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Digital imaging and radiographic practise in diagnostic radiography: An overview of current knowledge and practice in Europe

S. Mc Fadden [a,*], T. Roding [c], G. de Vries [c], M. Benwell [b], H. Bijwaard [c], J. Scheurleer [c]

[a] Ulster University Belfast, Northern Ireland, United Kingdom
[b] London South Bank University, London, United Kingdom
[c] Inholland University of Applied Sciences, The Netherlands

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ABSTRACT

Introduction: Recent research has identified the issue of 'dose creep' in diagnostic radiography and claims it is due to the introduction of CR and DR technology. More recently radiographers have reported that they do not regularly manipulate exposure factors for different sized patients and rely on pre-set exposures. The aim of the study was to identify any variation in knowledge and radiographic practice across Europe when imaging the chest, abdomen and pelvis using digital imaging.

Methods: A random selection of 50% of educational institutes ($n = 17$) which were affiliated members of the European Federation of Radiographer Societies (EFRS) were contacted via their contact details supplied on the EFRS website. Each of these institutes identified appropriate radiographic staff in their clinical network to complete an online survey via SurveyMonkey. Data was collected on exposures used for 3 common x-ray examinations using CR/DR, range of equipment in use, staff educational training and awareness of DRL. Descriptive statistics were performed with the aid of Excel and SPSS version 21.

Results: A response rate of 70% was achieved from the affiliated educational members of EFRS and a rate of 55% from the individual hospitals in 12 countries across Europe. Variation was identified in practice when imaging the chest, abdomen and pelvis using both CR and DR digital systems. There is wide variation in radiographer training/education across countries.

Conclusion: There is a need for standardisation of education and training including protocols and exposure parameters to ensure that there is continued adherence to the ALARA principle.

Introduction

The digital imaging techniques of computed radiography (CR) and digital radiography (DR) have made a significant impact on imaging departments and has led to the potential for reductions in radiation doses for standard imaging examinations.[1] However, current research suggests that the radiation dose has actually increased due to the wide exposure latitude of digital systems. Great variations in practice have been identified by recent authors[2] which results in a large range in radiation doses for similar examinations and has resulted in "dose creep".[3–5] Dose creep is a phenomenon whereby radiation doses have crept upwards due to imaging staff sometimes opting to use higher exposure factors which results in a higher signal to noise ratio (SNR), producing a higher quality image with less noise. Staff can then post process the digital image to produce a better quality image.[4]

It is well recognised that the three most important factors to consider when producing good image quality in digital imaging include appropriate selection of (i) tube voltage (ii) tube current (iii) exposure time.[6,7] However, pre and post processing image manipulation is available for all digital radiography and enables manipulation of the resultant image hence, the selection of these technical factors may be perceived to play a less critical role in providing a good diagnostic image.[8] When compared to film screen radiography, both computed and digital image receptors respond to x-ray exposure and produce digital data over a wider range of

* Corresponding author. Present/permanent address: Room 14J15, Shore Road, Newtownabbey, Co. Antrim, BT370QB, The Netherlands.

E-mail addresses: s.mcfadden@ulster.ac.uk, s.mcfadden@email.ulster.ac.uk (S. Mc Fadden), Thom.Roding@INHOLLAND.nl (T. Roding), Geert.deVries@INHOLLAND.nl (G. de Vries), martin.benwell@lsbu.ac.uk (M. Benwell), harmen.bijwaard@inholland.nl (H. Bijwaard), Jelle.Scheurleer@INHOLLAND.nl (J. Scheurleer).

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exposure intensities i.e. wider dynamic range.[9] With conventional radiography the resultant radiograph reflects the quality and quantity of radiation interacting with the film as contrast and optical density. In CR and DR digital image processing takes place in the form of histogram analysis and look up tables. These processes adjust the raw linear data and amend the image contrast and brightness intensity, including those images that have been moderately under or over exposed. Therefore, diagnostic images can be obtained using a wider range of exposure factors as digital radiography is less mAs and kV dependent; this may reduce the need for repeat exposures however patients may be incurring higher radiation doses than are necessary.[8,9] Previous studies have highlighted the trend for staff to overexpose rather than underexpose patients as this reduces quantum mottle on the resultant image and improves image quality.[5,10] In light of this, more recent authors have highlighted the need to optimise the performance of the digital system by ensuring the appropriate selection of technical parameters.[11–15]

In compliance with article 56.2 of the European Directive 2013/59/Euratom (https://ec.europa.eu/energy/sites/ener/files/documents/CELEX-32013L0059-EN-TXT.pdf) employers in each EU Member State must ensure "the establishment, regular review and use of diagnostic reference levels for radiodiagnostic examinations, having regard to the recommended European diagnostic reference levels….".[16] Diagnostic reference levels (DRL) are defined as radiation dose levels for typical x-ray examinations for standard sized patients using standard equipment. These levels help to highlight recurrent over or under exposures but they also allow for higher doses to account for such times when a higher dose is required for diagnosis. Use of DRL has been shown to reduce the overall radiation dose and the range of doses observed in clinical practice[17] however the ways DRL are being developed across Europe varies.[3] Data from 2014 highlights that DRL for adult x-ray examinations have been established in 72% of the 36 European countries, whilst only 39% of the countries have established DRL for paediatric x-ray examinations.[3] For adult DRL, 77% are based on national dose surveys in Europe while the rest are based on published values or recommendations e.g. EC recommendations. Similarly, 64% of paediatric DRL are based on national dose surveys while the rest are based on published European guidelines or other publications.[3]

The respective DRL for a variety of hospitals are discussed by the European Commission Radiation Protection Nº 180[3] and highlight a wide variation in practice across Europe. Standard exposure techniques currently used internationally are determined in the individual imaging departments and variation exists between departments. Therefore, a standard adult radiation dose for a particular examination can vary depending on which hospital/department they are examined in. This variation has previously been identified, at both national and international levels by several authors.[18–20]

A report of 'dose creep' in American hospitals[21] states that between 20% and 35% of patients in the US are overexposed by at least a factor of two and claim that this is due to the introduction of CR and DR technology. In addition to this, research of digital imaging systems from five different suppliers performed with the aid of phantoms[9] concluded that it was technically possible to both, under and over expose the imaging plates and still be able to process the data to produce an acceptable image quality. Results concluded[9] that radiographers need to become more knowledgeable about the digital imaging systems to ensure that they produce high quality images with the least amount of exposure to patients. More recently, it has been reported[4] that radiographers are not manipulating exposure factors for different sized patients and rely on preset exposures with staff openly admitting to "bumping up" their x-ray exposure to ensure a diagnostic image. As identified recently[22] staff selecting the most appropriate exposure factors at the time of x-ray exposure is the simplest and most effective way to ensure adherence to the As Low As Reasonably Achievable (ALARA) principle.

Aim and objectives

The aim of the study was to identify any variation in radiographic practice across Europe when imaging commonly performed examinations of the chest, abdomen and pelvis. The objectives of the study included exploring

1. the standard operating parameters used across departments,
2. the range of imaging equipment currently used in hospitals,
3. levels of awareness and use of DRL in the different countries
4. the education and qualification level of radiography staff employed in the imaging departments.

Methods

Ethical permission was sought and granted from Ulster University in Northern Ireland. The research design was an online survey using a questionnaire designed via SURVEYMONKEY. The survey was sent as a link embedded in an e-mail and the focus of the questionnaire was current practice when using digital imaging in clinical departments. The questionnaire consisted of 30 questions in total with 15 open-ended questions allowing respondents to provide their own answers combined with 15 closed questions requiring specific information on the use of CR and DR. To prevent irrelevant questions being asked, "questionnaire skip logic" was used to skip respondents to specific questions on a later page, based on their answer to a previous closed-ended question. The questionnaire consisted of two parts.

(i) The first part focused on the characteristics of the department (hospital type, number of beds) and radiography staff (number, EQF level and years of experience), the type of x-ray equipment used (Film screen, CR or DR), equipment age and staff awareness of the existence of local or national DRLs.
(ii) The second part of the questionnaire focused on the acquisition parameters for the three common examinations i.e. PA chest, AP abdomen and AP pelvis (the questionnaire asked respondents to supply average exposure data specifically for average sized male patients between 65 kg and 75 kg in weight to ensure results would be comparable across centres).

kVp, mAs, Source to Image receptor distance (SID) or Focus to Film Distance (FFD), anti-scatter grid use. Data was also collected on staff training on the use of CR and DR.

A pilot study was performed among a total of six radiographic staff in educational institutions in the UK, Ireland and the Netherlands to highlight any ambiguity in questions and test the validity and reliability of the questionnaire prior to use. This included native and non-native English speakers, who would not be included in the target distribution group. Following feedback from the pilot study, the questionnaire was revised to decrease ambiguity of questions for non-native English speakers and also decrease the length of time commitment required to complete the questionnaire. Inter-rater reliability was tested by inviting two staff members of the same institution to answer the questionnaire and a high correlation was noted between the two respondents in each institution. The respondents in the pilot study were then asked to

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