Creating a regional patient dosimetry system using Siemens Teamplay

Ian Birch

Background: As part our work at Medical Physics Newcastle, we provide quality control (QC) services to 12 regional trusts and other organisations covering 700+ items of x-ray equipment across 80+ sites. We also provide a patient dosimetry audit service to assist our medical physics experts (MPEs) in fulfilling various duties regarding patient dose optimisation. Currently, around 75% of radiology equipment across our region have the facility to automatically export electronic radiation dose information relating to individual patient procedures. This increases to 90% when excluding low dose dental x-rays. The aim of this work was to harvest this data from multiple organisations, transfer it to medical physics for centralised processing and to display data with specific search functionality.

Methods: To harvest data, we worked with Siemens Healthcare, recommending and adopting their 'Teamplay' dosimetry system to the NHS Trusts that we provide services to. For early adopters the software was free to install and use. A key feature of Teamplay is that it operates independently of the equipment manufacturer and PACS provider. Our system involves Teamplay data being automatically filtered and stored in a medical physics administered database. The data is then presented in an excel based analysis 'dashboard'. Several library files help manage x-ray equipment matching, inconsistencies in x-ray procedure naming between organisations and between x-ray manufacturers, the import of local and national diagnostic reference levels (DRLs) and application of dose indicator calibration factors from our medical physics QC records.

Results: We have a lot of data; passing the milestone of **two million patient examinations in May 2023,** and increasing by over 90,000 exams on average each month. As of September 2023, we have dose information covering 120+ regionally defined study groups for almost 300 items of equipment. The data is refreshed monthly, but can be updated in near real-time, usually on urgent request for data by one our MPEs. To navigate through the dashboard, we have a useful array of search functionalities including Trust, x-ray modality type (CT, plain film etc), x-ray examination type, date range and patient age.

Discussion: Users have reported that the dashboard provides efficient access to recent and historic data and is used for checking compliance against local DRLS for comparing their dose to other organisations within the region. MPEs report the dashboard is an important tool in targeted dose optimisation and assists with medical physics reviews of research studies involving ionising radiation.

Conclusion. Challenges remain; however, the project is deemed a great success and an excellent example of our multidiscipline medical physics team of scientists, technologists and IT specialists working together with a commercial organisation to make a positive impact on patient care.

Key references: DRLs, Optimisation, Patient Dosimetry, Teamplay

The dose audit for optimisation puzzle – a missing piece

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Background.

Dose Management Systems offer a powerful tool to gain insights into dose levels employed diagnostically. Initial multi-disciplinary guidance[1,2] advocated patient audit cohorts selected according to a defined weight range so as to avoid the confounding effect of weight on results where automatic dose control is employed. Audits utilising DMSs do not presently provide the benefit of patient size selection as patient habitus/BMI/weight metrics are not routinely collected, owing to the high overhead on imaging staff time.

A method utilising CT Topograms is proposed, as a proof of concept, for CT examinations of the trunk. This enables a DRL curve to be generated covering the range of patient sizes providing greater confidence in interpreting dose data and to support optimisation decisions. This is increasingly relevant as obesity is on the increase across populations[3,4].

Method

DMS at Portsmouth comprise OpenREM, and more recently SECTRA DoseTrack to which all CT systems provide dose and study data. CTs are also configured to send Topograms to our Dosimetry PC where images are organised by study and subdivided further by AP and Lateral for analysis using ImageJ. Patient Average Effective Diameter (AED) is determined from the topograms and data subsequently recombined with dose data from either OpenREM or DoseTrack. Median doses are determined for patient size classifications derived from VirtualDose™ covering Under-weight, Normal Weight, Obese level I & II and Morbidly Obese, and plotted to generate the DRL curves, i.e. DLP vs AED and CTDIvol vs AED.

Results

AED derived from topograms correlated well with Effective Diameter ranges from axial scans for each body habitus, derived via an API script submitted to VirtualDose, The ImageJ algorithm successfully analysed the majority of images, with exception of outliers, e.g. arms in the field, excessive body size. With the benefit of large sample sizes, whole study medians were found to be immune to exceptions, where these occurred. Whole study medians for CT Chest, and Abdo-Pelvis were found to be representative of Over-weight, Obese Level I or Level II for males and females.

Discussion

Our study population median was found to be representative of over-weight or obese body habitus. Median DLP and CTDIvol for normal weight patients (analogous to the national survey weight requirement) were up to 40% lower than the whole study medians, suggesting an over-estimation of dose where patient weight is unknown. DRL curves had strong correlation coefficients for median dose vs median AED per habitus. Correlation with VirtualDose phantoms allows straightforward calculation of Effective Dose for each body habitus.

Conclusion

Average AED derived from topograms provides a useful surrogate for patient weight. Additional radiology time is not required to collect this data. Such calculations could be incorporated into systems for direct inclusion in DMSs.

Key references

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So you have a DMS – what next? Development of a DMS independent method of data processing

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Background. Dose monitoring software (DMS) provides a valuable tool for data collection with several potential uses for dose auditing, optimisation, or the establishment of Diagnostic Reference Levels. Local experience with different DMS has demonstrated challenges in the practical utilisation of information from these system by Image Optimisation Teams (IOT). While some DMS have systems to address these challenges, not all do, and they can be time consuming or impractical to use. Locally, multiple DMS are used concurrently to ensure coverage of all systems.

It was recognised that data processing could be broken down into three stages: pre-processing of data, involving data cleansing, standardisation, and grouping data into suitable datasets; the calculation basic statistics; and outputting data into convenient formats for review. Only the first stage of this is particularly impacted by differences in data sources. A project was initiated to provide a single script that could analyse collected dose data without relying on specific scripting to accommodate different data sources.

Methods. A python script was developed to process a provided dataset using information in a configuration file requiring minimal programming expertise by the user. This configuration file allows for development of automated and reproducible data cleansing. The script optionally allows for the inclusion of a reference dataset and the current data will simultaneously be compared with the reference data.

Results. A functional tool is in place providing data to direct optimisation in the Trust. Standard tabular data is supported by automated box and whisker plots to provide a quick overview of data. The talk will focus on the development of the tool and logic behind it so that similar approaches could be taken.

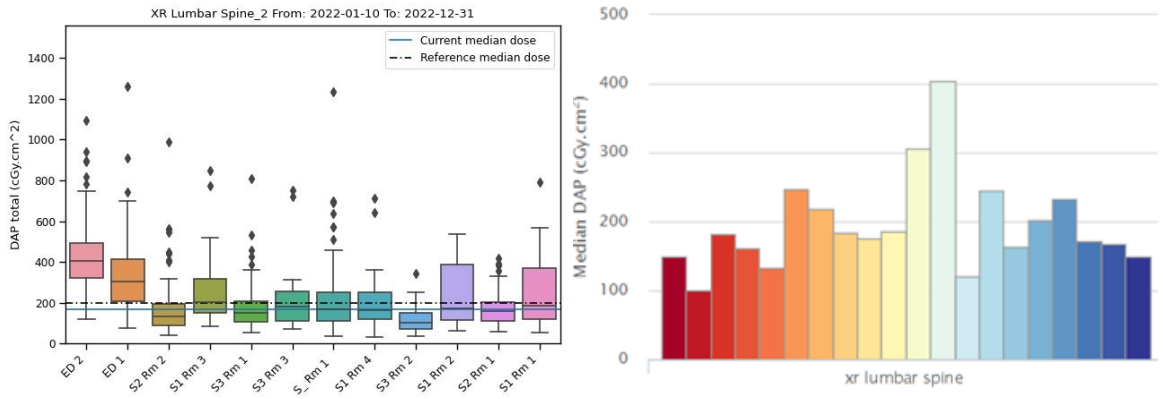

Fig 1: Graphs showing the distribution of data for adult Lumbar Spine examinations over the same time period produced as a box and whisker diagram by the tool (left) compared to the inbuilt DMS graphing feature (right).

Discussion. Available DMS features do not allow for detailed analysis to support optimisation without significant processing. It is hoped that this tool will provide a flexible alternative to drive direct optimisation and to efficiently perform routine dose audits.

Conclusion. The tool is currently undergoing initial use and has received positive feedback from the Medical Physics Expert. Further development is planned based on feedback to improve clarity of the outputs, as well as the usability and stability of the script.

Commissioning skin dose reports for interventional radiology within two dose management systems

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Aim: To transfer from calculating peak skin dose manually for interventional radiology procedures to using automated approaches within two dose management systems.

Background: Medical Physics at UHBW provide support to two tertiary centres; one for interventional cardiology at UHBW and one for neuro-radiology and interventional radiology at North Bristol Trust (NBT). Historically peak skin dose calculations have been carried out manually by medical physics using an in-house method. This method used acquisition data, images and PCXMC to map projections and estimate the overlap between x-ray fields. We wish to move to an automated approach in order to report more rapidly. Two different dose management systems have been installed which include skin dose mapping and peak skin dose calculations; these are OpenREM at NBT and Qaelum at UHBW.

Methods: As part of our commissioning, we compared the assumptions used in manual calculations to those used by OpenREM, with the support of the OpenREM development team. We carried out phantom work to investigate the field overlaps found by each method. We compared OpenREM skin dose maps and peak skin doses to those calculated manually for clinical cases in each interventional radiology lab. We considered different clinical procedures, including neuro, vascular and cardiac procedures. We will apply our learning from the OpenREM commissioning to Qaelum's equivalent calculations for cardiac procedures in UHBW.

Results: Overall, peak skin doses calculated by OpenREM were lower than those calculated manually. There were differences in the distance correction applied to each exposure, with minor differences in back-scatter factors, DAP correction and table/mattress attenuation. We found better agreement for certain labs and procedures than others. At the time of this work, the phantom used by the OpenREM code did not include a head, so skin dose maps were not displayed accurately for neuro procedures. The OpenREM code assumes a standard imaging table, so skin dose maps for procedures performed on a non-standard Maquet table were incorrectly displaced. The Philips Azurion unit used for cardiac procedures does not currently send enough information for OpenREM to produce a skin dose map.
We expect to also present results from Qaelum at UHBW.

Discussion: There are differences between the skin doses calculated manually and by OpenREM as they make different assumptions. Given that overall the peak skin doses are lower than those calculated manually, we have been cautious about fully moving to using automated calculations. The method is not yet fully suitable for specialist centres such as neuro-radiology, although the OpenREM developers have been extremely helpful in attempting to resolve the associated issues. Currently we are awaiting local installation of the latest release of OpenREM in order to test recent improvements made to the skin dose maps. We hope to take this learning from OpenREM and apply it to the Qaelum system which also calculates skin dose maps and peak skin doses.

Conclusion: The OpenREM and Qaelum dose management systems are able to produce skin dose maps and peak skin doses immediately after a procedure is carried out and the RDSR compiled. However, implementing these systems has taken more time than expected. Understanding the model they use is important; caution is required for specialist procedures where more adaptation is required. We anticipate using these skin dose maps in our clinical skin dose reports in the near future.

References:

[1] OpenREM main website, https://openrem.org/

[2] PCXMC 2nd Edition, STUK, Finland, 2008

[3] Qaelum DOSE main website, https://qaelum.com/solutions/dose

Key words: Peak skin dose, Interventional radiology, Dose management systems

A python script to batch process skin dose estimates using OpenREM fluoroscopic data.

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Background

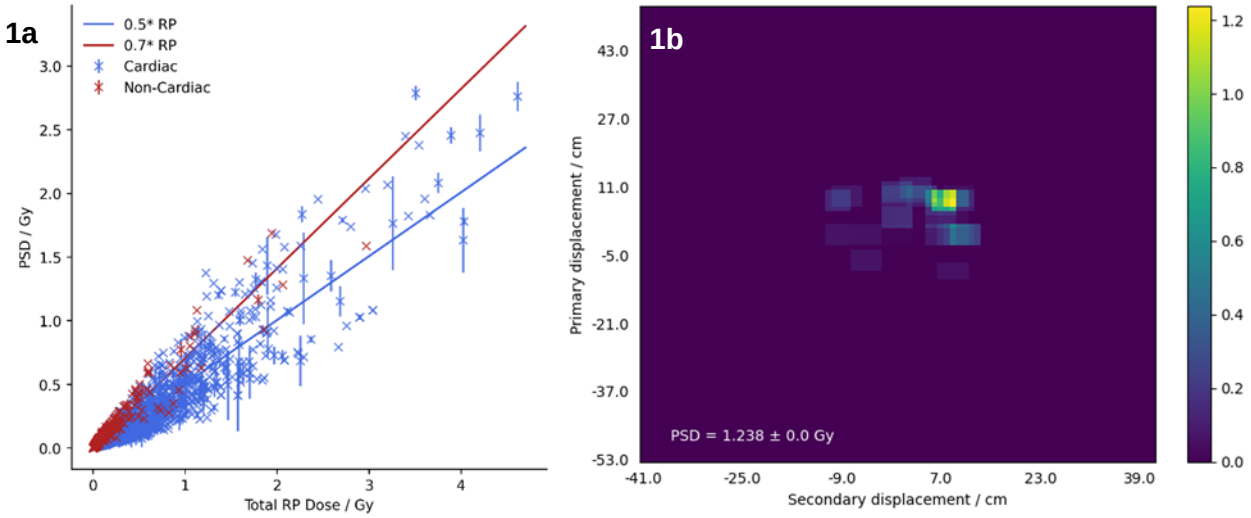
Peak skin dose (PSD) is used to evaluate the potential for skin injury from fluoroscopy procedures. PSD is not a standard DICOM output and requires calculation using additional software such as OpenREM's open-skin or Siemens' Caregraph. This takes time and therefore isn't feasible to perform for every examination. Instead, PSDs are only calculated when certain trigger levels (exam time or DAP) are exceeded [1,2].

Methods

For every event in an individual fluoroscopic exam, reference point (RP) doses and beam sizes were scaled and mapped onto a basic patient geometry which was defined as a function of primary and secondary angle. Events were then combined (see figure 1a) to find areas of maximum radiation exposure. This was performed using a python script and the metrics available in a bulk OpenREM export [3].

Results

We were able to rapidly (< one hour) produce PSD estimates for all 4600 fluoroscopic procedures performed by RCHT in 2022. This included an option to combine estimates for patients who underwent multiple exams. Additional metrics were recorded to look for correlations in patient data, for example between PSD, RP dose and procedure type (see figure 1b).



Discussion and Conclusions

Being able to quickly audit large datasets benefits not only high PSD detection, but also our understanding of how peak skin dose relates to RP dose, time, DAP, and study type. This informs choices with regards to trigger levels. Further, the ability to review cumulative dose across multiple exams is potentially important for determining the true doses administered to patients.

This analysis provides significant benefit as a tool alongside our Trust's current use of OpenREM.

References

1. Harries D, Platten DJ, Improving the effectiveness and efficiency of a skin dose investigation protocol in interventional radiology. *BMJ Open Quality* 2020;(9):e000722. doi: 10.1136/bmjoq-2019-000722

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3. McDonagh E, OpenREM. Open source. Available: https:// docs.openrem.org/

Setting local diagnostic reference levels using chart data from OpenREM

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Background

We wanted to use our own patient dose data to recommend local diagnostic reference levels (LDRLs) for CT, radiography, cardiology, and fluoroscopy examinations carried out at the Trust. The Trust's patient dose management system, OpenREM (1), contains data from a total of more than 1.5 million studies including CT, radiography, fluoroscopy and mammography examinations.

There has been no standardisation of acquisition protocol names on Trust x-ray systems, resulting in a range of names for the same type of exposure across the x-ray systems. This makes it difficult to compare doses between systems for a specific type of exposure.

For interventional cardiology and some fluoroscopy and CT procedures no useful study description names are contained in the DICOM data sent to OpenREM from the x-ray systems. This makes meaningful patient dose audit for these systems impossible with the default OpenREM data.

Methods

For interventional cardiology procedures OpenREM study description names were updated by running custom SQL statements on the OpenREM database. These were created from radiology information system (RIS) and a Heart Centre spread sheet data. A similar approach was used to update some fluoroscopy and CT study descriptions.

In addition, a new standard name mapping feature was added to OpenREM to enable ranges of acquisition protocol names and study descriptions to be mapped to user-defined standard names. OpenREM chart data using the standard names were used to audit patient dose and recommend LDRL values. In some cases chart data were exported to a spread sheet to enable DAP calibration factors to be applied.

Results

A comparison of median dose values from OpenREM chart data will be shown to demonstrate the effect of updating study descriptions using RIS data, and also the effect of implementing standard name mapping. The impact of applying DAP calibration factors to radiographic data will also be demonstrated. LDRLs derived from the data will be shown.

Discussion

Updating the study description field in OpenREM using RIS data was essential for meaningful patient dose audit for interventional cardiology and some fluoroscopy and CT procedures.

Introducing the standard study name feature has simplified patient dose audit.

A feature to apply equipment-specific and date range-specific DAP calibration factors may need to be introduced to OpenREM for radiography and fluoroscopy data. An issue has been raised to add this feature (2).

Conclusion

Patient dose data contained within a patient dose management system are useful for patient dose audit, but consideration of non-standardised names and DAP calibration factors must be made.

Key references. In alphabetical order, numbered.

(1) https://www.openrem.org/

(2) https://bitbucket.org/openrem/openrem/issues/745

Review of study deviations in clinical practice

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Background.

The regular review and management of imaging protocols is a way to ensure that patients receive the proper care and that the desired diagnostic image quality is achieved while keeping the radiation dose as low as possible, the ALARA principle, (ICRP 2007). However, the capabilities of the several vendors and equipment types may differ and together with the deviations that occur in practice (like additional requests or potential errors), the exam execution may vary, even in the same facility (Cody 2013). Considering that the Diagnostic Reference Levels are calculated for each exam protocol (Wall 2014), it is important to ensure proper execution and as few protocol deviations as possible. In the era of automation and radiation dose management systems, the close monitoring of the actual application of protocols in practice becomes easier even for devices of remote locations (EURATOM 2013, Fitousi 2017).

Methods.

Covering one year and four CT scanners over two sites within the same Health Board, retrospective analysis of studies was carried out using the radiation dose management system installed in the Health Board (DOSE, Qaelum, Belgium).
Study composition and number of irradiation events included in each exam were reviewed and the effect of the variations on DLPs was assessed.

Results.

Three study types were assessed ('CT Head', 'CT Thorax' and 'CT Thorax with Contrast').

The 'CT Head' studies were found to be the most standardised with all four scanners mostly having the expected number of irradiation events and median DLP of each scanner was within 4% of the organisation median. Studies of the thorax were the least standardised. There was a range of irradiation events between 2 and 12. Review of the outliers indicated other body parts were frequently included.

Review of the 'with contrast' exams highlighted practice differences between the sites. Only one site was using monitoring to trigger the scan after the contrast was administered.

The 'CT Thorax' data highlighted very clear protocol differences with DLPs ranging between -67% and +39% of the organisation median. Reviewing the study composition highlighted that this study description was being (mis) used for both standard and ultra-low dose Thorax exams, resulting in some outlier cases with DLPs a factor of 10 larger than the median value.

Discussion.

An advanced automatic dose management system provides all the right tools to assess more than just the radiation dose delivered during an exam. It provides an overview of the actual execution of exams, showing deviations from protocols in order to assess whether there is a need for extra training or for a protocol review.

Conclusion.

Patient dose management systems have become indispensable in clinical practice. They incorporate a very extensive dataset, so provide wide ranging possibilities for analysis beyond determination of typical doses for comparison to National DRLS. This study shows they are critical tools for use in optimisation.

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