Review Article

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Affordable Artificial Intelligence Tools In Cancers Diagnosis And Treatment

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1. Abstract

Numerous genetic and epigenetic differences contribute to the complexity and multifaceted nature of the disease known as cancer. Artificial intelligence is opening up a lot of possibilities in the fight against cancer. AI-guided clinical care has the potential to significantly reduce health problems, particularly in low-resource countries. Numerous tools and applications of AI are being offered in the field of oncology. The most significant illness at the moment is cancer.AI played a significant influence at a time when treating cancer was extremely tough. AI has the potential to significantly advance cancer surveillance, speed drug discovery, and help characterize cancers' genomes. Today, AI is utilized to treat tumors of the cornea, lungs, cervix, and other types. This article discusses all types of tumors, their effects, AI-assisted diagnosis, and treatment. In addition to highlighting the different ways artificial intelligence is exploding in oncology, this article also discusses the challenges that humans must face in overcoming AI's drawbacks.

2. Keywords:
Artificial Intelligence, Deep learning, Cancer, Diagnosis

3. Introduction

Cancer is the result of uncontrollable cell growth and proliferation. When a cell goes through mitosis to reproduce, they can also go through a process known as apoptosis, which typically happens when a cell loses its purpose or sustains some sort of damage. Malignant tumours can develop if the process is disrupted in any way, causing the cells to lose their equilibrium and grow uncontrollably. These tumours can then spread to other body organs by integrating into the blood stream. Both morbidity and mortality are caused by cancer. In 2020, there were 19.3 million new cancer cases reported, and more instances are anticipated in the next years. Because of this, it is crucial to encourage innovation in healthcare, particularly with regard to cancer. A significant global concern continues to be early cancer diagnosis. Expanding screening initiatives without the right evidence-based justification would be wasteful of money and resources. There is an urgent need to make cancer treatment more accessible and customized, despite the fact that cancer treatment alternatives have increased over the past few decades. A rising number of research point to AI as a new tool that can help personalise cancer treatment plans by examining existing data. In recent investigations, 97 registered clinical trials for AI in cancer detection were discovered, the majority of which started after 2017. This article provides an overview of the role of artificial intelligence in cancer, in addition to its current applications and anticipated future usage.

3.1. How Does AI Function?

In the subject of artificial intelligence (AI), computers are programmed to resemble human intelligence. The medical industry has a lot of data, which makes it a suitable candidate for machine learning-based problem resolution. Oncologists can utilise machine learning to identify and categorise tumours, find early-stage tumours, collect genetic and histological data, aid in planning before and after surgery and anticipate overall survival rates. Automating time-consuming processes like the detection and segmentation of lesions has proven to be successful with Deep Learning, a type of machine learning [1]. Lung, breast, ovary, and pancreatic cancer studies have creatively examined AI and Machine learning to create an evidence-based strategy in the field. Although in some studies AI tools have been used for screening breast cancer markers based on ethical and social aspects of the adoption and radiologist performance. However, there is evidence of innovative results such deep learning boosting the diagnosis of lymph node metastases from breast cancer [2] (Figure 1).

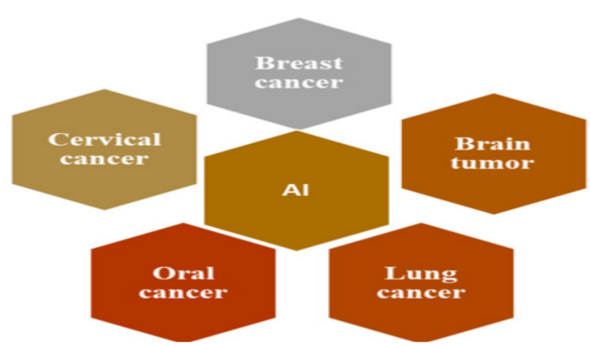

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Figure 1: Uses of AI in detection of various cancers

3.2. Role of Artificial Intelligence in Early Cancer Diagnosis

3.2.1. Pancreatic Cancer

Pancreatic cancer (PC) is the most lethal of all cancers. When it comes to tumors, PC incidence and mortality are, respectively, 2.47% and 3.64% in China. Only 20% of PC patients receive an early diagnosis, which is mostly to blame for the disease's dismal prognosis. It can be challenging to discern between cancer and non-cancer disorders because the majority of patients' initial symptoms are non-specific and include jaundice, lethargy, bowel pattern changes, and indigestion. Considering that most patients are already at an advanced stage with local invasion and distant metastases when they are discovered, most chemotherapy, targeted treatment, and immunotherapy are unsuccessful [3]. If there isn't a significant improvement in outcomes, pancreatic ductal adenocarcinoma (PDAC) will likely overtake lung cancer as the second most lethal malignancy in the United States within the next ten years [4]. Pancreatic ductal adenocarcinoma is still a big challenge to treat due to ineffective methods for early identification and therapy response prediction. A better knowledge of molecular carcinogenesis and treatment response led to the identification of novel biomarkers that can predict how well a patient will respond to conventional chemotherapy or targeted therapy [4].

High-frequency ultrasound (US) is used during endoscopic ultrasonography (EUS) to help doctors see the size and location of the pancreatic main tumour. Images of the whole pancreas or the exact locations of worrisome tumors or lesions can be captured using ultrasound probe can be moved quite close to the pancreatic [5]. The correct staging of pancreatic cancer and a good diagnosis depend on computed tomography (CT). Locoregional assessment is very crucial for accurate identification of patients, and will be beneficial in performing upfront surgery with negative margin. The highest tumor visibility is provided by the pancreatic arterial phase of a three-phase CT technique, which also includes a portal venous phase for evaluation of the peritoneum and liver. Due to its excellent performance and high spatial resolution, CT has a high sensitivity and specificity for the identification of pancreatic cancer. MPR images with high quality resolutions are used to provide more detailed information on the vascular invasion, vascular anatomy and resectability of pancreatic cancer. The sensitivity of CT for iso-attenuated tumour detection will rise with the development of dual-energy technology in the future [6].

Artificial intelligence technology plays an important role in early diagnosis of pancreatic cancer lesions as it can rapidly identify groups having high-risk using medical images, biomarkers and pathological data. In addition to this, AI algorithm could predict the recurrence risk, metastasis, survival time and therapy response [6]. Moreover, artificial intelligence is extensively used in maintaining health records of patients, computer supported diagnosis systems. Further advancement in AI applications for pancreatic cancer detection will require intensive effort among various groups of people such as scientists, clinicians, statisticians, and engineers. In present scenario, AI use have some limitations, but it will be overcome in coming future due to its mighty computing power [5].

3.2.2. Breast Cancer

The most prevalent form of cancer worldwide is breast cancer, with the greatest incidence and second-highest fatality rate after lung cancer [7]. Breast cancer has a complicated etiology, making it difficult for medical professionals to detect the disease early and stop its spread. Genetic and genomic variants are differentiated based on molecular markers and these markers detection is very important before starting breast cancer treatment. Generally patients with a family history of breast cancer or other tumors have high chance of developing bilateral breast cancers, or early-onset breast cancers. Consequently, genetic testing is essential to determine whether a cancer syndrome in patient is due to hereditary factor or other factors are responsible for syndrome [8]. In a systematic review of the AI literature as it related to treatment outcomes in breast cancer, the Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis statement, risk of bias using the Prediction model Risk of Bias Assessment Tool, algorithm design, and availability of both data and code were all assessed [9].

Technological developments have made deep learning (DL) widely used in medical image computing, the creation of essential DL algorithms and training techniques, including applications analyzing mammographic imaging data for breast cancer risk assessment [10]. Artificial intelligence (AI) system advancements that aid radiologists in reading mammograms could increase the effectiveness of breast cancer screening [11]. Breast cancer screening with mammography seeks to detect the disease when it's still treatable (Fig. 2). In order for early detection by screening to be beneficial, we anticipate that tumors would develop continuously and linearly, and we presume that breast cancer has not already spread by the time tumors are apparent on mammography. Therefore, if the assumptions regarding tumour growth are inaccurate or if tumour growth is heterogenic, screening mammography may not be a suitable method to reduce the burden of breast cancer [12] (Figure 2).

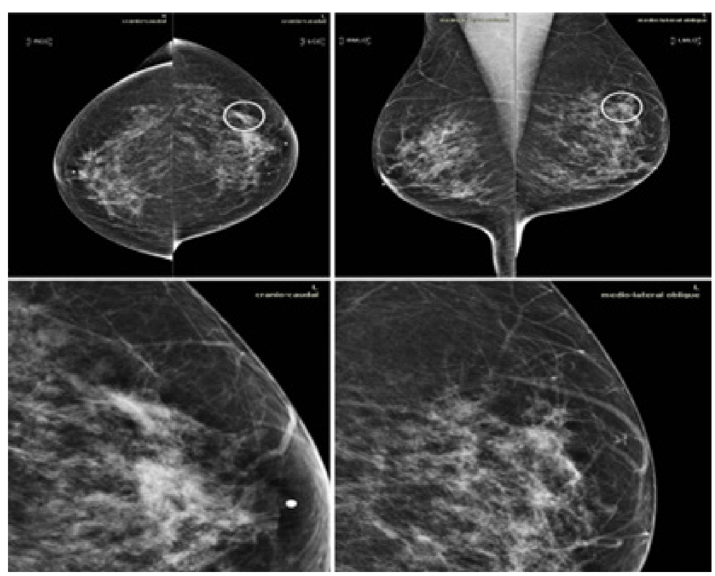

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Figure 2: Mammograms of a woman suffering with invasive ductal carcinoma

3.2.3. Lung Cancer

Due to the high mortality and morbidity rates linked with the disease, lung cancer screening methods must be improved and changed. Even while it is not practical to screen everyone for lung cancer, individuals who are at higher risk should at least be identified and their treatment should be started as soon as possible [13]. AI is a general phrase that refers to a wide range of subfields used in medical imaging for the early identification of lung cancer [14]. Lung cancer diagnosis and therapy have greatly improved because of AI (Fig 3). One example is computer-aided detection systems, which use AI to identify lung lesions in x-rays as a first reader, second reader, or in parallel with radiologists. Second, AI makes it possible to track and measure nodule features automatically, such as by straightforward nodule segmentation. Thirdly, computer-aided diagnosis (CADx) systems, in which AI determines the likelihood of malignancy in order to diagnose lung cancer. In order to provide the best lung cancer detection, AI could be employed for image processing, including dosage image reduction and rebuilding [14] (Figure 3).

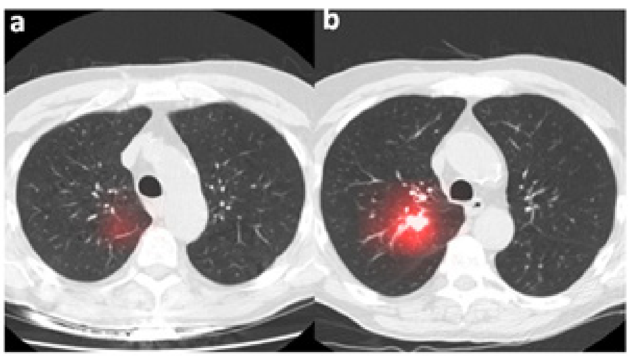

Figure 3: CT scan of patient suffering from lung cancer (a) previous scan (b) two year later scan

3.2.4. Brain Tumor

Artificial intelligence (AI) has emerged as a popular method of medical diagnosis and is crucial in the identification of brain tumours [15]. Brain tumors can either be fast-growing or slow-growing. [16]. A benign (slow-growing) tumor does not infiltrate the surrounding tissues, in contrast to a malignant (aggressive) tumor that moves from one location to another. The WHO describes brain tumors in grades I through IV. Grades I and II tumors are believed to grow slowly, whereas grades III and IV tumors grow more aggressively and have a worse prognosis. [16]. Innovative and disruptive technologies that have changed how both acute and chronic conditions are treated and have frequently been pioneered by neurosurgery. The discipline of brain tumor surgery is an attractive candidate for more AI integration due to its complicated and complex neurosurgical operations [17]. Even before radiological pictures are produced, AI may have an effect—using a natural language processing machine learning algorithm [18].

3.2.5. Cervical Cancer

Cervical cancer is the fourth most frequently diagnosed malignancy and the one of the main cause of women's deaths in the world [19]. Cervical cancer accounts for 570,000 incident cases and 310,000 deaths yearly worldwide [19- 20]. Numerous risk factors for cervical cancer are linked to the HPV virus. It may take up to 20 years or more for Invasive cancer development from the precursor lesion, caused by sexually transmitted HPV. The causes for cervical cancers are early sexual engagement, sex with multiple partners, smoking, high parity, and low socioeconomic position [20]. Three screening methods are used to detect cervical cancer in early stages, and these includes cytology, visual inspection with acetic acid (VIA), and cytology which includes the standard pap smear and liquid-based cytology smear. The cytological examination uses a microscope to examine cells taken from the cervix for probable cervical cancer or precancerous lesions [21].

Federation International of Gynecology and Obstetrics (FIGO) has allowed the use of imaging and pathologic data in diagnosis of cervical cancer and precancerous lesions [21]. Colposcopy and MRI uses AI technology for the diagnosis and staging of cervical cancer and results are satisfactory. The powerful image analysis ability of AI has solved the problem of diagnosing cervical cancer using a large number of colposcopy images (Figure 4). Using AI technology assistance, lesions can be accurately detected, and performing biopsy under colposcopy becomes relatively high, thus reducing the misdiagnosis rate of colposcopy.

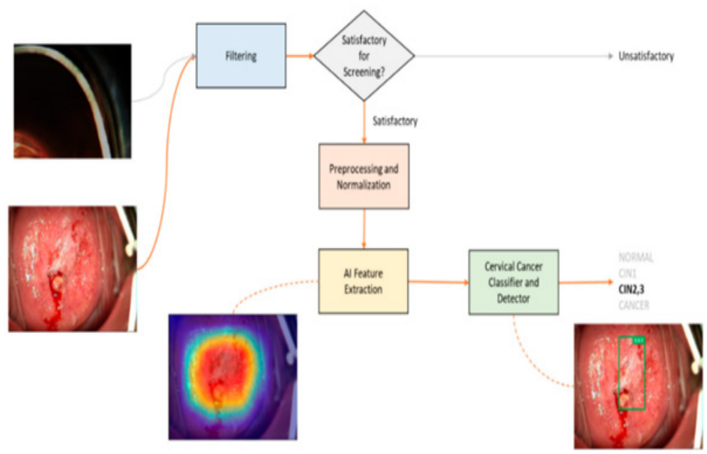

Figure 4: Cervical AI interpretation for colposcopy images (Kim et al., 2022)

3.2.6. Oral Cancer

Oral cancer has grown to be a serious issue for public health on a global scale. According to the literature, this disease's global incidence, mortality, and disability-adjusted life years increased by almost a factor of two between 1990 and 2017 [22]. One of the reasons oral cancer is so extensive in the region is the high incidence of tobacco. Nearly thirty percent of the Indian population use tobacco. According to the most recent Global Adult Tobacco Survey [23]. Although exact causes of head and neck cancers are unknown, tobacco use and chewing are frequently linked to the disease. Age, male gender, alcohol consumption, sun exposure, ionizing radiation, chewing betel, immunosuppression, and graft versus host disease are other factors that may raise the risk of oral cancer [24]. The place of involvement affects the predominant symptoms. Lips, gums, or other oral tissues that are swollen, thickened, lumpy, eroded, or have rough surfaces [24]. The usage of technology could help in early oral cancer detection. Technology such as artificial intelligence (AI) has the potential to improve oral cancer detection. It has been encouraging to see the development of AI-based medical imaging and diagnosis research [25]. There are numerous uses for AI in the early diagnosis and prevention of oral cancer. Optical coherence tomography, a type of optical imaging, has been thoroughly researched in the field of oncology with the purpose of detecting oral cancer [26].

3.2.7. Esophageal Cancer

Esophageal carcinoma (EC) is becoming more common. People from particular parts of the world may be more susceptible to a subtype as a result of the various risk factors associated with adenocarcinoma and squamous cell carcinoma subtypes [27]. Barrett's esophagus (BE) esophageal squamous cell carcinoma (ESCC) and esophageal adenocarcinoma (EAC) are the two main histologic forms of esophageal cancer. Even though EAC predominates in Western nations, ESCC continues to be the most prevalent subtype [28]. High-grade dysplasia and adenocarcinoma confined to the mucosa exclusively are the definitions of early esophageal adenocarcinoma (EEAC), which is of particular relevance for a number of reasons. First off, the lack of nodal involvement and metastases makes the prognosis for EEAC favorable. Second, EEAC can be treated with local endoscopic procedures that have comparatively low complication rates, and most crucially, esophagostomy can be avoided [29]. When AI becomes a clinical reality that doctors can access, upper endoscopy will be one proposed use where live video pictures will be uploaded and immediately analyzed. The program will be able to identify regions that might be neoplastic and gauge the size and appearance of lesions [30] (Figure 5).

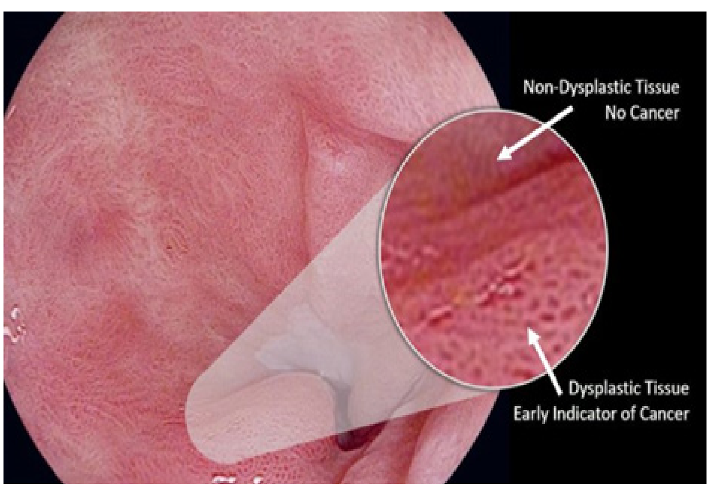

Figure 5: Artificial intelligence (AI) to help detect early signs of esophageal cancer.

3.2.8. Corneal Cancer

The application of technology to support diagnosis and treatment of ocular illnesses has consistently been a forerunner in the cornea specialization. In early XVII century, Scheiner examined the cornea and obtained image by reflecting on calibrated glass spheres. This experiment was the beginning of corneal surface characterization. Later on when we first had the computing power to successfully combine both techniques' subjective and objective components, the keratometer and keratoscope were invented and utilized individually throughout the 1900s. As a result, progressive corneal disorders in their early stages might be diagnosed before they had any negative effects on vision [31]. Resources linked to AI are being poured more and more into these fields in order to deliver accurate and rapid disease grading and screening in clinical settings [32].

These are the top three global causes of blindness: cataract, corneal disorders, and uncorrected refractive errors. As the desire for flawless vision is rising, so is the number of refractive procedures, whether they are lens- or cornea-based [33]. The interpretation of corneal topography has a more than ten-year history of using AI or machine intelligence. Since 1995, researchers have made an effort to assess the potential and utilizing a robotic system based on artificial neural networks for deciphering corneal topographic maps [34]. With a wide range of potential uses for ECPs (eye care professionals), Artificial intelligence in corneal topography has the potential to improve clinical judgment and expand the availability of fundamental eye care facilities [35].

3.3. AI in Cancer Related Image Analysis

AI is applied for detection and diagnosis in the field of oncology using radiographic imaging. Although computer-aided detection is utilized for breast cancer imaging, it has not shown to have a significant clinical benefit. AI-based imaging algorithms are being utilized in clinical practice to locate and monitor possibly malignant tumors and to direct treatment [36]. The automated examination of medical images is known as radiomics. The pictures can be scalar, like in a computed tomography (CT) scan, where the CT value is directly related to the tissue electron density, or they can be vector-valued, like in a 2D X-ray, 3D computed tomography, or 4D ultrasound. Radiomics' major objective is to use algorithms that can recognize patterns in images, exploit those patterns to produce predictions, and then use those predictions to support clinical decision-making [37].

3.4. AI in Transcriptomics

Transcriptomics is a useful tool for comprehending the workings of cancer and locating biomarkers because it evaluates for alternative splicing and alternative polyadenylation, identifies fusion transcripts, explores noncoding RNAs, annotates transcripts, and discovers novel transcripts [38]. Biomarkers and possible treatment targets for human malignancies have been studied using transcriptomic research. Through complementary probe hybridization, which is facilitated by microarray analysis, we can evaluate the levels of gene expression, and a number of genes connected to breast cancer can be discovered. We now know more about breast cancer

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thanks to the widespread use of RNA sequencing tools. We can measure the expression of genes at really low levels using RNA sequencing [39].

4. Conclusion

AI has enhanced its beneficial significance in cancer care therapy in recent years. AI is increasingly being employed in every industry, including medicine delivery, immunotherapy, and cancer treatment. The reliability of using artificial intelligence (AI) in clinical research and treatment has increased because to advancements in technology. AI is now more accessible, and it will continue to advance. With the development of technology, there are certain additional issues that must be resolved as well as some negative aspects.

References

1. Vobugari N, Raj V, Sethi, U, Gandhi K, Raja K, Surani SR. Advancements in Oncology with Artificial Intelligence—A Review Article. Cancers. 2022; 14: 1349.
2. Musa IH, Afolabi LO, Zamit I, Musa TH, Musa HH, Tassang A, Akintunde TY, Li W. Artificial Intelligence and Machine Learning in Cancer Research: A Systematic and Thematic Analysis of the Top 100 Cited Articles Indexed in Scopus Database. Cancer Control. 2022: 29: 10732748221095946.
3. Huang B, Huang H, Zhang S, Zhang D, Shi Q, Liu J, Guo J. Artificial intelligence in pancreatic cancer. Theranostics. 2022; 12(16): 6931-6954.
4. Sturm N, Ettrich TJ, Perkhofer L. The Impact of Biomarkers in Pancreatic Ductal Adenocarcinoma on Diagnosis, Surveillance and Therapy. Cancers (Basel). 2022; 14(1): 217.
5. Hameed BS, Krishnan, UM. Artificial Intelligence-Driven Diagnosis of Pancreatic Cancer. Cancers. 2022; 14: 5382.
6. Dallongeville A, Silvera S, Haouari MA, Zins M . Computed Tomography for Diagnosis and Staging in Pancreatic Cancer. In: Søreide, K., Stättner, S. (eds) Textbook of Pancreatic Cancer. Springer, Cham. 2021.
7. Zheng D, He X, Jing J. Overview of Artificial Intelligence in Breast Cancer Medical Imaging. J Clin Med. 2023; 12(2): 419.
8. Litton JK, Burstein HJ, Turner NC. Molecular Testing in Breast Cancer. Am Soc Clin Oncol Educ Book. 2019; 39:e1-e7.
9. Corti C, Cobanaj M, Marian F, Dee EC, Lloyd MR, Marcu S, Dombrovschi A, Biondetti GP, Batalini F, Celi LA, Curigliano G. Artificial intelligence for prediction of treatment outcomes in breast cancer: Systematic review of design, reporting standards, and bias. Cancer Treat Rev. 2022; 108:102410.
10. Gastounioti A, Desai S, Ahluwalia VS, Conant EF, Kontos D. Artificial intelligence in mammographic phenotyping of breast cancer risk: a narrative review. Breast Cancer Res. 2022; 24(1):14.
11. Lauritzen AD, Rodríguez-Ruiz A, von Euler-Chelpin MC, Lynge E, Vejborg I, Nielsen M, Karssemeijer N, Lillholm M. An Artificial Intelligence-based Mammography Screening Protocol for Breast Cancer: Outcome and Radiologist Workload. Radiology. 2022; 304(1): 41-49.
12. Løberg, M., Lousdal, M.L., Bretthauer, M. et al. Benefits and harms of mammography screening. Breast Cancer Res 2015; 17: 63.
13. Joy Mathew C, David AM, Joy Mathew CM. Artificial Intelligence and its future potential in lung cancer screening. Excli J. 2020; 19: 1552-1562.
14. Chassagnon, G, De Margerie-Mellon, C, Vakalopoulou, M. et al. Artificial intelligence in lung cancer: current applications and perspectives. Jpn J Radiol. 2023; 41: 235-244.
15. Das S, Nayak GK, Saba L, Kalra M, Suri JS, Saxena S. An artificial intelligence framework and its bias for brain tumor segmentation: A narrative review. Comput Biol Med. 2022; 143: 105273.
16. Amin J, Sharif M, Haldorai A et al. Brain tumor detection and classification using machine learning: a comprehensive survey. Complex Intell. Syst. 2022; 8: 3161-3183.
17. Williams S, Layard Horsfall H, Funnell JP, Hanrahan JG, Khan DZ, Muirhead W, et l. Artificial Intelligence in Brain Tumour Surgery-An Emerging Paradigm. Cancers (Basel). 2021; 13(19): 5010.
18. Williams S, Layard Horsfall H, Funnell JP, et al. Artificial Intelligence in Brain Tumour Surgery-An Emerging Paradigm. Cancers. 2021; 13(19): 5010.
19. Allahqoli L, Laganà AS, Mazidimoradi A, Salehiniya H, Günther V, Chiantera V, et al. Diagnosis of Cervical Cancer and Pre-Cancerous Lesions by Artificial Intelligence: A Systematic Review. Diagnostics (Basel). 2022; 12(11): 2771.
20. Zhang S, Xu H, Zhang L, Qiao Y. Cervical cancer: Epidemiology, risk factors and screening. Chin J Cancer Res. 2020; 32(6): 720-728. vv
21. Kim S, Lee H, Lee S, Song J-Y, Lee J-K, Lee N-W. Role of Artificial Intelligence Interpretation of Colposcopic Images in Cervical Cancer Screening. Healthcare. 2022; 10(3): 468.
22. López-Cortés XA, Matamala F, Venegas B, Rivera C. Machine-Learning Applications in Oral Cancer: A Systematic Review. Appl. Sci. 2022; 12: 5715.
23. Haj-Hosseini N, Lindblad J, Hasséus B et al. Early Detection of Oral Potentially Malignant Disorders: A Review on Prospective Screening Methods with Regard to Global Challenges. J. Maxillofac. Oral Surg. 2022.
24. Chaurasia A, Alam SI, Singh N. Oral cancer diagnostics: An overview. Natl J Maxillofac Surg. 2021; 12(3): 324-332.
25. Hegde S, Ajila V, Zhu W, Zeng C. Artificial intelligence in early diagnosis and prevention of oral cancer. Asia Pac J Oncol Nurs. 2022; 9 (12):100133.
26. Ramezani K, Tofangchiha M. Oral Cancer Screening by Artificial Intelligence-Oriented Interpretation of Optical Coherence Tomography Images. Radiol Res Pract. 23; 2022: 1614838.
27. DiSiena M, Perelman A, Birk J, Rezaizadeh H. Esophageal Cancer: An Updated Review. South Med J. 2021; 114(3):161-168.
28. He S, Xu J, Liu X, Zhen Y. Advances and challenges in the treatment of esophageal cancer. Acta Pharm Sin B. 2021; 11(11): 3379-3392.

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29. Bhatti KM, Khanzada ZS, Kuzman M, Ali SM, Iftikhar SY, Small P. Diagnostic Performance of Artificial Intelligence-Based Models for the Detection of Early Esophageal Cancers in Barret's Esophagus: A Meta-Analysis of Patient-Based Studies. Cureus. 2021; 13(6): e15447.
30. Hamade N, Sharma P. 'Artificial intelligence in Barrett's Esophagus.' Therapeutic Advances in Gastrointestinal Endoscopy. 2021; 14.
31. Rampat R, Deshmukh R, Chen X, Ting DSW, Said DG, Dua HS, Ting DSJ. Artificial Intelligence in Cornea, Refractive Surgery, and Cataract: Basic Principles, Clinical Applications, and Future Directions. Asia Pac J Ophthalmol (Phila). 2021; 10(3): 268-281.
32. Lopes BT, Eliasy A, Ambrosio R. Artificial Intelligence in Corneal Diagnosis: Where Are we?. Curr Ophthalmol Rep. 2019; 7; 204-211.
33. Shih KC, Tse RH, Lau YT, Chan TC. Advances in Corneal Imaging: Current Applications and Beyond. Asia Pac J Ophthalmol (Phila). 2019; 8(2): 105-114.
34. Shreve JT, Khanani SA, Haddad TC. Artificial Intelligence in Oncology: Current Capabilities, Future Opportunities, and Ethical Considerations. Am Soc Clin Oncol Educ Book. 2022; 42: 1-10.
35. Koh, DM., Papanikolaou, N., Bick, U. et al. Artificial intelligence and machine learning in cancer imaging. Commun Med. 2022; 2: 133.
36. postolia M. Tsimberidou, Elena Fountzilas, Leonidas Bleris, Razelle Kurzrock. Transcriptomics and solid tumors: The next frontier in precision cancer medicine, Seminars in Cancer Biology. 2022; 84: 50-59.
37. Li Y, Kong X, Wang Z, Xuan L. Recent advances of transcriptomics and proteomics in triple-negative breast cancer prognosis assessment. J Cell Mol Med. 2022; 26(5): 1351-1362.