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Review Article

Precision Medicine

Precision Medicine: Personalizing The Fight Against Cancer

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Abstract: Over the past two decades, advancements in cancer research have influenced the molecular landscape, revealing the intricate heterogeneity inherent in various tumors and diseases. It has challenged the viability of universal treatment approaches, leading to the rise of precision oncology, a strategy focused on administering personalized treatments to the right patient at the right time. Leveraging molecular biomarker profiling, precision oncology aims for optimal clinical efficacy, minimal safety concerns, and reduced financial burden. Predictive biomarker assays have become pivotal in therapy selection, evaluating specific biological characteristics like protein expression or gene mutations associated with positive treatment responses. Profiling DNA emerges as a pivotal aspect, unraveling the genetic intricacies guiding personalized treatment plans. Treatment decision-making in precision medicine, coupled with the transformative impact of immunotherapy, underscores the paradigm shift in patient care. Nanomaterials exhibit promise in precision therapy, revolutionizing drug delivery. Biomarkers play a crucial role in tailoring interventions, while radiotheranostics further enhance precision in cancer treatment. The integration of artificial intelligence amplifies diagnostic and therapeutic precision, fostering a dynamic landscape in personalized medicine. Tackling these challenges is crucial, particularly in the face of tumor heterogeneity and high mutation rates in certain cancers that resist standardized approaches. Precision medicine acknowledges diverse variables influencing outcomes but focuses on genetic and molecular elements grounded in an enhanced understanding of cancer biology. The primary goal of precision medicine is to selectively intervene to benefit responsive patients while avoiding unnecessary and potentially harmful treatments. This review comprehensively explores key facets of precision medicine, focusing on DNA profiling, and seeks to elucidate the role of genetic information in personalized treatment decisions. Additionally, it delves into the intersection of precision medicine with immunotherapy, showcasing advancements in tailoring therapies to individual immune responses. The article also discusses the innovative use of nanomaterials for precise therapeutic interventions, emphasizes the significance of biomarkers in guiding targeted treatments, explores radio theranostics, and evaluates the transformative impact of artificial intelligence in precision medicine.

Keywords: Precision Oncology, Molecular Biomarker Profiling, Predictive Biomarker Assay, Tumor Heterogeneity, Nanomaterials in Precision Therapy, Artificial Intelligence in Precision Medicine

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1. INTRODUCTION

Major strides have been made in gaining insight into the fundamental biological mechanisms of cancer formation. During the last two decades, much research has been conducted to examine the genetic characteristics that differentiate cancers or diseases [1]. Consequently, the diversity of cancer is now generally acknowledged, and a one-size-fits-all strategy for patient therapy is becoming unworkable for the majority of cancer types. Instead, precision oncology refers to administering the appropriate therapy to the correct patient at the optimal moment. It includes a variety of quickly developing cancer therapy approaches that use the information obtained from molecular biomarker profiling to develop tailored strategies for cancer therapy that maximize clinical effectiveness, the fewest possible safety concerns, and the least amount of financial burden [2-4], Enhancement of clinical validation of precision oncology drugs and direct treatment decisions has led to the development of many molecular diagnostic tests for precision oncology products. The decision to choose a therapy, one of the most common uses of precision medicine, is implementing a predictive biomarker test for certain cancer patients. These tests often assess the patient's tumor exhibiting a specific biological trait, such as the production of a certain protein or the presence of a specific gene mutation, which is directly associated with a positive response to treatment. Patients are beginning to believe that precision medicine approaches may play a more routine role in choosing appropriate therapy as the accessibility of specific medications increases and the cost of comprehensive genome-wide analysis decreases. The challenges presented by big data are already apparent at the molecular level when analyzing a precision medicine profile for an individual patient [5]. In addition, the analysis of precision medicine data for extensive groups of patients necessitates the establishment of connections and correlations, as well as the use of hierarchies and multilevel interconnections. The development of direct-to-consumer genetic testing raised questions about traditional notions of privacy even before the advent of precision medicine and large-scale population genome research initiatives.[6] An important issue in precision medicine techniques is how recognized somatic occurrences and isolated case studies may be applied to a wider population. The existence of tumor heterogeneity and a high mutation rate in malignancies like melanomas provide further difficulties in implementing a one-dimensional disease treatment strategy that may be universally successful for all patients. Precision medicine acknowledges the existence of several variables that might contribute to this diversity. Still, its main focus is emphasizing the potential influence of genetic and molecular elements based on a better understanding of cancer biology. The main objective of precision medicine is to provide an intervention to patients who would derive advantages from it while refraining from delivering it to those who will either not benefit or experience damage. Another objective is to minimize the adverse effects and expenses associated with administering the intervention to patients who will not get any benefits or may experience damage.

2. PROFILING DNA FOR PRECISION MEDICINE

In precision oncology, the process of analyzing germline DNA and DNA from tumor samples has now been firmly established. This method has been effective in finding novel cancer-related genes that may serve as prospective targets for therapy and describing the genetic alterations seen in different forms of tumors[7]. The correct choice of treatments for individuals with endometrial cancer takes into account the tumor genotype, which may have an impact on the Prognosis of the illness, therapeutic response, and likelihood of recurrence.[8] Genomic analyses of cancer revealed significant genetic differences not only between various types of tumors but also among tumors with similar tissue traits from different people. This diversity was observed between primary tumors and those that spread from the same person and within different sections of the same primary tumor. The creation of molecularly targeted drugs, which have been used therapeutically for almost twenty years, is based on the scientific understanding of somatic genetic alterations that lead to the genesis and progression of cancer. Hence, selecting these drugs requires a comprehensive comprehension of the cancer genome[9,10]. The importance of selecting biomarkers for molecularly targeted drugs is demonstrated by the following evidence: patients who received personalized treatment based on biomarker selection had notably higher median response rates (30.6%) and longer median periods of progression-free survival (5.7 months) compared to those in the non-personalized treatment group (4.9% and 2.95 months, respectively)[11]. The use of a "genomic (DNA) biomarker" resulted in a higher response rate (42%) in the customized group compared to the "protein biomarker" group (22.4%), indicating the better effectiveness of genomic selection. Most cancer patients are administered one or more cytotoxic anticancer drugs without the availability of reliable predictive indicators, either to identify those who are likely to benefit or to exclude persons at greater risk of severe side effects. For patient stratification, pharmacokinetic or pharmacodynamics germline variations are also crucial [12]. Constructing a precision medicine framework entails allocating resources toward enhancing diagnostic capabilities and refining treatment methods. State-of-the-art molecular techniques and efficient data analysis methods drive the understanding of systems biology and facilitate discovering new connections between genetic variations and observable traits in human melanoma[13]. The field of cancer precision medicine must address obstacles to facilitate the successful incorporation of genetic technologies implemented in the field of clinical oncology. Melanoma is characterized by either frequent alteration in the genome or genetic heterogeneity. Therefore, integrating acquired genomic precision data requires fusion with cancer databases and clinical statistics. The objective is distinguishing between cancer drivers with clinically actionable targets or phenotypically neutral occurrences. It enables the precision medicine team to determine the order of importance for therapeutic choices that should be pursued to provide individualized cancer therapy tailored to the patient's distinct DNA. The already authorized mono and combination treatments show great potential. Additionally, precision medicine provides molecular insights that may guide the development of therapy strategies focusing on the study of epigenetics and metabolism.

3. TREATMENT DECISION IN PRECISION MEDICINE

Precision oncology utilizes the retrospective integration of clinical evidence with data to accurately anticipate patients' responses to targeted medicines and ensure that each patient receives the best suitable therapy for their illness. It helps in clarifying the biological processes that underlie the response and resistance. Large dataset processing, exchange, storage, interpretation, and confirmation of diverse clinical trial data

pose considerable challenges. Precision oncology is rapidly advancing via integrating molecular profiling, clinical data, cloud computing, and artificial intelligence algorithms to develop predictive models[14]. The development of liquid biopsy methods may provide extensive data from several disease locations or heterogeneous tumors, allowing for the identification of individuals who might reap advantages from the use of combination medicines that specifically focus on various tumor features via independent methods [15]. Future cancer treatment plans might involve adaptive regimens designed to sustain a competitive milieu among drug-sensitive tumor cells while managing the proliferation of drug-resistant tumor cells. It would allow the disease to be controlled by lowering the tumor burden to a manageable level rather than eliminating it. Treatment guidelines are expected to incorporate recommendations for biomarker-guided treatment modifications for certain types of tumors. [16] This will help high-risk patients receive more effective treatment, and low-risk patients will experience improved quality of life and reduced financial burden associated with cancer care. Efforts are underway to enhance equity, diversity, and inclusion in clinical trials and ensure that reference genomes sufficiently encompass the complete spectrum of sequence diversity among human populations. It is necessary because current clinical trial findings and public genomic databases may not be relevant to all patient populations [17]

4. PRECISION MEDICINE IN IMMUNOTHERAPY

Only a small percentage of patients can receive molecularly tailored medications, while 20–30% of individuals without known prognostic markers benefit from anti-immune checkpoint antibodies[18]. The majority of these individuals do, however, relapse at some point and pass away as a result. The effectiveness of immune checkpoint inhibitors has amply shown the importance of the host immunological treatment microenvironment of cancer[19]. It has also been suggested that a crucial factor in determining the effectiveness of immunotherapy relies on achieving a delicate equilibrium between immunological activation and immune suppression inside cancerous tissues due to the development of numerous medications that block immunological checkpoint molecules. Neoantigens and shared antigens, namely oncoantigens and CD8+, primarily the cancer/testis antigens respectively, are two categories of cancer peptide vaccines that can stimulate cytotoxic T cells [20]. Neoantigens refer to tissue-specific proteins, also known as cancer/testis antigens, that are generated due to somatic missense mutations. Shared antigens refer to peptides that are generated from these proteins. Shared antigens are relatively frequent. However, they are limited by HLA type, whereas neoantigens are entirely individualized antigens (except a few oncogene-specific antigens like KRAS). Numerous clinical research has demonstrated the immunogenicity of common antigens. Neoantigens are specifically associated with cancer cells, but only a small fraction, ranging from one in five to one in twenty, of the anticipated neoantigens have been seen to trigger an immune response. Cytotoxic T lymphocytes (CTLs) that are specific for the antigen in cancer patients or to CTLs using lymphocytes obtained from individuals without any health issues [21]. One of the typical cancer treatment alternatives may be the neoantigen vaccination. Second-generation CAR T cell therapy, specifically targeting CD19, has shown remarkable efficacy in many studies, achieving enhanced remission rates in pediatric and adult patients with relapsed or refractory acute lymphoblastic leukemia (ALL)[22].

5. NANOMATERIALS FOR PRECISION THERAPY

Precision medicine has encountered several obstacles that conventional medical approaches need help to overcome, such as focused gene delivery effectively. Nanomaterials and nanotechnology have demonstrated potential in addressing important medical diagnosis and treatment needs over the last ten years[23]. These include precise targeting of cells, medical imaging, delivery of drugs and genes, and various therapeutic methods that leverage the chemical and physical properties at the nanoscale, such as magnetic hyperthermia and photothermal therapies[24]. The particle carrier systems have been specifically designed with advanced features that enable intelligent activation of drug release, effective transport of genes, precise detection of biological substances, high-resolution imaging at the nanoscale, transmission of signals at the nanoscale, and analysis of biological nanostructures [25]. The hydrodynamic size is the primary design parameter that significantly influences the transfection effectiveness, endocytosis, and toxicity of gene nano vectors in vivo or in vitro[26]. Integrating sophisticated nanomaterials and nanotechnology, gene sequencing technologies, new biomarkers, and targeted treatments against dysregulated epigenomes in cancer cells is necessary for achieving the desired outcome. Precision medicine, particularly in a clinical context, is of utmost importance. Polymeric materials possess extended blood circulation, elevated bioavailability, exceptional biocompatibility, and degradability, making them potent delivery vehicles[27]. The nanocapsule consists of a protein core and a porous polymer shell, which may be selectively destroyed or remain stable under certain pH conditions[28]. The disintegration of the capsule results in the breakdown of its outer shell, allowing the entry of the core protein into the cell to carry out its regular duties. This approach facilitates the translocation of a group of proteins into cells, thus creating a novel avenue for the delivery of sgRNA, Cas9-RNP, and cancer treatment[29]. Arrangement of the nanocapsules in mice according to their topical distribution demonstrated strong gene editing ability[30]. Nanomedicine, a field of study, significantly emphasizes using customized nanostructures for precise cancer detection and treatment in the biological and clinical domains[31]. Cancer precision treatment has effectively harnessed distinct nano characteristics and facilitated the progressive advancement of diverse nanoparticles. To address intricate medical problems, it is necessary to modify nanoparticles with various components for diagnosis and treatment in a clinical environment. These components include anticancer medications, biological substances, fluorescent dyes, ligands unique to tumors, and genetic entities[32]. The proper assembly of these components at the nanoscale is essential for their independent or cooperative functioning to achieve optimal efficiency in medical theranostics. The key challenges in cancer treatment revolve around addressing the extended circulation period of nanocarriers, achieving precise targeting of tumor tissue and cancer cells, ensuring high cellular uptake and rapid escape from endosomes, enabling substantial cargo loading and regulated release, and minimizing toxicity via comprehensive body clearance [33]. A biological organism may be considered a complex enclosed system with various changing physiological factors and surroundings. The application of medical therapeutics to such a system necessitates using intelligent

nanocarriers tailored to the design's complexity and the specific strategies employed in precision tumor therapy. These nanocarriers must possess the ability to adapt to the physiological environment to ensure their survival and enable efficient delivery of therapeutics. When the nanocarriers come into contact with serum and stroma in the blood and tissue, some physiochemical characteristics of the nanocarriers will be changed and weakened, resulting in the loss of certain biological effects [34]. To advance precision medicine, it is necessary to establish specific criteria for nanocarriers used in systemic distribution, considering all elements of biological needs, medical effects, and fundamental medical.

6. BIOMARKERS IN PRECISION MEDICINE

In human cells, RNA, DNA, and proteins are found in varying amounts and play important roles. While DNA carries genetic information, RNA is a genetic information transmitter and regulatory component. In contrast, proteins work as structural elements, regulators, and catalysts within the cell[35]. A human cell typically includes 130-150 picograms of proteins, 6 picograms of DNA, and 10-30 picograms of RNA. Proteins are noticeably more plentiful in 1 mL of plasma than RNA or DNA, both present in 1-1000 nanograms [36,37]. The biological stability of these biomolecules varies; alkaline circumstances make RNA unstable, whereas the same conditions make DNA stable, and proteins are often more stable than nucleic acids. RNA and DNA are mostly used for clinical counseling and are still in the early stages of research about their status as biomarkers. Proteins, on the other hand, are frequently employed in standard diagnostics. Biomarkers are measurable alterations in a living matter associated with typical or atypical conditions [38]. In the cancer domain, biomarkers often fall into one of three categories with clinical significance: diagnostic, prognostic, or predictive. The diagnostic values of early illness detection, tumor origin tracking, and cancer subtype classification are all exemplified. The predictive values include the evaluation of risk regardless of treatments and the prediction of illness outcomes. The predictive values include anticipating treatment results, among other factors [39,40]. Precise and early prediction of clinical outcomes is essential in many clinical research, making sensitive and specific biomarkers critical to precision medicine. Furthermore, biomarkers serve as promising objectives for the advancement of treatments. RNA biomarkers have greater sensitivity and specificity compared to protein biomarkers [41]. PCR amplifies RNA sequence traces, allowing for their specific and sensitive detection. The extraction, purification, and preservation of exRNAs from physiological fluids are essential for future applications in high-throughput sequencing and bioinformatics investigations because exRNA is relatively rare and is easily damaged by RNAase [42]. Additionally, because a separate antibody is needed to identify each protein, RNA biomarkers are far less expensive than protein biomarkers. The detection of RNA molecules consisting of protein-coding RNAs, namely messenger RNAs (mRNAs), as well as many forms of non-coding RNAs, including small nuclear RNA, micro RNA, small nucleolar RNA, and others, has been made possible by high-throughput sequencing technology. A brand-new piwi-interacting RNA (piRNA), a short non-coding RNA, interacts with the piwi subclass argonaute proteins[43]. These proteins are involved in the process of transposon silencing by DNA methylation. There is a correlation between piRNAs and the processes of cell invasion and proliferation [44]. A piRNA called piR-651, whose low expression was discovered to be related to lymphoma patients' poor survival times, may be used as a prognostic indicator. lncRNAs, or long non-coding RNAs, may also be used as biomarkers. Even though it is currently too early to classify and characterize lncRNAs, there is mounting evidence that they exist and have some purpose. Due to their ease of detection and ability to provide non-invasive molecular testing methods, exRNAs show great potential as diagnostic and prognostic biomarkers. Patients with glioblastoma and those who have brain metastases from breast and lung cancer have been discovered to have higher concentrations of a Some individuals have a limited number of miRNAs, namely miR-10b and miR-21, present in their cerebrospinal fluid (CSF). Starting with the initial identification of the biomarker, the process involves developing a research assay and ultimately creating an analytically and clinically reliable test. This test provides useful information to diagnose, predict outcomes, or select appropriate treatments; the development of a useful predictive biomarker assay advances along a certain process. Clinical validation involves figuring out the assay's true positive rate (also known as sensitivity) and true negative rate (also known as specificity), which are crucial factors in determining the cost-effectiveness of precision medicine procedures[45]. Analytical validation involves determining the assay's limit of detection, accuracy, and repeatability Figure 1.

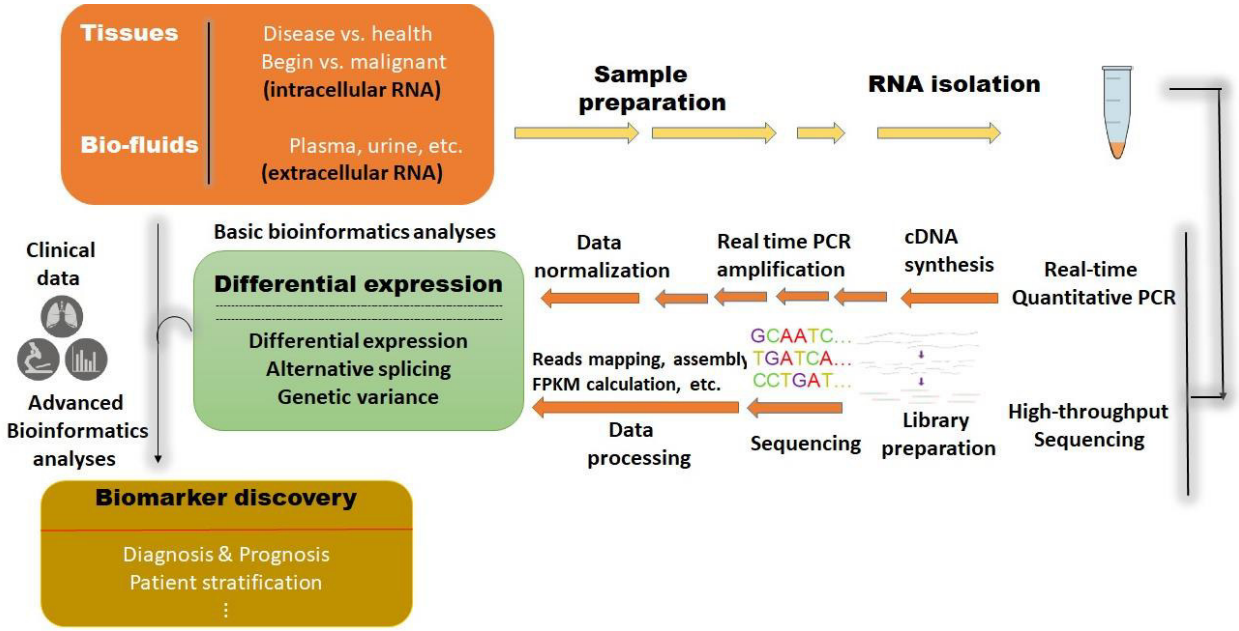

Fig 1: Methods for the detection and characterization of new RNA biomarkers using both experimental and analytical approaches

7. RADIOTHERANOSTICS IN PRECISION MEDICINE

Recently, theranostics was proposed as a future focal point of cancer research in the United States. The notion of precision medicine alludes to the systematic fusion of focused diagnostics and therapies. Recently, theranostics was proposed as a potential area for cancer research [46]. Imaging, particularly with positron emission tomography, facilitates the noninvasive and precise examination of any abnormalities present in the body, not just those that have undergone biopsies, but in contrast to the analysis of biopsies using immunohistochemistry. The generated images demonstrate the targeting molecule's distribution, which can be used to predict the distribution of the same or similar molecule during treatment. Information about potential adverse effects or potential responses or failures. The quantitative PET single-photon emission computed tomography (SPECT) technique uses a radiotheranostic compound to identify the presence and level of a specific molecular target in each cancer lesion in the body. It helps determine which patients would be suitable for the corresponding radio-theranostic drug (also known as a "companion radiotheranostic"). Oncology is at the forefront of radio theranostics innovation, having identified specific proteins and other factors that are only expressed in cancerous tissue as opposed to healthy tissue, advanced imaging technology that can reveal these tissue variables, together with a comprehensive comprehension of chemical targeting and nanodevices. To enable imaging and therapy, the radiolabel accumulates via cellular internalization in conjunction with target Excessive expression on either tumor or stromal cells. Regarding hematologic malignancies, lymphomas have been treated with radiolabeled antibodies that target CD20: Ibritumomab tiuxetan (Zevalin) and situ,[47] Momab (Bexxar; GlaxoSmithKline), which are antibodies that have been tagged with the isotopes 90Y and 131I[48]. Due to the absence of CD20 expression in some lymphomas, CD45, an antigen in all hematologic cells except for mature erythrocytes and platelets, is used for radiotheranostics. The availability of a target does not ensure radiotheranostics success on its own. Dosimetry (radiation dose to tumor lesions and all bodily organs) and radioresistance (the ability of cancer cells to mend damaged DNA mildly or moderately damaged) are two more factors to consider. At the very least, during early phase studies, accurate assessment of the actual incident radiation dosage is crucial in radiotheranostics. Radiation therapy balances cancer cell destruction with minimizing harm to healthy tissues, gauging the dosage to optimize treatment. The dose-predicted therapeutic index evaluates radiation amounts in tumors against nearby critical organs. This comparison guides oncologists in determining an effective yet safe radiation dosage. By assessing the balance between eradicating cancer cells and safeguarding adjacent healthy tissues, this index helps refine treatment strategies. It aims to maximize the therapeutic impact on tumors while minimizing adverse effects on vital organs, ensuring the most favorable outcome for patients undergoing radiation-based cancer therapy.

8. AI IN PRECISION MEDICINE

Precision medicine (PM) is a methodology that considers an individual's genetics, environment, and lifestyle, focusing on elucidating, diagnosing, and treating diseases. It aims to develop a personalized patient treatment plan by gathering multi-omics or multi-mode information from individuals [49]. Artificial intelligence (AI) employs computers or robots to do tasks by imitating or replicating human intellect, primarily via machine learning and deep learning [50]. Artificial intelligence can analyze and interpret vast data efficiently, facilitating PM's groundbreaking discovery. Artificial intelligence (AI) has shown exceptional capabilities in efficient processing, extracting valuable information from, and analyzing large volumes of data. Furthermore, AI can use this data to create various models that may assist in accomplishing project management (PM) objectives. Following the detection of cancer, patients need to undergo further diagnostic procedures, including physical examination, medical imaging, pathology analysis, and measurement of serum tumor markers[51]. These discoveries will enable precise diagnosis, staging, and classification of tumors, hence facilitating precision therapy for the benefit of patients. Artificial intelligence (AI) may Contribute to several aspects of tumor management, including prevention, screening, diagnosis, therapy, and

prognosis prediction. Integrating AI into the clinical process enhances lesion identification accuracy and optimizes the screening approach. Furthermore, AI has the potential to enhance diagnostic accuracy by assisting medical professionals in differentiating genuine disease progression from misleading indications [52]. AI can assess the benefits and drawbacks of several treatment plans and recommend the most optimal course of therapy for patients. The significant expansion and accessibility of patients' health data, including electronic medical records, clinical trial data, and medical pictures, have ushered in the era of "big data [53]. Data analysis based on artificial intelligence (AI) is the most effective method. It is because machine learning and deep learning techniques may uncover hidden patterns, extract crucial information, and reveal associated knowledge from the data. The disease-related data is extracted to facilitate clinical analysis and to get relevant information. Quantitative image analysis is a viable option for precision medicine and may aid cancer management. Machine learning (ML) and deep learning (DL) techniques have been used to quantitatively extract picture characteristics to develop models for diagnosing, monitoring, and forecasting the recurrence and spread of diseases, identifying biomarkers, and determining prognosis [54]. Big data technology primarily encompasses data analysis, mining, and sharing. The potential impact of this technology on cancer diagnosis, treatment, prevention, and prognosis is groundbreaking. However, the progress in converting data into actionable information for the benefit of patients is now stagnant[55]. The technology can examine visible and invisible characteristics in medical pictures and extract and refine these characteristics to ascertain information about diagnosis, therapy, and prognosis. AI is used to analyze, extract, and manipulate data pertaining to tumors. This data is then utilized to construct a healthcare provider platform that relies on substantial tumor-related information[56]. Artificial intelligence plays a pivotal role in the prediction of prognosis and the treatment of patients. It can forecast the likelihood of a patient's viability by analyzing imaging characteristics and ascertaining the appropriate degree of therapy required to get the highest chance of survival. The ability to forecast the likelihood of recurrence, metastasis, surgical margins, and treatment responses may be used to devise an appropriate therapeutic approach for each patient[57]. Precisely diagnosing and assessing lesions before surgery may facilitate the development of suitable treatment strategies for patients and prevent unnecessary interventions such as surgery, postoperative radiation, and chemotherapy. It is advantageous for both patients and medical practitioners.

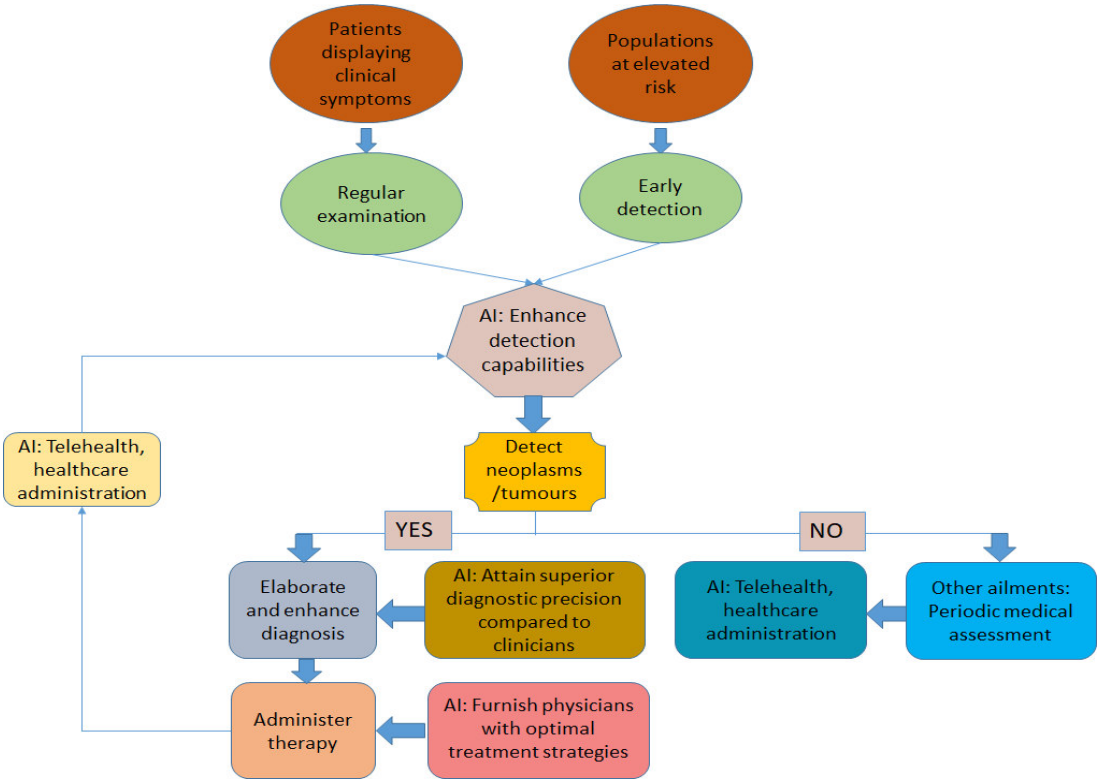

Fig 2: Potential Transformations Resulting from the Integration of AI in Clinical Practice.

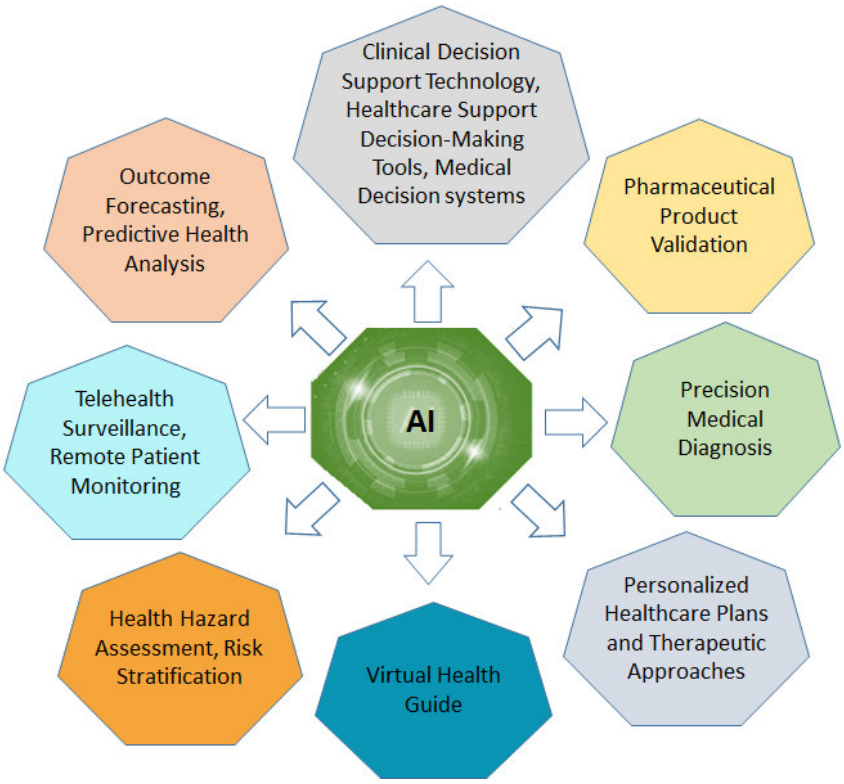

Fig 3: Prospects for Implementing Artificial Intelligence in Tumor Applications.

9. CONCLUSION

Significant progress has been made in melanoma precision medicine and extensive sequencing initiatives. The analysis of the genetic makeup of melanoma has resulted in the discovery of vital genetic indicators, the creation of medicines that specifically target these indicators, and encouraging results in clinical settings. These advancements have created the opportunity for a personalized and efficient treatment of this aggressive kind of skin cancer. Collaborative and multiplatform methods of sequencing genomes in cancer would have a crucial impact on the development of clinical practice. The use of exome-wide and genome-wide sequencing methods has significantly contributed to the comprehension of the genetic makeup of melanoma. These technologies enable the examination of the full coding area of genes (exome) or the entire genome of people. These efforts have led to the discovery of several genetic mutations and changes, some of which are directly linked to the development and advancement of melanoma. Incorporating collaborative, multiplatform genome sequencing into mainstream clinical practice is imminent. Consequently, genetic data must be included in the diagnosis and treatment of melanoma, offering a more accurate and individualized approach to patient care. The ongoing progress in sequencing technology and the collection of extensive genomic datasets are paving the way for significant advancements in melanoma precision medicine. It offers promising prospects for those impacted by this aggressive form of cancer. The joint effort involving medical professionals, scientists, and technological advancements has the potential to revolutionize the field of melanoma therapy and perhaps extend its influence to other forms of cancer.

10. AUTHORS CONTRIBUTION STATEMENT

Dr Ammar A. Razzak Mahmood, Dr. Anand Mohan Jha and Kavitha Manivannan contributed substantially to conception and design, or acquisition of data, or analysis and interpretation of data; drafting the article or revising it critically for important intellectual content; and final approval of the version to be published.

11. CONFLICT OF INTEREST

Conflict of interest declared none.

12. REFERENCES

1. Nature. Milestones in cancer [cited Jun 27, 2023]. Available from: https://www.nature.com/immersive/d42859-020-00083-8/index.html.
2. Shin SH, Bode AM, Dong Z. Addressing the challenges of applying precision oncology. npj Precis Oncol. 2017;1(1):28. doi: 10.1038/s41698-017-0032-z, PMID 29872710.
3. Fröhlich H, Balling R, Beerenwinkel N, Kohlbacher O, Kumar S, Lengauer T; et al. From hype to reality: data science enabling personalized medicine. BMC Med. 2018;16(1):150. doi: 10.1186/s12916-018-1122-7, PMID 30145981.
4. Schwartzberg L, Kim ES, Liu D, Schrag D. Precision oncology: who, how, what, when, and when not? In the American Society of Clinical Oncology educational book. Vol. 37. Alexandria, VA: American Society of Clinical Oncology; 2017. p. 160-9.
5. Qian T, Zhu S, Hoshida Y. Use of big data in drug development for precision medicine: an update. Expert Rev Precis Med Drug Dev. 2019 May 4;4(3):189-200. doi: 10.1080/23808993.2019.1617632, PMID 31286058.

6. Knoppers BM. Consent to 'personal' genomics and privacy. Direct-to-consumer genetic tests and population genome research challenge traditional notions of privacy and consent. EMBO Rep. 2010;11(6):416-9. doi: 10.1038/embor.2010.69, PMID 20448662.
7. Smith JC, Sheltzer JM. Genome-wide identification and analysis of prognostic features in human cancers. Cell Rep. 2022;38(13):110569. doi: 10.1016/j.celrep.2022.110569, PMID 35354049.
8. Cuccu I, D'Oria O, Sgamba L, De Angelis E, Golia D'Augè T, Turetta C; et al. Role of genomic and molecular biology in the modulation of the treatment of endometrial cancer: narrative review and perspectives. Healthcare (Basel). 2023;11(4):571. doi: 10.3390/healthcare11040571, PMID 36833105.
9. Ossandon MR, Agrawal L, Bernhard EJ, Conley BA, Dey SM, Divi RL; et al. Circulating tumor DNA assays in clinical cancer research. J Natl Cancer Inst. 2018;110(9):929-34. doi: 10.1093/jnci/djy105, PMID 29931312.
10. Bedard PL, Hansen AR, Ratain MJ, Siu LL. Tumour heterogeneity in the clinic. Nature. 2013;501(7467):355-64. doi: 10.1038/nature12627, PMID 24048068.
11. Schwaederle M Et al. Association of biomarker-based treatment strategies with response rates and progression-free survival in refractory malignant neoplasms: a meta-analysis. JAMA Oncol. Published online June 6, 2016; 2016.
12. Hertz DL, Rae J. Pharmacogenetics of cancer drugs. Annu Rev Med. 2015;66:65-81. doi: 10.1146/annurev-med-053013-053944, PMID 25386932.
13. Filipp FV. Precision medicine driven by cancer systems biology. Cancer Metastasis Rev. 2017 Mar;36(1):91-108. doi: 10.1007/s10555-017-9662-4, PMID 28265786.
14. Le Tourneau C, Kamal M, Tsimberidou AM, Bedard P, Pierron G, Callens C et al. Treatment algorithms based on tumor molecular profiling: the essence of precision medicine trials. J Natl Cancer Inst. 2016 Apr 1;108(4):djv362. doi: 10.1093/jnci/djv362, PMID 26598514.
15. Russo A, Incorvaia L, Del Re M, Malapelle U, Capoluongo E, Gristina V; et al. The molecular profiling of solid tumors by liquid biopsy: A position paper of the AIOM-SIAPEC-IAP-SIBioC-SIC-SIF Italian Scientific Societies. ESMO Open. 2021;6(3):100164. doi: 10.1016/j.esmoop.2021.100164, PMID 34091263.
16. Strobl MAR, West J, Viossat Y, Damaghi M, Robertson-Tessi M, Brown JS et al. Turnover modulates the need for a cost of resistance in adaptive therapy. Cancer Res. 2021;81(4):1135-47. doi: 10.1158/0008-5472.CAN-20-0806, PMID 33172930.
17. Miga KH, Wang T. The need for a human pangenome reference sequence. Annu Rev Genom Hum Genet. 2021;22:81-102. doi: 10.1146/annurev-genom-120120-081921, PMID 33929893.
18. Lazar V, Magidi S, Girard N, Savignoni A, Martini JF, Massimini G et al. Digital Display Precision Predictor: the prototype of a global biomarker model to guide treatments with targeted therapy and predict progression-free survival. npj Precis Oncol. 2021 Apr 28;5(1):33. doi: 10.1038/s41698-021-00171-6, PMID 33911192.
19. Tang T, Huang X, Zhang G, Hong Z, Bai X, Liang T. Advantages of targeting the tumor immune microenvironment over blocking immune checkpoint in cancer immunotherapy. Signal Transduct Target Ther. 2021 Feb 20;6(1):72. doi: 10.1038/s41392-020-00449-4, PMID 33608497.
20. Schumacher TN, Schreiber RD. Neoantigens in cancer immunotherapy. Science. 2015;348(6230):69-74. doi: 10.1126/science.aaa4971, PMID 25838375.
21. Strønen E, Toebes M, Kelderman S, van Buuren MM, Yang W, van Rooij N et al. Targeting of cancer neoantigens with donor-derived T cell receptor repertoires. Science. 2016;352(6291):1337-41. doi: 10.1126/science.aaf2288, PMID 27198675.
22. Majzner RG, Theruvath JL, Nellan A, Heitzeneder S, Cui Y, Mount CW et al. CAR T cells targeting B7-H3, a pan-cancer antigen, demonstrate potent preclinical activity against pediatric solid tumors and brain tumors. Clin Cancer Res. 2019 Apr 15;25(8):2560-74. doi: 10.1158/1078-0432.CCR-18-0432, PMID 30655315.
23. Wang Y, Sun S, Zhang Z, Shi D. Nanomaterials for cancer precision medicine. Adv Mater. 2018 Apr;30(17):e1705660. doi: 10.1002/adma.201705660, PMID 29504159.
24. Smith BE, Roder PB, Zhou X, Pauzauskie PJ. Nanoscale materials for hyperthermal theranostics. Nanoscale. 2015;7(16):7115-26. doi: 10.1039/c4nr06164k, PMID 25816102.
25. Adams FC, Barbante C. Nanoscience, nanotechnology and spectrometry. Spectrochim Acta B. 2013 Aug 1;86:3-13. doi: 10.1016/j.sab.2013.04.008.
26. Lehto T, Simonson OE, Mäger I, Ezzat K, Sork H, Copolovici DM et al. A peptide-based vector for efficient gene transfer in vitro and in vivo. Mol Ther. 2011 Aug 1;19(8):1457-67. doi: 10.1038/mt.2011.10, PMID 21343913.
27. Prajapati SK, Jain A, Jain A, Jain S. Biodegradable polymers and constructs: A novel approach in drug delivery. Eur Polym J. 2019 Nov 1; 120:109191. doi: 10.1016/j.eurpolymj.2019.08.018.
28. Shimanovich U, Bernardes GJ, Knowles TP, Cavaco-Paulo A. Protein micro- and nanocapsules for biomedical applications. Chem Soc Rev. 2014;43(5):1361-71. doi: 10.1039/c3cs60376h, PMID 24336689.
29. Qin X, Yu C, Wei J, Li L, Zhang C, Wu Q Et al. Rational design of nanocarriers for intracellular protein delivery. Adv Mater. 2019 Nov;31(46):e1902791. doi: 10.1002/adma.201902791, PMID 31496027.
30. Chen G, Abdeen AA, Wang Y, Shahi PK, Robertson S, Xie R, et al. A biodegradable Nano- capsule delivers a Cas9 ribonucleoprotein complex for in vivo genome editing. Nat Nanotechnol. 2019;14(10):974-80. doi: 10.1038/s41565-019-0539-2.
31. Goossens R, van den Boogaard ML, Lemmers RJLF, Balog J, van der Vliet PJ, Willemsen IM, et al. Intronic SMCHD1 variants in FSHD: testing the potential for CRISPR-Cas9 genome editing. J Med Genet. 2019;56(12):828-37. doi: 10.1136/jmedgenet-2019-106402, PMID 31676591.
32. Tiwari P, Yadav K, Shukla RP, Gautam S, Marwaha D, Sharma M et al. Surface modification strategies in translocating nano-vesicles across different barriers and bio-vesicles' role in improving anticancer therapy. J Control Release. 2023 Nov 1;363:290-348. Doi: 10.1016/j.jconrel.2023.09.016, PMID 37714434.

33. Zhu X, Vo C, Taylor M, Smith BR. Nonspherical micro- and nanoparticles in nanomedicine. Mater Horiz. 2019;6(6):1094-121. doi: 10.1039/C8MH01527A.
34. Solanki R, Rostamabadi H, Patel S, Jafari SM. Anticancer nano-delivery systems based on bovine serum albumin nanoparticles: A critical review. Int J Biol Macromol. 2021 Dec 15;193(A):528-40. doi: 10.1016/j.ijbiomac.2021.10.040, PMID 34655592.
35. Rindi G, Wiedenmann B. Neuroendocrine neoplasia of the gastrointestinal tract revisited: towards precision medicine. Nat Rev Endocrinol. 2020 Oct;16(10):590-607. doi: 10.1038/s41574-020-0391-3, PMID 32839579.
36. Vlassov VV, Laktionov PP, Rykova EY. Circulating nucleic acids as a potential source for cancer biomarkers. Curr Mol Med. 2010 Mar 1;10(2):142-65. doi: 10.2174/156652410790963295, PMID 20196731.
37. Zocco D, Ferruzzi P, Cappello F, Kuo WP, Fais S. Extracellular vesicles as shuttles of tumor biomarkers and anti-tumor drugs. Front Oncol. 2014 Oct 8;4:267. doi: 10.3389/fonc.2014.00267, PMID 25340037.
38. Strimbu K, Tavel JA. What are biomarkers? Curr Opin HIV AIDS. 2010;5(6):463-6. doi: 10.1097/COH.0b013e32833ed177, PMID 20978388.
39. Mayeux R. Biomarkers: potential uses and limitations. Neurorx. 2004;1(2):182-8. doi: 10.1602/neurorx.1.2.182, PMID 15717018.
40. Mehta S, Shelling A, Muthukaruppan A, Lasham A, Blenkiron C, Laking G et al. Predictive and prognostic molecular markers for cancer medicine. Ther Adv Med Oncol. 2010;2(2):125-48. doi: 10.1177/1758834009360519, PMID 21789130.
41. Xi X, Li T, Huang Y, Sun J, Zhu Y, Yang Y et al. RNA biomarkers: frontier of precision medicine for cancer. Non Coding RNA. 2017 Feb 20;3(1):9. doi: 10.3390/ncrna3010009, PMID 29657281.
42. Kannemeier C, Shibamiya A, Nakazawa F, Trusheim H, Ruppert C, Markart P et al. Extracellular RNA constitutes a natural procoagulant cofactor in blood coagulation. Proc Natl Acad Sci U S A. 2007 Apr 10;104(15):6388-93. doi: 10.1073/pnas.0608647104, PMID 17405864.
43. Höck J, Meister G. The Argonaute protein family. Genome Biol. 2008 Feb;9(2):210. doi: 10.1186/gb-2008-9-2-210, PMID 18304383.
44. Mei Y, Clark D, Mao L. Novel dimensions of piRNAs in cancer. Cancer Lett. 2013;336(1):46-52. doi: 10.1016/j.canlet.2013.04.008, PMID 23603435.
45. San Miguel L, Hulstaert F. The importance of test accuracy in economic evaluations of companion diagnostics. J Comp Eff Res. 2015;4(6):569-77. doi: 10.2217/cer.15.41, PMID 26529499.
46. Jaffee EM, Dang CV, DB, et al. Future cancer research priorities in the USA: a Lancet Oncology commission. Lancet Oncol. 2017;18(11):e653-706. doi: 10.1016/s1470-2045(17)30698-8.
47. Fendler WP, Pabst KM, Kessler L, Fragoso Costa P, Ferdinandus J, Weber M, et al. Safety and efficacy of 90YFAPI-46 radio ligand therapy in patients with advanced sarcoma and other cancer entities. Clin Cancer Res. 2022;28(19):4346-53. doi: 10.1158/1078-0432.CCR-22-1432, PMID 35833949.
48. Witzig TE. Yttrium-90-ibritumomab tiuxetan radioimmunotherapy: a new treatment approach for B-cell non-Hodgkin's lymphoma. Drugs Today (Barc). 2004 Feb 1;40(2):111-9. doi: 10.1358/dot.2004.40.2.799423, PMID 15045033.
49. MacEachern SJ, Forkert ND. Machine learning for precision medicine. Genome. 2021;64(4):416-25. doi: 10.1139/gen-2020-0131, PMID 33091314.
50. Gore JC. Artificial intelligence in medical imaging. Magn Reson Imaging. 2020;68:A1-4. doi: 10.1016/j.mri.2019.12.006, PMID 31857130.
51. Zhou J, Sun H, Wang Z, Cong W, Wang J, Zeng M, et al. Guidelines for the diagnosis and treatment of hepatocellular carcinoma. 2019 ed. Liver Cancer (2020) 9(6):682–720. doi: 10.1159/000509424.
52. Le Berre C, Sandborn WJ, Aridhi S, Devignes MD, Fournier L, Smaïl-Tabbone M, et al. Application of artificial intelligence to gastroenterology and hepatology. Gastroenterology. 2020;158(1):76-94.e2. doi: 10.1053/j.gastro.2019.08.058, PMID 31593701.
53. Wang K-T. Clinical databases for breast cancer research. In: Noh D-Y, Han W, Toi M, editors. Translational research in breast cancer. Singapore: Springer Singapore (2021). p. 493-509.
54. Lambin P, Leijenaar RTH, Deist TM, Peerlings J, de Jong EEC, van Timmeren J, et al. Radiomics: the bridge between medical imaging and personalized medicine. Nat Rev Clin Oncol. 2017;14(12):749-62. doi: 10.1038/nrclinonc.2017.141, PMID 28975929.
55. Barker AD, Lee JSH. Translating 'Big data' in oncology for clinical benefit: progress or paralysis. Cancer Res. 2022;82(11):2072-5. doi: 10.1158/0008-5472.CAN-22-0100, PMID 35416976.
56. Zheng J, Gao ZJ, Pu LX, He MJ, Fan JP, Wang S, et al. Analysis of tumor disease patterns based on medical big data. J Med Imaging Health Inform. 2021;11(2):478-86. doi: 10.1166/jmihi.2021.3306.
57. Preuss K, Thach N, Liang X, Baine M, Chen J, Zhang C, et al. Using quantitative imaging for personalized medicine in pancreatic cancer: a review of radiomics and deep learning applications. Cancers. 2022;14(7). doi: 10.3390/cancers14071654, PMID 35406426.