Imaging techniques in breast cancer

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Abstract

Imaging plays a critical role in the diagnosis and management of breast cancer. Two-view mammography and ultrasound form the mainstay of breast imaging and are essential components of the triple assessment. Digital mammography is rapidly replacing analogue mammography, and recent advances such as digital tomosynthesis add a third dimension to conventional 2D mammographic images. The versatility of ultrasound allows assessment of the breast and axilla as well as accurately targeted interventions, from the simple diagnostic core biopsy to preoperative tumour localization. It also guides large volume biopsies and excision of certain benign lesions, which in some cases can obviate surgical excision. Newer ultrasound techniques being applied to the breast and axilla include elastography and the use of intradermal microbubbles to guide the radiologist to the sentinel axillary node. Breast MRI is a powerful modality in assessing breast cancer. It can provide accurate information on size and multifocality of lesions, particularly those that are mammographically challenging such as lobular cancers, and it is also used to assess response to neoadjuvant chemotherapy and guide surgical management. CT scans, and in selected cases Positron Emission Tomography, play important roles in the assessment of metastatic disease.

Keywords Breast biopsy; breast imaging; breast MRI; mammography; tomosynthesis; ultrasound

Introduction

Imaging plays a central role at each stage of the breast cancer pathway. Breast screening by definition relies on mammographic imaging to detect asymptomatic cancers. On the other hand, patients with breast symptoms presenting to one-stop clinics will have immediate imaging to investigate their problem. From there any significant abnormality will be biopsied under image guidance to allow tissue diagnosis. Patients may then have staging using cross-sectional imaging modalities, and MRI can be used to monitor response to neoadjuvant chemotherapy or to aid surgical planning. Prior to surgical excision of breast cancers radiologists may be required to localize the lesion using ultrasound or stereotactic (mammographic) guidance to assist the surgeon in accurate tumour removal with satisfactory margins. Imaging is also key in follow-up assessment and detecting recurrence.

These established diagnostic and interventional imaging techniques continue to evolve, and there is a constant drive to develop new approaches to help achieve the best possible outcomes for the patient. Some of the more promising new developments are discussed below.

Optimizing patient care also depends upon radiologists and surgeons maintaining a strong working relationship and as such it is important for us to have a reasonable understanding of one another's roles. This article aims to give the surgeon an overview of the role of imaging techniques and radiological interventions in the diagnosis and management of breast cancer.

Mammography

Two-view mammography (low-dose X-rays of each breast compressed in two different planes: craniocaudal [CC] and mediolateral oblique [MLO]) is the most fundamental and frequently employed imaging modality in breast imaging. In recent years digital mammography has largely replaced analogue (film) and is now used throughout the NHS Breast Screening Programme (NHS BSP). The technology is partly a spin-off from NASA and their development of light detectors used on the Hubble Space Telescope! Digital receptors and computers are used to analyse the X-rays, and the resulting mammograms are viewed on very high-resolution monitors.

In the NHS BSP two trained film readers (radiologists or film reader mammographers) read each set of mammograms, and a third reader may be required to 'arbitrate' if there is disagreement between the first two readers. In some screening programmes computer-aided detection (CAD, see below) is used as a second reader in place of a human being. Film readers analyse the pattern on each mammogram and compare them with previous examinations, looking for abnormal patterns that may represent breast cancer (Figure 1). Any densities are analysed for signs that have a high predictive value for the presence of malignancy (such as ill-defined or spiculate margins, or architectural deformity of the tissue), and for features more reassuring of benignity (such as well defined margins). Any calcification within the breasts is also appraised. Macrocalcifications of various different patterns — for example, parallel vascular calcification, 'popcorn' (fibroadenoma) calcification, duct ectasia type clacification and cystic 'tea cupping' — are relatively straightforward to classify as benign on mammogram with no further investigation required. Diffuse bilateral microcalcification is also benign. Clustered or segmental microcalcification, however, can be a sign of pre-invasive or invasive carcinoma. Clusters may have signs suggestive of malignancy, such as a branching or 'sharp' appearance, but most malignant microcalcification will actually have no specific suspicious signs and therefore radiologists tend to maintain a low threshold for further investigation even in the absence of suspicious features. Densities or microcalcifications that are judged to have a risk of malignancy are recalled to an assessment clinic for further assessment. In the NHSBSP approximately 1 in 20 screening mammograms lead to a recall.

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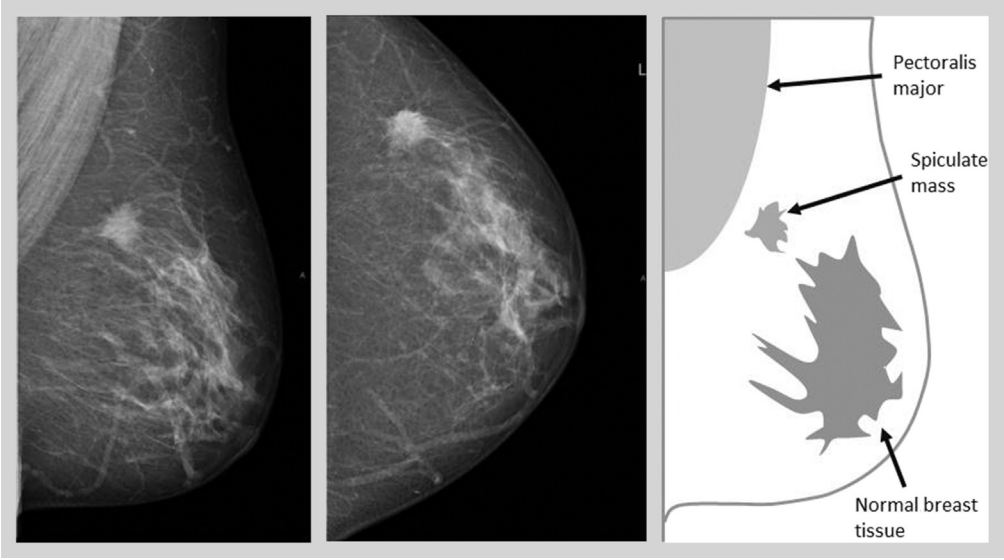

Figure 1 Digital mammogram mediolateral oblique view (left image) and craniocaudal view (middle image) demonstrating a spiculate mass in the upper outer quadrant. This is grade M5 (malignant). The line diagram (right image) illustrates the mass on the mediolateral oblique view.

Recalled mammographic abnormalities undergo further imaging that may lead to needle biopsy. The threshold for recall is deliberately set low as the programme needs to detect small cancers in order to make a difference to population mortality, and because of this low threshold for recall the majority of cases recalled to assessment clinic will prove to be benign.

In a symptomatic setting such as a one-stop clinic, mammogram is the first-line imaging investigation for almost all abnormalities in patients aged 40 or above. Mammography is also first line for clinically suspicious or clinically malignant lesions in those aged 35–39 years.[1] Under the age of 35 the density of the breast tissue reduces the sensitivity of mammography, the risk to benefit ratio in relation to the radiation dose is more uncertain, and therefore ultrasound is the primary imaging modality. When mammograms are performed, the radiologist assesses the mammogram in much the same way as in the screening setting, looking for features which may guide further investigation. When reporting the mammogram it is good practice for the radiologist to include a grade to indicate the likelihood of malignancy, ranging from M1 (normal) to M5 (malignant).

Mammography is also used *after* surgical treatment of primary breast cancer. The technique for surveillance is the same as for screening: an MLO and a CC view on each breast (no mammography on mastectomy side or mastectomy with reconstruction). A surveillance regimen containing mammography is important for detecting recurrence and second cancers, and confers a survival advantage when compared to surveillance without imaging. There is no clear evidence for the optimum frequency of imaging, or optimum duration of mammographic surveillance. Recurrence can occur many years post treatment and late detection of recurrence is expensive. Taggart[2] showed that patients with a history of breast cancer also have an increased risk of developing a second primary breast cancer that is maintained for at least 20 years, that ipsilateral breast cancer recurrences are mainly detected either by the patient or by mammography, and that these recurrences are associated with improved survival when compared to those found by physical examination by a clinician. Also, non-attendance for mammographic follow up is associated with poorer survival versus attendance.

Ipsilateral breast cancer recurrence is often similar in mammographic appearance to the original breast cancer – for example, a patient with a mass containing microcalcification will frequently demonstrate microcalcification in tumour recurrence. Where the primary breast cancer is mammographically occult there is an increased rate of mammographically occult recurrence, for example 32% versus 12% in a study by Yang et al.[3] Some centres therefore have follow-up guidelines for these patients that include either surveillance ultrasound or MRI. Mammographically dense breasts are also associated with an increased risk of primary and recurrent breast cancers, and of delay in detection of these cancers when using mammography. Mammography, however, is a cheap, quick and easy examination to perform. Moreover, mammograms are easily compared with previous films and have a low false positive rate when compared with MRI and ultrasound.

National Institute for Health and Care Excellence (NICE) guidelines[4] recommend annual mammography if diagnosed with primary breast cancer up to 50 years old, and for a minimum of 5 years if diagnosed after 50 years of age. This is common, although not universal, practice in UK breast units. The Cancer Reform Strategy[5] recommended a personalized risk-adjusted follow up to meet individual patient needs, and ideally mammographic frequency should be determined by the lead time achievable for a patient's specific characteristics (young age, for example) and tumour biology. The MAMMO-50 trial is currently recruiting patients over the age of 50 years, aiming to establish whether certain patient and/or tumour characteristics are better served by a regimen of less frequent mammographic surveillance but over a longer period of time. Ideally we should tailor all imaging, including the interval between mammograms and the duration of surveillance, to each patient's needs.