Journal of Medical Imaging and Radiation Sciences 46 (2015) 162-173

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

Examining Practitioners' Assessments of Perceived Aesthetic and Diagnostic Quality of High kVp–Low mAs Pelvis, Chest, Skull, and Hand Phantom Radiographs

Jenna R. Lorusso, MA[a*], Lyndsay Fitzgeorge, PhD[b], Daniel Lorusso, BMSc[cd] and Elizabeth Lorusso, MRT(R)[b]

[a] *Faculty of Education, Western University, London, Ontario, Canada*
[b] *School of Health Sciences, Fanshawe College, London, Ontario, Canada*
[c] *Department of Physiology and Pharmacology, Schulich School of Medicine and Dentistry, Western University, London, Ontario, Canada*
[d] *Imaging Research Laboratories, Robarts Research Institute, Schulich School of Medicine and Dentistry, Western University, London, Ontario, Canada*

ABSTRACT

This study investigated the usefulness of the dose optimization strategy of increased tube voltage (kVp) and decreased tube current-exposure time product (mAs) (or high kVp–low mAs) by examining practitioners' assessments of perceived aesthetic and diagnostic quality of direct digital radiographs acquired using this strategy. Ninety-one practitioners (radiologists, radiology residents, radiographers, and radiography students) from eight clinical sites in Ontario examined three types of radiographs ("standard" image, +20 kVp image, and +30 kVp image) for anthropomorphic pelvis, chest, skull, and hand phantoms and rated (on a five-point scale) each image in regard to its perceived aesthetic quality, perceived diagnostic quality, and visualization of anatomic structures. Our primary findings are that for the pelvis, skull, and hand–although not the chest–images acquired using standard technical factors were rated significantly higher in diagnostic and aesthetic quality than those acquired using the high kVp–low mAs strategy. Despite this, both standard and dose-optimized images of the pelvis, skull, and hand were rated to be of acceptable diagnostic quality for clinical use. In conclusion, for the pelvis, skull, and hand, an increase of 20 kVp was an effective strategy to reduce dose while still acquiring images of diagnostic quality.

RESUMÈ

Cette étude évalue l'utilité de la stratégie d'optimisation de la dose fondée sur l'augmentation de la tension du tube (kVp) et de la diminution du produit tube de courant/temps d'exposition (mAs) (ou kVp élevé–mAs faible) en examinant l'évaluation que font les praticiens de la qualité esthétique et diagnostique perçue des radiographies numériques directes prises à l'aide de cette stratégie. Quatre-vingt onze praticiens (radiologistes, résidents en radiologie, radiographes et étudiants en radiographie) de huit sites cliniques en Ontario ont examiné trois types de radiographies (image « standard », image à +20 kVp, image à +30 kVp) de fantômes anthropomorphiques du pelvis, de la poitrine, du crâne et de la main et les ont cotées (sur une échelle de 1 à 5) selon (a) qualité esthétique perçue, (b) leur qualité diagnostique perçue et (c) la visualisation des structures anatomiques. Nos constatations initiales montrent que, dans le cas des images du pelvis, du crâne et de la main, mais non celles de la poitrine, les images prises avec les facteurs techniques standard ont reçu une note significativement plus élevée pour la qualité esthétique et diagnostique que celles prises en utilisant la technique kVp élevé–mAs faible. Cependant, les images standard et à dose optimisée du pelvis, du crâne et de la main ont été jugées de qualité diagnostique acceptable pour un usage clinique. En conclusion, pour le pelvis, le crâne et la main, une augmentation de +20 kVp est une stratégie efficace pour réduire la dose tout en produisant quand même des images de qualité diagnostique.

Keywords: Anthropomorphic phantom; chest; direct digital radiography; dose optimization; hand; high kVp-low mAs; multiple anatomic areas; practitioner assessments; pelvis; perceived diagnostic image quality; perceived aesthetic image quality; skull

Introduction

The importance of regularly investigating dose optimization strategies for general radiographic examinations is critical to ensure that practitioners are delivering a dose to patients that is "as low as reasonably achievable" (ALARA) [1]. Hence, much research has been conducted to investigate strategies that can reduce the dose delivered to patients while still producing images of diagnostic quality [2]. From this research, a variety of dose optimization strategies have been identified that reduce dose by a considerable percentage without

* Corresponding author: Jenna R. Lorusso, MA, Faculty of Education, Western University, 1137 Western Road, London, ON, N6G 1G7.
E-mail address: jlorusso@uwo.ca (J.R. Lorusso).

1939-8654/$ - see front matter
http://dx.doi.org/10.1016/j.jmir.2015.01.109

significant effect on the quality of the images for diagnosis [3]. In particular, the strategy of increasing the tube voltage (kVp) and decreasing the tube current-exposure time product (mAs) shows particular promise [4]. When this strategy is used, the photons in the radiation beam have a higher energy and are more penetrating. Thus, instead of being absorbed into the patient as a lower kVp radiation beam would, more of the beam is able to penetrate and exit the patient's tissues, resulting in a lesser dose delivered to patients [5, 6].

Many previous studies have investigated the use of this particular dose optimization strategy by examining qualified observers' perceptions of resultant image quality using a variety of different methods [7–11]. However, more robust and comprehensive work is still needed, particularly in terms of the number and type of participants providing assessments of perceived image quality and the number of anatomic areas examined in a single study. With respect to the number and type of participants, many of the similar existent studies have used very small sample sizes. The smallest study reviewed included only two radiographers [12], and the largest study reviewed included six radiographers and one radiologist [9]. This, of course, lessens the external validity, or the generalizability, of the results. With respect to the number of anatomic areas examined, many of the similar existent studies reviewed have only used one anatomic area [4, 7, 9–11]. This limited focus is problematic because different anatomic areas vary in thickness and require that images be acquired with differing technical factors that in turn affect image quality and dose delivered to the patient.

Furthermore, despite the Canadian Association of Medical Radiation Technologists' clearly outlined ALARA mandate and the wealth of evidence regarding dose optimization strategies, there is evidence that these strategies, including the high kVp–low mAs strategy, are not being fully realized within radiology departments [13]. Is it that practitioners do not find high kVp–low mAs images to be aesthetically pleasing? Do they not find these high kVp–low mAs images to be of acceptable diagnostic quality? Are they unable to visualize the relevant anatomic structures on these high kVp–low mAs images? In particular, the question of practitioners' aesthetic preferences does not appear to have been explicitly investigated in similar existent studies.

Thus, the present study aimed to investigate the usefulness of the dose optimization strategy of high kVp–low mAs radiography by examining practitioners' assessments of aesthetic and diagnostic quality of images acquired using this strategy. The objective was to conduct a robust and comprehensive study by including a large number of participant assessors, incorporating multiple anatomic areas, and explicitly investigating practitioners' aesthetic preferences. The study included 91 practitioners (radiologists, radiology residents, radiographers, and radiography students) from eight clinical sites in Southwestern Ontario who examined three types of direct digital radiographic images (a "standard" image, a +20 kVp image, and a +30 kVp image) of anthropomorphic pelvis, chest, skull, and hand phantoms and rated (on a five-point scale) each image in regard to its perceived aesthetic quality, perceived diagnostic quality, and visualization of anatomic structures.

Materials and Methods

Participant Sample and Recruitment

Following the granting of ethical clearance by an institutional research ethics board (file number: 14-01-13-1; date of approval: January 29, 2014), all radiologists, radiology residents, radiographers, and student radiographers from eight clinical sites within a Local Health Integration Network (LHIN) in Southwestern Ontario were invited to participate in the study. One hundred individuals participated in the study out of a potential pool of approximately 200 individuals; however, the data from nine participants were excluded because these individuals did not complete all portions of the informed consent form. Of the 91 participants, six were radiologists, four were radiology residents, 48 were radiographers, 31 were student radiographers, and two identified their professional role as "other" and specified their position to be Picture Archiving and Communication System (PACS) administrators. The participants had a range of 0.5 to 38 years of experience, or an average of 11.44 years (standard deviation [*SD*] = 11.29), and a total of 1,030 years. All participants provided informed consent after reading the letter of informed consent enclosed in the study package. The inclusion criteria required that participants were members of one of the aforementioned professional groups at a clinical site within the LHIN and that they regularly reviewed or acquired radiographic images; there were no exclusion criteria.

Anthropomorphic Phantoms

Radiographic images of anthropomorphic phantoms (all from The Phantom Laboratory) were acquired, which is common in dose optimization and/or image quality studies [7, 9, 10, 12, 13]. These phantoms are tissue equivalent to an adult male of average size and consist of real bone. Specifically, a phantom pelvis (SK250 Torso), chest (SK200 Thorax), skull (SK100 Skull), and hand (XA231 R Hand) were used. These particular anatomic areas were purposefully selected for the following reasons. The pelvis was selected because it is one of the most common radiographic examinations performed [12, 14] and appears to be the second most commonly used anatomic area for studies examining dose optimization and/or image quality [9, 12, 14]. The chest was selected because it is also one of the most common radiographic examinations performed in typical clinical practice [8, 15, 16] and appears to be the most commonly used anatomic area for studies examining dose optimization and/or image quality [4, 7, 8, 10, 11, 14, 17, 18]. The skull was selected because, although it is not a common radiographic examination in developed countries, it is still frequently performed in developing countries because of the prohibitive costs of computed tomography [19]; it is an area for which high-quality examinations are required for diagnosis, especially in