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Establishment of the practical peak voltage for standard computed tomography radiation qualities at a Calibration Laboratory

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1. INTRODUCTION

At the Calibration Laboratory of IPEN (LCI), several instruments are routinely calibrated using different types of radiations (beta, gamma, X). To guarantee the required accuracy in the calibration procedures, it is necessary to characterize the X-ray equipment. Therefore several parameters need to be known such as tube voltage, tube current, anode angle, and inherent and added filtrations. One of the most important parameters is the tube voltage, because it strongly influences the dose to patients and the exposure of the image receptor.

In order to define a measurable standard quantity for the X-ray tube voltage, the practical peak voltage (PPV) was proposed by Kramer and collaborators (1998). The PPV presents some interesting characteristics: capability to define a reproducible physical method for voltage measurement; easiness in its measurement; clinical relevance and pertinence to technical aspects of the X-ray equipment (IAEA, 2007).

2. OBJECTIVES

In the present work noninvasive meters were utilized for the measurement of the PPV and the peak and mean kilovoltage values at the X-ray system of LCI in the established standard computed tomography radiation qualities

3. MATERIALS

Radcal Accu-kV® noninvasive meter

PTW Diavolt noninvasive meter

Standard computed tomography radiation qualities at the Pantak/Seifert X-ray equipment, using a constant tube current of 10 mA (IEC, 2005)

Radiation quality	Tube voltage (kV)	Additional filtration		Half-value layer (mmAl)	Air kerma rate (mGy/min)
		mmAl	mmCu		
RQT8	100	3.2	0.30	6.90	22.0 ± 0.33
RQT9	120	3.5	0.35	8.40	34.0 ± 0.51

4. Results

PPV Measurements

Mean values of the PPV, measured with the Accu-kV® and Diavolt meters in **RQT8** standard computed tomography standard radiation quality

	PPV (kV)		
Distance (m)	Accu-kV™	Diavolt™	Difference (%)
0.37	102.2±2.7	104.8±3.1	2.5
0.50	102.2±2.9	104.2±3.0	1.9
1.00	102.0±2.5	104.2±3.1	2.1

Mean values of the PPV, measured with the Accu-kV® and Diavolt meters in **RQT9** standard computed tomography standard radiation quality

	PPV (kV)		
Distance (m)	Accu-kV™	Diavolt™	Difference (%)
0.37	122.1±3.0	118.9±3.4	2.7
0.50	122.0±3.2	118.5±3.2	3.0
1.00	121.8±3.0	118.6±3.3	2.7

All values, obtained with both meters, are within the international recommendations (IAEA, 2007) which establish a maximum variation of 5%.

It is important to note that in this work the X-ray system characteristics were evaluated specific of LCI, and thus the purpose is not to address the advantages or limits of the two noninvasive meters utilized for the measurements.

The main reason for the higher variation of the PTW Diavolt™ equipment is probably due to the difference between the setup configurations and the materials utilized for the additional filtration. The standard computed tomography radiation qualities established at LCI utilize both aluminum and copper filters while the Diavolt™ equipment presents just aluminum filters on its software menu. In another study, Vivolo *et al.* (2012), using the standard diagnostic radiology radiation quality RQR5, presented results in a better agreement among the meters and the nominal applied voltages.

kVp Measurements

kVp values, measured with the Accu-kV™ noninvasive meter and the nominal applied voltage in **RQT8** standard computed tomography radiation quality

	kVp (kV)		
Distance (m)	Accu-kV™	Nominal	Difference (%)
0.37	102.3±2.7	100.0	2.3
0.50	102.2±2.5	100.0	2.2
1.00	102.1±2.5	100.0	2.1

kVp values, measured with the Accu-kV™ noninvasive meter and the nominal applied voltage in **RQT9** standard computed tomography radiation quality

	kVp (kV)		
Distance (m)	Accu-kV™	Nominal	Difference (%)
0.37	122.2±2.9	120.0	1.8
0.50	122.2±2.7	120.0	1.8
1.00	122.0±2.5	120.0	1.7

Mean kV values, measured with the Accu-kV™ noninvasive meter and the nominal applied voltage in RQT8 standard computed tomography radiation quality

	Mean kV (kV)		
Distance (m)	Accu-kV™	Nominal	Difference (%)
0.37	102.2±2.5	100.0	2.2
0.50	102.2±2.4	100.0	2.1
1.00	101.9±2.5	100.0	1.9

Mean kV values, measured with the Accu-kV™ noninvasive meter and the nominal applied voltage in RQT9 standard computed tomography radiation quality

	Mean kV (kV)		
Distance (m)	Accu-kV™	Nominal	Difference (%)
0.37	122.1±2.8	120.0	1.7
0.50	122.1±2.7	120.0	1.7
1.00	121.8±2.6	120.0	1.5

The mean and peak kV values are very close. This result was expected for constant potential X-ray systems, where the voltage applied to the X-ray tube usually does not change during the exposure (X-ray beam power on). Otherwise, if the value of the kVp quantity is increased, the kinetic energy of the electrons that reach the target (anode) increases, and the mean energy of the X-ray spectrum will be increased too (Bushong, 1997).

4. Conclusions

An evaluation of the noninvasive measurement of the PPV and kVp in the standard computed tomography radiation qualities is presented in this work. These measurements are part of the quality control program of the X-ray systems at LCI, with the main purpose to ensure reliable calibrations. The advantage of the noninvasive meters is related to the fact that they are precise and of easy handling. All results were considered satisfactory and in good agreement with the recommended limits. At the calibration distance (1.0 m), the maximum difference between the PPV values obtained using the two meters was 2.7% (RQT9). The maximum differences between the nominal voltage and kVp measurements were 2.3% for the peak kVp and 2.2% for the mean kV, showing good agreement between the meter and the applied tube voltage.

5. Ackowledgements

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