

Facing Radiologists' Reluctance of a Degraded although Diagnostic Image Quality of Low/Ultra-low-dose CT: Our Experience

Francesco Macri^{1,2*}, Elina Khasanova¹, Joel Greffier¹, Gianfranco Gualdi² and Jean Paul Beregi¹

¹Department of Radiology, Nîmes University Hospital, Medical Imaging Group Nîmes, France

²Department of Emergency Radiology, Umberto I Hospital, Sapienza University, Rome, Italy

*Corresponding author: Francesco Macri, Department of Radiology, Nîmes University Hospital, Medical Imaging Group Nîmes, France, Tel: +33.466.683.309; Fax: +33.466.683.308; E-mail: francesco.macri@chu-nimes.fr

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Abstract

The radiological community is endeavouring to raise the awareness about the radiation-induced cancer. Computed Tomography (CT) is the main source of medical irradiation. Manufacturers provided efficient technological tools on CT to achieve a significant radiation dose reduction while maintaining a diagnostic quality of the image. Yet, the implementation of all these improvements allowing the low-dose (LD) and ultra-low-dose (ULD) CT imaging has difficulty to take hold. Radiologists do not easily accept to read images with a degraded image quality although diagnostic. As every cultural change, even in a radiological department the acceptance of the LD/ULD-CT imaging requests time. Constant meetings with substantial exempla and constructive discussions among radiologists, without abrupt modifications to the CT protocols in clinical practice, are the key to the success.

Keywords: Radiologist reluctance; Computed tomography; Iterative reconstruction; Low-dose-CT; Ultra-low-dose-CT; Radiation safety

Abbreviations:

CT: Computed Tomography; FBP: Filtered Back Projections; IR: Iterative Reconstruction; LD-CT: Low-dose Computed Tomography; ULD-CT: Ultra-low-dose Computed Tomography

Short Communication

The decision-making process for patients' care is increasingly dependent on Computed Tomography (CT). CT revolutionized medicine with a tangible reduction of morbidity and mortality [1]. Despite a long list of advantages there is a serious disadvantage represented by the fact that CT became the main source of ionizing radiation [2,3]. This evolution is worrisome because of the already known long-term effects of radiation-induced carcinogenesis, especially for subjects that undergo frequently CT examinations (eg. oncologic patients) [4]. Thus, in the last years, the radiological community strived for a cultural change to educate radiologists and referring physicians to a wise irradiation for the patient safety. Consequently the manufacturers provided some interesting tools on CT to reduce the dose, as in particular the iterative reconstruction (IR). The IR is an image reconstruction method that improves the quality of the image, independently of the dose, decreasing the image noise in comparison to filtered back projection (FBP) [5,6]. Thus the IR can be used to reduce dramatically the dose while maintaining a diagnostic image quality [7,8].

Why does the CT low/ultra-low dose imaging delay to take hold?

"Existing habits are hard to change" and this unfortunately affects medicine being detrimental for the patient health.

The IR allowed entering the CT low-dose (LD-CT) and ultra-low-dose (ULD-CT) imaging era. Although the image quality is degraded, LD/ULD-CT protocols with IR can be performed for some selected indications (e.g. lung nodule follow-up, pediatric fractures) [9, 10] without impediment for the diagnosis. Moreover, some radiographic studies indications (e.g. chest X-ray for lung cancer screening) can be replaced with a CT delivering a radiation dose in the range of the X-ray examination [11]. This opportunity should be seized especially for those indications that it is known the contribution of X-ray is not so peremptory (eg. minor blunt thoracic trauma) [12]. Especially in emergency settings, the referring physicians want a fast and definitive response from the radiologists and CT allows them to do so.

To date, the IR is not diffused yet everywhere. Not all radiological departments possess a CT with IR and even if they do, it is not so simple to implement the LD/ULD CT imaging for two reasons. First, turning the standard CT protocols in LD/ULD-CT protocols it is not benevolently accepted at the beginning. Radiologists and referring physicians have been educated to read a pretty image reconstructed with filtered-back-projections (FBP) generated with a standard dose and do not easily accept sudden changes in their habits [13,14]. Second, the conversion of some radiographic studies into LD/ULD-CT will result in a workload increase at CT scan, especially in the radiology departments with only one scanner. Moreover this would be conspicuously costly in the short term for the public health care system and may encounter oppositions, despite the possibility to reduce the potential expenses in the long term thanks to an in-depth CT examination.

Implementation of the CT dose reduced protocols: a long process

Four years ago we started the LD/ULD imaging in our department.

A group of driven radiologists and the medical physicist was crucial for this pragmatic approach to CT dose reduction [14]. The majority of

radiologists were not thoroughly familiar with tube parameters and methods to optimize the radiation dose and image quality [13]. Working together with the medical physicist improved the radiologists' knowledge about methods of CT radiation safety and motivated both professionals. The medical physicist tested several CT protocols starting from the already used reference doses to the lowest dose achievable for different organs (e.g. for chest CT from 120 kVp/200 mAs to 100 kVp/10 mAs). These acquisitions were carried out on phantoms and on human cadavers (under approval of our ethic committee and informed consent of next of kin, since we perform post-mortem CT scan in our department). The radiologists of the department evaluated independently these CT images by using a simple 5-points Likert scale of subjective quality (1 excellent; 2 good; 3 fair; 4 poor; 5 unacceptable). Finally we implemented institutionally in clinical practice the majority of the protocols that were rated excellent/good. We considered these CT protocols as low-dose, depending on the anatomical area and their reduction compared to the French Diagnostic Reference Levels (DRLs) [15], as summarized in the Table 1. For some specific indication we put into practice also the chest ULD-CT protocol (eg. pneumothorax follow-up). We defined ULD those CT protocol with a dose lower than 0.5 mSv. The whole CT protocols testing process took about 16 months before a constant use in clinical practice.

	DLP French DRL (mGy.cm)	DLP average at University Hospital of Nimes (mGy.cm)	Dose reduction percentage (%)
Skull	1050	715.9	-32
Thorax	475	110.8	-77
Thorax ULD	475	13.9	-97
AP	800	309.4	-61
TAP	1000	488.5	-51
LS	700	522	-25

DLP dose-length-product, DRL diagnostic reference level. AP abdomen-pelvis, TAP thorax-abdomen-pelvis, LS lumbar spine. Comparison between French DRL thresholds and the DLP averages of University hospital of Nimes and related reduction percentages.

Table 1: Radiation Dose values per anatomical regions.

If you do not have the possibility to test your own CT dose reduced protocols on test subjects, you may want to evaluate them on patients under ethical committee approval and informed consent as other research teams did [10,16,17]. It is obvious that you cannot test several protocols on the same individual but you may acquire a CT volume with a lower dose than your institutional dose and immediately after you can acquire a second CT volume with a LD/ULD dose for comparison. In other words, for instance, whether you standardly acquire a chest CT with an effective dose of 6 mSv, on the same patient you may obtain a first acquisition with a dose of 4.5 mSv and a second with a dose of 1.5 mSv. The main important thing is not to exceed your standard dose or the doses recommended by your DRLs.

How to ease your staff radiology members' adaptation to LD/ULD images

Immediately the majority of the senior radiologists complained about the quality of imaging. New arrived staff members, locum radiologists or residents coming from other hospitals complained about the CT LD/ULD imaging. The old radiologists complained about a smoothed image compared to the standard with FBP [7] and the young radiologists, especially coming from other institutions, about a noisier image. However they habituated to interpret this type of images in average after about 3/4 months.

To foster the adaptation process we reconstructed each CT LD/ULD protocol with FBP and different strengths of IR simultaneously [14]. This in order the radiologists to become familiar with the LD/ULD images reconstructed with IR. Finally the radiologists were able to read every type of LD/ULD image. At this point, we started to reconstruct LD/ULD images only with the IR.

The tip to introduce a culture of ULD/LD imaging is not to do it abruptly. Staff radiologists must be involved in this process. Constant meetings should be set up to discuss the pros and cons of such imaging. To respond to questions as: What is expected? What can be attained? What are the effective consequences for the patient care? To convince the most reluctant and argumentative radiologists that a diagnosis can be made, regardless of the degraded quality of image, it is important to show constantly LD/ULD-CT diagnostic achievements in different clinical settings. The fundamental message to convey is to acquire with the lowest dose possible while maintaining a diagnostic quality of image.

FMC (Frequently Made Complaints)

1. The image is altered: Check if the clinical question can still be addressed even if for instance the contours of the structure are not perfectly defined (eg. is there a vascular occlusion of the internal carotid artery or not?). Provide automatic reconstructions at least at 3 mm. The thicker is the slice the less is the noise. With regard to the smoothing effect it is just a matter of time to get used.
2. This is not an imaging for oncological use: Right for some organs or situations. We believe that for solid organs (e.g. liver, pancreas) especially the ULD imaging is not reliable in distinguishing tumor boundaries. Conversely the dose reduction for lung nodule is highly applicable thanks to the high inherent contrast of air. However an effort should be done also for oncological use, notably for patients that undergo repetitive CT examinations.
3. This imaging can hide potential anomalies depicting normal structures: Then, a CT with a standard dose may do it. The reduction of the dose does not generate fake "normal" images. It might happen that a radiologist new to LD/ULD imaging identifies a lesion and struggles to describe it with a good confidence degree.
4. The referring physicians do not appreciate these images. The referring physicians are not the direct responsible (depending on the country's law) of the examination report and the radiation safety of the patient. The radiologists are. Over the time the referring physicians will be accustomed as well to this type of imaging.
5. We risk repeating CT with a higher dose because the first one was not informative or doubtful. True, but before to rescan request a second opinion of a colleague. Finally whether a new scan is

needed, it should be done with a higher dose than the previous and lower than the standard one (refer to your medical physicist).

6. Transforming some X-ray examinations into ULD CT will increase the workload. Yes, it is likely so. Keep in mind the patient's care as first. The aim is to decrease for some indications the useless X-ray study due to its low sensitivity that can mislead, irradiates without information gain and delays the patient's care.

Conclusion

The acceptance to reduce the CT dose at the cost of a less pretty image but still diagnostic struggles to take hold for the majority of radiologists. This cultural change should be the fruit of effort at persuasion by evidences without an abrupt implementation of LD/ULD protocols in clinical practice. The promoter group of radiologists favourable to this change of gear should arouse the curiosity of the rest of colleagues with meetings and providing exempla. The progressive involvement of all the staff radiology members is the key to success for the radiation safety of the patients aiming to a diagnostic image rather than a beautiful image.

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