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Application Of Contrast Limited Adaptive Histogram Equalization (CLAHE) On The Quality And Pathological Information Of Chest X-Ray (CXR) Images In Covid-19 Patients In The Intensive Care Unit (ICU) Room

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ABSTRACT

Background: The advantages of mobile or portable Chest X-Ray (CXR) in Covid-19 patients are the minimal radiation received compared to CT Scan, as well as evaluating or evaluating patient diagnoses in the Intensive Care Unit (ICU) room. CXR in the Anterior Posterior (AP) projection with a Covid-19 patient who sleeps on his back or sits in the ICU room is usually uncooperative in adjusting the patient's position, resulting in low image quality, requiring Digital Imaging (DIP) in an effort to improve image quality. This study used DIP Contrast Limited Adaptive Histogram Equalization (CLAHE) on images of Covid-19 patients in the ICU, and compared before and after CLAHE to quality and pathology information.
Objectives: Improving the quality and pathological information of CXR images in Covid-19 patients in the ICU with the application of CLAHE and to find out the most optimal differences in pathology information.
Methods: Quasi experiment with the Pretest Posttest Without Control Group Design. Sample calculation using purposive sampling with saturation time, Where this study used 20 samples of Covid-19 patients in the ICU room and used 2 Observers, namely radiologists and pulmonologists as Visual Grading Analysis (VGA) assessment of pathology information.
Results: Improving image quality in Covid-19 patients in the ICU before and after CLAHE with MSE values (0.0339), PSNR (111.2541). The after CLAHE image has a higher mean rank than the before CLAHE image.

Keywords: CLAHE, CXR, Covid-19

INTRODUCTION

The Coronavirus disease 2019 (COVID-19) pandemic is considered one of the deadliest epidemics with numbers and cases growing exponentially without a promising treatment and vaccine, creating havoc for the health and financial systems of countries in the world (1). Wuhan HUBAI Provence, CHINA in December 2019, Covid-19 disease has been confirmed and is now known as Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) spreading throughout the world which generally invades the respiratory system such as Acute Respiratory Distress Syndrome (ARDS)) (2). Until now, Real Time Transcription Polymerase Chain Reaction (RT-PCR) has become a reference for diagnosing Covid-19 (3),(4).

Several countries such as China, apart from using RT-PCR to improve their ability to diagnose Covid-19, Computed Tomography (CT) is recommended as an initial diagnosis because CT scan has a higher sensitivity than RT-PCR, especially in cases of SARS-CoV-2 (5). Imaging CT scan is the most effective method for detecting abnormalities such as the respiratory system, especially evaluating the development of the disease from the initial stage to the end. The use of CT scan without contrast media injection and 3D visualization reconstruction can improve management understanding or better follow-up, especially in Covid-19 cases (6).
Chest CT scan imaging in Covid-19 patients can reveal pathological information such as Ground Glass Opacity (GGO), pulmonary consolidations, crazy paving stones, in the peripheral, sub-pleural and basal areas of the lung properly (7), when compared to a Chest X-ray (CXR) the only good

ones are exposing GGO and consolidations (8). Chest CT scan is considered to be the main diagnosis in Covid-19 cases so that it becomes a burden on the radiodiagnostic department and requires intense infection control, so the American College of Radiology finds that this can interfere with the availability of radiology services and recommends mobile (portable) CXR for triage patients (triage).) or the intensive care unit (ICU) Covid-19 (9).

CXR was used for decades as a portable tool, due to its cost-effectiveness and speed of evaluating Covid-19 patients. Portable CXR is one of the most frequently requested examinations, especially in the ICU which aims to diagnose and monitor various cardiopulmonary disorders and assess the position of the medical device (thorax) which provides valuable diagnostic information in Covid-19 patients (10). Generally, Covid-19 patients in the ICU use the Anterior Posterior (AP) projection, so that the clinical information obtained is unclear between the heart and the mediastinum because the patient does not take a deep breath and does not hold it for a few seconds. In addition, the AP projection of Covid-19 patients in the ICU is taken while sitting or supine in bed so that it can affect image quality (11)

Digital image processing (DIP) is a form of image signal processing that is transformed into a new image output using several techniques such as image restoration and image enhancement which can improve image quality (12). Image enhancement such as Contrast Limited Adaptive Histogram Equalization (CLAHE) is a quality improvement technique image that minimizes low contrast and limits excessive contrast levels while retaining image detail. The CLAHE method, especially on CXR images, is able to provide better quality compared to Histogram Equalization (HE), Unsharp Masking (USM) and the CLAHE method has a high Peak Signal To Noise Ratio (PSNR) value and a small Mean Square Error (MSE) (13). Compared to Normalization (N-CLAHE) and Min-Max (MMCLAHE) so that CLAHE is very good in terms of structure and information on image (14)

Digital image quality is analyzed quantitatively by calculating MSE and PSNR. The higher the PSNR value, the better the image quality, while the higher the MSE value, the lower the resulting image quality and image quality testing usually uses the MATLAB application (15). Matlab is a simple coding software in which all data variables are considered as an operation matrix which is used to analyze according to the toolbox in the application. Image quality improvement has been widely used in the field of technology, especially in the medical field (16). The advantages of portable CXR in Covid-19 patients are the lack of radiation and monitoring or evaluating patient diagnoses in the ICU. CXR in the AP projection with a Covid-19 patient who sleeps supine or sits in the ICU room is usually uncooperative in adjusting the patient's position, resulting in low image quality. By using the CLAHE filter in an effort to improve image quality in Covid-19 patients in the ICU, researchers want to compare the quality and information of the resulting images (before and after) using the CLAHE filter in Covid-19 patients in the ICU.

METHOD

Type and Design of Reserch

This research method is Quasi experimental with the Pretest Posttest Without Control Group Design. Sample calculations used purposive sampling with time saturation, where this study used 20 samples of Covid-19 patients in the ICU and used 2 observers, namely radiologists and pulmonologists as subjective assessments of Visual Grading Analysis (VGA) for pathology information.

Data Analysis

Data analysis carried out by this study was testing image quality, namely MSE and PSNR as well as pathological information. Several statistical tests were also carried out, such as the kappa test, which aimed to assess the level of understanding among observers. The strength rating of this kappa score is a "very good", and is then followed by the Wilcoxon test. This test was conducted to see the difference in mean rank values in the images before and after CLAHE.

RESULT

Calculation Results Of Mean Square Error (MSE) And Peak Signal To Noise Ratio (PSNR) Of CXR Image in Covid-19 Patients In The ICU Before And After Implementation Of CLAHE.

Based on the results of MSE calculations from before and after CXR images using the CLAHE technique, the MSE value is 0.033, the average result of calculating the MSE of CXR images using the CLAHE technique is that the MSE value is close to 0. The MSE is obtained by comparing the difference between the pixels. Before and after images at the same pixel position. where the CLAHE technique is able to provide a low average squared error value or close to 0. The smaller the MSE value, the better the image display will be, while the greater the MSE value, the worse the display of the resulting image will be. The results of MSE calculations in this study are more optimal than in previous studies, where the application used the CLACHE method to improve image quality, where the CLAHE technique was carried out using 2 techniques, namely FFT and DCT, for MSE results with the FFT technique, the value was (36.96) while for DCT (35.59)

Table 1: The Results Of Before And After MSE And PSNR Calculations Were Carried Out Using The CLAHE Technique

	Value CXR	
PX	MSE	PSNR
Px1	0.0408	110.2263
Px2	0.0398	110.3344
Px3	0.0398	112.1348
Px4	0.0359	110.7739
Px5	0.0430	109.9971
Px6	0.0323	111.2345
Px7	0,0255	112.2645
Px8	0.0250	112.3520
Px9	0.0324	111.2219
Px10	0.0272	111.9851

PX	MSE	PSNR
Px11	0.0405	110.2558
Px12	0.0308	110.3544
Px13	0.0395	112.1248
Px14	0.0354	110.7749
Px15	0.0431	109.9871
Px16	0.0321	111.2335
Px17	0,0355	112.2655
Px18	0.0240	112.3540
Px19	0.0344	111.2229
Px20	0.0282	111.9841
Avg	0.0339	111.2541

Based on the PSNR calculation results from before and after CXR images using the CLAHE technique, the PSNR value is 111 dB. PSNR is obtained by comparing the maximum value of the measured signal with the magnitude of the signal that affects the signal, PSNR is used to determine the comparison of the quality of the cover image (original) before and after, image quality improvement is carried out . Where to determine the PSNR first determine the value of the MSE, the PSNR value falls 30 dB identifying relatively low quality, where distortion due to insertion is clearly visible, and high image quality is at a value > 40 db. Where the CLAHE technique operates on a small area of the image called a tile, so that the contrast produced by that area matches the specified histogram shape. The calculation results in this study are more optimal than in previous studies, where the application used the CLACHE method to improve image quality, where the CLAHE technique was carried out using 2 techniques, namely FFT and DCT, for PSNR results with the FFT technique a value of (32,67) while for DCT (32.85).

Differences In CXR Image Pathology Information In Covid-19 Patients In The ICU Before And After Implementation Of CLAHE.

Based on the results of the data normality test (Saphiro-Wilk), the before and after image results were obtained using the CLAHE technique, the distribution was not normal or had a p-value below 0.05 for each pathology information criterion, so it was continued with the Wilcoxon test because the data not normally distributed. Based on the results of the Wilcoxon non-parametric test, the mean rank was obtained on before and after CXR images using the CLAHE technique per pathological criteria. Based on the mean rank results of the Wilcoxon test specifically per pathological criteria on objects (Ground Glass Opacity (20.00), Consolidations (20.00)) it shows that the after image performed by the CLAHE technique has the highest mean rank value compared to the before CLAHE technique (Ground Glass Opacity (0.00), Consolidations(0.00)).

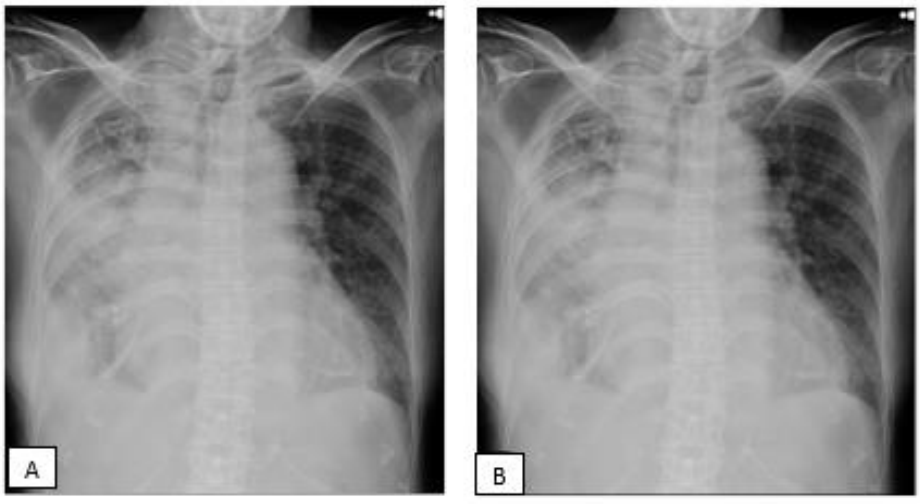

Fig 1: Image CXR (a) CXR Image Before CLAHE (b) CXR Image After CLAHE

Table 2: Wilcoxon Test Results On CXR Pathological Information Images, Before And After CLAHE

No	Anatomi Patologi	Citra CXR	Mean Rank
1	*Ground Glass Opacity*	Before CLAHE	0,00
		After CLAHE	20,00
2	*Consolidations*	Before CLAHE	0,00
		After CLAHE	20,00

The difference in image information from both before and after images was carried out using the CLAHE technique per pathological information criteria due to the significantly different visual quality of the images. This can happen because in the portable CXR before CLAHE image on the AP projection with a Covid-19 patient who sleeps supine or sits in the ICU room, it is usually uncooperative in adjusting the patient's position, resulting in low image quality. Whereas in the after image, image quality improvement (image processing) with the CLAHE technique can lead to an increase in image quality either from high or low contrast. This is consistent with the PSNR value obtained, which is more than 40 dB, resulting in good CXR image information with clear pathology appearance, clear structure and clear boundaries and easy for observers to analyze.

The Most Optimal Pathology Image Information Between Before And After Application Of CLAHE

Based on the Cohen's Kappa test, the inter-observer assessment for each image has a very strong agreement (very good) with a value of 0.83. Based on the statistical provisions of the results of the Cohen's Kappa test, a measure of agreement between 2 or more observers is said to be in agreement (objective) if <0.20 is declared low agreement (poor) 0.21-0.40 fair agreement (fair), 041-0, 60 agreement is sufficient (moderate), 0.61-0.80 agreement is strong (good) and 0.81-1.00 agreement is very strong (very good). So that the results of the observer's assessment of the before and after carried out by the CLAHE technique have very strong agreement strength (very good).

Table 3: The Results Of The Cohen's Kappa Observer Before And After Test Were Carried Out Using The CLAHE Technique On CXR Images

Observer	Value
R1*R2	.831

Table 4: Wilcoxon Test Results On The Most Optimal Pathology Information Image CXR, Before And After CLAHE

NO	Citra CXR Optimal	*Mean Rank*
1	Before CLAHE	*0,00*
2	After CLAHE	39,50

Based on the results of the Wilcoxon mean rank test on the overall assessment of the observer visually on CXR images with before and after performed the CLAHE technique. The afterCLAHE image has a value of 39.50 and the before CLAHE image has a value of 0.00. This shows that the most optimal mean rank value for the CXR image is the after CLAHE image, because it has a higher mean rank than the before CLAHE image. PSNR for optimal assessment of image quality. CLAHE provides a limit value on the histogram, this limit value is called the clip limit which states the maximum height limit of a histogram, so that the histogram is evenly distributed

CONCLUSION

Based on the results and discussion in this study, it was stated that there was a significant presence in the application of CLAHE which was able to provide good image quality and pathological information, especially on CXR images in Covid-19 patients in the ICU. The application of CLAHE can be recommended especially on CXR images, and further research is needed with different pathological information.

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