E2. Breast imaging and screening – technology update

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Digital mammography – technical update (Ruben van Engen)

The first digital mammography units became available for clinical use in 1999 and since then developments have been rapid. New systems using different physical principles have emerged and major improvements in technology have occurred. In addition techniques like 3-D imaging, the use of contrast agents, dual energy imaging, alone or in combination are being tried in mammography and systems are being developed to facilitate these. [1]

The current digital systems can be subdivided into Direct Radiography (DR) systems in which the image receptor is integrated in the bucky of the mammography unit and Computed Radiography (CR) systems, which use a film screen mammography unit, cassettes with phosphor screens and a separate readout system. [2]

Three physical detector technologies are currently used in DR systems:

1. Silicon detector. In this detector a phosphor is used to convert X-rays in light. In silicon photodiodes this light is collected and converted to charge.
2. Selenium detector. In this detector X-rays are directly converted to charge which is collected on electrodes.
3. Photon counting detector. In this detector the individual X-ray quanta, which interact in the detector, are counted.

In all technologies the current detectors have improved considerably compared to the first generation of detectors on the market. Major problems which have occurred (ghosting, crystallisation, inhomogeneity etc.) in the past with some detectors have been solved by changes in the architecture of detectors.

All CR systems use the same basic principle. A latent image is formed on the phosphor screen by X-rays. By stimulating the phosphor the latent image is released as light, which is collected and amplified by a photomultiplier. Some CR systems collect the light emitted from both sides of a phosphor screen, some only from one side.

Some years ago most CR systems did not comply with the Euref Guidelines. However, since quality has improved considerably, most systems now comply with the Guidelines.

Recently EUREF started a new project to update the Guidelines and is performing typetesting in which it is determined whether a system is able to pass the Guidelines. When buying new mammography equipment this might be taken into account.

Digital mammography – clinical results (Per Skaane)

Experimental clinical studies and prospective trials comparing screen-film mammography (SFM) and full-field digital mammography (FFDM) have demonstrated a slightly superior diagnostic performance for FFDM. Seven studies comparing SFM and FFDM in breast cancer screening have so far been published: The Colorado-Massachusetts study, [3] Oslo I study, [4] Oslo II study, [5] DMIST study, [6] Florence study, [7] and Vestfold County study [8] and the Helsingborg study. [9] Different study design of these trials only partly explains the conflicting results. The two first studies showed a lower cancer detection rate for FFDM, but all of the four following studies have demonstrated a higher cancer detection rate for FFDM: borderline significant in Oslo II, significant for premenopausal women and women with dense breast in the DMIST trial, higher but not significant in the Florence study, and of borderline significance in the Vestfold study. The last two published studies have shown a significant higher detection rate for DCIS. There have also been conflicting results on recall rate, three studies showing a higher recall rate and three studies showing a lower recall rate at FFDM.

Overall, FFDM has been shown to be superior to SFM in breast cancer screening.

Digital breast tomosynthesis (Fabienne Thibault)

A limitation of mammography is the combination of normal structures in two-dimensional views that can

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either obscure a significant lesion or create a false positive summation shadow. Three-dimensional mammography has the potential to greatly reduce the limitation of such combination shadows. Tomosynthesis describes a technique where digital images are obtained with flat panel detectors or scanning systems.[10] Multiple projections of the breast from different angles generate a set of low-dose source images from which thin-slice reconstructions are used to provide detailed visualisation of the breast volume.[11]

The aims of tomosynthesis are better detection and characterisation of small breast cancers, increasing the sensitivity of digital mammography while keeping a high positive predictive value. Demonstration of tissue overlap, subtle architecture disruption, precise depiction of lesions' margins, localisation of multiple or one-view-only lesions are means to reach these objectives.

Few data on the clinical effectiveness of tomosynthesis have been published. Investigation in the screening setting has shown the potential of tomosynthesis to decrease the recall rate when added to standard mammography.[12] Initial experience with contrast-enhanced tomosynthesis has shown interesting characterisation of breast lesions.[13]

The results of an ongoing study of the clinical value of tomosythesis at the Institut Curie are presented to demonstrate how tomosynthesis can overcome some limitations of standard mammography. More evaluation is required to select the situations best served by this new tool, whether screening or advanced diagnostic work-up.

Other imaging techniques for screening?

X-ray mammography has been the method of choice for population breast screening for more that 30 years. However, mammography requires ionising radiation and has significant limitations. Are there other imaging techniques that could replace mammography for screening? Established imaging methods that could be alternatives that have been evaluated in recent years are ultrasound (US) and magnetic resonance imaging (MRI). To replace mammography these techniques would need to provide at least equal efficacy and effectiveness. While ultrasound has been shown to be an effective additional intervention in some women with dense breast on mammography it does not have sufficient sensitivity for small breast cancers or for detecting ductal carcinoma *in situ* for it to ever replace mammography as the primary screening method. MRI on the other hand offers greater sensitivity than mammography for all types of breast cancer. However, it is associated with significantly higher false positive rates, requires intravenous contrast, is not widely available, is time consuming and is comparatively very expensive. These are major barriers to its routine use for normal risk population screening. However, there are data now that indicate that MRI should be considered the technique of choice for screening younger women at high genetic risk of developing breast cancer.

Computed tomography, scintigraphy, PET scanning and elastography are all not suitable for routine use in breast imaging. There are a number of imaging techniques that are potentially being developed for breast imaging, including electrical impedance, electropotential, infrared (thermal), microwave, Hall effect and magnetomammography; none of these are currently in routine clinical use.

At present x-ray mammography appears to be the best technique for population screening and its effectiveness has been significantly enhanced by the introduction of full field digital imaging (FFDM). There are remaining shortcomings of mammography that could be partly offset by the use of other techniques. The addition of ultrasound to mammography in screening women with dense breasts on mammography has been shown to improve the detection of small breast cancers but at a cost of high false positive rates that cause significant morbidity. Similarly, MRI can be used as a problem solving method when conventional assessment is equivocal. Comparable results of population-based randomised studies for both imaging techniques have not yet been conducted; therefore, only estimates of potential benefits from US and MRI can be described. In general, any additional imaging test will result in additional assessment.

Conflict of interest statement

Some of the data Fabienne Thibault will present comes from a study done at her institution (Institut Curie) part funded by GE Medical Systems.

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