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BREAST CANCER DETECTION USING ARTIFICIAL INTELLIGENCE

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ABSTRACT The scientific boundaries we use to configure our research lines in oncology today have immensely been providing us with the benefaction of AI with which we have momentously shaping our research means and tools with a vibrant global modus of work up. We, now ,with the AI easer, have been universally acclimatizing the use of clinical blood markers incorporate with the current routine data.Here,with the AI constituent, we probe into availabilities and results in breast cancer study done with the AI constituent's predictive models within a capacious range, from early breast cancer detection to predicting distant metastasis with higher accuracy and from more effective usage and application of demographic data to easier clinical evaluation and assessment.

KEYWORDS : Artificial intelligence (AI), 3D mammography, Profound AI,Saige DX, Transpera, Neoadjuvant chemotherapy [NAC],

INTRODUCTION

Mammography screening has been a cornerstone of early detection of breast cancer since the 1980s. A (1)

There is a global shortage of breast radiologists that is exacerbated by increasing demands for precision diagnostics from both providers and patients.(2,3)

The incidence of breast cancer has been increasing, with breast cancer surpassing lung cancer as the most commonly diagnosed cancer in women (4,5)

However, the combination of advancements in early detection through screening and the emergence of personalized treatment strategies has led to a decline in breast cancer mortality rates (6)

. The introduction of innovative treatment options tailored to specific tumor characteristics has significantly improved patient outcomes.(7)

Despite advances in diagnostic modalities, the current workflow for breast cancer diagnosis is not without errors (8)

Artificial intelligence (AI), with its potential to extract intricate details from images, automate workflows, and offer predictive insights, presents a promising avenue to address existing limitations (9,10)

The diagnostic workflow for breast cancer typically involves several stages, including screening, diagnostic imaging, biopsy, pathologic diagnosis, staging, additional testing (11,12)

Breast cancer screening detects cancer at earlier stages1, leading to a meaningful reduction in breast cancer mortality (13)

Although breast screening reduces overall mortality, it has limitations that result in failure to detect cancer in a considerable number of screened individuals. (14).

Among them, the proportion of cancer cases that could be detected retrospectively at previous rounds is estimated to be 22% (15)

In the past, computer-aided detection (CAD) systems were developed to improve cancer detection. However, the benefits of CAD found in experimental studies did not translate into real-world clinical benefits. (16)

Modern artificial intelligence (AI) based on deep learning is a different technology from past CAD systems and has demonstrated higher potential in supporting the quality of screening (17)

Breast cancer is one of the most pressing issues women of the 21st century face. (18)

It is a significant health problem and the most frequently diagnosed cancer among women worldwide (19)

Many lives are lost due to breast cancer . It has a great effect on the physical and mental health of women. Breast cancer is more effective to treat if diagnosed early (20)

The Potential of AI and Machine Learning in Revolutionizing Mammography

Mammography is a crucial tool in screening breast cancer and detecting it at early stages, thereby contributing to improve treatment outcomes and survival rates. However, it has been learnt that traditional mammography techniques possess certain limitations, like false negatives, false positives, and has variability in interpretation.

Role of AI and ML in Enhancing Diagnostic Accuracy

The accuracy of interpretation is one of the primary challenges observed in mammography. Based on mammographic images it is often difficult for a radiologist to distinguish benign and malignant lesions. Several studies had now proven that AI can significantly improve diagnostic accuracy.

Study published in *JAMA Network Open*, 2020 has become a landmark study as this study had evaluated the performance of AI models in the detection of breast cancer. The researchers opinioned that AI systems could able to match or even may exceed the diagnostic performance of human radiologists, particularly in reducing false negatives and false

positives (21)

Detection errors as false negative or positive are quite significant issues noticed in mammography. False positives may cause unnecessary anxiety, adds up additional testing parameters and more invasive procedures, while false negatives may cause delay in diagnoses. In this scenario a second layer of analysis is a must and is achieved by AI which helps to mitigate such issues. For instance, AI system has the ability to flag the potentially suspicious areas which could be further reviewed by radiologists, thus reduces the likelihood of missed diagnoses.

A study had explained the potential of AI in contributing towards decrease of false positive results got published in *Nature*, 2021. Yet another study found that mammography assisted by AI had reduced the false positive rates by about 7% and false negative rates to about 5%, this in comparision to traditional methods.(22)

This improvement enhances both patient outcomes but also reduces the burden on healthcare systems.

Improves Efficiency and Workflow

The integration of AI in mammography reading systems will automate routine tasks, such as categorizing lesion detection, etc; this automation helps to faster processing times and give more consistent results. A study demonstrated that AI of integration into mammography workflows will significantly reduced reading time while ensuring the maintaining of high diagnostic accuracy (23)

On can accept that by using AI tools the radiologists can easily manage their workload more efficiently and can improve their overall productivity with quality and consistency.

AI and ML Enhances the Accessibility and Equity

AI and ML contribute to enhance the accessibility and equity of mammography services. Radiologists are unavailable in remote and underdeveloped regions,which causes delay in screening and diagnosis. In such scenarios implications of AI can help to bridge this gap as AI provides preliminary analyses and support to radiologists in underserved areas.(24)

Technology has Challenges and Considerations

Despite the promising potential of AI and ML in mammography, there are still many challenges and considerations that need to be addressed. Among those one of the major challenges is the need for a large and diverse datasets to train AI algorithms more effectively. The performance of AI models is crucially dependent on the quality and diversity of the data that they are trained on. It should be ensured that these datasets used, represent different populations and different types of breast tissues which is very important and main objective for developing robust and generalizable models. Another consideration is the integration of AI with existing clinical workflow.

Artificial Intelligence (AI) can significantly enhance breast cancer prediction

In early detection, and personalized risk assessment through various methods and models. Here are key points to consider when utilizing AI for breast cancer prediction:

Data Collection and Preparation

1. Data Sources: Utilize diverse datasets including medical imaging (mammograms, ultrasounds, MRIs), genetic information, patient history, and other relevant health data.

2. Data Preprocessing: Clean and preprocess data to handle missing values, normalize features, and ensure high-quality input for AI models.

3. Feature Engineering: Identify and extract significant features from the data that can improve the model's predictive power.

Model Selection and Development

1. Machine Learning Models: Traditional machine learning models like logistic regression, support vector machines, decision trees, and random forests can be used for initial assessments.

2. Deep Learning Models: Convolutional Neural Networks (CNNs) are particularly effective for image data. In contrast, Recurrent Neural Networks (RNNs) or Long Short-Term Memory (LSTM) networks can be used for sequential data.

3. Ensemble Methods: Combining multiple models to improve prediction accuracy and robustness.

Artificial Intelligence In Breast Cancer

Artificial intelligence(AI) can help improve detection of breast cancer & diagnosis in a number of ways like-
Accuracy in diagnosis
Early detection of cancer
Possible prediction in vulnerable population.

Breast cancer is a significant cause of cancer related mortality in women worldwide. Early & precise diagnosis is crucial & clinical outcomes can be markedly enhanced.

- The invention of artificial intelligence has revolutionized the detection, diagnosis & treatment patterns with remarkable clinical outcome.
- Although the role of AI is immense in detection/diagnosis & treatment, but its integration in the actual clinical practice is for behind the expectations.
- The problem of over diagnosing the disease in otherwise low-risk population leads to increased workload on radiologist & pathologist. The role of Artificial intelligence comes here where by its accurate detection/diagnosis, inaccurately suspected. Low-risk cases will be excluded & focus could be kept only on the positive cases. This will take off the burden on Radiologists & pathologists & the delay in diagnosis & treatment – could be minimized to diagnosis a very significant levels.

AI techniques can help radiologists identification/detect/diagnose that would have otherwise been undetectable in its early stages.

How AI Detects Breast Cancer?

- The process of AI detecting breast cancer involves the utilization of software(machine) & application of algorithms on datasets of labeled images, & there by acquiring distinguishing features of cancerous tissues.
- Mammography has long been the gold standard for breast cancer screening & is highly effective in detecting abnormalities in breast tissue that could be cancer, long before patients experience lumps & other symptoms. But mammography are not 100% accurate & needs additional imaging modalities at many a times like ultrasound & MRI. This is especially true in people who have dense breasts or because they have certain risk factors(gene mutations/family history)
- Still mammography & other screening tools undoubtedly save lives. But needs to be raised to accurate detection/diagnosis levels where in the role of AI comes in play.

Integration of AI & Radiologist Findings:

- Integrating Artificial Intelligence (AI) with radiologists can help improve patient outcomes & reduce diagnostic delays.
- Algorithms can analyze large amounts of data and identify patterns that humans might miss, which can help radiologists make more accurate diagnosis. AI can also help radiologists understand the patient's condition better, & can be used for tasks like cancer screening, detection, diagnosis and treatment.

Drawback:

Some studies say that AI doesn't always work well with radiologists, & that the impact of AI can vary from radiologist to radiologist.

Some setbacks to AI integration include- time delays, additional work steps & unstable AI performance. To achieve the benefits of AI, it is important to design tools that are suited to the needs of individual radiologists.

How AI is used in Radiology?

Self learning artificial intelligence algorithms is used to analyze medical images, in the fields of X-ray, CTs & MRI scans & assist radiologists.

How is AI changes the outlook of Radiological Pathology

AI can help automate & streamline many aspects of both pathology & radiology workflows such as image analysis, report generation & communication with other health-care professionals.

Application of AI in medical imaging
AI algorithms can detect early signs of breast cancer on mammograms, lung nodules on CT scans & detect signs of Alzheimer's disease on MRI scans.

When was AI introduced in Radiology:
Although AI was first applied in radiology to detect micro-calcifications in mammography in 1992, it has gained much more attention recently.

Trends in Radiology AI
Key AI trends like informed decision making, integrated diagnostics & digital twins focus very much on how radiology plays a major role in the digital transformation of healthcare & how radiologists & clinicians can be empowered to make the right decision for every patient.

Screening detection methods:
Methods of screening are:
- Breast Palpation – By clinician/self
- Breast Imaging Techniques:
- Mammography
- Ultrasonography
- MRI
- DBT (Digital breast tomosynthesis)

Mammography:
- Most common screening test for breast cancer.
- It plays a major role in the early detection of breast cancer & about 75% of cancers are detected well before they are manifested.
- One study says that 25% reduction in deaths from breast cancer for people who regularly screen.
- National Cancer Institute SEER data shows that about 43% of breast cancer deaths are reduced through a regular mammography screening.
- Mammography is useful to find out problems like- Lump/mass in the breasts, abnormal nipple discharges, cyst & calcifications etc.

Ultrasonography
- A breast ultrasound is the most often used imaging modality for screening of the breast cancers along with mammography.
- The advantage with this is radiation free modality.
- It is also useful to guide for FNAC & biopsies.
- It helps to detect & classify a breast lesion that can not be interpreted adequately through mammography alone.
- It also differentiates well whether the lesion is cystic(mostly benign) or solid(may be benign/malignant) nature which helps in arriving to a nearest diagnosis.
- It is also useful to identify calcifications within the lesion which aid in excluding/confirming the malignancy.
- MRI
- It can be used for high-risk screening, after a biopsy or to monitor treatment.
- Detailed anatomical extensions of the lesions can be made out with accuracy.

Screening
- MRI can be used with mammography to screen for breast cancer in people at high risk, such as those with a strong family history or inherited breast cancer possibilities.
- It can also help detect breast cancer in women with dense breast tissue or breast implants.
- It is also been useful tool for further evaluation, characterization & extent of lesion after initial mammography/ultrasound.

Role of AI in Mammographic Detection
AI algorithms, particularly deep learning models, analyze mammographic images to detect anomalies and potential cancers with high accuracy. These models are trained on large datasets and can identify subtle patterns that might be missed by human radiologists (27)

AI systems can prioritize cases based on risk, thus streamlining the workflow for radiologists. By flagging images that require further attention, AI assists radiologists in focusing on the most critical cases, potentially speeding up the screening process (28)

AI can analyze patient history and mammographic findings to provide personalized screening recommendations. This includes adjusting screening intervals based on individual risk factors, which helps in tailoring prevention strategies (29)

AI models assess risk factors and identify patients at high risk for developing breast cancer, enabling earlier and more frequent screening for those who need it most (30)

Some of the FDA approved AI softwares to detect malignant findings on mammograms are as follows:

ProFound AI: ProFound AI for digital breast tomosynthesis (DBT) is FDA-cleared and clinically proven in a large reader study to improve cancer detection by 8% and reduce the rate of of false positives and unnecessary recalls for women by 7% (31)

SaigeDX: Saige-Dx examines DBT mammograms to detect soft tissue lesions and calcifications that could suggest cancer. For each DBT mammogram, Saige-Dx assigns a Suspicion Level to each identified finding and the overall case, indicating the likelihood of cancer. The results from Saige-Dx are designed to assist interpreting physicians during the reading of screening mammograms using compatible DBT hardware (32)

Transpara: Transpara AI software aids in early breast cancer detection by analyzing mammograms and highlighting suspicious areas, offering radiologists a second opinion to enhance accuracy and efficiency. A prospective study showed that AI-supported mammography screening with Transpara achieved similar cancer detection rates to standard double reading while significantly reducing the screen reading work load demonstrating the safety of AI use in mammography.(33)

Breast cancer management
Managing early-stage breast cancer typically involves a multimodal approach that includes surgery, radiation therapy, and sometimes systemic treatments such as hormone therapy or chemotherapy, tailored to the tumor's characteristics and patient preferences(34)

Early detection through mammographic screening plays a crucial role in this management strategy by identifying tumors at a stage when they are smaller and more treatable, often leading to less aggressive interventions and better outcomes (35)

Mammographic screening has been shown to significantly reduce breast cancer mortality by detecting tumors before they become symptomatic (36).

The integration of regular screening into clinical practice has led to a decrease in the incidence of advanced breast cancer, improving survival rates and quality of life for patients (37).

Advances in screening technology, such as digital mammography and tomosynthesis, have further enhanced the ability to detect early-stage disease and reduce false positives (38).

Role of AI in Precision Oncology
AI is revolutionizing precision oncology by enhancing the ability to tailor cancer treatment to individual patients. AI algorithms can analyze vast amounts of genomic, clinical, and imaging data to identify patterns and predict treatment responses, leading to more personalized and effective therapies. For instance, AI-driven tools can assist in identifying genetic mutations and biomarkers that are crucial for determining the most appropriate targeted therapies (39)

Additionally, AI models can predict patient outcomes and potential side effects, enabling oncologists to make more informed treatment decisions (40).

The integration of AI in radiology,such as using deep learning to interpret medical images, has improved the accuracy of cancer detection and staging (41).

Moreover, AI can optimize clinical trial designs by matching patients with trials based on their genetic profiles, thus accelerating the development of new therapies (42).

The use of AI in electronic health records helps in identifying high-risk

patients and monitoring their response to treatment in real-time (43).

Despite these advancements, challenges such as data privacy, the need for large annotated datasets,and integration into clinical workflows remain (44).

Ongoing research and collaboration between AI experts and oncologists are essential to address these issues and fully realize the potential of AI in precision oncology. Overall, AI holds significant promise in improving the precision, efficiency, and outcomes of cancer treatment.

AI in diagnosis of breast cancer

AI is increasingly becoming a pivotal tool in the early diagnosis of breast cancer. AI algorithms, particularly those based on deep learning, are adept at analyzing mammographic images to identify potential tumors and abnormalities with high precision (45).

These AI systems can detect patterns and subtle features that may be missed by the human eye, thereby improving diagnostic accuracy and reducing false positives and negatives (46).

For instance, recent the promise of AI, challenges such as data quality, algorithm transparency, and integration into clinical workflows need to be addressed (47).

Ongoing research and clinical studies have demonstrated that AI can match or even surpass radiologists in detecting breast cancer in mammograms, leading to earlier and more accurate diagnoses (48).

AI-driven tools also assist in interpreting digital breast tomosynthesis (DBT) images, enhancing the ability to differentiate between benign and malignant lesions (49).

Moreover, AI technologies are being integrated into risk assessment models to predict the likelihood of breast cancer based on patient data and imaging results (50).

This integration aids in personalized screening strategies and helps prioritize patients for further diagnostic procedures. Despite trials are crucial for validating AI systems and ensuring their effective implementation in breast cancer diagnosis. Overall, AI holds significant potential to revolutionize breast cancer diagnosis by improving accuracy, reducing diagnostic delays, and enhancing patient outcomes.

Future Directions

The integration of AI and ML into mammography has several promising directions with great advancement in future research and development. These may include - Personalized screening protocols based on individual risk factors, like family history, genetic predispositions and various other factors leading to more tailored and much effective screening strategies. Mammography combined with other imaging modalities, like MRI or ultrasound, along with AI tools could help to analyze these multi-modal datasets with enhanced accuracy and comprehensiveness of breast cancer detection.

Traditional CAD systems use rule-based algorithms in detecting anomalies, wherein modern AI-powered CAD systems leverage the advanced machine learning techniques with promisingly improved performance.

CONCLUSION

Use of AI in mammography could also help to decrease the costs associated with screening and diagnosis. This task is achieved through improving diagnostic accuracy and thereby, reducing the need for follow-up, thus, AI can lower the overall cost of breast cancer care by early detection. The integration of AI with RIS (Radiology information system) has the potential to revolutionize radiology practices. By enhancing diagnostic accuracy & streamlining workflow & efficiencies, AI can assist radiologists in providing patients with the best possible care.

AI provides and acts as a decision support system, helping radiologists with additional insights and required recommendations .The future of radiologist is bright by the integration of AI with Radiology reporting services—

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