Evaluating Chest X-Ray Image Quality from Multiple X-Ray Machines Using ImageJ: A Comparative Study

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Abstract:
This study compares the image quality of Chest X-rays (CXR) obtained from three different X-ray machines. ImageJ software was utilized to calculate the Signal-to-Noise-Ratio (SNR) and Contrast-to-Noise-Ratio (CNR) of all(CXR)images.
A total of twelve images were analyzed, with four images from each machine. The findings highlight significant variations in image quality, were the machine in group A and B achieved Close values in CNR. while the mean of CNR in third machine in group C was less than them, and the mean values in SNR in group A was better than group B and C. Results also showed that machine in group A has highest mean values in SNR among the other machines, and highest mean values in CNR was recorded in group B, which have implications for diagnostic Accuracy and clinical decision making.

Keywords: *Contrast-to-noise ratio (CNR), Signal-to-noise ratio (SNR), chest x-ray (CXR), Image J*

1.Introduction

X-ray images are the product of a photographic process that begins from pressing the exposure button and ends at the image receptor. The radiologist relies heavily on the clarity of the image to write reports and make correct diagnoses of patient conditions. Despite advancements in imaging techniques, chest radiography remains one of the most frequently performed X-ray examinations, accounting for 30-40%of such procedures and serving as a primary diagnostic tool. It is favored for its rapid acquisition, rapid interpretation and low cost. Image quality is an attribute of the image that influences the clinician's certainty in perceiving the appropriate diagnostic features from the image visually [1]. Many factors affect image quality, such as kilovoltage (KV), milliampere- second (MAS), source image distance (SID), object image distance (OID) and the use of filters …etc. These parameters impact image resolution, contrast, and noise.
Contrast refers to the fractional difference in signal or brightness between the target structure and its surroundings[2]. Spatial resolution is the ability of the imaging system to differentiate adjacent structures as sepa rate entities [2].Noise is the random or patterned variation within an image that does not correspond to the actual X-ray attenuation differences of the object [2]. Variations in body tissues (in terms of density and thickness) create a gradient between black and white on the image, known as the gray scale (fig 1), [3]. with high- density tissue, like bone, has more attenuate of the X-ray beam, and thus appear off-white with a gray scale value close to 255. In contrast, areas of low attenuation, like air, appear dark with gray scale values near 0. With the increasing popularity of medical examinations and the resulting surge in the number of images, manually managing image quality has become increasingly challenging[4]. This study compares three different X-ray machines by calculating the contrast-to-noise ratio (CNR) and signal-to-noise ratio (SNR) for a total of twelve chest X-ray (CXR) images using ImageJ software. ImageJ is a widely-used open-source software that allows users to visualize, inspect, quantify, and valuate scientific image data. [5]

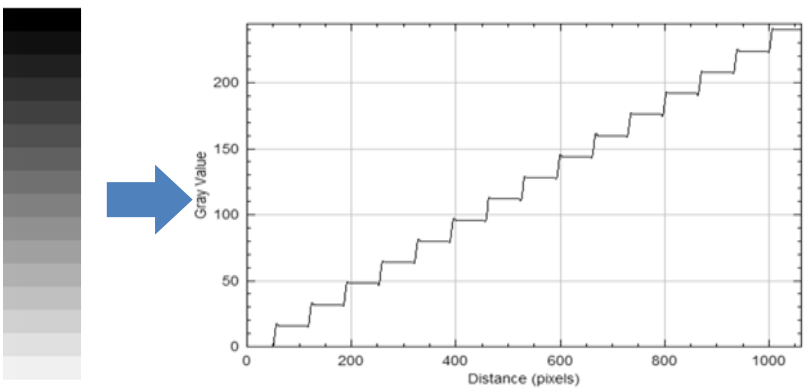

Figure (1) shows shades of grayscale [3]

2. Material and Method

Images were taken for twelve adult cases of chest X-ray examinations, with four images captured from each of the three different machines. The X-ray exposure parameters for all machines followed the standard routine used in radiology departments. The details of the X-ray radiography systems, including maximum kVp, mAs, and other specifications, are shown in Table 1. The chest X-ray images were taken in the posterior-anterior (PA) position. **Table 1: Details** of X-ray radiography system specification

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	Manufacturer	Year	Tube model number	Tube filtration	Max. kVp	Max. mAs
A	GEBG Private Limited	2018	5331186	1.3mmAL 75 KVP	150	300
B	GE HUALUN MEDICAL SYSTEM	2018	5189248	1.5mmAL 75 KVP	150	300
C	PHILIPS	2018	18C1055	0.9AL 75 KVP	150	300

Image quality was evaluated by using Image J software version 1.8.0. developed by the National Institute of Health, USA, that performs image quality assessment objectively where CNR [6]. The mean signal of the region of interest (ROI) and the standard deviation (StdDev) of the ROI were measured to calculate CNR and signal-to-noise ratio (SNR) consecutively. The quality of the twelve chest X-ray (CXR) images was assessed using ImageJ by measuring both CNR and SNR.

Contrast to noise ratio (CNR):

CNR assesses the contrast level between two distinct regions. To evaluate this, two circular regions of interest are selected: ROI1 is placed in the lung area, and ROI2 is placed in the soft tissue region with the highest density, as shown in (Fig 2).

Then the contrast is determined by calculating the difference between the mean signal of ROI2 and ROI1, divided by the standard deviation of ROI1, using the equation number (1) [7].

$$CNR = \frac{mean\ signal\ of\ ROI_2 - Mean\ signal\ of\ ROI_1}{StdDev\ of\ ROI_1} \quad (1)$$

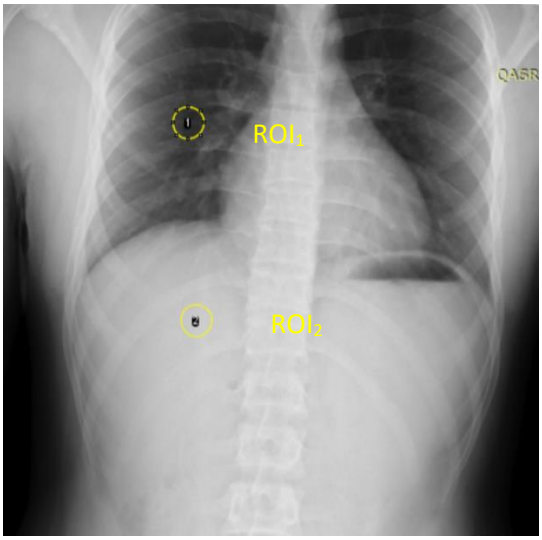

Figure (2) shows ROI in Posterior Anterior Chest X-ray

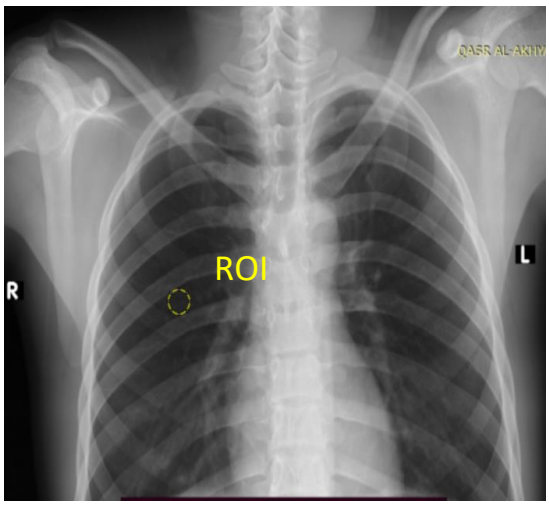

Figure (3) shows selecting ROI

Signal to noise ratio (SNR):

For SNR determination, a homogeneous region on the image is selected as the ROI, and its mean signal is measured Then, the mean signal is divided by the standard deviation, as shown in (Fig 3). Then, the mean signal is divided by the standard deviation, using the equation number (2)[7]. Estimating the SNR is a common method to quantify image noise [6]. The threshold SNR for detecting objects in a medical image is ≥ 5 [8].

$$SNR = \frac{mean\ signal\ of\ ROI}{StdDev\ of\ ROI} \quad (2)$$

3. Results and Discussion:

Table (2) demonstrates that Group B achieved higher CNR values while Group A achieved higher SNR values in all examinations compared to Groups C. This suggests that the differences in X-ray tube output may be due to variations in machine calibration or radiographer setup.

The mean CNR values are 18.82 for Group A, 22.59 for Group B, and 15.32 for Group C. The mean SNR values are 13.69 for Group A, 8.53 for Group B, and 6.98 for Group C, as shown in (fig 4). The machine in Group B has the highest mean CNR, while Group C has the lowest CNR mean at 15.32. The highest mean SNR is found in Group A at 13.69, with Group C recording the lowest mean SNR. And it was consistent to the study of *Daniel* Ackom (2017).

Table (2) show the result of mean CNR and mean SNR for each case of three group

P. N	Mean CNR	Mean SNR	
1	21.277	10.589	Group A
2	17.615	11.003	
3	26.074	21.673	
4	10.302	11.511	
5	22.467	8.08	Group B
6	14.554	6.532	
7	37.31	8.454	
8	16.047	11.04	
9	27.152	9.689	Group C
10	13.089	2.545	
11	15.561	5.275	
12	5.481	10.394	

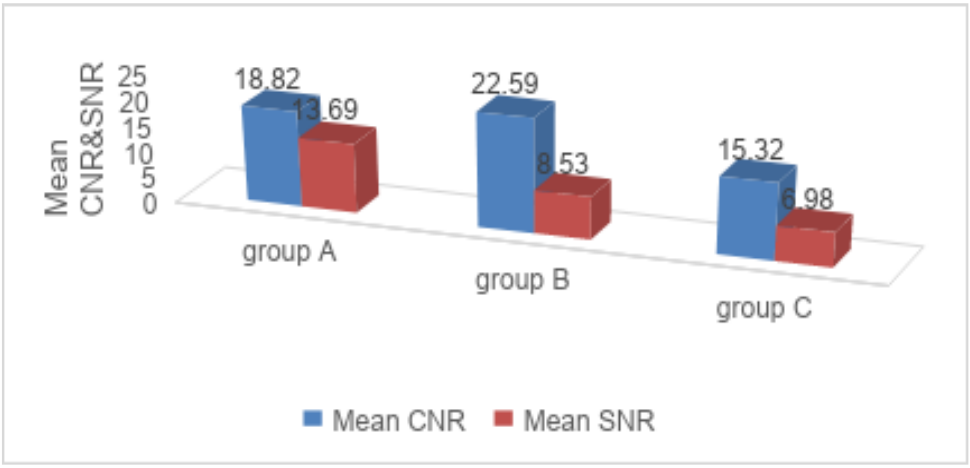

Figure (4), shows comparative bar chart of mean CNR and SNR for three groups

4. Conclusion:

This study has highlighted differences in image quality, noise, and contrast among the machines. Group B's machine excels in tissue contrast, while Group A's machine exhibits the least noise. Conversely, Group C's machine shows the lowest CNR and SNR values, resulting in noisier images with lower contrast and resolution compared to Groups A and B. Measuring Contrast-to-Noise Ratio (CNR) and Signal-to-Noise Ratio (SNR) using ImageJ proves essential for assessing image quality, making this software valuable for such evaluations.

5. References:

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