Implementação das qualidades do Radiodiagnóstico: Mamografia

Implementation of the qualities of Radiodiagnostic: Mammography

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Resumo: O objetivo do presente trabalho foi avaliar a incerteza expandida e apresentar o resultado final da auditoria interna realizada no Laboratório de Ciências Radiológicas (LCR). As qualidades dos feixes mamográficos que são referências nas calibrações no LCR tiveram suas incertezas e conformidades com a norma avaliadas. A incerteza expandida foi de 1,40 %, e o resultado da auditoria interna foi satisfatório. Concluímos que o LCR está apto a realizar calibrações nas qualidades de mamografia destinadas aos usuários finais.

Palavras-chave: calibração, mamografia, incerteza expandida

Abstract: The objective of the present study was to evaluate the expanded uncertainty and present the result of the internal audit performed at the Laboratory of Radiological Sciences (LCR). The qualities of the mammographic bundles that are references in the LCR calibrations had their uncertainties and conformities with the standard evaluated. The expanded uncertainty was 1.40%, and the result of the internal audit was satisfactory. We conclude that LCR can perform calibrations on mammography qualities for end users.

Keywords: calibration, mammography, expanded uncertainty

1.INTRODUCTION

It is important to note that as society evolves, management systems tend to accompany it, given the focus on environment, health, and occupational safety.

The current trend is the integration of all these requirements into a management system that includes all stakeholders in the organization, ie employees, customers and society [1].

The Laboratório de Ciências Radiológicas (LCR), belonging the Universidade do Estado do Rio de Janeiro (UERJ), is already accredited to perform calibrations on area and individual monitors. With the objective of attending to society providing calibration services as a laboratory tracked to the Laboratório Nacional de Metrologia das Radiações Ionizantes (LNMRI / IRD / CNEN), the LCR is increasing its scope of calibration and implementing the calibration service for the mammography qualities, in order to fill a gap that exists between ionizing radiation users and the Primary Standard Dosimetry Laboratory (PSDL) [1], in addition to providing Metrology training of ionizing radiation, to improve calibration techniques, to keep its traceable standard to a primary laboratory, with recalibration every 3 years [2, 3]. To do so, the LCR will be treated as a Secondary Standard Dosimetry Laboratory (SSDL).

It is desirable that the influence quantities of a SSDL have a relative standard uncertainty less than 0.1% [2]. The influence of the magnitudes relative to the user's detector is not considered here.

The objective of the present study was to evaluate the expanded uncertainty in this scope increase and present the final result of the internal audit performed.

2. MATERIAL AND METHOD

For the quality of radiation in non-attenuated mammography bundles, the Comet MXR-160/22 industrial tube with Tungsten target and additional 0.060 mm nominal Molybdenum filtration was used to obtain a similar energetic spectrum as a tube with molybdenum target and 0.030 mm Mo filtration [4], similar to those used in clinic.

For the mammographic qualities under attenuated condition, 2 mm of nominal Al are inserted, under conditions already obtained previously. Tables 1 and 2 shows the mammographic qualities that are references in LCR calibrations for end users

To calculate the relative uncertainty, we used equation (1), with 14 input quantities, discriminated in Table 3.

$$\left[\left(\frac{u_G}{G}\right)\right]^2 = \sum_{i=1}^{14}\left(\frac{u_i}{M_i}.100\right)^2 \qquad (1)$$

Table 1- Mammographic qualities for non-attenuated condition (0.060 mm nominal Mo)

Condition not attenuated				
Quality	Voltage (kV)	HVL (mm Al)	Filtration (mm Mo)	HC
W23_60Mo	23	0,3318	0,060	0,81
W25_60Mo	25	0,3499	0,060	0,82
W28_60Mo	28	0,3520	0,060	0,79
W30_60Mo	30	0,3626	0,060	0,80
W35_60Mo	35	0,3905	0,060	0,76

Table 2- Mammographic qualities for attenuated condition (0.060 mm nominal Mo + 2.0 mm nominal Al)

Condition attenuated				
Quality	Voltage (kV)	HVL (mm Al)	Filtration (mm Mo+ mm Al)	HC
W23_60Mo_2Al	25	0,5246	0,060+2,00	0,93
W25_60Mo_2Al	28	0,5780	0,060+2,00	0,90
W28_60Mo_2Al	30	0,6359	0,060+2,00	0,89
W30_60Mo_2Al	35	0,7133	0,060+2,00	0,87

where u_i is the standard uncertainty of the i-th quantity and M_i is the value of the i-th quantity of influence. If $u_i(\%) = \left(\frac{u_i}{M_i}\right).100$, we can replace in (1):

$$\left(\frac{u_G}{G}\right) = \sqrt{\sum_{i=1}^{i=14} u_i(\%)^2} \qquad (2)$$

where u_G is the combined uncertainty concerning the ionization chamber reading unit, Coulomb (C), and G the reference value of the charge. Doing $u_r = \left(\frac{u_G}{G}\right)$ the relative combined standard uncertainty, we have:

$$u_r = \sqrt{\sum_{i=1}^{i=14} u_i(\%)^2} \qquad (3)$$

To find the expanded uncertainty, with a confidence level of approximately 95% and a coverage factor k = 2, simply multiply (3) by 2.

3. RESULTS

Table 3 presents the results referring to the sources of uncertainties considered, as well as the expanded uncertainty.

3.1 Expanded uncertainty

Calibration and Measurement Capacity (CMC), defined as the smallest uncertainty that a laboratory can present within its scope of accreditation [8], is the expanded uncertainty itself in question. In the LCR, the value was 1.31% for both the non-attenuated condition and the attenuated condition. Table 3 shows the relation of the influence quantities considered in the CMC calculation.

3.2 Increase of Scope

Considering the increasing demand for mammography examinations, it is necessary to trace the mammographic beam qualities practiced in the clinics, in order to focus on patient safety.

Given the scientific importance of the LCR, an increase in scope was requested from the National Institute of Metrology, Quality and Technology (INMETRO) so that calibrations could be carried out on the radiation qualities listed in Tables 1 and 2. An external audit was also conducted to ensure fairness.

3.3 Audit

The internal audit was carried out with the purpose of verifying the conformity of the operations referring to the request of the increase of scope with those required in standard [11]. The non-conformities were corrected, thus allowing a CMC of 1.31% for both conditions

4. DISCUSSION

The average relative humidity value is 46.72% in the laboratory. So it can be disregarded, since it is in the range of 30% to 80% [2].

The uncertainty regarding the calibration of the LCR standard was obtained by dividing the value of the relative uncertainty given in the certificate issued by the secondary laboratory LNMRI, by the coverage factor 2, corresponding to a confidence level of approximately 95%.

Table 3 - Considered influence quantities, relative combined standard uncertainty and expanded uncertainty, for a coverage factor k = 2, for the non-attenuated CMC.

Condition: No Attenuated / Attenuated

	Input Quantity	Unity	Relative Uncertainty
u1	Charge	*nC*	0,06%
u2	Temperature	*°C*	0,07%
u3	Pressure	*kPa*	0,00%
u4	Distance	nC	0,23%
u5	Time	nC	0,00%
u6	Calibrated standard	nC	0,56%
u7	Electrometer resolution	nC	0,00%
u8	Leakage	nC	0,00%
u9	Energy Dependence	nC	0,00%
u10	Loss by recombination	nC	0,00%
u11	Positioning	nC	0,00%
u12	Homogeneity	nC	0,20%
u13	Spectral Difference	nC	0,00%
u14	Kerma Rate on Air	nC	0,13%
	Relative combined uncertainty (%)	=	0,66%
	Expanded Uncertainty (%)	=	1,31%
		k=	2

With the addition of 0.060 mm Mo as an additional filter, in a tungsten anode tube, we are simulating the X-ray spectrum of a conventional Mo-target mammograph and 0.030 mm Mo filtration.

Since both laboratories used the same irradiation conditions, the uncertainty of the spectral difference is negligible. However, it will become significant when performing the calibration of the user's detector, assuming the uncertainty in the difference of the two spectra a value of 0.46% [6].

The kerma rate in the air can be influenced by possible oscillations in the tube current as well as in the voltage. The uncertainty value associated with this oscillation was not considered to be 0.13%, following the literature [7].

For the calculation of the leakage current, measurements were made in the W28_60Mo quality, an electric charge accumulated in 1 minute. Thereafter, the tube was disconnected and the variation thereof was varied within 5 minutes. The uncertainty associated with the leakage current, given by the variation of the load with time, was negligible.

The ion recombination loss in an ionization chamber is small, since its electric field is sufficient to collect almost all the charges released in the ionization process [7]. The value of this type B uncertainty was 0.03%.

The uncertainty associated with the focus-detector distance, which is 1000 mm, was 0.14%, as it was considered that it could vary by ± 5 mm. This value was considered because the measurement of the focus-detector distance was not performed with a laser but with a millimeter meter.

The positioning was analyzed by displacing the ionization chamber ± 2 mm perpendicular to the focus-detector axis, with no significant contribution, with an uncertainty of less than 0.00%.

The resolution of the electrometer, in the fourth decimal place, had no influence on the result, being negligible. The same for energy dependence, because the spectrum is similar to that of the chamber to which the CSF pattern is tracked.

The field size, or homogeneity of the field, had an associated uncertainty of 0.20%,sendo o efeito anódico do tubo o maior contribuinte, uma vez que a angulação do alvo é de 20°.

5. CONCLUSION

In view of the above, we have seen that the LCR is able to perform calibrations intended for users in the mammographic qualities presented in tables 1 and 2, since the expanded uncertainty, with a factor of comprehensiveness equal to 2, is less than 2%, which Allows to deliver to the end user an uncertainty of less than 5%. [9].

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