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DOSE TRACKING AND RADIOLOGY DEPARTMENT MANAGEMENT

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The purpose of this work was to review the reasonable measures that should be implemented as part of a routine practice in the process of managing CT radiation risks in a typical average radiology department. Based on 6 y of experience in the management of a general radiology department and the newly implemented supportive software for dose tracking, analysing and reporting, the approach towards radiation risk reduction is presented. Thanks to this approach, some problems have been resolved, and reasonable measures have been introduced into daily practice.

INTRODUCTION

Public concern regarding the health risks of ionising radiation reached its peak in the last 20 y, due to the enormous use of computed tomography[1, 2]. The widespread of multidetector-computed tomography (MDCT) as a basic imaging modality and diversity of computed tomography (CT) protocols and patient radiation exposure require a new management approach in promoting, performing and controlling the diagnostic imaging process.

In the Radiology Department of Tokuda Hospital Sofia, a strong control over the radiation dose for all patients has been accepted and implemented. The utilization of the Dose Watch software (GE Healthcare) allows detecting improper use easily, along with immensely improving efficiency and quality of the CT procedures performed in the department. This article briefly outlines the main initiatives that were undertaken, and the results achieved.

The aim is to identify challenges, available tools and opportunities for improving the patient's dose in the MDCT sector of a general radiology department (RD).

MATERIALS AND METHODS

Collected data were based on the radiation dose to individual patients who had undergone MDCT examinations in a general RD with an overall annual rate of ~9000 MDCT examinations. All exams were carried out with a 64-row MDCT system LightSpeed VCT, GEHC, Milwaukee. The hospital logbook was used to identify the number of MDCT examinations, along with the dose levels associated with some common diagnostic procedures in order to make the analysis. The information was obtained and analysed from the picture archiving and communication system (PACS), and the Dose Watch software. Measures were implemented towards improving organization and reducing the radiation dose, but at the same time ensuring the quality of the exams that were performed.

LightSpeed VCT software provides values of CT dose index. These include volume CT dose index (CTDIvol) and the corresponding value of dose–length product (DLP) (DLP = CTDIvol × scan length). DoseWatch provides effective dose (ED) to DLP conversion coefficients to permit DLP values to be converted into a corresponding value of ED (ED = DLP × conversion coefficient). It is imported to note that the conversion coefficients depend on the anatomic region examined.

RESULTS AND DISCUSSION

The efforts were focused on reasonable measures that could be realistically implemented in the everyday practice as a response to the current increase of public concern regarding radiation risk. Many of the items discussed reflect the changes that have been successfully introduced.

As a first step, a CT workflow analysis was done, focusing on the:

(1) Type and number of examinations;
(2) Gender and age distribution of the examined patients;
(3) Clinical situations and required radiology examinations;
(4) Protocols and dose distribution;
(5) Number of repeated CT examinations in a short period of time.

With the help of the DoseWatch software, all voluntary and nonvoluntary changes in the protocols have been recorded. This allows all MDCT protocols and doses in a clinical workflow to be tracked and doses to be collected in the register. In commencing the process, the authors realized the first, and main, organizational problem was the lack of uniformed classification of procedures, which led to a miss-registration of doses, and thus, an inaccurate statistic. After the official introduction of a unified nomenclature of the MDCT examinations, followed by appropriate adjusting in accordance with the hospital information coding system, a work-list server implementation and unification of the protocols was made available.

The second step focused on the protocols' standardization. The authors' results showed a significant variability in the radiation dose acquired by CT examinations of the same anatomical area that were performed in a clinical environment. This finding is consistent with data previously reported in literature and is due to several factors, such as the use of different target noise image (and hence radiation dose) depending on the radiologist's preferences, variations in the training of radiographers and diversified diagnostic scenarios requiring the use of different CT image acquisition protocols. Factors that contributed to increasing the radiation dose were selected from excessively high kV and/or mAs settings for the patient and/or the clinical condition under evaluation, deactivation of tube current modulation, inaccurate positioning of the patient inside the gantry and unnecessary prolongation of CT data acquisition beyond the anatomical limits of the body area to be examined. Based on the aforementioned information, and the national referral guidelines, fixed protocols have been implemented and adjusted using the above-mentioned classification system. After standardization of the protocols, patient doses still varied due to differences in the patient's body mass index and inappropriate clinicians' referral.

The third step focused on the high dose and more frequently performed protocols, because they account for the highest radiation dose in the patient population. Substantial dose reduction was expected from optimization of these protocols. The Dose Watch analysis showed that the most often performed protocols were those involving brain (Figure 1), and the highest dose protocol was that of peripheral lower leg MDCT angiography (Figure 2).

The logical step was to ensure optimization tailoring CT parameters to match the presenting indication, scanned region and patient size, keeping in mind that not all examinations require the highest image quality. Radiation dose in terms of DLP from the control group and newly proposed protocols were compared and adjusted with the European Dose Reference levels (DRL). In order to keep the image quality for each type of CT examination, at least 30 CT studies were randomly assessed by retrieving data from the PACS. Blinded assessment of image quality

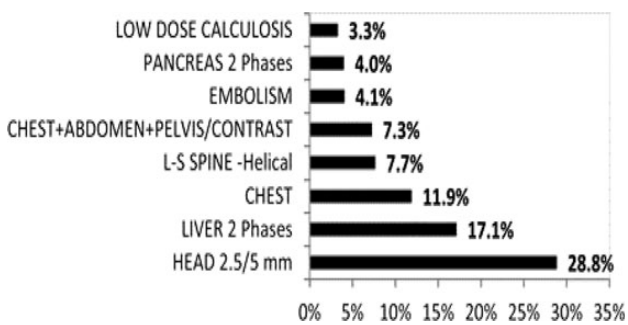

Figure 1. Graph demonstrating the most often performed CT protocols.

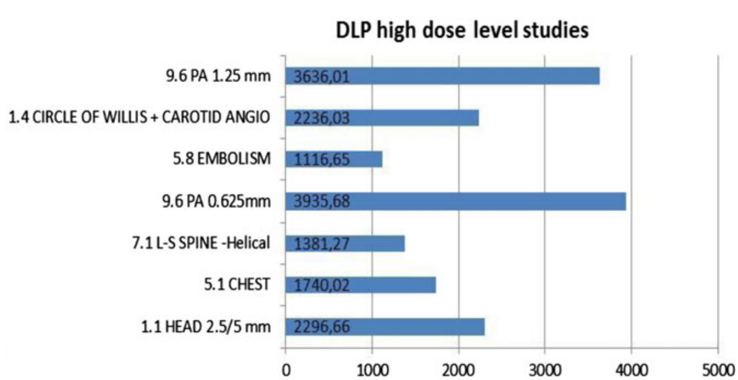

Figure 2. Graph demonstrating the highest dose protocols.

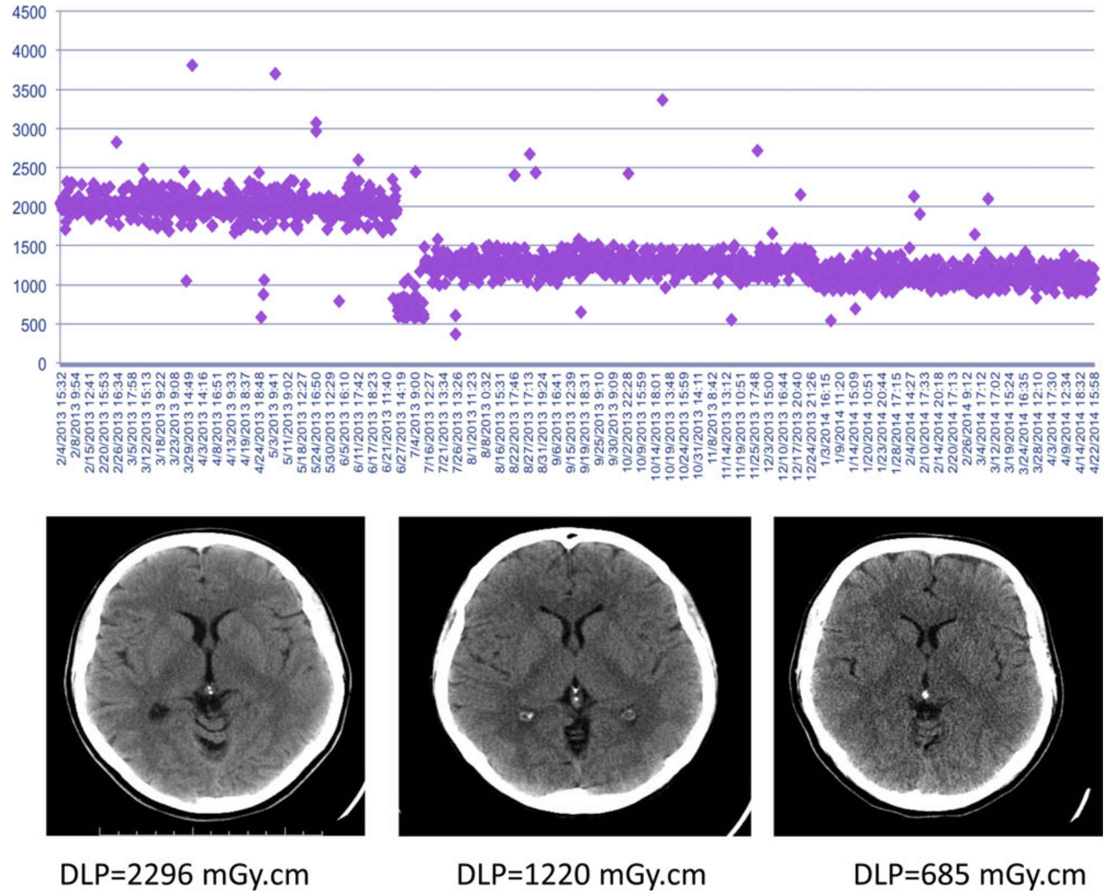

Figure 3. The graph shows the changes in the "General brain" protocol. After the modification of the exposure parameters, the DLP value dropped down from 2296 to 685 mGy cm, without any compromise to the image quality.

was performed by two different radiologists using a three-point scale. After an inter-observer agreement, the proposed protocol was validated and implemented into routine practice.

In accordance with the study initiatives, varying parameters have already been shown to permit significant reductions in dose. This is especially true for examinations with high inherent contrast where high image quality is not required, such as renal stone protocol and lung nodule follow-up. The figures present the result after applying three different approaches for optimizing the CT protocols based on the different levels of contrast between the various organs and intra-venous contrast material administration. Figure 3 shows changes in the 'General brain' protocol with an initial ED of 4.8 mSv. After modifications of exposure parameters, the DLP value dropped down from 2296 to 685 mGy cm^{-1}, which is lower than the DRL, without any compromise to the image quality. Figure 3 shows images of brain before and after the optimization, with the corresponding DLP values.

Figure 4 shows the drop in an ED in chest CT protocol focused on lung nodule evaluation, and diffuse interstitial lung diseases follow up. Images 4a and 4b demonstrate baseline and follow-up chest MDCT performed on the same patient, same slice level and thickness with different values of tube current. Based on the natural high inherent contrast between the lung parenchyma and the soft tissue nodules, the reduction of patient dose was achieved by reducing the mAs. The quality of the image decreased without any loss of information.

Figure 5 shows the difference between the baseline DLP level and those after the optimization of the CT angiography protocol by lowering the kVp[3]. The level of noise into the surrounding structures was found to be acceptable for recording unexpected and supplementary changes. The evaluation was done by measuring some objective parameters of image

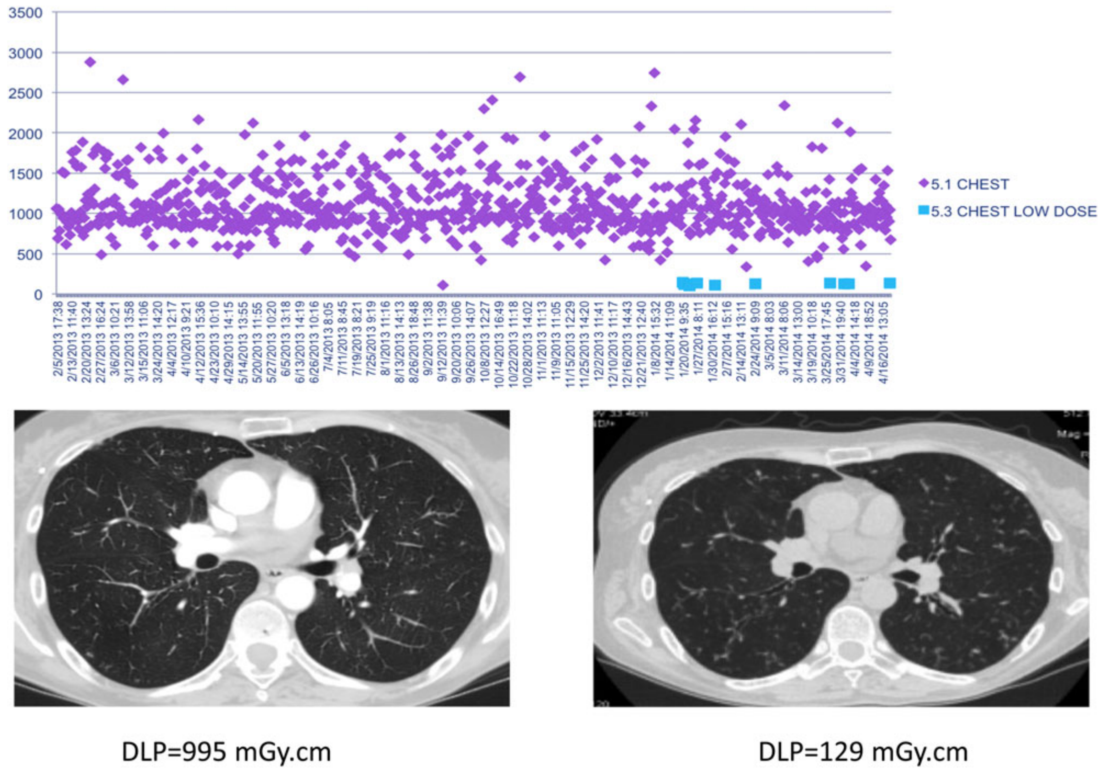

Figure 4. The graph shows the changes in the "Chest- low dose" protocol. After the modification of the exposure parameters, the DLP value dropped down from 2296 to 685 mGy cm. The noise level of the image increases without any loss of information.

quality, as the image noise, signal-to-noise ratio and contrast-to-noise ratio.

The fourth step focused on the list of repeated procedures because of low-quality performance. Reviewing the data consisting of patients that had received extremely high doses, the authors realized that they were all rescanned for some other reason. The most exposed patient category was the one from the emergency department, which received an average cumulative dose of 4 mSv and a maximum of 10.5 mSv.

The fifth step targeted the radiology staff education, along with efforts to enable technicians to adjust the protocols according to the individual patient or diagnostic need. The authors' department of radiology is truly 'general' as it deals with a very wide range of clinical conditions, resulting in the adoption of various CT protocols that can significantly differ in radiation dose for numerous reasons. In this latter respect, patients with several co-morbidities are often referred for a CT with the intent of solving as many diagnostic queries as possible with a single contrast-enhanced CT examination. Such an approach is often seen, on the one hand, as a cost- and time-effective solution for the healthcare system, and yet, on the other hand, it contributes to substantially increasing patients' radiation dose. After the collection of DLP values, an intensive training course was organized in an attempt to verify and improve the professional performance of the radiological staff operating in the CT room. Radiological staff, training simultaneously, involved radiologists, medical physicists and technologists and consisted of monthly training events in which medical and technical topics related to CT imaging (i.e. appropriateness criteria, protocol optimization, assessment of cancer risk due to ionising radiation exposure, risk communication to patients and referring physicians, ethical and legal issues and continuing education) were tackled[(4)].

The sixth step was focused on referring clinician training. The most effective way to reduce the radiation exposure is to avoid radiation when it is not needed. This is independent of the technical parameters, and the CT scanner, and relates only to the concept of justification. Justification is implemented in the clinical practice by applying local referral guidelines for medical practice, and balancing the needs of the individual patient with the risks of the examination.

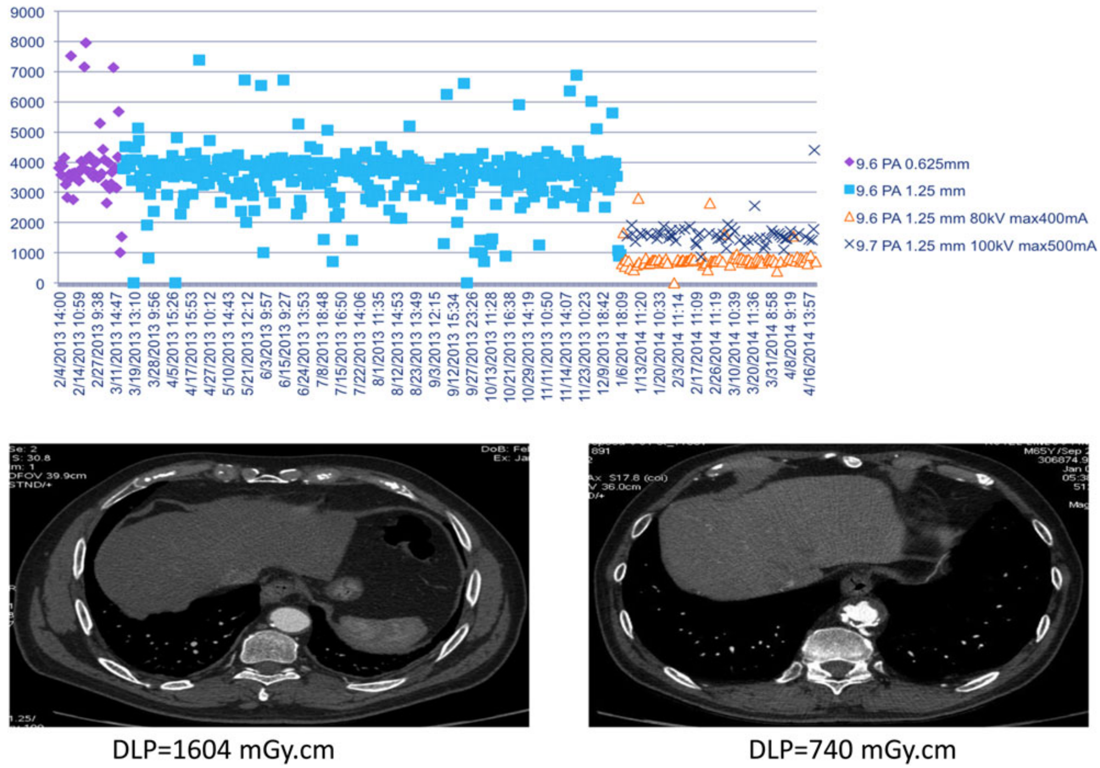

Figure 5. The graph shows the difference between the baseline DLP level and those after the optimization of the CT angiography protocol by lowering the kVp. Note the highest vessel attenuation and the acceptable level of noise into the surrounding soft tissue structures.

At present, the numbers of CT examinations that lack accuracy are not systematically assessed. In cases of equivocal indications, the radiologists contact the referring clinician and suggest an alternative examination. Empirical data based on personal communication with clinicians and patients suggest that ~20 % of CT referrals could be declined. The reasons for rejecting or modifying a radiology exam include: an alternative modality is more appropriate, the interval between consecutive CT examinations is too short and the result would not change the therapeutic strategy.

CONCLUSIONS

In conclusion, the authors' policy allowed for the implementation of good practices in radiation protection. Thanks to the supportive software for dose tracking, analysing and reporting, some problems have been solved and reasonable measures have been implemented into daily practice. The present study has some drawbacks as it is a pilot study, partly retrospective, and focused on a single-centre practice, even though a large number of studies were performed. The project covers a wide range of data and measures orientated towards dose reduction in a general RD and thus permits it to serve as a base for building a national project for standardizing MDCT protocols, referral guidelines and dose-reduction politics.

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