Journal of Medical Imaging and Radiation Sciences 46 (2015) 372-379

Journal of Medical Imaging and Radiation Sciences

Journal de l'imagerie médicale et des sciences de la radiation

www.elsevier.com/locate/jmir

Research Article

Decision Making and Variation in Radiation Exposure Factor Selection by Radiologic Technologists

Sarah Darcy [a*],
Louise Rainford, PhD (UCD), Dip RNI, Dip Rad (CoR), Dip Management (NCIR)[b],
Brendan Kelly, MB BCh BAO, BSc[a] and Rachel Toomey, PhD (UCD), BSc (Hons)[b]

[a] *School of Medicine and Medical Science, University College Dublin, Dublin 4, Ireland*
[b] *Department of Diagnostic Imaging, School of Medicine and Medical Science, University College Dublin, Dublin 4, Ireland*

ABSTRACT

The goal of radiographic imaging is to produce a diagnostically useful image while minimizing patient radiation dose. This study aimed to review variations in exposure factor selection by radiologic technologists for virtual patients with varying body mass index characteristics. Eleven technologists were asked to assign exposure parameters (kVp, mAs, source-to-image receptor distance, and grid use) to 10 computer-generated patient images for each of four radiographic examinations (anteroposterior [AP] shoulder; AP lumbar spine; lateral lumbar spine; AP portable chest). The virtual patients represented five body mass index categories–underweight, healthy weight, overweight, obese, and superobese. As participants assigned exposures, their visual patterns were recorded by a Tobii TX300 eye-tracker. Significant ($P < .05$) correlation was found between radiographer age/experience and assignment of mAs for AP shoulder and lumbar examinations. Greater age/experience correlated with higher mAs for the AP shoulder examination, but with lower values for lumbar examinations. Strong correlations also existed between times to first fixations on relevant anatomic areas, and kVp/mAs values existed for the AP portable chest examination. Exposure selection differences related to age/experience highlight inconsistencies in the practice of exposure parameter setting. The reason for these inconsistencies requires further investigation, and how to address deficiencies in practice requires consideration to optimize safe patient care. Because of the small sample size used, further research into the relationship between visual factors and individual examinations is suggested, after the findings regarding the AP portable chest examination.

RÉSUMÉ

L'imagerie radiographique vise à produire une image utile sur le plan diagnostique tout en minimisant la dose de radiation pour le patient. La présente étude vise à examiner les variations dans le choix des facteurs d'exposition par les technologues en radiologie pour des patients virtuels présentant des caractéristiques d'indice de masse corporelle variées.

Onze technologues ont été invités à attribuer des paramètres d'exposition (kVp; mAs; SID; utilisation de grille) à dix images de patients générées par ordinateur pour chacun de quatre examens radiographiques (vue antéro-postérieure (AP) de l'épaule; vue AP de la colonne lombaire; vue latérale de la colonne lombaire; et vue AP de la poitrine à l'aide d'un appareil portatif). Les patients virtuels représentaient cinq catégories d'IMC–insuffisance pondérale, poids santé, surcharge pondérale, obésité et obésité morbide. Pendant que les technologues attribuaient les facteurs d'exposition, leurs patrons visuels étaient enregistrés par un système de suivi oculaire Tobii TX300.

Une corrélation significative ($p<0,05$) a été constatée entre l'âge/expérience du radiographe et l'attribution des mAs pour les vues AP de l'épaule et les examens lombaires. Un âge/niveau d'expérience plus élevé présentait une corrélation avec un mAs plus élevé pour les vues de l'épaule, mais plus bas pour les examens lombaires. Une forte corrélation apparaît également entre la durée de la première fixation sur les zones anatomiques pertinentes et les valeurs de kVp/mAs pour l'examen AP de la poitrine sur appareil portatif.

Les différences dans le choix de l'exposition reliées à l'âge et au niveau d'expérience soulignent les incohérences dans la pratique du réglage des paramètres d'exposition. Les motifs de ces incohérences nécessiteront d'autres études, et la façon de traiter les déficiences dans la pratique devra être considérée afin d'optimiser la sécurité des soins offerts aux patients. En raison de la petite taille de l'échantillon utilisé, il est suggéré d'effectuer des recherches plus poussées sur le lien entre les facteurs visuels et les examens individuels, dans la foulée des résultats concernant l'examen AP de la poitrine sur appareil portatif.

Keywords: Image perception; radiation dose; eye-tracking

The author(s) has no financial disclosures or conflicts of interest to declare.

* Corresponding author: Sarah Darcy, School of Medicine and Medical Science, University College Dublin, Belfield, Dublin 4, Ireland.
E-mail address: sarah.darcy@ucdconnect.ie (S. Darcy).

1939-8654/$ - see front matter
http://dx.doi.org/10.1016/j.jmir.2015.09.003

Introduction

The exposure factors selected for radiographic examinations (eg, tube kilovoltage peak, tube current, use of antiscatter grids, and time) influence not only image quality, but also the patient's effective dose. This effective dose should be kept as low as reasonably achievable to reduce the risk of mutation, which may lead to side effects such as carcinogenesis after a latent period. Therefore, it is important that radiographers choose appropriate technique factors. Different methods of adjusting exposure factors to accommodate varying patient body types or sizes have been described, although there is little research to show which methods are most diagnostically efficacious. Furthermore, none of the methods have been tested comprehensively with digital image receptors (either computed radiography or direct digital radiography) [1], that now dominate clinical practice in many countries.

The advent of digital radiography has lead to the phenomenon of "dose creep," a gradual increase in administered radiation doses over time [2]. This is due in part to the fact that, with the use of digital manipulation and automatic adjustment of window width and level, overexposure does not necessarily produce diagnostically poor images–often the image quality is good, with reduced noise encouraging subsequent higher exposures [3, 4].

Clearly, radiographers' choice of exposure factors can have important consequences for both image quality and patient dose. Although significant effort has been made to avoid consistent overexposure of patients on a broad scale through the introduction of diagnostic reference levels [5], there has been little research to date investigating why dose/exposure factor variation occurs in terms of the individual approach of the radiographer. A clear understanding of how decisions are made could potentially lead to improved training and practice of technologists, and in turn reductions in unnecessary overexposure and dose creep.

Existing literature has discussed the increasing medical radiation dose to the patient population in terms of unjustified imaging [6], dose creep [7], and the widespread use of modalities with higher levels of radiation, including computed tomography (CT) [8]. There has been much emphasis on dose for higher risk imaging (CT, coronary angiography, and nuclear medicine) and the risk-to-benefit ratio has been thoroughly discussed [9, 10], with a focus on the principles of justification, optimisation and dose limitation [11]. The potential carcinogenic risk of this kind of imaging is relatively well documented [12, 13]. However, there has been little comparative focus on the arguably more benign modalities, including plain x-rays, because of the assumption of lessened long-term risk—an abdominal x-ray provides approximately one tenth the dose of a CT scan of the abdomen/pelvis [14]. This does not render the exposures from lower dose imaging unimportant–the potential risks are still considered in a manner directly proportionate to dose, and the principles of justification and optimisation must still be rigorously applied to keep patient dose as low as reasonably achievable.

This study is largely concerned with optimisation, particularly in the area of exposure factor selection by radiographers. Dose creep is a recognised entity in modern radiographic imaging and presents new challenges in terms of optimisation of patient care. This has been identified in current literature and much emphasis has been placed on measures such as the introduction of appropriate diagnostic reference levels [15] and on methods of optimising exposure settings and dose delivery [13]. Despite this effort to combat rising dose, there is a paucity of research concerning the radiographer's decision-making process when assessing patients before the radiographic examination, which is arguably an important factor in the ultimate dose delivered. This preimaging assessment involves an appraisal of examination type, the imaging equipment being used, the body part in question, and patient thickness. The radiographer visually evaluates the latter two criteria and an understanding of that visual process forms the basis for this study.

Eye tracking is a continuously evolving technology that has found applications in many arenas, including clinical research in the diagnostic imaging domain. However, in imaging, it has thus far focused mainly on interpretation of radiographs [16–19] rather than on the assessment of patients before image acquisition. It has been used to analyse search patterns [20], to differentiate between failures of detection versus decision in diagnostic imaging [21], and to assess the efficacy of various approaches to imaging interpretation [22], to name a few. General research in the area of eye-tracking technology has shown it to be an accurate and useful tool in understanding visual attention [23, 24], and the importance of understanding visual attention itself has been described in great detail [25]. To the authors' knowledge, there has been no application of eye-tracking software attempting to evaluate the decision-making process of radiographers when visually assessing patients before imaging.

It is the aim of this study to determine what inter-technologist and intra-technologist variation exists in exposure factor selection, and furthermore, to investigate how visual assessment of the patient influences this variation by using an eye-tracker. Understanding technologist decision making in setting exposure parameters is potentially a step toward targeted intervention to optimise radiation exposure in medical imaging and to maintain the best possible risk-to-benefit ratio for patients.

Methods

Radiographers (n = 11) who participated in the study were recruited as volunteers in a teaching hospital in Dublin, Ireland, over a 2-week period. The recruitment process was carried out via posters and flyers circulated within the