Creating a Unified Patient Radiation Dose Tracking System: Multiple Modalities, Vendors, and Techniques

T O’Connell MEng MD1, D Chang MD2, JE Aldrich PhD3, JR Mayo MD4

BACKGROUND

Patient radiation dose is a public and controversial topic, due to both its risks and the increasing medical radiation exposure of the public. As a result, it is important that patient radiation dose is tracked to both prevent overexposure and to provide patients information about the risks associated with radiation-based tests and procedures. Radiation dose to patients is calculated via multiple techniques:

- Absorbed dose: indicates the amount of energy absorbed per unit mass, and is specified in Grays (Gy) where 1Gy = 1J/kg
- Equivalent dose: is a risk estimate to humans that incorporates the energy absorbed, the type of radiation, and the sensitivity of a particular tissue to radiation
- Effective dose: is a more general estimate that is a sum of equivalent doses to different tissues/organ to give an estimate of the impact of an absorbed dose on an organism

Effects of radiation exposure to patients are described as either deterministic or stochastic effects. A deterministic effect depends on the dose of radiation administered; e.g. skin erythema (redness) will occur at a skin dose of 5Gy. A stochastic effect is one that is produced by chance e.g. there is a small chance that even a single photon of x-ray energy could induce a cancer - i.e. the severity of stochastic effects is independent of radiation dose.

The main concern with medical radiation tests is cancer risk, which is a stochastic effect - i.e. that even very small doses of radiation (from a single photon) could induce a cancer - thus there is a need to track as many radiation doses administered to patients as possible.

SYSTEM FUNCTION

The dose software works as follows:

1. A Daily UNIX cron script runs which executes the system’s retrieve script. This script performs a DICOM C-FIND operation to find the SOP Instance UID for the dose reports.
2. If a dose report, the image is manipulated and the text is extracted. The DLP value and required DICOM header fields are stored in the database. A JPEG image of the dose report created and stored in the database which can be viewed for verification purposes through the user interface.
3. If a DAP report, the DICOM header fields are extracted and stored in the database and the image is discarded.

TECHNICAL BACKGROUND:

This project was designed to manage the radiation doses administered from five CT scanners and two digital X-Ray units:

1. CT Scanner
2. PACS Server
3. Dose Server

CT DOSE REPORTING

The computed tomography (CT) scanners in this project produce an image with every examination that contains patient data. The useful metric provided on these reports is the dose-length product (DLP), in mGy•cm. Effective dose can be calculated from DLP using conversion factors. The DICOM images from the CT scanners used in this project are shown. The right - Toshiba Aquilion ONE - Dr. Leipsic; Bottom right - Siemens Sensation Cardiac 64; (DLP 340); Bottom left - GE LightSpeed Ultra (DLP 1200 S5).

These images demonstrate the differences in the dose reports from different vendors and the challenges involved in creating a programmatic method of extracting DLP values. Scanner vendors can produce DICOM structured reports that contain dose information which feature is not available on all the scanners used at our institution.

OUTPUT

When the dose software is viewed in Microsoft Internet Explorer on a computer running Windows 2000 or newer, and has Microsoft Excel 2003 or newer installed, if a user right-clicks on the tables created by the dose software, the option “Export to Microsoft Excel” will appear.

Using this technique, data from this software is easily exported to a spreadsheet program for data analysis. Using the sort functions of the spreadsheet, data can be rapidly segmented, and by using the “Data Analysis Toolpak” plugin for Excel, descriptive statistics can be easily produced. Once in Excel format, the data can be easily exported as comma-separated variable (CSV) for export into any software package. It would require minimal programming effort for the dose software to directly export to CSV format.

TECHNICAL CHALLENGES

- **DICOM:** This standard is rarely, if ever, used in medical imaging. The variation in how vendors report DLP on their dose reports is problematic in that the DLP value can appear in different locations, the text is in free text and not a standard typeface, making optical character recognition difficult.

REFERENCES


FUTURE PLANS

Experiences from this project in the addition of fluoroscopy and nuclear medicine dose information, automatic reporting for departmental QA purposes, and the production of patient reports with cumulative dose information, and estimates of radiation risks for patient education purposes.