PERFORMANCE OF MAMMOGRAPHIC UNITS

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ABSTRACT

The performance of about 50 mammographic units used for mammographic screening in Finland was measured according to the Nordic QA recommendations. The measurements focused on radiation output and quality, focal spot size and spatial resolution, performance of the automatic exposure control (AEC) system, the sensitivity of the image receptor, and film processing. The results show substantial deviations from the recommended values in older units, especially in the focal spot size and in the performance of AEC, but most of the modern mammographic units meet the Nordic performance recommendations to a great extent.

INTRODUCTION

The frequency of mammographic examinations increased manyfold in Finland when the nationwide breast cancer screening programme started in 1987. About 150 000 women are screened annually in Finland[1]. In 1994, about 190 mammographic units were used for mammographic examinations, of which 81 units were used for screening.

High requirements are placed on low–contrast and spatial resolution in order to detect small density differences and small microcalcifications in the breast. The whole imaging chain should be included in the performance measurements, because many parameters in the imaging chain affect the breast dose and image quality. Many studies show deficiencies in the performance of mammographic units. In a Swedish study[2], the tube current deviated from the recommended values in 25%, the focal spot size and spatial resolution in about 60% and the base plus fog in film processing in about 40% of the units measured. A study of the Dutch mammographic quality control[3] revealed deviations of over 30% in darkroom light tightness,in AEC exposure settings and phantom density, in AEC object thickness compensation, in viewing box illumination and in breast compression force. The Nordic countries and the European Union have issued recommendations for the performance and quality assurance of mammographic units[4,5]. We have measured the performance of about 50 mammographic units used for mammographic screening in Finland according to the Nordic QA recommendations.

MATERIAL AND METHODS

The measurements focused on radiation output and`quality, image quality, the performance of the automatic exposure control (AEC) system, the sensitivity of image receptor, and film processing. The measurements were made according to the Nordic QA recommendations[4]. The x–ray tube voltage was measured with a kV_pmeter calibrated against an x–ray spectrometer. Focal spot size was measured with a star–test plate. Performance of AEC was tested with respect to object thickness compensation. Film processing was tested sensitometrically by measuring base & fog, gradient and relative speed. Film–screen sensitivity was tested by measuring the dose to image receptor for net optical density 1.0. Spatial resolution was measured with a spatial resolution test plate in a CGR test phantom perpendicular and parallel to the tube axis. Breast compression was measured with a bathroom scale. Radiation output, and linearity was measured by using an MDH 1515 radiation monitor provided with a mammographic ionization chamber (Model 10x5-6M) calibrated in the

secondary standard laboratory. The measuring parameters and methods are described in more detail in the Nordic recommendations for quality assurance in mammography[4].

RESULTS

Table 1 shows the mean values and ranges of the various measured parameters and the recommended values. The greatest deviations from the Nordic recommendations were found in the focal spot size and spatial resolution and in the performance of automatic exposure control. AEC performance fails in the sense that the film optical density depends on the object thickness. Figure 1 shows the distrubution of the focal spot length. Figure 2 shows the gradient distribution (OD 0.25..2.0) of sensitometric curves in film processing.

DISCUSSION

The results show major deviations from the Nordic recommendations. The greatest deviations were detected for older mammographic units. The performance of the new units meets to a great extend the Nordic recommendations. With regard to various parameters about 80% of the units meet the linearity recommendation of the radiation output, film processing meets about 80-90%, automatic exposure control about 45%, spatial resolution about 25-75% (two directions) and sensitivity of image receptors about 70% of the corresponding recommendations. Some of these deviations are similar to the findings reported earlier[2,3]. The performance of all units cannot be expected to meet the recommended values completely within a short time. When old units are replaced by new types, the recommended performance will be achieved gradually.

REFERENCES

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4. Mammography. Quality Assurance in Mammography– Quality Control of Performance and Constancy. Series of Nordic Reports on Radiation Safety No 1:1990. Report on Nordic Radiation Protection Co–operation. Finnish Centre for Radiation and Nuclear Safety, Helsinki, Finland, 1994.

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Table 1. The mean values and ranges of the measured parameters.

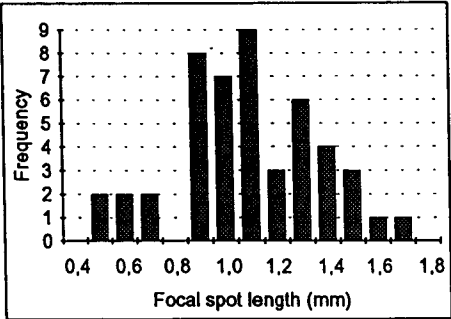| Parameter	Mean value (range)	Recom. value[4]

Radiation output:
   – mGy/mAs
   – linearity (%)
	11.4 (5.0– 24.8)
	0.7 (–11.9 – +11.0)
		$\pm$ 5

Accuracy of tube voltage (kV)	–0.4 (–2.1 – +2.7)	$\pm$ 1.0
Half value layer (HVL mm Al)	0.34 (0.26 – 0.40)	$\geq$ 0.25
Focal spot size (large focus, mm)	1.1 (0.5 – 1.7) length 0.8 (0.3 – 1.4) width	$\leq$ 0.4 (IEC)

Spatial resolution
   (parallel tube axis, lp/mm)
   (perpendic. tube axis, lp/mm)
	14.4 (10 – 16.6)
	12.7 (9 – 16.6)
		$\geq$ 15

Spatial resol. of image receptor (lp/mm)	20	$\geq$ 20

Automatic exposure control
   – mean (OD) (4.5 cm phantom)
   – object thickness comp. (OD) (3 – 6 cm)
	1.35 (0.8 – 2.4)
	0.5 (–1.1 – +0.7)
		1.0 – 1.5
		$\pm$ 0.2

Sensitivity of image receptor (µGy)	73 (28 – 201)	< 70

Film processing
   – Developer time (s)
   – Developer temperature (°C)
   – Base & Fog (OD)
   – Gradient (0.25 – 0.50 OD)
   – Gradient (0.5 – 1.5 OD)
   – Gradient (0.25 – 2.0 OD)
   – Relative speed
	100 – 260
	33 – 37
	0.19 (0.16 – 0.25)
	1.8 (1.5 – 2.2)
	3.3 (2.4 – 3.9)
	3.0 (2.2 – 3.4)
	2.0 (1.1 – 2.8)
		180 – 240
		34 – 37
		$\leq$ 0.20
		$\geq$ 1.6
		$\geq$ 3.0
		$\geq$ 2.8

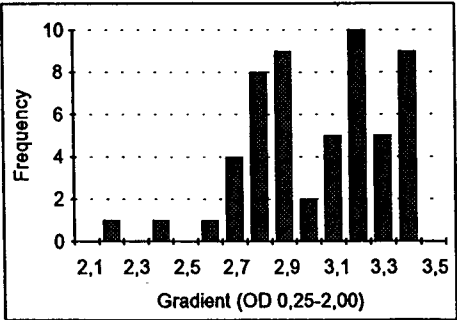Figure 1. Distribution of focal spot length.

Figure 2. Gradient distribution of sensitometric curves (0.25..2.0 OD) in film processing.