

THE PERSPECTIVE AND FUTURISTIC TECHNIQUES FOR THE DIAGNOSIS OF CANCER DISEASES

Abstract

Cancer has emerged as a prevalent ailment in contemporary times. A range of clinical and pathological diagnostic methods are available for the detection of cancer. However, to this day, a comprehensive understanding of the precise diagnostic methods and stages of cancer has not been entirely achieved. In this chapter, we explored various advanced techniques for the detection and diagnosis of cancer. One of the ways includes the utilization of artificial intelligence, specifically deep learning, in combination with microfluidics chip technology. Deep learning models offer a dependable, expeditious, and efficient approach to addressing the complexities of these diseases in the given circumstances. Microfluidic devices generally detect various cancer-diagnostic variables present in sample biological fluids, as well as facilitate the production of nanoparticles suitable for drug delivery. Therefore, the utilization of microfluidics, deep learning in the domain of cancer diagnosis and research has significant promise owing to its exceptional sensitivity, capacity for high-throughput analysis, and cost-effectiveness.

Keywords: Cancer, Artificial intelligence, Deep learning, Microfluid

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I. INTRODUCTION

The medical profession has widely acknowledged the existence of cancer since the 1600s. According to the established definition, cancer refers to the abnormal proliferation of cells or cells that have lost their regulation of the cell cycle. Cancer metastasis refers to the process by which the unregulated proliferation of cells originates at a specific location within the human body and subsequently disseminates to other anatomical sites [1, 2].

Cancer remains one of the leading causes of mortality worldwide. In the year 2016, a total of around 1.6 million newly diagnosed instances of cancer in the United States[3]. Based on estimations, the number of individuals in the United States who have received a cancer diagnosis exceeds 15 million. Projections indicate that this figure is expected to surpass 19 million by the year 2024. Consequently, this upward trend in cancer cases would impose a substantial economic strain, amounting to over 130 billion dollars annually [4].

There exists a diverse array of over 150 distinct cancer types, for which there is currently a dearth of effective techniques for early-stage treatment. Cancer stem cells have been identified as a viable approach for generating stromal cells, hence offering potential avenues for the treatment of cancer. In addition to stem cells, the WNT16B protein has been observed to enhance resistance to cancer in conjunction with chemotherapy[5]. Laser therapy and cryotherapy are among the prominent therapeutic modalities utilized in the treatment of cancer. Among the most commonly observed forms of cancer on a global scale are skin, colon, oral cavity, breast, cervical and thyroid cancers. In contrast, there exists a subset of uncommon malignancies, including osteosarcoma, Ewing's sarcoma, male breast cancer, gastrointestinal stromal tumors, chondrosarcoma, and mesothelioma[6].

Cancer cells have a higher frequency of genetic alterations, including DNA mutations, compared to their normal cell counter parts. Cancer is a pathological condition primarily driven by genetic alterations. The continual alterations observed in both normal and cancer cells are attributed to the processes of replication, mitosis, and oxidative stress induced by oxygen cells[7]. The aforementioned process commences at the inception of a malignant cell and persists until the cessation of life. Throughout this biological process, cancer cells undergo an increase in mass by utilizing many types of cells, including stromal support cells, immune cells, and endothelial cells[8]. The incorporation of these cells into a cancerous tumor is facilitated by many stimuli, such as stress ligands and antigens. Additional indicators of cellular stress related to cancer include proteotoxicity, alterations in cellular metabolism, and perturbations in nucleotide acid levels. Chromosomes constitute an additional set of genetic patterns that exert influence on organisms. The individuals in question serve as operators of the cellular nucleus. The human body contains around 20,000 genes within its somatic cells. The field of cytogenetic, which focuses on the study of these genes, has made significant advancements in recent decades. Notably, the ability to construct three-dimensional models of chromosomes has been achieved[9].

While it is now commonplace to identify solid tumors using new technologies, the detection of cancers before symptom manifestation, monitoring disease progression, and evaluating treatment efficacy in patients necessitate more sophisticated technologies. These advancements are crucial for enhancing prognostic accuracy, improving quality of life,

mitigating medical expenses, and augmenting the likelihood of recovery among individuals with cancer.

1. Complications Associated with Cancer: During cancer therapy, individuals may encounter a multitude of complications that have a significant impact on the patient's overall health. Nevertheless, it should be noted that not all forms of cancer elicit pain for cancer therapy; however, individuals may still encounter varying degrees of discomfort. However, there exists a limited number of drugs and alternative methods that are effective in managing pain associated with cancer [10]. During cancer, individuals may encounter weariness and a variety of symptoms, although often these manifestations are within a bearable range. Respiration is an additional challenge in the context of cancer or cancer therapy. Nevertheless, various therapeutic interventions have the potential to alleviate symptoms, but it should be noted that certain forms of cancer and their corresponding treatment regimens may induce episodes of nausea [11]. Malignant cells disrupt the supply of essential nutrients to healthy cells, potentially leading to a subsequent decline in body weight. The indications and symptoms of chemical imbalances may include frequent urination, disorientation, increased thirst, and constipation [12]. In certain cases, cancer has the potential to exert an influence on the immune system of the body, leading to the targeting of both cancerous and healthy cells. Paraneoplastic syndrome, an infrequent occurrence, can manifest with various symptoms and indications such as gait disturbances and seizures [13]. The presence of cancer can significantly disrupt the normal functioning of a certain bodily component due to its potential to exert pressure on adjacent nerves. The involvement of the brain in this condition may lead to the manifestation of headaches, signs and symptoms like those of a stroke, and perhaps result in unilateral weakness in the human body. Assuming an individual has success in overcoming cancer, it may provide temporary relief, as those who have survived cancer are constantly susceptible to its recurrence [14]. The patient must get communication of the precautionary measures from the attending physician.

The clinical applications of a particular field refer to the practical and real-world uses of the knowledge and techniques developed within that field. These Medical professionals can formulate a prospective strategy, which involves scheduling periodic scans and examinations at predetermined intervals to investigate the effects of radiation therapy. In the context of radiation therapy, the objective is to selectively target malignant cells [15, 16]. A considerable proportion of cancer incidences and mortalities can be mitigated by a comprehensive comprehension of environmental and behavioral risk factors from both an epidemiological and mechanistic standpoint. Cancer therapies now exhibit the lowest rate of clinical trial success among all major diseases. As a consequence of the limited availability of efficacious anti-cancer medications, malignant neoplasms are projected to emerge as the primary cause of mortality in developed nations. In addition to etiological factors, there are determinants for the detection of the early stages of cancer. The early detection of cancer ultimately results in increased rates of survival, reduced morbidity, and decreased costs of treatment [17].

2. To Ensure Timely Execution, it is Imperative to Undertake Three Fundamental Actions:

- The state of being alert and taking precautionary measures
- The assessment, examination, and classification of medical conditions.
- Engage in the field of therapeutics.

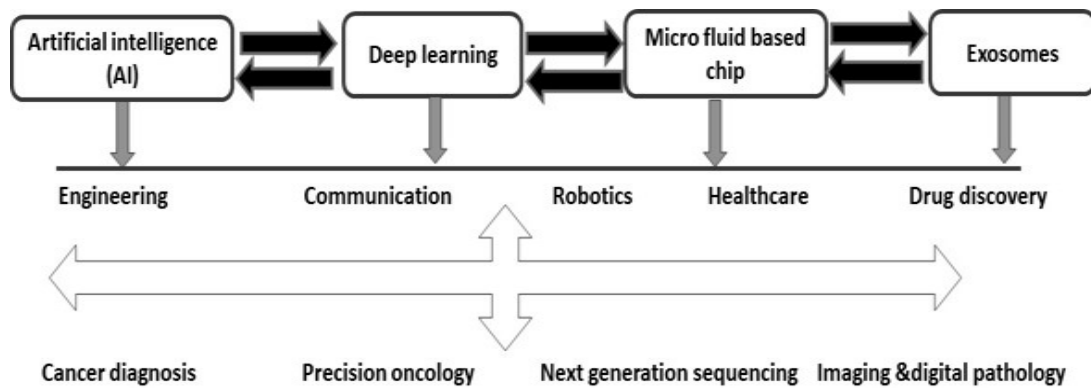


Figure-1. Represent the various futuristic uses of AI, Deep learning, Microfluid & Exosomes on cancer diagnosis

3. The Present Approaches Employed in the Prediction of Cancer: This section provides an overview of the current clinical procedures utilized for the prediction of cancer.

- **Some Ways are Delineated as Follows:** Covering endeavors to identify individuals who are at risk for specific types of cancer or pre-cancerous conditions, but remain asymptomatic, to promptly refer them for further evaluation and intervention. Screening for a particular form of cancer can yield positive outcomes when appropriate tests are employed following the unique requirements and progression of the disease[18]. Furthermore, the procedure of screening is inherently more intricate to adhere to as compared to the practice of early diagnosis. The process of screening is crucial to achieve a precise diagnosis. The primary cause of all forms of cancer is the requirement for a specialized treatment regimen involving one or more methods, such as chemotherapy, surgical, and radiation therapy. The primary objective is to effectively address the tumor and substantially prolong longevity, as enhancing the quality of life for patients is also an indelible goal [19, 20].
 - Chemotherapy is primarily designed to eradicate cancer cells through the administration of drugs that specifically target cells undergoing fast division. The administration of pharmacological agents aimed at reducing the size of tumors is associated with adverse effects that pose potential risks[21].
 - Hormones are known to have a significant impact on individuals afflicted with prostate or breast malignancies [22].
 - Personalized medication, an emerging paradigm, utilizes genetic testing to tailor treatment regimens for individual cancer patients, hence optimizing therapeutic outcomes. However, the efficacy of tailored medication in treating various types of malignancies has yet to be conclusively demonstrated [23].

- Radiation therapy is a medical intervention that eradicates malignant cells or retards their proliferation by the infliction of DNA damage. According to medical professionals, this treatment is frequently recommended as a means to reduce tumor size or alleviate cancer symptoms in advance of surgical intervention[20].
- Stem cell transplantation is a therapeutic intervention employed in the management of hematologic malignancies, namely those blood-related cancers such as leukemia or lymphoma.[24].
- Surgery is typically performed as a treatment modality for individuals afflicted with malignant neoplastic cells. Targeted therapies are employed to impede the metastasis of cancer and enhance the immune response. Targeted therapies, such as small-molecule medicines and monoclonal antibodies, exemplify certain types of therapeutic interventions[25].

II. THE ARTIFICIAL INTELLIGENCE IMAGING TO DIAGNOSE CANCERS.

Within the realm of imaging, computer-aided detection (CADe) or computer-aided diagnosis (CADx) serves as a system-based framework that facilitates the expeditious decision-making process for professionals [26]. Medical imaging is responsible for the management of data included inside images, which are utilized by clinical specialists and experts to evaluate and analyze abnormalities during a specific time [27]. The utilization of artificial intelligence techniques in the preparation of clinical images has the potential to enhance the accuracy of diagnosing different stages of cancer. The utilization of clinical imaging for the early detection and diagnosis of malignancies is a highly effective approach. Undoubtedly, clinical imaging has been widely employed for early detection, monitoring, and post-treatment assessment of malignancies[28]. Specifically, a computed tomography (CT) scan has proven vital in facilitating cancer diagnosis and providing valuable insights into the morphology and dimensions of tumors. Nuclear medicine imaging techniques can aid healthcare professionals in the identification and assessment of cancer metastases[29]. The prevalent nuclear imaging techniques encompass bone scans, PET scans (positron emission tomography), thyroid scans, MUGA scans (multi-gated acquisition), and gallium scans. Magnetic resonance imaging (MRI) plays a crucial role in aiding specialists in the detection of cancer within the human body, as well as in the identification of potential indications of metastasis. X-ray imaging serves as a valuable tool for healthcare professionals in the strategic planning of cancer treatments, such as surgical interventions or radiation therapy. Furthermore, mammography, which involves the utilization of low-dose X-rays, plays a crucial role in the early detection of breast cancer[30].

The detection of cancer typically involves the utilization of radiological imaging techniques to assess the scope of the disease and monitor its progression following therapy. The field of oncological imaging is continuously expanding and becoming increasingly comprehensive and accurate [31]. Some new computer-based method for cancer immunotherapy that utilizes image-based techniques. The suggested methodology has improved the process of vaccine development through the utilization of Dendritic Cell (DCs) immunotherapy[32]. The study has integrated multiple image-based algorithms into the system, ensuring efficient computational performance.

III. THE PRESENT UTILIZATION OF DEEP LEARNING IN THE DOMAINS OF CANCER DIAGNOSIS AND PREDICTION.

This section will explore contemporary research developments in the field of deep learning (DL) about problems involving cancer diagnosis, prognosis, and prediction. This session will address several methodologies employed in the prognosis and prediction of malignancies, including breast cancer and other forms of cancer[33]. The prognostication and prediction of several types of cancer, including tumors, breast cancer, skin cancer, head and neck cancer, brain cancer, liver cancer, colorectal cancer, ovarian cancer, and other forms of cancer, are examined.

An Artificial Neural Network (ANN) approach was utilized to integrate signatures from histological subclasses of these tumors, aiming to fulfill the requirement for accurate grading of these tumors[34]. The auto-encoder approach comprises three main steps. The three stages involved in the construction process are building, pre-preparing, and approving. The initial step involves constructing the fundamental design, which consists of an input layer, a hidden layer, and activation functions[35]. The encoder and decoder are sequentially coated following predetermined cycles. Furthermore, the model incorporates a comprehensive process of meticulous preparation and approval. In summary, the first stage involves the establishment of the foundational structure of the deep neural network, followed by the training of the individual layer nodes, and finally, the validation process that traverses all levels. The strategy proposed by a group of scientists involved the utilization of a deep belief network to acquire knowledge about 3D brain images[36]. The methodology employed by the researchers resulted in a reduced calculation time and a decreased memory requirement.

1. An Examination of Microfluidic Lab-on-a-Chip Platforms: The field of microfluidic research originated in the early 1990s and is presently seeing significant advancements. A microfluidic device refers to a set of fluidic working units that have been designed to be smoothly included in a particular fabrication process. A microfluidic platform can offer a conventional approach to achieve minimization, integration, automation, and parallelization of chemical (biological) processes. Over the past three decades, numerous scientists have dedicated significant efforts toward the advancement of micropumps, microvalves, micromixers, and various other instruments designed for the manipulation of liquid in microfluidic systems[37]. Nevertheless, the absence of a cohesive manufacturing and interface system remains a prominent obstacle to achieving optimal design for lab-on-a-chip technology. The aforementioned gap can only be addressed by the development of a microfluidic system that facilitates the rapid and straightforward implementation of biochemical protocols using established components.

The demand for microfluidic devices is higher compared to conventionally sized devices for several reasons. These include reduced energy, increased flexibility, decreased usage of samples, lower production, rapid sample analysis, automation, high-resolution, and high-efficiency screening [38]. The advancement of micro or nanofabrication procedures through the utilization of diverse soft lithography methods has facilitated the development and progression of microfluidic platforms. These methodologies facilitate the production of tangible objects at the micro or nano scale level. This device is often comprised of basically channels, chambers, and other

nanostructured elements [39]. The incorporation of these nanoscale components into a unified microfluidic platform enables the continuous observation of cancer cell activities in reaction to various occurrences and stimuli.

2. The Utilization of Microfluidic Technologies In vitro Cancer Detection: Circulating tumor cells (CTCs) refer to cancer cells that have basically detached from the primary tumor cells and entered the bloodstream or lymphatic system, enabling them to potentially spread. Circulating tumor cells (CTCs) are capable of infiltrating the bloodstream from both primary tumor sites and secondary metastatic sites, hence exhibiting notable indications of cancer advancement and the spread of cancer to distant locations. The aforementioned cells have a limited lifespan and possess the capacity to retain substantial data to identify, describe, and track cancer [40]. The efficient and pure capture and retention of these seldom cells from the circulatory system of individuals with cancer poses a significant obstacle in the examination of circulating tumor cells (CTCs) as a prognostic biomarker. In recent studies, researchers have investigated several techniques for the detection of circulating tumor cells (CTCs) in patient blood. These methods include molecular identification, immunocytological assays, enzyme-linked immunosorbent assay (ELISA), comparative genomic hybridization, functional characterization, and fluorescence in situ hybridization. Nevertheless, the implementation of these procedures necessitates a significant investment of time and expertise from proficient operators, as well as the utilization of advanced instrumentation [41]. CTC isolation and enrichment are frequently accomplished through the utilization of size-based and affinity-based techniques. The isolation methods that rely on size are predicated upon the physical characteristics of circulating tumor cells (CTCs). The aforementioned techniques are characterized by their simplicity, speed, and effectiveness in exploiting the size disparities between circulating tumor cells (CTCs) and non-tumor cells. Consequently, they are presently employed for CTC identification. Membrane microfilters are mostly utilized to isolate circulating tumor cells (CTCs) through size-dependent techniques, owing to their ability to separate cells that have not been changed or tagged. The separation efficiency and efficacy in the cross-flow filtration process is enhanced when larger or dense particles are maintained in a suspended form, hence mitigating the issue of clogging [42].

- **The Utilization of Microfluidic Aptamer Sensors for the Identification of Circulating Tumor Cells (CTCs):** Aptamers represent a distinct class of single-stranded genetic materials either DNA or RNA oligonucleotides that exhibit superior selectivity and stability compared to antibodies. These molecules possess the potential to selectively attach to proteins, ions, or tiny molecules with high specificity. A wide range of analytes can be detected at a relatively low cost and afterward converted into signals that can be measured catalytically [43]. A range of microfluidic biosensors employing aptamers has been developed specifically to detect circulating tumor cells (CTCs). Pulikkathodi et al. has developed a microfluidic apta sensor utilizing gallium nitride (GaN) high electron mobility transistor (HEMT) technology. This sensor employs a thermocurable polymer chip containing miniaturized sensors, which are capable of quantifying the presence of circulating tumor cells (CTCs) in a solution. The detection and quantification process is facilitated by microfluidic channels [44]. There is a significant level of interest in field-effect transistor (FET)-based

biosensors. There exists a wide range of microfluidic aptasensors that have been developed to directly analyze non-labeled biological materials and generate valuable electrical signals. The utilization of screen-printed electrodes and peptides in the development of electrochemical biosensors, as well as the incorporation of nanomaterials in the fabrication of microfluidic biosensors based on peptides, holds significant promise in the detection of circulating tumor cells (CTCs) [45]. In current times, there has been significant progress in the advancement of sensor technologies for application across a range of therapeutic domains.

- **The Utilization of Micro Fluidic Immune Sensors for the Identification of Circulating Tumor Cells (CTCs):** The immunity-based tactics employed by basically circulating tumor cells (CTCs) involve leveraging the interaction between antibodies and particular antigens, especially epithelial cell adhesion molecule. The utilization of immune affinity purification is exemplified by the microfluidic device known as a CTCchip. The foundation of CTCchips is formed by micro-posts, which are constructed from flexible silicone material and functionalized with anti-epithelial cell adhesion molecule[46]. In comparison to the other cellular entities, circulating tumor cells (CTCs) present in the bloodstream exhibit a distinctive behavior when traversing the microchannel. Specifically, they adhere to the antibodies present on the surface of the microposts, resulting in their capture. Cancer cells derived from epithelial tissues in humans exhibit a unique affinity for anti-EpCAM antibodies, enabling their detection without the need for additional separation techniques [47].

IV. EXOSOMES GENERATED FROM TUMOR CELLS.

Exosomes are small vesicles composed of various biomolecules, like lipids, proteins and micro RNAs (miRNAs). It has also various other molecules that are generated through the mechanism of endocytosis. Exosomes have been implicated in a diverse range of biological phenomena, encompassing the immune response, viral pathogenesis, pregnancy, cardiovascular disease, neurological diseases, and carcinogenesis. Exosomes possess the ability to exert a significant impact on the biological response of receiving cells through the transportation of proteins, metabolites, and nucleic acids[48]. Exosome-mediated reactions have the potential to lead to either disease progression or repression. The intrinsic capabilities of exosomes in regulating complex intracellular pathways have generated significant interest in their potential therapeutic applications for various medical conditions, such as neurological diseases and cancer[49]. Exosomes possess the capacity to transport several therapeutic cargoes, including small interfering RNAs (siRNAs), chemotherapeutic medicines (chemo), and immunological modulators. Tumor-derived exosomes hold significant significance as biomarkers due to the extensive biological information and their involvement in many stages of tumor initiation and cancer progression[50].

V. CONCLUSION AND FUTURE PROSPECTS

In conclusion, the topic at hand holds significant implications for future research and development. Moving forward, it is imperative to explore further avenues and conduct further investigations to fully comprehend the complexities and nuances associated. This study offers a comprehensive analysis and evaluation of contemporary cancer diagnosis and detection

techniques. AI approaches play a crucial role in the early prognosis and identification of cancer by utilizing machine and deep learning methods to extract and identify disease signals. The findings of our study indicate that a majority of prior scholarly publications have utilized deep learning methodologies, with a particular emphasis on Convolutional Neural Networks. The study investigated the impact of utilizing deep learning models on pre-processed and segmented medical pictures, revealing improved performance in categorization measures including sensitivity and accuracy. There exists a potential for further research in the field of early identification various types of cancers, as less investigation has been undertaken about both types of malignancies. Moreover, the utilization of the federated learning model has the potential to facilitate cancer detection by leveraging distributed datasets. These platforms have been widely utilized in many domains about cancer research, like cancer screening to drug delivery and the implementation of various treatment modalities such as gene therapy, and radiation therapy. Additionally, it enables the evaluation of the effects of encapsulated medications on cancer cells, hence facilitating early screening and ensuring their efficacy. Additionally, microfluidics can replicate the features of organ-on-a-chip and human organ systems, enabling researchers to assess the safety profile of new therapeutic medications before their application in clinical settings. Currently, this technique enables researchers to efficiently and cost-effectively identify cancer. The system possesses a notable advantage in accurately assessing specific diagnostic parameters, even with a smaller sample size. This characteristic has positioned it as an unparalleled contender against conventional diagnostic techniques.

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REFERENCES

- [1] Paul D (2020) The systemic hallmarks of cancer. *JCMT* 2020:. <https://doi.org/10.20517/2394-4722.2020.63>
- [2] Diori Karidio I, Sanlier SH (2021) Reviewing cancer's biology: an eclectic approach. *J Egypt Natl Canc Inst* 33:32. <https://doi.org/10.1186/s43046-021-00088-y>
- [3] Mattiuzzi C, Lippi G (2019) Current Cancer Epidemiology. *J Epidemiol Glob Health* 9:217–222. <https://doi.org/10.2991/jegh.k.191008.001>
- [4] Siegel RL, Miller KD, Fuchs HE, Jemal A (2022) Cancer statistics, 2022. *CA A Cancer J Clinicians* 72:7–33. <https://doi.org/10.3322/caac.21708>
- [5] Quail DF, Joyce JA (2013) Microenvironmental regulation of tumor progression and metastasis. *Nat Med* 19:1423–1437. <https://doi.org/10.1038/nm.3394>
- [6] Rossi F, Noren H, Jove R, et al (2020) Differences and similarities between cancer and somatic stem cells: therapeutic implications. *Stem Cell Res Ther* 11:489. <https://doi.org/10.1186/s13287-020-02018-6>
- [7] Torgovnick A, Schumacher B (2015) DNA repair mechanisms in cancer development and therapy. *Front Genet* 6:157. <https://doi.org/10.3389/fgene.2015.00157>
- [8] Baghban R, Roshangar L, Jahanban-Esfahlan R, et al (2020) Tumor microenvironment complexity and therapeutic implications at a glance. *Cell Commun Signal* 18:59. <https://doi.org/10.1186/s12964-020-0530-4>
- [9] Balajee AS, Hande MP (2018) History and evolution of cytogenetic techniques: Current and future applications in basic and clinical research. *Mutation Research/Genetic Toxicology and Environmental Mutagenesis* 836:3–12. <https://doi.org/10.1016/j.mrgentox.2018.08.008>
- [10] Chen HHW, Kuo MT (2017) Improving radiotherapy in cancer treatment: Promises and challenges. *Oncotarget* 8:62742–62758. <https://doi.org/10.18632/oncotarget.18409>
- [11] Maltser S, Cristian A, Silver JK, et al (2017) A Focused Review of Safety Considerations in Cancer Rehabilitation. *PM R* 9:S415–S428. <https://doi.org/10.1016/j.pmrj.2017.08.403>

- [12] Altea-Manzano P, Cuadros AM, Broadfield LA, Fendt S-M (2020) Nutrient metabolism and cancer in the in vivo context: a metabolic game of give and take. *EMBO Rep* 21:e50635. <https://doi.org/10.15252/embr.202050635>
- [13] Fanous I, Dillon P (2015) Paraneoplastic neurological complications of breast cancer. *Exp Hematol Oncol* 5:29. <https://doi.org/10.1186/s40164-016-0058-x>
- [14] Vasan N, Baselga J, Hyman DM (2019) A view on drug resistance in cancer. *Nature* 575:299–309. <https://doi.org/10.1038/s41586-019-1730-1>
- [15] Bidgood WD, Horii SC, Prior FW, Van Syckle DE (1997) Understanding and using DICOM, the data interchange standard for biomedical imaging. *J Am Med Inform Assoc* 4:199–212. <https://doi.org/10.1136/jamia.1997.0040199>
- [16] Côté MJ, Smith MA (2018) Forecasting the demand for radiology services. *Health Syst (Basingstoke)* 7:79–88. <https://doi.org/10.1080/20476965.2017.1390056>
- [17] van den Boogaard WMC, Komninos DSJ, Vermeij WP (2022) Chemotherapy Side-Effects: Not All DNA Damage Is Equal. *Cancers* 14:627. <https://doi.org/10.3390/cancers14030627>
- [18] Beaber EF, Kim JJ, Schapira MM, et al (2015) Unifying screening processes within the PROSPR consortium: a conceptual model for breast, cervical, and colorectal cancer screening. *J Natl Cancer Inst* 107:djv120. <https://doi.org/10.1093/jnci/djv120>
- [19] Debela DT, Muzazu SG, Heraro KD, et al (2021) New approaches and procedures for cancer treatment: Current perspectives. *SAGE Open Med* 9:20503121211034370. <https://doi.org/10.1177/20503121211034366>
- [20] Baskar R, Lee KA, Yeo R, Yeoh K-W (2012) Cancer and radiation therapy: current advances and future directions. *Int J Med Sci* 9:193–199. <https://doi.org/10.7150/ijms.3635>
- [21] Anand U, Dey A, Chandel AKS, et al (2023) Cancer chemotherapy and beyond: Current status, drug candidates, associated risks and progress in targeted therapeutics. *Genes & Diseases* 10:1367–1401. <https://doi.org/10.1016/j.gendis.2022.02.007>
- [22] Okwuosa TM, Morgans A, Rhee J-W, et al (2021) Impact of Hormonal Therapies for Treatment of Hormone-Dependent Cancers (Breast and Prostate) on the Cardiovascular System: Effects and Modifications: A Scientific Statement From the American Heart Association. *Circ: Genomic and Precision Medicine* 14:e000082. <https://doi.org/10.1161/HCG.0000000000000082>
- [23] Singla P, Musyuni P, Aggarwal G, Singh H (2021) Precision Medicine: An Emerging Paradigm for Improved Diagnosis and Safe Therapy in Pediatric Oncology. *Cureus* 13:e16489. <https://doi.org/10.7759/cureus.16489>
- [24] Patel SA, Rameshwar P (2011) Stem Cell Transplantation for Hematological Malignancies: Prospects for Personalized Medicine and Co-therapy with Mesenchymal Stem Cells. *Curr Pharmacogenomics Person Med* 9:229–239. <https://doi.org/10.2174/187569211796957548>
- [25] Tohme S, Simmons RL, Tsung A (2017) Surgery for Cancer: A Trigger for Metastases. *Cancer Res* 77:1548–1552. <https://doi.org/10.1158/0008-5472.CAN-16-1536>
- [26] Firmino M, Angelo G, Morais H, et al (2016) Computer-aided detection (CADe) and diagnosis (CADx) system for lung cancer with likelihood of malignancy. *BioMed Eng OnLine* 15:2. <https://doi.org/10.1186/s12938-015-0120-7>
- [27] Willemink MJ, Koszek WA, Hardell C, et al (2020) Preparing Medical Imaging Data for Machine Learning. *Radiology* 295:4–15. <https://doi.org/10.1148/radiol.2020192224>
- [28] García-Figueiras R, Baleato-González S, Padhani AR, et al (2019) How clinical imaging can assess cancer biology. *Insights Imaging* 10:28. <https://doi.org/10.1186/s13244-019-0703-0>
- [29] Beyer T, Bidaut L, Dickson J, et al (2020) What scans we will read: imaging instrumentation trends in clinical oncology. *Cancer Imaging* 20:38. <https://doi.org/10.1186/s40644-020-00312-3>
- [30] Haldorsen IS, Lura N, Blaakær J, et al (2019) What Is the Role of Imaging at Primary Diagnostic Work-Up in Uterine Cervical Cancer? *Curr Oncol Rep* 21:77. <https://doi.org/10.1007/s11912-019-0824-0>
- [31] Fass L (2008) Imaging and cancer: a review. *Mol Oncol* 2:115–152. <https://doi.org/10.1016/j.molonc.2008.04.001>
- [32] Sprooten J, Ceusters J, Coosemans A, et al (2019) Trial watch: dendritic cell vaccination for cancer immunotherapy. *Oncoimmunology* 8:e1638212. <https://doi.org/10.1080/2162402X.2019.1638212>
- [33] Tran KA, Kondrashova O, Bradley A, et al (2021) Deep learning in cancer diagnosis, prognosis and treatment selection. *Genome Med* 13:152. <https://doi.org/10.1186/s13073-021-00968-x>
- [34] Jujjavarapu SE, Deshmukh S (2018) Artificial Neural Network as a Classifier for the Identification of Hepatocellular Carcinoma Through Prognostic Gene Signatures. *Curr Genomics* 19:483–490. <https://doi.org/10.2174/1389202919666180215155234>

- [35] Desai M, Shah M (2021) An anatomization on breast cancer detection and diagnosis employing multi-layer perceptron neural network (MLP) and Convolutional neural network (CNN). *Clinical eHealth* 4:1–11. <https://doi.org/10.1016/j.ceh.2020.11.002>
- [36] Iqbal S, N. Qureshi A, Li J, Mahmood T (2023) On the Analyses of Medical Images Using Traditional Machine Learning Techniques and Convolutional Neural Networks. *Arch Computat Methods Eng* 30:3173–3233. <https://doi.org/10.1007/s11831-023-09899-9>
- [37] Convery N, Gadegaard N (2019) 30 years of microfluidics. *Micro and Nano Engineering* 2:76–91. <https://doi.org/10.1016/j.mne.2019.01.003>
- [38] Preetam S, Nahak BK, Patra S, et al (2022) Emergence of microfluidics for next generation biomedical devices. *Biosensors and Bioelectronics: X* 10:100106. <https://doi.org/10.1016/j.biosx.2022.100106>
- [39] Bargahi N, Ghasemali S, Jahandar-Lashaki S, Nazari A (2022) Recent advances for cancer detection and treatment by microfluidic technology, review and update. *Biol Proced Online* 24:5. <https://doi.org/10.1186/s12575-022-00166-y>
- [40] Micalizzi DS, Maheswaran S, Haber DA (2017) A conduit to metastasis: circulating tumor cell biology. *Genes Dev* 31:1827–1840. <https://doi.org/10.1101/gad.305805.117>
- [41] Deng Z, Wu S, Wang Y, Shi D (2022) Circulating tumor cell isolation for cancer diagnosis and prognosis. *EBioMedicine* 83:104237. <https://doi.org/10.1016/j.ebiom.2022.104237>
- [42] Agarwal A, Balic M, El-Ashry D, Cote RJ (2018) Circulating Tumor Cells: Strategies for Capture, Analyses, and Propagation. *Cancer J* 24:70–77. <https://doi.org/10.1097/PPO.0000000000000310>
- [43] Zhou J, Rossi J (2017) Aptamers as targeted therapeutics: current potential and challenges. *Nat Rev Drug Discov* 16:181–202. <https://doi.org/10.1038/nrd.2016.199>
- [44] Pulikkathodi AK, Sarangadharan I, Hsu C-P, et al (2018) Enumeration of circulating tumor cells and investigation of cellular responses using aptamer-immobilized AlGaIn/GaN high electron mobility transistor sensor array. *Sensors and Actuators B: Chemical* 257:96–104. <https://doi.org/10.1016/j.snb.2017.10.127>
- [45] Benjamin SR, de Lima F, Nascimento VA do, et al (2023) Advancement in Paper-Based Electrochemical Biosensing and Emerging Diagnostic Methods. *Biosensors* 13:689. <https://doi.org/10.3390/bios13070689>
- [46] Karabacak NM, Spuhler PS, Fachin F, et al (2014) Microfluidic, marker-free isolation of circulating tumor cells from blood samples. *Nat Protoc* 9:694–710. <https://doi.org/10.1038/nprot.2014.044>
- [47] Bankó P, Lee SY, Nagygyörgy V, et al (2019) Technologies for circulating tumor cell separation from whole blood. *J Hematol Oncol* 12:48. <https://doi.org/10.1186/s13045-019-0735-4>
- [48] Kumar R, Ahmad S (2023) EXOSOME' EMERGING FUNCTION IN CARCINOGENESIS AND CANCER CHEMOTHERAPY RESISTANCE. *EJMR* 10:113–120. <https://doi.org/10.24041/ejmr2023.18>
- [49] Tan S, Xia L, Yi P, et al (2020) Exosomal miRNAs in tumor microenvironment. *J Exp Clin Cancer Res* 39:67. <https://doi.org/10.1186/s13046-020-01570-6>
- [50] Dilsiz N (2020) Role of exosomes and exosomal microRNAs in cancer. *Future Sci OA* 6:FSO465. <https://doi.org/10.2144/fsoa-2019-0116>