

GE Healthcare

DoseWatch

Gathering Radiation Dose Data



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After your organization crosses the bridge of “Why?” for patient radiation dose management – either due to regulation, risk mitigation or an enhanced focus on patient outcomes – figuring out the “How?” for the rest of the journey may seem daunting. Effective patient radiation dose tracking and optimization requires comprehensive and complete data collection. Many healthcare providers face a formidable task – gathering and aggregating information across multiple modalities and devices, likely from different vendors and certainly at different points in their lifecycle.

In fact, according to IMV's 2012 CT Market Outlook Report, the average CT replacement cycle is now 8.9 years (up from 6.7 years as of 2007 and 8.3 years as of 2011).¹ For interventional radiology and cardiovascular imaging, that lifecycle is even longer at 10 to 12 years.² Think about how technology has evolved just for your home PC in the last decade – its memory, communication capabilities and speed. CT scanners and other x-ray imaging devices have undergone similar developments, including significant changes in how dose information is stored and communicated. Collecting data across a diverse imaging install base is incredibly challenging, but GE Healthcare has a solution to help.

Everything is DICOM, shouldn't this be easy?

Digital Imaging and Communications in Medicine (DICOM®) is an evolving standard created to facilitate the communication,

storage and printing of medical imaging data. However, even with this standard, dose information may (or may not) be present in a variety of data messages and objects. In fact a device's software version, make and model can affect how, where and what information is available – making it essential that a dose management system be not just accurate, but also flexible in its approach to data collection. To be truly comprehensive, it must have the capability to receive and interpret multiple DICOM data sources. In some cases it may need to calculate radiation output metrics from other available parameters in order to estimate patient dose.

DoseWatch from GE Healthcare is a radiation dose management solution which simplifies the collection, analysis and interpretation of dose metrics and acquisition parameters across CT, interventional, mammography and radiography / fluoroscopy devices. The system supports flexible, direct-to-device integration, leveraging a variety of DICOM data sources including image headers, modality performed procedure step (MPPS) messages and structured reports (SR). PACS connectivity with optical character recognition (OCR) is included as an option for older systems and legacy data. Finally, GE CT and Innova customers can realize added value by accessing proprietary data stored on the device – expanding the available information beyond DICOM and achieving improved network performance.

Different Data Sources: Computed Tomography (CT)

DICOM CT Dose Sheet

One of the more familiar ways for radiologists to access CT radiation output data is via dose reporting screens – secondary capture images in the DICOM CT object where the volume CT Dose Index (CTDI_{vol}) and the Dose Length Product (DLP) values for the study have been “burned in”. These images are assigned a unique series number (series 999 for GE systems) and have a DICOM header associating them with the imaging study. Unfortunately neither the layout nor the information displayed in the image is standardized among vendors.

Figure 1. Excerpt from CT Dose Sheet

Dose Report					
Series	Type	Scan Range (mm)	CTDI _{vol} (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	—	—	—	—
200	Axial	I131.500-I131.500	25.51	12.78	Body 32
2	Helical	I13.000-I248.000	10.31	308.93	Body 32
2	Helical	I253.250-I698.250	15.49	789.37	Body 32
Total Exam DLP:				1111.08	

Getting this information out of the image and into a database presents a challenge. Optical character recognition (OCR) is typically required to extract useful information, a difficult process which requires error correction algorithms to account for split-text and misidentified characters, resulting in a data set that may not be 100% accurate.³ The lack of structured content, information sparseness and difficulty of accurate data extraction make this avenue of data collection far from ideal.

In some older CT models data options are limited and DoseWatch has been developed to accommodate this method of data collection. Often though there are better ways to collect more comprehensive data on patient radiation exposure in CT. DoseWatch can leverage one or more of these approaches when integrating with a healthcare system's imaging device portfolio.

DICOM Image Headers

Medical images contain a DICOM header describing technical parameters and device attributes associated with the creation of an image, e.g., x-ray generator energy setting (kVp), exposure (mAs), collimation width, pitch factor and slice location.⁴ This information can be collected to gain a detailed understanding of the acquisition process.

However, the image header is not an ideal place for the storage of dose information. Images may be sent to PACS prior to study completion, original thin-slice data may never be sent, but rather reconstructed into thicker slices or other viewing planes, and rejected series may never be sent at all. These scenarios and others can result in under- or over-counting of dose,⁵ particularly when that data is retrieved from PACS and there is no other available DICOM source for dose information.

DoseWatch takes these issues into consideration by not just offering PACS-based communication, but also providing the ability to directly connect to imaging devices. This ensures that all relevant images and metrics, regardless of whether they were sent to PACS, are harvested in order to provide an undistorted view of dose, acquisition technique, use of mA modulation and patient centering. For many systems DoseWatch can even recalculate missing metrics such as $CTDI_{vol}$ and DLP. With make, model and software version specific dose calculators, coupled with the ability to link directly to an imaging device, DoseWatch provides comprehensive and accurate data collection for newer and older CT systems.

DICOM Modality Performed Procedure Step

Images and image headers aren't the only source of dose data. The DICOM standard introduced a network transaction that is typically initiated by modalities at the beginning and end of imaging acquisitions. The transaction, called the Modality Performed Procedure Step (MPPS), is sent to the Picture Archiving and Communication System (PACS) and / or Radiology Information System (RIS), although other systems requiring information about acquisition status may also receive the message. The transaction allows efficient workflow management of radiology sub-processes such as image processing and reporting.⁶ MPPS may contain organizational and medical details related to the procedure, as well as billing data, material management data and in some cases radiation dose metrics.

Although MPPS may contain dose information not directly available from image headers, two significant drawbacks exist with respect to the use of MPPS in dose management. First, MPPS is essentially a transient message – the supplied data is not maintained in a DICOM object for storage, query or retrieval. Second, there is no standardization of CT dose information in MPPS,^{5,7} making the available dose and acquisition information highly variable across devices.

Still, DoseWatch supports MPPS for a large number of older makes and models which rely on this approach to communicate dose data. DoseWatch goes a step further by providing the ability to forward MPPS messages, a very useful feature when interfacing with systems that restrict the number of transaction recipients.

DICOM Structured Reporting

DICOM structured reporting (SR) classes bridge the gap between medical images and information systems, allowing for transmission and storage of relevant clinical documents, free-text reports and structured information.⁸ The Radiation Dose SR (RDSR) template accommodates the recording and storage of dose information and related metrics from imaging modalities, described in DICOM PS 3.16-2011 (template ID 10011, 10012, 10013 and 10014 for CT).⁹ The RDSR provides detailed information which may be missing from image header data or not included as part of MPPS. It is also persistent, unlike MPPS which was designed for workflow.¹⁰ Like other DICOM objects, the RDSR may be created, archived, anonymized, queried and retrieved. As a result these reports may be stored on PACS together with images – provided the PACS vendor has the capability and the site chooses to archive them.

Figure 2. CT Radiation Dose Structured Report

CT Radiation Dose – TID 10011	
CT Accumulated Dose Data – TID 10012	Provides information on dose value accumulations over several irradiation events from the same equipment over the scope of accumulation defined by the report.
CT Irradiation Event Data – TID 10013	Dose and equipment parameters for a single irradiation event, including the anatomical target region and $CTDI_{vol}$.
CT Scanning Length – TID 10014	Contains information regarding the exposed range, scanned length and length of reconstructable volume.

Not all CT devices support structured reporting. Where RDSR is supported, the data available in the report will vary by make and model as described in the device's DICOM conformance statement. In other words while the RDSR template provides a location and framework for information, certain fields may not be populated by a particular device. As an example, "CT Effective Dose Total" is a data field in the RDSR template, but it is not typically provided by the CT scanner.

DoseWatch is capable of not only receiving and interpreting an RDSR from a device, but also performing additional dose calculations, such as effective dose, creating a more complete report. The DoseWatch RDSR can be sent to SR friendly RIS systems for automatic inclusion in the patient electronic medical record. For example, in GE Centricity RIS-IC (10.8 Update 1), dose information can be automatically extracted from the RDSR supplied by DoseWatch.

Table 1. Examples of data which may be available in the CT RDSR. Note that the current template DICOM PS 3.16-2011 did not originally contain information fields for Size-Specific Dose Estimate (SSDE), an important metric in the assessment and optimization of pediatric CT dose.^{11, 12, 13} A DICOM Correction Proposal (CP-1170) was submitted to the standard committee and approved as final text (January 2012). DoseWatch is able to calculate this value automatically and include it in the patient's dose history.

Dose and Dose Related Values	Mean Volume Computed Tomography Dose Index (CTDI _{vol}) Dose Length Product (DLP) Effective dose (E) Effective dose evaluation method Size-Specific Dose Estimate (SSDE) Number of irradiation events
Device Settings	Acquisition protocol Scanned anatomical region Scanning length X-ray energy (kVp) X-ray tube current (mA) X-ray tube current modulation type Pitch factor Collimation width

Different Data Sources: Interventional and Cardiovascular Imaging (IR/CV)

In many ways the collection of dose information for fluoroscopy-guided procedures is more complex than CT. This is partly due to the longer lifecycle of these systems, resulting in a large number of older units which are limited in their communication and dose reporting capabilities. Also the intended use of these systems differs from CT, where the focus is on diagnostic imaging. Most IR/CV exposures are not associated with a recorded image, but rather used in guidance of a procedure. Accordingly any images that do arrive in PACS are typically a subset of those seen in the procedure room and are not a suitable means of estimating patient dose. This means that direct device connections are crucial to obtaining accurate information.

MPPS

As in CT, dose information provided in MPPS messages is not standardized across manufacturers or models. Where MPPS is available, the device may provide study metrics such as Dose Area Product (DAP), Air Kerma (dose in air at a reference point) and fluoroscopy beam time. More detailed exposure information may or may not be communicated by the device. DoseWatch supports this communication method and records any relevant data fields provided by the system.

RDSR

Most state-of-the-art IR/CV devices support RDSR DICOM objects, although these systems represent a minority compared to the overall install base. Again the RDSR is not a simple text document and requires a tool like DoseWatch to parse and present relevant dose information.

The X-Ray Radiation Dose SR template (used by IR/CV as well as mammography) is described in DICOM PS 3.16-2011. Dose and exposure is defined for a specific system, for each plane. In other words a biplane irradiation is recorded as two individual events, with accumulated values recorded separately for each plane. DoseWatch is able to gather all single and biplane data presented by the device, as well as compose a visual interpretation of the dose in the form of an incidence map – a plot of air kerma delivered at each gantry angulation, including an estimation of maximum dose due to beam overlap.

Figure 3. X-Ray Radiation Dose Structured Report

Projection X-Ray Radiation Dose TID 10001
<p>Accumulated X-Ray Dose Data – TID 10002</p> <p>Provides information on dose or dose-related value accumulations over several irradiation events from the same equipment over the scope of accumulation defined by the report.</p>
<p>Irradiation Event X-Ray Data – TID 10003</p> <p>Dose and equipment parameters for a single irradiation event.</p>
<p>Accumulated Projection X-Ray Dose – TID 10004</p> <p>Detailed information on projection x-ray dose value accumulations over several irradiations from the same equipment.</p>
<p>Accumulated Mammography X-Ray Dose – TID 10005</p> <p>Detailed information on mammography x-ray dose value accumulations over several irradiation events from the same device.</p>

Table 2. Examples of data which may be available in the X-Ray RDSR.

Dose and Dose Related Values	Dose Area Product (DAP)
	Fluoro Time
	Reference Point Air Kerma
Device Settings	Gantry Angle
	Acquisition Plane
	Fluoro Mode
	Frame Rate or Pulse Rate
	Table Height
	Collimated Field Area
	X-ray filter material and thickness
	X-ray energy (kVp)
	X-ray tube current (mA)

Other Solutions

For GE Innova systems not supporting MPPS or RDSR, DoseWatch can collect information stored in a proprietary format on the device, offering highly detailed dose information for every exposure event. This allows patient specific information to be recorded and managed – expanding on the features available in GE Innova Reports. No other dose informatics vendor has this capability.

GE CT customers also have the option to access data stored at the scanner, bypassing DICOM messages and their inherent limitations with respect to completeness and network speed. Highly detailed acquisition information can be collected, with the potential to access specific series or cross-sectional images, minimizing lag and network bandwidth. It's just another way GE brings added value to its existing customers.

A flexible and complete solution

Whether you have an older install base, the latest imaging technology or more likely a combination, DoseWatch is capable of providing a comprehensive and accurate view of your patient dose data across multiple modalities and vendors. With capabilities beyond simple, single stream data collection, DoseWatch provides the power to fill in missing dose metrics, calculate patient size-specific dose estimates (SSDE), and provide insight into protocol settings, patient centering and use of dose-sparing technologies.

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