Automated Extraction and Management of Radiotherapy Imaging Dose Data

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Background.
Radiotherapy departments are strongly encouraged to establish reference levels for imaging doses and to actively engage with each other in the optimisation of imaging practices as part of a peer review network (NRIG, 2012). Despite enthusiasm within both the diagnostic and radiotherapy communities implementation to date has been limited, one of the reasons being the difficulty in obtaining and interpreting reliable data on radiotherapy imaging activity and the associated dose.

A system has been developed which automatically extracts CT and CBCT performance and dose information from the hospital PACS and the ARIA oncology management system (OMS) and stores it in a structured, centrally accessible data warehouse. Although similar data extraction methods have previously been employed in diagnostic imaging (Sutton et al., 2014, McDonagh, 2014) it is believed this is the first large scale implementation in radiotherapy.

Methods
DICOM query/retrieve functionality is utilised to first index and then retrieve CT dose report objects known to the PACS and other DICOM archives. Protocol information, patient details, CTDI and DLP are extracted. A script is also run against the OMS which extracts CBCT activity information, including exposure settings and scan length. This is shown schematically in Figure 1.

Information gathered from source systems is converted into a standard format and stored in a data warehouse structured to make exploration of the data straightforward using readily available reporting and data mining tools. Data can be plotted and tabulated as a function of scanner, linac, operator, day of week, etc. Authorised operators can drill down to the patient, study and series level to understand the pre-treatment and on-treatment imaging performed for individual patients and review the overall imaging dose record. Data can also be presented anonymised or pseudonymised for research, development and audit purposes. An example report is shown in Figure 2.

Results
For a large cancer centre (12 linacs) the data extract from PACS takes approximately 3 hours per year and a complete extract from the OMS approximately 5 minutes. When fully automated, the processing burden required to regularly update the data warehouse on a nightly basis is negligible.

Radiotherapy pre-treatment exposures were consistent with the equivalent diagnostic investigations and both were in line with local and national DRLs (Figure 3a). There was an overall trend of a yearly increase in linac CBCT doses across all patients (Figure 3b). However, the increase for the lowest dose studies is proportionately largest, resulting in greater homogeneity in dose across all studies and only a marginal increase in the DRL (third-quartile dose) of 4% (Figure 4). There is evidence that when more advanced and automated linac imaging equipment is available more CBCTs are acquired.

Discussion
Site information may be coded differently between individual CT scanners and between diagnostic systems and the OMS. Also, a limitation of ARIA is that it does not always record the correct CBCT exposure information. However, if on-treatment imaging is protocol driven there is a unique relationship between recorded values and the protocol selected. Data warehouse mapping tables were employed to standardise site descriptions and identify the actual protocols utilised.

The system facilitates proactive monitoring of dose reference levels and imaging practices (Figure 5). Linking to the PACS and OMS would also enable images to be viewed and image quality considered in context with the dose information, thus supporting a review of optimisation strategies.

Conclusion
A fully automated data warehouse empowers professionals who are not IT experts to ask clinically relevant questions of a rich data source of imaging performance and dose information.

References

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