Academic Research Publishing Group

International Journal of Healthcare and Medical Sciences
ISSN(e): 2414-2999, ISSN(p): 2415-5233
Vol. 3, No. 12, pp: 117-123, 2017
URL: http://arpgweb.com/?ic=journal&journal=13&info=aims

Effective Dose of Computed Tomography (CT) Chest and Abdomen-Pelvis in Some Selected Hospitals in Federal Capital Territory, Abuja, Nigeria

E. C. Nwokorie* Department of Radiology, Garki Hospital Abuja, Nigeria

S. A. Jonah Centre for Energy Research and Training (CERT), Ahmadu Bello University, Zaria, Nigeria

M. Y. Onimisi Department of Physics, Faculty of Science, Nigerian Defence Academy, Kaduna, Nigeria

Abstract: The Computed Tomography (CT) dose output of some selected hospitals in the Federal capital Territory, Abuja, Nigeria have been determined by calculating the Effective doses of CT Chest and Abdomen-Pelvis of selected hospitals and compared its average with the Mean Reference Dose of CT Chest and Abdomen-Pelvis from four hospitals in the Federal Capital Territory, Abuja, Nigeria. Effective Dose and Scan type were extracted from the CT Chest and Abdomen-Pelvis examinations recorded. The Effective Dose of each patient undergoing the Chest and Abdomen-Pelvis examinations were calculated using the coefficient factor and the DLP values. Patients' CT dose data from the ages of 18 to 60years from each of the 4 centres for each study type from January, 2013 to December, 2014 was extracted. A total of 112 patients' CT dose data was extracted. Chest CT Effective Dose ranged from 9.0 to 34.0mSv, while Abdomen-Pelvis CT Effective Dose ranged from 15.9 to 61.0 for all the Centres in Federal Capital Territory, Abuja. This is higher than the recommended Reference Effective Dose range for CT Chest which is from 5 – 7mSv. and for CT Abdomen-Pelvis is from 8 – 14mSv. The mean effective dose from the Chest CT is 21.8mSv and from the Abdomen-Pelvis is 31.9mSv.

Keywords: Computed tomography scan; Effective dose; CT chest; CT abdomen; CT pelvis, CT scan in Abuja; Nigeria.

1. Introduction

Computed tomography (CT) scanning is a high radiation dose diagnostic radiological modality. It is estimated to be 2% of radiological examinations and constitute 20% of total patient dose. (National Radiological Protection Bureau,(NRPB) (UK), Survey, 1989).In 1999, National Radiological Protection Bureau (NRPB) (UK) estimated that 4% of radiological examinations were from computed tomography examinations. A 40% of total patient dose were also from computed tomography examinations. While, National Radiological Protection Bureau (NRPB)'s 2003 – 2004 figure revealed that 9% of radiological examinations were from computed tomography examinations and 47% of the total patient dose were from computed tomography examinations [1, 2].

The above assertions informed the need to assess the effect of computed tomography scan of the body.

Literature available only showed work done on high radiation doses on different parts of the body, few work on radiation dosimetry of computed tomography scans on head, abdomen and other parts of the body. Similarly, some work on the effect of computed tomography on children, but, no work on the effect of computed tomography scans

Van, *et al.* [3] tried to investigate and establish an achievable dose levels in 16 slice CT by evaluating CT doses indices (CTDI) and effective doses of dose-optimized protocols compared with 4-slice dose surveys.

In their method, they calculated volume CTDI for adult protocols for brain, cardiothoracic pulmonary angiography (CTPA), abdomen and biphasic liver CT. Effective doses were calculated first by using volume CTDI with conversion factors and second from CTDIair values using the IMPACT dose calculator. Their result showed that brain, chest, CTPA, abdomen and biphasic liver protocols were 1.9±0.4; 3.8±0.4; 3.0±0.2; 7.2±0.9; 10.2±1.3mSv respectively. In their conclusion, they stated that for 16 slice spiral brain CT, there was a trend of equal doses compared with sequential brain CT in the dose surveys.

2. Computed Tomography Dosimetry

This simply means the estimation, determination or calculation of the radiation dose delivered by computed tomography machine in a given protocol to a part of the body or region of interest.

Mathias and Michael [4] stated that the radiation dose from the computed tomography is usually 5-100 times higher than conventional radiography of the same anatomical region. Their emphasis was on the importance of

*Corresponding Author

radiation dose and tailoring of scan parameter to the individual patients. They suggested some accepted parameters that described the patient/ local dose, these are

- Volume Computed Tomography Index (CTDIvol).
- The Total Scans dose, (Dose Length Product (DLP)
- The radiation risk involved in Computed Tomography is calculated as the Effective Dose.

2.1. Volume Computed Tomography Dose Index (CTDIvol)

This is a means of measuring the average local dose to a patient within the scan volume. Its unit is in milligray(mGy). The CTDIvol is a measure of the average local dose delivered by computed tomography (conventional slice by slice; single slice or multi slice spiral scanning) to a cross section of a phantom. Usually, 32cm phantom is used for body application. While, for head scan 16cm phantom is used. This does not however, indicate the precise dose for any individual, but is rather an index of radiation dose for a particular scanner and examination [5, 6].

The absorbed dose is calculated using computed tomography dose index (CTDI) Shope, *et al.* [7]. It gives information about the dose due to a particular set of acquisition parameters. This can be read out from the Viewer card of each examination done. It is useful for dose comparison between protocols for a given CT system and can be used to calculate the Dose Length Product (DLP).

CTDI = Total dose/n.T…………………………………………………………..… (1)

Where T is the width of the slice; n is the number of slices

CTDI = Area under the dose profile/ nominal collimation.

The Computed Tomography Dose Index Volume ($CTDI_{vol}$.)

$CTDI_{Vol}$ = x $CTDI_W$ ……………………………………………... ………………… (2)

Where I = the increment of per axial scan in mm.

Pitch is defined as the ratio of the table travel per rotation (I) to the total nominal beam width (N x T).

Pitch = I/(NxT)………………………………………………………………………. (3)

$CTDI_{Vol}$ = 1/pitch x $CTDI_w$.. (4)

$CTDI_w$ represents the average absorbed radiation dose over the x and y directions at the centre of the scan from a series of axial scans where the scatter tail are negligible beyond the 100mm integration limit.

$CTDI_{Vol,}$ represents the average absorbed radiation dose over the x, y and z directions, it is smaller for the multi-scan average dose.

$CTDI_{Vol}$ provides a single CT dose parameter, based on a directly and easily measured quantity which represents the average dose within the scan volume for a standardized (CTDI) phantom.

The SI units are milligray (mGy)

I. Dose Length Product (DLP)

The overall energy delivered by a given scan protocol, the absorbed dose can be integrated along the scan length to compute the dose length product (DLP) [5, 6].

DLP (mg. cm) = $CTDI_{Vol}$ x scan length (cm)……………………………………………...(5)

DLP represent the total energy absorbed (and thus the potential biological effect) attributable to the complete scan acquisitions.

For example, CT abdomen may have the same CTDI with Abdomino-Pelvic CT, but the DLP will be greater for the Abdomino-Pelvic CT because of the Scan Length used.

Helical acquisitions require data from z-axis projections beyond the defined "scan" boundaries. This increases the DLP due to the additional rotations required for the helical interpolation algorithm. It is usually referred to as 'over ranging'.

In Multidimensional Computed Tomography, it is Pitch dependent.

Effective Dose, E (mSv) = k x DLP………………………………………………..……... (6)

The use of DLP to estimate Effective dose appears to be a reasonable method for estimating effective dose with maximum deviation from the mean approximately 10% - 15% [5].

II. Effective Dose (E)

It is a dose analyser that reflects this difference in biological sensitivity [6].

It also reflects the risk of a non-uniform exposure in terms of equivalent whole body exposure – The SI units are Sieverts (milliSieverts is used in diagnostic radiology).

Table-2. CT typical effective dose reference values (mSv)

Parts	Effective dose (mSv)	Mean Reference Effective dose(MRED) (mSv)
Head	1 -2	1.5
Chest	5-7	6.0
Abdomen	5-7	6.0
Pelvic	3-4	3.5
Abdomen & pelvic	8-14	11
Trunk	5-15	10

The conversion factor k is the coefficient that is used to calculate the effective dose, as it is written in equation 6. All other conversion factors assume the use of the 32cm diameter CT body phantom [5, 8, 9].

Table-3. Typical conversion factors values (mSv $mGy^{-1}cm^{-1}$)

Region of body	Conversion factor k (mSv $mGy^{-1}cm^{-1}$)
Head	0.0021
Neck	0.0059
Chest	0.014
Abdomen & pelvic	0.015
Trunk	0.015

3. Methodology

Data were collected at four hospitals in the Federal Capital Territory, Abuja, Nigeria.

Abuja Clinics, Maitama, using 64 slice GE CT scanner; Life Bridge Diagnostic Centre, Garki, using 64 slice Toshiba CT scanner; State House Hospital, Aso Rock, Abuja using 16 slice GE CT scanner and Zankli Hospital Utako, using 8 slice Hitachi CT scanner machine. These facilities were selected because of their relative large size, diverse area locations that allows for geographic diversity and availability of dose area product, which is found in modern multi-slice CT scanner. The most important factor was the CT scanner functionality at the point of data collection. For each patient's body parts like the Head, the technical parameters and dose report data (DLP), Scan area, Scan length, Slice thickness, kVp, mAS, Pitch, DLP, $CTDI_{vol,}$ quantity of contrast used, Effective Dose and Scan type were extracted from the CT examinations recorded.

The Effective Dose of each patient undergoing Chest and Abdomen-Pelvis examinations were calculated using the coefficient factor and the DLP values. Patients' CT dose data from the ages of 18 to 60years from each of the 4 centres for each study types from January, 2013 to December, 2014 was extracted. A total of 112 patients' CT dose data were extracted.

4. Results

The results are shown using bar charts and tables as shown below;

Figure-1. Effective Dose values for CT Chest in Abuja Clinics

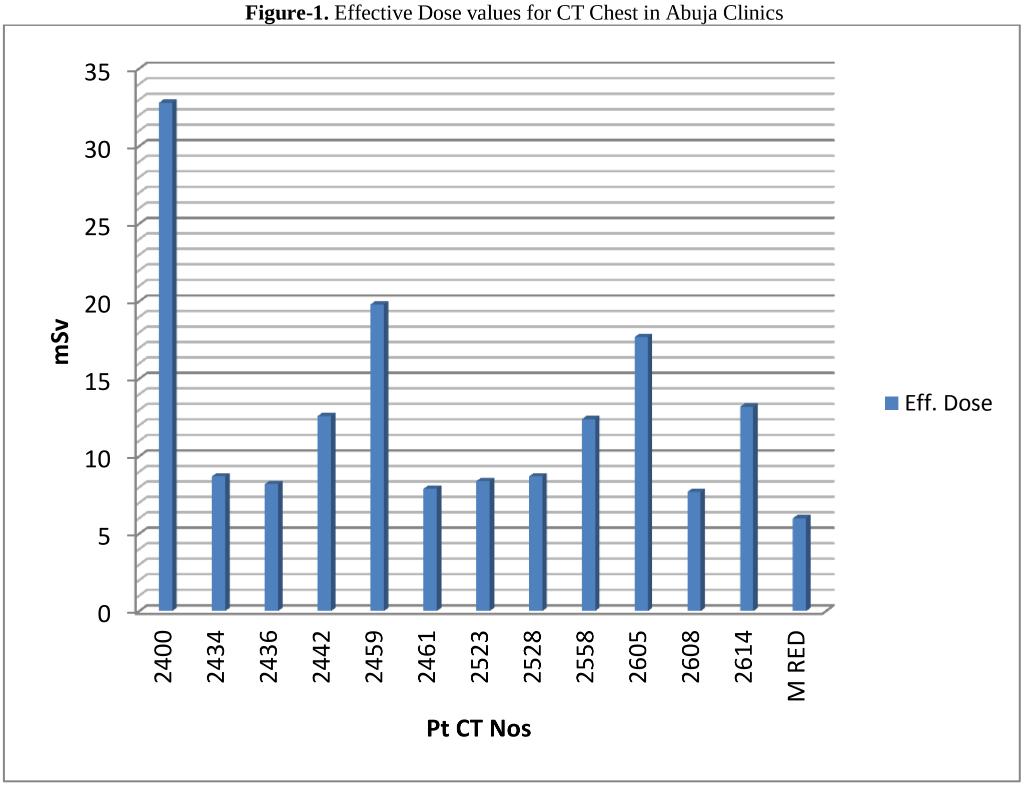


Figure-2. Effective Dose values for CT Chest in Lifebridge

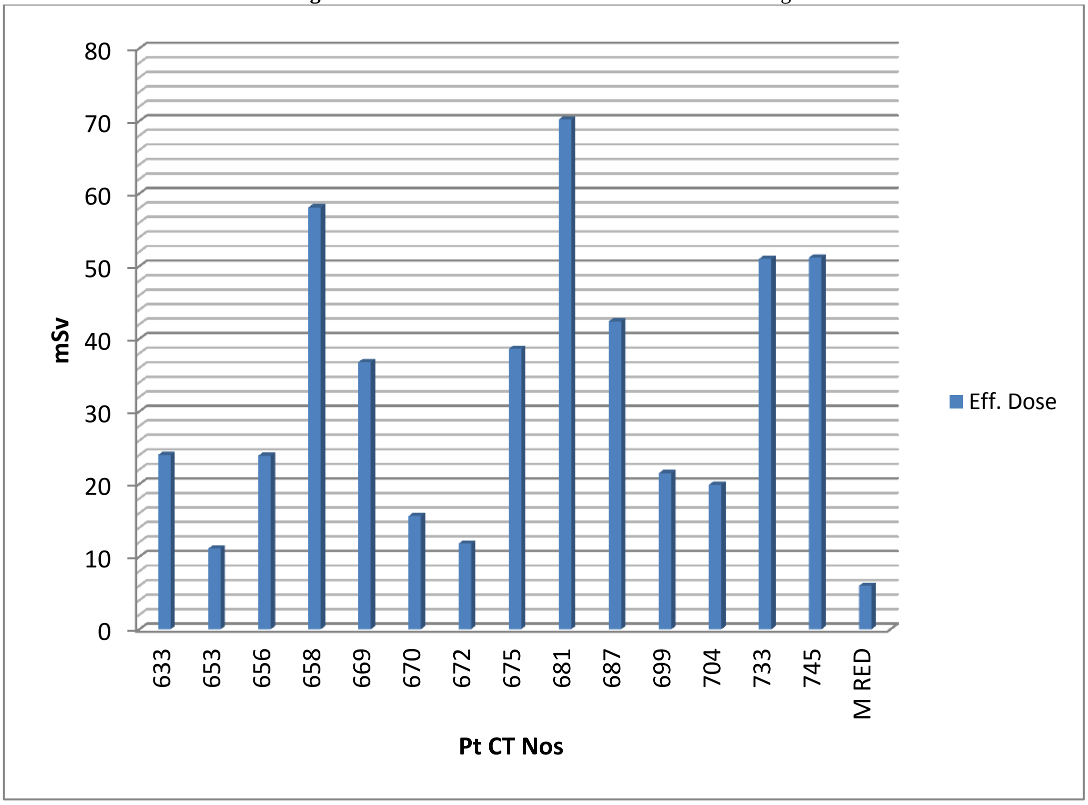


Figure-3. Effective Dose for CT Chest in State House Medical Centre

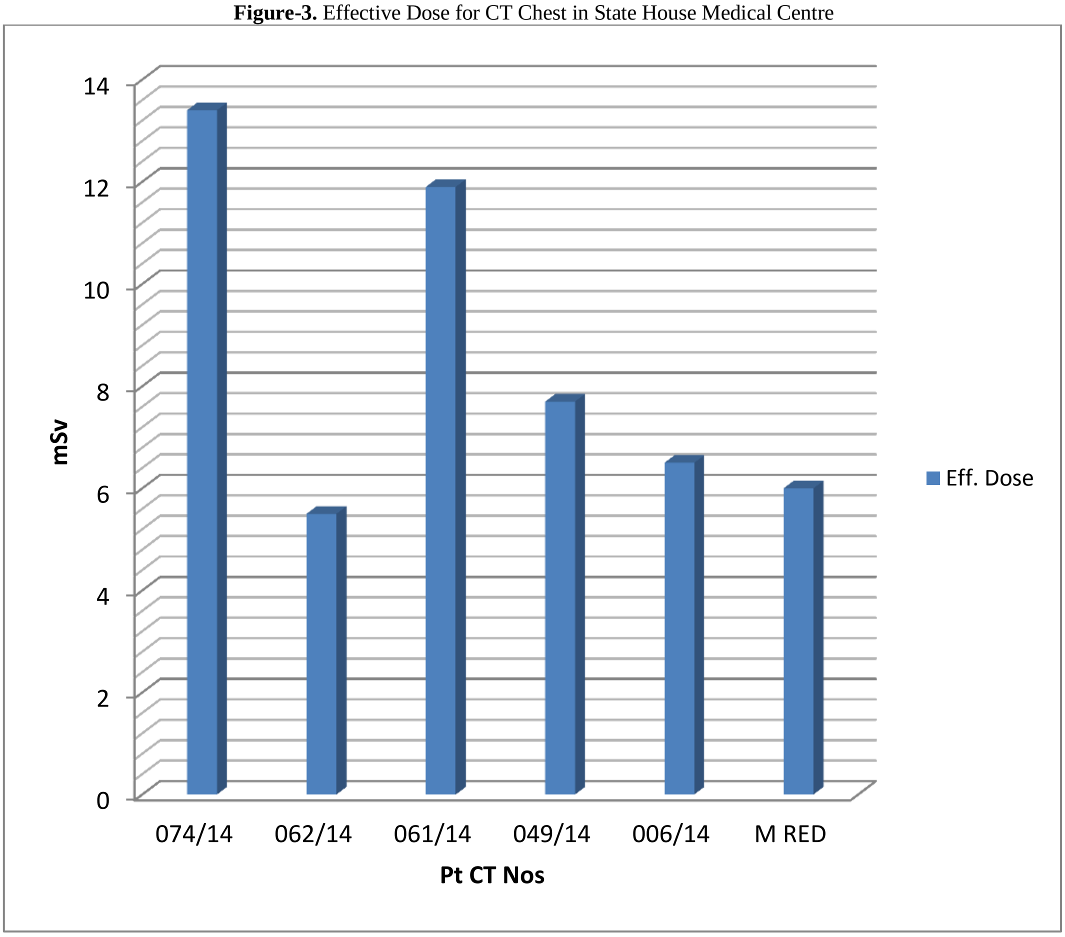


Figure-4. Effective Dose values for Abdomen-pelvis in Lifebridge

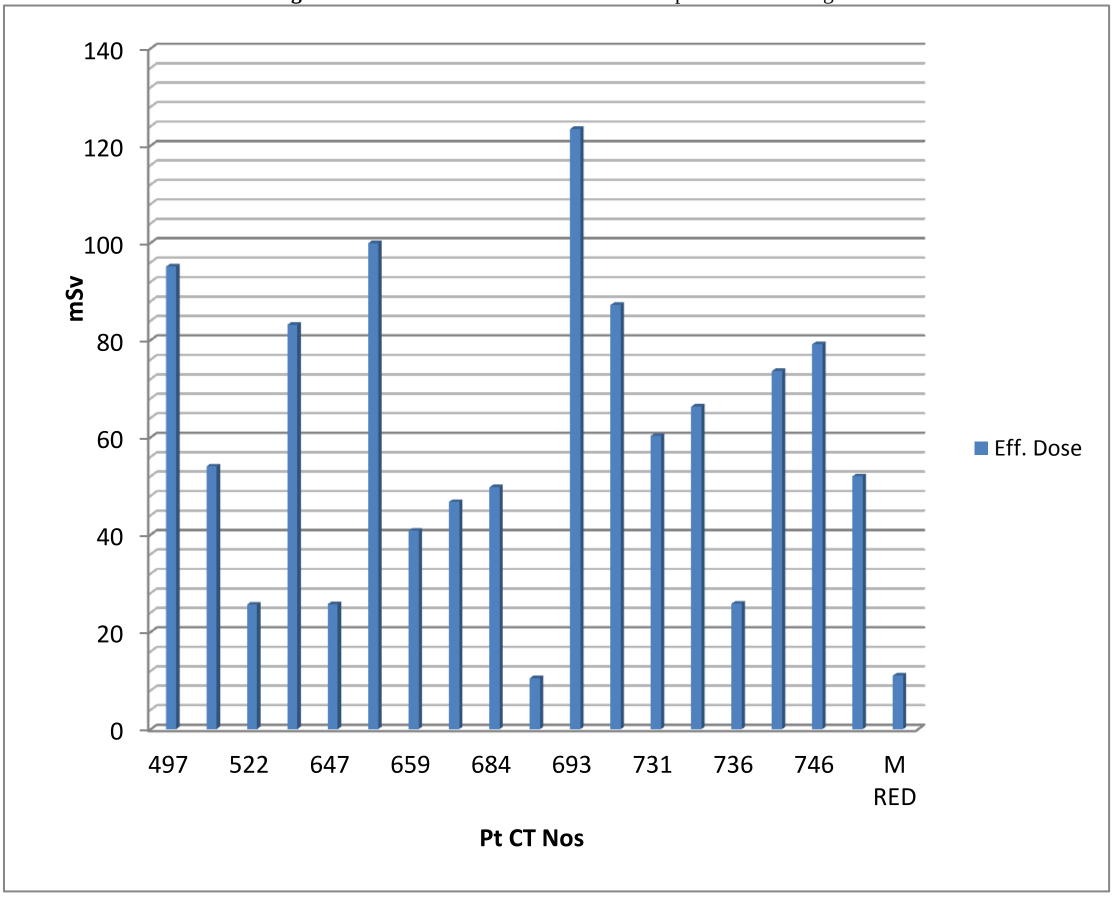


Figure-5. Bar Chart of Effective Dose of CT Abdomen-Pelvis in Abuja Clinics

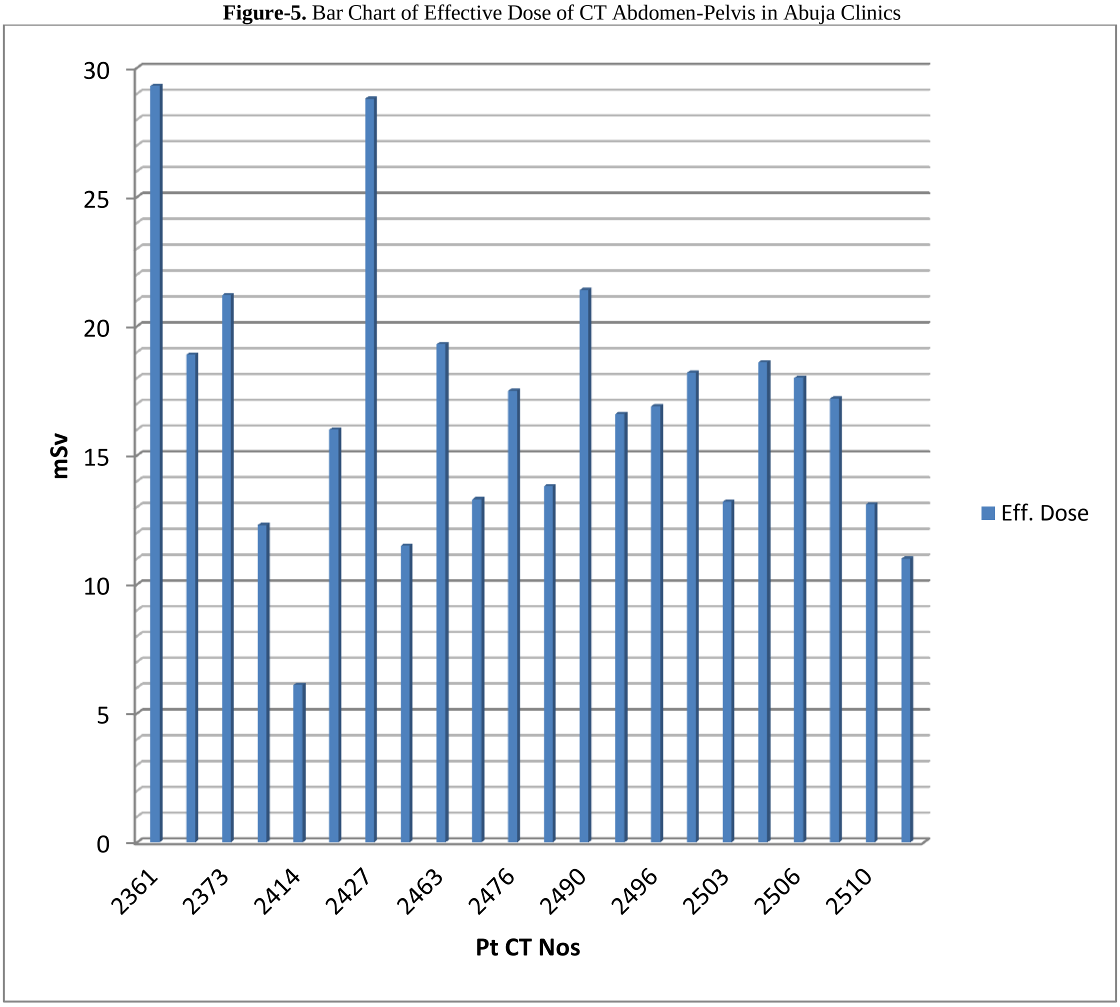
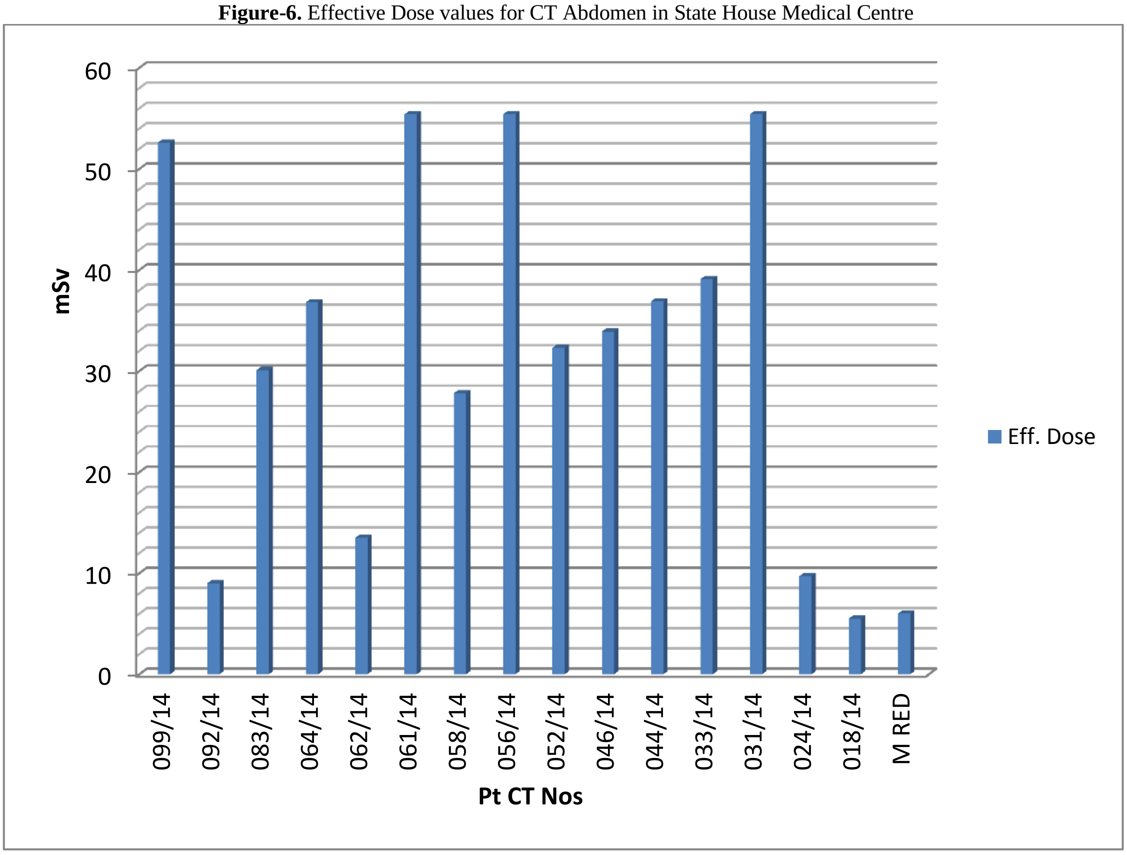


Figure-6. Effective Dose values for CT Abdomen in State House Medical Centre



5. Data Analysis

I. Abuja Clinic, Abuja

The Mean Effective Dose is 13.2 mSv and is illustrated using bar chart in Figure 1. This value is slightly more than the Mean Reference Effective Dose for Chest CT of 6mSv.

II. Life Bridge Diagnostic Centre

The Mean Effective Dose is 34.0 mSv is illustrated using bar chart in Figures 2. This is much higher than the Mean reference Effective Dose for Chest CT of 6mSv.

III. State House Hospital, Abuja

The Mean Effective Dose is 9.0mSv and is illustrated using bar chart in Figure 3. This value is slightly higher than the Mean Reference Effective Dose of 6mSv for Chest CT.

IV. Zankli Hospital Abuja

The Mean Effective Dose is 21.4mSv. This is much higher than the Mean Reference Effective Dose of 6mSv for Chest CT.

From the result above, the Chest CT Effective Dose ranges from 9.0 to 34.0mSv for all the Centres in Federal Capital Territory, Abuja. This is higher than the recommended Reference Effective Dose range for CT Chest which is from 5 – 7mSv [8, 9].

This has a mean scan length of 48.98cm, so the DLP and effective dose will be high.

V. Abuja Clinics

The Mean values are illustrated using bar chart in Figure 4; it revealed that the Mean Effective Dose is 15.9mSv. This is more than the Mean Reference Effective Dose of 11mSv for Abdomen/Pelvis CT.

VI. Life Bridge Diagnostic Centre

The Mean Effective Dose is 61.0 mSv as is illustrated using bar chart in Figure 5. This value is much higher than the Mean Reference Effective Dose of 11 mSv for Abdomen/Pelvis CT.

VII. State House Clinic, Abuja

The Mean Effective Dose is 32.9 mSv as is illustrated using bar chart in Figure 6. This value is much higher than the Mean Reference Effective Dose of 11mSv for Abdomen/Pelvis CT.

VIII. Zankli Hospital Abuja

The Mean Effective Dose is 59.9 mSv .

From the above results, the range of effective doses for Abdomen/Pelvis CT for the Centres in Federal Capital Territory is 15.9 to 61.0mSv. This is much higher than the Reference Effective Dose range for Abdomen/Pelvis [10].

6. Conclusion

The mean effective dose from the study Chest CT is 21.8mSv, with State House Hospital recording the lowest at 9.0mSv and the highest from lifebridge diagnostic centre at 34.0mSv. All the centres will need to start implementing CT radiation dose reduction measures to reduce the radiation dose to acceptable level [8, 9].

The Chest CT Effective Dose ranges from 9.0 to 34.0mSv for all the Centres in Federal Capital Territory, Abuja. This is higher than the recommended Reference Effective Dose range for CT Chest which is from 5 – 7mSv [8]

For CT Chest, the risk is moderate that is 1 in 1,000 to 1 in 500 cases are at risk of fatal cancer from CT Chest examination [2].

The mean effective dose from the study for Abdomen-Pelvis is 39.1mSv, with Abuja Clinics recording the lowest at 17.2 mSv and the highest from Lifebridge diagnostic centre at 61.0mSv. All the centres will need to start implementing CT radiation dose reduction measures to reduce the radiation dose to an acceptable level [10].

The additional lifetime risk of fatal cancer [9] from CT scan examinations is high for CT Abdomen/Pelvis. This means that 1 in 500 to 1 in 100 cases are at risk of fatal cancer from Abdomen-Pelvis examinations. This is quite worrisome and alarming. There is an urgent need for the centres that carry out these CT examinations to start CT dose reduction practices [7].

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References

[1] Brenner, D. J., 2004. "Most people got a tenth or a hundredth of the dose of a CT." *AJR.*, vol. 176, pp. 289-296.

[2] Brenner, D. J. and Elliston, C. D., 2004. "Estimated radiation risks potentially associated with full body CT screening." *RSNA; Radiology*, vol. 232, pp. 735-738.

[3] Van, D. M. A. J., Veldkamp, W. J. H., and Geleijns, J., 2007. "16-Slice CT: Achievable effective doses of common protocols in comparison with recent ct dose surveys." *BJR.*, vol. 80, pp. 248-255.

[4] Mathias, P. and Michael, G., 2003. *Spiral and Multislice Computed Tomography of the Body vol. 1; edited by Miles V., Aart J., Shaefer P., Cornelius m.* London: Stanford press. pp. 132-137.

[5] Kak, C. A. and Slaney, M., 1999. "Principles of computing effective doses from dose length product (DLP) in CT." *Radiology*, vol. 248, pp. 321-327.

[6] McCollough, C. H. and Schueler, B. A., 2006. "Calculation of effective dose." *Med Physc*, vol. 27, pp. 828-837.

[7] Shope, T. B., Gagne, R. M., and Johnson, G. C., 1981. "A method for describing the doses delivered by transmission X-ray Computed Tomography." *Med. Phys.*, pp. 488-495.

[8] IAEA, 2001. "International Conference (IAEA/EC/PAHO/WHO). Developing and Using Dose Guidance (Reference) Levels in Radiology and Nuclear Medicine Examination. Contributing papers, pages 403-487, in Radiological Protection in Diagnostic and Interventional Radiology." pp. 403-487.

[9] Jessen, K. A., Panzer, W., and Shrimpton, P. C., 2000. *European guidelines on quality citeria for computed tomography*. Luxembourg: European Communities.

[10] ICRP, 1991. *International Commission on Radiological Protection. 1990 Recommendations of the International Commission on Radiological Protection.* ICRP Publication 60. Annals of the ICRP 21, no 1-3 (pergammon press, oxford).