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The potential of dose management software in computed tomography

INTRODUCTION

Over the last few decades, the level of radiation to which the public have been exposed through the use of medical imaging has grown by an estimated 600% [1–3]. A large part of this increase can in particular be attributed to the increasing number of computed tomography (CT) scans being carried out. Against this background and as a result of the growing awareness of the issue of radiation exposure, radiation monitoring and safety is nowadays becoming an ever more important part of quality assurance in radiology. Whereas in fluoroscopically guided intervention both patient and staff radiation protection need to be considered [4], keeping the patient's radiation exposure as low as possible is the major issue in CT.

A basic requirement in all CT studies is that the three fundamental principles of the International Commission for Radiation Protection (ICRP, 2007), namely "**justification, optimization, and limitation**" should be respected. In an endeavor to underscore the importance of these three principles, several dose awareness campaigns such as Image Wisely [5], Image Gently [6] or EuroSafe [7] have recently been introduced worldwide.

The aim of the first of the ICRP principles, **justification,** is to limit the number of unnecessary examinations while still providing net patient benefit. For this, the diagnostic information that is likely to be obtained from the examination needs to be taken into consideration together with the associated radiation doses and risks to which the patient is exposed [8, 9]. This requires regular interdisciplinary communication and consultation between radiologists and referring physicians so that a joint decision on the most appropriate imaging solution for an individual patient can be taken.

Optimization means conforming to the ALARA principle (as low as reasonable achievable) so that when the need for a CT exam is agreed on, only the lowest possible amount of radiation is applied, namely the dose needed to provide adequate images, with a quality of image sufficient to answer the diagnostic question being posed. It is in this area that the implementation of technical innovations such as new reconstruction algorithms (e.g. iterative reconstruction), dose modulation, or ultra-low-dose protocols have resulted in significant improvement.

Finally, dose **limitation** means that certain dose levels must not be exceeded since otherwise an individual's risk of suffering from stochastic dose sequelae such as radiation-induced cancer would be out of proportion to the benefit derived. To address the issue of dose limitation, it is recommended that guidelines such as the Dose Check Standard from the National Electrical Manufacturers Association (NEMA) be adhered to [10].

Dose Check Standard operates by issuing alerts in cases where the scanning parameters set by the CT technologists seem likely to result in a dose higher than predefined thresholds. Through these alerts, the CT technologists are prompted to review the parameters in order to prevent unnecessary high levels of radiation output. Another useful tool in dose limitation is the implementation of a dose management software, which provides dose data immediately after completion of the CT scan [11].

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DOSE MANAGEMENT IN COMPUTED TOMOGRAPHY

Recently, several vendors have developed dose management software that can be connected to all imaging modalities using ionizing radiation. However, given that CT is much more standardized than, for instance fluoroscopically guided interventions, it is reasonable that the initial focus has been on first connecting CT scanners and on setting up the dose management software in the clinical CT workflow. Irrespective of the particular vendor, all of these software tools enable registration, tracking, and analysis of radiation doses applied to patients.

The basic dose information that is given in CT is the CT dose index (CTDI), the dose-length-product (DLP) as well as the size-specific dose estimate (SSDE). For in-house quality assurance, an individual patient's dose values are automatically matched with those of other patients who have undergone the same CT protocol, thus enabling the establishment of institutional diagnostic reference levels. These data can also be used to meet any statutory requirements by allowing easy comparison of dose data from one institution with national or international reference values.

An additional feature of the software allows comparison,

FIGURE 1. Placing the computer with the dose management software next to the CT console stimulates active involvement and collaboration by the CT technologists.
DoseWatch is a GE Healthcare product and is a dose management solution designed to automatically collect and analyze patient radiation and iodine exposure in multi-modality and multi-vendor imaging environments.

immediately after completion of the scan, of the actual dose received by an individual with the preset dose thresholds. If the thresholds have been exceeded, the software releases a dose notification, which is visible on the overview window of the software. Through this, it is possible to immediately assess whatever reason (or reasons), were responsible for the excess dose. Such information is very useful for avoiding future repetition of excess doses. The system allows the implementation of real-time monitoring of patient dose, which can be summarized as the process of reading dose data and receiving feedback on the reason(s) for exceeding thresholds directly upon completion of each scan. Such real-time monitoring of patient dose approach can be effectively integrated into the clinical workflow as shown by two recent studies [11, 12] which described the practical implementation of real-time monitoring of patient CT dose in clinical routine.

In their studies, the authors analyzed the reasons for dose notifications and found that the two most frequent causes were the patient being overweight and improper patient centering with regard to the isocenter of the scanner [11, 12].
Being overweight, defined as BMI ≥ 25 kg/m^2 (BMI: body mass index, the weight in kilograms divided by the square of height in meters) is a factor that can only be influenced by the patient herself/himself. In contrast, centering of the patient depends significantly on the technologists' performance. Several studies have demonstrated that even small deviations of 2-6 cm from the vertical position can negatively influence image quality and dose by preventing optimal operation of the bowtie filter whose role is to modify the spatial distribution of emitted radiation within the fan beam. As a consequence of errors in patient centering, dose values can increase by up to 51% [13, 14].

"... the two most frequent reasons for dose notifications were the patient being overweight and improper patient centering..."

Assuming that the performance of technologists depends both on their level of training as well as on the time pressures they are faced with when positioning the patient on the CT table, it could be expected that improper patient centering would be more of a problem in an emergency setting than in routine scanning of out-patients. However, in reality in one of the two studies the very opposite was seen [11], while the other study did not find any significant difference between emergency or routine scanners [12].

The third most frequent cause of the issuance of a notification was scan repetition due to severe motion artifacts, which can hamper adequate diagnostic imaging reading.
Motion artifacts can result from improper/impractical patient positioning in the head-holder or can occur with confused or agitated patients, who are unable to keep still. From a quality improvement point of view, and just as with overweight patients, there is little the technologists can do to reduce number of scan repetition notifications except for trying to reassure the patients as much as possible. As confused or agitated patients are more often scanned in an emergency setting, it was again anticipated that scan repetition notifications would occur significantly more frequently on the emergency scanner than on the out-patients scanner. This was indeed shown in one of the studies [11]. However, the other study again did not demonstrate any significant difference between both scanners as far as the number of scan repetition notifications was concerned [12].
Other, more rare causes of dose notifications included orthopedic hardware located within the scanning field, leading to upregulation of the current. Yet other causes were scanning of the patient on a spine-board or the patient's inability to lift arms [11, 12].

Since the dose management software enables real-time monitoring of patient dose, and involves technologists' active participation, the aim of one of the two studies was to evaluate whether in practice the technologists' dose awareness would actually increase after the implementation of such a real-time monitoring of patient dose [12]. The study was again carried out on two scanners, one predominately used for emergency and intensive care patients and the other mostly for out-patients. When the number and reasons for dose notifications were compared before and after the implementation of real-time monitoring of patient dose in clinical CT routine, it was found that the total number of notifications decreased significantly on both CT scanners after the introduction of real-time monitoring of patient dose. The main reason for this decline was a significant reduction — almost 75% — in the number of improper centering notifications issued.

In the authors' opinion, this in turn is the result of the increased dose awareness on the part of the CT technologists, induced by their involvement with the dose management software. This assumption was supported by the fact that although the number of all other notifications, which cannot directly be influenced by technologists also showed a small decline in both scanners when real-time monitoring of patient dose was used, nevertheless the level of such declines did not reach statistical significance. The authors therefore concluded that, in addition to the radiation dose-based information provided, the increase in dose awareness by the CT technologists should be regarded as an additional strength of dose management software. In this context, one practical finding was that by placing the computer screen with the dose management software next to the CT console the collaboration of the CT technologists was stimulated and their involvement increased [Figure 1].

CONCLUSION

The management of reasonable dose in computed tomography is an important part of overall quality assurance in radiology and can be achieved with dose management software that provides dose data upon completion of the scan. The main features of such software are the ability to perform real-time monitoring of patient dose and the easy comparison of dose data with other institutions or with national or international diagnostic reference levels. Moreover, from a less "pure dose value" point of view an important impact of the dose management software is that it increases the general awareness of dose that the technologists have, and is associated with a decline of dose notifications due to human error. Now it will be the aim of future studies to determine the long-term effect of dose management software on such technologists' dose awareness and to evaluate further dose-saving strategies from the data provided by the software (e.g. constitution-based CT protocols using SSDE).

"... an important impact of the dose management software is that it increases the general awareness of dose that the technologists have..."

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Book review

Handbook for Clinical Trials of Imaging and Image-Guided Interventions
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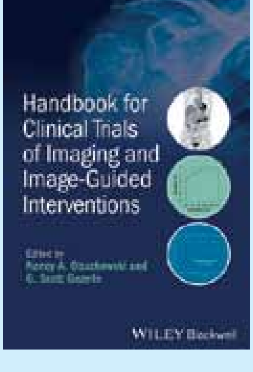

This book is the first single-source, multidisciplinary reference, based on the didactic sessions presented at the annual 'Clinical Trials Methodology Workshop' for radiologists, radiation oncologists and imaging scientists (RSNA). It focuses on educating radiologists, radiation oncologists and those involved in imaging research with how to design and conduct clinical trials to evaluate imaging technology and imaging biomarkers.

The internationally renowned contributors take a broad approach, starting with principles of technology assessment, and then move into specific topics covering the clinical trials of therapy and clinical research in imaging guided interventions including radiotherapy. They discuss the use of imaging as a predictor of therapeutic response, screening trial design, and the practicalities of how to run an efficient clinical trial and good working practices. Later chapters provide a comprehensive array of quantitative methods including: an introduction to statistical considerations in study design, biostatistical analysis methods and their role in clinical imaging research, methods for quantitative imaging biomarker studies, and an introduction to cost effectiveness analysis.

Spectral computed tomography (SCT) generates better image quality than conventional computed tomography (CT). It has overcome several limitations for imaging atherosclerotic plaque. However, the literature evaluating the performance of SCT based on objective image assessment is very limited for the task of discriminating plaques.Â In this step, the spectral image in each energy bin was decorrelated using localized prewhitening and matched filtering with a set of Laguerre-Gaussian channel functions. Second, the series of the intermediate scores computed from all the CHOs were integrated by a Hotelling observer with an additional prewhitening and matched filter. Radiation doses for computed tomography (CT) vary substantially across patients, institutions, and countries.1 2 3 4 Ionizing radiation is a known carcinogen,5 6 7 8 9 10 and CT radiation is associated with increased cancer incidence.11 12 13 14 Therefore, it is important to minimize exposure from medical imaging and reduce unnecessary variation by optimizing examination protocols. Evidence suggests that in many instances, CT doses can be reduced by 50% or more without reducing diagnostic accuracy.15 However, differences in patient populations and inconsistencies in data collection and analysi Computed Tomography Dose Index volume (CTDIvol) indicates the intensity of the radiation being directed at that patient and Dose Length Product (DLP) is a quantity that combines both aspects of intensity and extension of patient exposure, thus estimate total patient dose. These dose metrics are equivalent to Dose Area Product (DAP) in projection radiography (fluoroscopy, mammography, conventional radiography) that can be further used to estimate the effective dose received for a particular examination. Computerized Axial Tomography. Pros and Cons. What are the advantages and disadvantages of computed tomography? Why is it important? Ad by Raging Bull, LLC.Â Disadvantages: relatively high radiation dose compared to projection radiography ('x-rays') BUT getting lower and lower as new understanding, hardware and software is deployed. Expensive. 1.2K views Â·. Presentation on theme: "Managing Patient Dose in Computed Tomography (CT)"â€” Presentation transcript: 1 Managing Patient Dose in Computed Tomography (CT) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION â€”.Â 12 Organ doses in CT Breast dose in thorax CT may be as much as mGy, even though breasts are not the target of imaging procedure Eye lens dose in brain CT, thyroid in brain or in thorax CT and gonads in pelvic CT receive high doses INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION â€”.