Review Paper on Cancer: Classification, Molecular Insights, and Therapeutic Advancements with Emphasis on Breast and Lung Cancer

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Abstract: *Cancer remains a leading cause of morbidity and mortality worldwide. Characterized by uncontrolled proliferation and spread of abnormal cells, it encompasses a heterogeneous group of diseases. This review provides a comprehensive overview of cancer classification, highlights the molecular mechanisms underlying oncogenesis, discusses advancements in diagnosis and therapy with a special focus on breast and lung cancers, and evaluates emerging treatment strategies such as immunotherapy, targeted therapy, CAR-T cell therapy, nanomedicine, and artificial intelligence in oncology. Cancer is a group of diseases characterized by the uncontrolled growth and spread of abnormal cells. If not controlled, it can result in death. The transformation of normal cells into cancerous ones involves multiple steps, typically progressing from a pre-cancerous lesion to malignant tumors.*

Keywords: Cancer, Breast Cancer, Lung Cancer, Immunotherapy, CAR-T therapy, Nanomedicine, Artificial Intelligence, Targeted Therapy

I. INTRODUCTION

Cancer is a genetic disease caused by changes to genes that control the way cells function, especially how they grow and divide. Globally, cancer is responsible for approximately 10 million deaths annually [1]. The complexity of cancer lies in its heterogeneity, both intertumoral and intratumoral, making early diagnosis and effective treatment challenging. Cancer is a group of diseases characterized by the uncontrolled growth and spread of abnormal cells. If the spread is not controlled, it can result in death. Cancer can develop in almost any tissue or organ and is typically caused by genetic mutations that disrupt normal cell growth and division. These mutations may result from external factors such as tobacco use, radiation, infectious organisms, or internal factors like inherited genetic mutations and hormonal imbalances. Early detection, effective treatment, and lifestyle modifications significantly improve the chances of survival and quality of life for cancer patients.

II. CLASSIFICATION OF CANCER

Cancer is classified based on the tissue of origin, cellular features, and molecular alterations:

2.1 Carcinomas
Originating from epithelial cells, carcinomas are the most common type of cancer. They include:
- Adenocarcinomas (e.g., breast, lung, prostate)
- Squamous cell carcinomas (e.g., skin, esophagus)

2.2 Sarcomas
Developing from connective tissues such as bone, muscle, and cartilage:

- Osteosarcoma (bone)
- Rhabdomyosarcoma (muscle)

2.3 Leukemias
Cancers of blood-forming tissues, leading to excessive production of abnormal white blood cells:
- Acute lymphoblastic leukemia (ALL)
- Chronic myeloid leukemia (CML)

2.4 Lymphomas
Cancers of lymphatic tissues:
- Hodgkin lymphoma
- Non-Hodgkin lymphoma

2.5 Central Nervous System (CNS) Cancers
Tumors originating in the brain and spinal cord:
- Glioblastoma multiforme
- Medulloblastoma

2.6 Germ Cell Tumors
Derived from pluripotent germ cells:
- Testicular cancer
- Ovarian germ cell tumors

2.7 Blastomas
Typicallypediatric cancers resembling immature cells:
- **Retinoblastoma**
- **Neuroblastoma**

III. MOLECULAR MECHANISMS OF CANCER PROGRESSION
Cancer development is a multistep process involving:
- Oncogene Activation: e.g., HER2/neu in breast cancer.
- Tumor Suppressor Gene Inactivation: e.g., TP53 mutations common in lung cancer.
- Epigenetic Alterations: DNA methylation, histone modifications.
- Angiogenesis: Tumors induce formation of new blood vessels via VEGF.
- Metastasis: Spread of cancer cells through epithelial-mesenchymal transition (EMT).

IV. BREAST AND LUNG CANCER: FOCUS AND BURDEN
4.1 Breast Cancer
Breast cancer is the most diagnosed cancer among women worldwide, characterized by the uncontrolled growth of cells within the breast tissue. It can occur in both men and women, though it is far more prevalent in women. The disease typically begins in the inner lining of milk ducts or the lobules that supply them with milk. Early detection through screening methods such as mammography significantly improves the prognosis and treatment outcomes. Genetic, hormonal, and environmental factors all contribute to the risk of developing breast cancer, making it a complex and multifactorial disease

Key subtypes include:
- Hormone receptor-positive (ER+/PR+)

- HER2-positive
- Triple-negative breast cancer (TNBC)

Recent treatments emphasize targeted therapies like trastuzumab for HER2+ tumors[2].

4.2 Lung Cancer

Lung cancer remains the leading cause of cancer deaths globally, Lung cancer is one of the most common and deadly forms of cancer worldwide, responsible for the highest number of cancer-related deaths among both men and women. It typically begins in the cells lining the bronchi and parts of the lung such as the bronchioles or alveoli. The two main types are non-small cell lung cancer (NSCLC), which accounts for about 85% of cases, and small cell lung cancer (SCLC), which is more aggressive and fast-growing. Major risk factors include cigarette smoking, exposure to radon gas, asbestos, and other environmental toxins. Early detection and advancements in treatment have improved outcomes, but the prognosis often depends on the stage at diagnosis.

Divided into:

- Non-small cell lung cancer (NSCLC)
- Small cell lung cancer (SCLC)

Molecular profiling (EGFR mutations, ALK rearrangements) has revolutionized targeted therapy [3].

V. CONVENTIONAL DIAGNOSIS AND TREATMENT

- Imaging: MRI, CT, PET scans
- Biopsy and Histopathology
- Blood-based tumor markers: CA-125, PSA, CEA
- Surgery, Radiation, Chemotherapy

Limitations include toxicity, resistance, and incomplete eradication of tumors.

VI. NEW ADVANCES IN CANCER THERAPY

6.1 Immunotherapy

Checkpoint inhibitors (PD-1/PD-L1 inhibitors) have dramatically improved survival in melanoma, NSCLC, and other cancers [4].

6.2 Targeted Therapy

Drugs like osimertinib (EGFR inhibitor) and trastuzumab (HER2 inhibitor) exemplify precision oncology [5].

6.3 CAR-T Cell Therapy

Chimeric antigen receptor T-cell therapy shows promise in hematological malignancies such as acute lymphoblastic leukemia[6].

6.4 Nanomedicine

Nanoparticles improve targeted drug delivery, minimizing systemic toxicity [7].

6.5 Artificial Intelligence (AI)

AI assists in early detection (radiology imaging) and treatment decision-making [8].

6.6 Cancer Vaccines

Emerging therapeutic vaccines aim to stimulate the immune system to fight cancers [9].

VII. CHALLENGES AND FUTURE PERSPECTIVES

- Tumor heterogeneity and drug resistance

- High cost and accessibility of new treatments
- Need for reliable biomarkers
- Ethical concerns in gene editing and personalized therapies

Future directions include combination therapies, CRISPR-based editing, and microbiome modulation to improve outcomes.

VIII. CONCLUSION

Cancer research has made substantial progress, notably with molecular targeted therapies and immunotherapies. Continued multidisciplinary collaboration is essential to develop novel, affordable, and effective cancer treatments globally, especially for breast and lung cancer.

REFERENCES

[1]. Sung H, et al. CA Cancer J Clin. 2021;71(3):209-249.
[2]. Slamon DJ, et al. N Engl J Med. 2001;344(11):783-792.
[3]. Mok TS, et al. N Engl J Med. 2009;361(10):947-957.
[4]. Borghaei H, et al. N Engl J Med. 2015;373(17):1627-1639.
[5]. Soria JC, et al. N Engl J Med. 2018;378(2):113-125.
[6]. Maude SL, et al. N Engl J Med. 2018;378(5):439-448.
[7]. Bobo D, et al. Adv Drug Deliv Rev. 2016;108:3-21.
[8]. Esteva A, et al. Nature. 2017;542(7639):115-118.
[9]. Schlom J. J Natl Cancer Inst. 2012;104(8):599-613.
[10]. American Cancer Society. (2024). Breast cancer.
[11]. World Health Organization. (2022). Cancer.