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Breast Imaging: Comparison of Mammography, Ultrasound, and MRI

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Background

Mammography uses low-dose x-rays to detect breast cancer with an advantage of detecting microcalcifications, which is associated with early stages when it is the most treatable. Conventional mammography units became available for use worldwide in 1969 (RamSoft, 2017). Conventional mammography has a sensitivity of 75-85% for detecting breast cancer (Li et al., 2017). Technological advancements continue to occur with the latest evolution of tomosynthesis or 3D mammography, improving sensitivity for imaging dense breast tissue and microcalcifications.

Throughout the 1990's, the role of breast ultrasound evolved as an important adjunctive tool used to characterize suspicious areas or masses seen on mammography (Dempsey, 2004). Conventional ultrasound has a high sensitivity of 100% and a specificity of 85.0%. Specifically regarding breast neoplasms, conventional ultrasound has a diagnostic accuracy of 91.4% (Arafa et al., 2018).

Magnetic resonance imaging, commonly referred to as MRI, produces images by using magnetic fields and radio waves. MRI has a sensitivity of 79-98% for detecting breast cancer. However, it also has a variable specificity of 52-77% due to limitations within the modality (Li et al., 2017). Within the past two decades, MRI has been more widely used for breast imaging, primarily in patients with high risk factors since mammography exhibits a limitation for detection of breast malignancy.

Introduction

In healthcare, mammography, ultrasound, and MRI have become known as the eyes of medicine. This is because of the essential role they play in differentiating breast tissue characteristics that can lend to rendering a diagnosis. These three imaging modalities each have defined advantages, as well as limitations that are specific in regards to breast imaging. Mammography is the most popular and first choice for imaging of the breasts because it is used as a screening and diagnostic tool, while ultrasound and mammography are often used diagnostically following mammography. Based on mammography findings, patient risk factors, and clinical history, the radiologist or referring physician may request additional imaging for further characterization and management.

Comparison of Mammography and Ultrasound

Mammography is widely used for screening with recommendations for all women over the age of 40 to have annual mammograms. Screenings are used for women who do not have any symptoms of breast disease. Once a suspicious or documented mass is seen, imaging becomes diagnostic. Mammography is cost effective and time efficient. All breast tissue and some of the muscular wall can be imaged using only two different scan planes. The sensitivity of mammography is dependent upon the patient's breast density. Studies have shown that women who have dense breast tissue have a lower sensitivity. When patients have dense breast tissue or when suspicious findings are found, a further workup may be required.

Ultrasound is not widely used for breast screenings, but instead for diagnostic purposes together with mammography. It is primarily used to characterize lesions since mammography cannot determine if a lesion is cystic or solid. Ultrasound can also provide a more precise location of a lesion, such as distance from the nipple. Ultrasound is beneficial for patients who have high breast density and fibrocystic breasts, as well as those who have contraindications to mammography. Ultrasound is operator-dependent and time consuming to scan both breasts. A key limitation of ultrasound is that it is not sensitive in detecting microcalcifications, which is often associated with early stage malignancy.

Comparison of Mammography and MRI

Mammography is an accessible, affordable, and time efficient choice for breast imaging. Mammography use for screening purposes is crucial since it has been proven to reduce the mortality of breast cancer (Joe & Sickles, 2014). Since breast cancer can be hidden behind dense breast tissue on mammograms this has caused an increased number of false negatives, false positives and biopsies, which has added to patient stress and increased costs.

MRI breast imaging is the most rapidly growing imaging modality that is being used for breast cancer screenings in high-risk women. MRI is considered the most sensitive imaging modality in regards to breast cancer and has been recognized as the primary additional method used for

screening high-risk patients in addition to mammography (Joe & Sickles, 2014). However, MRI has its limitations which include the expensive cost, longer exam time, limited availability, and contraindications. Some contraindications are patients with pacemakers or those who are claustrophobic. Another challenge would be obese patients who physically may not be able to fit in the MRI machine. MRI breast imaging has not been proven to show decreased rates in survival or disease reoccurrence.

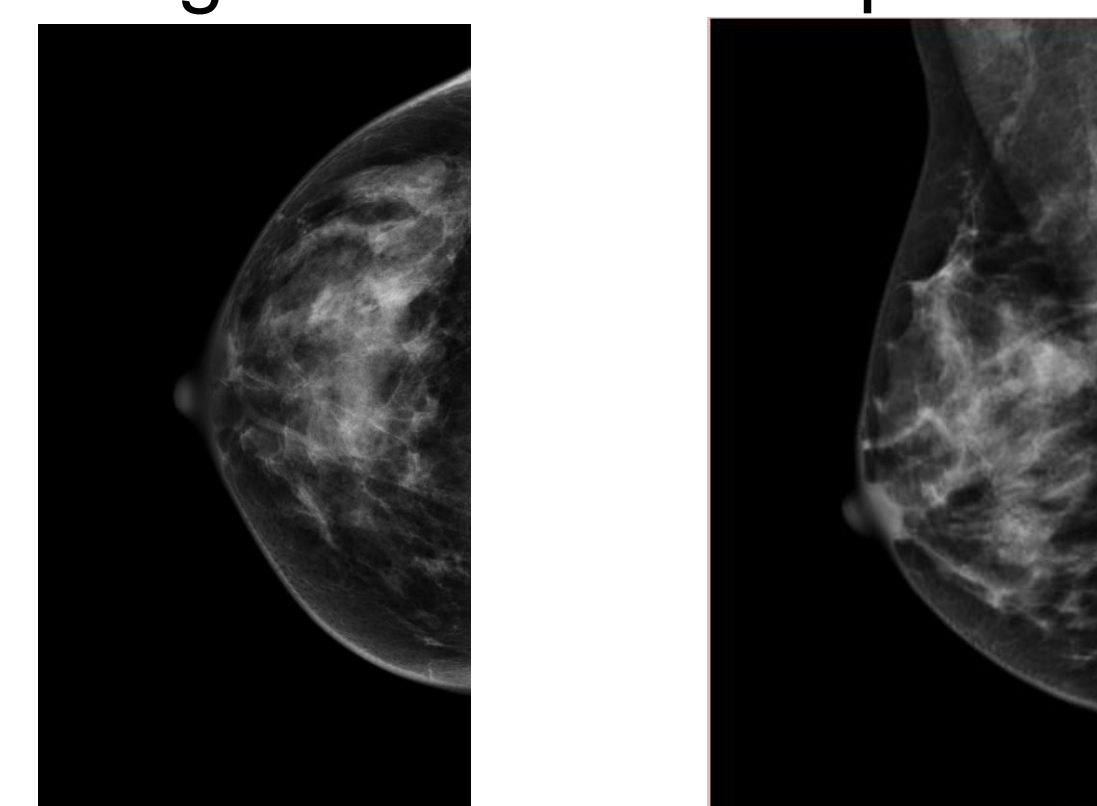
Comparison of Ultrasound and MRI

Ultrasound is a more accessible and less expensive option than MRI. Ultrasound is also used as an alternative for patients who have contraindications to MRI. However, conventional ultrasound is more operator-dependent than MRI.

Along with being used for high risk populations, MRI is also used to find out the extension of disease. It can be used to compliment mammography and ultrasound, but not for screening low risk populations. MRI is not the modality of choice for biopsies due to the patient prone position, accessibility to the breast for the physician, and it does not allow for real time visualization. However, MRI is the most accurate modality for imaging implants, especially when looking for implant rupture (Klimas, 2020).

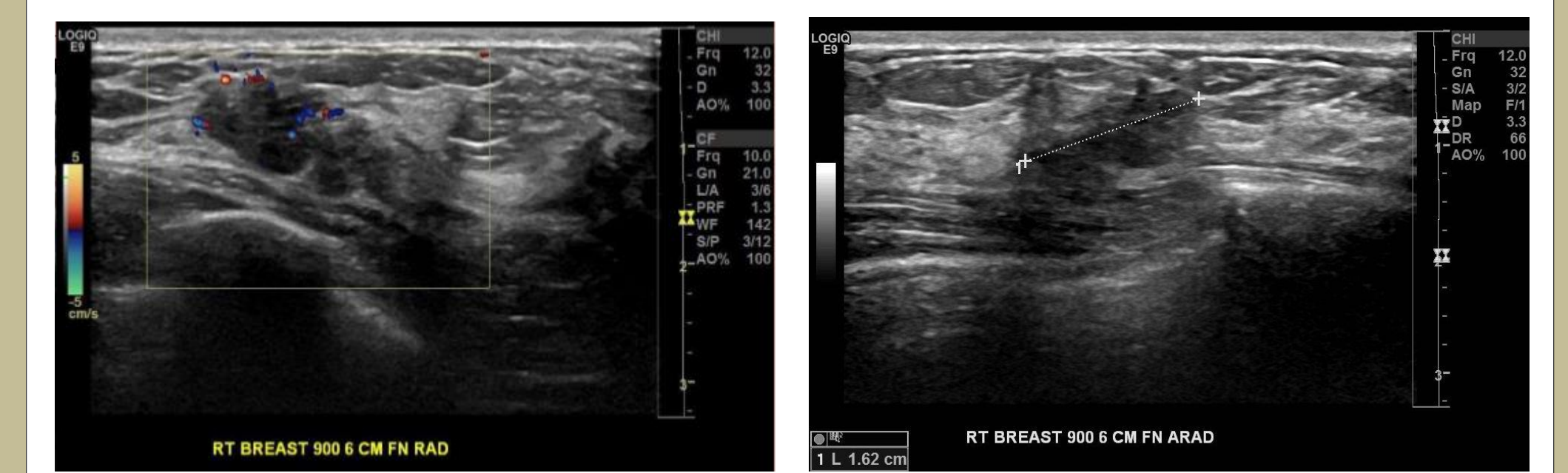
Case Study

A 46 year old female who has been compliant with annual mammograms presented for a diagnostic mammogram for a palpable right upper quadrant lump. Bilateral lesions were found, but there is a focus on the right breast for this presentation.



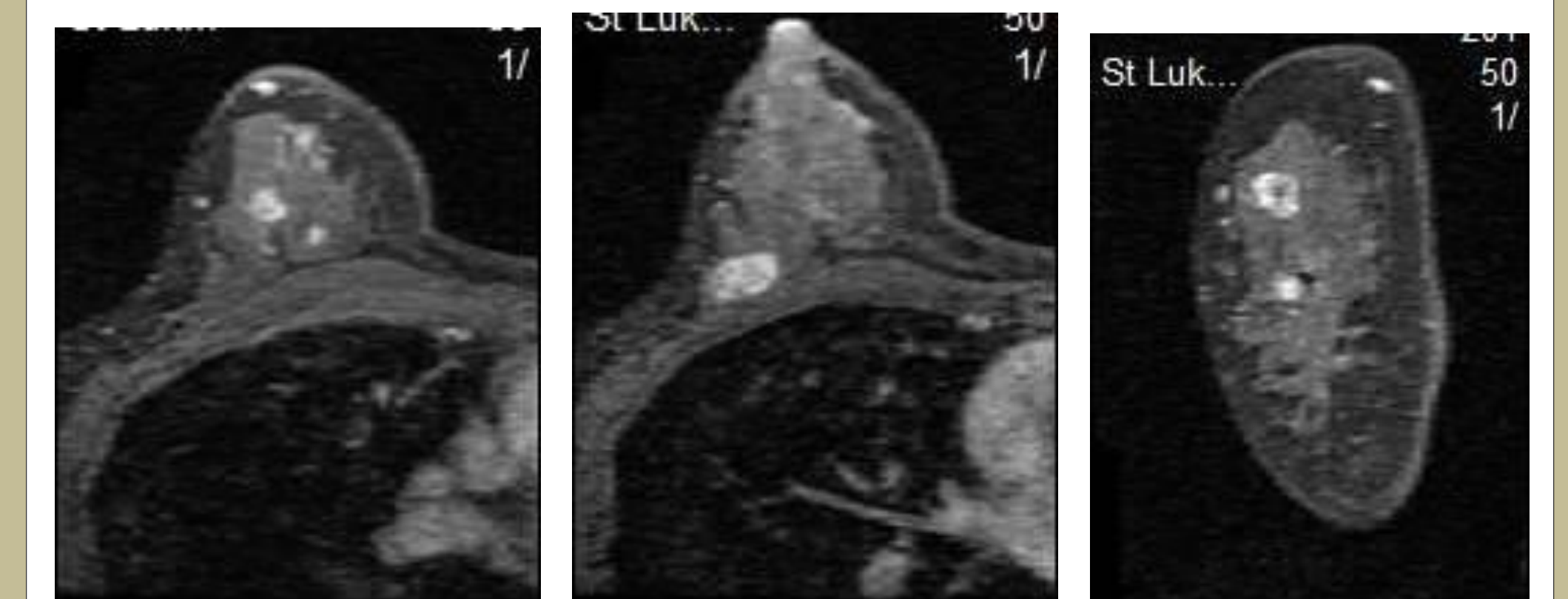
Misericordia University (2016c,d).

The appearance of the diagnostic mammograms above were similar to the patient's previous mammograms except for an area in the posterior right upper outer quadrant that had slightly increased parenchymal density. This area was partially well-defined with partly obscured borders. Although no spiculation, malignant calcifications, or axillary adenopathy was found in this area.



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An ultrasound was performed demonstrating multiple suspicious lesions. The above images were taken at the 9:00 o'clock position, which show an irregular hypoechoic solid nodule. A second lesion located at 9:00 o'clock was a smooth fibroadenoma. At the 10:00 o'clock position there was a hypoechoic, oval-shaped lesion with posterior enhancement. When using color Doppler, there was no color flow. At the 11:00 o'clock position, another lesion was found that appeared as a slightly irregular hypoechoic lesion with no shadowing and some small adjacent simple cysts noted. After the ultrasound, the patient had a biopsy performed on the right breast of these suspicious areas.



Misericordia University (2016b,e,f).

An MRI was performed and several more similar enhancing lesions were found in the upper outer quadrant. After these findings and biopsy results, the recommendation was made for the patient to have a mastectomy because of multicentricity malignancy. Although no dominant masses were suspicious, an area in the left lower outer quadrant had duct like enhancement that could not rule out ductal carcinoma in situ (DCIS).

Conclusion

From this group of testing it was determined that the patient had invasive and in-situ ductal carcinoma of the right breast, as well as in-situ ductal carcinoma of the left breast. This case study provides an example of how mammography is used as the first line of defense in breast imaging, but there are times when mammography is used in conjunction with the other imaging modalities, ultrasound and MRI, in order to properly diagnose and provide optimal patient management.