# A PROCEDURE FOR ROUTINE RADIATION PROTECTION CHECKING OF MAMMOGRAPHY EQUIPMENT

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In Sweden, screening for mammography is only permitted in demonstration projects in a few parts of the country including Gävle. After evaluation around 1983 it is possible that screening might be widely used at the 60 installations where mammography equipment is available. Should this occur, standardized checking of the equipment will be an essential radiation protection task.

As radiation protection physicists can be consulted fairly simply at all equipment sites, we wanted to design a checking system that could easily be handled by them on-the-spot. The system should include adequate instruction about criteria for remedial action.

Techniques in Sweden are fairly standardized and the main difference between screening and clinically indicated examinations is in the number of projections, where screening normally employs only the oblique one. Almost all mammography units have molybdenum anodes, automatic exposure control and 0.03 mm Mo filter. Only low-dose film-screen systems are used. Potential differences range from 24 kV to 37 kV with a tendency towards the lower end, and typical tube charges range from 5 mAs to 200 mAs.

## RADIATION PHYSICS PROPERTIES OF BREASTS

The distribution of breast thickness in screening situations measured in three locations with the following result:

| | Number of measurements | Brest thickness, mm min | max | mean |
|---|---|---|---|---|
| Location 1 | 111 | 15 | 75 | 41 |
| Location 2 | 413 | 15 | 80 | 48 |
| Location 3 | 486 | 15 | 95 | 50 |

In all locations the relative standard deviation of the breast thickness was about 27%. The differences in mean thickness are thus significant at the 99% confidence level.

For the estimation of energy imparted to the total breast, the breast area was derived from the exposed x-ray films for 200 films at one location. To a good approximation, the area was proportional to the breast thickness, being 150 $cm^2$ at 50 mm breast thickness. The relative standard deviation of the area for a given thickness was about 30%.

We have also looked at the attenuation properties of breasts compared with those of water, polymethylmetacrylate and 85% solution of ethyl

alcohol in water. The following results were obtained for the average ratio of the tube charges required to trip the automatic exposure control for breasts of a given thickness and for polymethylmetacrylate of the same thickness:

| Breast thickness, mm | 30 | 50 | 70 |
|---|---|---|---|
| Tube charge ratio breast/polym. | | | |
| Location 1 | 1.35 | 0.9 | 0.4 |
| Location 2 | 1.0 | 0.8 | 0.6 |
| Location 3 | 1.3 | 1.1 | 0.9 |
| Mean | $1.17 \pm 0.15$ | $0.91 \pm 0.15$ | $0.60 \pm 0.3$ |

The uncertainly interval assigned to the mean covers the full range of variation between the three locations. This variation may have been due to different screen-film systems having different energy dependence, and to the employed tube potential differences. An error of 10-20% may have been caused since the cassette used at the phantom measurements did not represent exactly the mean of all cassettes used in the breast exposures.

Smaller breasts approached water in linear attenuation properties, larger breasts approached alcohol/water solution. Polymethylmetacrylate seemed the best approximation when the entire range of breast thicknesses was considered, but obviously it can overestimate the breast dose by more than a factor of 2 at large breast thicknesses.

RECOMMENDATIONS

The recommended checking method includes the use of the Kodak mammography image quality phantom (3) placed above 40 mm of polymethylmetacrylate. Reference pictures will be included in the set of recommendations, and it is recommended that remedial action be taken if the actual image quality subjectively appears to be significantly poorer than that of the reference film. This qualitative recommendation has been thought to be sufficient since the high professional competence in diagnostic radiology in Sweden makes poor image quality rather unlikely.

Radiation dose is to be based on phantom measurements using 50 mm polymethylmetacrylate. Detailed instructions are given for the measurements using either thermoluminescent LiF dosimeters (4 dosimeters per measurement), ionization chambers or a specially designed plastic scintillator (1) with diameter 25 mm and height 50 mm. The exposure at the phantom surface should be multiplied by the following conversion factors to give mean absorbed dose in the breast:

| Potential difference, kV | 25 | 28 | 31 | 34 |
|---|---|---|---|---|
| Conversion factor, mGy/R | 1.19 | 1.28 | 1.34 | 1.39 |

According to a preliminary recommendation, a mean breast dose of 2 mGy indicates a need for remedial action. Suggestions will be given for countermeasures.

## DISCUSSION AND CONCLUSIONS

Since the range of potential differences is rather small, the TLD, ionization chamber and plastic scintillator methods are about equally accurate and expected to yield the same alleged mean absorbed dose to the breast within about ± 10%. A larger range of potential differences might be handled most accurately using the plastic scintillator. The three month reproducibility (double standard error with a given exposure) will according to long term tests be about ± 3% with the ionization chamber and plastic scintillator (mean of two measurements) and considerably higher with TLD (mean of 4 dosimeters).

The day-to-day variations of the x-ray equipment for a given exposure setting may give doses outside a range of ± 10% from the mean. In practice it is difficult to make the dose with the cassette used at phantom measurements represent the average dose for all cassettes within less than ± 10%.

The country-wide consistency may thus be rather poor for the reasons just discussed. In national dose intercomparisons a standards laboratory could provide an assessment of "true" dose using the methods recommended. Several centers would then be asked to irradiate the phantom as if it were a 50 mm breast and state the mean breast dose as assessed by them using a recommended method. It is believed that this dose might be up to ± 30% off from the "true" dose. This variability would mainly be due to errors associated with the automatic exposure, and similar variability would be inherent in the normal breast exposures.

In addition, there are the problems of representativity. Results obtained at any installation using the phantom measurements are expected to represent the mean for a screened population within -30% and +50% for the mean breast dose, and within -40% and +60% for the mean energy imparted to the breast. These errors are mainly due to the previously discussed variations in radiation physics properties of breasts. They have little relevance for the levels selected for remedial action but should be kept in mind when it comes to assessment of population risk. The thickness 50 mm was selected as the best compromize with representativity criteria for mean energy imparted and mean breast dose. A thickness of 40 mm would have been a much poorer compromize and 60 mm a somewhat poorer. If representativity is sought only for the mean energy imparted to the breast as compared with the mean breast dose, a thicker phantom results.

Measurements by one team employing the recommendations at about half of the 60 Swedish mammography installations (2) gave a mean breast dose of 1.6 mGy, a minimum of 0.5 mGy and a maximum of 4 mGy. About one fifth of all installations had doses above 2 mGy, mostly because of different film-screen systems, sub-optimal developing procedures or unusally high optical density of the films.

REFERENCES

(1) Studsvik Energiteknik AB, (1979): private communication with Erik Dissing.

(2) Leitz, W and Eklund, S (1979): private communication