Current Developments and Prospects in the Diagnosis of Breast Cancer

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***Abstract*—We will give a thorough review of breast cancer in this review article, paying particular attention to its epidemiology, risk factors, molecular mechanisms, diagnostic techniques, and available treatment options. The article will also discuss how recent developments in science and technology are influencing the treatment of breast cancer. We will also talk about the shortcomings of current approaches and highlight some promising future developments, such as immunotherapy, targeted therapies, early detection using liquid biopsies, personalized medicine, and the use of artificial intelligence in diagnosis and treatment planning. This review attempts to close the gap between current practices and cutting-edge tactics that could soon revolutionize the treatment of breast cancer by examining both current knowledge and emerging trends.**

I. INTRODUCTION

Overview The most common cancer in women and a major contributor to cancer-related deaths globally is breast cancer. Nearly one in four of all cancer cases among women were female, with 2.3 million new cases and 685,000 deaths reported, according to Global Cancer Statistics 2020 (). It can develop from non-invasive lesions to invasive and metastatic disease and is mainly caused by the epithelial cells of the breast ducts or lobules (2). Breast cancer is a diverse disease that is impacted by environmental, hormonal, and genetic factors. It has a wide range of molecular subtypes, including triple-negative, HER2-enriched, luminal A, and luminal B, each of which has a different prognosis and response to treatment (3).

II. WHY BREAST CANCER COMMONLY SEEN IN MALE

Less than 1% of all breast cancer diagnoses worldwide are male breast cancers (MBCs), making them an uncommon cancer. Compared to female breast cancer (FBC), its low incidence has led to a lack of awareness, which frequently results in late detection and diagnosis at more advanced stages (III or IV). Accordingly, men with breast cancer typically have higher death rates and worse survival outcomes than women (4). Since MBC is so uncommon, it is impossible to conduct randomized controlled trials efficiently, and the majority of the evidence that is currently available comes from small retrospective studies. As a result, clinical trials on women with breast cancer are used to largely extrapolate therapeutic recommendations for men (5). MBC exhibits unique clinical and pathological characteristics, even

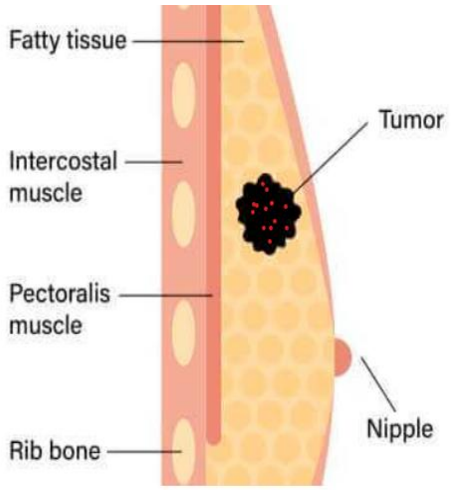


Fig1 -Breast tumor (6)

III. PREVALENCE OF BREAST CANCER

3.1 Breast cancer statistics Global data

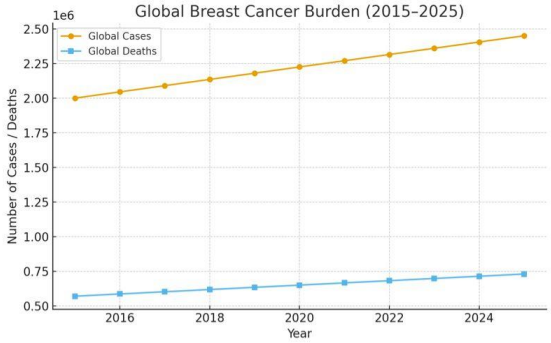
1.Worldwide Data approximately 2.3 million women worldwide received a breast cancer diagnosis in 2022. (7)

2. Globally, breast cancer is responsible for about 670,000 deaths in 2022. (8)

3. Share of all female cancers: In 2022, breast cancer was responsible for 15.4% of female cancer deaths and 23.8% of new cancer cases. (9)

4. Lifetime risk: According to 2022 rates, 1 in 20 women worldwide will receive a breast cancer diagnosis, and 1 in 70 will pass away from the disease. (10)

5. Age distribution: Women 50 years of age or older account for 79% of fatalities and 71% of new cases. (11)



3.2 Indian data

1. Total cancer cases (2022): An estimated 1,461,427 incident cases of cancer (crude rate of 100.4 per 100,000) were reported in India. (12)

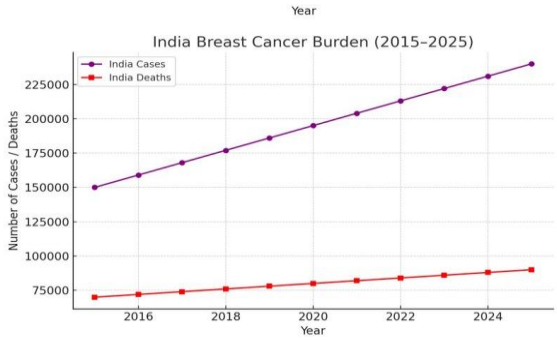
2. Breast cancer share: According to estimates from 2020, breast cancer accounted for approximately 13.5% of all new cancer cases in India. (13)

3. Age-standardized incidence and mortality in 2016: 32.0 and 15.1 per 100,000 women, respectively. (14)

4. The 2016 DALY burden estimate was 515.4 age-standardized DALYs per 100,000 women. (15)

5. India's projection for 2025 is that there will be approximately 5.55 million DALYs from breast cancer. (16)

6. Screening coverage: According to the NFHS-4, only 12.9% of Indian women aged 30 to 49 said they had ever had a breast exam. (17)



IV. PRESENT DAY SCEENING TECHNIQUES

4.1 MAMMOGRAPHY

Mammography The gold standard for breast cancer screening. detects breast tumors early, frequently before they are palpable, using low-dose X-rays. Women 40 years of age and older are advised, though international recommendations differ. Particularly for dense breasts, digital breast tomosynthesis (3D mammography) enhances detection. (18)

4.2 EXAMINATION OF THE CLINICAL BREAST

Examination of the Clinical Breast (CBE) carried out by qualified medical professionals to feel for lumps or anomalies. less sensitive than mammography, but useful in low-resource environments. Reference: Regular CBE can lower the incidence of advanced breast cancer in low- and middle-income countries. (19)

4.3 BREAST SELF EXAMINATION

BSE, or breast self-examination Women examine their own breasts for nipple changes, pain, or lumps. Although it doesn't do much to lower mortality, it does increase awareness and promote early reporting. Reference: BSE raises awareness and encourages health-seeking behavior, but Thomas et al. (2002) found no mortality benefit. (20)

4.4 ULTRASOUND

Ultrasonography (USG) frequently used in conjunction with mammography, particularly in young women with large breasts. can assist in differentiating between solid and cystic lesions. Reference: According to Berg et al. (2008), women with dense breast tissue have a higher chance of

detecting cancer when ultrasound is added to mammography. (21)

4.5 MAGNETIC RESONANCEN IMAGING

MRI stands for magnetic resonance imaging. high sensitivity, particularly in women who are at high genetic risk (carriers of the BRCA1/2 mutation, for example). utilized in high-risk groups as an additional screening tool. Reference: Kuhl et al. (2005) demonstrated that in high-risk women, MRI can identify cancers that mammography and ultrasound are unable to detect. (22)

4.6 IMAGING ADVANCE

Imaging methods Images created by imaging devices display variations in contrast due to changes in physical characteristics. Compared to X-ray-based methods, digital imaging technologies are becoming increasingly popular for cancer imaging. Cancer is detected, staged, treatment response is evaluated, and biopsy procedures are guided by a magnetic resonance imaging system. (23) Technology for digital imaging One popular screening method is mammography. (24) The "gold standard" for identifying breast cancer is film-based mammography. (25) A helpful imaging technique for breast screening, full-field digital mammography (FFDM) has several advantages over conventional film-based procedures. Among the benefits are reduced dosage, digital archiving, telemedicine, softcopy review, and tomosynthesis (26). Skaane and Skjennald (2004) conducted a study titled "Screen-Film Mammography versus Full-Field Digital Mammography with Soft-copy reading".

V. MOLECULAR AND GENETIC DIAGNOSIS

Genetics of Breast Cancer: Identification and Management Genetics of breast cancer (BC) has emerged as a key component of BC treatment. In women with a germinal BC susceptibility gene, it affects screening, follow-up, prophylactic, and treatment recommendations. Finding patient subgroups with distinct prognoses or responses to treatment is also beneficial. This Special Issue covers the diagnostic and therapeutic implications of genetics in British Columbia and includes one case report, two original research articles, and five reviews. The strongest hereditary risk factor for the development of disease, especially in the case of early onset breast cancer (EOBC), is pathogenic variants in the BC susceptibility genes. In fact, between 10 and 20 percent of EOBC cases are inherited (27). As a result, people with a personal or family history of prostate, ovarian, or breast

VI. DIGITAL PATHOLOGY AND ARTIFICIAL INTELLIGENCE

Artificial intelligence and digital pathology in breast cancer Histopathological slides are digitized into high-resolution whole-slide images in digital pathology, allowing for remote analysis, storage, and sophisticated computational evaluation. The specifically deep learning and machine learning algorithms, has significantly improved the diagnostics of breast cancer by making it possible to classify tumor subtypes, automatically detect malignant regions, and accurately quantify prognostic and predictive biomarkers like HER2, PR, and ER. AI-based models enhance diagnostic reproducibility, lessen inter-observer variability, and help pathologists handle demanding workloads. Beyond diagnosis, artificial intelligence (AI) tools are being used more and more to predict molecular subtypes, therapy response, and patient outcomes—all of which are critical for precision medicine. Large-scale digital pathology datasets also enable AI to facilitate multicenter research collaborations and biomarker discovery. (28)

VII. DIFFICULTIES IN DIAGNOSIS

Digital pathology plays a vital role in contemporary clinical practice and is becoming a more important technological necessity in the setting of scientific laboratories. Pathologists can now more easily manage and share digital slide images for clinical use thanks to the introduction of whole-slide imaging, faster networks, and less expensive storage options. Simultaneously, previously unheard-of developments in machine learning have made it possible for artificial intelligence and digital pathology to work together to provide image-based diagnosis options that were previously restricted to cardiology and radiology. Advanced algorithms, computer-aided diagnostic techniques, and the integration of digital slides into the pathology workflow expand the pathologist's perspective beyond a microscopic slide

and allow for the true use and integration of knowledge that transcends human limitations. We believe

VIII. FURTHER PATHS

Research on breast cancer has entered a new era where more individualized, biology-driven therapies are replacing more standard approaches to treatment. Antibody-drug conjugates (ADCs), which combine cytotoxic payloads with tumor-targeting antibodies, represent a significant advancement. According to Modi et al. (2022), these agents have demonstrated high activity even in HER2-low breast cancer, extending the range of treatment options beyond conventional HER2-positive disease. Additionally, ADCs are being studied in combination regimens to overcome resistance and in earlier disease settings (Bardia et al., 2023).Half In parallel, the creation of biomarkers is essential for directing therapy. ADC effectiveness is dependent on antigen expression and internalization rates, in contrast to small-molecule inhibitors. To identify which patients will benefit most from these treatments, research is concentrated on improving predictive biomarkers (Waks & Winer, 2019). Including

IX. ACKNOWLEDGEMENT

Breast cancer continues to be a major cause of cancer-related deaths and is recognized as one of the most prevalent cancers affecting women globally. The urgent need for early detection, better treatments, and increased public awareness is highlighted by the recognition of breast cancer as a serious public health issue. Societies can lessen the impact of this illness and enhance patient outcomes globally by promoting equitable access to care, conducting ongoing research, and raising awareness.

X. CONCLUSION

Millions of women and men are affected by breast cancer every year, making it one of the biggest health issues in the world. Many patients now have significantly higher survival rates and better quality of life thanks to developments in early detection, molecular diagnostics, and personalized therapies. Nonetheless, there are still issues with late-stage diagnoses, the burden in low-resource settings, and differences in access to care. Future possibilities for more efficient, less harmful, and patient-centered care include liquid biopsy, AI in screening, antibody–drug conjugates, and precision medicine. Strengthening awareness, prevention tactics, and equitable healthcare delivery across populations are equally critical. In summary, long-term research, innovation, and international cooperation are critical to lessening the effects of breast cancer, guaranteeing that advancements benefit all patients regardless of location or financial means.

REFRENCE

[1] Sung, H., Ferlay, J., Siegel, R. L., Laversanne, M., Soerjomataram, I., Jemal, A., & Bray, F. (2021). Global Cancer Statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA: A Cancer Journal for Clinicians, 71(3), 209–

[2] DeSantis, C. E., Ma, J., Gaudet, M. M., Newman, L. A., Miller, K. D., Sauer, A. G., Jemal, A., & Siegel, R. L. (2019). Breast cancer statistics, 2019. CA: A Cancer Journal for Clinicians, 69(6), 438–451.

[3] Perou, C. M., Sørlie, T., Eisen, M. B., van de Rijn, M., Jeffrey, S. S., Rees, C. A., … & Botstein, D. (2000). Molecular portraits of human breast tumours. Nature, 406(6797), 747–752.

[4] Cutuli B, Cohen-Solal Le-Nir C, Serin D, Kirova Y, Gaci Z, Lemanski C. Male breast cancer, evolution of treatment and prognostic factors: Analysis of 489 cases. Breast. 2016;28:123–130.

[5] Giardano SH. A review of the diagnosis and management of male breast cancer. Oncologist. 2005;10(7):471–479. doi:10.1634/the oncologist.10-7-471.

[6] yashoda hospital.com/blog/breast-cancer-in-men.

[7] World Health Organization. Breast cancer fact sheet. WHO; 2023.

[8] World Health Organization. Breast cancer fact sheet. WHO; 2023.

[9] Sung H, et al. Global burden of breast cancer in 2022: incidence, mortality, and trends. The Lancet Oncology. 2025.

[10] International Agency for Research on Cancer (IARC). Global Cancer Observatory, Press Release No. 361. IARC; 2025.
[11] International Agency for Research on Cancer (IARC). Global Cancer Observatory, Press Release No. 361. IARC; 2025.
[12] Mathur P, Sathishkumar K, et al. Cancer statistics, 2022: Report from National Cancer Registry Programme, India. JCO Global Oncology. 2022.
[13] Ghosh A, et al. Burden of female breast cancer in India: Estimates and projections. Indian Journal of Cancer. 2024.
[14] Ghosh A, et al. Burden of female breast cancer in India: Estimates and projections. Indian Journal of cancer 2024.
[15] Ghosh A, et al. Burden of female breast cancer in India: Estimates and projections. Indian Journal of Cancer. 2024.
[16] Ghosh A, et al. Burden of female breast cancer in India: Estimates and projections. Indian Journal of Cancer. 2024.
[17] Yadav A, et al. Prevalence and determinants of breast and cervical cancer screening in India: NFHS-4 analysis. Indian Journal of Cancer. 2022.
[18] Skaane P, Skjennald A. Screen-film mammography versus full-field digital mammography with soft-copy reading: randomized trial in a population-based screening program-the Oslo II Study. Radiology.
[19] sankaranarayanan, R., et al. (2011). Clinical breast examination: preliminary results from a cluster randomized controlled trial in India. Journal of the National Cancer Institute, 103(19), 1476–1480.
[20] Thomas, D. B., et al. (2002). Randomized trial of breast self-examination in Shanghai: Final results. Journal of the National Cancer Institute, 94(19), 1445–1457.
[21] Berg, W. A., et al. (2008). Combined screening with ultrasound and mammography vs mammography alone in women at elevated risk of breast cancer. JAMA, 299(18), 2151–2163.
[22] Kuhl, C. K., et al. (2005). MRI for diagnosis of pure ductal carcinoma in situ: A prospective observational study. The Lancet, 370(9586), 485–492.
[23]. Fass L. Imaging and cancer: a review. Mol Oncol. 2008; 2:115–152. doi: 10.1016/j.molonc.2008.04.001.
[24] Niell BL, Freer PE, Weinfurtner RJ, Arleo EK, Drukteinis JS. Screening for breast cancer. Radiol Clin North Am. 2017; 55:1145–1162. doi: 10.1016/j.rcl.
[25] Karellas A, Vedantham S. Breast cancer imaging: a perspective for the next decade. J Med Phys. 2008; 35:4878–4897. doi: 10.1118/1.2986144.
[26] Andreea GI, Pegza R, Lascu L, Bondari S, Stoica Z, Bondari A. The role of imaging techniques in diagnosis of breast cancer. Curr Health Sci J. 2011; 37:241–248.
[27] N. Zerbe et al.Joining forces for pathology diagnostics with AI assistance: the EMPAIA initiative.
[28] Madabhushi, A., & Lee, G. (2016). Image analysis and machine learning in digital pathology: Challenges and opportunities. Medical Image Analysis, 33, 170–175.