DUAL ENERGY TECHNIQUES WITH CONTRAST MEDIA IN DIGITAL MAMMOGRAPHY: SNR AND DOSE EVALUATION

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In mammography, 10%-20% of breast cancers, including at least 9% those already palpable, are not depicted. In fact, early manifestation of breast cancer is often very subtle and is displayed in a complex and variable pattern of normal anatomy that may obscure the disease. This is particularly important in dense breasts, found in approximately 25% of women, caused by the complexity of overlying fibroglandular structures. The use of dual exposure techniques, that remove the structure noise, and contrast medium that enhances the region surrounding the tumour could help to improve the detectability of lesions.

In recent years pioneering studies have been published on the application of the contrast agent in digital mammography that show the potentiality of this technique although neither the optimal contrast medium concentration nor the optimal X-ray spectra are known.

The aim of this work is to investigate the use of contrast media in mammography with three different double exposure techniques: Dual Energy Mammography (DEM), K-Edge Subtraction Mammography (KESM) and Temporal Subtraction Mammography (TSM). The first one is based on the acquisition of two images at different energies after the contrast medium injection; by combining these images it is possible to produce hybrid images in which the contrast of relevant structures is preserved while unwanted masking contrast is largely removed. The second technique is based on the K-edge absorption of the contrast medium which obtains, from two initial images, acquired at energies below and above the K-edge, two final images: the first one is the contrast medium concentration map and the second one is the distribution of all other materials. The last technique is based on the acquisition of two images at the same energy, before and after the injection of the contrast medium.

These three techniques have been investigated by using an ideal source like the monochromatic x-ray beams from synchrotron radiation and a digital clinical system.

As far as contrast media is concerned, Iodine-based and Gadolinium-based contrast media have been tested.

A dedicated three-component phantom has been developed by choosing materials whose attenuation is similar to breast tissue. The structure of the phantom had been thought to simulate the variable pattern of the normal anatomy of the breast. Details of two different sizes containing various concentrations of Iodine or Gadolinium simulate the region surrounding the tumour.

For each technique, information about contrast medium concentration which provides a significant enhancement of the visibility of the pathology by minimizing the risk of high dose and high concentration of the contrast agent has been obtained. The parameter SNR^2/MGD has been introduced as figure of merit to compare the three techniques. In particular the minimum contrast medium concentration needed to visualize a detail with a SNR = 5 and a MGD = 2 mGy, has been achieved.

Results obtained with different kinds of sources permit understanding of the potentiality and the limitations of the use of contrast media in mammography and allow for definitions of the optimal conditions in terms of dose and contrast detectability for the application in clinical practice.