QUALITY CONTROL OF MAMMOGRAPHY EQUIPMENT

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Abstract

The role of mammography in diagnostics of breast cancers is well established. The image quality and dose received by patients depend on the equipment used. In accordance with the national regulations, a periodic quality control of physical and technical parameters is needed to monitor and evaluate the absorbed dose and image quality. In this study is performed the quality control of mammography referring to the international standards and different protocols of the quality control of mammographic equipment. The results of this study show that the physical and technical parameters are within the reference levels, therefore this data will serve as a useful baseline information for monitoring the performance of the equipment.

Key words: mammography, quality control, protocols.

Introduction

The most frequent cancer among women is the breast cancer, impacting 2.1 million women each year. Breast cancer causes the greatest number of cancer related deaths among women (WHO, 2019). In order to improve breast cancer outcomes and survival, early detection is critical. Mammography is a radiological examination allowing systematic detection of breast cancer, as early detection. Mammography uses low energy X-rays to identify abnormalities in the breast. Mammogram, the most of time, is used to look for breast cancer that is too small in women who have no breast complaints or symptoms (ACS, 2010). The quality of the mammography image is essential for diagnosis of breast cancer. The quality control of the mammography equipment, establishing periodic tests, is important for the quality of the image and the security of the patient to monitor the breast absorbed dose. In this work is presented the quality control of a mammography equipment, installed in a Tirana private clinic, according to the International protocols and Albanian Government by Council Ministers Decision CDM No. 414, date 18.6.2014 (VKM, 2014).

Materials and methods

The mammography equipment is manufactured by Siemens (USA). The anode/filter is Mo/Mo. The mammography is digital. To perform the quality control, the multimeter RaySafe Xi is used with the appropriate detector. The RaySafe Xi R/F MAM detector is capable of measuring kVp, dose, dose rate, pulse, pulse rate, dose/frame, time, HVL, total filtration and waveforms simultaneously. The dose measurement range is 10nGy-9999Gy with uncertainty of 5%. The kV/kVp measurement range is 35-160 kV/kVp with uncertainty of 2% (for up to 0.5 mmCu equivalent) and with uncertainty of 3% (0.5-1mm Cu equivalent). The HVL measurement range is 1-14 mm Al with uncertainty of 10%. The exposure time measurement range is 1ms-999s with uncertainty of 0.5% or 0.2ms. The Focus Detector Distance is 77cm. In Figure 1 is presented the multimeter and the detector used for measurements.

Figure 1. The multimeter RaySafe Xi

Based on the Albanian Government CMD No. 414, date 18.6.2014 and International Protocols we have considered basic techniques for the quality control of the physical and technical aspects of the mammography, such as tube voltage accuracy, reproducibility, output rate and beam quality. Referred to the Mammography Quality Standards Act regulation (MQSA) these controls are annually quality control tests. The tube voltage accuracy should be within ±5 percent of the indicated kV. At the most commonly used clinical settings of kVp, the coefficient of variation of reproducibility shall be equal to or less than 0.02 (2%). Referred to the Albanian Government CMD No. 414, date 18.6.2014 the kV accuracy should be within ±10% of the indicated kV and reproducibility should be within ±5%. When the system is operating at 28kVp, it shall be capable to produce a minimum output (dose rate) of 7mGy/s (MQSA).

The European Protocol for the Quality Control of the Physical and Technical Aspects of Mammography Screening1999, recommends that the dose rate should be within the range 10mGy/s – 30mGy/s and the control should be every six months. The beam quality is expressed by the Half Value Layer (HVL). The HVL is defined as the thickness of attenuating material required to reduce the beam intensity to half of its original value.The limited value of HVL for 28kVp with anode/filter Mo/Mo must to be over 0.3 mm Al (MQSA, The European Protocol for the Quality Control of the Physical and Technical Aspect of Mammography Screening, 1999). Based on the Radiation Protection and Quality Standards in Mammography, Safety Code 36 (2013) the HVL of aluminium measurement, with the compression paddle, must be within the range defined by:

$$\frac{XrayTubeVoltage\ (kV)}{100} + 0.03 \le \text{HVL (mm Al)} \le \frac{X\ ray\ Tube\ Voltage\ (kV)}{100} + C$$

(1)

where: C= 0.12 for Mo/Mo

For tube voltage 28kV the HVL must be within the range:

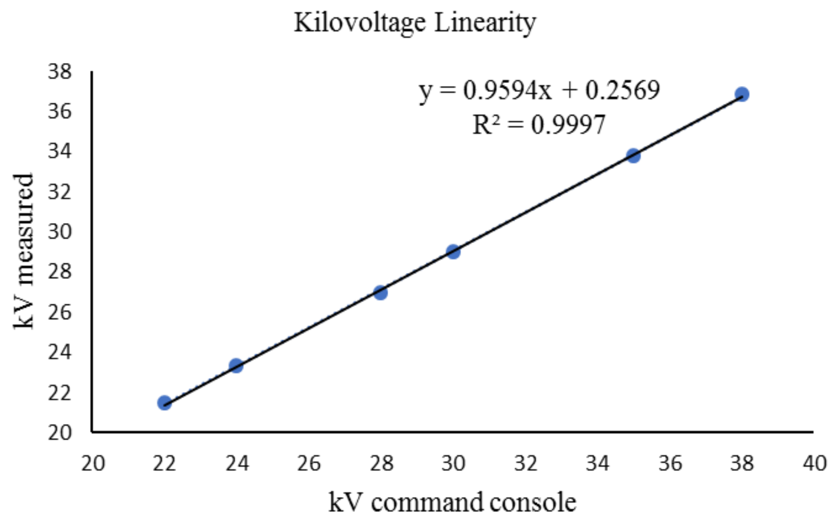
$$0{,}31 \le \text{HVL (mm Al)} \le 0{,}4$$

The coefficient of variation (COV) of reproducibility shall be equal to or less than 5% (Bloomquist et al, 2006).

Results and discussions

The kilovoltage linearity of the mammography equipment with the regression coefficient R^2= 0.9997 is presented in Figure 1. The consistency of the tube kilovoltage from the product I*t is presented in Table 1. The maximum deviation of the kV measured from the kV of the command console is less than 5%. In Table2 is presented the reproducibility of the voltage values with the parameters: U=28kV, It=20mAs, FDD=77cm. The coefficient of variation COV is 0.06% and is less than 2%. Also the coefficient of variation is less than 2% for other voltage values. In Table 3 is presented the reproducibility of the voltage values with the parameters: U=28kV, I*t=100mAs, FDD=77cm. The coefficient of variation is 0.02% and is less than 2%.

In Table 4 are presented the average dose rate values at 28kV (tube voltage) for different product I*t I, with FDD = 77cm. The average dose rate values are within the range 10mGy/s-30mGy/s based on the European Protocol for the Quality Control of the Physical and Technical Aspects of Mammography Screening criteria and also fulfil the criteria of minimum value of 7 mGy/s. In Table 5 are presented the average HVL values at 28kV (tube voltage) for different product I*t. The HVL-s are 0.36 mm Al equivalent and fulfil the criteria of MQSA, European Protocol for the Quality Control of the Physical and Technical Aspects of mammography screening and criteria of Radiation Protection and Quality Standards in mammography, Safety Code 36. The maximum COV value is 0.23% and fulfil the criteria to be less than 5%.



Kilovoltage linearity of mammography equipment, (I*t=100mAs),

Figure 1. Table 1 Consistency of output from product I*t

	U = 24 kV, FDD = 77 cm			
kV measurement	23,44	23,51	23,58	23,6
mAs prescribed	10	20	40	80
ΔkV (%)	-2,33	-2,04	-1.75	-1,67

Table 2- The reproducibility of the X-tube voltage

Deviation from average value. U=28kV, It=20mAs, FDD=77cm

	U=28kV, I*t=20 mAs FDD=77cm					
kV measurement	27.3	27.28	27.25	27.29	27.29	27.3
ΔkV (%)	-0.04%	0.05%	0.00%	-0.01%	0.00%	0.00%

*Average Value U_m=27.29, ST.DEV=0.02, COV=0.06%

Table 3- The reproducibility

of the X-tube voltage

Deviation from average value. U=28kV, It=100mAs, FDD=77cm

	U=28kV, I*t=100 mAs FDD=77cm					
kV measurement	27.40	27.42	27.42	27.42	27.41	27.41
ΔkV (%)	-0.03%	0.01%	0.03%	0.03%	0.01%	0.01%

*Average Value U_m=27.41, ST.DEV=0.01, COV=0.02%

Table 4. The average values of Dose rate at 28kV for different product I*t

	U = 28 kV, FDD = 77 cm			
mAs prescribed	10	20	63	100
Average value Dose Rate (mGy/s)	10.36	10,41	10,49	10,49

Table 5. The average values of HVL at 28kV for different product I*t

	U = 28 kV, FDD = 77 cm			
mAs prescribed	10	20	63	100
Average value HVL (mm Al eq)	0,36	0,36	0,36	0,36

Conclusions

The results show that tube voltage accuracy, reproducibility, output rate and beam quality met the reference level recommended by the international protocols also by the Albanian Government CMD No. 414, date 18.6.2014.

Periodic control is important for the security of the patient, for the quality of the image and the performance of the mammography equipment. We recommend to perform the quality control of the mammography equipment as is shown in this work. The measured data are useful as a baseline for the performance of the equipment in the future.

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