Patient doses of CT examinations in Western and Eastern Azerbyjan provinces of Iran

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ABSTRACT

Medical X-rays are the largest man-made source of public exposure to ionizing radiation. While the benefits of computed tomography (CT) are well known in accurate diagnosis, those benefits are not risk free. CT is a device with higher patient dose in comparison with other conventional radiation procedures. So it is important to avoid conditions where the amount of radiation used is more than that needed for the procedure. Since that there is not any report on the radiation doses received by patients in CT scan wards in hospitals under control of Eastern and Western Azerbyjan medical sciences university, in the North West of Iran; this study was a part of national project to establish and optimize local and national diagnostic guidance levels. This work intends to calculate CT Dose Index (CTDI) and Dose Length Product (DLP) in common CT procedures in two north western provinces of country. Two hospitals got involved in the present study. CTDI and DLP measurements were done according to AAPM report no. 96 for head, chest and abdomen CT procedures. The mean $CTDI_w$ for head (base), sinus, chest and abdomen were 12.22, 13.13, 13.3 and 7.6 mGy, respectively.Patient dose levels in CTDI and DLP in our study aren't higher than those in developed countries.

Keywords: Patient dose inWestern and Eastern Azerbyjan ; CTDI; DLP.

INTRODUCTION

Computed tomography has made dramatic advances, both in its breadth of application and in its technological improvements. The advances are such that it is possible with the spiral technique to carry out an entire examination of the chest within a single breath hold as against a few minutes in earlier system. Yet these advances have brought with them the potential for greatly increased doses of radiation to the patient[1]. Furthermore, CT provides high quality X-ray imaging and clinical application of this technique has continued to increase.

It is indicated that patient doses from CT procedures are quite higher than doses from other imaging modalities based on ionizing radiation. Therefore, however, CT procedures include just 5% of entire number of medical X-ray procedure; they accounts 49% of annual collective dose from all medical X-ray examinations to the population in 2006 [2].So, evaluation of patient dose in different ionizing diagnostic techniques and its optimizations especially in CT procedures has a major concern in many countries [2-8]. This article represents the outcomes on typical dose levels to patients having the most common CT examinations to assess the patient dose in terms of $CTDI_{vol,w}$ and DLP and compare the results with other studies toward establishing Local and National Diagnostic Reference Levels (LDRLs, NDRLs) for mentioned examinations.

MATERIALS AND METHODS

Present study was done in two hospitals in Urmia, Western Azerbyjan (Hospital A) and Tabriz, Eastern Azerbyjan (Hospital B). Collecting data was a one month process done in July 2011.

Assessment of patient doses in CT examinations

Data collection

Detailed specifications of CT scanners are shown in Table 1. For this study a questionnaire which was included the following items: Hospital name, scanner model & manufacturer, year of installation

and for each CT examination exposure parameters (kilovoltage (kVp), tube current (mA), exposure time, slice thickness and number of slices) was prepared. At least 10 patients parameters were used to fill out the related forms for common CT examinations including, Head, Chest, Abdomen & Pelvis.

CT dose measurements

CTDI and Dose length product (DLP) have been measured and calculated, respectively for CT procedures. CTDI which is a measure of the dose from single-slice irradiation [9, 10] is defined as the integral along a line parallel to the axis of rotation (z) of the dose profile, D (z), divided by the nominal slice thickness (T) [11, 12]

CTDI= $\frac{1}{T}\int_{-\infty}^{+\infty} D(z)dz$

Calculation of CTDI in air ($CTDI_{100, air}$) and in the cylindrical polymethylmethylacrylate (PMMA) phantoms ($CTDI_{100, phantom}$) capable of both head (16 cm diameter) and body (32 cm diameter) were done as recommended by EC guidelines and AAPM report no. 96 [9, 13]. $CTDI_{100, air}$ was measured in the center of gantry rotation using a 10 cm pencil ionization chamber (RTI AB Electronic, Sweden). Weighted CTDI ($CTDI_w$) using $CTDI_{100}$ at 1 cm below the surface ($CTDI_{100, p}$) and at the center ($CTDI_{100, c}$) of standard head and body PMMA phantoms were measured according to below formula.

$CTDI_w = (1/3\ CTDI_{100, c} + 2/3\ CTDI_{100, p})$ (mGy)

Which $CTDI_{100, p}$ is mean of measurements at four locations around the periphery of phantom.

The normalized average dose to the slice is approximated by the $CTDI_w$, normalized to unit mAS:

$nCTDI_w = 1/c\ (1/3\ CTDI_{100, c} + 2/3\ CTDI_{100, p})$ (mGy)

Which C is the mAS[10, 11]

In spiral mode, volume CTDI ($CTDI_{vol}$) is calculated.

$CTDI_{vol}=CTDI_w/$ Pitch (mGy)

Where, pitch is the ratio between table increment per rotation and beam width [9, 14]. Patient dose in a complete CT examination was assessed in terms of DLP:

DLP = $\sum_i nCTDIw$. T. N. C (mGy.cm) for Axial scan and DLP = $\sum_i nCTDIvol$. L. C forspiral scan Where, i represents each scan sequence forming part of an examination and N is the number of slices, T (cm) is the thickness of slice, L is the scan length in cm for spiral scan and radiographic exposure C (mAS), in a particular sequenc[9, 14].

RESULTS

The mean $CTDI_w$ in brain and body phantoms were 13.75 and 5.63 mGy/100mAS, respectively. The mean $CTDI_w$ for head (base), sinus, chest and abdomen procedures (in adult patients) were 12.22, 13.13, 13.3 and 7.6 mGy, respectively, and the mean DLP for head (base), sinus, chest and abdomen procedures (in adult patients) were 99.64, 96, 369.44, 412.73 mGy.cm, respectively.

Complete $CTDI_w$ and DLP values in the most common CT procedures for different age groups are reported in Table 2.

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Table1. Specifications of CT scanners used at each hospital

Hospital	Manufacturer	Scanner model	Year of Installation	slice classes	No. of patients/ year
A	Toshiba	Xvision/EX	1999	1	28000
B	Siemens	Somatom Balance	2001	1	33000

Table2. Calculated $CTDI_w$ and DLP of the most common procedures in participating hospitals.

Examination	Hospital A					Hospital B				
	kVP	mAS	$CTDI_W$(mGy) ±SD	DLP(mGy.cm) ±SD	Axial (A)/ Helical (H)	kVP	mAS	$CTDI_W$(mGy) ±SD	DLP(mGy.cm) ±SD	Axial (A)/ Helical (H)
Head(sinus)	120	100	15.34±5.3	139.59±20.6	A	110	135	10.92±2.3	52.416±15.2	A
Head(base)	120	100	15.34±5.3	53.69±10	A	110	140	9.10±1.2	145.6±30	A
Head(Cereberum)	120	100	15.34±6.2	122.72±7	A	110	140	9.10±3.5	145.6±50.2	A
Chest	120	250	14.04±2.6	336.96±45	A	110	120	12.56±4	401.92±60.4	A
Chest(HRCT)	120	150	8.4±1.2	126.36±20.1	A	-	-	-	-	A
Abdomen	120	190	10.67±2.6	373.46±46.5	A	110	120	4.52±1.6	452±46	A
For pediatric patients age < 1 year										
Head(sinus)	120	60	9.2±4.8	13.8±8	A	110	60	9.1±1.7	27.31±10	A
Head(base)	120	60	9.2±4.8	46±10.2	A	110	180	9.1±1.8	45.52±15.4	A
Head(Cereberum)	120	60	9.2±3.5	32.21±9.6	A	110	180	9.1±1.8	45.52±15.4	A
Chest	120	60	3.37±1.2	33.7±8.2	A	-	-	-	-	A
Chest(HRCT)	-	-	-	-	A	-	-	-	-	A
Abdomen	120	60	3.37±1.6	50.5±30.2	A	80	80	4.24±1.3	212.25±84	A
For pediatric patients age 1-5 year										
Head(sinus)	120	85	13.04±5.2	58.67±16.2	A	110	60	9.1±3.5	27.31±12	A
Head(base)	120	85	13.04±5.6	32.6±12	A	110	110	9.1±3.5	45.52±16.3	A
Head(Cereberum)	120	85	13.04±3.5	91.27±20	A	110	110	9.1±3.5	72.84±30.2	A
Chest	120	85	4.76±2	66.64±25	A	-	-	-	-	A
Chest(HRCT)	-	-	-	-	A	-	-	-	-	A
Abdomen	120	85	4.76±2.3	95.2±17.2	A	110	36	4.52±1.2	226.4±32	A
For pediatric patients age 5-10 year										
Head(sinus)	120	110	15.34±5	118.12±20	A	110	140	9.1±3.2	27.31±4.5	A
Head(base)	120	110	15.34±3.4	53.69±12	A	110	140	9.1±3.2	91.05±10	A
Head(Cereberum)	120	110	15.34±3.4	122.72±36.2	A	110	140	9.1±3.2	72.84±23	A
Chest	120	200	11.2±2.6	224±26.3	A	110	120	-	-	A
Chest(HRCT)	-	-	-	-	A	-	-	-	-	A
Abdomen	120	150	8.4±3.6	235.2±32.1	A	110	120	4.52±2.1	226.4±20	A
For pediatric patients age 10-15 year										
Head(sinus)	120	100	15.34±5	139.59±23	A	110	135	9.1±3.6	145.6±11.3	A
Head(base)	120	100	15.34±4	53.69±14.2	A	110	140	9.1±2.1	145.6±32	A
Head(Cereberum)	120	100	15.34±4.5	122.72±32	A	110	140	9.1±1.6	145.6±32	A
Chest	120	200	11.2±2.3	268.8±26	A	-	-	-	-	A
Chest(HRCT)	-	-	-	-	A	-	-	-	-	A
Abdomen	120	190	10.64±3.2	372.4±65	A	110	120	4.52±1.3	226.4±42.1	A

Table3. The mean $CTDI_w$ and DLP compared with other city in Iran and European Guidelines (EG)

Dose quantities	Examination	Urmia (W-A)	Tabriz (E-A)	Yazd [17]	Saskatchewan 2006 [16]	EG [9, 15]	IRSN (FRA) [3]	Swiss [18]	Nigeria [19]	India [20]
$CTDI_w$(mGy) in adult patients	Sinus	15.34	10.92	-	-	35	-	30	-	-
	Head(base)	15.34	9.10	20.25	-	60	65	60	73.5	32
	Chest	14.04	12.56	8	-	30	15	15	22.7	10
	Abdomen	10.69	4.52	8.3	-	35	-	20	37.9	13
DLP(mGy.cm) in adult patients	Sinus	139.59	52.416	-	-	360	-	510	-	-
	Head(base)	53.69	145.6	322.2	1173.91	1024	1050	800	1898	875
	Chest	336.96	401.92	209.2	664.7	650	475	480	1189	340
	Abdomen	373.46	452	243.9	780	780	-	710	1902	427

DISCUSSION

There are many methods to express radiation dose from CT examinations. $CTDI_w$ (measured in mGY) is the radiation dose in a single slice over a standard length(9,10). DLP (measured in mGY.cm) is the product of $CTDI_{vol}$ and scan length. $CTDI_w$ values in CT procedures are related to exposure parameters including mAS and kVp. In addition; DLP increases by elevating of number of slices and scan length. Therefore DLP in abdomen and chest examinations are higher than head examination. On the other hand DLP and $CTDI_w$ increase as well as age (subsequently size) goes up. In hospital A, the values of mean $CTDI_w$ in all CT examinations and in all age groups were higher than in hospital B. It could be because of wider scanner related collimation in hospital A and/or due to the absence of a special protocol for each age group.Controversarily, quantity of DLP in hospital A is noticeably higher (except for Sinus protocol) which the number of slice or slice thickness could be the effective factors. The mean $CTDI_w$and DLP values in Western and Eastern Azerbyjan (W-A, E-A) were below in comparison with European Guidelines (EG) and Saskatchewan [9, 15, 16]. The mean $CTDI_w$for chest and abdomen scans in Western and Eastern Azerbyjan were higher than those in Yazd and India but lower than those in France, Nigeria and Swisss. Although DLP in these procedures are much higher in comparison with results of this study which could be due to using high mAS or exposure field (Table 3).

CONCLUSION

Comparison with other studies proves that CTDIw in these two hospitals aren't higher than those in developed countries, and also QA program in CT is proven to be powerful tool for decreasing doses and increasing diagnostic efficiency.

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