A SURVEY ON PAEDIATRIC RADIATION DOSES AT DUBAI HEALTH AUTHORITY HOSPITALS

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Abstract

Dubai Health Authority (DHA) established a radiation safety program to protect patients, staff and the general public from unnecessary ionizing radiation sources associated with the use of medical imaging facilities within its hospitals and clinics. Along with educational and awareness activities, quality control of radiological equipment and patient radiation dosimetry are the main components of the DHA radiation safety program. Since paediatric patient group is more sensitive to ionizing radiation, a dedicated program for children radiation safety was significantly considered within the DHA. Furthermore, the DHA joined regional and coordinated research projects of the IAEA to further develop its radiation protection program. In this paper, we aim to present the patient dosimetry results obtained through the DHA radiation safety initiatives and the projects conducted in cooperation with the IAEA.

The paediatric dosimetry data gathered in this study included fluoroscopy, interventional radiology (IR), computed tomography (CT) and dental radiology applications. The children data covered in this study stand for the paediatric radiology examinations during the years 2008-2012. In this study, we investigated and presented patients' doses given as averaged values of kerma air product (KAP in Gy. cm^2) and entrance dose (mGy) for fluoroscopy clinical applications, dose length product (DLP in mGy.cm) for CT, while for IR the patient dosimetry was demonstrated as KAP ($Gy\cdot cm^2$) and cumulative air kerma (mGy) for plane A & B. For dental radiology, the patient entrance dose (PED in mGy) is presented. These DHA paediatric dosimetry data were classified according to the standard paediatric age groups and compared to those documented and published by the IAEA and some European regions. The results of this study indicate that the dose levels within the DHA are equivalent to those published in the literature. However, further studies and wider hospital coverage are required to establish local and UAE DRLs.

1. INTRODUCTION

Special attention is recommended to be considered for paediatric patient group who undergo medical imaging procedures. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the International Commission on Radiation Protection (ICRP), the International Atomic Energy Agency (IAEA), the World Health Organization (WHO) and many professional organizations have stated that the development in modern state of art medical imaging technology has increased the use of ionizing radiation for both adult and paediatric patient groups [1]. Several reports affirmed that exposure during childhood results in a likely two- to three-fold increase in lifetime risk for certain detrimental effects (including solid cancers) compared with that in an adult [2, 3]. The possibility of deterministic effects in diagnostic radiology for staff and patients is small. However, monitoring radiation doses to patients undergoing radiological procedures is recommended and encouraged to avoid any small risk and to comply with the radiation protection principles and requirements. Unfortunately, the published data on paediatric doses and reference levels are limited worldwide and there is a large variation in the existing data. At the UAE level, there is a lack of national studies on paediatric dosimetry. The aim of this study is to evaluate the paediatric radiation doses at Dubai Health Authority (DHA) hospitals and to initiate the step at the UAE national level to develop paediatric dosimetry and diagnostic reference levels (DRLs).

2. MATERIALS AND METHODS

For fluoroscopy and IR dosimetry data collection, the IAEA forms were used to collect patients' data which includes patients' details (age, weight and gender) and image parameters (exposure time, no. of images/frames, dosimetry data,.etc.). Radiographers/Technicians in each imaging modality took the initivative to periodically collect these data and send it to the project team. The paediatric cases done on the Phillips IR Bi-plane unit at Dubai Hospital were covered in this project. The IR unit is equipped with built-in dose area product (DAP). The Phillips fluoroscopy unit at Latifa hospital (Women and Children Hospital) is fitted with external DAP and diameter dose reading devices.

Radiation doses from the 4MDCT Ge LightSpeed unit at Dubai Hospital (DH) were evaluated during the years 2008-2011. Dose measurements in terms of weighted CT dose index $CTDI_w$ (mGy) were frequently monitored using head (16 cm diameter) and body (32 cm diameter) ACR Accredited Cylindrical PMMA CT phantoms, Nero mAx 8000 meter and 10 cm pencil ion chamber. Patient radiation doses in terms of dose length product (DLP, mGy·cm) and volume CT dose index ($CTDI_{vol}$, mGy) along with patient and imaging parameters (age, weight, kVp, mA, pitch, slice width, no. of slices, IQ, etc.) were manually recorded during 2008 for the common CT examinations: head, chest and abdomen and pelvis scans. Subsequently, with the implementation of Radiology Information System (RIS) and the Picture Archive and Communication System (PACS), these CT dose data are recorded digitally. CT effective doses (ED mSv) within the DHA were followed and are presented in this paper.

The dental dose survey in this work covered 60 intra oral (I.O.) systems (22 conventional film based and 38 digital units) and 9 panoramic (OPG) machines at the DHA dental services department and the DHA hospitals and peripheral clinics. Radiation exposures from I.O. units were measured using UNFORS electronic dosimeters: ThinX Intra (for film based I.O. units) and Multi-O-Meter (for the digital units). The dose survey for the OPG machines was performed using CT Cylindrical Ionization Chamber. The exposures for the I.O. were measured in air at the end of the spacer cone; this estimated as the Patient Entrance Dose (PED) while the exposure for the OPG was measured as the dose at the surface of the image receptor. Exposure parameters implemented in this work were reflecting those used in the clinical situations.

The common fluoroscopy examinations included in this study were micturating cystourethrogram (MCU), contrast enema and contrast swallow. The total number of paediatric patients included in this work was 100 patients: 15, 48, 33 and 4 aged 0-1m, 1m-1y, 1-5y and 5-10y, respectively. The number of patients who underwent IR cardiac examinations were 72 paediatric patients grouped according to the standard age groups (29, 23, 16 and 4 aged 0-1y, 1-5y, 5-10y and 10-15 y, respectively). The CT doses collected for paediatric were for 404 patients (55, 184 and 165 in 2008, 2009 and 2010, respectively). No patients were involved in the dental radiology dosimetry; the procedures were done in air using a dosimeter. The grand total of paediatric patients covered in this study was 576.

3. RESULTS & DISCUSSIONS

3.1. Fluoroscopy results

The contrast enema fluoroscopy examination show the highest KAP and entrance doses compared to the MCU and the contrast swallow studies. Since the number of patients in each paediatric age group is small, we in our comparison in this study considered the average dose values for all age groups. However, the process of collecting further patients' doses are in progress to manage obtaining significant population sample for each standard age paediatric age group. The DHA fluoroscopy average KAP dose ranges (in mGy cm^2) were 274-3033, 405-1931, 418-2151 while the average entrance doses ranges (in mGy) were 1313-8447, 1750-4966, 891-4376 for MCU, contrast enema and contrast swallow, respectively. In the UNSCEAR report [1], the KAP ranges (in mGy cm^2) were given as 430-1640 and 560-2400 for age group ranges 0-10 years for MCU and barium swallow, respectively. The KAP dose ranges in the UK HPA report [5] were 274-1155 and 529-2272 (mGy cm^2), for MCU and barium swallow, respectively. DHA dose level for fluoroscopy examinations in this work were compared to the UNSCEAR and the UK reports; it was found that the MCU KAP doses for the age group 5-10 y were higher while the doses for the contrast swallow were within the same ranges. This study showed that the fluoroscopy time (in seconds) ranges were 43-129, 73-117 and 53-79 for MCU, contrast enema and contrast swallow, respectively.

3.2. IR results

The IR paediatric doses were gathered for cases that had undergone cardiac diagnostic and therapeutic procedures. A majority of the cases were therapeutic (occlusion of patent ducts arteries (PDA), valvuloplasty and LPA ballooning and stenting). The DHA results are given in Figure 1. These DHA paediatric IR dosimetry results were found to be lower than the dose levels given in the UNSCEAR report [1] and to other literature (paediatric interventional cardiology (IC) range: 49-400 mGy [6]). Average fluoroscopy times for plan-A were.7.13, 4.02 and 6.42 seconds for age groups 0-1y, 1-5y and 5-10y while for plan-B these were 7.14, 2.81 and 2.222 seconds.

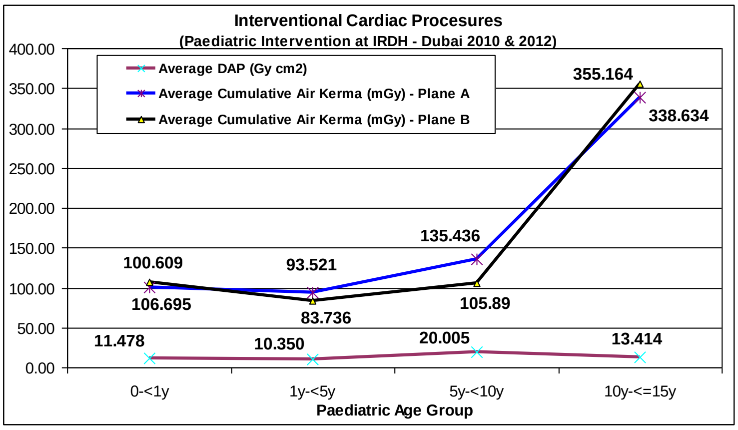

FIG. 1. DHA paediatric IR doses.

3.3. CT results

The doses results (DLP, $CTDI_{vol}$ and ED) in this study were analyzed as average and 3rd quartile as shown in Figure 2. The paediatric age was considered to be 15 years and below and were grouped based on the age as: 0- <1 year, 1-<5 years, 5-<10 years and 10->=15 years. The results of these age groups are demonstrated for the common CT examinations: head, chest and abdomen and pelvis. The findings in this study were compared to results published at the Europe regions [7-9] and to the initial dose reference levels (DRLs) adopted locally for the DHA hospitals (DLP as 1000, 500 and 1000 mGy·cm for head, chest and abdomen and pelvis, respectively).

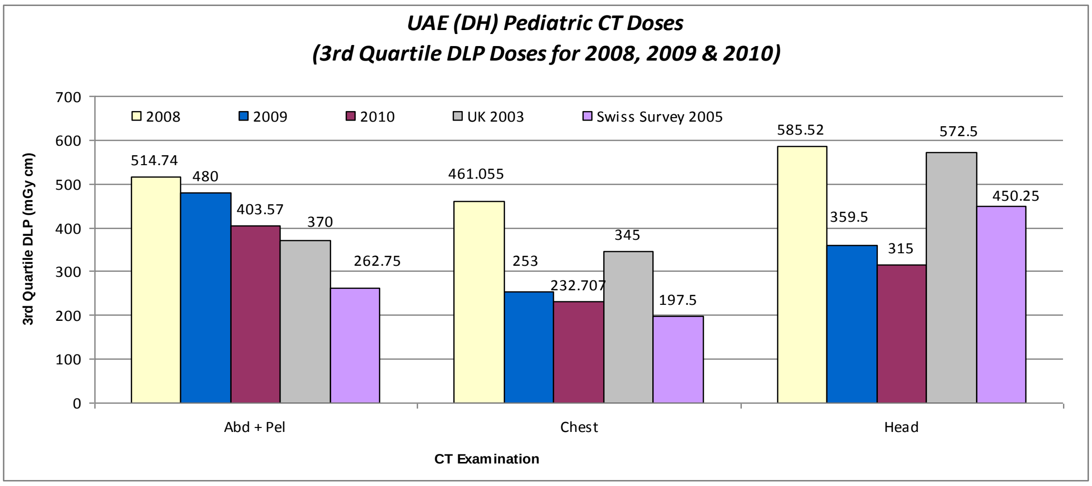

FIG. 2. Third quartile value of the dose length product for paediatric patients (all age groups) at DH compared to European data.

In comparison to the local DRLs, the paediatric patients' doses were reduced by about 46%, 38.6% and 48.6% for head, chest and abdomen and pelvis examinations, respectively. CT effective doses for paediatric patients were compared to the data published by the ICRP (Report 102) as survey carried out at the UK and other European Commission (EC) countries [8, 11-13]. For paediatric group, the doses were, in general, lower than those reported in EC countries with slight increase of the abdomen and pelvis data which where averaged among all the paediatric age groups. The CT effective doses are considered as a limiting dose indicator and not as an absolute; however it is useful to compare different protocols or imaging techniques. The DHA effective doses were within the same range as those in EC countries, and also demonstrated the same trends among the different CT examinations. There were variations in the total number of patients for each common CT examination over the 3 years of this study; the total number of patients for 2008 was not confidently comparable to 2009 and 2008. Hence, we did not consider the estimation of effective doses for the patients in year 2008.

3.4. Dental results

The DHA local diagnostic reference levels (DRLs) in this study were based on the third quartile dose values (Tables 1 and 2). The results show that the paediatric PEDs for all views for film based and digital intraoral systems were 2.5 mGy and 0.642 mGy, respectively. PEDs were also evaluated for the common image views in the dental radiology. The OPG 3rd quartile doses were 4.9 mGy for paediatric settings. The dental dose ranges for paediatric patients showed a significant variation which reflects the variation between different vendors and the diversity in imaging parameters, mainly the exposure time, that are followed at the DHA hospitals. Patient doses incurred in the dental radiology practices at the DHA are comparable to the accepted dose level stated by the International Atomic Energy Agency (BSS, 1996) and the European Commission [14].

Digitization system (Digora) was implemented for some film based dental radiology units within the DHA during the progress of this study. This showed a significant dose reduction by about 70%. Compared to the UK HPA [5], the DHA film based intra oral doses were higher, while the digital ones were lower. The OPG dosimetry obtained for the DHA panoramic units were in mGy while most of the published data were as dose width product (in mGy mm). Paediatric dental doses within the DHA were lower than the adults' values. This is a good optimization indication within the dental radiology practices at the DHA.

TABLE I. FILM BASED AND DIGITAL INTRA ORAL DOSIMETRY RESULTS OF THE DHA, (2010/2011)

Dental imaging view	Paediatric 3rd quartile dose (mGy) (Film based X ray)	Paediatric 3rd quartile dose (mGy) (Digital I.O. X ray)
Apical / Preapical (anterior view)	2.154	0.438
Molar / Premolar (posterior view)	2.540	0.882
Bitewing view	2.923	0.712
All views	2.635	0.642

TABLE II. OPG DOSIMETRY RESULTS OF THE DHA.

DHA OPG Dosimetry (2010/2011) (in mGy)		
Average	6.410	5.128
3rd Quartile	6.721	6.693

4. CONCLUSIONS

The results of the paediatric dosimetry in radiology practices at the DHA show an acceptable level compared to the literature. The dosimetry levels in this study showed an increasing trend with patients' age. This reflects the use of dedicated paediatric protocols and hence reveals a good practice in view of patient radiation safety. The sample population of the paediatric dose data presented in this work is small compared to studies carried out in Europe. Hence, the comparison stated in this work needs to be re-evaluated in view of a larger paediatric sample that may reflect the actual situation of dose levels at radiology procedures within the DHA hospitals. This proposed step is essential to enable the dosimetry data to be implemented to establish local and national DRLs.

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