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Digital tomosynthesis of the chest: A review article

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ABSTRACT *Multiple randomized controlled trials have demonstrated that substantial reduction in breast cancer mortality can be realized through mammographic screening. Breast tomosynthesis is a digital mammographic technique that permits individual planes of the breast to be visualized while reducing the impact from overlapping tissue. Unlike conventional digital mammography, in which each image is created from a single x-ray exposure, tomosynthesis images are reconstructed from a series of low-dose exposures as the x-ray source moves in an arc or linear trajectory above the breast. The resultant imaging data set minimizes the effect of overlapping structures, affording tomosynthesis the potential to enhance both the sensitivity and specificity of mammographic imaging. It has the ability to provide greater detection of nodules than conventional radiography at a considerably lower dose than CT. However large-scale studies are needed to confirm its benefits and place in the clinical stetting.*

Introduction

Despite its clearly documented benefit, it is well recognized that mammography is imperfect. As many as 20%–30% of breast cancers will not be detected on a mammogram [1,2]. One of the factors negatively affecting the performance of mammography is breast density. Mammographic sensitivity decreases with increasing parenchymal density [3,4]. On a two dimensional mammographic projection, radiographically dense structures can be superimposed, potentially obscuring cancers. Conversely, these same overlapping structures can result in summation artifacts that mimic mammographic

Digital tomosynthesis is a newly evolving imaging modality recently made clinically possible by advances in digital flat panel detector technology. It is a type of limited angle tomography providing the benefits of 3D imaging. Currently this new technology is being tested for mostly for breast and chest examinations. This literature review will be focusing on digital tomosynthesis of the chest where it is suggested to be beneficial in the detection of lung nodules.1,2. In addition, it yields fewer suspicious images that can result from superimposition of normal or benign structures. Breast tomosynthesis, which was invented and developed by Daniel B. Kopans, MD, and Richard H. Moore at the MGH, was approved by the U.S. Food and Drug Administration (FDA) in early 2011 as a screening method for detecting breast cancer, based on a clinical study that demonstrated the superiority of tomosynthesis plus digital mammography in detecting cancer while reducing the number of false positive readings compared to digital mammography alone.

Unlike conventional digital mammography, in which each image is created from a single x-ray exposure, tomosynthesis images are reconstructed from a series of low-dose exposures as the x-ray source moves in an arc or linear trajectory above the breast. The resultant imaging data set minimizes the effect of overlapping structures, affording tomosynthesis the potential to enhance both the sensitivity and specificity of mammographic imaging.

Pulmonary nodules can easily be missed or misinterpreted on conventional X-rays, when a 3D object, the chest, is displayed as a 2D image resulting in overlap of anatomy. Tomosynthesis, much like CT, allows greater detection of pulmonary nodules by viewing one slice at a time. This is achieved by blurring out structures above and below the selected slice thereby eliminating much of the overlying anatomy. Not only is chest tomosynthesis meant to provide greater sensitivity of nodules but it is also intended to have a lower dose and cost compared to CT.[5,6]

Prior investigations of breast tomosynthesis have reported potential value of the technique in the diagnostic setting [7,8]. Others have focused on feature visibility by using tomosynthesis imaging compared with conventional mammography [9, 10]. Two small retrospective observer studies showed recall rate reductions of 42% and 30% when using breast tomosynthesis combined with digital mammography compared with digital mammography alone. Of note, use of breast tomosynthesis alone did not result in a significant reduction in recall rate. Gennaro and colleagues[11] compared single- view tomosynthesis to two-view digital mammography in 200 women and found no significant difference in reader accuracy. However, to our knowledge, no multi-institutional trials comparing two-view tomosynthesis combined with digital mammography versus digital mammography alone have been reported.

Tomosynthesis Procedure

The procedure for breast tomosynthesis is similar to digital mammography. Both require careful positioning and compression of the breast to acquire craniocaudal and mediolateral oblique views. The procedure for tomosynthesis differs in that the breast is imaged in a series of exposures as the X-ray tube moves through a limited arc. Current protocols require that tomosynthesis be combined with digital mammography to allow easy comparison of side-to-side symmetry. The total time for the combined examination is approximately 10 seconds. By performing both tomosynthesis and digital mammography, the radiation exposure is approximately double that of digital mammography alone, although the total exposure is well within the American College of Radiology guidelines for radiation dose for mammography. The FDA has approved technology to create a synthesized mammogram from tomosynthesis data but it is not yet validated in clinical practice.

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The reporting system for tomosynthesis is the same as the BI-RADS system used for digital mammography. In cases of suspicious findings, diagnostic imaging procedures may include additional mammographic studies, ultrasound, or MRI. MRI may also be used as a screening method for women who have significant risk factors. In addition, MRI is sometimes used to stage newly diagnosed cancer and guide treatment planning.

Clinical Applications

Chest tomosynthesis has the potential to provide a good level of nodule detection at a lower dose to CT. Nevertheless, it's place in the clinical setting is unclear. There are many ways in which the detection of pulmonary nodules using tomosynthesis could be beneficial in the clinical setting.6,9,18 Lung cancer causes many deaths every year.33 By having a relatively low dose modality with the ability to detect approximately three times more pulmonary nodules could help in the early detection of cancer without patients needing to receive a large effective dose. One way that chest tomosynthesis could be employed in hospitals is as a problem-solving alternative to CT.[12] Often patients with suspicious opacities that cannot be confidently diagnosed from a chest X-ray will undergo CT to ensure they are no malignant lesions. Tomosynthesis offers a high level of sensitivity for nodule detection by minimizing the anatomical overlap, obscuring or mimicking pathology. Therefore radiologists would be able to more confidently report malignant nodules without the use of CT. Potentially tomosynthesis could reduce the number of patients being sent to CT, due to uncertainties on their X-ray by about 75%.

Tomosynthesis could obviate the lateral chest examination when used in conjunction with the posteroanterior radiograph. The depth resolution of tomosynthesis is more superior to that of conventional radiography owing to the ability to scroll through different depth in the chest. This allows radiologists to more confidently diagnose and locate the exact depth of cancerous nodules without the need of a lateral chest X-ray.

Conclusion

Digital chest tomosynthesis offers several real benefits for chest imaging and the detection of cancerous pulmonary nodules. It has the ability to provide greater detection of nodules than conventional radiography at a considerably lower dose than CT. However large-scale studies are needed to confirm its benefits and place in the clinical stetting.

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