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Canadian Association of Radiologists Radiation Protection Working Group: Automated Patient-Specific Dose Registries—What Are They and What Are They Good for?

Thorarin A. Bjarnason, PhD, MCCPM[a,b,c,*], Yogesh Thakur, PhD, MCCPM[b,d], Santanu Chakraborty, MD[e,f], Peter Liu, MD[g], Martin E. O'Malley, MD[h,i], Richard Coulden, MD[j], Michelle Noga, MD[j], Andrew Mason, MD[k], John Mayo, MD[b,d]

[a]*Diagnostic Imaging Services, Interior Health, Kelowna, British Columbia, Canada*
[b]*Department of Radiology, University of British Columbia, Vancouver, British Columbia, Canada*
[c]*Department of Mathematics, Statistics, Physics & Computer Science, University of British Columbia Okanagan, Kelowna, British Columbia, Canada*
[d]*Integrated Medical Imaging, Vancouver Coastal Health Authority, Vancouver, British Columbia, Canada*
[e]*Department of Radiology, University of Ottawa, Ottawa, Ontario, Canada*
[f]*Department of Diagnostic Imaging, The Ottawa Hospital, Ottawa, Ontario, Canada*
[g]*KMH HealthCare Centres, Mississauga, Ontario, Canada*
[h]*Joint Department of Medical Imaging, University of Toronto, Toronto, Ontario, Canada*
[i]*Princess Margaret Hospital, Toronto, Ontario, Canada*
[j]*Department of Radiology and Diagnostic Imaging, University of Alberta, Edmonton, Alberta, Canada*
[k]*Medical Imaging Department, Ridge Meadows Hospital, Maple Ridge, British Columbia, Canada*

Abstract

Medical radiation should be used appropriately and with a dose as low as reasonably achievable. Dose monitoring technologies have been developed that automatically accumulate patient dose indicators, providing effective dose estimates and patient-specific dose histories. Deleterious radiation related events have prompted increased public interest in the safe use of medical radiation. Some view individualized patient dose histories as a tool to help manage the patient dose. However, it is imperative that dose monitoring technologies be evaluated on the outcomes of dose reduction and effective patient management. Patient dose management needs to be consistent with the widely accepted linear no-threshold model of stochastic radiation effects. This essay reviews the attributes and limitations of dose monitoring technologies to provoke discussion regarding resource allocation in the current fiscally constrained health care system.

Résumé

Le recours à la radiation médicale se doit d'être pertinent et de respecter le principe ALARA (le niveau de dose le plus faible qu'il soit raisonnablement possible d'atteindre). Les technologies de surveillance de la dosimétrie qui compilent les indicateurs de doses des patients fournissent une estimation des doses efficaces ainsi que les antécédents dosimétriques du patient. Des cas de manifestions d'effets délétères liées à l'exposition à des rayonnements ont ravivé l'intérêt public en ce qui a trait à l'utilisation sécuritaire de la radiation médicale. Certains considèrent les antécédents dosimétriques du patient comme un outil de gestion de la dosimétrie. Il est toutefois essentiel d'évaluer la mesure dans laquelle les technologies de surveillance de la dosimétrie favorisent la réduction des doses et la prise en charge efficace du patient. La gestion des doses administrées au patient doit respecter le modèle linéaire sans seuil (largement accepté) en ce qui concerne les effets stochastiques de la radiation. Cet essai examine les caractéristiques et les limites des technologies de surveillance dosimétrique afin d'alimenter les discussions concernant l'allocation des ressources dans un contexte de système de santé assujetti à des contraintes financières.

Key Words: Cumulative dose; Dose history; Patient-specific dose history; Diagnostic reference levels

* Address for correspondence: Thorarin A. Bjarnason, PhD, MCCPM, Diagnostic Imaging, Interior Health Authority, Kelowna General Hospital, 2268 Pandosy Street, Kelowna, British Columbia V1Y 1T2, Canada.

E-mail address: thor.bjarnason@coolth.ca (T. A. Bjarnason).

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Radiation is believed to be a weak carcinogen and the amount used in medical imaging should be as low as reasonably achievable (ALARA). With technological improvements and innovation, new dose monitoring technologies are able to: 1) automatically accumulate and sort modality/equipment based dose indicators; 2) provide estimates of effective dose; 3) compile patient dose histories; and 4) provide the medical physics and radiology community with additional quality control tools to further enforce ALARA principles. In diagnostic radiology, current standards for new equipment require the transmission of modality specific dose indicators to picture archiving communication systems (PACS) as a component of the permanent patient imaging medical record and enable radiologists to monitor appropriate dose. Deleterious radiation related events have increased public interest regarding the safe use of radiation in medical imaging, resulting in some jurisdictions passing laws requiring the recording of dose into the patient's medical record [1]. The radiology community must practice ALARA and explore new technologies to enable dose reduction, including automated dose registries. The introduction of this new technology needs to be assessed to ensure we use the information in a clinically appropriate manner and under the constraints of the linear no-threshold (LNT) model of radiation related stochastic risk. It is imperative that dose monitoring technologies are evaluated on their merit with regards to aiding dose reduction and appropriate patient management, rather than a reaction to media or public pressure.

To this aim, we present a review of dose monitoring technology and the utility of patient-specific dose histories. We hope this review will assist medical imaging departments in rationally assessing the purchase and implementation of cumulative dose tracking technologies.

Diagnostic Reference Levels: Automated Sorting of Scanner/Patient Data

Diagnostic reference levels (DRLs) are an established, effective technique to set guidelines for imaging radiation dose [2–5]. Comparative analysis of DRL data relies on the procurement of patient doses for standard sized patients (70 ± 20 kg), or other specific patient size metrics. The acquisition of these data is typically performed by a medical physicist or the site radiation safety officer. To effectively establish a DRL for a given scanner type and examination, data are required from multiple sites for the same scanner type (eg, make, model, available dose reduction technologies). It is standard practice to collect at least ten samples from each clinically indicted examination and patient size category to get an estimate of the dose distribution [4,6]. If practical, collecting more than 10 samples is recommended and will give a better estimate of the true dose distribution. The 75th percentile of the dose distributions for a given exam, specified patient size or weight range, and equipment type, is typically stated as the DRL. Doses above this level require investigation by the medical imaging team, including radiologists, medical physicists, and radiation technologists, to decide what action, if any, is required.

When performed widely, the DRL approach to dose reduction is effective. UK reference levels have been reduced by 10% since 2005 and by over 50% since inception in the mid-1980s [4]. While this reduction is not solely due to applying DRLs (other dose reduction technologies such as the transition to flat panel detectors instead of film have also played a role), DRLs were pivotal in narrowing the ranges of doses used for particular examinations [4].

Although DRL methodology is well established, it has several limitations:

1. Data collection and analysis are time consuming.
2. The data are prone to error, both systemic (ie, technologist misinterpreting parameters) and random (ie, including appropriate high dose data due to implants).
3. The data are only a snapshot and captures a limited number of exams performed.

Medical informatics has enabled automated solutions to both collection and analysis of DRL data. Some commercially available products include: American College of Radiology – Dose Index Registry [7], General Electric – DoseWatch [8], Bayer – Radimetrics [9], and popular free systems (General Radiation Observation ToolKit [10] and Radiance [11]) are also available. More recently, Radiology Information Systems have incorporated the ability to collect DICOM Structured Reports to record radiation utilization within a patient's Electronic Medical Record.

The strengths and limitations of specific software are beyond the scope of this essay. We suggest that medical imaging leadership at each hospital or health region analyze the costs and benefits of implementation of a traditional DRL method compared to an automated system.

The natural consequence of automated dose registries is the establishment of patient-specific dose history databases.

Patient-Specific Dose History Databases

Patient-specific dose history tracking software must be carefully examined as a potential clinical tool. A short list of considerations includes:

1. Completeness of medical dose history.
2. Accuracy of effective dose calculations.
3. Clinical utility of patient specific dose histories.
4. Effective use of financial resources to implement a dose registry.

Completeness of Dose History

Radiation exposure is part of many aspects of daily life. Patient-specific cumulative medical dose histories need to capture all instances in order to be complete. Besides medical radiation from hospitals and clinics, additional sources of individual dose that might need to be considered include