

ORGAN AND EFFECTIVE DOSES FROM A MULTIDETECTOR COMPUTED TOMOGRAPHY IN CHEST EXAMINATION

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Abstract: The growth of Multidetector Computed Tomography (MDCT) associated with the large number of images per examination offers many clinical benefits. It is easy to use for radiologist and physician, and these reasons are the cause of increasing exposure for populations rapidly. Organ and effective doses from CT examination are the important quantities to assess radiation risk. The objective of this study is to calculate the organ and effective doses from patient data. The beam data was collected for 30 cases of patient over 20 years old underwent 64 slices GE VCT MDCT scanner in the chest examinations. The computed tomography dose index (CTDI) values were measured in air and in body phantom with SOLIDOSE ionization chamber then the CTDI values and the exposed parameters were entered in ImPACT CT Patient Dosimetry Calculator version 1.0 for calculation of organ and effective doses. The exposure parameters of chest protocol were 120 kVp, 330 mA, 0.6 sec rotation time, and 1.375 pitch. The average scan length was 34.9 cm for the range of 23.1 to 56.5 cm. The high organ doses in the irradiated field occurred in lung, breast, esophagus, heart, stomach, liver, adrenal gland, kidney, pancreas, spleen and small intestine, the maximum dose ranged from 15 to 23.0 mGy. The average effective dose was 8.6 mSv with the range of 5.7 to 13.0 mSv. The maximum number of scan series of examination was three which made the maximum effective dose of 39.0 mSv. The scan length was one of the variable factors that made the higher organ and effective doses in CT examination. The more series of examination was another factor to increase the organ and effective doses. The estimated radiation risk for cancer and hereditary effect for chest CT examination was about 5 cases for 10,000 populations. This study has shown that the CT doses used in clinical practice are not higher than commonly report but the careful used of radiation must be considered. Estimated organ and effective doses in chest MDCT scanning are a guide line for radiologists and physicians in order to judge the frequency of scan and suitable scan length.

Keywords: organ dose, effective dose, Computed Tomography Dose Index, Multidetector Computed Tomography

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I. INTRODUCTION

The Multidetector Computed Tomography is one of the most important methods of radiological diagnosis. It displays cross-sectional images of the body, scans large anatomic range, makes faster scan, and reduces examination times. The growth of MDCT associated with the large number of images per examination offers many clinical benefits and these reasons are the cause of increasing exposure for populations rapidly. The higher dose in CT examination than other x-ray diagnostic procedures must be considered for the safety used, Fred et.al [1] reported the estimated of the NCRP Scientific Committee 6-2 subgroup that in 2006 the per capita dose from medical exposure has increased almost 600%. The largest contributions and increases have come primarily from CT scanning and nuclear medicine. The 67 million CT scans account for 15% of the total medical radiation procedures and about 50% of collective dose.

Effective dose which focus on dose to individual organs and tissues is the important quantity using for estimating risk of radiation-induced cancers. The individual CT patient dose is not possible to be measured for the exact organ dose. One common method for estimating organ and effective doses is the dose calculation from CTDI or DLP and conversion factors.

Another method employed the Monte Carlo radiation transport code which was developed to simulate photon interaction within mathematical model of human body in CT examinations; the common used is the IMPACT CT Patient Dosimetry Calculator (ImPACT, London, England). Many studies [2] demonstrated the agreements of calculation and measurement using this IMPACT software. It was noted that high dose was most likely in multiphase studies [3]. The patient effective dose will be directly proportional to the number of phase that is performed when scanning are the same for each phase. Factors that affect the patient effective dose include the techniques (mAs and pitch) scan length, and voltage. Individual dose are also affected by patients characteristics.

The objective of this study is to calculate the organ and effective doses from patient data of chest examination of 64 slice CT scan using ImPACT Calculator Program.

II. MATERIALS AND METHODS

A. CT unit

In this study, the machine used was 64 slices GE VCT MDCT scanner. (General Electric Medical Systems,

Waukesha, WI, USA). The exposure parameters employed in chest examination is shown in Table 1 and the operating voltage was 120 kVp in all cases.

Table 1.Exposure parameters of chest protocol.

mA	Rotation time (sec)	Pitch (mm/rotation)	Collimation (mm)	Slice width (mm)
330	0.6	1.375	40	5

B. CT dosimetry

The computed tomography dose index (CTDI) was measured by 100 mm long pencil ionization chamber: DCT 10 with digital dosimeter: SOLIDOSE, Model 400 (RTI Electronics AB, Molndal, Sweden). The cylindrical phantom was 32-cm diameter Polymethyl Methacrylate (PMMA). The doses were measured in air at the isocenter of gantry and in phantom at the center and peripheries at 12, 3, 6, 9 o'clock, respectively.

C. The ImPACT CT Patient Dosimetry Calculator

The ImPACT Calculator Program version 1.0 is a free download program. It simulates almost all of the commercial CT scanner. The data needed to enter in the program are: the CTDI value at center and the average value at periphery of the phantom together with exposure parameters, type and model of CT and the scan length in each patient were put into the ImPACT Calculator Program version 1.0 in order to calculate organ and effective doses. The ImPACT CT software package coupled organ weighting factors of International Commission on Radiological Protection (ICRP) publication 103.

D. Effective dose, E

The effective dose is the sum over all the organs and tissues of the body of the product of the equivalent doses, H_T , to the organ or tissue and a tissue weighting factor, W_T for that organ or tissue.

$$E = \sum_T W_T H_T \quad (1)$$

The unit for the effective dose is Sv.

Organ and effective dose can be estimated using IMPACT software that precalculated the dose distribution for specific commercial CT scanner.

E. The data collection

The exposure of chest protocol examination (Table1) and patient parameters were collected for11 male and 19 female patients over 20 years old.

III. RESULTS AND DISCUSSION

The minimum, maximum and average scan length and effective dose for 30 patients in chest examination are listed in Table 2. The average scan length was 34.9 cm with the range of 23.1 to 56.5 cm and the average effective dose was 8.6 mSv with the range of 5.7 to 13 mSv. The maximum effective dose was 39 mSv from three scan series (phases) of chest scanning.

Table 2.Calculated effective dose and scan length in routine chest CT protocol technique.

	*N	Min	Max	Aver.	SD
Scanlength (cm)	30	23.1	56.6	34.9	6.6
ED (mSv)	30	5.7	13.0	8.6	1.5

N = number of cases, ED = Effective Dose, SD = Standard Deviation

The various organ doses for chest examination are shown in Table 3. The high doses in the irradiated field occurred in lung, breast, esophagus, heart, stomach, liver, adrenal gland, kidney, pancreas, spleen and small intestine, the maximum dose ranged from 15 to 23 mGy.

Table 3.The calculated organ doses (mGy) in chest examination

Organ/dose(mGy)	Min	Max	Aver.	SD
Lung	15.0	20.0	19.5	1.0
Breast	14.0	15.0	14.9	0.2
Esophagus	22.0	23.0	22.6	0.5
Heart	12.0	20.0	19.2	1.5
Stomach	0.5	19.0	8.5	5.4
Liver	1.2	18.0	10.4	4.5
Adrenal gland	1.4	17.0	12.9	4.7
Kidney	0.1	20.0	6.4	6.2
Pancreas	1.2	16.0	10.0	4.7
Spleen	0.9	17.0	9.9	5.3
Small intestine	0.0	16.0	1.3	3.1

The main variable factor that makes higher organ and effective doses in CT examination was the scan length, the routine of chest scans started from apex of lung ended at first lumbar spine. Two series of the scan for non contrast and with contrast were undertaken as the routine chest examination. In some cases, the radiologist wanted to observe the portal vein or the contrast could not be filled in aorta properly, the extra scan series with the increasing of scan length was ordered. However, the over scanning and incorrect protocol including scout for scan planning had an effect on organ dose. These factors were extra dose that increased patient dose.

Our study revealed the average effective dose for chest examination of 8.6 mSv per series with the risk of about 5 cases for 10,000 population (risk estimates for cancer and hereditary effect was $5.7\%Sv^{-1}$) [4] which agreed with the Dendy et.al study [5], they showed effective dose of 8 mSv,

Fujii et al [6] measured the dose in adult anthropomorphic phantom for 64 slice CT examination, the organ dose and the estimated effective dose were 8-35 mGy, and 7-18 mSv, respectively. Our result showed less maximum organ dose of 15-23 mGy and less effective dose of 5.7-13 mSv.

This work employed the patient data and the measured standard CTDI value to estimate organ and effective doses by the calculation software, the dose verification with the measurement was not performed. However, the other studies [3] and the previous work of Nerysunnoen B [7] in our institute supported that the organ and effective doses could be estimated by Impact software with the accuracy within 20%.

IV. CONCLUSION

This study has shown that the organ and effective doses of patient in clinical practice are not higher than commonly report but the careful used of radiation must be considered. These include the optimal of exposure parameters, the scan length and the series of scan.

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REFERENCES

- [1] Fred A, Mettler Jr, Bruce R et.al (2008) Medical radiation exposure in the U.S. in 2006 : Preliminary Results. Health Physics Society: 502-507
- [2] Breiki G, Abbas Y, Ashry M EL et al. (2008) Evaluation of radiation dose and image quality for patients undergoing computed tomography (CT) examinations. IX radi (ation physics & protection conference, Cairo, Egypt, 2008 pp 141-156
- [3] Bindman R S (2010) Is the computed tomography safe? at <http://www.nejm.org>
- [4] International Commission on Radiological Protection. (2007) International Commission on Radiation Unit and Measurements ICRP publication 103, New York, Pergamon Press
- [5] Dendy P P, Heaton B(1999) Physics for diagnostic radiology second edition, Institute of Physics publishing, London: 296-297
- [6] Fujii K, Aoyam T, Yamauchi-Kawaura C, et.al.(2009) Radiation dose evaluation in 64 slice CT examinations with adult and pediatric anthropomorphic phantoms, The British Journal of Radiology, 82: 1010-1018
- [7] Nerysunnoen B, (2007) Comparison of effective dose in phantom from CT using Monte Carlo Simulation and TLD methods, A thesis submitted in partial fulfillment of the requirements for the degree of master of science program in medical imaging, Faculty of medicine, Chulalongkorn University