Radiation dose management in CT imaging: Initial experience with commercial dose watch software

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Abstract. In this study, a patient dose tracking software was utilised for the management of patient doses and optimisation of scanning protocols for computed tomography (CT) imaging. This study aimed to evaluate the use of GE DoseWatch software for local dose tracking and management. The commercial DoseWatch software was first installed at Imaging Unit, Advanced Medical and Dental Institute, Universiti Sains Malaysia (AMDI, USM), Penang on November 2018. All the CT scans were tracked by this software connected on-line to the Siemens SOMATOM AS+ CT scanner and GE Discovery SPECT/CT scanner. A total of 361 CT dose dataset were evaluated during the period of 10 months started from November 2018 until August 2019. From the initial experience, this software allows rapid and reliable collection and management of the CT dose data involving large number of examinations. From comparative study with our established local dose reference level, the mean DLP for few CT protocols exceeded the LDRLs such as TAP (10%), Routine Brain (89%), and HeadRoutine (38%) CT study which need further assessment and audit on the current local CT protocols. However, implementation of the software required knowledgeable and well-trained user for the full-benefits. Accurate data and protocol types should also be selected by the users during the CT scanning as it will influence the whole process of dose tracking and management on the software.

1. Introduction
Computed tomography (CT) imaging is one of the major imaging procedures that contributes to higher patient dose in diagnostic radiology. The current CT advancements are dedicated in reduction of patient’s dose, while maintaining the best image quality in order to sustain the balance between dose and image quality (Chatzoglou et al., 2016). The most important part is delivering sufficient dose to patient during imaging procedure as to ensure effective patient care. Besides, the Ionising Radiation (Medical Exposure) Regulations (IRMER, 2000) also recommended a regular audit on patient doses to ensure quality images are produced at the lowest possible radiation dose.

CT dose management is defined as dose review and optimisation program after CT examination for dose optimisation and improvement of patient safety. An ideal dose management solution should include multiple elements such as radiation dose tracking software, clinical protocol mapping, alert notification and support for dose optimization experts’ team. Traditionally, CT dose management is
done through retrospective dose surveys by extracting information manually from picture archiving and communication system (PACS) or radiology information system (RIS) (Nicol et al., 2016). The manual method has tendency to typographic errors, inconsistencies in data tracking and required longer time.

Recently, a digital dose monitoring software is commenced as an automated tool to track and analyse the big data for patient dose management (Parakh et al., 2016; Samei and Christianson, 2014). This study aims to present our initial experience and assess the feasibility of commercial GE DoseWatch software for local CT dose management and consequently suggest strategies for reducing patient dose. DoseWatch software by GE Healthcare (Milwaukee, Wis) is a software for monitoring radiation dose of patients undergoing CT examinations by tracking simultaneously dose-related data and systematically analysed the dose data. This study aimed to evaluate the used of GE DoseWatch software for local dose tracking and monitoring. A comparative study was also performed to compare the auto-tracked dose data by this software with our manual data from previous study (Razali et al., 2019).

2. Materials and Methods

The commercial GE DoseWatch software was first installed at Imaging Unit, Advanced Medical and Dental Institute, Universiti Sains Malaysia (AMDI, USM), Penang on November 2018. All the CT dose-related data were tracked by the DoseWatch software connected on-line to the Siemens SOMATOM AS+ CT scanner (Siemens Healthcare, Germany) and GE Discovery NM/CT 670 SPECT/CT scanner (General Electric Healthcare, Milwaukee, WI, USA). All CT studies performed are transferred from the PACS database to the DoseWatch servers. A dose team consisting of medical physicists, radiologist, radiographers, local DoseWatch coordinators and application specialist together with the CT application specialist of the vendor is performed at our institution.

2.1. Patient Data Collection

Institutional committee review for human ethical approval on clinical data study was obtained (study protocol code: USM/JEPeM/16040164). A retrospective review of all patients underwent CT scans at our institution between November 2018 until August 2019 was performed to review the local patient’s dose data and assess the current CT scanning protocols. The DoseWatch software allowed us to extract the radiation exposure data (as well as dose dataset) from CT studies performed by both CT scanners. The dose length product (DLP) displayed in unit mGy.cm was taken as the dose indicator.

2.2. CT Dose Monitoring

The CT dose data were analyzed using different filtering methods that is available on DoseWatch software which were CT protocol analysis, patient or study description, patient cumulative dose, and CT high dose level studies. The monitoring of local CT dose is performed based on CT scanning protocols and individual patients underwent CT scans for both CT scanners. One of the special features of DoseWatch is the dose team can set the dose limits according to a practice’s procedure guidelines or available established Diagnostic Reference Levels (DRLs) and the software automatically sends alerts when dose parameters exceed the established thresholds (Hassan A, 2015).

3. Results and Discussion

A total of 361 CT dose dataset were evaluated during the period of 10 months started from November 2018 until August 2019. From the initial experience, this software allows rapid and reliable collection and management of the CT dose data involving large number of CT studies. Figure 1 shows the distribution of the most performed CT protocols at our institution. The highest number of performed CT for both CT scanners was Thorax TAP (Thorax-abdomen-pelvis) CT scan (25% of total studies) and is followed by TAP CT study (23%). From the graph, it can be observed that similar protocols such as CT attenuation correction low dose (CTACL) study were tracked as two different protocols by DoseWatch software.
However, the CT protocols tracking was based on the selection of scanning protocols by radiographers based on default scanner setting. The limitation with commercial software is no uniform CT protocol assigning and some of them often redundant. Besides, the dose data from CT scanner of other vendor were transferred manually to DoseWatch servers after the completion of CT scanning and for some studies that were unsuccessfully transferred will not be tracked by the software.

Table 1 summarizes the CT dose analysis (presented as DLP) per protocols. Table 1 shows the minimum, maximum, and mean values of DLP (in mGy.cm) for the ten most performed CT protocols at AMDI USM, Penang. From the dose tracking, CTACL low dose CT protocol yields the highest DLP values of 10893.57 mGy.cm. From the dose analysis based on individual patient or study description, the highest individual DLP was 6668.99 mGy.cm for neck/thyroid CT contrast study. For patient cumulative dose analysis, the cumulative dose ranged between 30.74 – 8028.83 mGy.cm.

| CT Protocols                      | No. of studies (percentage) | DLP (mGy.cm) | Min     | Max     | Mean    | LDRLs$^{[6]}$ |
|----------------------------------|----------------------------|--------------|---------|---------|---------|---------------|
| Thorax_TAP                       | 77 (21.3%)                 |              | 637.42  | 3371.25 | 1386.33 | 1413          |
| TAP                              | 72 (19.9%)                 |              | 122.16  | 4156.80 | 1548.06 | 1413          |
| Routine Shoulder                 | 46 (12.7%)                 |              | 688.23  | 1638.16 | 1044.42 | -             |
| CTACL Low Dose                   | 29 (8.0%)                  |              | 263.57  | 1260.73 | 589.08  | -             |
| CTACL Low Dose                   | 25 (6.9%)                  |              | 160.13  | 10893.57| 1040.36 | -             |
| DE_Abd_Kidney Stones             | 15 (4.2%)                  |              | 203.18  | 1370.53 | 659.17  | -             |
| Routine Brain                    | 14 (3.9%)                  |              | 338.57  | 6668.99 | 2624.04 | 1385          |
| HeadRoutine                      | 13 (3.6%)                  |              | 540.27  | 3508.81 | 1905.34 | 1385          |
| CT Abdomen                       | 5 (1.4%)                   |              | 138.24  | 854.04  | 464.06  | 1059          |
| Head_PNS                         | 5 (1.4%)                   |              | 194.11  | 2518.09 | 1088.17 | -             |
The software also allows comparison of local dose with established local diagnostic reference levels (LDRLs). From Table 1, the mean DLP for few CT protocols exceeded the LDRLs such as TAP CT (10%), Routine Brain (89%), and HeadRoutine (38%) study. From the comparative study, we are able to identify the high dose level or overexposure studies that need further assessment and audit on the current protocols. Based on investigation, one of the factors that contributes to higher DLP values is due to multiple scan phases. Besides, the LDRLs were established based on third quartile (75th percentile) of dose distribution as compared to mean DLP values. The DoseWatch software allows the dose team to identify and further investigate individual patient with high dose level, and helps the team to strategies dose reduction technique. One of the dose reduction strategies is by modification and optimisation of current scanning protocol.

4. Conclusions
Initial experience with DoseWatch software demonstrates rapid collection and reliable management of CT dose data involving large patient’s data. Other advantages of this software are it allows comparison of local dose with other established DRLs and also able to identify the high dose level or overexposure studies that need further assessment and may lead to improvement of the related scanning protocols. Dose data centralisation is important for institution that has multiple imaging modalities and dose management software facilitate the dose audit. However, the software implementation required knowledgeable and well-trained user for full-benefits. Accurate data and proper selection of CT protocols is critical as it will influence the whole process of dose tracking and management. The initial experience with DoseWatch has created a growing dose awareness and optimization into a habit among the imaging professionals in our department.

5. References
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Acknowledgments
Authors would like to express our deep gratitude to GE Healthcare Sdn. Bhd. (Malaysia) and GE Healthcare (ASEAN Service) team for assistance during GE DoseWatch installation and valuable discussion on this study. Any use of this software is subject to GE Healthcare Standard Software End-User. Authors would also like to thank all staff at Imaging Unit, AMDI USM for their help & support throughout this work.