By Gilles Hameury

Reducing Patient X-ray Exposure through protocol management

The upcoming EURATOM 2013/59 directive requires European imaging centers to engage on the path of X-ray dose reduction for increased patient safety. The cornerstone of the regulation is the imaging center's dosimetry activity evaluation. Among other things, the directive requires rigorous recording of the technical details for every acquisition, for every study, and the construction of a comprehensive history of patient exposure. But the root factor, or the key to the successful reduction of patient exposure remains the ability to optimize protocol settings and to manage their utilization in the control room.

We know that protocol settings will determine image quality and the radiation dose received by the patient. For example, in CT, increasing the pitch will result in lower radiation exposure, provided all other imaging parameters remain constant. It will also affect image quality (e.g. limit spatial resolution and increase image noise).

Management of protocol settings is thus aimed at determining the optimal balance between image quality and radiation dose. It is not limited to CT scanners and should be conducted on all imaging modalities involving ionizing equipment (e.g. X-ray tables, C-arms, mammographs, etc.).

Dosimetry applications have emerged as useful tools for protocol management. They help medical physicists obtain a clear picture of the patient dose-related activity and to efficiently engage in improvement of practical procedures, with limited disruption to the workflow.

"... the key to the successful reduction of patient exposure remains the ability to optimize protocol settings and to manage their utilization..."

This paper describes the different primary steps of a typical investigation.

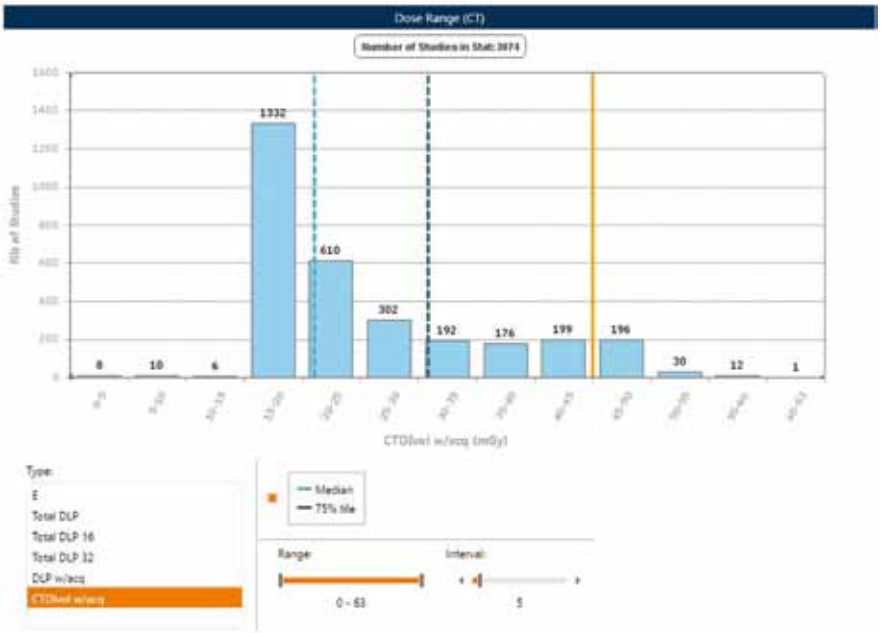
For this, anonymized data from a French hospital were gathered over a period of one year and Guerbet's DoseCare ® application was used to conduct the analysis and to generate graphs of the data [1,2].

STEP 1: IDENTIFY THE MOST PROBLEMATIC PROCEDURES

Starting from a blank page is always a difficult task, in particular when the number of studies is large and covers a wide range of procedures. But trying to improve all procedures at the same time is certainly not the best approach. What we first want to achieve is to identify the procedures which cause the most problems, either in terms of volume (i.e. the number of studies which exceed the Diagnostic Reference Levels, DRLs) or in terms

Graph 1: Ranking of the 10 procedures which have the highest number of studies above DRLs over one year

The Author
Gilles Hameury, MBA
Global Product Manager
Guerbet
email: gilles.hameury@guerbet-group.com



Graph 2: positioning of studies' CTDIs against DRLs

of the level of potential negative health effects that the exam could have on the patient (i.e. the amount by which the dose level is exceeding the threshold).

A quick analysis in DoseCare ® enables us to rank procedures conducted on a single modality (in this example, a CT scanner), according to the number of studies above DRLs [Graph 1].

Graph 1 shows that the Lumbar Spine Scanner procedure has the highest number of studies above level 1 (yellow area, 37.05% of studies exceed DRL average) and level 2 (red area, 7.61% exceed DRL maximum). The second procedure (Shoulder scanner) is also of concern as 98.51% of studies exceed level 1, and 80.03% are above the level 2 threshold. A quick explanation is that the shoulder procedure is within the chest region, where the European DRLs are generally low. Nevertheless, the number of studies (606) is much lower than that of the Scanner Lumbar Spine procedure (3074), therefore it remains a secondary issue to investigate.

STEP 2: CTDIvol AND DLP ANALYSIS

This part of the study is essential to understand how and why the patient is exposed to radiation.

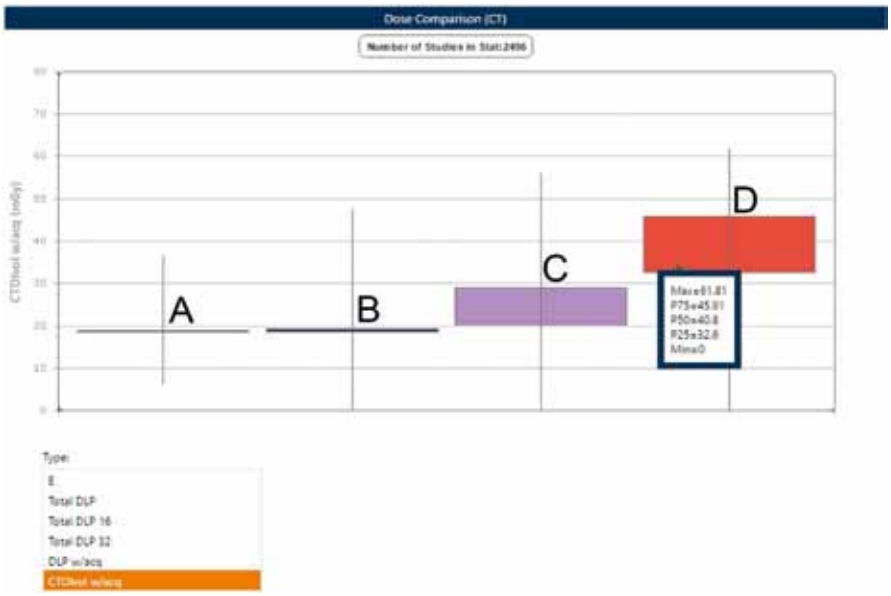
The Volume CT Dose Index (CTDIvol) records technical parameters such as mA (miilliamps), kV (kilovolt) and pitch used for patient exposure. In effect, it represents the acquisition protocol settings.

The Dose-Length-Product (DLP) is calculated by multiplying the CTDIvol by the scan length. It is used as an indicator of overall exposure for a complete examination and so can be used to benchmark local practices. Simply put, with this additional dosimetry metric, the DLP reflects the protocol utilization in the scanner room.

The investigation on the lumbar spine procedure should consist in positioning CTDIvols and DLPs from all the studies against the DRLs [Graph 2 and Graph 3, respectively].

In Graph 2, the 75th percentile is located at 31 mGy.cm, and the level 1 DRL is at 45 mGy.cm. Graph 2 shows that most studies are well below the level 1 DRL threshold (yellow line). This indicates a good setting of the acquisition protocol and that there is no urgent need for further tuning.

Graph 3: positioning of studies' DLPs against DRLs



Graph 4: Comparison of doses with respect to patient BMI
A: BMI 0 to 18: Underweight
B: BMI 18.5 to 25: Normal weight
C: BMI 25 to 30: Overweight
D: BMI 30 or greater: Obesity

Graph 3, however, shows that if the 75th percentile remains below the level 2 threshold, it is significantly above level 1.

Combining messages from both graphs indicates that the issue here could come from an acquisition that is too lengthy. The number of lumbar disks to scan is defined, either on the protocol itself or by the radiologists, according to the particular indication. A safe assumption in this case would be that the radiologists are not willing to risk missing an injury at a lumber level that lies outside the range of the scan window and have therefore requested an extended scan. Indeed, protocol setting remains a matter of balancing the advantage or the necessity of a complete scan with the negative effects an increased radiation exposure could have on the patient. In consequence, one of the approaches for further investigation would be to have a closer look at the correlation between the range of scan and the indication, and from these results, to then evaluate the need for additional control or fine-tuning.

STEP 3 EXPOSURE ANALYSIS PER CATEGORY OF PATIENT

The medical physicist can also investigate whether the protocols comply with the appropriate procedure guidelines, and if these guidelines are directly applicable to all patients.Additional investigations allow us to better understand the reality of patient exposure and to identify the type of measures which should be taken.

The next analysis consists in studying doses levels according to the patient's BMI and in comparing the range of dose for each category.

To construct Graph 4, we grouped patients into four categories of BMI, from the thinnest to the heaviest. The graph shows the 25th percentile and the 75th percentile dose level which were used on patients in each of these four categories. The CTDIvol comparison reflects the variations in the protocol settings, in terms of tube kilo voltage (kV) or milliamps (mA) applied during the study.

The standard deviation is small for group A, large for group D. This significant variation indicates that the kV is not properly adapted in group D. In such a case, good practice would consist of the creation of additional Lumbar Spine protocols, each dedicated to one BMI category, so as to avoid such variation and to be able to monitor any excessive levels more closely.

CONCLUSION

This simplified example of a real world investigation illustrates one of the many options available for reducing patient dose exposure. Provided the data are available, patient safety through X-ray dose reduction can be approached through many other different angles. Additionally, such investigation can — and should — be conducted in all departments, on all modalities involving ionizing radiation, in order to achieve consistent and long term progress.

With the help of dose monitoring applications, significant progress can be quickly achieved in finding suitable approaches for procedural improvement.

REFERENCES

1. *DoseCare® is a software application which records and presents patient X-ray exposure data and provides a set of tools to document and analyze this information. DoseCare® is intended for use by medical imaging and diagnostic health professionals and by the personnel in charge of the X-ray security and administration of an imaging center. For complete information and optimal utilization of the solution, please refer to the user's manual.*

2. DoseCare is a medical device, Class I/CE.
Legal Manufacturer: MPTronic (Paris, France),
Distributor: Guerbet, (Roissy CdG cedex, France),
tel.: +33 (0)1 45 91 50 00,
www.guerbet.com,
dosecare@guerbet.com