REVIEW ARTICLE

Role of interventional radiology in surgical diseases of breast

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Abstract

Since the publication of the first imaging-guided wire localisation technique, the art of breast treatments has made great strides. Radiologists like Hall, Frank, Kopans, DeLuca, and Homer were all the pioneers in innovative breast interventional radiology field. Their approaches and gadgets for enhancing surgical outcomes in cases with breast diseases aided progress in the discipline and have withstood the ravages of time. Many of their methods are still in use. We are all standing together at the beginning of a new chapter in medicine. Cost effectiveness, comparative effectiveness studies, and an older population are all causing clinicians to reconsider what they perform. Similarly, we are now united on a global scale. The studies described in the current narrative review relate to multiple nations around the world. Breast cancer is a worldwide health problem. With the expansion of technological advances, as well as the apparent ease of worldwide travel, we must all collaborate to improve the outcome in the battle against breast cancer.

Keywords: Mammography, Stereotactic biopsy, US-guided, Interventional radiology, Cryoablation.

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Introduction

Since the publication of the first imaging-guided wire localisation technique, the art of breast treatments has made great strides.[1] Radiologists like Hall, Frank, Kopans, DeLuca, and Homer were all pioneers in the field of innovative breast interventional radiology. Their approaches and gadgets for enhancing surgical outcomes in cases with breast diseases aided progress in the discipline and have withstood the ravages of time.[2] Many of their methods are still in use.[2] Many variables lead to the enhancement and advancement of imaging-guided therapies.

The most important thing is to increase patients' quality of life. Some of this expansion is targeted at consumers, but the vast majority is motivated by clinicians seeking improved results.[3] Novel imaging methods are another element driving the creation of new breast treatments. New modalities need the development of up to date therapies. Due to advancements in ultrasound (US) technology, we got introduced to the technique of US-guided breast biopsy.[4]

Whenever the findings of the stereotactic biopsy did not agree, the operation was not halted. An investigation was conducted to understand how to enhance the method and confirm outcomes.[5] It was after many years of research that surgeons able to perform the US-guided percutaneous biopsy of the breast lesion, for the very first time in 2005. In case a pathology needs to be identified by image analysis, image-directed biopsy should be the first option for diagnosing the disease of breast rather than a conventional surgical biopsy.[6]

Therefore, with new gadgets and techniques like positron emission mammography and digital tomosynthesis, modified techniques are required to successfully biopsy pathologies detected with this new machinery that otherwise would not be noticed with standard imaging.[7] Aside from imaging advances, the industry is developing new and better equipment to do breast invasive treatments in conjunction with clinicians.[8] Lastly, and probably most crucially, genuine growth is founded on methodological ingenuity. Clinicians tend to struggle to do more by developing innovative minimally invasive imaging-guided treatments by never being content and questioning the status quo. These are frequently more patient-friendly and less costly than the standard surgical methods.[9]

US-guided breast biopsy: past perspective and future horizons

Ultrasonography (USG) is without a doubt one of the simplest and the most well-tolerated imaging methods for the portrayal of breast pathologies. Breast US needs no radioactive exposure or contrast agent injection and can be done in a patient-friendly supine posture.[10] These aspects were realised more than about 30 years ago due to the spread of breast USG and the connection of mammographic and sonographic irregularities, which resulted in the creation of and need for reliable US-guided breast biopsy procedures.[10] Method of using phantom chicken and turkey breasts with implanted targets is

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beneficial for instruction. It has been used by early adopters and is being used as a teaching medium today.[5] The safety and effectiveness of US-guided breast biopsy have been extensively established across decades.[11]

The usefulness of US-guided breast biopsy versus conventional surgical biopsy has been demonstrated via experience and development, including radiological and pathological concordance of tissue samples. The incidence of misinterpreted breast lesions has been demonstrated to be equal to, if not superior to, that of conventional operative percutaneous biopsy.[12] Bioequivalence studies and cost reductions have been established, as has the utility and usability of US-guided breast biopsy vs conventional percutaneous breast sampling. Breast pathologies are more seen and defined now than they were a decade ago, thanks to USG advancements.[13] Industry-developed high-frequency sensors and advancements in US screen resolution have enhanced the capacity to observe and describe the breast with better transparency. Mysterious microcalcification is a possible anomaly which at present is better recognised than in the past because of technological improvements.[14] The study found ultrasound's capacity to identify microcalcifications of the breast well before the emergence of today's advances.[15] It is now commonly acknowledged that mammographically visible solid lumps or structural distortions can be further described using USG. If a congruent aberration is found, an ultrasound-guided tru-cut needle biopsy is the preferred method for documenting a pathological aberration.[15] A study established the possibility of doing an US-guided biopsy of the breast for microcalcifications. With a few significant differences, the method for US-guided biopsy of suspected breast microcalcifications is similar to the US-guided biopsy of clumps. The ability to tell under sampling of calcifications with spring-loaded 14-gauge tru-cut biopsy needles for stereotactic-guided breast biopsy has been extensively reported.[16] The standard treatment for stereotactic biopsy is to use large-gauge vacuum-assisted or mechanically spinning biopsy instruments to capture the microcalcifications along with surrounding tissue effectively.[17] Moreover, it can be asserted whether a large-gauge pressure washer helped or mechanical rotating biopsy machine is required for USG-steered biopsy of breast microcalcifications compared to a 14-gauge spring-loaded needle which is used with amazing precision to biopsy larger solid particles.[18] Furthermore, marker implantation at the site of biopsy and the use of post-biopsy mammography to establish congruence of the biopsy site with pre-biopsy radiography should be undertaken in all situations.[19] Sample mammography can also be done to ensure that the calcifications are contained within the material and have been appropriately collected before the biopsy process is completed. When compared to a stereotactic-guided breast biopsy, the positive effects of this treatment include comfort and an absence of radiation dose.[20] Significant outcomes include the potential to correctly biopsy microcalcifications in females who would not be applicants for a stereotactic biopsy due to the proximity of the calcifications, size of breast, or incapability to accept the deformation, lack of mobility, or placement needed by the stereotactic process.[21] As a result, the capacity to execute an US-guided breast biopsy of suspected microcalcifications would reduce the number of conventional surgical biopsies necessary for identification in this patient group.[21] More studies, preferably done prospectively, are needed to confirm this method as a credible option to stereotactic breast biopsy for worrisome microcalcifications.

A review of stereotactic breast biopsy and the potential for stereotactic lumpectomy

Those with recently detected worrisome microcalcifications on mammography or electronic tomosynthesis who are categorised as Breast Imaging Reporting and Data System (BI-RADS) grade 4 or 5 will need treatment to obtain a histopathological diagnosis.[22] Females with BI-RADS category 3 calcifications are not uncommon to have a detection investigation. A solid family record of malignancy in a first-degree relation, a life background of malignancy or atypia, or the worry and pain of watching for follow-up investigations to confirm stabilisation are all possible reasons.[23] The mainstay of treatment for the identification of these calcifications in the early 1990s was a pin or wire positioning technique followed by open conventional surgical lumpectomy.[24] The stereotactic-aided breast biopsy method was invented in the early 1990s and was a significant advance compared to the conventional open surgical breast biopsy approach.[24] Various studies confirmed specimen quality, rate of concordance between people treated by both conventional surgical and stereotactic biopsy techniques, and sequelae.[25-27] Originally, the experiments were carried out with 14-gauge mechanised spring-loaded sampling needles. The original study was carried out by interventional radiologists or those who do breast scanning and invasive treatment.[28] The surgical society, like the radiological community, took part in the study as well. For most part, preliminary studies relied on high-quality clinical trials to confirm ideas and create a novel alternative method that has to change the way breast sampling is conducted. Brenner et al. conducted multi-institutional longitudinal research to investigate operator skill and analytical needs for biopsy with only five 14-gauge quick-release biopsy needles.[29] The conclusions were extremely

promising, with 99% sensitivity indicated for aggressive breast tumours but only 67% sensitivity for ductal carcinoma in situ(DCIS).[21] The invention of the vacuum-assisted core needle, which enabled bigger specimens and even greater agreement between stereotactic-guided biopsy findings and conventional open surgical histology, altered the scene once more. The vacuum-assisted probes improved classification yield, specifically in the region of DCIS.[30] Further, mostly retrospective investigations published the development of stereotactic biopsies all across the years to corroborate previous findings and demonstrate the efficacy of this method.[31] Several types of research have been done to examine the variations in analysis and results when bigger size vacuum probes were accessible. In instances with atypical ductal hyperplasia, Eby et al. found that there was no substantial promotion rate to cancer or DCIS after surgery with 11-gauge needles compared to 9-gauge needles.[32] The stereotactic lumpectomy was discovered in that paper and numerous previous researches as an unanticipated side effect of the stereotactic biopsy technique. A lumpectomy is performed to excise a pathological mass from the breast.[33] This is exactly what the first doctors who performed stereotactic-guided breast sampling with large-gauge suction probes discovered. The interventionist breast radiologist or surgeon conducting these treatments never intended to completely remove atypical ductal hyperplasia (ADH), DCIS, and, in some circumstances, invasive cancer.[17] It occurred quite recently. Liberman et al. published one of the first studies in 1998, reporting excision of the target lesion detected on mammography using an 11-gauge needle in 15 of 51 tumours.[4] Gajdos et al. stated in 1999 that histology signs of breast tumours were completely removed in nine of 52 tumours.[34] "Total elimination is much more likely with excision of a high sample from tiny regions of mammographic calcifications owing to ductal carcinoma in situ," the investigators found.[34] A further retrospective study conducted by Liberman et al. in 2002 examined 800 abnormalities in 797 women aged 22-88 years who had stereotactic sampling with an 11-gauge suction needle in which the interventional radiologist did not expressly strive to attain full target removal.[35] Up to 47 samples were acquired, with 99% of patients obtaining eight or more cores; 466 lesions, including 91 malignancies, were detected. Nineteen of the 91 females had no remaining malignancy at the time of operation.[35]

Penco et al. performed a comprehensive retrospective investigation of 4086 suction stereotactic breast samples utilising 8- or 11-gauge devices in 2010.[36] In 30% tumours with an original diagnosis of malignancy when the target disease was fully eliminated radiographically, no remaining cancer was identified during surgical removal.[36] Even though the target calcifications were eliminated, the scientists discovered that suction breast sampling may not be deemed a curative technique. However, in 30% cases, the tumours were excised inadvertently. Villa et al. conducted a retrospective study in 2011, in which 114 of 1173 valid responses with 11-gauge stereotactic biopsies were diagnosed with terminal cancer. The treatment fully eliminated the calcifications of 65 individuals. Four of the 65 were missed in follow-up, and just one of the 61(1.6%) converted to a low-grade DCIS after 48 months of check-up.[36] These researchers found that ADH individuals who had an 11-gauge suction biopsy and had no remaining microcalcifications following the operation can be treated with mammographic follow-up at facilities that can replicate an underestimated rate of little less than 2%(36). It is not uncommon to see extremely tiny clusters of questionable microcalcifications of 10mm or less.[37] With imaging-aided stereotactic biopsies, they can be precisely addressed and fully eliminated.[37] Individuals who do this surgery regularly are also mindful, as were our forefathers who pioneered the area, that stereotactic lumpectomies are often and accidentally conducted. A new study is now needed to determine why, how and for whom this surgery should be performed. Curiosity is something we offer to our clients and is our job as clinicians. None of the preceding studies conducted an imaging-aided stereotactic lumpectomy. A prospective study should be conducted utilising large-gauge suction-guided biopsy equipment and addressing small teams of microcalcifications to remove them and their borders through a large number of biopsies.[38] Indeed, as per the American Society of Breast Surgeons' most recent policy document on breast tumour lumpectomy borders, "greater radial width gains, but has no relevance when corrected for patients getting a radiation boost or endocrine therapy".[39] This indicates that an appropriate surgical border for aggressive or in situ breast tumour is higher than or equivalent to 1mm.[39] The policy paper also states that re-excision may not even be required for sparsely involved edges or edges lesser than 1mm because "many variables, such as age of the patient, co-morbidities, lifespan, the area of resection, extent of edges involved, tumour qualities, or whether the patient will obtain chemoradiation therapies, must be considered before continuing with a repeated excision.[40] " This method of study must be conducted by collaborating with surgeons and oncological peers to ascertain if stereotactic lumpectomy, both with and without combination therapy, could be a new non-invasive curative option for such instances of ADH, DCIS, and possibly even malignant breast carcinoma, as a substitute to surgical lumpectomy in a subgroup of patients.

Thermal ablation of benign fibro adenomas and breast cancer

Thermal ablation procedures utilising image aid have become generally acknowledged as tumour treatment options during the last decade.[41] Even though the technique has been extensively modified and approved in order to use in organs like liver, kidneys and lungs, it had not been used in breast cancers.[42] Many studies were published in the 2000s, demonstrating the effectiveness and creation of a technique for cryoablation of benign fibroadenomas of the breast as an option to conventional open resection.[43-45] The goal was to assess the fibroadenoma cryoablation method, results and patient comfort. Generally, the results for 444 treated fibroadenomas were excellent, especially in case of tumours <2cm. At 12 months, nearly all nodules >2cm in size had shrunk altogether, but retained some palpability in the treated region. At 12 months, overall patient satisfaction was 88%.[45] The American Society of Breast Surgeons approved a joint resolution for the diagnosis and treatment of fibroadenomas in 2008, promoting both imaging-aided percutaneous resection with a suction aided device and percutaneous imaging-aided cryoablation of fibroadenomas, approved by the Food and Drug Administration (FDA), as reasonable options to conventional open surgical removal for women receiving care.[46] Cryoablation should thus be regarded as a first-line therapy for such individuals.[46] Breast cancer therapy has progressed across time, from drastic mastectomy to more breast-conserving options. These methods reduce morbidity, enhance cosmesis, and produce better clinical results.[46] The very next natural milestone in this evolution was to treat some breast tumours with percutaneous imaging-aided treatment rather than conventional open surgical technique.[47] Many have investigated patients being treated with breast tumours with interventional imaging-aided ablation treatment. Fornage et al., conducted one of the earliest investigations, which demonstrated full ablation of the culprit lesion with US-guided radiofrequency ablation in 21 patients who had tumours of up to 2cm.[48] Sabel et al., also registered a multi-institutional pilot safety trial utilising cryoablation guided by USG in 29 patients in 2004, who had 100% removal of tumours <1cm.[49] Oura et al. described effective US-aided radiofrequency ablation under sedation in 52 patients who had lesions 2cm or less, without removing the foci, and no signs of recurrence 6-30 months later.[50] Littrup et al. published the findings of a feasibility analysis utilising US-guided cryoablation to treat breast tumours up to 5.8cm in 11 patients not willing for surgical excision in 2009. These patients were managed between 2003 and 2008, and the findings showed a 95% decrease in ablation size and no relapse in follow-up tests.[51] Manenti et al. used a group of 15 patients(mean age: 73 years) who had US-guided cryoablation of malignancies followed by surgical lumpectomy to corroborate the earlier findings.[52] The findings were positive, with full tumour death in 14 of 15 patients; the one loss was believed to be technically complex. The largest multi institutional trial to date is the American College of Surgeons Oncology Group Z1072 clinical cryoablation experiment.[53] The trial's goal was to see if transdermal US-aided cryoablation could be used to successfully treat stage I breast cancers. A total of 19 locations provided patients, with 87 malignancies deemed evaluable by the study guidelines. Individuals who satisfied the eligibility requirements received magnetic resonance imaging (MRI) before and after cryoablation before having open surgical lumpectomy. On pathological evaluation of the focussed disease, researchers discovered that 100% patients with cancers <1cm cured with cryoablation had no remaining invasive malignancy.[53] Tumours of any size had an 80.5% success rate.[53] Other techniques, such as high-intensity focussed USG, laser and radiofrequency, have also been recorded. Thermal ablations, in contrast to cryoablation, which is generally tolerable and can be conducted under local anaesthesia, generally need some type of general anaesthetics. Skin and chest muscle heating damage, as well as post-operative discomfort, are potential consequences of heat-based ablations.[54] Adequately powered multi-institutional research trials are required to confirm the risk assessments described thus far, with the eventual objective of using ablation as initial therapy for specific individuals and kinds of breast tumour without the requirement for surgery. The individuals, as well as the amount and kind of lesion, have yet to be defined, but the notion of an imaging-aided ablation as a novel initial therapy for a breast tumour is intriguing.

Challenges and opportunities

The area of interventional radiology is ever-changing and vibrant. It provides several problems as well as numerous possibilities.[55] This is especially true in the realm of breast-related procedures. Traditionally, the road to breast procedures did not take place through academics or interventional radiology units.[55] Nonetheless, the mixture of education and competencies in radiology and imaging-aided treatments renders interventional radiology an ideal specialty for the task. By teaching and engaging in these operations, interventional radiologists can considerably contribute to the area of women's health and breast treatments.[55] Several of the treatments that have revolutionised the methods we treat patients today were developed by interventional radiologists. Uterine fibroid ablation has replaced hysterectomy, vascular stenting has replaced vascular bypass surgery, aortic endograft has

replaced open correction of abdominal aortic aneurysms, and imaging-aided breast sampling has replaced conventional open surgical breast sampling.[56] The efforts of the many great peers who helped develop interventional radiology have significantly altered how medicine is practised. These titans examined clinical issues of the day, imagined solutions by the use of image-guided approaches, and gave us many of the instruments and procedures that are today regarded as the gold standard. As previously stated, there is room for additional investigation in USG-aided microcalcification sampling, stereotactic-aided lumpectomy and USG-aided ablation of breast tumours[57]. We must also "blaze a path" in the realm of breast therapies, but we must do it in collaboration with our peers. Many talented and enthusiastic breast detectors and surgeons have forged their path in the field of breast therapies. Their efforts have yielded some remarkable achievements and inventions. Rather than pursuing confrontation, we must work together to establish connections and rely on one another's talents. The new interventional radiology and diagnostic radiology certificate programme offers a once-in-a-lifetime opportunity to expand the conventional interventional radiology syllabus to also incorporate breast invasive procedural training and research cooperation with colleagues in the breast imaging specialty area. We are all standing together at the beginning of a new chapter in medicine. Cost effectiveness, comparative effectiveness studies, and an older population are all pushing the clinicians to reconsider what they perform. Similarly, we are now united on a global scale. The literature described in the current review is from nations around the world.

Conclusion

Breast cancer is a global health problem. With the expansion of technological advances, as well as the apparent ease of worldwide travel, we must all collaborate to improve our chances of success in the battle against breast cancer. We will realise the aim of increasing the quality of life of patients and their families via cooperation and partnership. We shall increase the standard of women's health through fresh research and the development of these innovative approaches.

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