REDUCTION OF PATIENT EXPOSURE PRESERVING IMAGE QUALITY IN MAMMOGRAPHY

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ABSTRACT

A programme for mammography optimization in each unit is briefly outlined. The principal parameters affecting dose and image quality (H.V.L., focal spot and exposure) are measured by means of simple devices (exposimeter, star pattern and phantoms) in 28 units. The dose and image quality evaluations show that mammography is not optimized in practice. For example even units employing the same types of X-ray apparatus and film-screen comination present very different exposure values, i.e. from 0.64 R to 10.70 R (1.65×10^{-4} - 27.6×10^{-4} C/kg).

INTRODUCTION

As is well known radiography is one of the most effective means for an early diagnosis of breast carcinoma; therefore the reduction of breast dose,preserving image quality, is an important point.

We carry out a programme for mammography optimization in each unit, named D.Q.M.(Dose and Quality in Mammography).

The steps of the programme are:

a) collection of the working parameters in each unit (1,2)
b) dose and quality evaluation by means of a computerized programme (3)
c) suggestions for improvements in each unit and for starting a quality assurance work with our help

INSTRUMENTS AND METHODS

The working parameters are measured by means of the following devices:

Exposimeter

The exposimeter is made up of two groups of TLD-100 detectors; the first group is put over a 0.5 mm Al filter and the second one below. Detectors and Al filter are held on the top of a plexiglass cylinder 5 cm high and 5 cm wide.

The device is exposed in the same way as a breast 5 cm thick. Exposure is measured by the first group of detectors; the ratio between the second and the first group gives H.V.L. value, on the basis of a calibration curve obtained employing a Mo anode tube with a Be window and a 0.03 Mo filter.

Star Pattern

The pattern is made by etching a Cu coated board for printed circuit (Cu thickness 0.07 mm); the very cheap cost of the pattern makes its employment easier.

A star pattern support defines the geometrical conditions for an optimal radiographic magnification of the pattern image.

The recording system, for the star pattern, consists of a sandwich of three filters and three films instead of a single film, so that whatever the exposure value may be, at least one film can have a sufficient image contrast.

Plexiglass Phantom

A plexiglass phantom (10x10x5 cm) containing TLD-100 detectors, at various depth (0, 2.5, 5 cm), is exposed in the same way as breast 5 cm thick. The exposure for a radiograph is repeated at least five times, so that even TLD-100 detectors placed inside the phantom can reach a sufficient total exposure.

ITO Kodak for Mammography

As is well known ITO Kodak for mammography is a phantom having inside various kinds of details. It may be used both for optical and for physical evaluation of radiographs. It is exposed in the same way as a breast, and the film is developed by the unit operators.

RESULTS

Measurements were perfomed only in 31 units, 28 units employ Mo anode X-ray tube and 3 units W anode tube; only a unit employs a direct X-ray film, all the others use film-screen combinations.

Table I gives a syntesis the measurements and calculations referred only to Mo anode X-ray tubes (28 units), because the exposimeter calibration for W anode is in preparation.

The Mo anodes are devided into two groups : static and rotating anodes. The second group has high emission intensity, shorter exposure time, larger focus skin distance, so they may present better results.

H.V.L. values for static anodes range in a shorter interval than those for rotating anodes, see Table I and Figure 1.

The exposure distribution ranges in a large interval, see Fig. 2; the mean exposure of all the units is high, but the mean exposure for rotating anodes is about 40% of that for static ones. That is due both to larger focus skin distance and to sensitivity increase of film screen combination for shorter exposure time.

Nominal focal spot dimensions(values declared by the Firms) are smaller than those measured, for static anodes the mean value evaluted is twice the mean nominal focal spot.

The optical density of ITO radiographs measured in a region without details (4.5 cm thick) ranges in a large interval, see Tab.I and Figure 3. The different densities of radiographs do not allow a significant contrast intercomparison.

The computerized programme for breast dose calculation can give dose values at every centimeter of depth. The most significant dose values are presented in Table I : dose in the firt cm (0-1 cm) and dose in the mid plane (2-3 cm).

The resolution in the object plane at 5 cm from the recording system is expressed by MTF(total), product of geometry MTF and film screen MTF, see Fig. 4. In Table I resolution is expressed by the spatial frequency (lp/mm) corresponding to 0.5 value of MTF(total).

The resolution for rotating anodes is better than for static ones, because they present larger focus skin distance and, in some cases, a small focal spot ; but when a rotating anode has a too large focal spot, the MTF(total) is comparable or worse than for static ones.

TAB I. Mo anode units results.

		TOTAL	STATIC ANODE	ROTATING ANODE
N° OF UNITS		28	11	17
EXPOSURE (R)	mean	2.20	2.58	1.04*
	min ÷ max	0.16 ÷ 16.60	0.74 ÷ 10.70	0.16 ÷ 3.60
HVL (mm Al)	mean	0.32	0.29	0.33
	min ÷ max	0.20 ÷ 0.50	0.20 ÷ 0.37	0.20 ÷ 0.50
FOCAL SPOT (mm)	mean	1.34 x 1.01	1.48 x 1.07	1.12 x 0.97
OPTICAL DENSITY	mean	0.84	0.97	0.76
	min ÷ max	0.19 ÷ 1.37	0.27 ÷ 1.37	0.19 ÷ 1.20
1st cm DOSE (mrad)	mean	960	1100	460*
	min ÷ max	90 ÷ 7420	295 ÷ 4260	90 ÷ 1360
midplane DOSE (mrad)	mean	135	149	66*
	min ÷ max	18 ÷ 1110	36 ÷ 500	18 ÷ 158
RESOLUTION**	mean	3.34	3.01	3.47
	min ÷ max	2.4 ÷ 5.2	2.6 ÷ 3.3	2.4 ÷ 5.2

(*) The exposure value of the centre using direct film is not included

(**) Resolution is expressed by the spatial frequency (lp/mm) corresponding to 0.5 value of total M.T.F..

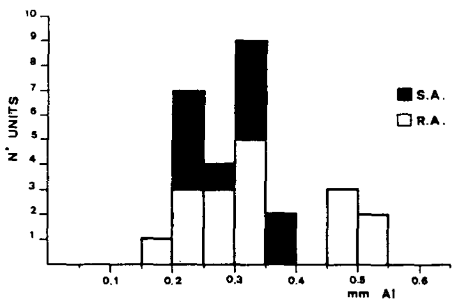

Fig. 1. H.V.L. distribution.

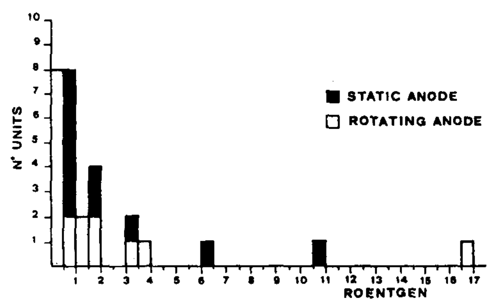

Fig. 2. Exposure distribution.

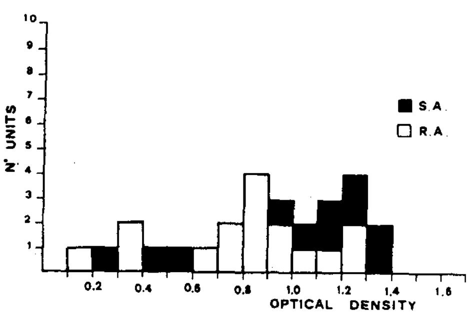

Fig. 3. ITO radiographs desity distribution.

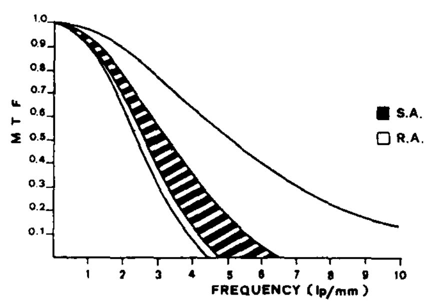

Fig. 4. Total M.T.F. range.

COMMENT

We compared exposure and dose values of Table I with those presented by G.R.Hammerstein et al. in Table V of Ref.(4).

The lowest exposure we found is 0.16 R, in Ref. (4) it is 0.17R, the highest exposure is 16.6 R, in Ref. (4) it is 1.10 R; the lowest mid plane dose is 18 mrad, in Ref. (4) it is 18 mrad; the highest mid plane dose is 1110 mrad, in Ref. 4) it is 83 mrad.

From the analysis of all the results we can see that mammography is not optimized in practice. In fact even units using the same types of X-ray apparatus and film screen combination present very different exposure values, i.e. from 0.64 R to 10.70 R (1.65×10^{-4} to 27.6×10^{-4} C/kg). This variation is due to various causes that have to be found out in each case.

For a significant comparison of the results it is important to know the real exposure parameters(kVp, mA, t), they may be different from those read on the plant instruments.

Another point to take into consideration is the control of film processing, an assured correlation between exposure and optical density is very important for technique standardization.

At last, units that now are working in optimal conditions may start (with our help) a quality assurance activity, employing the simple instruments named above: exposimeter, star pattern and phantoms.

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