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## The Radiation Dose Measurement of the Computed Tomography Scan to Ensure the Safety for Medical Staff in Dr. Sardjito General Hospital, Yogyakarta, Indonesia

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**GJMR-D Classification:** *NLMC Code: WN 206*



*Strictly as per the compliance and regulations of:*



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**Methods:** Measurement the radiation dose by taking three different reading from different CT scans; brain, chest and abdomenat different points in CT scan department. Subject in this study is 36 points scattered around CT machine in CT department were it divided into 3 groups: group (I); which represent the radiation dose rate in workplace area and it include ten points (thirty different CT scans), group (II) which Represent the dose rate inside CT room and it include fifteen points (forty five different CT scans), group (III); which represent the radiation dose rate outside the CT room and it include eleven points (thirty three different CT scans), therefore the radiation dose were measured in three groups through one hundred and eight CT scans. A cross- sectional design to determine the radiation dose that maybe exposed to the medical staff who is working in CT department by measured the radiation dose rate. Statistical analysis was performed by using one way ANOVA test and posthoc test of LSD, HSD. RAM ION meter was used to detect the radiation dose rate.

**Results:** Group (I) with the mean dose is (0.0035mSv/h) and standard deviation (0.00485), group (II)with mean (10.7451 mSv/h) and standard deviation (12.87781) and group (III) with mean (0.008 mSv/h) and standard deviation (0.00185). ( $P < 0.05$ ), thus conclude that there are a difference between the points (the dose rate (mSv/h) value in thirty six dose rate points around the CT machine as well ( $p < 0.05$ ), therefore there are a difference between the three groups(the mean of dose rate (mSv/h) between the three groups in CT scan department.

**Conclusion:** Theradiation dose rate from CT scan examinations that reach to medical staff workplace Group (I) at Dr. Sardjito General Hospital, Yogyakarta, Indonesia is safe according to the ICRP recommendations, the research has revealed that the less radiation rate dose inside CT room Group (II) is point number three which equal (0.127 mSv/h), as well as point number twenty seven which equal (1.05 mSv/h).

**Keywords:** *computed tomography, dose rate, international commission on radiological protection.*

## I. INTRODUCTION

Computed tomography (CT) system consists of an X-ray source, a rotary table, which creates cross section images by projecting a beam of emitted photons through one plane of an object from defined angle positions performing one revolution. <sup>(1)</sup> The radiation dose in X-ray CT has become a topic of high interest due to the increasing number of CT examinations performed worldwide. <sup>(2)</sup>

When Godfrey Hounsfield developed the first clinical CT scanner in 1969, a new time of cross-sectional imaging of the human body was initiated. The use of CT examinations has increased rapidly since then. Recent surveys in large medical centers have found that CT studies now often account for 25% of all examinations and 60 to 70% of the patient dose received from diagnostic radiology. In addition, patient surveys reveal a wide range of patient doses for the same examination. Also, there is now widespread concern about the increase in CT doses. Several different factors contribute to the trend of increasing use of CT scanning and is being documented by international organizations. <sup>(3,4)</sup>

Lead the world in number of CT scanners per head in Japan, United States and Australia with 64, 26

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and 18 scanners per million citizens respectively. Although typical CT radiation doses have not significantly changed over the years, usage of CT as a diagnostic tool has dramatically increased.<sup>(5)</sup>

The CT scanning has been recognized as a high radiation dose modality, when compared to other diagnostic X-ray techniques, since its launch into clinical practice more than 30 years ago.<sup>(6)</sup>

The regulatory bodies lay down norms for protection against radiation and also recommend the dose limits for radiation workers and the general public. The ICRP or the International Commission for Radiation Protection is the international regulatory body. Each country has its national counterpart of the ICRP.<sup>(7,8)</sup>

The importance of radiation dose from x-ray CT has been underscored recently by the attention given in the scientific literature to issues of dose and the associated risk. The dose levels imparted in CT exceed those from conventional radiography and fluoroscopy and the use of CT continues to grow, often by 10% to 15% per year. According to 2006 data, approximately 62 million CT examinations were performed in hospitals and outpatient imaging facilities in the United States (American Association of Physicists in Medicine).<sup>(9)</sup>

medical staff who is working in CT department by measurement the radiation dose by taking three different reading from different CT scans; brain, chest and abdomen at different points in CT scan department. Subject in this study is 36 points (Figure 1) which scattered around CT machine in CT department were it divided into 3 groups: group (I); which represent the radiation dose rate in workplace area and it include ten points (thirty different CT scans), group (II) which Represent the dose rate inside CT room and it include fifteen points (forty five different CT scans), group (III); which represent the radiation dose rate outside the CT room and it include eleven points (thirty three different CT scans), therefore the radiation dose were measured in three groups through one hundred and eight CT scans. A cross-sectional design to determine the radiation dose that maybe exposed to the medical staff who is working in CT department by measured the radiation dose rate. Statistical analysis was performed by using one way ANOVA test and post hoc test of LSD, HSD. RAM ION meter was used to detect the radiation dose rate.

## II. MATERIAL AND METHODS

This study is a cross-sectional design to determine the radiation dose that maybe exposed to the

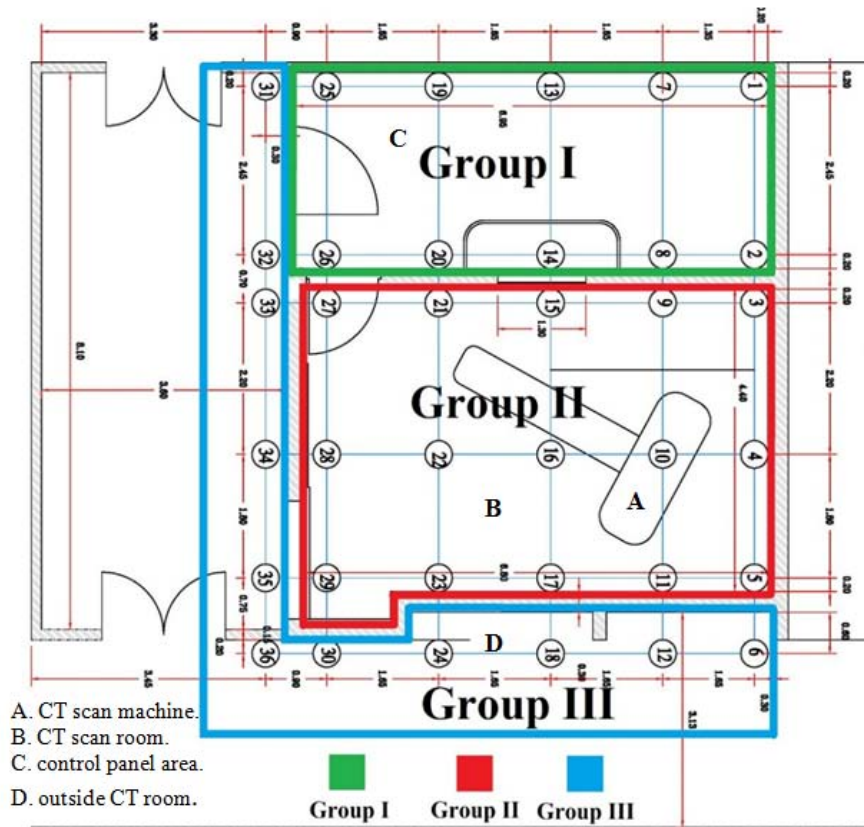


Figure 1: The three groups and the points position in each group.

### III. RESULT

The data of this research was obtained from Dr. Sardjito General Hospital of Yogyakarta, Indonesia. A radiation dose rate (DR) of 36 points were measured in the CT scan Department through one hundred and eight CT scans for different examinations (brain, chest, and abdomen); the different points scattered around the CT Machine in different position.

The different of dose rate (mSv/h) value was obtained according to the CT scan type as well as the distance between CT machine and the interest area where the points were measured as shown in (Table 1). The data was collected at the same level of iso-center of CT Machine which equals 103 centimeter from the floor

level, therefore all the points (108) in three groups of this research was measured at the same level, after applying one way ANOVA test ( $P < 0.05$ ), thus conclude that there are a difference between the points (the dose rate (mSv/h) value in thirty six dose rate points around the CT machine.

And also to detect if there are a different between the three groups where the dose rate was measured (Table 2), it is done by applying one way ANOVA test ( $p < 0.05$ ), thus conclude that there are a difference between the three groups (the mean of dose rate (mSv/h) between three groups in CT scan department).

*Table 1: The descriptive statistic of different dose rate (mSv/h) value, mean of dose rate, standard deviation, standard error of mean in each point around the CT machine*

Point	n	Mean of dose rate	Standard deviation	Standard error of mean
1	3	0.0000	0.00000	0.00000
2	3	0.0043	0.00404	0.00233
3	3	0.1277	0.09579	0.05531
4	3	37.7333	1.16762	0.67412
5	3	16.5000	3.06431	1.76918
6	3	0.0003	0.00058	0.00033
7	3	0.0020	0.00000	0.00000
8	3	0.0050	0.00265	0.00153
9	3	14.8333	2.11975	1.22384
10	3	42.8333	1.06927	0.61734
11	3	8.7333	3.20208	1.84872
12	3	0.0000	0.00000	0.00000
13	3	0.0020	0.00000	0.00000
14	3	0.0070	0.00265	0.00153
15	3	6.8667	2.56580	1.48137
16	3	12.6333	6.22923	3.59645
17	3	2.6000	1.45258	0.83865
18	3	0.0000	0.00000	0.00000
19	3	0.0043	0.00058	0.00033
20	3	0.0047	0.00208	0.00120
21	3	1.0660	0.30638	0.17689
22	3	4.3667	2.21209	1.27715
23	3	4.8000	0.26458	0.15275
24	3	0.0000	0.00000	0.00000
25	3	0.0023	0.00058	0.00033
26	3	0.0040	0.00265	0.00153
27	3	1.0500	0.62650	0.36171

28	3	3.1667	1.25033	0.72188
29	3	3.8667	0.47258	0.27285
30	3	0.0000	0.00000	0.00000
31	3	0.0033	0.00577	0.00333
32	3	0.0007	0.00115	0.00067
33	3	0.0010	0.00100	0.00058
34	3	0.0010	0.00100	0.00058
35	3	0.0020	0.00100	0.00058
36	3	0.0000	0.00000	0.00000
Total	108	4.4787	9.82373	0.94529

Results of one-way ANOVA:

Groups:  $df = 35, 72; F = 128.44.P = 0.00$

ANOVA, analysis of variance;  $df$ , degree of freedom;

$F$ ,  $F$  value;  $n$ , number of points were the dose rate measured.

**Table 2:** The group's descriptive statistic of different dose rate (mSv/h) value, mean of dose rate, standard deviation, standard error of mean in each group around the CT machine

Group	n	Mean	Standard deviation	Standard error of mean
1.00	30	0.0049	0.00485	0.00089
2.00	45	10.7451	12.87781	1.91971
3.00	33	0.0008	0.00185	0.00032
Total	108	4.4787	9.82373	0.94529

Results of one-way ANOVA:

Groups:  $df = 2, 105; F = 21.79.P = 0.00$

ANOVA, analysis of variance;  $df$ , degree of freedom;

$F$ ,  $F$  value;  $n$ , number of groups were the dose rate measured.

a) *The Three Groups in CT Scans Department*

This study divided the CT scan department to the three groups (group I; workplace area, group II; inside CT room area, group III; outside area) each one has a number of points (Figure 1) where the dose rate was obtained, the result of dose rate will describe to show the dose rate in each point of all groups.

*Group (I)*: this group represent the radiation dose rate in workplace area, which include ten points (thirty different CT scans) with the mean dose is (0.0049 mSv/h) and standard deviation (0.00485) as shown in (Figure 2).

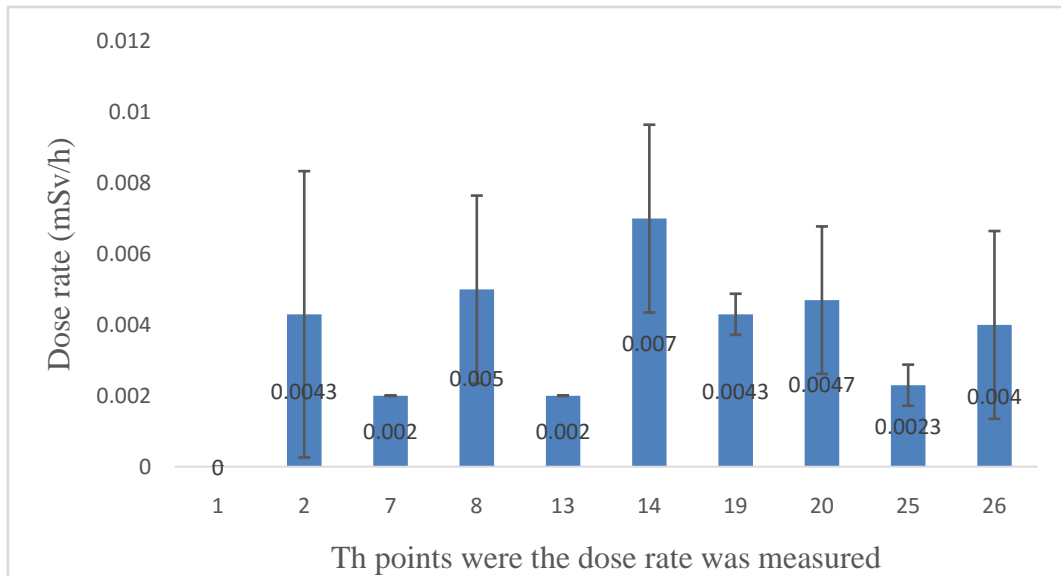


Figure 2: The dose rate (mSv/h) at each point in group (I).

Group (II): This group represents the dose rate inside CT room, which includes fifteen points (forty five different CT scans) with mean (10.7451 mSv/h) and standard deviation (12.87781) as shown in (Figure 3).

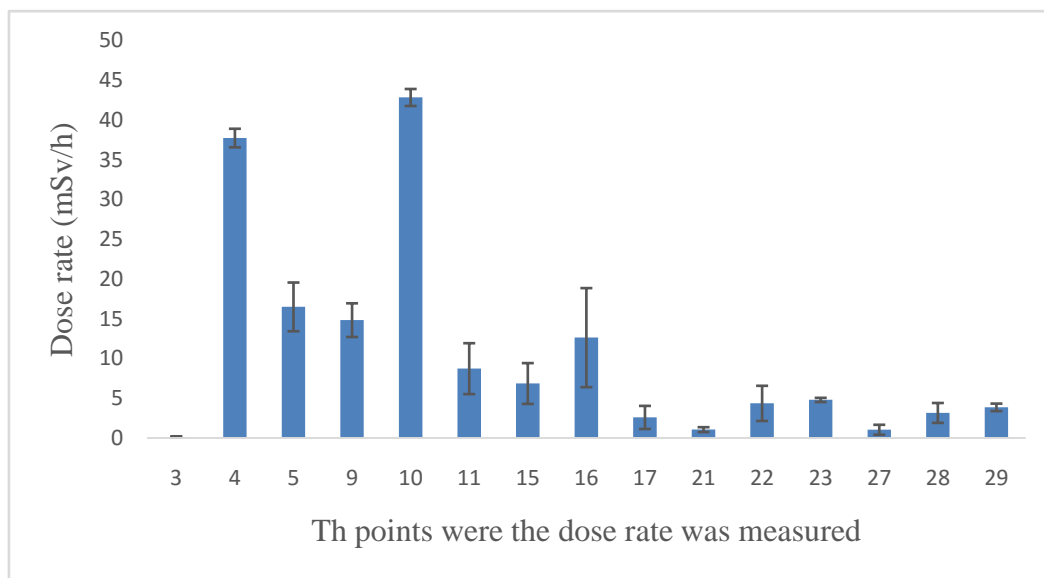


Figure 3: The dose rate (mSv/h) at each point in group (II).

Group (III): This group represent the radiation dose rate outside the CT room, which include eleven points (thirty three thirty different CT scans) with mean (0.008 mSv/h) and standard deviation ( 0.00185) as shown in (Figure 4).

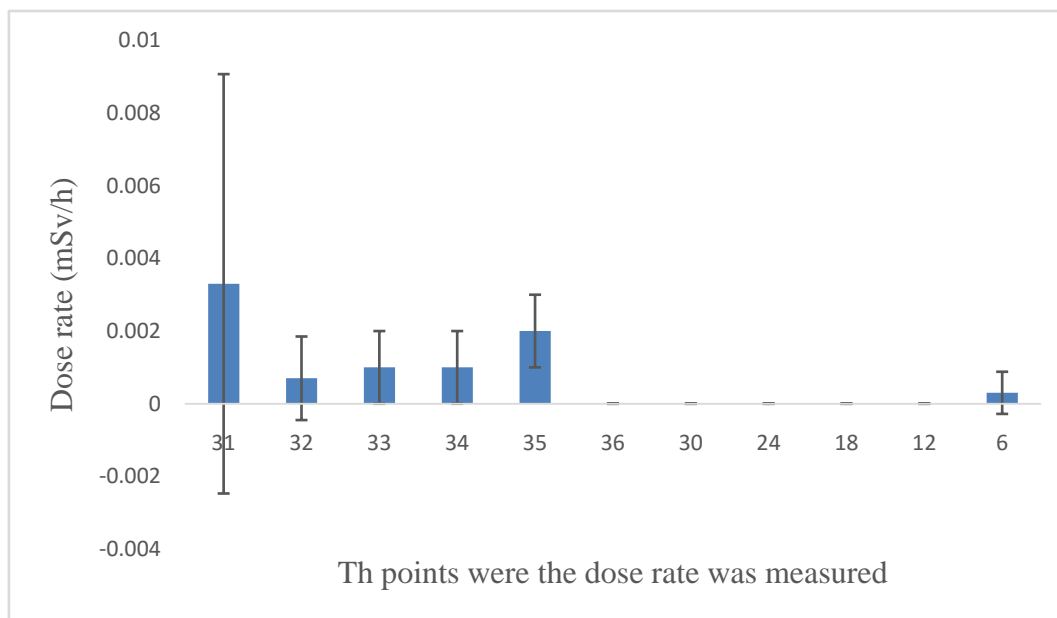


Figure 4: The dose rate (mSv/h) at each point in group (III).

#### IV. DISCUSSION

In this study, the measurement of dose rate that reach to medical staff workplace at Dr. Sardjito General Hospital, Yogyakarta, Indonesia from CT scans exposure in different points was done, and compare the average of dose rate in each point with ICRP recommendations to ensure that the workplace is safe for medical staff, as well to measure the dose rate that reach to medical staff workplace at Dr. Sardjito General Hospital, Yogyakarta, Indonesia from CT scans exposure in different points, and compare the average of dose rate in each point with the average of dose rate in other points (inside, outside) CT room to define the safest area from CT radiation dose.

During the CT scan operation there are an X ray production and the x-ray beam passes through the human body, three possible fates await each photon; it can penetrate, it can interact with the human body and be completely absorbed, it can interact and be scattered (secondary radiation) or deflected from its original direction and deposit part of its energy, after all this study was measured the dose rate of scatter radiation during CT examination, in this study there are three groups it will be discussed.

*Group (I):* This group represented the core of this study because the result from this group can answer the research question that; does the quantity of radiation from CT examinations that reach to medical staff workplace at Dr. Sardjito General Hospital, Yogyakarta, Indonesia is less than ICRP recommendations?, as well the result from this group can prove the research hypothesis. The Commission recommends a limit on effective dose of 20 mSv per year averaged over 5 years (100 mSv in 5 years), with the further provision that the

effective dose should not exceed 50 mSv in any single year. The 5-year averaging period is intended to provide more flexibility than would be the case with a strict annual limit, while still meeting the Commission's objective that the total effective dose received in a full working life should not exceed about 1 Sv received moderately uniformly year by year.<sup>(10)</sup> In CT scan department the medical staff work eight hours per day, five days per week, forty week per one year so the total work hours of medical staff in Dr. Sardjito General Hospital, CT scan department is two thousand hours. Therefore 20 mSv/h divided by (2000 h) the result will be (0.01mSv/h) or in another way its equal (10 $\mu$ Sv/h). The group (I) has a ten different dose rate values points fluctuated from (0  $\mu$ Sv/h) in point number one the safest area in medical staff workplace to the 0.007mSv/h (4 $\mu$ Sv/h) in point number fourteen, the most commonly used place from medical staff in points eight, fourteen, and twenty, the mean of this three points is 0.0053 mSv/h (5.3  $\mu$ Sv/h) which mean less than ICRP recommended level and its safe for medical staff that work in this three points, anyway the mean of dose rate in group I area is 0.0049 mSv/h (3.6  $\mu$ Sv/h) which mean the dose rate value in group I medical staff workplace is less than ICRP recommended level (3.6  $\mu$ Sv/h < 10  $\mu$ Sv/h), therefore the group (I) medical staff workplace in CT department is safe.

*Group (II):* The measurement of radiation dose rate in this group to compare the average of radiation dose rate in each point with the average of dose rate in other points inside CT room to define the safest area from CT radiation dose, this objective is very important to the patient companion to find less harmful area inside CT room by receiving as low as of radiation dose from CT machine during CT scan, The group (II) have a fifteen

different dose rate values points that fluctuated from (0.1277 mSv/h) in point number three the lowest dose rate point to the (42.83 mSv/h) in point number ten the highest harmful point area because it situated closest to the CT machine gantry iso-center, there are a different of dose rate around CT machine.

*Group (III)*: this group represented the radiation dose rate outside the CT room, which include different dose rate values points that fluctuated from (0 mSv/h) in points number thirty six, thirty, twenty four, eighteen, and twelve the lowest dose rate point to the (0.0033 mSv/h) in point number six the highest point area because it situated more close to the gantry if it is compared with another points in group (III).

## V. CONCLUSION AND RECOMMENDATIONS

Radiation dose rate from CT scan examinations that reach to medical staff workplace Group (I) at Dr. Sardjito General Hospital, Yogyakarta, Indonesia is safe according to the ICRP recommendations.

Research has revealed that the less radiation rate dose inside CT room Group (II) is point number three which equal (0.127 mSv/h), as well as point number twenty seven which equal (1.05 mSv/h). This two points are very important to the patient accompanist to find less harmful area inside CT room by receiving as low as of radiation dose from CT machine during CT scan.

The radiation dose rate outside the CT room is very low with radiation dose rate mean (0.008 mSv/h).

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