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RESEARCH **Open Access**

Quality of Thorax CT Scan Images among Covid-19 Cases using Variations of Filter

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Abstract

A typical image of the Thorax CT Scan as a sign of the early stages and development of Covid-19 is the finding of Ground Glass Opacities (GGO). GGO is an insignificant increase in the density of the lungs without occlusion of blood vessels and bronchi. In mild cases, GGO tends to be difficult to identify and requires high-resolution CT scanning. In this study, we intend to improve the resolution of the Thorax CT Scan image through filter settings, to analyze the difference in the variations of filters B50s, B70s, and B90s towards the quality of the CT Scan image and obtain the optimal use of filter in the Thorax CT Scan examination among Covid-19 cases. This was a quantitative analytical study conducted at one of the Regional General Hospital in Jakarta on March-April 2022. The samples were secondary data derived from 10 patients by using MSCT Siemens Somatom Perspective 128 slices. Data were collected through observation and experiment. The images collected were further analyzed using Image j software to find values of Signal to Noise Ratio (SNR) and Contrast to Noise Ratio (CNR). Furthermore, the values were compared by assessing the anatomical image information through various filters. The results of this study indicated that there were differences in the SNR and CNR values of the three filters. The higher resolution of the filter used, the more capable it was to sharper and more detailed the image but the noise level was also higher. Thorax CT Scan examination should be carried out using the B70s very sharp filter that was able to produce images with the optimal information and fairly low noise level. A very thin GGO image in the early stage of the manifestation of Covid-19 could be identified in the Thorax CT Scan examinations for diagnosis of Covid-19 case.

Keywords: Thorax CT-Scan, Signal to Noise Ratio, Contrast to Noise Ratio, Covid-19, Filter.

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1. INTRODUCTION

Coronavirus Disease 2019 is an infectious disease caused by the Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV-2). It was first reported in December 2019 in the city of Wuhan, Hubei Province, China (Huang et al., 2020; Perlman, 2020; Wang, et al., 2020; Wang, et al., 2020; Zhu et al., 2020). The first confirmed case of Covid-19in Indonesia was reported on March 2, 2020 (Kementerian Kesehatan Republik Indonesia, 2020). Until the end of August 2021, more than 4 million confirmed cases of Covid-19 were reported in Indonesia and 128,252 people died (Johns Hopkins University & Medicine, 2021).

The standard for establishing a diagnosis to confirm Covid-19 is the Reverse Transcriptase-Polymerase Chain Reaction (RT-PCR) examination. However, the results of the RT-PCR examination take a long time and can give false negative results thereby reducing the effectiveness of early identification and isolation of Covid-19 patients (Prokop et al., 2020; Wang et al., 2020; Xie et al., 2020). On the other hand, Thorax CT-Scan has been applied as an essential complementary indicator in Covid-19 screening because of its high sensitivity (Ai et al., 2020; Fang et al., 2020; Gündüz, Öztürk, & Tomak, 2020; Liu, Yu, & Zhang, 2020; Wang et al., 2020).

CT-Scan is a diagnostic technology tool that combines rotating X-rays, detector arrays, and computerized reconstruction to produce cross-sectional images of the body (Bushong, 2017). There are important organs of the respiratory system inside the thorax cavity, such as the lungs, heart, bronchi, and blood vessels (Long, Rollins, & Smith, 2016). Thorax CT scan should be viewed with at least two window settings namely the mediastinum window and the lung window (Seeram, 2016). Lung window is a window that is set to observe the lung parenchyma tissue.

A typical image on Thorax CT-Scan which is considered a marker of the early stages and progression of Covid-19 disease is the finding of Ground Glass Opacities (GGO), with or without consolidation with bilateral peripheral involvement in several lobes of the lung which can develop into a crazy paving pattern (Bernheim et al., 2020; Ye, et al., 2020). GGO is an insignificant increase in lung density without blood vessel and bronchial obscuration, while consolidation is accompanied by clouding of blood vessels. In mild cases, GGO tends to be difficult to identify, therefore high resolution CT-Scan is required (Cozzi et al., 2021).

Images with high resolution and detail are also required in the CT Scan Thorax examination because the lung cavity has a very small structure and is very similar to pulmonary blood vessels and bronchi. One way to increase the resolution of CT Scan Thorax images is by setting filters or reconstruction algorithms. The higher the resolution of the selected algorithm, the higher the resolution of the CT Scan image produced. This method can clearly distinguish images such as bone, soft tissue, and other tissues that are produced on the monitor screen. The higher resolution of the algorithm (lungs and bones) will increase the high spatial frequency. In addition, a softer algorithm (soft network) will reduce the contribution of high frequency (Webb, Muller, & Naidich, 2015).

Thorax CT Scan examination for Covid-19 case is performed by using a high-resolution filter to get the best image resolution (Wu et al., 2020). Siemens MSCT imaging modality provides a variety of high-resolution filter settings for thorax CT scans, especially for lung window condition, namely B50s, B60s, B70s, B80s, and B90s. The higher the resolution of the filter used, the more capable it is to clarify the boundaries/edges of the organ so that the resulting image display will be sharper and more detailed but with a higher noise level (Bequet, et al., 2019; Sutrisno et al., 2021).

According to the results of observations made by researchers at one of the Regional General Hospitals in Jakarta and a journal written by Sanli, & Yildirim, (2021), Thorax CT-Scan for Covid-19 examination was performed using a very sharp filter B70s. Meanwhile, according to the journal written by Zhao et al., (2020) Thorax CT Scan for Covid-19

examination was performed using a medium sharp filter B50s. Furthermore, according to Li et al., (2020), it was performed using an ultra-sharp filter B90s (Li et al., 2020; Şanli & Yildirim, 2021; Zhao et al., 2020). Based of the background, researchers are interested in conducting a study on the use of various filters namely B50s, B70s and B90s on Thorax CT-Scan for lung window condition among Covid-19 cases. There were different image results by the variations of filters B50s, B70s, and B90s analyzed through image j software to find the SNR and CNR values among the three variations of filter. This study aims to obtain the optimal type of filter to produce image with optimal quality to establish a diagnosis.

2. RESEARCH METHOD

This was a quantitative analytical study conducted at one of the Regional General Hospital in Jakarta on March-April 2022. The population of this study was all patients who had CT Scan Thorax at the Radiology Installation as using MSCT siemens Somatom perspective 128 slices. The samples were 10 secondary data of patients with suspected COVIS-19 and the existence of GGO. Data were collected by conducting observations and experiments.

Images from raw data reconstructed with filters B50s, B70s, and B90s were assessed objectively using data derived from DICOM and then one coronal slice was taken from each sample on the filter used. Data derived from the DICOM slices were further analyzed for individual pixel value, mean value, and standard deviation using Image J software. This software performed analysis through ROI (Region of Interest). ROI was placed on the object (right upper lobe of lung, right lower lobe of lung, left upper lobe of lung, and left lower lobe of lung) and outside the object (background) with a size of 10 mm to obtain the object mean HU, background mean HU, object standard deviation, and background standard deviation. These values were used to calculate the SNR and CNR values according to equations (1) and (2) (Kim et al., 2014) which were then applied for statistical analysis of the ANOVA test using statistical data processing software.

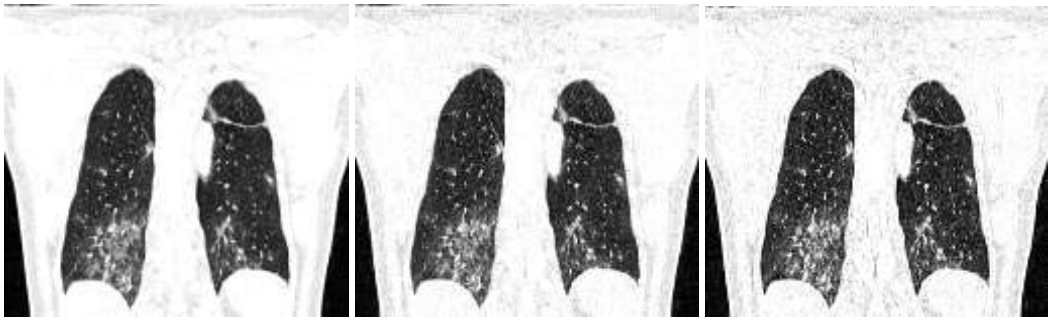
$$SNR = \frac{\text{Object Mean HU}}{\text{Object Standar Deviation}} \quad (1)$$

$$CNR = \frac{\text{Object Mean HU} - \text{Background Mean HU}}{\text{Background Standar Deviation}} \quad (2)$$

Subjective assessment was also carried out by delivering questionnaires containing questions about anatomical information on CT Scan Thorax images to five respondents who were radiology specialists and radiographers. The questions had 5 levels of Likert scale rating namely 1 for very poor, 2 for poor, 3 for moderate, 4 for good, and 5 for very good. Furthermore, statistical analysis through the Kruskal wallis test was conducted using statistical data processing software. This study has obtained ethical approval and ethical review.

3. RESULTS AND DISCUSSION

The research was conducted at one of the Regional General Hospitals in Jakarta on March-April 2022. For further analysis, the raw image data obtained after scanning were then reconstructed using filter variations namely medium sharp filter B50s, very sharp filter B70s and ultra sharp filter B90s. Those filters were applied for a lung window condition with a window width of 1200 HU and a window level of -600 HU. In addition, the examination parameters applied were full helical scan type; 130 kV; Quality reff mAs 100 (Care Dose4D) was active; rotation scan of 0.6 s; pitch of 1.3; length of 512 mm and slice reconstruction of 1 mm as shown in Figure 1.



(A) (B) (C)

Figure 1. Results of Thorax CT Scan Reconstruction Image: (A) medium sharp filter B50s (B) very sharp filter B70s (C) Ultra Sharp filter B90s

The results of the image reconstruction using filter variations of B50s, B70s, and B90s using software image J obtained the mean object HU, background mean HU, object standard deviation, and background standard deviation values with ROI size of 10 mm made on the right upper lobe of lung, right lower lobe of lung, left upper lobe of lung, left lower lobe of lung, and background. The same ROI size was placed to measure the pixel value on the use of the three variations of filter on each organ, as shown in figure 2. These results were then processed using the SNR and CNR equations.

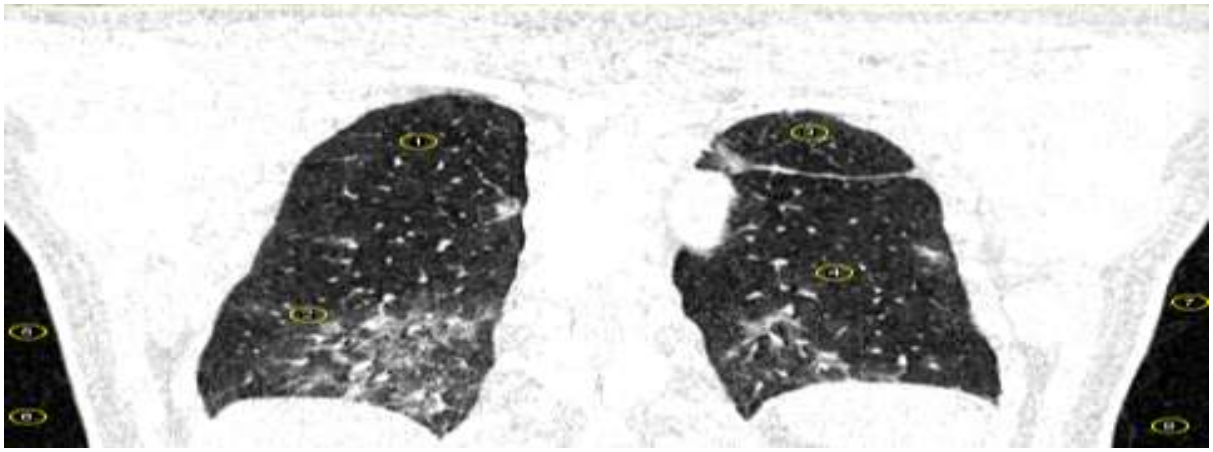


Figure 2. Placement of ROI on CT Scan Thorax image

The SNR and CNR equations obtained the SNR and CNR values on filters B50s, B70s, and B90s as shown in Table 1 and Table 2. Then the values were further analyzed statistically.

Table 1. Signal to Noise Ratio (SNR) Values.

Patient	SNR		
	Filter B50s	**Filter B70s**	**Filter B90s**
1	-19.928	-12.343	-9.393
2	-15.072	-12.644	-8.652
3	-19.778	-18.035	-13.812
4	-19.762	-15.300	-11.648
5	-11.376	-8.640	-7.293
6	-15.370	-11.697	-7.023
7	-10.102	-8.244	-5.416
8	-7.689	-6.230	-4.697
9	-19.015	-13.954	-10.681
10	-16.052	-12.928	-7.799

Table 1 presents the SNR values for filters B50s, B70s, and B90s. Filter B50s obtained the lowest mean SNR value and Filter B90s obtained the highest mean SNR value.

Table 2. Contrast to Noise Ratio (CNR) Values.

Patient	CNR		
	Filter B50s	**Filter B70s**	**Filter B90s**
1	10.354	5.428	4.172
2	13.848	9.730	5.965
3	8.913	6.785	5.062
4	12.455	6.733	5.002
5	4.203	3.548	2.988
6	8.588	6.800	4.332
7	4.979	3.780	2.468
8	11.164	10.315	8.012
9	19.911	10.893	7.809
10	8.567	5.988	3.250

Table 2 presents the CNR values for filters B50s, B70s, and B90s. Filter B50s obtained the highest mean CNR value and Filter B90s obtained the lowest mean CNR value.

Before the statistical test was conducted, the data that had been obtained were tested for normality first to determine whether the data were normally distributed or not and to determine the appropriate statistical test. The Shappiro-wilk test was applied on SNR and CNR of the filters B50s, B70s and B90s which obtained a p-value of >0.05, which indicated that the data were normally distributed. Thus, the statistical test applied to test the differences in the data was the ANOVA test.

After the ANOVA test on the SNR and CNR values of the three filter variations, it was obtained a significance value of 0.001 for SNR and a significance value of 0.003 for CNR. Since the p values were < 0.05, then H0 was rejected. Thus, it can be concluded that there was a difference in the means SNR and CNR values between filters B50s, B70s, and B90s. Furthermore, a post hoc test was conducted to find out group(s) with differences. Since the data were normally distributed, the further test applied was the Bonferroni test.

The results of the Bonferroni test on SNR obtained a significance value between filter B50s and filter B70s of 0.138, a significance value between filter B50s and filter B90s of 0.001, and a significance value between filter B70s and filter B90s of 0.147. The findings indicated that there was a difference in the mean SNR values between filter B50s and filter B90s. Meanwhile, there was no significant difference in the mean SNR values between filter B50s and filter B70s and between filter B70s and filter B90s.

The results of the Bonferroni test on CNR showed a significance value between filter B50s and filter B70s of 0.087, a significance value between filter B50s and filter B90s of 0.002, and a significance value between filter B70s and filter B90s of 0.463. The findings indicated that there was a difference in the mean CNR values between filter B50s and filter B90s. Meanwhile, there was no significant difference in the mean CNR values between filter B50s and filter B70s and between filter B70s and filter B90s.

Table 3. Anatomical Image Information Based on Questionnaire Data.

Respondent	Filter		
	Medium Sharp Filter B50s	Very Sharp Filter B70s	Ultra Sharp Filter B90s
1	4.0	4.4	2.8
2	3.8	4.5	4.5
3	4.5	4.5	3.6
4	3.8	4.7	3.0
5	3.4	5.0	2.0

Table 3 presents the mean value of the questionnaire data among 5 respondents who were radiology specialists and radiographers. Those respondents performed subjective assessments towards the results of the thorax CT-Scan by using 3 variations of filters B50s, B70s, and B90s. Anatomical information of the right upper lobe of lung, the right lower lobe of lung, the left upper lobe of lung, and the left lower lobe of lung were presented in the table. Filter B70s obtained the highest mean value while Filter B90s obtained the lowest mean value.

Table 4. Results of Kruskal Wallis Test.

Kruskal Wallis Test		
Filter	Mean Rank	p-value
B50s	7.30	0.021
B70s	12.20	
B90s	4.50	

Table 4 presents the results of the Kruskal Wallis test for the anatomical image information questionnaire. The Kruskal Wallis statistical test was applied since the questionnaire data for anatomical image information were ordinal data. The Kruskal Wallis test was performed to determine whether there were significant differences between the three variations of filter. After the Kruskal Wallis test was performed, a significance value of 0.021 was obtained. Since the p value was <0.05, then H0 was rejected. It can be concluded that there was a significant difference in anatomical image information of filters B50s, B70s, and B90s. Based on the table, it was also shown that filter B90s obtained the lowest mean rank value of 4.50 and filter B70s obtained the highest mean rank value of 12.20. Such finding indicated that respondents agreed that the use of the B70s filter could visualize the most optimal anatomical image information.

The current study is the first study that presents evidence regarding different image quality by variations of filter using filters B50s, B70s, and B90s. The calculation of the SNR and CNR values applied the image J software on the CT Scan Thorax examination for Covid-19 cases by placing the ROI in the same areas on 10 samples. The coronal sections of the thorax anatomy were chosen, especially the right upper lobe of lung, the right lower lobe of lung, the left upper lobe of lung and the left lower lobe of lung because signs of Covid-19 infection are often found in such areas (Şanli & Yildirim, 2021). Based on the calculation of the statistical test through ANOVA test, it was found p values of 0.001 and 0.003 for SNR and CNR, respectively which indicated that there were differencea in SNR and CNR values. The difference between the SNR and CNR values was found for filter B50s and filter B90s filter. Based on Table 1, it can be seen that filter B90s obtained the highest SNR value. The higher the SNR value, the clearer the radiographic image when there is a small difference between an organ and the surrounding area (Irsal & Winarno, 2020).

Based on Table 2, it was shown that of the three filter variations, filter B50s obtained the highest CNR value and filter B90s obtained the lowest CNR value. The sharper the image produced by a filter, the lower the CNR value. The lower the CNR value, the higher the noise in the image (Irsal & Winarno, 2020). Higher noise value lead to better ability to clarify the

boundaries/edges of the organ so that the resulting image display can be sharper and more detailed (Bequet et al., 2019; Sutrisno et al., 2021). The increased noise is due to the high pass filtering process, specifically when the filter suppresses the low spatial frequency (input raw data image with large pixels that contain little frequency information) so that a prominent difference is obtained between the output pixels of the raw data (Seeram, 2016).

Based on the calculation through the Kruskal Wallis test on the questionnaire filled in byby 5 respondents regarding the anatomical image information of right upper lobe of lung, right lower lobe of lung, left upper lobe of lung and left lower lobe of lung, it was obtained a p value of 0.021. Such finding indicated that there was a significant difference in anatomical image information of the three filter variations. Based on Table 8, it can be seen that filter B70s obtained the highest mean rank value of 12.20 which indicated that respondents agreed that the use of the B70s filter could visualize the most optimal anatomical image information.

In summary, the use of filter B70s was able to optimally visualize anatomical image information, was able to clarify the boundaries/edges of organs, and had a fairly low noise level. This is compatible with the Standard Operating Procedure at one of the Regional General Hospitals in Jakarta and the journal written by Sanli, & Yildirim, (2021), that Thorax CT Scan for Covid-19 examination was performed using a very sharp filter B70s. The study findings are also in accordance with the literature which states that Thorax CT Scan for Covid-19 requires high-resolution images so as to identify GGO which is very thin and has unclear edges in the early stage of CT manifestation of Covid-19 (Chinese Society of Radiology, Chinese Medical Association, 2020; Cozzi et al., 2021).

4. CONCLUSION

The study revealed that there were differences in the quality of the CT Scan Thorax images for Covid-19 cases using the filters B50s, B70s, and B90s. During the CT Scan Thorax examination, especially regarding lung window conditions, image reconstruction should be performed by using very sharp filter B70s to obtain optimal image and information results. A very thin and unclear edge of GGO image in the early stage of the manifestation of Covid-19 could be identified more clearly and sharply in the Thorax CT Scan examinations for diagnosis of Covid-19 case. Future research is recommended to be conducted using different variations of filter.

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