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# Emerging biomarkers in cancer diagnosis and prognosis: Novel approaches for precision oncology

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ABSTRACT

Background: This study analysed the emerging biomarkers in cancer prognosis and diagnosis, with a special focus on novel approaches for precision oncology. The incorporation of cancer biomarkers in oncology has significantly transformed cancer treatment by developing remarkable advancements within cancer therapeutics. Novel biomarker helps in utilising biological samples, for instance, urine, blood and tissue biopsies for the identification of proteins, metabolites and nucleic acids. This approach guides the use of spatial and temporal variables for gene expression to understand cellular proliferation and angiogenesis by reflecting different degrees of signals.

Methodology: This study has used secondary sources to collect relevant qualitative information to offer sound conclusions. In order to illustrate the collected data, content analysis has been used here. Lastly, this study has maintained proper reliability & validity while conducting the research.

Results: It has been found from the study that the accessibility of a high throughput process for the determination of transformed cellular molecules permits the use of biomarkers for cancer diagnosis.

Conclusion: In conclusion, precision oncology is generally dependent on the high-throughput significant molecular profiling of cancer cells which permits the determination of genomic modifications through the use of biomarkers.

**Keywords:** cancer, biomarkers, diagnosis, oncology, tumour, immune cells

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## INTRODUCTION

The biomarkers are defined as tools for the identification of cancer cell presence, progression and response towards ongoing treatment. This aspect enhances precision in oncology by offering accurate prognosis and diagnosis with the implementation of personalised treatment strategies. Novel biomarker assists in utilising biological samples such as urine, blood and tissue biopsies for the identification of proteins, metabolites and nucleic acids. This approach leads to the use of spatial and temporal variables for gene expression to understand cellular proliferation and angiogenesis by reflecting different degrees of signals. Transcriptomic biomarkers use RNA sequencing to deliver promising cancer prognoses [1]. This aspect posed gene expression for the classification of cancer advancement that portrayed prognostic and therapeutic adoption with 21 gene recurrences. Machine learning and deep learning were implemented to expand the development of autonomous and effective disease identification for screening of immunological profile and drug sensitivity. Technological development of microarray helps to automate DNA and RNA sequences for comparative genomic hybridisation that expands the exploration of tumour biomarkers [2].

Radio-genomics guides health professionals in implementing data acquisition, pre-processing and tumour segmentation to reduce the impact of avoidable errors in multicentre studies. This aspect guides to enhancement the robustness of 108 radiomic features by the usage of the semi-automatic and interactive segmentation method. 'Isocitrate dehydrogenase' promotes the improvement of molecular biomarkers that contribute to the regulation of citric acid cycle that increases angiogenesis. The biomarker such as 'prostate-specific antigen' guides to enhance the determination of prostate cancer and CA-125 for ovarian cancer through tissue biopsies.

## LITERATURE REVIEW

### Impact of biomarkers on cancer detection and prognosis

The tumour cells, stromal cells and immune cells had an internal influence that portrayed the influence of exosomes in reshaping tumour cells with mutation of cancer cells in advancement procedure. This aspect portrayed 'Cancer-Associated Fibroblasts' (CAF) which reduced miR-320a level and expanded suppression of PBX3 in recipient cells. CAF exosomes promote signal

feedback for naive fibroblast with the stimulation of Platelet-Derived Growth Factor (PDGF) that contributes to cancer growth [3]. However, tumour-associated macrophages had anti-tumour M1 and M2-pro tumoral phenotypes that caused drug resistance and proliferation in expanding cancer growth. This aspect showcased that BRCA 1 and BRCA 2 mutations had a relation with breast and ovarian cancer. The implementation of Genetic screening assists in identifying the changes in exosome and cell mutation that expand proactive surveillance in cancer screening activity. This aspect leads to expanding the treatment procedure through prophylactic surgeries and customised chemoprevention with biomarkers. Assay of Oncotype DX helps to evaluate the expression of 21 genes related to cancer cells and makes it easier to identify tumour location [4]. This approach contributed to enhancing the prediction of cancer occurrence and its development for expanding decisions of chemotherapy.

Moreover, proteomic biomarkers use protein launch in the bloodstream for the identification of cancer cells through protein mutation analysis. The presence of Prostate-Specific Antigen (PSA) acts as a screening tool for prostate cancer that enhances the chances for early detection in offering an effective therapeutic approach. This protein analysis can guide biomarkers to identify the aggressiveness of tumour cells and the chances of metastasis which indicate the severity of cancer cell growth. 'Human Epidermal Growth Factor Receptor' 2 (HER2) presence in high levels had a direct relationship with the aggressiveness of breast cancer with a limited prognosis [5]. This approach leads to the use of 'Trastuzumab' for expanding the binding of HER2 through stimulation of the immune system with the help of chemotherapy drugs. On the contrary, metabolomic biomarkers lead to utilised body fluids such as blood and urine that promote insights for metabolic alteration which reflect the presence of cancer cells [6]. This biomarker leads to identifying the change in the metabolite level of patients that expands the quality of screening of ovarian and bladder cancer through imaging approach. The usage of liquid biopsies outlines the circulation of tumour DNA and tumour cells for getting prognostic insights. This analysis assists healthcare professionals in evaluating changes in ctDNA that improve therapy analysis by offering real-time details of tumour progress.

## Challenges of biomarkers on cancer detection and prognosis

The biomarkers faced difficulty in maintaining high specification and sensitivity which caused complications in the identification of cancer cells [7]. This approach leads biomarkers with low specialists to create complications in expanding follow-up procedures and reduce therapy approaches negatively. PSA implemented for screening of prostate cancer, however, did not specify the presence of prostatitis tumour that caused false positive results. On the other hand, biomarkers with low sensitivity promote failure in the detection of cancer cells and contribute to diagnosis errors effectively.

The biomarkers are developed based on specific demographic groups for the identification of cancer advancement stages that develop the chance of generalisation [8]. This aspect portrayed limited knowledge of biomarker diagnosis creating chaos in developing clinical workflows. The knowledge barriers promote delays in delivering appropriate treatment towards cancer patients.

However, the improvement and implementation of biomarkers remarked as costly reduced their accessibility and usage with effective investment in technology. This aspect portrayed that advanced genomics used machine learning and deep learning to get molecular information on tumour growth in low-resource settings. Additionally, biomarkers are disrupted due to the chances of genetic mutation and differentiation of molecular profiles that reduce population treatment negatively [9]. This aspect portrayed complications in universal biomarkers that hamper cancer screening activity drastically.

## Strategies for expanding biomarker's effectiveness on cancer detection and prognosis

The implementation of next-generation sequencing leads to determining cancer cell mutation with epigenetic changes that enhance the application of mass spectrometry for protein profile [10]. This aspect can improve quality management with liquid chromatography that enhances the detection of cancer cell changes with metabolomic profiling initiatives. On the other hand, a combination of genomic and transcriptomic will help to promote the generation of multi-omics biomarkers through high specificity and sensitivity. This aspect guides to improve standardisation of biomarker testing through development of comparison of past cancer screening activity. Biomarkers can implement effective cohorts for the understanding of the diagnostic and prognostic value in a large population by maintaining consistency in laboratory and therapeutic services.

# METHODOLOGY

Qualitive research typically helps in promoting the analysis of existing information for the construction of critical conclusions through comprehending the subject matter appropriately [11]. In this study, the secondary data of medical record has been used to analyse the emerging biomarkers in cancer diagnosis and prognosis through the use of existing research on this topic. Although, quantitative research has not been used due to the lack of quantitative information and associated issues in answering the stated objectives. Here, the qualitative research helps in performing an in-depth study on biomarkers in cancer diagnosis and prognosis through its effectiveness and mechanism presentation that increase the reliability of this study.

The approach in research mainly guides comprehending the nature of the identified issues in the study that improves the way of collection, extraction, and interpretation of information with the in-detailed method [12]. Among many research approaches, the deductive approach has been used here through the integration of clinical trials and diagnosis results for identifying suitable biomarkers effectively. This factor guides researchers to utilise existing medical data and observation for broadening the research structure on emerging biomarkers in cancer prognosis and diagnosis.

Qualitative analysis is typically defined as an entire interpretation strategy for answering stated questions that contribute to the data gathering and analysis procedure [13]. Here, medical data related to oncology and biomarkers used for the exploration of qualitative information through the illustration of cause-and-effect association in different variables. This strategy guides researchers to exhibit the significant relationship among various emerging biomarkers in cancer diagnosis and prognosis through appropriate mechanism-effect analysis. Therefore, it can be stated

that qualitative analysis extends quality exploration through the use of different peer-reviewed journals for comprehending future development in biomarkers for cancer diagnosis by reflecting the novel approaches for precision oncology.

The data collection guides the utilisation of relevant sources in collecting data regarding the subject matter and helps in promoting the analysis of information from a strategic perspective [14]. Among different types of data collection and analysis processes, a secondary qualitative process has been followed here and the collected data has been analysed through the interpretation of different contents. Secondary sources, for instance, journals, online websites, and scholarly articles have been used for the collection of needed qualitative information that enhances sound decisions in this study effectively. This factor assists in collecting relevant data from journals and articles from 2020 to till date and those that used the English language to study the emerging biomarkers in cancer diagnosis and prognosis. Meanwhile, the content analysis has been used to present the association among different emerging biomarkers in cancer diagnosis, with a special focus on novel approaches for precision oncology. This process broadens the reliability of the study through the use of peer-reviewed journals from PubMed and NHS that expand accuracy in illustrating critical conclusions. The qualitative research portrayed focus on oncology treatment for expanding communication with patients. This approach offered qualitative findings on emerging biomarkers on treatment of cancer and portrayed its potentiality in further development.

Ethical consideration is defined as the grounded principles of maintaining required accuracy in promoting research designs and practices which helps to portray study accountability properly [15]. Here, data privacy has been maintained by providing necessary respect towards the privacy considerations and confidentiality agreements in studying emerging biomarkers in cancer diagnosis and prognosis. Appropriate citation of different secondary sources helps to avoid plagiarism by acknowledging the authors of the used articles and journals.

# RESULTS

## Novel cancer diagnostic process

Present advanced in the cancer diagnosis field have observed an extensive accurate and rapid high throughput diagnostic assessment. Different novel diagnostic biomarkers have been recognised for clinical prognosis and diagnosis of cancers as presented in figure 1. Some of the biomarkers are druggable targets, especially against which relatively small inhibitors of molecules are still under development. The targeted therapies repertoire has been speedily expanding [16]. These typically encompass markers regarding the hematological malignancies, for instance, NMP1, FLT3, PRAM1, and CEBPA in acute myeloid leukemia. BCR-ABL acts as a significant diagnostic marker in myeloproliferative neoplasms such as chronic myelogenous leukaemia [17]. Recent research has presented the importance of EGFR, ALK, BRAF, and KRAS in lung cancer.

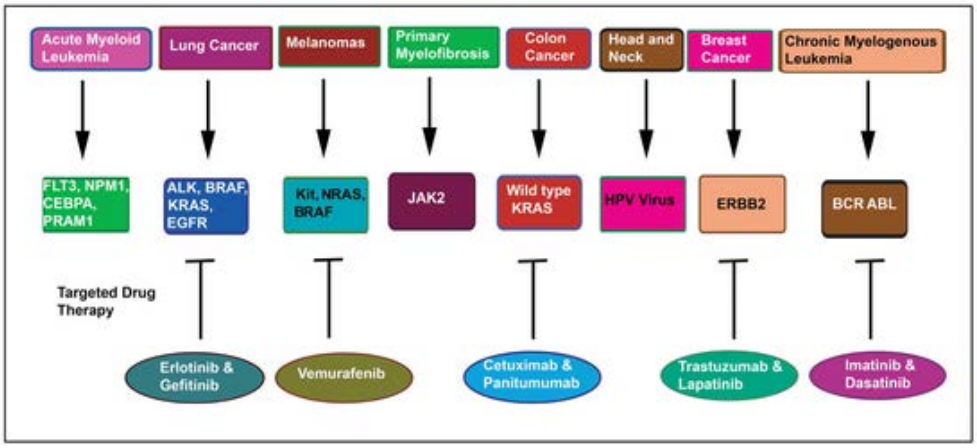


**Fig. 1.** Novel diagnostic biomarkers [17]

Furthermore, NRAS, BRAF, and KIT is critically applicable in melanomas. Apart from the cancer markers, the tumour microenvironment comprising different host immune cells might control tumour function or behaviour as a significant biomarker. These critical diagnostic strategies for cancer have typical far-reaching outcomes within the therapeutic attribution of cancer patients. The identified molecules have been integrated in the patient management for accurate yet early diagnosis by determining risk and prognosis stratification of the disease [18]. Initially utilised as critical research tools the molecular diagnostics clinical tests highlighted in table 1, have presently been identified to be significant for precision oncology.

**Tab. 1.** Present throughput test for diagnosis of cancer

| Analysis | Method |
|---|---|
| Methylation analysis | Pyrosequencing and quantitative sequenom |
| Hotspot cancer mutations | MammaPrint |
| Thyroid nodules classification | Afirma gene profiling |
| RNA and MicroRNA | Microarray technology |
| Mutations in hotspot cancer | Ampliseq |

The utilisation of these biomarkers within cancer diagnosis has been fostered by the accessibility of various high-resolution processes and throughput for the identification of abnormalities in novel biomarkers as highlighted in table 1. In the meantime, de-

pending on basic, clinical and translation study new platforms, for instance, qualitative RFLP and PCR-ARMS, capillary electrophoresis, nested PCR, pyrosequencing or sequencing, microarrays, and FISH are available for medical use in cancer prognosis-diagnosis.

## Biomarkers in precision oncology

Over the past decades, analytical processes in tumour biomarker assessment have been significant tools for quantifying, characterising, and identifying proteins or molecules that can critically act as indicators of cancer progression, response, or presence to treatment (Figure 2). These significant techniques include a range of processes, each providing unique applications and advantages. Signified the factor of next-generation sequencing within the generation of precision oncology approaches [19]. This study highlighted that individualistic targeted therapies can offer medical advantages for cancer patients on a condition to be used in the premises of clinically relevant genomic alterations.

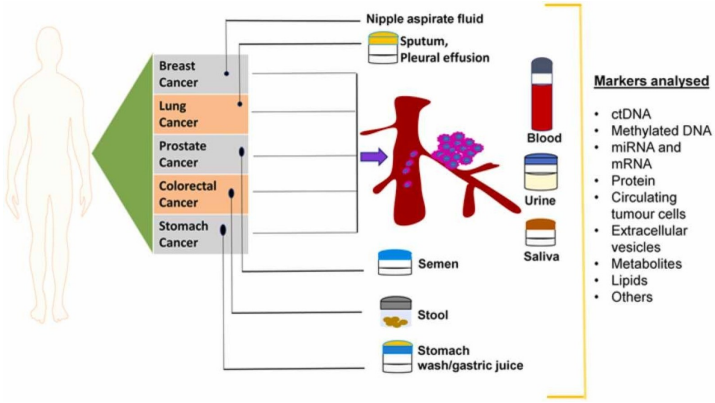


**Fig. 2.** Different biomarkers [19]

As per the study of Brown and Elenitoba-Johnson, CEP55 and ctDNA acts as an ICI efficacy prediction and prognostic biomarker, typically impacting tumour immune microenvironments around different cancers [20]. On the other hand, Alarcón-Zendejas et al. used the estimate R package to quantify the stromal and immune cells scores to determine 7 new biomarkers [21]. This study designed a risk model by classifying HNSCC samples into high- and low-risk groups which are validated for validity using RIC and kaplan-meier survival interpretation. CIBERSORT algorithm highlighted critical variation within immune cell infiltration among risk groups. These critical findings highlighted the roles of TME and revealed advanced prognostic biomarkers for all HNSCC patients. The resection quality among patients with sarcoma is a significant factor in terms of disease-free survival, yet there are no critically accurate molecular biomarkers for predicting or prognosis responses to tested chemotherapy. Hoeben et al., analysed the predictive aspect of molecular alterations determined in 2 precision medicine trials, for instance, ProfiLER and MOSCATO, to anthracycline-based chemotherapy [22]. This study stated that validation is required within prospective analysis with critical homogeneous histocytes for the identification of the biomarker's utility of different TP53 mutation types.

## Clinical validation of biomarkers

Validation is the procedure to establish that the execution of a tool, instrument, or test is accessible for its actual intended purpose. Internal validation also defines the performance of a biomarker in the critical data in which that biomarker has been developed and must be evaluated through a resampling process, for instance, cross-validation or bootstrapping to offer realistic expectations [23]. External validations present the performance of a biomarker in an entirely independent dataset not utilised during the developmental stage (Figure 3).

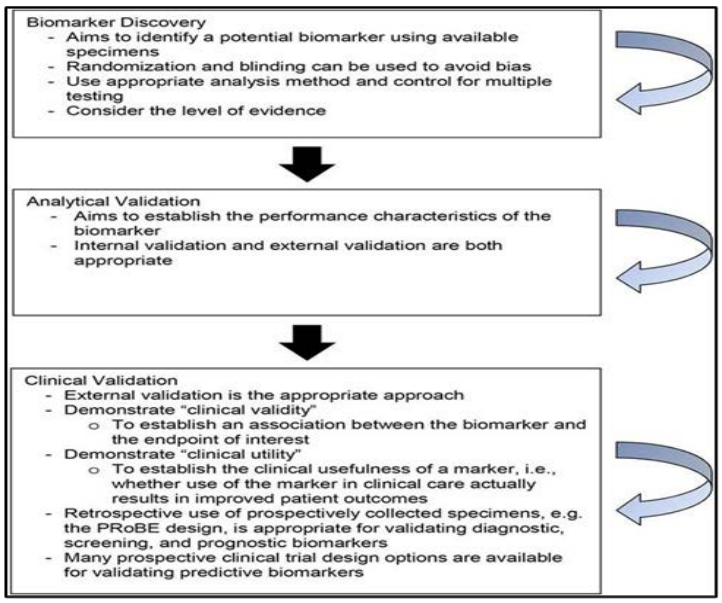


**Fig. 3.** Validation of biomarkers [23]

Clinical validation and analytical validation are two important factors of biomarker validation. A randomised study by Gomes Marin et al. signified that incorporating miRNA with low-dose CT scans improved detection sensitivity by nearly 25% which led to accurate yet early diagnosis [24]. Some of the biomarkers have been observed to predict survival outcomes and treatment response. The PD-L1 expression presence and well-designed biomarkers regarding immune checkpoint inhibitors have been associated with enhanced progression-free survival in patients obtaining pembrolizumab to treat non-small cell lunch cancer. Therefore, the utilisation of specimens gathered prospectively from the related targeted population before knowing outcomes in a significant design characteristic of all validation assessments eliminates the impact of bias.

## DISCUSSION

In present times, the development and discovery of cancer biomarkers have progressed through critical assessment of substances within tissue. These biomarkers are mainly developed by integrating immunological processes, for instance, the radioimmunoassay. Gambardella et al. argued that genome sequencing is a significant advancement which has broadened the identification of tumour-suppressor genes or oncogenes [25]. This has presently catalysed the development of cancer biomarkers, which act as constructive instruments for diagnosis, screening, prediction, and prognosis. Contrarily, Hu et al. argued that initially rooted within critical observations, the investigations of early cancer biomarkers have evolved with the advanced testing technologies [26]. The shift from serial to parallel assessment process promoted the swift determination of different markets by offering critical insights into complicated disease patterns. On the other hand, Chen et al., highlighted that current cancer biomarkers include diverse components, for instance, RNA, DNA, metabolites, proteins, and dynamic procedures such as angiogenesis and apoptosis, highlighting a significant array of combination patterns [27]. This study has found that the ideal biomarker of cancer must possess critical attributes that foster reliable, cost-effective, and easy evaluation, with high specificity and sensitivity. Another study by Condrat et al. signified that the non-invasive characteristic of biomarkers, mainly in liquid biopsies form, presents a critical advancement compared to conventional diagnostic processes, for instance, imaging and tissue biopsies [28]. The capability of the biomarkers to identify treatment procedures is a prime advantage in terms of precision oncology. As such, the PD-L1 expression predictive value and tumour mutational burden in assisting making immunotherapy decisions. Whereas Wallington-Beddoe and Mynott, determined the role of exosomal protein in diagnosing metastasis within prostate cancer [29]. Contrarily, Xiao et al. highlights a promising attribution for immune-related biomarkers within the myelodysplastic syndrome pathogenesis [30]. This study also suggested that the absence of predictive biomarkers for glioblastoma multiform cancer offers a critical impetus for the patient selection who could advantage from the combined treatment of appropriate therapy. Therefore, it can be discussed that an individual biomarker cannot capture the overall picture of cellular and molecular mechanism underscoring immune activation, or clinical responses, thus, multimodal strategies, encompassing non-invasive biomarkers is needed for appropriate prognosis.

## CONCLUSION

In conclusion, biomarkers are critically defined as central to advancing precision cancer therapeutics which highlights a transformation stage in oncology. This study illustrates the diagnostic and prognostic abilities of biomarkers, for instance, immune profiling as a significant part of individualities cancer treatment. Biomarkers are set to transform cancer therapy by promoting clear recognition of genetic mutations, thus permitting treatment design that broadens efficacy while minimising any side effects. The adoption of biomarkers within therapeutic protocols highlights a revolution towards a strategy where these help in diagnosis as well as relevant therapeutic choices, monitor cancer heterogeneity, and track residual disease regarding the treatment resistance. Predictive biomarkers appear as important tools in maximising treatment strategies by ensuring that associated therapies are effective and specifically developed as per the molecular profiles of each patient. Thus, optimising benefits while minimising associated risks, emerging as significant for the diagnosis and prognosis of precision oncology.

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