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Analysis Of The Effect Of Pitch Value Variation On Image Quality And Examination Time Using A Water Phantom On Head CT Scan Examination Protocol At Ibnu Sina Islamic Hospital Pekanbaru

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Abstract *Background: The component that can affect image quality is noise. Noise in CT Scan images comes from random variations in photon detection. Scan time is the time it takes for x-rays to exit for data collection of each slice. Pitch is one of the important component parameters in the CT Scan protocol and fundamentally affects the quality of the resulting image, as well as the time required for scanning. The use of pitch in the Radiology Installation of Ibnu Sina Islamic Hospital Pekanbaru in the head CT Scan examination is 0.55. The pitch value variations used by the author in this study are pitch 0.55, 0.75, 1, 1.25 and 1.5.*
Methods: This type of research is quantitative research using an experimental approach. The study was conducted to determine the effect of pitch value variation on image quality (noise) and scan time using a water phantom on head CT Scan examination protocol using pitch 0.55, 0.75, 1, 1.25 and 1.5. A sample of 10 CT Scan images was taken, and the image quality (noise) was measured by identifying a specific region in the image (Region of Interest or ROI), while the scan time value was observed from the consul monitor. Data analysis was performed using one-way ANOVA statistical test with a significance level of 5%.
Results: The results show that there is a significant difference in image quality (noise) on pitch value variation, with a significance level of 0.004, and there is also a significant difference in scan time on pitch value variations with a significance level of less than 0.001.
Conclusions: Based on the conclusion, pitch 1 is the value that produces optimal noise level and scan time in head CT Scan protocol using water phantom.

Keyword *: Pitch, Image Quality (Noise), Scan Time.*

Abstrak Latar Belakang: Komponen yang dapat mempengaruhi kualitas gambar adalah noise. Noise pada gambar CT Scan berasal dari variasi acak dalam deteksi foton. Waktu pemindaian adalah waktu yang diperlukan sinar X untuk keluar untuk pengumpulan data setiap irisan. Pitch merupakan salah satu parameter komponen penting dalam protokol CT Scan dan secara mendasar mempengaruhi kualitas gambar yang dihasilkan, serta waktu yang diperlukan untuk pemindaian. Penggunaan pitch di Instalasi Radiologi RS Islam Ibnu Sina Pekanbaru pada pemeriksaan CT Scan kepala sebesar 0,55. Variasi nilai nada yang penulis gunakan pada penelitian ini adalah nada 0.55, 0.75, 1, 1.25 dan 1.5.
Metode: Jenis penelitian ini adalah penelitian kuantitatif dengan menggunakan pendekatan eksperimen. Penelitian dilakukan untuk mengetahui pengaruh variasi nilai pitch terhadap kualitas gambar (noise) dan waktu scan menggunakan water phantom pada protokol pemeriksaan CT Scan kepala dengan menggunakan pitch 0.55, 0.75, 1, 1.25 dan 1.5. Diambil sampel sebanyak 10 gambar CT Scan, dan kualitas gambar (noise) diukur dengan mengidentifikasi wilayah tertentu pada gambar (Region of Interest atau ROI), sedangkan nilai waktu pemindaian diamati dari monitor konsul. Analisis data dilakukan dengan menggunakan uji statistik ANOVA satu arah dengan tingkat signifikansi 5%.
Hasil: Hasil penelitian menunjukkan terdapat perbedaan kualitas gambar (noise) yang signifikan pada variasi nilai pitch, dengan tingkat signifikansi 0,004, dan terdapat pula perbedaan signifikan waktu pemindaian pada variasi nilai pitch dengan tingkat signifikansi kurang dari 0,001.
Kesimpulan: Berdasarkan kesimpulan tersebut, pitch 1 merupakan nilai yang menghasilkan tingkat kebisingan dan waktu scan optimal pada protokol CT Scan kepala menggunakan water phantom.

Kata Kunci : Pitch, Kualitas Gambar (Noise), Waktu Scan.

INTRODUCTION

Computed Tomography Scan (CT Scan). Computed Tomography (CT) is a diagnostic device that uses X-rays to produce cross-sectional images of the body based on the absorption of X-rays in slices of the body, which are then displayed on a computer screen. The use of CT

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scanning was first introduced in the early 1970s, and since then its development has continued rapidly until today, (Listiyani et al., 2021). One of the modalities that is the main choice in establishing pathological diagnoses is CT scan of the head, (B , Kartini., 2018).

One component that can affect image quality is noise. Noise in CT scan images comes from random variations in photon detection. If the noise level in the image increases, the resolution contrast will decrease, which can affect the image quality. This can be seen from the grainy or grainy appearance of the image which is affected by noise. Several factors that influence the noise level in CT Scan images are kVp, mA, Scan Time, slice thickness, interpolation method and helical pitch, (Ronot et al., 2018).

Pitch is an important component parameter in the CT Scan protocol and fundamentally influences the radiation dose received by the patient, the quality of the resulting image, and the time required to perform scanning (Bushberg, 2012). The pitch used in the Radiology Installation at Ibnu Sina Islamic Hospital Pekanbaru for CT scans of the head is 0.55. The variations in pitch values used by the author in this research are pitch 0.55, 0.75, 1, 1.25 and 1.

METHODS

This type of research is quantitative research using an experimental approach, which aims to determine the effect of variations in pitch values on image quality (noise) and examination time (scan time) using a water phantom in the head CT scan examination protocol using a pitch of 0.55, 0.75, 1, 1.25 and 1.5., This research was designed with a One-Shot Case Study design, the intervention carried out was varying pitch values of 0.55, 0.75, 1, 1.25 and 1.5 using a water phantom on head CT scan examination protocol. This research was carried out at the radiology installation at Ibnu Sina Islamic Hospital Pekanbaru, which will be carried out in July 2023. The population in this study is all Phantom CT Scan data in the head CT Scan examination protocol. characteristics of the population, namely 10 image sampleswater phantom Head CT Scan protocol. Sample determination was carried out using criteria according to the number of variables used, namely pitch 0.55, 0.75, 1, 1.25 and 1.5.

RESULTS

Based on research, the author obtained the following data:

1. The influence of image quality (noise) and scan time on pitch variations
    a. Image quality (*noise*)

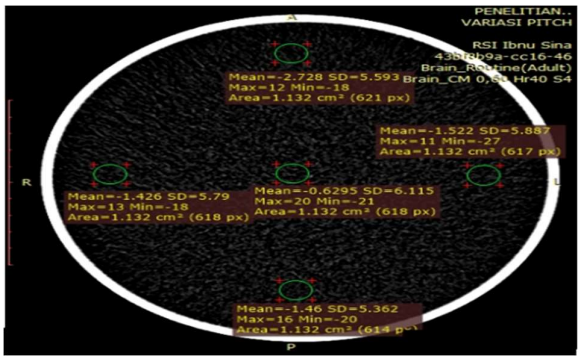

Figure 1, Scanning results of water phantom noise image, measurement using ROI from RADiant Dicom software

Taking noise data is measuring the ROI in the middle position, top direction, right direction, bottom direction and left direction then converting it using the equation:

$$Ss = \mathrm{Sm}\frac{kV}{120}\sqrt{\frac{mAs\ x\ Sllicewidth}{300\ x\ 8}}$$

The image noise measurement table for pitch variations is as follows:

Table 1. Measurement of the standard deviation of noise values corrected for pitch variations

Variation*pitch*	*Noise* image measurable	*Noise* corrected image(HU)
0,55	5,51	1,984
0,75	5,76	2,071
1	5,97	2,145
1,25	6,11	2,198
1,5	6,26	2,252

Based on Table 1 above, it shows that the image noise value in the image variations experiences fluctuations, the largest image noise is in the 1.5 pitch variation with a value of 2,252 HU. Meanwhile, the lowest noise value is at a pitch variation of 0.55 with a value of 1.984 HU. Based on the results of the one-way ANOVA statistical test, there is a significant difference in the noise value relative to the pitch value variation. The results of the analysis show that the p-value is 0.004, which means (p-value < 0.05), so it can be concluded that Ho is rejected and Ha is accepted. In other words, there is a significant difference between the effect of varying pitch values on noise.

b. Examination time (*scan time*)

Measurements are carried out by recording the inspection time produced by each scanning that appears on the monitor screen*CT Scan*.

Measurement of inspection time for pitch variations is shown in the following table:

Table 2. Measurement of inspection time for pitch variations

Variation*pitch*	time*scanning*(s)
0,55	7,9
0,75	6,5
1	5,8
1,25	4,9
1,5	4,3

Table 2 shows that the pitch variation experienced fluctuations, the largest inspection time was at a pitch variation of 0.55, namely 7.9s, while the lowest inspection time was at a pitch variation of 1.5, namely 4.3s. Based on the results of the one-way ANOVA test, there is a significant difference in the inspection time regarding variations in pitch values. The results of the analysis show that the p-value < 0.001, which means (p-value < 0.05), so it can be concluded that Ho is rejected and Ha is accepted. In other words, there is a significant difference between the effect of pitch value variations on inspection time.

2. Variation pitch values produces optimal image quality (noise) and scan time

Based on data on variations in pitch value with image quality (noise) and inspection time combined in a table, then create a graph to determine the variation in pitch value with image quality (noise) and optimal inspection time in the following table:

Table 3. Results of variation in values*pitch* with image quality(*noise*) and examination time

Variation*pitch*	Mean value *Noise* image (HU)	Mean value Examination time(s)
0,55	1,984	7,9
0,75	2,071	6,5
1	2,145	5,8
1,25	2,198	4,9
1,5	2,252	4,3

Based on table 3, a graph is then made between the variation in pitch value and image quality (noise) and the graph inspection time can be seen in the following figure:

Figure 2. Graph of pitch variations on image quality (noise) and inspection time (scan time)

Based on Figure 2, it can be seen that there are fluctuations, so to determine the direction of increase in the image noise value and the inspection time from pitch variations, then add a

linear trend. The result is an intersection that reflects the pattern of the graph. The linear trend for image noise (blue line) shows that the higher the pitch, the higher the noise level. Meanwhile, the trendline for check time (orange line) shows that the higher the pitch, the check time tends to be lower. Based on Figure 2, the graph above shows that the intersection point with the linear trend is exactly at the variation of pitch value 1, thus the optimal pitch value is pitch 1.

DISCUSSION

1. The effect of varying pitch values of 0.55, 0.75, 1, 1.25 and 1.5 on image quality (noise) and examination time (scan time) of head CT scans at Ibnu Sina Islamic Hospital Pekanbaru.

In this study, researchers varied the pitch value on image quality (noise) and examination time. Based on the results of the one-way ANOVA test, it produces a significance value of 0.004, which means (p-value <0.05), Ho is rejected and Ha is accepted, so it can be concluded that there is an influence of pitch variations on image quality (noise). Pitch affects image quality and image volume, a high pitch will increase image volume because it affects image resolution along the z-axis, (14). A low value of pitch will produce a low level of image noise, while a high value of pitch will produce a high level of image noise (Goldman, L, 2008).

The research results showed that the lowest noise value was when using a pitch of 0.55, while the highest noise value was obtained when using a pitch of 1.5. The higher the image noise value, it can be said that the quality of the CT scan image will decrease, and vice versa (Seeram, 2016). This is in line with research using multislice scanning, increasing pitch will significantly increase image noise. This is a result of the various types of rhythmic helical interpolation algorithms used in multislice CT that reduce helical artifacts and slice thickness degradation (Ranallo, 2015).

The results of this research show that the image noise value is still within the acceptable range, namely -4 to 4, in accordance with the provisions stated in Bapeten Regulation Number 02 of 2018 concerning suitability tests for diagnostic and interventional X-ray radiology equipment, (Bapeten, 2018). Therefore, when choosing the pitch value for carrying out a Head CT Scan, it can be adjusted to the needs and conditions when carrying out the examination.

Furthermore, the effect of pitch variations on inspection time is on pitch variations. Based on the test results in this research, it produces a significance value of <0.001 (p-value <0.005), so Ho is rejected and Ha is rejected, so it can be concluded that there is an influence of pitch variations at the time of inspection. The research results showed that the highest

inspection time was at a pitch variation of 0.55, while the lowest inspection time was obtained at a pitch variation of 1.5. This is in line with theory. Changes in the pitch value will have an impact on the image noise value, scanning time, and the coverage area of the scan to be carried out. The greater the pitch value, the faster the scanning time but will increase the noise level in the image (Primak, 2006).

Based on the test results above, it can be concluded that there is an influence of pitch value variations on image quality (noise) and examination time using a water phantom in the head CT scan examination protocol.

2. Choice of pitch value variations of 0.55, 0.75, 1, 1.25 and 1.5 which are optimal for image quality (noise) and examination time in CT scans of the head

Pitch selection in a CT scan is very important to achieve the best image quality with the least amount of radiation possible, with the aim of reducing the biological impact of radiation exposure on the patient. Setting a small pitch with the same scan area will increase acquisition time, reduce image noise, and avoid artifacts. On the other hand, a large pitch setting will result in an unacquired scan area, so that certain anatomical information is not detected by the detector, reducing the radiation dose proportionally, but increasing image noise significantly. If the pitch increases, the scanning time and radiation dose received by the patient will decrease (Primak, 2006).

Graph in Figure 2. The result is an intersection that reflects the pattern of the graph. The linear trend for image noise (blue line) shows that the higher the pitch, the higher the noise level. Meanwhile, the trendline for check time (orange line) shows that the higher the pitch, the check time tends to be lower. Based on Figure 4.3, the graph above shows that the intersection point with the linear trend is exactly at the variation in pitch value 1, thus the optimal pitch value is pitch 1.

This is in line with the theory that using helical (spiral) CT scans of 1.0 or 1.5 offers the ability to obtain higher quality 3D reconstructions than comparable conventional CT scans (Hopper, 2016). By reducing the pitch and rotation time by the same amount, helical and patient movement artifacts can be reduced without increasing the examination time. The use of a low pitch can provide better imaging of the patient whereas a larger pitch with the use of mAs is more effective if the examination time is reduced. extended without disturbing the examination, (Ranallo, 2015).

CONCLUSION

Based on the results and discussion, the author concludes that there is an influence of pitch value variations on image quality (noise) with one-way ANOVA test results of 0.004 (p-value <0.05) and examination time with one-way-ANOVA test results <0.001 (p-value <0.05) using a water phantom in the head CT scan protocol. Based on the choice of variation, the optimal pitch value is pitch 1 in the CT scan head examination protocol in terms of image quality (noise) and optimal examination time.

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