HIGH SCHOOL EDITION
Journal of Student Research

Volume 13 Issue 3 (2024)

Interventions of Bioinformatics, AI, Diagnostics and Cancer Research

Avyukta Tatta

Eleanor Roosevelt High School, USA

ABSTRACT

The growing usage of nanotechnology has left a great impact on oncology by increasing efficiency and flexibility with patients and cancer types. Previous research has proven new ways to utilize nanotechnology to assist in diagnostics and treatment. AI and ML, Biomarkers, and biomedical engineering of biopsies and other forms of diagnosis have been made to aid in treating large populations. These new forms of cancer research are being implemented by more researchers and medical professionals, and have the potential to be used globally to decrease the mortality rate of cancer. This publication will focus on the adaptations of artificial intelligence, usages of biomarkers, implementations of nano and biotechnology, the ability to target and treat cancer, and point-of-care diagnostics to study the global impact of interventions of cancer.

Introduction

Since the "War on Cancer" that was declared by President Richard Nixon that revolutionized the scope of cancer research, researchers today are unveiling new methods, biomedical advancements, technological implications and interventions that continue to present new solutions in the space of oncology. One area of focus is nanotechnology that has led to a significant advancement in the mechanisms of cancer, molecular mechanisms behind cancer, chemical properties, as well as the novel forms of diagnostics and treatment methods available to cancer patients. In the 1980s and 1990s, scientists rapidly witnessed a significant breakthrough in nanomaterial synthesis, whereby chemical properties were seen being adapted as a biological form of piece that can be pieced together to see how the immune system can respond to genetic mutations and early detection of cancer. In the modern context of microbiology, nanoparticle-based cancer therapies have emerged as a prominent form of treatment that has been tested through various preclinical to clinical trials, allowing more researchers to tap into the R&D of such clinical implications.

Implementation of AI and ML to Improve Clinical Outcomes of Detecting Cancer

Through the revolution of Artificial Intelligence and Machine Learning, researchers have inched closer towards being able to implement proper and appropriate diagnostics and interventions that can be key to ensuring that oncology can one day provide an optimal solution for all cancer patients. As appropriate courses of action in the early stage of cancer are essential, researchers have witnessed how AI algorithms can be utilized to assist clinicians with both screening asymptomatic patients, investigating symptomatic patients, as well as effectively diagnosing cancer recurrence. Thus, in order to better detect and classify premalignant lesions in areas, researchers have leveraged models that have implemented both a 3D inception model as well as a cutting-edge platform that has incorporated AI. (Hunter et al., 2022) For instance, Shen et al. utilized deep learning with PET scans to construct a particular model that can have effective precision in predicting recurrence of cervical cancer following chemoradiotherapy. (Hunter et al., 2022) Such results led to a 71% specificity, and was further enhanced by other researchers that found precision in applying machine learning and NLP algorithms towards developing a recurrence prediction model for gastric cancer. Even for research behind skin cancer, when retrieving over 129,450 clinical images, researchers witnessed how despite the potential limitations surrounding structural racism and bias that can emerge as potential contradictions, AI tools can uniquely implement "Advanced encryption, transfer learning, synthetic data and appropriate heterogeneous data sets" to diversify such results. (Hunter et al., 2022)

Analysis of Certain Biomarkers to Analyze Early Onset

The usage of biomarkers has expanded over the past 30 years since the discovery of "genome and exome sequencing" (Diamandis, 2014) . This allows for the easy identification of mutations in certain cells to allow them to be used as biomarkers for specific cancer types. Since 2014, the ability to use biomarkers has expanded. Researchers have been analyzing an early-onset of a specific form of cancer, colorectal cancer, through analyzing the clinical challenges and the necessity to identify appropriate biomarkers to develop tangible solutions. Researchers specifically looked into available RNA expression through miRNAs to analyze the "polymerase chain reaction assays." (Nakamura et al., 2022) As a result, with 95% confidence, the usage of miRNAs were able to identify Early Onset Colorectal Cancer (EOCRC) in its early stage.

MicroRNA have also contributed to identifying Lung Cancer in early stages. Specific combinations of miRNA are used "under the receiver operating characteristic curve value" (Wang et al., 2015) to give an accurate value distinguishing lung cancer in patients. Diagnosis for Lung Cancer often results in false positives and requires a patient to undergo surgical procedures. MiRNA can "provide a highly sensitive and specific diagnostic test for early stage lung cancer". Similar results are also proven with Breast Cancer. Collected data presents that biomarkers showed the same results when it comes to identifying a tumor. To add on, "biomarkers and miRNAs can effectively detect the early onset of anthracycline induced cardiotoxicity before it is even apparent on the echocardiogram" (Lakhani et al., 2021), which proves the reliability of biomarkers to help diagnose a patient with Breast Cancer. As more trends between diseases and the ability to identify mutations are discovered, biomarkers and miRNA can be used to identify a wide range of cancers in an early stage.

These findings may have its limitations due to the lack of many test groups to find if the usage of biomarkers is significant. Wang et al and Diamandis' research is also outdated so newer findings may contain more evidence of the successfulness of biomarkers, or even prove otherwise. Still, Lakhani et al's research displays great development in biomarkers in cancer diagnosis.

Composition of Biotechnology for Cancer Research (Nanotechnology)

The physical and chemical properties of nanomaterials are important to their impact on the human body and "the effects of nanomaterial depend on their size, shape, etc," (Soni et al., 2023). These characteristics also change their role in cancer diagnosis and treatments. For example, inorganic nanoparticles (INPs) have been found to be extremely useful in "enormous potential for drug delivery, [and] gene therapy." The usage of INPs can be further amplified through changing its structure. Camouflaging them to seem more like a red blood cell can "prolong the short half-life of INPs and increase the biocompatibility of INPs, making INPs more suitable for drug delivery, tumor imaging, and other applications."

However, many nanomaterials, including INPs, have limits in their precision of cancer treatments and diagnosis. Luckily, the implication of AI in nanotechnology assists in this issue. "A functional AI-guided robotic nanoparticle synthesis and analysis system will start with genetic analysis of individual patients and personalized treatment selection," (Egorov et al., 2021). Specialized treatment means that cancer diagnosis and treatments will be more accurate for each individual patient.

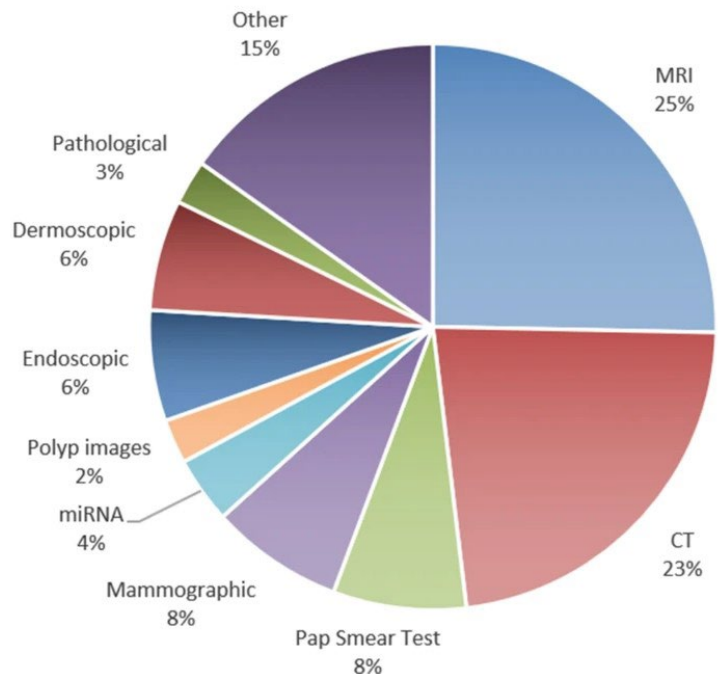

Figure 1. Kumar et al., 2022

However, the implementation of using AI or in general, nanotechnology, in laboratory medicine and pathology is still minor, according to the graph above. This makes it difficult to determine the positive effects of nanotechnology on cancer research.

Theranostics for Targeting and Tumor Characteristics (Morphology, Biopsy)

Theranostic systems have been capturing the attention of many oncologists and biomedical engineers due to their potential to have better image enhancement, its potential in making advancements in the field of personalized medicine, as well as the effective forms of process that are combining imaging signals in vitro and in vivo to provide cancer-targeting theranostics. For instance, particular theranostic development can ensure that targeted drug delivery is able to target cancer cells selectively, through providing cytotoxic chemotherapeutics. (Sargazi et al., 2022) For instance, in cancer cells, endogenous cells are over expressed, which tend to lead to a higher local concentration, in distinguishing cancer cells from normal cells. (Sargazi et al., 2022) Thus, theranostic agent **2**, which is capable of providing both magnetic resonance imaging (MRI) and fluorescence-based imaging for monitoring cellular uptake and prodrug activation process. In this case, a widely used therapeutic agent, doxorubicin (Dox), was conjugated to a gadolinium (Gd3+) texaphyrin *via* a disulfide bond resulting in theranostic implications that can generate better reactive oxygen and higher potency. (Sargazi et al., 2022) In the context of DDS, the ability to precisely control the drug release kinetics once a prodrug is successfully taken up by cancerous tissues holds tremendous appeal.

Point-of-Care Diagnostics for Cancer Research

In treating cancer, many diagnostic tools rely upon "POC" point-of-care diagnostics, which can help to reduce and mitigate the overall cost of implementing materials, equipment and personal concepts. Intrinsically, the POC diagnostics are applied by implementing a "lab-on-a-chip" technology, where laboratory technologies have made the medical applications more effective towards treating all forms of cancer. However, in order for these POC diagnostics to be simplified, these laboratory-based results need to be moved through the "test and treat" cycle, in order to ensure that they are cost-effective, simple, and have high functions in processing various forms of samples.

(Hayes et al., 2018) Particularly in POC diagnostics, the technology that has been implemented relies upon the LFIA-based technologies that rely upon lateral flow of devices, that ensure the appropriate management of biomarkers in a short period of time by relying upon samples. Such LFIA-based technologies have been seen to rapidly revolutionize POC diagnostics by implementing onsite biotech rapid tests that can measure the cancer-associated biomarkers, specific prostate antigens and immunochromatographic tests that can help ensure the monitoring of the sample of biomarkers. (Hayes et al., 2018) In current biomedical advancements, a device is currently being implemented to apply a micr-Hall chip in macon ga cost-effective platform for POC use, that could detect 100% of patients that have such "human epithelial growth factor receptor-2" in unveiling new forms of antibodies and immunoassays that can be used against the biomarker of interest. (Hayes et al., 2018)

Global Healthcare Solutions for Underprivileged Nations for Oncology Development and Research

Cancer continues to be a leading cause of death. Although extensive improvements have been made to detecting cancer in its early stages to to treat it better, a vast majority of the improvements have yet to have an effect on developing countries. Families and physicians themselves are facing problems in having the right resources to diagnose and treat many cancers in third world countries. So much so that "it is estimated that only 1 of 10 children with acute leukemia receive any kind of treatment in these less privileged countries. Hence, even though 70% of childhood ALL is currently curable, it is not 70% curable worldwide, since 90% of the world's children do not have access to curative treatment." (Ching-Hon et al., 2003) This trend has not been broken even in recent times where "cancer research currently is heavily skewed toward high-income countries (HICs), with little research conducted in, and relevant to, the problems of low- and middle-income countries (LMICs)." (Pramesh et al., 2022) Oncology needs to emphasize all parts of the world equally to address the high rate of deaths from cancer, prioritizing access to resources regardless of economic standing, "value-based care", and elevating biotechnology to improve cancer control. Research on citizens of countries around the world needs to be made to make improvements to biotechnology and cancer research as well, as "the paucity of clinical trials in regions with the greatest global burden of cancer contributes to a lack of context-specific high-quality evidence on which to base treatment decisions, clinical guidelines and resource allocation." (Pramesh et al., 2022) A policy that can be issued to bridge health disparities is focusing on health equity. Prioritizing countries and people that need more immediate health care without taking into account their wealth can make the gap between the rich and poor less as well as countries with and without medical help availability. More policies like Obamacare, limiting how much money a patient has to pay for healthcare, can be issued by governments not only in America, but all around the world.

Discussion, Ethics, Limitation

While such results derived from oncology results that fuse the integration of biomedical engineering, public health and oncology are essential to the success of future development and R&D, it is essential to also consider potential ethical limitations. For instance, although some of these results are derived from empirical data, collecting data points from longitudinal studies may be more efficient, as they can help track the relative progress of biomedical advancements, interventions and applications that have helped scientists better provide solutions for cancer research. In addition to this, when testing many of the new medical advancements in biotechnology and diagnostics for cancer research, there are many ethical limitations that may arise – for instance, informed consent and proper disclosure may not be able to be provided to patients that are nearing the end of their illness and disease, or their battle against cancer. Thus, it is essential to consider the demographics of patients that are being treated through such biomedical advancements in treatment methods, tech interventions and applications. Additionally, it is important to consider that in the years to come, more AI advancements may pave the way for more clinical outcomes to benefit from the adaptations and applications of clinical research in oncology.

Conclusion

In conclusion, researchers have witnessed how new research efforts in plunging into the R&D of improving diagnostics and clinical outcomes in the sector of cancer research have mobilized scientists to pave the way for more treatment solutions, tailored to patients battling the diagnosis of cancer. Now, with the rapid health of nanotechnology that serves as the biological units, AI and ML frameworks for cancer research in the incoming years will see future advancements, combined with significant technological and clinical outcomes to be mobilized. With the combined help of Point-of-Care diagnostic tools, theranostic systems as well as global policies that ensure cancer research meets underprivileged nations worldwide with accessible and tailored treatment plans, researchers will be able to inch forward to a closer comprehensive cancer care.

Acknowledgments

I would like to thank my advisor for the valuable insight provided to me on this topic.

References

Al Kez, Dlzar, et al. "Energy poverty assessment: Indicators and implications for developing and developed countries." *Energy Conversion and Management* 307 (2024): 118324.

Diamandis, Eleftherios P. "Present and future of cancer biomarkers." *Clinical Chemistry and Laboratory Medicine (CCLM)* 52.6 (2014): 791-794.

Hayes, Bryony, et al. "Developments in point-of-care diagnostic technology for cancer detection." Diagnostics 8.2 (2018): 39.

Hunter, Benjamin, Sumeet Hindocha, and Richard W. Lee. "The role of artificial intelligence in early cancer diagnosis." Cancers 14.6 (2022): 1524.

Kumar, S., A. Mohan, and R. Guleria. "Biomarkers in cancer screening, research and detection: present and future: a review." *Biomarkers* 11.5 (2006): 385-405.

Lakhani, Hari Vishal, et al. "Detecting early onset of anthracyclines-induced cardiotoxicity using a novel panel of biomarkers in West-Virginian population with breast cancer." *Scientific Reports* 11.1 (2021): 7954.

Mantula, Fennie, Yoesrie Toefy, and Vikash Sewram. "Barriers to cervical cancer screening in Africa: a systematic review." *BMC Public Health* 24.1 (2024): 525.

Moten, Asad, Daniel Schafer, and Mauro Ferrari. "Redefining global health priorities: Improving cancer care in developing settings." *Journal of global health* 4.1 (2014).

Nakamura, Kota, et al. "A liquid biopsy signature for the detection of patients with early-onset colorectal cancer." *Gastroenterology* 163.5 (2022): 1242-1251.

Pramesh, C. S., et al. "Priorities for cancer research in low-and middle-income countries: a global perspective." *Nature medicine* 28.4 (2022): 649-657.

Pui, Ching-Hon, ed. Treatment of acute leukemias: new directions for clinical research. Springer Science & Business Media, 2002.

Sargazi, Saman, et al. "Recent trends in mesoporous silica nanoparticles of rode-like morphology for cancer theranostics: A review." Journal of Molecular Structure 1261 (2022): 132922.

Soni, Ambikesh, et al. "Nano-biotechnology in tumour and cancerous disease: A perspective review." *Journal of Cellular and Molecular Medicine* 27.6 (2023): 737-762.

Wang, Ping, et al. "Early detection of lung cancer in serum by a panel of microRNA biomarkers." *Clinical lung cancer* 16.4 (2015): 313-319.