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Investigation of Backscattered Dose in a Computerized Tomography (CT) Facility during Abdominal CT Scan by Considering Clinical Measurements and Application of Monte Carlo Method

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Abstract: X-ray computed tomography (CT) related to computer-processed combination or X-ray images obtained from different angles to create patient's cross-sectional body parts images. CT ensures to have imaging various organs, bones, blood vessel etc. and more advantageous than normal plain X-ray devices in consequence of 360 degree image of internal organs, the spine and vertebrae. For decades, Radiation protection became a main topic in research areas since CT uses various dose of X-ray for imaging body. Distance factor is the one of fundamental principle of radiation protection. Maximum dose occurs around gantry and dose rate is decreases by distance in CT facilities. To know the rate of reduction of the amount of dose by distance is very significant for radiation protection procedure especially for apply criteria of International Commission on Radiological Protection (ICRP) on radiation protection. Our study aimed to measure scattered dose rates during abdominal CT scan by considering small distance ranges from gantry until exit door and comparing the empirical result with Monte Carlo (MC) calculations. As a next step of study, we modeled a simulation input for CT facility by using MCNP-X (version 2.4.0). We obtained the changes of dose rate on distance factor by using Monte Carlo method. We achieved that MCNP-X calculations were in concordance with clinical experimental measurements. It can be concluded that Monte Carlo (MC) is an effective tool for obtain dose rate variations around CT gantry and especially radiation protection calculations in CT facilities.

Key words: CT abdomen, Monte Carlo, MCNP-X.

1. Introduction

Computed tomography is an imaging modality which produces cross-sectional images, representing in each pixel the local X-ray attenuation properties of the body. The imaging technology and capabilites of Ct scanners have developed enormously in the early 1990's since the introduction of helical computed tomography (CT). In respect of developing technology on diagnostic devices, procedures are performing with detailed informations about patient. The patient is positioned between the source and detector, and the detector is configured that its geometric center located at the x-ray source. In addition to various advantages of medical imaging by using CT, of course the exposure to ionizing radiation may cause a small increase in a person's lifetime risk of developing cancer. Table 1 represents the dose which could be received by a patient during the procedure [1]. As we can see from the table 1, values should be considered as which would cause biological effects.

When the computed tomography fluoroscopy runs, high-radiation exposure generated [2]. This high rate of radiation can be accepted to the patient by the reason of the imagine procedure but we have to consider in the

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Table 1 Effective dose rates due to examination.

Examination	Effective Dose (mSv)
IVP	2.5
Barium Swallow	1.5
Barium Enema	7.0
CT Head	2.0
CT Chest	8.0
CT Abdomen	10.0
CT Pelvis	10.0
Angioplasty	7.5-57.0
Coronary Angiogram	4.6-15.8

case that radiation dose around CT device that can be effect the CT operator or other staff. For the CT operator, exposure is primarily a function of scattered radiation and collimator or gantry leakage [3]. In past several years, some study has been done on this subject [3-5]. In recent years, such dosimetry processes become possible to perform by using Monte Carlo (MC) method. Monte Carlo calculations, some investigations and dose calculations by using patient and phantom have been done by using MC method [6].

2. Material and Method

In this study, our investigations consist of two steps that clinical measurements around CT devices and Monte Carlo studies by using MCNP-X. Experimental measurements were obtained in the processes performed by GM-Optima 660 CT (128 Slice) device for the same imaging parameters of CT Abdomen examinations which frequently performing by 120 kV. In this study, nine different locations from CT gantry until exit door were designated for measurements. Figure 1 indicates the measurements locations according to the position of the gantry.

In figure 1, point of a is the location of patient door, b is location of control room for operators, c is location of patient table and d is the gantry of CT device. As is seen from figure 1, the measurements locations are specified with the numbers from 1 until 9. The exact values of measurement locations are given in table 2 in the ID, column with measured dose rates respectively. All the dose measurements are carried out by using the Polimaster Survey Meter (PM1405) represented in

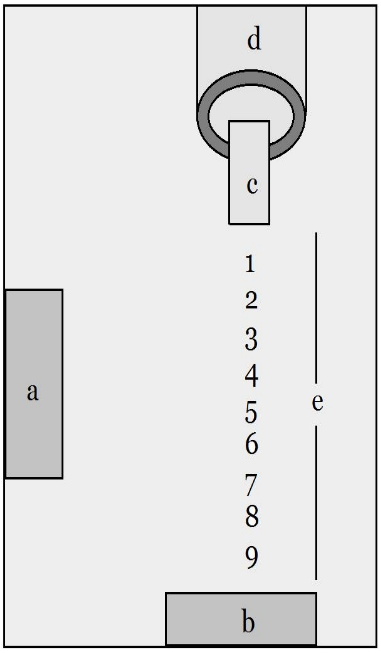

Fig. 1 Schematic view of CT room.

Fig. 2 Polimaster Survey Meter PM1405.

figure 2 that compact multifunction and capable of measuring x-ray, gamma and beta radiation. During CT Abdomen examinations, we used the PM1405 in order that we performed the simultaneous and selective measurements of the x-ray radiation intensity. All the measurements were accomplished by using user interface of PM1405 in operating room by remote control with personal computer which comes with detector as an install driver by considering radiation protection justification.

As a next step of study, we calculated the x-ray intensities by using MCNP-X code. MCNP-X (Monte Carlo N-Particle extended), is a general purpose Monte Carlo radiation transport code for modeling the interaction of radiation with materials. MCNP-X is fully three-dimensional and it utilizes extended nuclear cross section libraries and uses physics models for particle types. MCNP-X is used for nuclear medicine, radiation physics, nuclear safeguards, accelerator applications, nuclear criticality etc. It also allows the various specific working area about simulations. One of them is modeling the detector geometry. The detector geometry is modeled with the MCNP-X code, which allows simulating physical events occurring during the detection and registers them to build energy spectra. MCNP-X is also allowed for calculating the flux at a point or ring that name is F5 tally. For each source particle and each collision event, a deterministic estimate is made of the fluence contribution at the detector point.

3. Results

We did measurements in nine different distances respectively by increasing 50 cm in each measurement. We considered the average dose rates in each distance Table 3 gives the examination and dose values in different distances and the dose rates.

Gamma radiation is the part of the electromagnetic spectrum. A gamma radiation ray not absorbed by the air, but its intensity decreases because it spreads out. Accordingly, the intensity changes with the inverse square of distance: it follows an inverse square law. As we see from the table 1, the dose rates decreased by the increased distance from CT gantry. By considering clinical parameters, we also calculated the changing of dose rate by using MCNP-X. In our calculations, we used 10^6 particle as a number of particle. In our calculations, we also used the Intel Core 930—2.80 GHz 64 bit operating system as a simulation device. As we see from figure 2, measured and calculated values are compared in the same graph to see statistical differences.

Since some special experimental conditions can be occur during the measurements, we can see from the figure 2, there is a remarkable increase in 170 cm and 270 cm during the abdominal CT process. As a discussion subject, we can emphasize on a possible backscattering in related distances. Since Monte Carlo simulates all the interactions by considering framework of formulization and interaction within the material the same value difference did not observed in MCNP-X calculation.

4. Conclusions

For decades, studies on Monte Carlo applications in medical studies achieved great development especially by developing different Monte Carlo codes. By considering real clinical conditions, we can mention about some small result differences. Of course any small clinical device can cause different backscattering in room. It can be concluded that Monte Carlo is a strong tool for dose rate calculations and by considering this study's results it can be also concluded that method can also be used for future clinical size and radiation protection studies which also in discussion with ICRP and IAEA for better shielding in radiology clinics.

Table 2 Distance to CT gantry and dose rates.

Examination	CT Dose (kV)	Distance	Measured Dose (mSv/h)	ID.
Abdomen	120	20	98.1	1
Abdomen	120	70	23.71	2
Abdomen	120	120	4.6	3
Abdomen	120	170	5.9	4
Abdomen	120	220	2.75	5
Abdomen	120	270	3.82	6
Abdomen	120	320	1.78	7
Abdomen	120	370	1	8
Abdomen	120	420	0.74	9

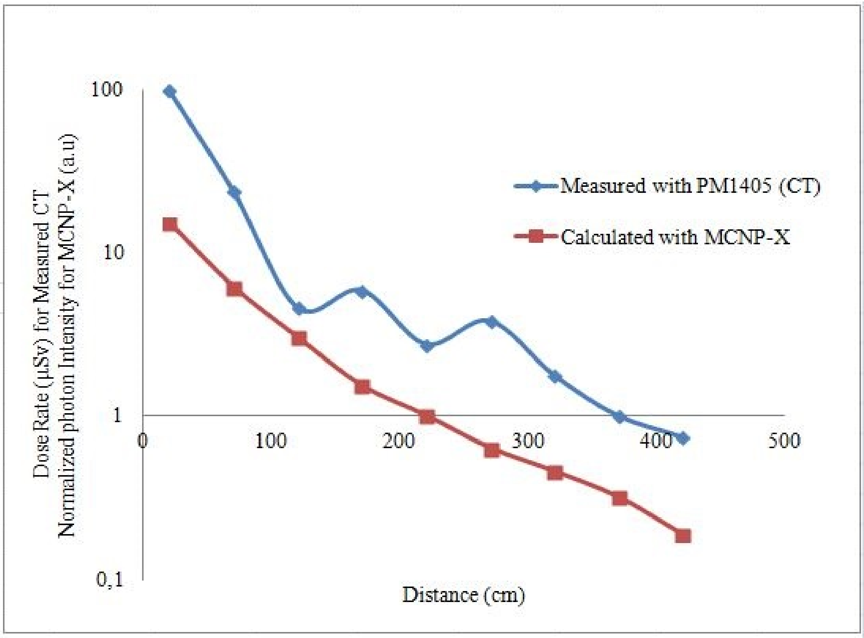

Fig. 2 Comparison of measurement and calculation.

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References

[1] Wall, B. F., and Hart, D. 1997. "Revised Radiation Doses for Typical X-ray Examinations." *The British Journal of Radiology* 70: 437-9.

[2] Neeman, Z., et al. 2006. "CT Fluoroscopy Shielding Decreases in Scattered Radiation for the Patient and Operator." *J. Vasc. Interv. Radiol.* 17 (12): 1999-2004.

[3] Stoeckelhuber, B. M., Leibecke, T., and Schulz, E., et al. 2005. "Radiation Dose to the Radiologist's Hand during Continuous CT Fluoroscopy-guided Interventions." *Cardiovasc. Intervent Radiol.* 28: 589-94.

[4] Richard, D., et al. 2000. "Patient and Personnel Exposure during CT Fluoroscopy-guided Interventional Procedures." *RSNA Radiology V.* 216 (1).

[5] Every, V., and Petty, R. J. 1992. "Measurements of Computed Tomography Radiation Scatter." *Australas. Phys. Eng. Sci. Med.* 15 (1): 15-24.

[6] Salvado, M., et al. 2005. "Monte Carlo Calculation of Radiation Dose in CT Examinations using Phantom and Patient Tomographic Models." *Radiation Protection Dosimetry* 114 (1-3): 364-8.