Dose configurations

Philips MicroDose Mammography

Introduction

The purpose of this white paper is to explain the two different dose configurations used by the Philips MicroDose Mammography system, C100 and C120. Both configurations result in lower mean glandular dose (MDG) than limiting values noted in the European guidelines.[1] This is made possible due to the excellent dose efficiency of MicroDose's multi-slit scanning, photon counting digital technology.[2,3]

In general, reducing radiation dose is important, as noted by the As Low As Reasonably Achievable (ALARA) principle. To quantify the radiation dose in mammography, the MGD is used. The efficacy of mammography relies on the high-quality control standards that are followed. The European guidelines for quality assurance in breast cancer screening[1] specify the limiting values both for MGD and image quality. The ALARA principle and the need to comply with the high-quality control standards indicate that the image quality and MGD are rigorously monitored by the medical physicists for mammography.

MicroDose's multi-slit, scanning, photon counting digital mammography system affords several advantages. The most significant advantages are rejection of scattered radiation with the scanned multi-slit geometry,[2] high-detective quantum efficiency (DQE) with the edge-on silicon detector,[3] and improved energy weighting with the photon counting detector.[4] Dose efficiency can be defined as the detector DQE multiplied by the scatter DQE.[5]

By using DQE and scatter DQE from published sources,[2,3] we can conclude that MicroDose is highly dose efficient. Thus, a measured image quality in parity with that of other detector technologies is achieved at lower radiation dose.[6]

Dose configurations

The term "dose configuration" is used in this white paper to express a configuration consisting of a set of figures describing a target image quality as a function of compressed breast thickness. Image quality can be quantified by how well the objects in a contrast-detail phantom are visualized or by the signal-difference-to-noise ratio (SDNR). Contrast-detail phantom image quality and the SDNR both increase with dose (through the mAs), and for digital systems, there is always a trade-off between image quality and dose.

MicroDose image quality follows European Guidelines,[1] where limiting values for the image quality as a function of breast thickness are specified. The two dose configurations available with MicroDose are:

- **C100:** Corresponds to a set of target image quality figures that meet the Acceptable limiting values as noted in the European Guidelines.[1]
- **C120:** Corresponds to a set of image quality figures that provide 20% higher SDNR than the C100 setting. This is equivalent to being able to see 20% thinner objects of the same size.

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sense and simplicity

Methods of dose calculation

The MGD is not measured physically, but calculated from entrance surface air kerma (ESAK) measurements and conversion factors derived from computer simulations. The method to measure ESAK is described in the European Protocol on Dosimetry in Mammography.[6] Conversion factors have been published to account for the actual mean glandular tissue content found in screening populations and anode-filter combinations used with modern mammography equipment.[7] In brief, the MGD is calculated as:

MGD = K x mAs x g x c x s

K is measured ESAK 6 cm from the chest wall edge normalized with the tube loading, 'g,' 'c,' and 's' are factors defined and calculated according to Dance et al.[7] The first describes the dose deposited in a breast of 50% glandular content, and the c-factor is a correction for the mean glandular content for a given breast thickness. Both depend on the beam quality and are functions of the half-value layer (HVL). The s-factor is a correction for the X-ray energy spectrum and is unity for a standard Mo/Mo anode-filter combination. For the tungsten/aluminum anode/filter combination used by the MicroDose system, the s-factor varies between 1.07 and 1.21, depending on breast thickness.

Automatic dose estimation

MicroDose estimates the MGD for each exposure and the result is stored as a DICOM-tag in the image, and is also displayed on the Acquisition Workstation. The method is the one described in the previous section, "Methods of dose calculation," where the compressed breast thickness is measured by the system and g-, c-factors are retrieved from look-up tables. These are generated based on factory-measured HVL-values. The tube output (ESAK/mAs) is estimated based on the measured detector signal and a conversion factor for each tube voltage value. Quality control procedures verify that this estimation is correct within 15%. Since the real breast composition is unknown and there is a measurement uncertainty of the actual compressed breast thickness, it is important to note that this dose calculation is only an estimate.

Measured MGD values

Here we present average MGD values measured and calculated from clinical images for an ensemble of produced MicroDose L30 systems. Data was collected from hospitals in Sweden equipped with MicroDose L30 and compiled by Philips researchers. For each thickness, the mean grandularity, according to Ref. 1, is used. MGD vs. breast thickness is shown in Figure 1 for the two dose configurations. The confidence intervals (two standard-deviations) are estimated based on the variation between the individual systems. This data is summarized in Table 1. Also included are two levels of limiting values from the European guidelines. The MicroDose MGD values are lower than the limiting values for all dose settings and breast thickness.

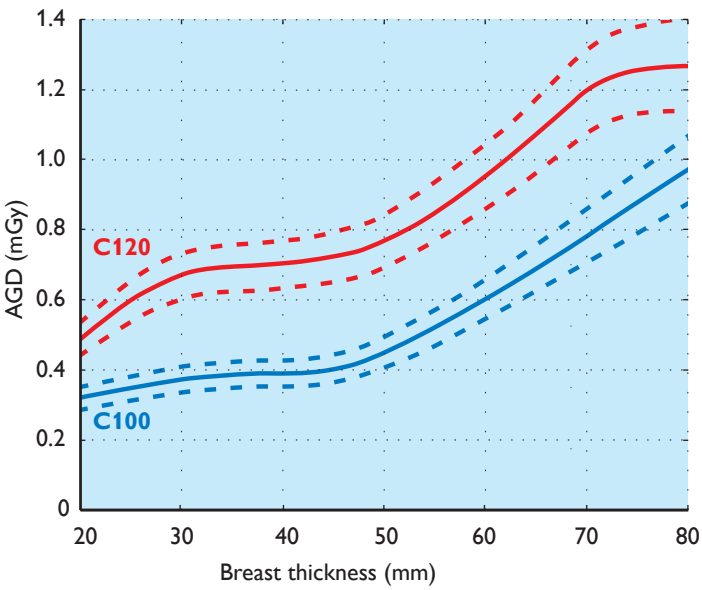

Figure 1: Measured MGD vs. breast thickness for the two different MicroDose dose settings. Confidence intervals (dotted lines) are two standard deviations.

Breast thickness	MGD (mGy) C100 dose setting	C120 dose setting	Acceptable level[1]	Achievable level[1]
3 cm	0.34 - 0.41	0.60 - 0.74	<1.20	<0.90
5 cm	0.40 - 0.49	0.68 - 0.84	<2.30	<1.80
8 cm	0.90 - 1.10	1.20 - 1.40	<5.70	<4.60
Population-averaged	0.50 - 0.60	0.80 - 1.00	n/a	n/a

Table 1: Measured MGD (mGy) and limiting values from the European guidelines.[1] Confidence intervals are two standard deviations. Also included are population-based dose values, i.e., dose averaged over a measured breast thickness distribution.

Population dose

In some situations, the dose to the population rather than the individual dose is of interest. The result based on more than seven thousand clinical exposures fits a Gaussian distribution with mean 54 mm and a standard deviation of 14 mm. Averaging the measured MGD over this distribution yields the values 0.54 and 0.90 mGy for the two dose levels, respectively. These values have an uncertainty of ±10%.

Summary

The two dose settings available with the Philips MicroDose Mammography system, C100 and C120, have been described and quantified. Furthermore, the image quality of the C100 dose level was connected to limiting values in the European guidelines.[1] The image quality of the C120 dose level is described as relative changes with respect to the C100 level. For any dose setting and breast thickness, the MGD is substantially lower than the limiting values as seen in Table 1. The reason for the low dose, without sacrificing image quality, is the high DQE[3] and almost complete rejection of scattered radiation.[2]

Philips MicroDose Mammography system

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