Our Contribution to the EuroSafe Imaging Call of Action
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CT dose registry with image quality quantification: an added value

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Aims and objectives

In recent years, the general public and the authorities have taken a greater interest regarding the ionising radiation doses received by patients exposed to medical imaging studies. The main regulatory body in Europe, the European Commission, published a directive (2013/59/EURATOM) in 2013 emphasising this issue. This directive requires registering the ionising radiation exposure to patients. It is therefore essential to fully control the radiation dose received by patients undergoing radiographic examinations.

Furthermore, as image quality is directly affected by the dose, this radiation dose must be related to final reconstructed image quality to always guarantee optimal and adequate diagnostic performance. In this regard, the optimisation criterion ALARA (as low as reasonably achievable) must be followed. This criterion prioritises exposing the patient to a dose of ionising radiation that is as low as reasonably achievable without losing the diagnostic efficacy of the radiological exam.

To achieve these goals, we have objectively set the automatic registration dose from all modalities involving ionising radiation. In this study we will evaluate both the CT dose record and the image quality quantification (border definition, noise) through automatic processing by using representative parameters.

Methods and Materials

In order to record the patient's radiation dose, the solution developed at Hospital Clínico Madrid was installed. This solution consists of a DICOM storage service class provider that receives the CT images as RDSR routing directly from the PACS. The system receives images and automatically generates a structured file containing the complete contents of the DICOM header of each study, as well as the information extracted from the RDSR. After finalising the reception of the studies, the structured file is processed to store all the relevant previously defined information in the database. Moreover, the system provides a tool to establish different levels of alert for detecting anomalous situations. These alerts are automatically sent via e-mail.

For the image quality part, an automatic tool to assess image quality from the patient's images has been developed. Border definition, representing spatial resolution, and image noise were evaluated as the main image quality parameters. Spatial resolution was obtained from each study and expressed as the mean value of the 10 observations at 10% of the modulation transfer function MTF. The extracting edge spread function was calculated (ESF) by segmenting image sections to get the edge and obtaining 10 perpendicular lines across it. After deriving the ESF and applying the Fourier Transform, 10 MTFs were calculated.

Results

Using QCOLINE, the registration CT doses of the last three years were retrospectively obtained from the PACS. Scans acquired between 01/01/2014 to 01/10/2014 were checked and a total of 21.877 CT examinations were extracted. In Table 1 the CT examinations are structured by body part, showing the DLP average and effective dose average. For 'others', the average DLP and effective dose were not calculated as meaningless.

	Number of explorations	Percentage (%)	DLP average (mGy cm)	Effective Dose average (mSv)
Abdomen/Pelvis	5,232	23.92	684.60	10.26
Chest	2,747	12.56	491.30	6.88
Head	7,436	33.99	741.00	1.60
Neck	814	3.72	568.10	3.37
Other	5,648	25.82	-	-

Tab. 1: Exploration, percentage of explorations, DLP average and Effective Dose average by body part

In the second step, we further evaluated the maximum values, quartiles and minimum values for each body region (Table 2).

	Abdomen/Pelvis		Chest		Head		Neck	
	DLP (mGy cm)	Effective Dose (mSv)	DLP (mGy cm)	Effective Dose (mSv)	DLP (mGy cm)	Effective Dose (mSv)	DLP (mGy cm)	Effective Dose (mSv)
Min. Value	201.30	3.02	24.50	0.38	55.96	0.25	160.70	0.95
1st quartile	573.20	8.60	214.85	3.01	721.80	1.54	322.95	1.90
2nd quartile	725.60	10.87	322.00	4.51	775.90	1.63	425.35	2.51
3rd quartile	832.55	12.49	573.55	8.03	902.30	1.90	993.83	5.86
Max. Value	2,052.30	30.78	2673.40	37.43	4,411.60	9.26	3,056.50	18.03

Tab. 2: Maximum value, quartiles and minimum value of DLP and Effective Dose by body part

To correlate radiation dose and image quality, the CT image quality of those studies in the first quartile with low doses and in the third quartile with high doses was assessed. The image quality was assessed from studies with the same protocol.

	Abdomen/Pelvis	Chest	Head	Neck
1º quartile	0.75	1.84	7.14	1.12
3º quartile	0.51	1.19	0.15	0.76

Tab. 3: Values of noise in a study of 1st quartile and 3rd quartile

In table 3, the mean noise values obtained from homogeneous regions within the images are represented. Noise values are higher for images from above the first quartile, as they were acquired with lower doses. Spatial Resolution (Figure 1) by border definition analysis was found to be constant, around 0.6 cy/mm, and independent of radiation dose.

Fig. 1: Screenshot of the software developed to calculate noise and spatial resolution

Conclusion:

Hospitals with a high number of CT examinations are likely to carry out procedures with high variability in radiation doses and image quality. Automatic systems receiving and processing patient dose values in real time allow corrective actions to be implemented quickly to improve protocols. However, it is necessary to also evaluate image quality in quantitative mode to balance efficiency.