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Assessment of Beam Quality in Some Radio Diagnostic Centers

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Abstract: In general, ionizing radiation and in particular X-rays plays a very important role in medical examinations for diagnostic purposes. The rapid growth of the number of procedures for diagnostic reason in medicine as a result led to increase the number of equipment for X ray generation, which consequently has increased the patients dose and in the same time is increased the risk of malignant diseases. Measurement parameters of quality assessment for X radiation generators are done at nine different diagnostic centers of public sector in Kosovo during the period 2014-2015. Measurements consist on accuracy of tube voltage, reproducibility of output voltage, total filtration of the x-ray tube and delivered radiation dose. Measurements were performed using Multimeter PTW NOMEX and DAP (Dose Area Product) Meter PTW Diamentor CM.

Key words: Ionizing radiation, x-ray, quality assessment.

INTRODUCTION

All imaging methods with ionizing radiation deliver energy to the patient's body during diagnostic examination. It is very important to have under control the quantity of deposited energy and at the same time it should be kept within the parameters of accepted international standards. On common diagnostic examinations, the beam should penetrate through the patient's body. The point that is exposed to the highest dose is definitely the surface (skin) that is closest to the source of the beam. There are two main reasons why this happens. Primary beam is not absorbed (weakened) by the tissue at this point and this part of the area is exposed also by scattered radiation of patient's body. The amount of surface dose is dependent by quality of primary beam, source to surface distance and by exposed size surface. For ordinary radiography exposures, the total dose will be increased about 20 % only by scatter radiation.

The x-ray beam is absorbed during penetration through the patient's body, it is absorbed (weakened) so that various body tissues weaken or absorb X-rays in different ways, depending on their composition. When homogeneous X-ray beam crosses human body, it will become non-inhomogeneous, because some tissue can absorbed more than others. The penetrated beam represents the form and the type of tissue that is passed. Also the level of weakening the power of the X-ray beam also depends by photon energy (kV and filtration) [1]. Basic Safety Standards [2] require special attention for quality of image and to consider all necessary actions to ensure that the patient exposure provide sufficient information to achieve the goal of radio diagnostics examinations. Also, in 1982, the International Commission on Radiation Protection (ICRP) asked that the dose delivered to the patients for specific practices by medical centers has to be within factors from two up to ten [3].

One of the biggest compromises that must be made in imaging procedures that use ionizing radiation is the dose at which the patient is exposed and the image quality obtained during diagnostics examinations. Therefore, the objective in raising diagnostics imaging procedures is to select factors that provide quality control. In this study are analyzed all parameters of X-ray which are used to calculate patient dose through the two-step protocol: 1. voltage measurement accuracy (kV) and repeatability of voltage accuracy, total filtration and 2. Entrance surface dose (skin). The average obtained surface dose values (skin) are compared with International Guiding levels recommended by the International Atomic Energy Agency (IAEA) for each examination.

MATERIALS AND METHODS

In practice, the parameters of X-ray generators (kV, mAs, sec, etc.) used in medical exposures are very important for reducing patient dose and to obtain acceptable quality images. Patient dose reduction can be obtained by appropriate changes to input parameters, without losing image quality.

Beam quantity (mR/mAs) at a specified distance varies as a function of tube voltage, tube voltage reproducibility, tube current and total filtration. The survey was conducted during regular quality control from 2014 and 2015 of diagnostic radiography departments of Main Family Medicine Centers in Kosovo. Measurements of output parameters of x-ray beam are conducted using Nomex PTW Multimeter device, calibrated in Dosimetry Laboratory Standard Secondary (Secondary Standard dosimetry Laboratory - SSDL).

PTW NOMEX Multimeter was positioned in central beam axis such that the X-ray tube focal spot–detector-distance (FDD) was 100 cm. The radiation field size (FS) at FDD was set just to cover the dosimeter in order to avoid the possible influence of scatter radiation to the dosimeter. Accuracy for parameters: tube voltage, tube voltage reproducibility. The tube potential was set at more than 70 kVp and any mAs value (depending on convenient tube load conditions), an X-ray exposure made and the dosimeter reading recorded. This step was repeated for 4 times more at same kVp and mAs settings and the average dosimeter reading determined. The X-ray tube output was determined as the ratio of average dosimeter reading (air kerma) to the tube current-time product used. These measurements cover voltage from 60 kV up to 110 kV (60, 70, 80, 90, 100 and 110).

The output parameters on x-ray beam were measured by NOMEX multimeter on the remote mode command from 60 to 110 kV. At some cases on table nr 3 are missing values above 100 kV due to lack of use by staff employees and in order to maintain the generators so (use these values is recommended in certain cases).

RESULTS AND DISCUSION

There are nine Main Family Medical Centers in Kosovo under the study, acronyms MFMC followed by specific number is used to distinguish them. For organization reasons results of this study will be presented in separate parts.

Accuracy of tube voltage: In screen film radiography, the choice of x-ray tube voltage (kV) affected the image contrast; of course this is no longer the case for any digital radiographic system. So it is very important to check if the output voltage is within 10%[4] of given voltage (nominal) by radiographer. Increasing kV increases the number of photons produced and also the penetration of the x-ray beam, this increase may also cause the image to be over-exposed and appear too dark. These measurements on accuracy of tube voltage cover voltage from 60 kV up to 100 kV (60, 70, 80, 90 and 100).

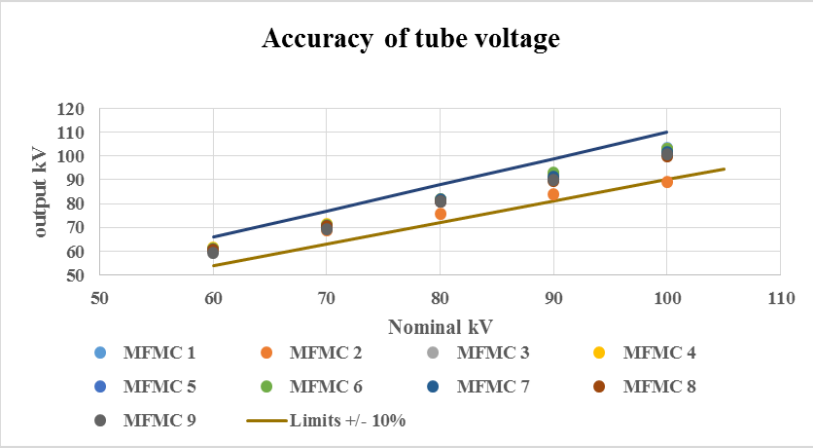


Figure 1: Accuracy of tube voltage.

Figure 1 shows the nominal voltage and the mean measured voltage of tube for each Main Family Medical Centers. The values presented in the figure shows the average of 4 or 5 exposures in the same conditions.

Deviation from nominal voltage is determined by the expression:

$$\Delta = \frac{(U_m - U_n)}{U_n} \cdot 100\% \quad \ldots [1]$$

Where: U_m – measured tube Voltage, and U_n –nominal tube Voltage. Only one from nine radiodiagnostic centers did not fill full standards on accuracy of tube voltage. It is Main Family Medical Centre number 2. To more specific this centre is not within international standards for voltage above 100 kV.

Reproducibility of output voltage: International standards gives limits for single and three phase generators used in general purpose radiography, kV indicators should represent the average of the peaks in the voltage waveform to within ±5%[4].

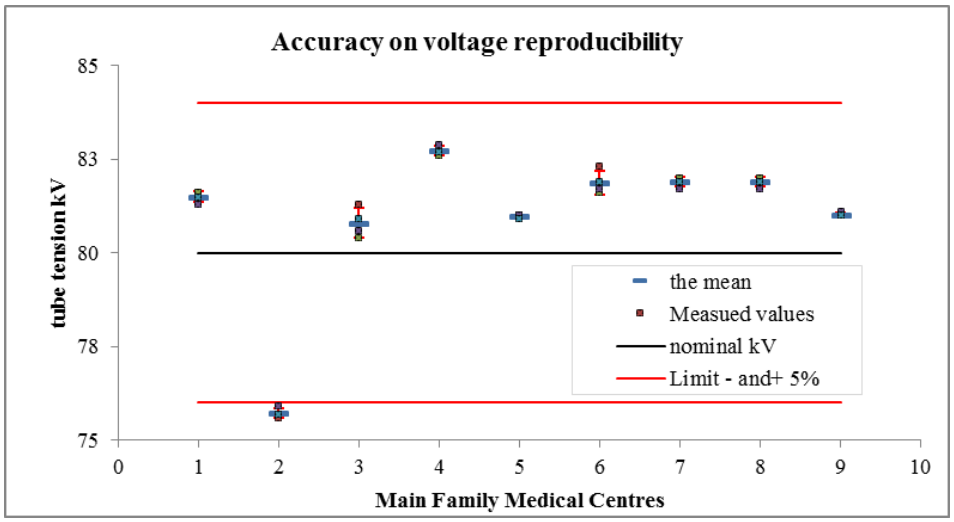


Figure 2: Accuracy on repeated tube tension.

On **Figure 2** shows the results of the repeated accuracy from given voltage (nominal).

Deviation from nominal voltage is determined by the expression:

$$\Delta = \frac{\sqrt{\frac{(U_m - \overline{U})^2}{n-1}}}{\overline{U}} \cdot 100\% \quad \ldots [2]$$

Where: U_m – measured tube Voltage, and $\overline{U}$ – is mean value of measured tube voltage. Only one from nine radio diagnostic centres did not fill full standards, it is MFMC2.

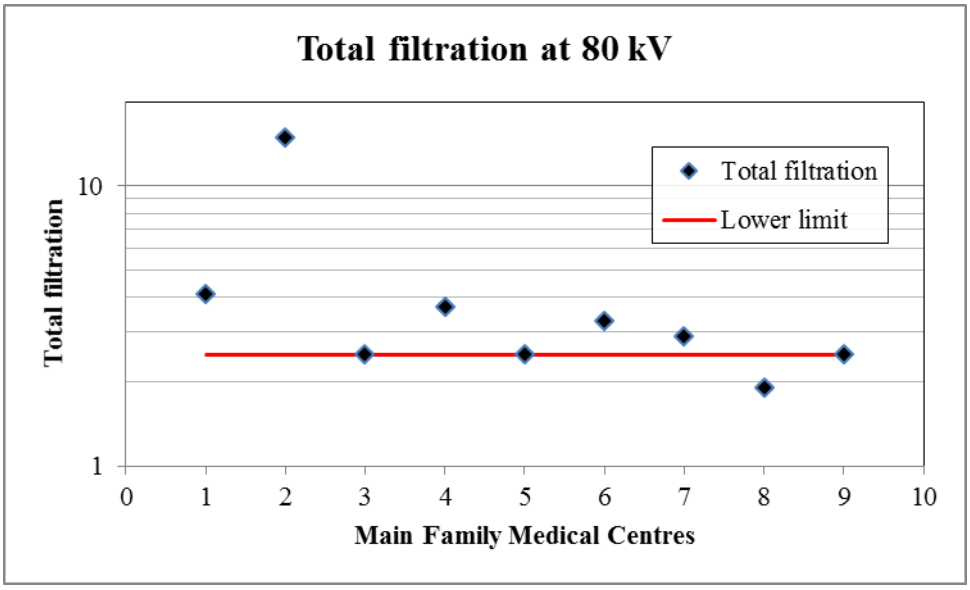


Figure 3: Total filtration at 80 kV.

Total filtration: Low energy photons cannot penetrate the part of patients, they contribute only to patient dose. Material purposefully introduced into the beam to further reduce the presence of low energy x-rays relative to high energy x-rays (hardening the beam) is often referred to as added filtration. The sum of all the material the x-rays must pass through before emerging as the useful beam is termed the total filtration. Total filtration at 80 kV must be more than 2.5 mmAl. Total filtration is made by the sum of Inherent filtration of x-ray tube, mirror and added Aluminum plate between tube housing and collimator. Total filtration of MFMC8 is less than 1mmAl, so this tube did not fill full international standard.

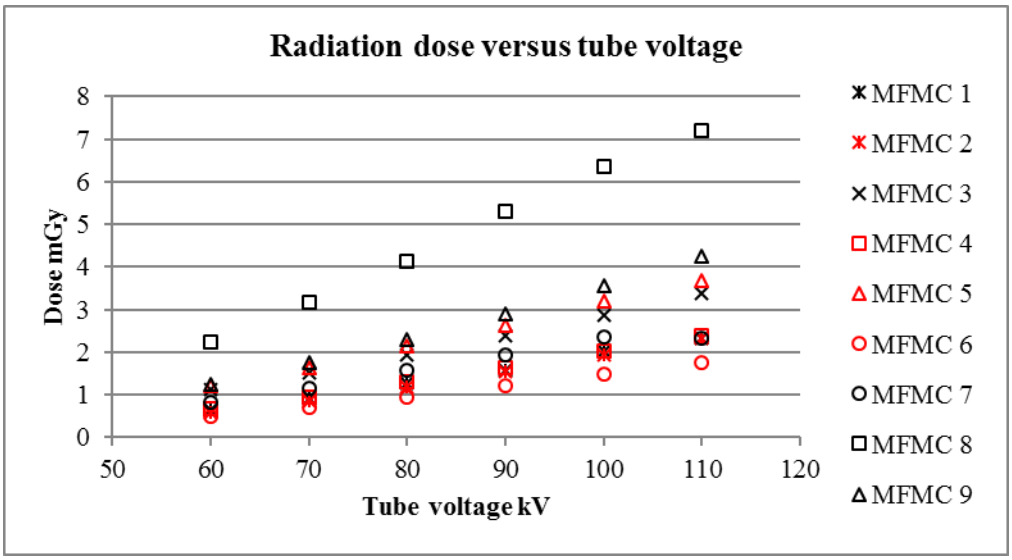


Figure 4: Radiation dose versus tube voltage.

Radiation dose: Tube tension and filtration have direct impact to delivered dose from x-ray machines. All of 9 MFMC's are showing similar characteristic of dose, but the highest values are from MFMC8. Already in all different tests MFMC8 shows twice dose than others. All of the x-ray generators under the test give good linearity between tube tension and radiation dose.

CONCLUSION

In this study, they are taken into account a number of important parameters for quality control of X-ray generators and patient dose reduction. Measurements carried out in different health treatment centers for tube voltage and reproducibility of output voltage show that in most cases this parameter is within the boundaries of international standards, Except in one case MFMC2, at voltages of 100 kV; Also in the case of total filtration, the greater deviation from international standard is observed at MFMC8, so this tube did not fill full international standard. The highest dose delivered by MFMC8 x-ray generator, in most of cases it gives twice dose than other generators for the same tube voltage. This higher dose is linked to lower total filtration. To managements of medical centers MFMC2 and MFMC8, is recommended to do calibration and A-test of X-ray generators.

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