RJ, et al. Reference values for diagnostic radiology: application and impact. Radiology [Internet]. 2005 May;235(2):354–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15758190

3 - Lee EJ, Lee SK, Agid R, Howard P, Bae JM, terBrugge K. Comparison of image quality and radiation dose between fixed tube current and combined automatic tube current modulation in craniocervical CT angiography. AJNR. American journal of neuroradiology [Internet]. 2009 Oct [cited 2012 Nov 9];30(9):1754–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19509074

Background/rationale

- Some studies have demonstrated the use of different strategies for reducing the dose in CT examinations[4]
  - automatic modulation current;
  - automatically selecting the technical parameters;
  - automatic collimation adapted to the patient;
  - use of post-processing images.

4 - Zanca F, Demeter M, Oyen R, Bosmans H. Excess radiation and organ dose in chest and abdominal CT due to CT acquisition beyond expected anatomical boundaries. European radiology [Internet]. 2012 Apr [cited 2012 Dec 15];22(4):779–88. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22105842

Background/rationale

- Ninety-eight percent (98%) of thoraco-abdominal and pelvic CT scans showed an increase in the volume of images obtained compared to the volume of interest, thus translating the contribution of excess dose to the patient[4].

4 - Zanca F, Demeter M, Oyen R, Bosmans H. Excess radiation and organ dose in chest and abdominal CT due to CT acquisition beyond expected anatomical boundaries. European radiology [Internet]. 2012 Apr [cited 2012 Dec 15];22(4):779–88. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22105842

Background/rationale

- Since there are several studies that show the importance of acquiring strategies for dose reduction in CT examinations, it is essential to appreciate that such additional images may also contribute to the increase in dose examinations, since patients being radiated beyond the intended area of interest[5,6].

5 - Liao E, Quint L, Goodsitt M, Khalatbari S, Myles J. Extra Z-axis Coverage at CT Imaging Resulting in Excess Radiation Dose: Frequency, Degree and Contributory Factors. J Comput Assist Tomogr 2012;35(1):50–6.
6 - Kalra MK, Maher MM, Toth TL, Kamath RS, Halpern EF, Saini S. Radiation from “extra” images acquired with abdominal and/or pelvic CT: effect of automatic tube current modulation. Radiology [Internet]. 2004 Aug;232(2):409–14. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15286312

Background/rationale

- CT examination planning is the focus of our study.
- Thus, the optimization of radiation exposure is crucial and this must be considered as one of the most important tasks when planning the scan.

Research question

- To what extent the exam planning is rigorous?
- According to the European guidelines, which is considered a rigorous planning?
- Does the range of exposure is exactly what we need and we are not radiate the patient beyond the limits that are supposed to?

Study type

- Observational study based on a retrospective and transversal design.
- The observational component of this study is based on information available from the clinical field (CT scans), which was authorized maintaining the confidentiality of data related to the patients.
- The data was collected from DICOM tags.

Patients

- A sample of 102 routine adult chest CT examinations (53 male and 49 female) was retrospectively analysed.
- Ages between 25 and 87 years old.

Study protocol

Hospital Protocol– Chest CT	
Equipment	GE light speed ultra - 8 slices
Tube Potential (kVp)	120
Intensity*time (mAs)	225
Colimation (mm)	8x5
Pitch	1,35
Thickness reconstruction(mm)	1,25/ 2,5/ 3,75
Range	Apical lungs to costophrenic angles

CT – Expo V 2.1

- The CT- Expo is a Microsoft Excel spreadsheet for dose calculation in patients undergoing CT examinations.
- CT- Expo offers a mathematical phantom for females and males (figure 1)
  - EVA (160 cm and 60 kg)
  - ADAM (170 cm and 70 kg).

Statistical analysis

- Descriptive statistics and one sample t-test at a 95% confidence interval (CI) was performed to test any statistical differences between
  - effective dose from the performed CT scans and;
  - the desirable scans accurately planned and referenced to the prescribed landmarks

Data analysis

Prescribed anatomical landmarks *vs* ideal limits:

→ *Software:* GE Centricity Dicom Viewer

Calculation and estimation of doses:

→ *Software* CT – Expo V 2.1

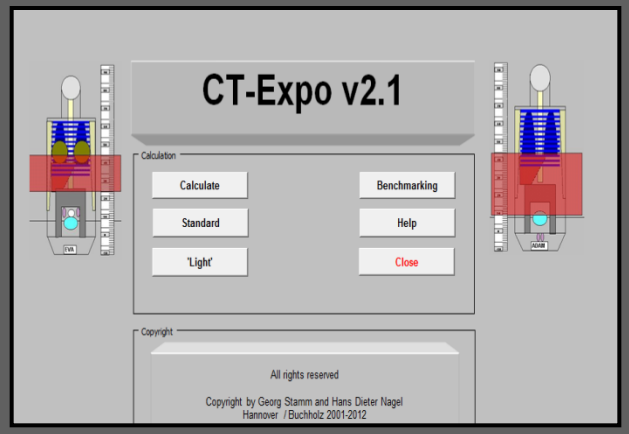
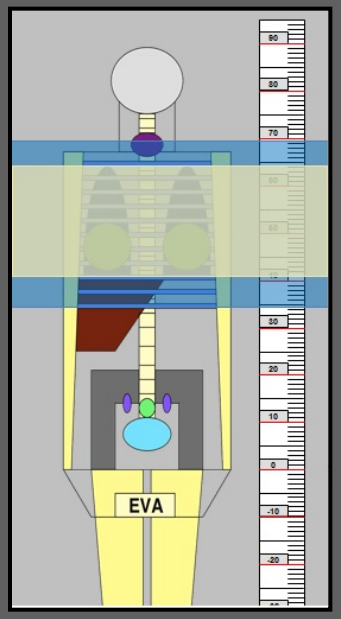


Fig.1 Illustrative picture of *software* CT – Expo V 2.1



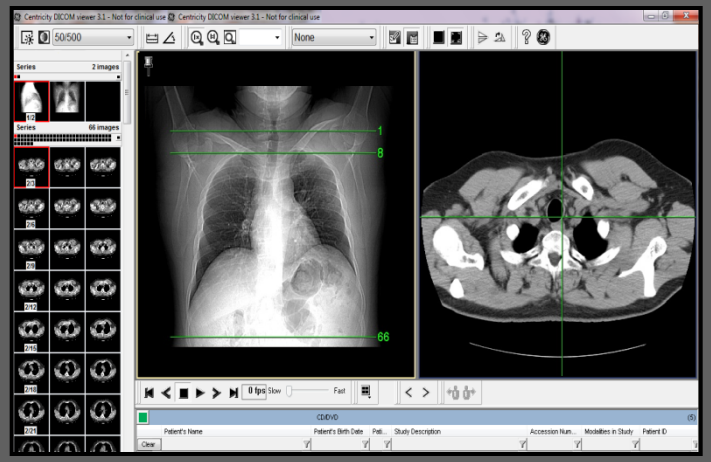
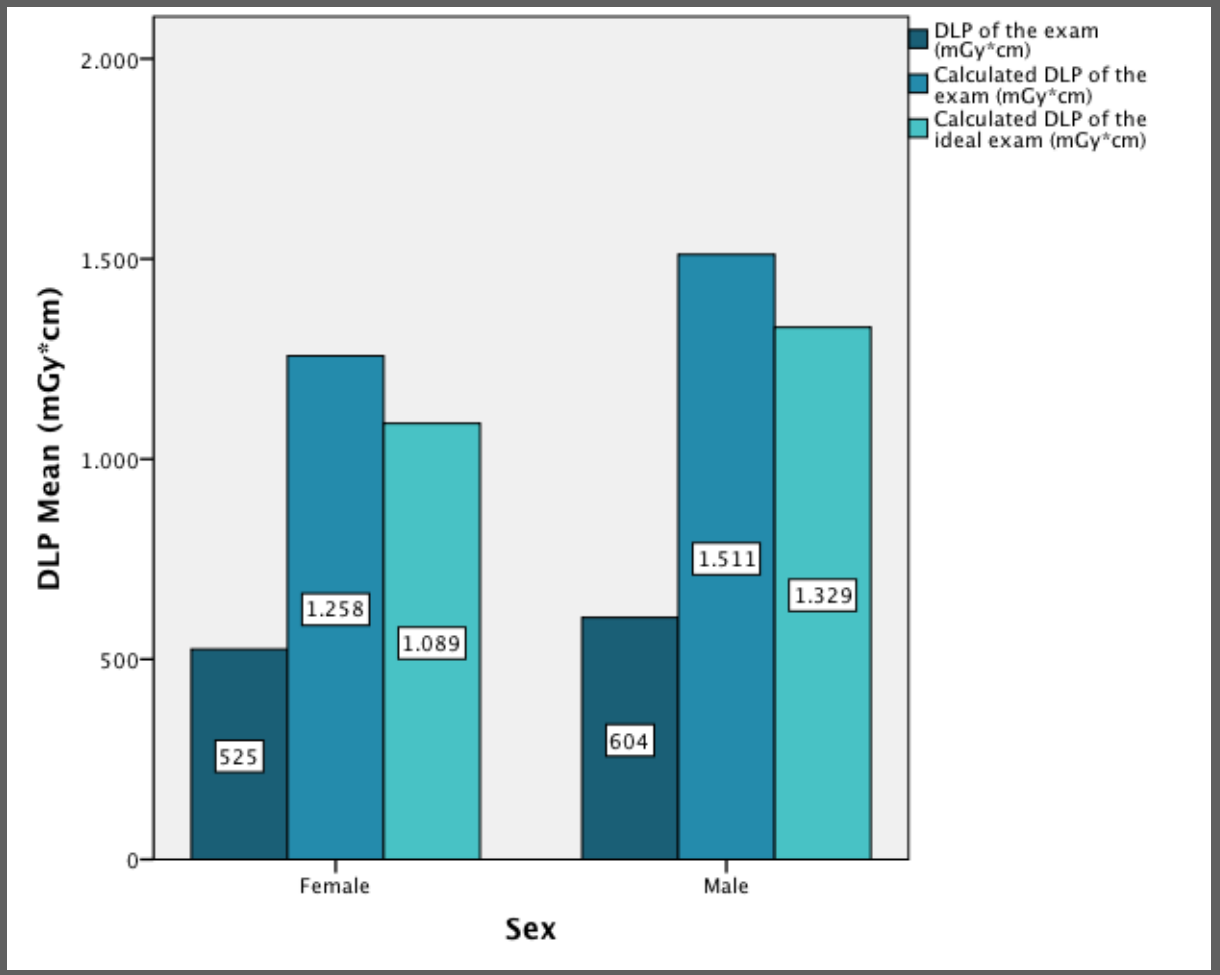


Fig.2 Illustrative picure of *software* GE Centricity Dicom Viewer

Fig.3 Illustrative picture of software CT- Expo – Prescribed Range vs Ideal Range vs *Range* Ideal

- G.Stamm H, H.D Nagel B. CT-Expo V 2.1 - A Tool for Dose Evaluation in Computed Tomography - User's Guide. 8th ed. 2012.
- Healthcare GE. Centricity OneView [Internet]. 2013. Available from: http://www3.gehealthcare.com/en/Products/Categories/Healthcare_IT/Medical_Imaging_Informatics_-_RIS-PACSCVIS/Centricity_OneView#tabs/tab0643B97DBC704EF4A2E17FCB4BDB6D0A

DLP Results


DLP of the exam (mGy*cm)
Calculated DLP of the exam (mGy*cm)
Calculated DLP of the ideal exam (mGy*cm)
DLP Mean (mGy*cm)
2.000
1.500
1.000
500
0
525
1.258
1.089
604
1.511
1.329
Female
Male
Sex

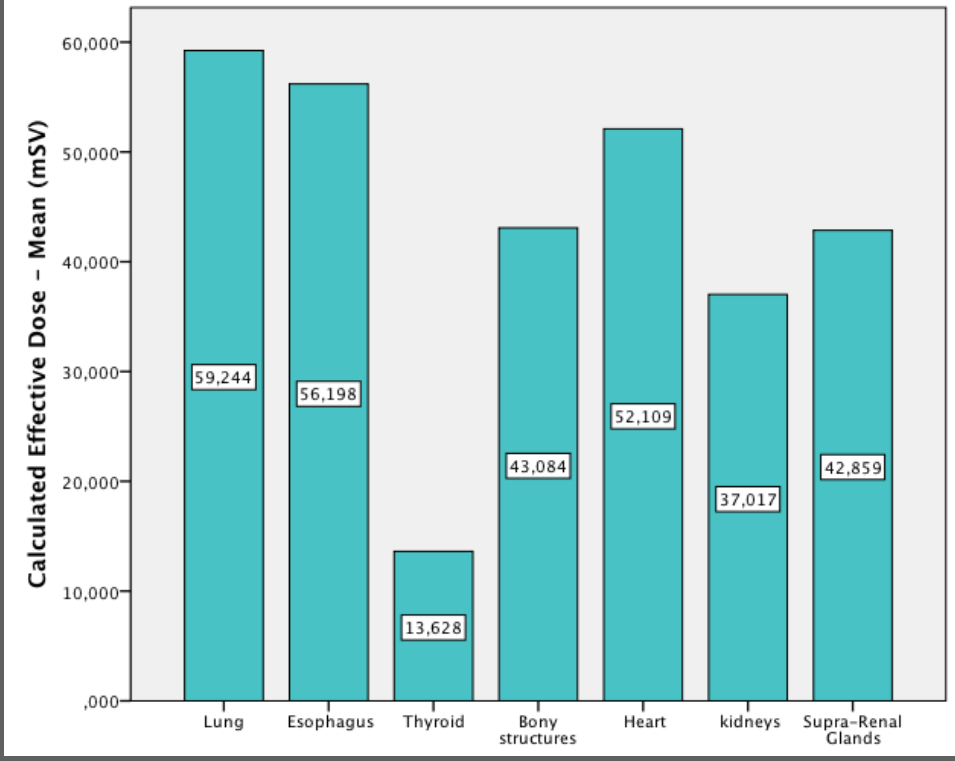
DLP Results

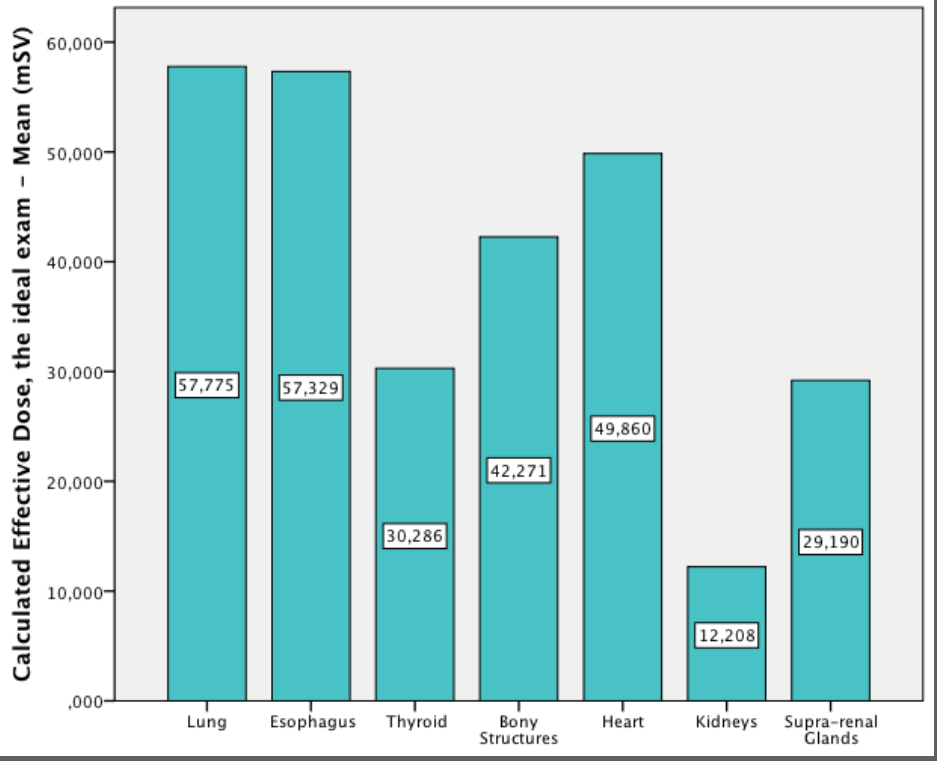
- Average DLP examination carried out > DLP Average of total calculated exams and ideals.
- DLP average calculated for the ideal exam < DLP average calculated for the total examination
  - As expected to happen, since the range is less.

Discussion

- 93% of chest CT examinations were planned and acquired beyond the prescribed anatomical landmarks.
- The mean effective dose in the 7 organs for the acquired exam versus the desirable prescribed landmarks under the routine scanning protocol was as follows.

Organs Results





Organs Results

- The radiation dose is higher in the lungs, esophagus , heart and bone structures .
- Thyroid , kidney and the adrenal glands, the dose is lower.
- Levels of effective dose thyroid < the ideal test.
- Levels of effective dose to the kidneys > that the ideal test.

Organs Conclusion

- Statistical significant differences in effective dose ($p<0.05$) were found in all organs, where extra-coverage was found, except thyroid.
- Major differences were found in kidneys (24.8 mSv) and thyroid (-16.7 mSv) due the fact that those organs are located at the anatomical boundaries.

Conclusions & take-home messages

- When the prescribed guidelines for CT scans of the chest are considered and applied, it results in a decrease of the dose received by the patient.

- An accurate scanning protocol should be followed to avoid unnecessary dose delivered to the patient.

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joanafragaferreira@gmail.com