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Patient dose audit of the most frequent radiographic examinations and the proposed local diagnostic reference levels in southwestern Nigeria: Imperative for dose optimisation

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ABSTRACT

Diagnostic reference levels (DRLs) is a veritable tool for dose optimisation and patient protection in diagnostic radiology. However, it is essential to have information on the local situation especially in a large hospital with several units or a cluster of healthcare centres within a geographical region with several X-ray units. In the present study, entrance surface doses (ESDs) were measured in twelve (12) healthcare centres consisting of 15 radiological units using thermoluminescent dosimeters (TLDs). Seven radiological procedures such as; chest PA, abdomen AP, pelvis AP, lumbar spine AP, skull AP, knee AP, and hand AP frequently carried out in Nigeria were included in the study, and their local diagnostic reference levels (LDRLs) were determined. The values of the determined LDRLs were compared with established NDRLs in UK, US, Slovenia, Italy and Brazil. The LDRLs determined in the two groups (healthcare centres) studied ranged from 1.78 to 3.01, 2.71 to 2.84, 2.11 to 3.79, 3.93 to 8.79, 1.06 to 1.73 and 1.10 to 1.44 mGy for chest PA, pelvis AP, lumbar spine AP, skull AP, knee AP and hand AP respectively. Large variations were found among the X-ray units studied even within the same centre. Entrance surface doses obtained in pelvis AP and lumbar spine AP in both GROUP A and were found to be lower than the NRPB-HPA 2010 review for UK, while in all other five examinations, value of the measured entrance surface dose (ESD) are higher than the doses reported in the UK review. The relative higher doses found in the study are attributable to higher tube load (mAs) used and indicative of the need for dose optimisation in Nigerian radiological practice.

1. Introduction

Radiation protection involves a process of safeguarding both the personnel and the public from undesirable effect of radiation. The main task of radiation protection is not only to minimise the stochastic risks but also to avoid deterministic injuries (Edmond, 2009). Radiation undesirable effects are minimised through the adoption of principles of justification

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and optimisation during the preparation and examination of patients.

Radiation dose measurement of patients undergoing routine diagnostic examinations to assess the level of their exposure is an integral part of dose optimisation. The need for regular assessment of patients' radiation doses arising from diagnostic examinations have been highlighted by various international regulatory policy making bodies and researchers (NOHSC, 1995). This is as a result of the increase in knowledge of hazards associated with low doses of ionising radiations, and the revealed large dose variations for patient undergoing the same type of diagnostic X-ray examination (Toosi & Azadinezhad, 2007; Huda, Nickoloff, & Boone, 2008). Regular dose measurement has been popularised in Europe and applied with good result (Brink & Miller, 2015). In the United Kingdom, periodic dose surveys and five-yearly reviews since 1980 to date have greatly reduced doses delivered to patients (Hart, Hillier, & Wall, 2009).

As a result of the need to ensure dose reduction in Europe, the European Commission mandated member states to promote the establishment and use of diagnostic reference levels (DRLs). In 2013, the Commission reaffirmed the requirement and provided more specific guidance for its use to ensure best practice (EU, 1997). The objective of diagnostic reference levels (DRLs) in radiology is to assist in the optimisation of radiation dose to patients, while maintaining diagnostic image quality, and to detect unusually high doses that do not contribute significantly to the clinical outcome of a medical imaging examination.

In Nigeria, in spite of the large number of examinations carried out yearly, the dose information available is grossly inadequate. Most of the dose data available are from the South West (SW), South East (SE), South South (SS) and Middle Belt (MB) of the country. In addition, there is no evidence of published data indicating the establishment of local diagnostic reference levels (LDRLs) of common examinations carried out in the Nigeria (Martin, Le Heron, Borras, Sookpeng, & Ramirez, 2013). In the past, most of the dose assessments carried out in Nigeria ended up as "academic exercise" (no feedbacks on the performance of hospitals), the likely few exceptions are Ajayi and Akinwumiju (2000), Ogunseyinde, Adeniran, Obed, Akinlade, and Ogundare (2002) and Ogundare, Uche, and Balogun (2004) sponsored by the International Atomic Energy Agency (IAEA). The feedback mechanism ensures that the participating hospitals make necessary adjustments where they fall short of the acceptable practices.

Diagnostic reference levels (DRLs) is deemed to be an important mechanism for the management of patient dose to ensure it is commensurate with the medical purpose of the X-ray examination (Charnock, Moores, & Wilde, 2013). In the recommendation of International Commission of Radiological Protection (Report 103), the principle for setting DRLs are enumerated: (1) the regional, national or local objective is clearly defined, including the degree of specification of clinical and technical conditions for the medical imaging task (2) the selected value of the diagnostic reference level is based on relevant regional, national or local data (3) the quantity used for the diagnostic reference levels can be obtained in a practical way (ICRP, 2007).

Diagnostic reference levels (DRLs) in diagnostic radiology are expected to be based on doses measured in various types of hospitals, clinics and practices and not only in well-equipped hospitals (EC, 1999). This would reflect the state of practice in a particular organisation, region or nation. The 75th percentile dose value for the distribution of sampled values has been taken as the national diagnostic reference levels (NDRLs) against which the mean ESD values for each X-ray room in any hospital are compared. In order to set up DRLs at least a minimum of ten (10) standard patients are required, but because of the shortage of standard sized patients some countries take all patients available in the measurement period and take the average of the dose results as the outcome for standard-sized patient. This will give a reasonable idea of the dose, provided that the number of patients is not too small:say, a minimum of ten (10) patients (EC, 1999). Patient size is an important factor in estimating the dose received from X-ray examinations. For adults, the influence of size is minimised by ensuring that the mean weight of the sample of patient is close to the reference weight (kg), that is 70 ± 5 kg for a standard patient (Kiljunen, Jarvinen, & Savolainen, 2007). The selection and use of standard patient gives room for comparison of doses among hospitals and nationalities.

In certain instances, it is possible that in a large hospital where many radiological departments are present, all examinations ESDs might be lower than the corresponding NDRLs, even though some differences between different departments exist. In such cases, a subtler and more refined use of DRLs concept are adopted to calculate ESD values that are to be used locally, as local diagnostic reference levels (LDRLs) (Compagnone, Pagan, & Bergamini, 2004). The study of LDRLs is a further step in patient dose optimisation, beyond the simple use of national or international DRLs (Ramsdale, Peet, Holloway, & Rust, 2001; Roger, 2001).

The aim of this study was to carry out dose assessment of some purposely selected healthcare centres in two parts of Southwestern (SW) geopolitical zone of Nigeria and proposed local diagnostic reference levels for some common diagnostic examinations. Results were compared with published reference doses.

2. Materials and methods

This study was carried out in the Southwestern part of Nigeria following the guidelines outlined in European Commission Guidelines (EC, 1999). Direct method of dose assessment using thermoluminescent dosimeters, TLD-100 (LiF: Mg, Ti) was adopted in this study. Calibrated LiF dosimeters (TLD chips) were used to measure the entrance surface dose (ESD) of 640 patient undergoing routine diagnostic examinations in two sub-regions of SW Nigeria.

The TLD chips were obtained from Stanford Dosimetry LLC Bellingham, USA. Facilities of National Institute for Radiation Protection and Research (NIRPR-University of Ibadan, Nigeria) were used to Irradiate and calibrate the chips (of dimension $3 \times 3 \times 1$ mm). The chips were irradiated using X-ray Beam Irradiator (Hopewell Design INC). The TLD chips were labelled batch-by-batch for easy identification before irradiation. Each batch (consisting of 10 chips) of pre-annealed chips were