SANITAS: JURNAL TEKNOLOGI DAN SENI KESEHATAN
ISSN : 1978-8843 (*PRINT*) / 2615-8647 (*ONLINE*) **Vol. 13 No. 2: 237 - 244**

The Effect of Kilovoltage and Milliampere-Second Parameters on CT Number: Study Phantom Quality Control CT Scan

Muhammad Irsal[12], Aulia Narindra Mukhtar[3], Guntur Winarno[2], Gando Sari[2]

[1]Jurusan Teknik Radiodiagnostik dan Radioterapi, Poltekkes Kemenkes Jakarta II
[2]Pusat Unggulan IPTEKS, Poltekkes Kemenkes Jakarta II
[3]Rumah Sakit Pelabuhan Jakarta

E-mail: muhammad.irsal@poltekkesjkt2.ac.id

Submitted: July 14th, 2022; Accepted: December 14th, 2022

https://doi.org/10.36525/sanitas.2022.20

ABSTRACT

CT number is one of the indicators in determining the diagnosis of disease, so it is necessary to ensure the level of accuracy. The aim is to determine the parameters of kilovoltage and tube current to the CT value. Descriptive quantitative analytic research method with previously tested linearity and the suitability of the CT number. Furthermore, the variation of kilovoltage: 80 kVp, 100 kVp, 140 kVp and the tube current value is 192 mAs. After that, the tube current variation was continued: 80 mAs, 100 mAs, 140mAs and the voltage value was 120 kVp. Phantom image results were analysed using radiant viewer software with a region of interest (ROI) size of 5 mm. Then analyse the correlation coefficient to determine the degree of relationship between the kilovoltage and milliampere-second parameters to the CT number. The results of the linearity test and the suitability of the CT number value were within the tolerance limit. For variations in kilovoltage to CT number, the correlation coefficient values are water R^2=0.09, fat R^2=1, soft tissue R^2=0.9, bone R^2=0.7. As for the milliampere-second variation of the CT number, the correlation coefficient values are: water R^2=0.7, fat R^2=0.8, soft tissue R^2=1, bone R^2=0.7.

Keyword: *CT number, kilovoltage, milliampere-second*

BACKGROUND

International radiation protection committees such as the International Commission Radiation Protection (ICRP) and International Atomic Energy Agency (IAEA) provide recommendations to conduct quality control (QC) for CT scans, this is related to the working system of CT scan equipment, especially on radiation dose and quality. image. In some countries testing of image quality and radiation dose is mandatory.(1) Image testing on CT is especially important to ensure that the patient's diagnosis results can be given correctly by the radiology doctor, one of the important components in order to keep the radiation dose as low as possible and optimal image quality, it is necessary to quality control periodically.(2)

The process of acquisition of CT scan imaging can affect changes in image quality which is related to radiographic contrast. Radiographic images can increase radiopaque because of low radiation doses, while radiographic images can increase radiolucent because of high radiation doses. In addition, increasing the radiation dose can cause harm to the patient. In general, the quality of the CT scan image can be known by measuring the CT number. This parameter is affected by the protocol selection of kilovoltage (kVp) and milliampere-second (mAs), slice thickness, helical pitch, reconstruction parameters, and scan speed.(3,4)

The CT number in the QC procedure is used to test the linearity and suitability of the CT number. The purpose of this test is to ensure that the quality of the image produced from the CT scan does not decrease due to noise generated during image acquisition, increasing noise can reduce radiographic contrast. In addition, the CT number is one of the indicators of anatomical diagnosis used by radiology doctors, so it is necessary to ensure that the level of accuracy is carried out by performing QC.(5) Therefore, it is necessary to measure the CT number as an indicator of the quality of the CT scan image on the effect of changes in the kilovoltage (kVp) and milliampere-second (mAs) parameters.

RESEARCH METHODS

Descriptive quantitative analytic research method using phantom QC CT scan standard, with the first data collection is to evaluate the linearity and suitability of the CT number. Phase 1st performs a kilovoltage variation: 80 kVp, 100 kVp, 140 kVp and the tube current value of 192 mAs does not change. Then Phase 2nd with tube current variations: 80 mAs, 100 mAs, 140 mAs and the voltage value of 120 kVp does not change. After that, the results of the phantom image will measure the CT number using radiant viewers software with a region of interest (ROI) size of 5 mm shown in Figure 1. Then perform a correlation coefficient analysis to determine the level of relationship between the kilovoltage and milliampere-second parameters to the CT number. In this study, a Philips Ingenuity Core with specifications: CT slice 64, pitch 0.5-1.5, 80-140 kVp, 20-665 mA, focal spot 0.5 x 1.0, slice thickness helical model 0.67 mm – 5 mm. maximum helical exposure 100 s and using a phantom QC CT scan standard head.

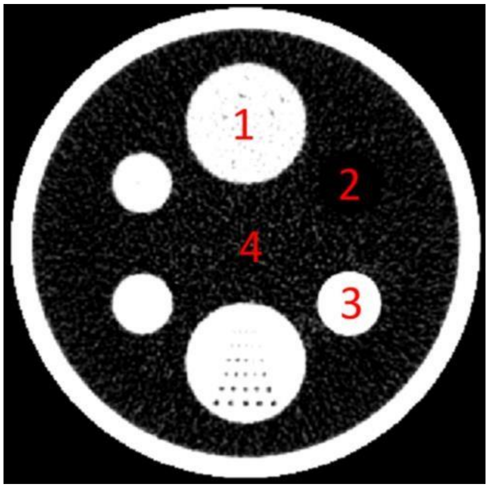
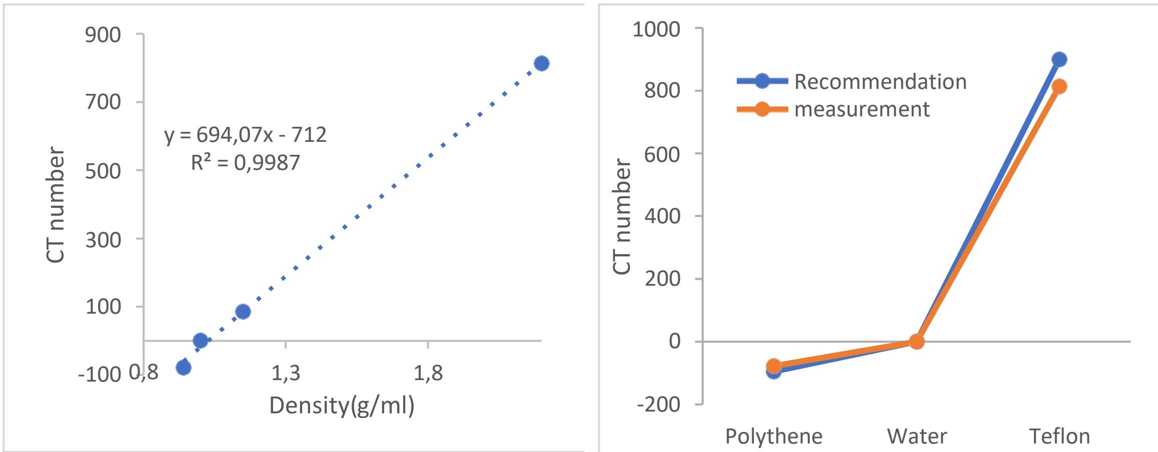


Figure 1. Phantom QC CT scan (1: soft tissue, 2: fat, 3: bone, 4: water).(6)

RESULTS AND DISCUSSION

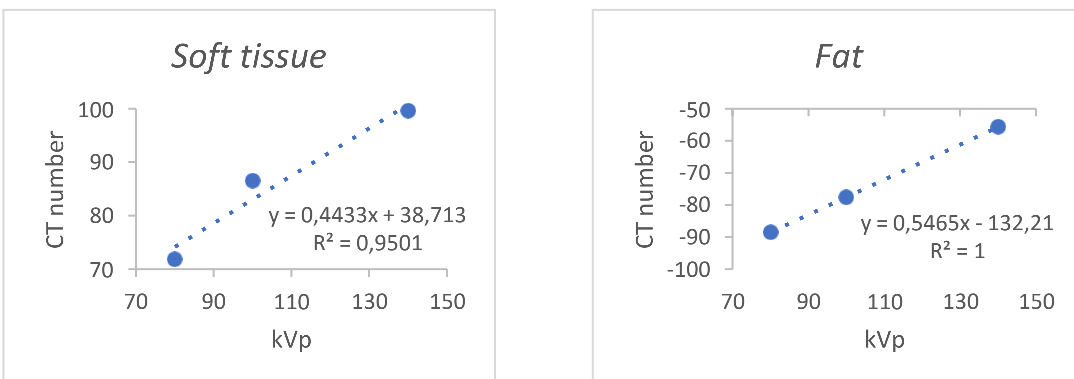
From the results of the linearity test and the suitability of the CT number, it shows that the results of the QC CT scan are still within the tolerance limits shown in Figure 2 (7–9). The measurement of the CT number on the effect of kilovoltage changes is shown in the correlation coefficient value shown in Figure 3. In addition, the results of the CT number measurement on the effect of milliampere-second changes are shown in the correlation coefficient value shown in Figure 4.

ISSN : 1978-8843 (*PRINT*) / 2615-8647 (*ONLINE*) **Vol. 13 No. 2: 237 - 244**

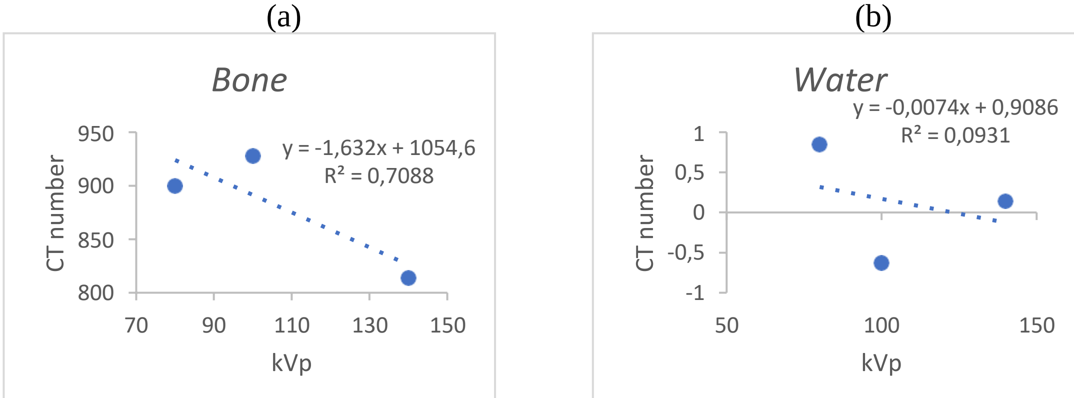


(a) (b)

Figure 2. Quality control CT scan (a) CT number linearity (b) suitability of CT number values



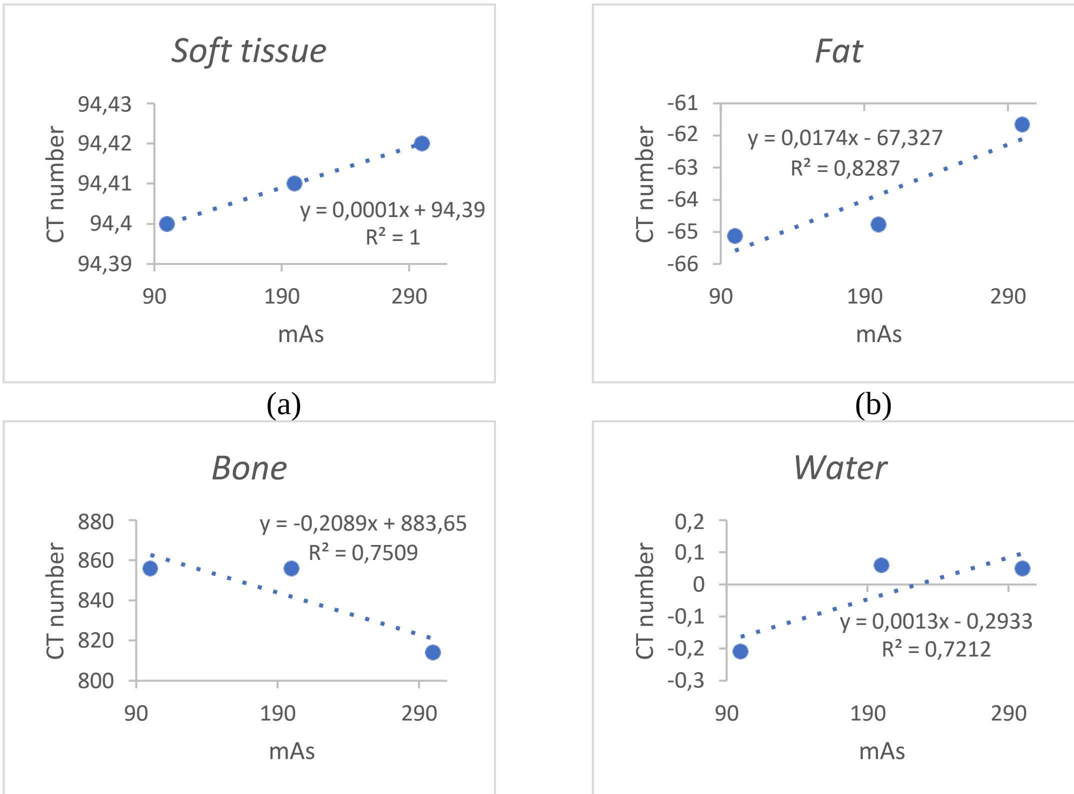
(a) (b)



(c) (d)

Figure 3. Kilovoltage changes to CT number (a) soft tissue, (b) fat, (c) bone, (d) water.

SANITAS: JURNAL TEKNOLOGI DAN SENI KESEHATAN
ISSN : 1978-8843 (*PRINT*) / 2615-8647 (*ONLINE*) **Vol. 13 No. 2: 237 - 244**



(c) (d)

Figure 4. Milliampere-second changes to CT number (a) soft tissue, (b) fat, (c) bone, (d) water.

The kilovoltage and milliampere-second parameters can affect the radiation dose and image quality on a CT scan. On all CT scan equipment there is always a standard QC CT scan phantom to conduct daily QC tests. However, in some cases that occurred in hospitals, the implementation was conducted within a period of weeks or months or conducted if artifacts were seen from the results of the patient's clinical examination. One of the CT scan image quality assessments is conducted objectively by measuring the CT number (10). In general, the CT number is influenced by energy, image reconstruction and filters. The CT number in some examination cases can provide diagnostic information to distinguish between tissue and fluid.(1) From the results of research conducted, it is known that the value of the CT number is influenced by kilovoltage and milliampere-second, in several journals also concluded that changes in kilovoltage and milliampere-second can affect image quality, especially the value of CT number and signa to noise ratio (SNR). This is influenced by the number of photons received by the detector determined by milliampere-seconds and photon energy which is determined by kilovoltage. In the CT scan examination procedure, it is necessary to consider the use of kVp and mAs as much as 50% or by increasing kVp and decreasing mAs as an effort to radiation protection.(11)

Based on the results of the research that has been done, it is known that the CT number is influenced by the phantom density value (g/ml) and energy. So that the higher the density and the energy used, the lower the CT number value.(12,13) Clinically, research conducted by Kazumi Araki found that the value of the CT number in anatomy with a low atomic number does not change the energy used as shown in Figure 3 (d).(14) Furthermore, the value of the correlation coefficient decreased due to heterogeneous beams from CT scans, namely beams that passed through a homogeneous material type did not experience an exponential reduction in beam.(5) In addition, the level of error in measuring the CT number will increase with the time of using phantom QC CT scan, this is due to the content of material in phantom which can cause errors in measurement, this may occur around less than 10%.(1) So in the research that we have done, we have limitations on the calibration of the phantom QC CT scan (15).

CONCLUSION

The results of the linearity test and the suitability of the CT number value were within the tolerance limit. For variations in kilovoltage to CT number, the correlation coefficient values are water R^2=0.09, fat R^2=1, soft tissue R^2=0.9, bone R^2=0.7. As for the milliampere-second variation of the CT number, the correlation coefficient values are: water R^2=0.7, fat R^2=0.8, soft tissue R^2=1, bone R^2=0.7.

REFERENCES

1. Gulliksrud K, Stokke C, Trægde Martinsen AC. How to measure CT image quality: variations in CT-numbers, uniformity and low contrast resolution for a CT quality assurance phantom. Phys Med [Internet]. 2014 [cited 2022 Jul 13];30(4):521–6. Available from: https://pubmed.ncbi.nlm.nih.gov/24530005/

2. Verdun FR, Racine D, Ott JG, Tapiovaara MJ, Toroi P, Bochud FO, et al. Image quality in CT: From physical measurements to model observers. Physica Medica. 2015;31(8):823–43.
3. Irsal M, Nurbaiti N, Mukhtar AN, Gunawati S, Hidayat W. Effect of Tube Voltage on the Use of Iterative Reconstruction on Computed Tomography Brain Examination. Jurnal Teori dan Aplikasi Fisika [Internet]. 2021 Jan 31 [cited 2022 Jul 13];9(1):103–10. Available from: https://jurnal.fmipa.unila.ac.id/jtaf/article/view/2715
4. Irsal M, Irsal M, Winarno G. Pengaruh Parameter Milliampere-Second (mAs) terhadap Kualitas Citra Dan Dosis Radiasi Pada Pemeriksaan CT scan Kepala Pediatrik. Jurnal Fisika Flux: Jurnal Ilmiah Fisika FMIPA Universitas Lambung Mangkurat [Internet]. 2020 Feb 27 [cited 2022 Jul 13];17(1):1–8. Available from: https://ppjp.ulm.ac.id/journal/index.php/f/article/view/7085
5. Computed Tomography - E-Book: Physical Principles, Clinical Applications ... - Euclid Seeram - Google Buku [Internet]. [cited 2022 Jul 13]. Available from: https://books.google.co.id/books?id=DTCDCgAAQBAJ&printsec=frontcover&hl=id&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false
6. Irsal M, Nurbaiti, Mukhtar AN, Jauhari A, Winarno G. Variation kVp and mAs on CT scan image quality using standard phantom. AIP Conference Proceedings [Internet]. 2020 Nov 16 [cited 2022 Jul 13];2296(1):020039. Available from: https://aip.scitation.org/doi/abs/10.1063/5.0030320
7. BAPETEN. Peraturan Badan No 2 Tahun 2022 Tentang Perubahan Atas Peraturan Badan Pengawas Tenaga Nuklir Nomor 2 Tahun 2018 tentang Uji Kesesuaian Pesawat Sinar-X Radioloagi Diagnostik dan Intervensional [Internet]. [cited 2022 Jul 13]. Available from: https://jdih.bapeten.go.id/en/dokumen/peraturan/peraturan-badan-no-2-tahun-2022-tentang-perubahan-atas-peraturan-badan-pengawas-tenaga-nuklir-nomor-2-tahun-2018-tentang-uji-kesesuaian-pesawat-sinar-x-radioloagi-diagnostik-dan-intervensional
8. Dillon C, Breeden W, Clements J, Cody D, Gress D, Kanal K, et al. Computed Tomography Quality Control Manual. 2017.

9. Quality control in cone-beam computed tomography (CBCT) EFOMP-ESTRO-IAEA protocol. 2017; Available from: http://dx.medra.org/10.19285/CBCTEFOMP.V1.0.2017.06
10. Zarb F, Rainford L, McEntee MF. Image quality assessment tools for optimization of CT images. Radiography. 2010 May 1;16(2):147–53.
11. Zarb F, Rainford L, McEntee MF. Developing optimized CT scan protocols: Phantom measurements of image quality. Radiography. 2011 May 1;17(2):109–14.
12. Alikhani B, Jamali L, Raatschen HJ, Wacker F, Werncke T. Impact of CT parameters on the physical quantities related to image quality for two MDCT scanners using the ACR accreditation phantom: A phantom study. Radiography (Lond) [Internet]. 2017 Aug 1 [cited 2022 Jul 13];23(3):202–10. Available from: https://pubmed.ncbi.nlm.nih.gov/28687287/
13. Mansour Z, Mokhtar A, Sarhan A, Ahmed MT, El-Diasty T. Quality control of CT image using American College of Radiology (ACR) phantom. Egyptian Journal of Radiology and Nuclear Medicine. 2016 Dec 1;47(4):1665–71.
14. Araki K, Yoshizako T, Yoshida R, Tada K, Kitagaki H. Low-voltage (80-kVp) abdominopelvic computed tomography allows 60% contrast dose reduction in patients at risk of contrast-induced nephropathy. Clin Imaging [Internet]. 2018 Sep 1 [cited 2022 Jul 13];51:352–5. Available from: https://pubmed.ncbi.nlm.nih.gov/29982133/
15. Racine D, Ba AH, Ott JG, Bochud FO, Verdun FR. Objective assessment of low contrast detectability in computed tomography with Channelized Hotelling Observer. Phys Med [Internet]. 2016 Jan 1 [cited 2022 Jul 13];32(1):76–83. Available from: https://pubmed.ncbi.nlm.nih.gov/26515665/