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Breast Imaging

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Breast cancer is the most common form of cancer in women, and the second leading cause of cancer death in women around the world, after lung cancer. The incidence of breast cancer in women increases dramatically with age, with most breast cancer cases reported in women over the age of 40. Recently, the number of cases reported in women under the age of 40 has been on the rise, although the most common reasons for breast cancer in younger women may be credited to genetic disposition. The main indicator of breast cancer is lumps in the breasts that can be located physically. But the cancer is formed even before it can be felt physically, and the abnormality can be detected using different imaging procedures, most commonly mammography. Early detection of breast cancer and efficient diagnosis of the severity not only enable more appropriate treatment, but also reduce mortality from the cancer.

The most important criterion that defines the standard of the breast imaging workflow is its efficiency. Higher efficiency of breast imaging procedures, along with rapid reporting times, allows the physician to provide excellent quality of care to the patient. The most commonly performed breast imaging procedure is mammography. With advances in technology, many novel techniques of imaging have risen over time, although mammography is still considered the 'Gold Standard' in breast imaging.

Mammography

The primary and most cost-effective imaging modality for breast screening is mammography. It functions as an X-ray imaging of breasts that is capable of detecting tumours and abnormalities. The technology has been consistently advancing, thereby improving the performance quality and reporting of studies. As imaging shifted from analogue systems to digital systems, it has become easier to record breast images electronically. Mammography also provides the ability to alter contrast and brightness of images to ensure effective evaluation of abnormalities. Mammography can identify and demonstrate microcalcifications, sometimes lower than 100 microns. Hence, a mammogram can report anomalies in the breast long before it can be identified by clinical breast examination (CBE). A mammography image is interpreted on the basis of standardised guidelines set by the Breast Imaging Reporting and Data System (BI-RADS). These guidelines help in analysing and indicating the potential risk of malignancy for a patient. Recent times have seen many developments in technology with the introduction of three-dimensional imaging mammography, lower dose radiation mammography, contrast enhancement imaging and computer-assisted diagnosis.

There are two types of mammography techniques commonly used:

a. Screening Mammography:

Screening mammography is a technique that enables detection of changes in the breasts of women with no physical symptoms. The main purpose of this technique is to screen and detect cancer before any physical signs are noticed. Screening mammography is done by collecting two mammogram images from different angles for each breast, which are analysed for lesions or abnormalities.

b. Diagnostic Mammography:

Diagnostic mammography is generally used to determine whether an identified lesion or lump is malignant. The technique allows the physician to screen all the surrounding tissue to check if the disease has spread. Diagnostic mammography is performed to investigate any symptoms that involve breast changes like lumps, pain, abnormal nipple pigmentation and discharge. The technique is also used to confirm and evaluate any abnormalities that were identified on screening mammography.

Limitations of Mammography

Though mammography is considered the best population-based breast imaging method for cancer screening, there are some issues that the technique faces which take a toll on the efficiency of diagnosis. The mean sensitivity of a mammography technique is about 68%, which is not ideal. The sensitivity of the technique falls largely as the density of the breasts being scanned increases, and it is well known that dense breasts have a greater risk of breast cancer. This reduced sensitivity while diagnosing radiological dense breasts may lead to false negatives, where an existing tumour may go undetected. Breasts generally contain fibro-glandular tissue and adipose tissue, and the density of the breasts is generally a result of increased fibro-glandular tissue. On a mammogram, adipose tissue appears black in colour, while the fibro-glandular tissue appears white on the scan. As the density of fibro-glandular tissue and the tumour are similar, the tumour may be ignored by the radiologist as fibro-glandular tissue, leading to false negative results and delay in treatment.

Sometimes mammography could misdiagnose a non-malignancy as a tumour, putting immense psychological pressure on patients. These patients who receive false positive mammograms generally undergo worries, anxiety and stress-related issues that are normally common in

breast cancer patients. The trauma that results from false positives may continue over time even after the cancer has been ruled out. Issues such as this generally require the radiologist to verify the test results using other modes in order to confirm the presence of a tumour. Along with these issues related to sensitivity, the mammography technique uses low dose ionising radiations for imaging, and these radiations may sometimes have harmful effects on the patient.

Ultrasonography

Ultrasonography is one of the most important adjunctive imaging techniques used in breast cancer diagnosis. Traditionally, ultrasonography has been used to differentiate solid masses in breasts from cysts. More recently, technological advancements have enabled ultrasonography to be used for determining if a particular solid mass that has been identified is benign or malignant. The most notable advancement of ultrasonography is its role in interventional procedures like biopsies and other therapeutic measures.

The biggest advantage of ultrasonography is that it does not use ionising radiation for imaging. The technology involves reading ultrasonic waves that have been reflected back by the tissue and identifying anomalies on the basis of variations in the received ultrasonic waves. The technique is highly suitable for dense breasts, and helps in detecting mammographically occult tumours.

A drawback of breast ultrasonography is its inability to detect microcalcifications. Ultrasonography is a highly operator-dependent procedure that demands high skilled practitioners to perform the procedure and analyse the images. The user dependence and long procedure duration of ultrasound paved the way for the development of Automated Breast Ultrasound (ABUS). This technology uses transducers that automatically scan breasts and obtain volumetric image data of the breasts that allow for effective diagnosis, even in dense breasts. By using ABUS, the time taken to perform a procedure is largely cut down, as the scan is completed in several seconds. The automation of the procedure also tackles the operator dependency issue effectively. Research is underway to determine if ultrasonography can be efficiently used for cancer screening on the same scale as mammography.

Magnetic Resonance Imaging

Magnetic Resonance Imaging (MRI) is a non-invasive imaging procedure that does not involve ionising radiation. It is commonly used as a supplement, along with mammography and ultrasonography, for staging breast cancers. A combination of MRI techniques along with 3-D contrast enhancement, when used with mammography and CBE, can be over 90% sensitive in detecting invasive cancers. MRI allows imaging of the breast from all possible imaging planes, and also provides images for complete breast volume.

A major drawback is that MRI is a highly expensive procedure in comparison to mammography, and is not as widely available as other modalities. MRI for breast cancer has a low specificity of 25% in comparison to 75% specificity of mammography, and therefore has a greater risk of providing false positive reads. The role of MRI in early scanning of breast cancers is unknown, and extensive research is being done in this area.

Positron Emission Tomography

Positron Emission Tomography (PET) is a type of nuclear medicine study that has recently found application in breast imaging for detecting cancers. The technique involves injection of a small amount of radioactive substance into the arm veins, and detecting the radiation from the substance with a PET scanner to form an image. The most commonly used radioactive substance is fluorodeoxyglucose (FDG). The substance moves to places in the body where the cells are most active, mainly highlighting cancerous tissue, and identifying the best method of treatment to be provided.

A PET scan is often combined with computed tomography (CT), and the fusion image provides anatomical and functional information of the tumour. PET plays a major role in identifying cancer cells and differentiating them from healthy cells, and along the same lines, it can also determine cancer metastasis. But PET fails to identify microcalcifications. The role of PET is that of an adjunctive, and it cannot be used as a complete screening tool.

Thermography

Thermography is a procedure that has been applied to breast imaging for a while, and has gained more application in breast cancer diagnosis as a supplement to mammography. The principle behind thermography is locating regions of increased surface temperature. Cancerous tissue and the cells surrounding the cancer are metabolically more active, and have higher blood vessel proliferation (vascularisation) than healthy cells. As a result of increased vascularisation, more blood is circulated to these tissues to facilitate tumour growth, therefore causing a rise in the regional surface temperature. Thermography involves using ultra-sensitive infrared (IR) cameras that detect the temperature variations, and provide high resolution images of these temperature differences. As the attenuation of IR in human tissue is very high, thermography can be used only to map surface temperature changes, while the depth information of the breast cancer remains unknown through this procedure.

Galactogram

Galactography or ductography is a technique that involves identifying tumours within the milk ducts of the nipple. The procedure is similar to an X-ray, where the milk ducts are dilated and a contrast medium is injected into them. The X-ray determines the shape of the contrast medium to identify any abnormal mass that is present within the duct. The procedure is generally performed in women who have a clear mammogram, but have abnormal discharge or pain in the nipples. The advantage of this procedure is it allows diagnosis of small tumours inside the ducts that may go unnoticed in other techniques, but a major concerning factor is that the ducts may be very small and dilation of an incorrect duct can lead to incorrect diagnosis.

Scintimammography

Scintimammography involves injecting a small amount of the compound Technetium Sestamibi into the arms of the patient, and using a special camera to identify the spot of radiation accumulation in the breasts. As the procedure can not differentiate benign lesions from cancerous

tumours like regular mammography does, it is generally not used as a tool for initial screening of breast cancer. Extensive research is underway to establish its applications towards accurate screening of breast cancers.

Conclusion

Research shows that the best tool for radiological imaging of breasts to identify cancers is mammography. Mammography is the only reliable tool that has been proven to be highly effective in initial screening of tumours. But, despite the benefits it provides, it has limitations, losing its sensitivity while used for women with dense breasts. Ultrasonography and MRI for breast imaging are excellent supplements to mammography, providing more opportunities for efficient cancer detection, and planning therapeutic procedures for the treatment of cancers, but their role as independent screening procedures is not established yet. While there are many novel techniques that are being studied, it is expected that advancing technology will add to the efficiency of identifying and staging cancers and planning the best possible treatment. The main aim of research is to facilitate breast imaging tools that are highly accurate in screening for cancerous lesions, and enable early detection of cancers, so that they can be treated at a nascent stage.

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