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QUALITY CONTROL ASSESSMENT OF EXPOSURE FACTORS OF SELECTED CONVENTIONAL X-RAY MACHINES

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ABSTRACT:

This study aimed to determine the Accuracy of Exposure Factors (Kvp and mAs) in Conventional X-ray Machines by using Kvp meter Nero-Max 8000, in this research Extensive measurements were made to assess the changes of KVp, mAs in terms of the accuracy of measurement. and compared with the international tolerance. The main result show that there was small variation between the stated (kvp and mAs) and (kvp and mAs) measured by the kvp meter at low (kvp and mAs) where at high kilovoltage there are big variation. The accuracy of Kvp measurement for [M1, M3, M4, M5] machines are within the tolerance limit and The accuracy of Kvp measurement for machine [M2] are out of the tolerance limit (± 5%) and this means that machine [M2] need to be calibrated and adjusted. for The accuracy of mAs measurement for [M2, M3, M4, M5] machines are within the tolerance limit and The accuracy of mAs measurement for machine [M1] are out of the tolerance limit (± 10%).

Introduction:

Diagnostic radiology involved low deliver very small amount of radiation dose to the patient and this has to give attention to implement quality assurance and quality control [1]. However, the diagnostic x-ray technology has rapidly increased and significantly increase the patient radiation dose, which can now reach very high, even deterministic values. Furthermore, the importance of accurate diagnosis for the patient management has created a new reality in which the requirements for quality have been tremendously expanded. [2, 3]. The problem is caused from incorrect use of radiography equipment and from the radiation exposure to patients much more than required. International Commission on Radiation Protection (ICRP), the International Atomic Energy Agency (IAEA) have been making publications in relation to ionizing radiation protection for more than fifty years. [2].

Quality control (QC) represents the most basic form of quality related activities and its main objective is to ensure that a system or a service fulfils the established quality requirements [4]. The principle goal of quality assurance of x-ray machine is to obtain accurate and timely diagnosis. The secondary goals are minimization of radiation exposure and obtain high image quality. This can be assessing by performance the x-ray machine by optimum operating parameters such as reproducibility of tube voltage, dose output, time, x-ray tube efficiency, Accuracy of kvp, mAs, focal spot size and One of the parameters used to assess the quality control of X-ray machine is Exposure factors (kvp, mAs). [2, 3].

To achieve the quality control goals, some hospitals in Sudan have implemented quality control programs in X-ray radiology follow the international guidelines [5, 6, 7].

Many authors published work concerning quality assurance of x-ray machine, describes quality assurance protocol for diagnostic x-ray equipment at the radiologic technologist level, Considering the importance of QC tests in Patients' radiation exposure, several previous studies have been performed (Mohammed, 2017: Behrouz Rasuli, 2015: M.H Kharita, 2008: M. Begum, 2011: Al-Kinani, 2014: Taha.M. T, 2015: Yesaya Y, et al, 2006) [8, 9, 10, 11, 12, 13, 14].

Some of those studies revealed that QC can reduce patient dose by at least 30%. The Objectives of this research is to determine the Accuracy of Exposure Factors (kV and mAs) to assurance quality in Conventional X-Ray Machines by Checking the accuracy of exposure factors (KVp and mAs) using KV meter.

2. Materials and Methods:

2.1Materials:

In this study five different units of X-ray machines from different hospitals in Khartoum state were selected and A digital KVP meter model Kvp meter NeroMax 8000 was used to check accuracy of exposure output factors (KVp and mAs). The devices selected belong to high-load radiology departments.

2.2. Methods:

This study was conducted in 5 hospitals in Khartoum State, the KV meter was Placed on the tabletop with the Detectors facing the x-ray tube positioned at 1 meter of the focal spot of the X-ray tube and centered the tube accurately to the sensor area and collimate the beam to its edges, switched on the KVp meter and allow it to warm up, ensure it is working correctly. Exposure factors KVp and mAs were sated from the console each time the test is carried out, referring to the operating instruction of digital meter for correct exposure conditions. And Recorded the reading on KVp meter display, for each kVp meter were made measurements in the range from 45kV to 85kV. The measurements were increased in steps of 5kV. For each selected X-ray equipment were take 9 measurements. Repeated the exposure 9 times and all readings were recorded on the result sheet, the data was analyzed using excel program, Extensive measurements were made to assess the changes of KVp, mAs in terms of the accuracy of measurement. and compared with the international tolerance.

KVp and mAs accuracy was calculated from measured parameters using the equation below:

$$\text{Accuracy} = \left| Xm\text{-}Xn/Xn \right| \; 100\ \%$$

Where: Xm is the measured value of peak tube kilovoltage (kVp) or mAs from the KV meter, and Xn is the value of the selected (setting) kilovoltage (kV) from the control panel of the X-ray machine.

3. Results:

This study involved assessment of Exposure Factors for 5 x-ray equipment, KV Accuracy and mAs accuracy for different settings of 5 X-ray machines was examined by setting the source to detector distance at 100 cm of exposure, different KV and mAs interval where measured. the table and figures below show the KV and mAs Measurement and the accuracy was calculated for each measurement.

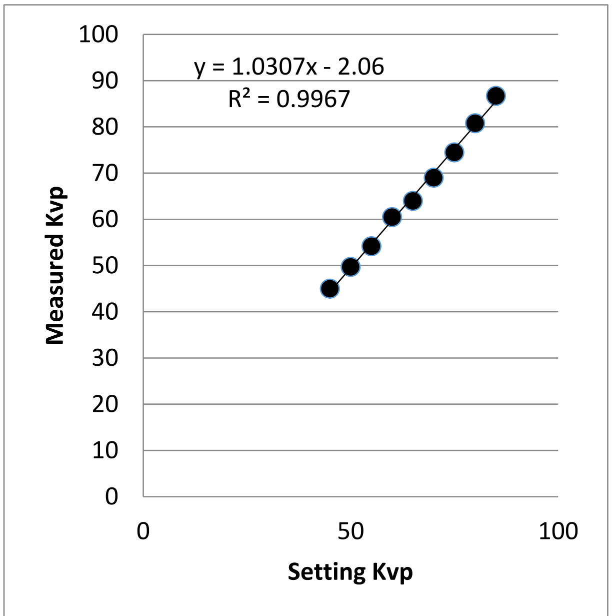

Figure (3-1) shows the correlation between setting Kvp and measured Kvp for machine [M1].

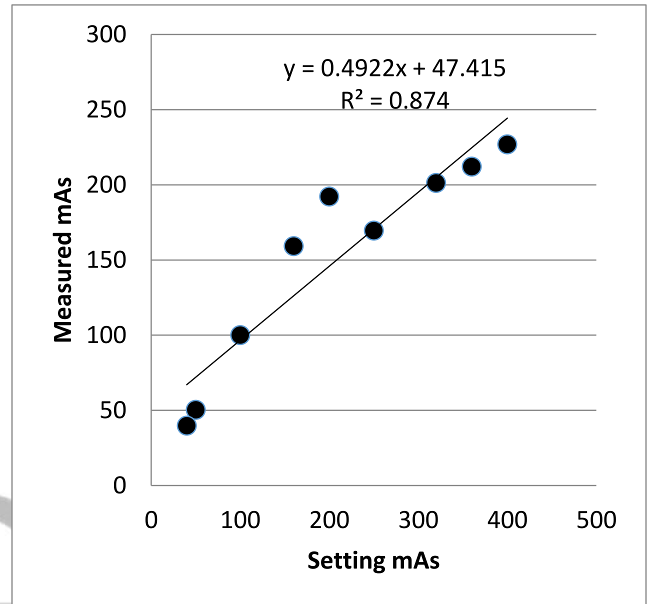

Figure (3-2) show the correlationship between setting mAs and measured mAs for machine [M1].

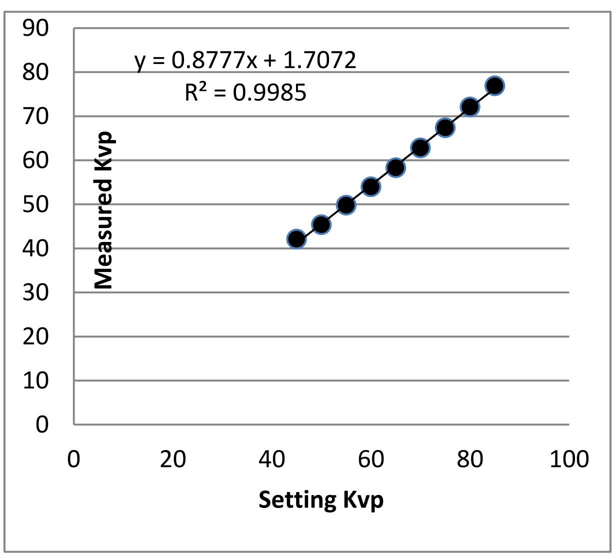

Figure (3-3) shows the correlation between setting Kvp and measured Kvp for machine [M2].

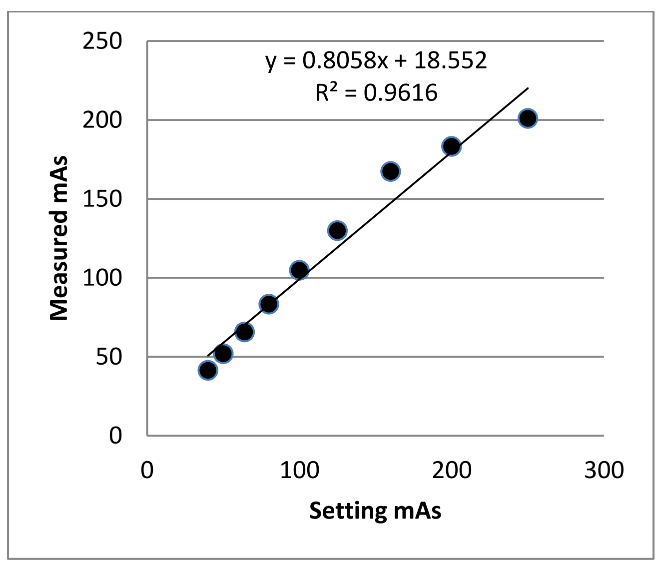

Figure (3-4) shows the correlation between setting mAs and measured mAs for machine [M2].

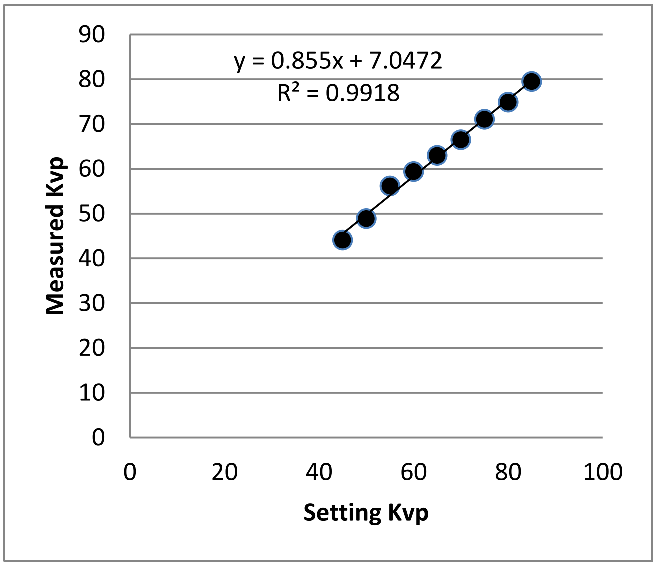

Figure (3-5) shows the correlation between setting Kvp and measured Kvp for machine [M3].

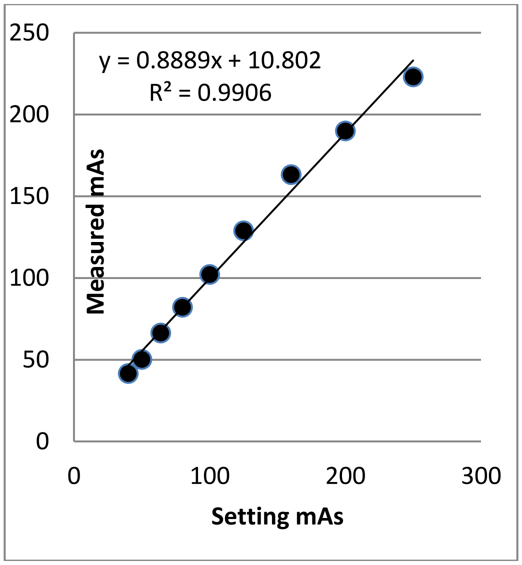

Figure (3-6) shows the correlation between setting mAs and measured mAs for machine [M3].

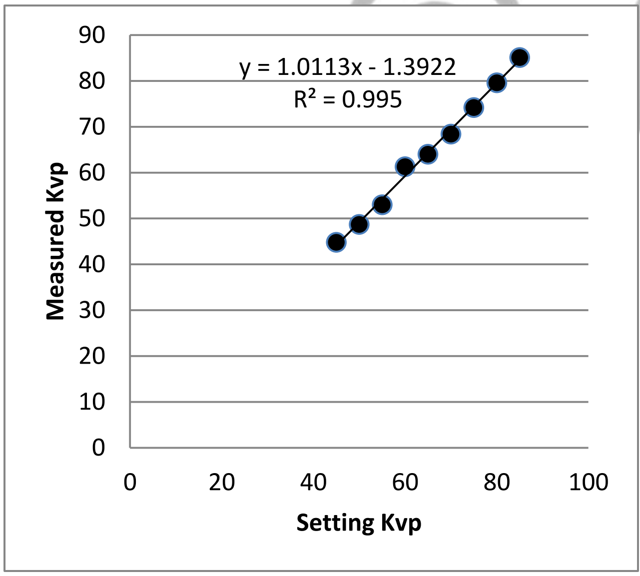

Figure (3-7) shows the correlation between setting Kvp and measured Kvp for machine [M4].

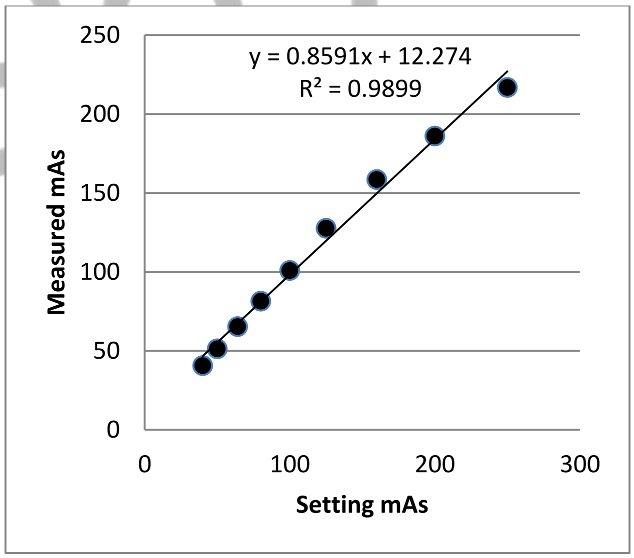

Figure (3-8) shows the correlation between setting mAs and measured mAs for machine [M4].

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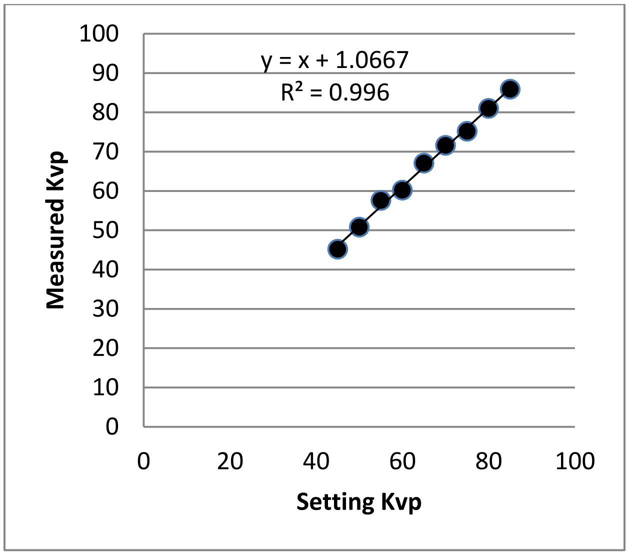

Figure (3-9) shows the correlation between setting Kvp and measured Kvp for machine [M5].

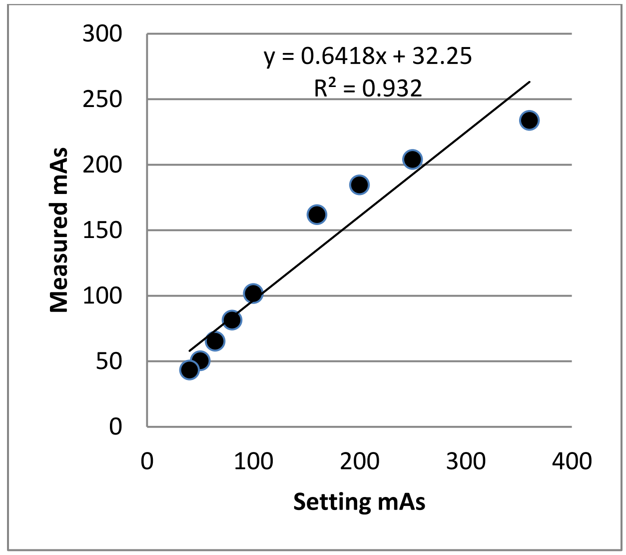

Figure (3-10) shows the correlation between setting mAs and measured mAs for machine [M5].

Table (3-1) show the average setting and measured Kvp and mAs for machines [M_1, M_2, M_3, M_4, M_5].

Machine	kilo voltage Accuracy %	Milliampere second Accuracy %
M_1	1.06	17.67
M_2	9.47	6.16
M_3	3.72	3.75
M_4	1.60	3.62
M_5	1.69	8.60

4. Discussions:

The absence of exposure factors accuracy plays a role in declination of the medical services standard and lead to the lack of manual operations, anatomical and the fact that the exposure chart was improbably used in the radiology departments and referring to image quality the poor quality image mainly due to bad positioning, bad selection of exposure factors. This study aimed to determine the Accuracy of Exposure Factors in Conventional X-ray Machines by using multifunction meter (Kvp and mAs) the main result show that there was small variation between the stated (kvp and mAs) and (kvp and mAs) measured by the kvp meter at low (kvp and mAs) where at high kilovoltage there are big variation. For machine [1] the highest poor accuracy obtained was 43.25% for mAs measurement at 400 mAs with error 173 mAs and the best measurement accuracy obtained is 0% with zero error and figure 3.1 shows positive correlation between Kvp selected and Kvp measured (R2 = .9967) and figure 3.2. Shows positive correlation between mAs selected and mAs measured (R2 = .874). For machine [2] the highest poor accuracy obtained was 19.64 % for mAs measurement at 250 mAs with error 49.1 mAs and the best measurement accuracy obtained is 2.66 % with 1.7 error and the correlation was showed in the figure 3.3 which is positive correlation between Kvp selected and Kvp measured (R2 = .8777) and figure 3.4. shows positive correlation between mAs selected and mAs measured (R2 = .9616). For machine [3] the highest poor accuracy obtained was 10.8 % for mAs measurement at 250 mAs with error 27 mAs and the best measurement accuracy obtained is .4 % with .2 error and the correlation was showed in the figure 3.5 which is positive correlation between Kvp selected and Kvp measured (R2 = .9918) and figure 3.6. shows positive correlation between mAs selected and mAs measured (R2 = .9906). For machine [4] the highest poor accuracy obtained was 6.95 % for mAs measurement at 200 mAs with error 13.9 mAs and the best measurement accuracy obtained is .12 % with .1 error and the correlation was showed in the figure 3.7 which is positive correlation between Kvp selected and Kvp measured (R2 = .995) and figure 3.8. shows positive correlation between mAs selected and mAs measured (R2 = .9899). For machine [5] the highest poor accuracy obtained was 35.03 % for mAs measurement at 360 mAs with error 26.1 mAs and the best measurement accuracy obtained is .27 % with .2 error and the correlation was showed in the figure 3.9 which is positive correlation between Kvp selected and Kvp measured (R2 = .996) and figure 3.10. shows positive correlation between mAs selected and mAs measured (R2 = .932). The accuracy of KVp measurement for [M1, M3, M4, M5] machines are within the tolerance limit and The accuracy of KVp measurement for machine [M2] are out of the tolerance limit (± 5%) which give accuracy of [9.47%] and that mean this machine need to be calibrated and adjusted and for The accuracy of mAs measurement for [M2, M3, M4, M5] machines are within the tolerance limit and The accuracy of mAs measurement for machine [M1] is out of the tolerance limit (± 10%) which give accuracy of [17.67%] and this means that [M1] machine need to be calibrated and adjusted. [15].

5. Conclusion:

The misunderstanding of the staff to their roles in implementing quality control program, in addition to the absence of essential advantage testing tools, this made most x-ray machines in diagnostic department in Khartoum state not calibrated which result in poor image quality. By implementing of kvp and time accuracy program many benefits can be reached. Saving of money by reducing material usage, save time, and reduce the radiation dose to both patient and the staff.

Finally, it is clear that applying of QC program concerning kV and time accuracy is very important to the production of image quality and reducing the radiation dose to the patient. Proper training courses should be established to improve staff skills regarding quality control, Essential test tools must be available in all departments, Establishment of staff regular meeting to discuss image quality, Controlling the exposure factor by introduce anatomical setting and exposure chart.

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