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HEREDITARY BREAST CANCER: UNRAVELING THE GENETIC LINK BETWEEN GENERATIONS

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Abstract

Breast cancer is very dangerous and harmful cancer at international level that harm Both the sexes. Many cases of cancer result from environmental, hormonal, or lifestyle influences, a notable portion steps from inherited genetic changes. Replacement in genes like BRCA 1, BRC A2, TP53, and PALB2 Can greatly heighten the chances of forming breast or egg producing cancer within families. Still, having such changes only raise exposure it does not confirm that cancer will develop through genetic testing and support, individuals at high level risk can be noted in early, allowing for timely preemptive and handling strategies. Precautions, including prevantive surgery, risk-reducing medications, healthier lifestyle choices, and daily base screenings, can notably lower the chance of cancer in mutational carriers. However, most breast cancer cases around 85-90% occur in individuals with no genetic history, indicating that environmental and lifestyle are responsible for the majority of incidences. While inherited mutations can transmit risk from one generation to the next, most cases are non-genetic. Therefore, the patient of breast cancer control relies on a combination of prevention, early detection, and personalized treatment that takes into account both genetic and environmental contributions.

1. Introduction

When cells in the breast begin to grow excessively and abnormally, they form a lump or tumour, which is known as breast cancer. Researchers have focused on this disease for years because it is one of the most common cancers in Females globally, although men can also be affected (Pharoah et al., 2002). Only about 6-10% cancer of breasts cases is allown to forefather's shifts, while rest arise from non-genetic factors (Lalloo & Evans, 2012). Patients and their families often inquire if breast cancer runs in families. Research has shown that female who inherit BRCA 1 or BRCA 2 mutation have a very likely of getting by cancer in their era (Antoniou et al., 2003). Risk assessment genetic testing has become as important intrument to fine out if someone has the inherited cancer or breast cancer chance (Nelson et al., 2013). Big work happened in the era of 1990s when BRCA1 and BRCA2 genes were identified or discoverd by scientists as major work in the hereditary cancer of chest (Miki et al., 1994). Because of these discoveries the Doctors enabled the introduction of genetic counselling and targeted DNA testing for the families which have high-risk (Wooster et al., 1995).

Family pedigree plays as major role accessing cancer probability. Having an Ancestry Tree of cancer disease nearly doubles the risk for the girls having breast cancer as compared to the girls

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which do not have the breast cancer. Even if someone doesn't not carry the BRCA mutations remain at high risk if they have close relatives with the disease Person (Langston et al., 1999). Knowing these mutations are important for detecting inherited genetic changes early and prevent disease. Women with BRCA1 or BRCA2 mutations have several options, including surgery, lifestyle adjustments, or daily base medical screenings (Metcalfe et al., 2015). By using this individualized approach, doctors can create targeted prevention and follow-up programs for the individual person (Rebbeck et al., 2002).

2. Genetics of breast cancer

2.1. Hereditary Cancer of breast

Cancer of Breast that runs in families usually results from genetic mutations inherited from one or both parents. Genes like BRCA 1, BRCA 2, TP53, PALB2, and others are frequently implicated in hereditary cases (Lalloo & Evans, 2012; Antoniou et al., 2003). A family link is often observed, with breast cancer and related cancers (like ovarian or prostate cancer) affecting multiple relatives (Ford et al., 1998). Hereditary breast cancer typically manifests at an earlier age than sporadic cases, and the long-term risk is significantly increased for mutation carriers. Preventive strategies, including lifestyle modifications, prophylactic surgery, early and frequent screening, and genetic testing, are often recommended (Metcalfe et al., 2015).

2.2. The Sporadic Breast of Cancer

About 86–90% of breast cancer is as the sporadic cancer, showing it the very known type. Unlike family breast cancer, sporadic breast cancer does not run in families and arises from genetic alterations that occur randomly during a person's lifetime (Pharoah et al., 2002). Sporadic cases usually occur after age fifty, and factors like early menarche, late menopause, obesity, and hormone replacement therapy can further rise risk (Key et al., 2001).

2.2 Percentage of breast cancer cases linked to genetics.

Genetic (hereditary) factors that is, inherited gene mutations passed down from a parent account for at least 5.5–9.9% of all type of breast cancer (Lalloo & Evans, 2012; Antoniou et al., 2003). The BRCA 1 and BRCA 2 genes carry the most of hereditary change, which significantly increase the threat of chest and Oophoral tumor (Miki et al., 1994). Other genes, as TP53, PALB 2, CHEK 2, and ATM, also contribute to genetic breast cancer, although their impact is relatively smaller (Rahman et al., 2007). The left 91-96% of cancer of breast is sporadic, caused by somatic mutations rather than Forefathers mutations. These arise from random genetic changes over a person's lifetime, and can also be influenced by lifestyle, hormonal, or environmental factors (Pharoah et al., 2002; Key et al., 2001).

3. Genes that Increase Breast Cancer Risk

Several genes, when mutated, can increase a person's chance of establising breast cancer. The most important genes and their associated risks and syndromes are summarized in table 01.

Table 01: Major types of susceptible genes of Breast Cancer

Associated Cancers	Percentage	Syndromes	References
BRCA1	65–80%	Ovarian, pancreatic	(Milli, L. I. 2024)
BRCA2	45–70%	Ovarian, prostate, male breast	(Kuchenbaecker et Al.,2017)
TP53	50–60%	Brain, bone, adrenal	(Bougeard et al., 2015)
PALB2	40–60%	Pancreatic, ovarian	(Rahman et al., 2007)
CHEK2	20–40%	Colon	(Rahman et al., 2007)
ATM	15–40%	Pancreatic	(Rahman et al., 2007)
PTEN	25–50%	Thyroid, endometrial	(Tan et al., 2012)

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Description:
This table lists the main genes that increase breast cancer risk. Each gene has a different risk percentage and may also be linked to other types of cancers or syndromes. (Antoniou 2003; Miki et al., 1994), medium threat genes like as PALB 2, CHEK 2, and AtM contribute smaller but meaningful risks (Rahman et al., 2007). PTEN and CDH1 mutations are linked to specific syndromes affecting other organs (Tan et al., 2012; Hansford et al., 2015).

3.1 Key genes such as BRC A1 and BRC A2.
The very famous molecular factors engaged in breasts cancer are BRCA1 and BRCA2. Normally, these genes help maintain cell health by contributing to DNA repair. However, when a person inherits a pathogeny mutation in either BRC A1 or BRC A2, the body's capacity to repair the DNA damage is reduced, allowing false cells to grow and potentially develop into cancer (Mehrgou, 2016). Research shows that the threat of chest cancer is about 65–80% For Girls have a BRC A1 changes or mutations 45–70% of chance of having cancer of breast at their lifetime with a BRC A2 mutation (Kuchenbaecker et al., 2017). Fig 01highlights breast, ovarian, and pancreatic cancers, and that some people may get more than one type. Normally, these genes help fix damaged DNA but when they don't work, cancer is more likely to grow.

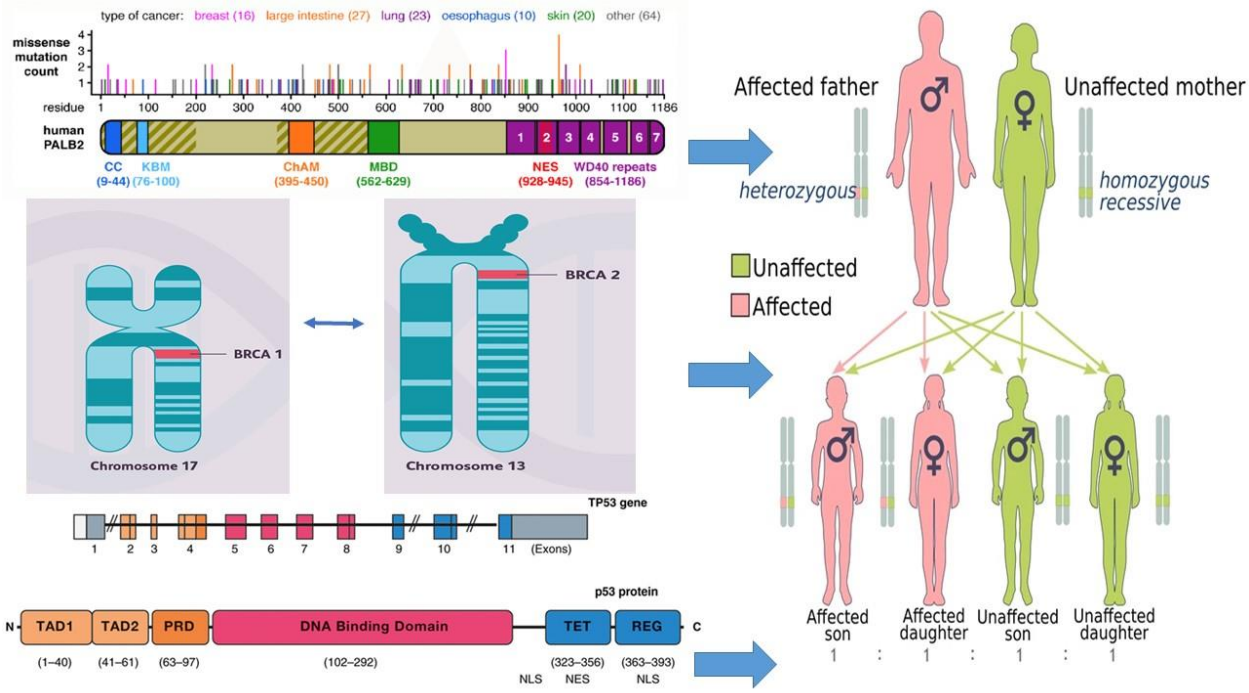

Fig. 01: Risk and Repair in BRCA1 and BRCA2 cancer

4. Can the father's family background contribute to breast cancer susceptibility?
Malignancy of the breast risk can be passed down through both mother and father side of family. Essential gene like BRCA1 and BRCA2 can increases the risk and Inherited in a dominant way.It means that if one parent having a harmful change in one of these genes, each child has about a 50% chance of receiving it. A parent does not need to have breast cancer themselves for the gene to be passed on their offsprings (Ray's. k., et al 2025). Many men carry BRCA gene changes without ever developing cancer, which mean they may pass these mutations to their offsprings. For this reason, cancer history on the parental lineage of the family is just as important as the mother's side when analyzing breast cancer risk. A father's own health record, as well as cases in his mother

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or sisters, should be carefully considered during risk assessment (Kuchenbecker et al., 2017; van Asperen et al., 2016).

Research shows that the female who receive BRCA gene changes from their father face a future exposure of malignancy of breast cancer by differencing situations to those who inherit the same mutations from their mother. This highlights the importance of including the father's family background when providing genetic counseling and conducting genetic testing. Moreover, men carrying BRCA2 Paternal inheritance of mutations in genes linked with cancer of breast elevates the threat of male cancer of breast . Other cancers, which further demonstrates the clinical relevance of paternal transmission. (Kuchenbaecker et al., 2017). Integrating history of cancer in parental lineage have more risk to excess and help healthcare professionals to identify at initial stage person with higher chance to have cancer. This dismisses at time also suggest the person for preventive measure like medical monitoring, change in lifestyle, for both men and women and other member of family (Ray's. k., et al 2025).

5. Causes of malignancy of breast:

Malignancy of breast caused by development of abnormal growth of Cancer cells and environmental factors. Thus, disease is caused by multiple factors not by one single factor (World Health Organization, 2023).

5.1. Genetic related Factors

Heridatory Mutations or changes in genes like BRCA 1 and BRCA 2 mostly rise the chance of malignancy of breast. These mutations are from the both parents may be Mother or may be Father. (Supportive, P.D.Q., et al 2024).

5.2. Hormonal Factors

The changes in hormones also cause the breast cancer. The increase in level of estrogen at long time can raise the level of breast cancer risk. The factors that increase the level are as follows: The pregnancy, Menstrual cycle, Hormone replacement therapy etc. (Susan G. Komen Foundation, 2022).

5.3. Lifestyle Factors

Unhealthy habits may cause the Breast Cancer. Physical inactivity, Smoking and have poor nutrition are the major keys which can raise the level of breast cancer (Shertaeva, A.B., et al 2022)

6. Role of Family History

Around 5- 10% of breast cancers are attributed to family history, making it a significant risk factor (Shertaeva, A.B., et al 2022). A study that analyzed 10,549 breast cancer patients between 2014 and 2017 examined the crash history of family on cancer characteristics, including the relative's cancer type and degree of relation. Tumors were classified by grade and growth receptor status (HER 2, Ki-67 etc.). The findings showed that patients with a tree of cancers other than cancer of breast were diagnosed at an old age compared with those who either had no family history or had relatives with breast cancer (Hao et al., 2021). Patients without any family history were more likely to present at later stages such as N2 or TNM stage III (Hao et al., 2021). The mediun age at diagnosis was 54.1 years, and disease tended to be more advanced among those with first-level relatives affected by breast or oophoric cancer. However, no significant differences were observed across groups in hormone-receptor status (ER, PR) or HER 2 expression (Hao et al., 2021). Fig 02: Shows where the BRCA1 and BRCA2 genes are found on our chromosomes. It also shows how changes can happen in these genes. On the right, the family diagram explains how a parent with the gene change can pass it to their children. Some children inherit the mutation and are at risk while others do not.

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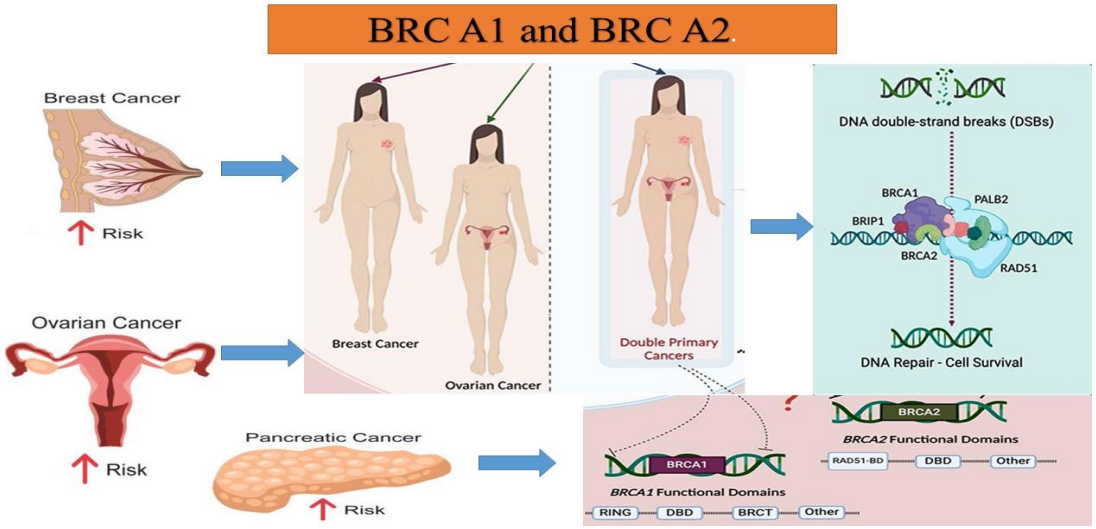

Fig. 02: BRCA1 and BRCA2 gene mutations and Inheritance patterns

6.1 Determining Your Breast Cancer Risk as a Patient's Child

A parent with cancer of breast can increase a human risk, particularly when the parent carries a hereditary mutation such as BRCA1 or BRCA2, which may be passed down from either parent and can markedly elevate lifetime breast-cancer risk (Michaels, 2023). Even when no mutation is detected, having a close relative effected with breast or ovarian cancer still results in a modestly increased risk due to shared genetic or environmental factors (Michaels, 2023). Consulting a genetic counselor and considering genetic testing can help determine personal risk more accurately, while routine screening, early detection, and healthy lifestyle practices can help minimize overall risk and improve outcomes.

6.2. Recommended screening guidelines for the individuals with high-risk level

The cancer of breast is the dangerous cancer in the Females worldwide, and its incidence is at the top. Since 1990, deaths in the US have decreased by roughly 41% thanks to improved treatments and routine screening mammograms (Shertaeva, A.B., et al 2022). Mammography is still the primary screening technique and has solid research backing it up. By minimizing the issue of overlapping breast tissue, a more recent technology known as digital breast tomosynthesis increases accuracy (Helvie, 2022). Mammograms and breast MRI scans should be performed annually on high-risk women, such as those with a lifetime risk of 19.99 % or more a genetic mutation like BRC A1 or BRC A2, or a history of radiation to the chest during childhood (American Cancer Society, 2024). Contrast-enhanced mammography or ultrasound can be used in place of MRI if it is not feasible (Helvie, 2022).

6.3. Myths about the Breast Cancer

Because so much has been written about breast cancer in recent decades, it can be challenging to keep up with all the new developments in surgery, radiology, and medicine. A notable reduction in the cancer of breast has been recorded over time, however chest cancer remnant the most often detected tumor in between Females globally (Finkel, 2021). Early detection and better treatment are to blame for this decline. The American Cancer Society reports that there are already have more than 3.6 million breast cancer survivors in their country and that this figure is expected to increase over time (Angela N Giaquinto., et al 2024). A human threat to develop cancer of breast is rise by many reasons. Depending on a person's genetic, demographic, and clinical characteristics, some women are more

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vulnerable than others, and survival rates also vary. However, a person's probability of developing cancer of breast is not rise by having one or more risk factors (Finkel, 2021).

7. Preventive Measures and Early Detection

Breast cancer is the very famous malignant tumor in female and female between the ages of 35 and 55 account for the high ratio of cases. Consequently, preventing the disease's onset and providing specialized medical care are regarded as essential strategies. Approximately 70% of malignant neoplasms are thought to be influenced by external factors, including lifestyle, diet, physical activity, and unhealthy behaviors, all of which can raise a female s threat of having cancer of breast (Dorosh, 2022; Lauby-Secretan., 2016). Prevention is therefore considered one of the most crucial components in the fight against breast cancer. Results are significantly improved by early detection. Women are willing to perform monthly breast self-examinations to identify any changes and to undergo regular clinical breast exams conducted by healthcare professionals (Hassan, 2025; Anderson et al., 2020). Women over 40 should have mammograms every one to two years, and those at higher risk may also require MRIs, ultrasounds, or genetic screening (Angela N Giaquinto et Al., 2024). Increasing public awareness and encouraging regular screening help in identifying the disease at an initial phase, this is the point at which treatment options are more successful and patient survival rates are significantly improved (Jankovic, 2018; Sung et al., 2021)

8. Awareness about breast cancer:

It is essential to understand cancer of breast because searching it early can protect lives.investigate breast cancer earlier normally make treatment easier for more opportunities to survive .knowing the sign like milk discharge or breast size change or doing regular examine to doctor It can help to solve the problem (Misbah et al., 2025) .Awareness campaigns that provide information to people related to symptoms of breast cancer and motivate people to screening test like mammograms or daily clinical checkup also help us to detect this cancer (Mehboob, 2023) Promotes Awareness decrease stigma, motivate people to talk openly and remind everybody that both men and women can get breast cancer .This supports patient ,survivors and promotes early testing (Mehboob, 2023)

9. Conclusion

In final statement, Breast cancer is most common and fatal disease it mostly affected females but, in some cases, it affects also men. The cases of Breast cancer mostly occur due to lifestyle environmental and harmonal factor. Somehow, about 6-10% of cases are inherited from parents due to gene mutations like BRCA1, BRCA2, TP53, and PALB2. By considering these factors is essential to identify people at high risk and to apply effective screening, prevention, and early detection methods. The patient risk is raised by ancestry of breast or ovarian cancer; thus, Gene testing are mainly early detection techniques. Together with better treatments, screening technology advancements like digital breast mosynthesis and breast MRI have decreased death rates and increased Survival rates.

However, it's also vital to know the majority of cancer of breast cases involve female who have no forefather history of breast. This emphasizes the need for greater public awareness, regular screening practices, and adopting healthy lifestyle habits. If we understand the genes and educate the persons, we can detect the disease on early stage and can treat the person on time and save their lives.

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