

# NATIONAL DIAGNOSTIC REFERENCE LEVELS OF COMPUTED TOMOGRAPHY IN THAILAND

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**Abstract-** The patient radiation dose survey on DRL of CT procedures was started after the quality control of CT system and the normalized weighted computed tomography dose index; nCTDI<sub>w</sub> (mGy/mAs) was obtained. The CTDI and DLP values per single scan among various CT procedures were collected from patient of size selection on brain, chest and whole abdomen with and without contrast media. DRLs were determined and compared to other NDRLs for further optimization on the CT protocols.

**Keywords-** CTDI, DLP, brain, chest, abdomen.

## I. INTRODUCTION

The computed tomography has been used in major medical imaging departments. In Thailand the number of CT systems is 903 in 2018 which most of them are installed in Bangkok and other big cities. There has been a dramatic increase in the use of CT, furthermore, CT is a relative high dose technique. UNSCEAR 2000 Report [1] showed that 34 % of patient cumulative radiation dose were from CT systems. Mettler FA Jr, et al [2] reported the entrance surface dose equivalent from chest PA from general X-rays was 0.02 mSv while CT chest was 7 mSv. The biological effect of radiation can lead to the stochastic effect or cancer induction. ICRP 103, 2007[3] reported the risk of cancer was 5.5 % Sv<sup>-1</sup>. If the patient received 10 mSv, the risk of cancer would be 5.5 x10<sup>-4</sup> Sv<sup>-1</sup> and the risk ratio would be 1:1800. ICRP, IAEA BSS recommended the three concepts of *justification* which the benefit is higher than risk, *optimization*; As Low As Reasonably Achievable: ALARA, for the reduction of patient dose from medical exposure when the image quality had been considered, and the *dose limit*. In the survey of patient dose, the Department of Medical Science, Ministry of Public Health of Thailand has established DRLs of CT in the national level to be used for the patient radiation dose reduction and optimization [4].

## II. MATERIALS AND METHODS

The data collection from the patients of both male and female with the body weight at 60± 15 kg and the patient age was over 15 years old. The data collected from CT system consists of CTDI volume; CTDI<sub>vol</sub> (mGy) dose length product; DLP (mGy.cm), normalized weighted computed tomography dose index; nCTDI<sub>w</sub> (mGy/mAs), scan length, (cm), and pitch factor. The measurement of each parameter follows IAEA TRS 457[5]. The DRLs

consists of CTDI and DLP values per single scan among various CT procedures.

## III. RESULTS

In 2018, the national survey of 135 CT systems, 6 manufacturers and 52 models of 4 to 128 detector slices to establish the DRLs started with the collection of nCTDI<sub>w</sub> from the central part of Thailand at 67 CT systems, 15 systems from the north, 35 systems from the north-east, and 18 systems from the south as the details in Table 1 and Table 2. The nCTDI<sub>w</sub> values were estimated from head and body phantom [5] as in Table 3. Table 4 shows technique parameters of brain, chest, and whole abdomen at with and without contrast media. Table 5 shows volume CTDI, mGy, per sequence while Table 6 shows DLP, mGy.cm per sequence. Table 7 shows the National DRLs from Thailand, Japan, USA and UK. Our DRLs values of various parts of the body, with and without the contrast media were lower than Japan but higher than USA and UK.

Table 1: The number of CT systems at different regions

Region Percentage	CT Systems	
Central	67	
49.6		
North	15	11.1
North-East	35	
25.9		
South	18	13.3
Total	135	
100.0		

Table2: CT systems according to number of detector slices

Number of Detector slices Percentage	CT Systems	
<16	25	18.5
16	49	36.3
>16-<64		35
25.9		
64	12	8.9
>64 - <128	4	3.0
128	10	7.4
Total	135	100.0

Table 3 nCTDI<sub>w</sub> values (mGy/mAs) according to model, phantoms used

Manufacturer	Model	kVp	nCTDI <sub>w</sub> (mGy/mAs) (mean±sd)		
			Head phantom	Body phantom	
GE	Optima	120		0.146±0.038	0.069±0.008
	Optima CT 520	120		0.162	0.111
	Optima CT 660	120		0.179±0.056	0.111±0.001
Brivo	120		0.161	0.066	
	BrivoCT325	120		0.180±0.050	0.066
	Brivo CT385	120		0.192±0.028	0.095±0.054
	Bright Speed	120		0.256±0.045	0.113±0.013
	BrightSpeed Elite Select	120		0.222	0.102
	Revolution EVO	120		0.181	0.088
	Revolution CT	120		0.153	0.071
	Revolution ACT	120		0.107	0.135±0.029
	Somatom Emotion	130		0.085	0.111
	Light Speed VCT	120		0.0995±0.0002	0.090±0.019
	Discovery CT750HD	120		0.106	0.103
PHILIPS	Ingenuity CT	120		0.047±0.008	0.057±0.026
	Ingenuity FLEX	120		0.038	0.059
	Ingenuity Flex 16	120		0.140	0.061
	Ingenuity 128	120		0.172±0.019	0.077±0.004
	Brilliance CT	120		0.115±0.04	0.064±0.026
	Brilliance 64	120		0.095±0.070	0.067±0.014
	Brilliance 16	120		0.105	0.057±0.012
	Brilliance 128	120		0.126	0.080
SIEMENS	Somatom go UP	130		0.120±0.0008	0.114±0.019
	Somatom Definition AS	120		0.096±0.025	0.077±0.009
	Somatom Definition128	120		0.090	0.520
	Somatom Scope	130		0.130	0.083
	Somatom Emotion	130		0.138±0.053	0.098±0.034
	Somatom Definition flash	120		-	0.026
	Somatom Sensation	120		0.108	0.096
	Somatom Spirit	130		0.193	0.159
	Somatom Perspective	130		0.131	0.120
	Definition AS	120		0.163	0.061
CANON	Alexion /16	120		0.153±0.068	0.073±0.032
	Alexion TSX-032A	120		0.328	0.137
Aquilion Lightning	120		0.230	0.092	
	Aquilion	120		0.287	0.067
	Aquilion PRIME	120		0.130±0.009)	0.052±0.008
	Aquilion 16	120		-	0.170
	Aquilion 6	120		0.197±0.078)	0.280±0.252
	Activion 16	120		0.243±0.079	0.145±0.061
	PRIME Aquilion	120		0.218	0.065
	PRIME Aquilion/160	130		0.124	-
	TSX-021B	120		0.219	0.107
	TSX-303A	120		-	0.070
NEUSOFT	CLASSIC	120		N/A	N/A
HITACHI	SCENARIO	120		0.157±0.070	0.098±0.023

Table 4 CT Technique parameters

Clinical procedures	kVp	mAs	pitch	Beam collimator width	Scan length (cm)
				or Slice thickness (mm)	
Brain without contrast media	120-130	91.2 - 468	0.270-1.600	0.375-5.000	13.8-22.3
Brain with contrast media	120-140	105.0-450.0	0.370-1.000	0.500-5.000	14.0-36.0
Chest without contrast media	120-140	48.8-295.0	0.375-1.750	0.500-5.000	14.1-50.0
Chest with contrast media	100-140	60.0-380.8	0.375-1.750	0.500-5.000	14.9-47.5
Whole abdomen without contrast media	100-135	37.5-492.0	0.641-1.750	0.500-5.000	13.5-50.5
Whole abdomen with contrast media	110-130	48.7-400.0	0.641-1.750	0.500-5.000	15.8-49.5

Table 5 CTDIvol per sequence

Clinical procedures	No. of Sequence	min		max		CTDIvol (mGy)	
		min	max	median	mean	3rdQ	S.D.
Brain without contrast media	1,273	18.6	108.7	48.1	50.1	55.9	16.77
Brain with contrast media	335	26.9	100.0	49.6	51.4	58.2	17.00
Chest without contrast media	415	3.1	33.6	10.6	12.0	13.8	6.44
Chest with contrast media	494	3.7	32.7	11.9	12.5	14.7	6.63
Whole abdomen without contrast media	907	2.7	57.5	11.5	15.2	18.0	11.58
Whole abdomen with contrast media	606	4.4	57.5	12.8	11.0	17.5	12.15

Table 6 DLP per sequence

Clinical procedures Sequence	No. of		DLP (mGy-cm)				
	min	max	median	mean	3rdQ	S.D.	
Brain without contrast media	1,273	266.7	2,028.0	901.3	953.4	1165	306.47
Brain with contrast media	335	461.0	1,901.1	967.8	1,030.8	1242	298.08
Chest without contrast media	415	101.6	1,267.7	417.2	455.3	557	222.40
Chest with contrast media	494	149.5	1,298.0	421.0	473.0	580	250.93
Whole abdomen without contrast media	907	125.9	1,572.7	470.0	584.7	737	322.64
Whole abdomen with contrast media	606	197.4	1,415.9	559.0	579.0	717	299.67

Table 7 National DRLs of CT from Thailand, Japan, USA and UK

Clinical procedures		Thailand, 2018	Japan, 2015[7]	USA, 2016[7]	UK, 2014[7]
Brain without contrast media	CTDI <sub>vol</sub> (mGy)	56	85	56	60
	DLP (mGy-cm)	1,165	1350	962	970
Brain with contrast media	CTDI <sub>vol</sub> (mGy)	58	-	-	-
	DLP (mGy-cm)	1,242	-	-	-
Chest without contrast media	CTDI <sub>vol</sub> (mGy)	14	15	12	12
	DLP (mGy-cm)	557	550	443	610
Chest with contrast media	CTDI <sub>vol</sub> (mGy)	15	15	13	10
	DLP (mGy-cm)	580	550	469	400
Whole abdomen without contrast media	CTDI <sub>vol</sub> (mGy)	18	20	16	15
	DLP (mGy-cm)	737	1000	781	745
Whole abdomen with contrast media	CTDI <sub>vol</sub> (mGy)	18	20	15	15
	DLP (mGy-cm)	717	1000	755	745

#### IV DISCUSSION

The objective of a diagnostic reference level is to help avoid radiation dose to the patients that does not contribute to the clinical purpose of a medical imaging task[6]. This is accomplished by comparison between the diagnostic reference value with the mean or appropriate value observed in practice for a certain reference group of patients or reference phantom. A diagnostic reference level is not applied to individual patient. In this survey of patient radiation dose from CT, the data had been collected from different healthcare regions in Thailand. The results obtained from all CT manufacturers and models available, and all

clinical procedures both with and without contrast media. The results show the reasonable value when compared to other national DRLs from Japan, USA and UK[7]. It is the first attempt to establish the DRLs on CT in Thailand. Hopefully, the second survey could be established in 2025 for the study of DRLs in CT.

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