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Dual-energy contrast-enhanced mammography☆

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Abstract The degree of vascularization in breast lesions is related to their malignancy. For this reason, functional diagnostic imaging techniques have become important in recent years. Dual-energy contrast-enhanced mammography is a new, apparently promising technique in breast cancer that provides information about the degree of vascularization of the lesion in addition to the morphological information provided by conventional mammography. This article describes the state of the art for dual-energy contrast-enhanced mammography. Based on 15 months' clinical experience, we illustrate this review with clinical cases that allow us to discuss the advantages and limitations of this technique.

Mamografía con realce de contraste mediante técnica de energía dual

Resumen Es bien conocido que el grado de vascularización de las lesiones mamarias se relaciona con su malignidad. Por ello, las técnicas de diagnóstico por imagen que estudian funcionalmente las lesiones han cobrado mucha relevancia en los últimos años. La mamografía con medio de contraste y energía dual es una técnica de reciente aparición, aparentemente prometedora en el cáncer de mama, que informa del grado de vascularización de la lesión

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Revisión

junto con la información morfológica habitual. El propósito de este artículo es presentar el estado actual de esta nueva técnica de imagen. Basándonos en una experiencia de 15 meses, ilustramos esta revisión con casos clínicos que nos permiten presentar también sus ventajas y limitaciones.

Introduction

It is well known that tumor cells are metabolically very active and require a great deal of nutrients which in their growth causes a process known as angiogenesis.[1] Its clinical importance has been established for breast cancer since it is an independent prognostic factor highly associated with the incidence of metastasis.[2] Since they are very rapidly forming micro-vessels, porosity is high and when injecting IV contrast media, they spread the interstitial liquid of tumor mass they enhance.[3] This is why since the 1980s different modalities have been born whose goal is to explore tumor angiogenesis by using contrast media like breast angiography,[4] CT[5] and magnetic resonance (MR).[6] The MR is the most widely used modality and the most important one clinical-wise since it is the most sensitive image diagnostic modality for the detection and study of breast cancer. However, the MR has several drawbacks mainly due to its high cost and also to its limitation in claustrophobic excessively obese patients or with a certain type of extra-breast prostheses, pacemakers or foreign bodies among others. This is why numerous patients cannot have access to it.[1,7]

With the arrival of the new millennium digital radiology has gained momentum and it is full of advantages.[8] One of the main ones is that it allows us to post-process images with computer applications aimed at improving diagnosis.[1,7] One of these computer apps is iodinated contrast enhanced digital mammography. Several studies have proven that it is a cheaper alternative than MR.[7,9–12] It is also an alternative to conventional mammography in order to avoid unnecessary biopsies[9] also and adjunct modality to conventional mammography and ultrasound in order to improve the diagnosis of malignant lesions,[7,9–12] and even better than MR for diagnosis.[13] However, this modality is still recent and no author has clearly established what role it plays in the diagnostic algorithm of breast disease.

During these years this technique has been developing parallel in two modalities. The first one, more like conventional angiography, is called temporal contrast-enhanced mammography (TCEM). The other one, based on image-acquisition at different energies, is called contrast-enhanced spectral mammography (CESM) (also called dual energy mammography). In both cases we must inject the patient an IV iodinated contrast media through an automatic injector to secure constant flow. During these first ten years of life several studies showing that both modalities are promising have been done since they improve both the specificity and sensibility to diagnose breast lesions. Nonetheless results indicate that TCEM has some important technical limitations still not worked out while the clinical performance of CESM can be improved. In this article we mainly deal with the dual energy modality but in the following segment we will discuss the main features, advantages and limitations of TCEM.

Temporal contrast-enhanced mammography

The main feature of this modality is that other than enhancing the images of those contrast media uptaking-lesions, it also gets information on the temporary pattern of uptake and further iodinated contrast clearance. This is why it is the most similar of the two to the MRI. Although there is some controversy about it, the information delivered by the uptake curves of breast lesions can be very relevant since it seems that the more slowly uptaking-lesions are usually benign while a fast pattern in the uptake is associated with a greater degree of malignancy.[14] To be able to use this pattern through digital mammography different images are taken in various moments. In the first place one image before injecting the contrast media with the compressed breast (''mask'') needs to be taken. Then while compressing the breast the contrast media is injected and sequential images are acquired (usually one image per minute) during a different time frame (4–10 min) depending on the pattern we want to explore (uptake or uptake + clearance). To improve the view of the lesions the ''mask'' is subtracted from the images acquired through the contrast agent.[1,7,14] One of the main limitations is that patients cannot tolerate so much time of compression (up to 15 min),[7] so there are usually numerous movement artifacts that makes images unable to be fully overlapping. This is why we need specific software to compensate all distortions caused by movement. Another important limitation is that with this modality we can study one breast and with one view only and that limits the confirmation of lesions previously diagnosed clinically or radiologically. If we want to study both breasts as we usually do through conventional mammography both the times and contrast doses will multiply by the number of views we want. This is why even though the dose of radiation needed to obtain each individual image is similar to that of routine mammographies (1–3 mGy),[1] the total dose will depend on the number of images obtained. Several studies done so far show that when artifact-free images are obtained the TCEM is way more sensitive and specific than conventional mammographies to diagnose cancer.[7,10,11,15] However, the main theoretical advantage of this modality with respect to CESM—that is the study of the uptake/clearance pattern