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Innovative Applications and Challenges of Artificial Intelligence in Surgical Oncology

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Abstract: This paper reviews the latest advances in the application of Artificial Intelligence (AI) technologies in the domain of surgical oncology, and the challenges they face. The application of AI in surgical oncology encompasses a wide range of medical image analysis, preoperative planning and simulation, surgical navigation and robotic-assisted surgery, as well as postoperative monitoring and follow-up. The utilisation of computer-aided diagnosis (CAD) systems, deep learning models (e.g., U-Net), three-dimensional reconstruction techniques, and virtual reality (VR) has led to a substantial enhancement in the accuracy of tumour detection, the precision of surgical planning, and the safety of surgical operations. Concurrently, the integration of AI with postoperative data analysis and prediction models furnishes patients with personalised recovery plans and an enhanced prognosis. However, the application of AI in surgical oncology still faces challenges such as data privacy and security, algorithm performance validation, and multidisciplinary cooperation. In the future, with the continuous optimisation of the technology and the integration of multimodal data, AI is expected to drive oncology treatment in the direction of greater precision and personalisation, bringing about a revolutionary change in oncology surgery.

1. Introduction

Recent years have seen rapid advancements in artificial intelligence (AI) technology across a range of disciplines, with particular significance in the field of healthcare. The potential and applications of AI in oncology surgery, a domain recognised as one of the most complex and challenging areas in medicine, have been extensively demonstrated. This article aims to review the current applications of artificial intelligence in the field of oncology surgery, including medical image analysis, preoperative planning and simulation, surgical navigation and robot-assisted surgery, as well as postoperative monitoring and follow-up. Additionally, it will also explore the challenges and future directions of AI technology in the application of oncology surgery.

2. Application status of artificial intelligence technology in tumor surgery

2.1. Medical Image Analysis

2.1.1. Computer-aided diagnosis (CAD) system

Computer-Aided Diagnosis (CAD) systems have become an important tool in medical image analysis, especially in tumor detection and early diagnosis. CAD systems utilize image processing, pattern recognition, machine learning, and artificial intelligence technologies to analyze features in medical images (such as X-rays, CT scans, MRI, etc.), assisting doctors in detecting lesion areas, assessing morphological features, and providing diagnostic suggestions. In the detection of diseases such as breast cancer and lung cancer, CAD plays a key role when combined with multimodal imaging. Multimodal imaging refers to the integration of different types of medical imaging data for comprehensive analysis, which improves the sensitivity and accuracy of detection. For example, combining mammography and ultrasound images, CAD can enhance the detection rate of tumors in dense breast tissue [1]; combining CT and PET images, CAD can improve the detection ability of lung nodules, especially small or low-density nodules, providing more reliable diagnostic support [2].

2.1.2. Application of Deep Learning in Image Analysis

Deep Convolutional Neural Networks (CNN) are a type of neural network that mimic the way the human brain processes visual information, achieving significant success in a range of applications, including image classification, object detection, object recognition, image segmentation, and more. In the field of medical image analysis, CNNs are particularly well-suited for identifying and classifying different types of tissue, organs, and lesion sites [3].

U-Net is a deep learning model based on CNN, which is particularly suitable for medical image segmentation tasks. The U-Net model is composed of an encoder and a decoder, which are capable of effectively extracting local features from high-resolution medical images and restoring the spatial information of image segmentation. A significant application of U-Net in medical image analysis is tumour segmentation, with successful cases including mammography image analysis, lung CT image analysis, and brain MRI image analysis [4].

2.2. Preoperative Planning and Simulation

2.2.1. 3D reconstruction technology

In the domain of oncology surgery, the accuracy of preoperative planning is paramount to the success of the surgical intervention. Three-dimensional reconstruction technology facilitates the conversion of medical images (e.g. CT, MRI, PET) into three-dimensional models, thereby assisting medical professionals in visualising the location, size, and relationship of tumours with surrounding tissues. In comparison with conventional 2D imaging, 3D reconstruction facilitates a more comprehensive depiction of the relationship between tumours and critical anatomical structures, such as blood vessels and nerves, thereby enhancing the safety of surgical intervention. A notable illustration of this is in liver cancer surgery, where 3D reconstruction assists in visualizing the relationship between tumours and blood vessels, thus facilitating the avoidance of damage [5].Similarly, in brain tumour surgery, 3D reconstruction aids in analysing the relationship between tumours and brain regions, enabling the selection of the most optimal resection pathway [6]. In the context of lung cancer surgery, 3D reconstruction facilitates the simulation of the resection effect and the prediction of complications, such as lung collapse or pneumothorax, thereby optimising treatment plans [7].

2.2.2. Virtual Reality (VR) Technology

In the domain of oncology surgery, the significance of preoperative planning and surgical simulation lies in their role in ensuring surgical safety, enhancing surgical efficiency, and mitigating complications. The advent of virtual reality (VR) technology in recent years has precipitated novel advancements in preoperative planning, surgical simulation, and training in oncology surgery [8].VR technology facilitates the generation of three-dimensional environments through computerised means, enabling surgeons to rehearse and simulate surgical procedures within a wholly virtual environment. Through repeated practice, surgeons can familiarise themselves with the surgical steps, improve technical proficiency, and reduce mistakes during actual operations. VR simulation provides a risk-free learning platform, especially for young surgeons with insufficient experience. Through VR simulation, surgeons can explore different excision paths without actual operations, which is particularly important for tumours involving complex anatomical structures (e.g. brain tumours, lung tumours). The meticulous planning of the surgical trajectory facilitates the avoidance of damage to vital nerves, blood vessels, and organs, thereby enhancing the safety of the surgical intervention [9].

2.2.3. Examples of pre-operative planning systems

The following section will present a number of AI-driven preoperative planning systems that have been applied in oncologic surgery. These examples demonstrate the potential of intelligent technology in the domains of surgical planning and simulation:

NCI-CTP (National Cancer Institute's Cancer Treatment Planning) is an intelligent tumour treatment planning system developed by the National Cancer Institute (NCI) in the United States, combining artificial intelligence (AI) and image processing techniques. The system analyses patients' CT, MRI, and PET image data to generate three-dimensional tumour models, assisting doctors in preoperative planning, dynamically evaluating the size and location of tumours, and simulating the effects of different surgical pathways. The system has been extensively adopted in surgical planning for tumors, including those of the liver and lung, providing a highly accurate virtual environment to assist medical professionals in making optimal resection decisions prior to surgery.

CIVCO Radiotherapy has developed a pioneering system, the Motion Management System, which incorporates Artificial Intelligence (AI) technology. This technology enables the real-time monitoring of a patient's tumour movement and the prediction of its trajectory during radiotherapy. By intelligently analysing tumour movement trajectories, the system optimises pre-operative radiotherapy planning and reduces damage to normal tissue. The primary applications of this technology include lung cancer, liver cancer, and other cases where tumour movement due to respiration is more pronounced. The AI technology provides precise planning and real-time adjustments for radiotherapy, thereby enhancing treatment efficacy.

The SpineJack system, developed by Vexim, is a pioneering integration of artificial intelligence (AI) technology, a field extensively applied in the surgical management of lung cancer and other thoracic tumours, particularly in the domain of preoperative planning. The system employs patient imaging data to facilitate precise tumour location and assessment of their relationship with surrounding tissues, thereby providing surgeons with accurate surgical pathways and facilitating the prediction of surgical risks. This, in turn, enables healthcare professionals to develop personalised preoperative plans, enhancing patient care and outcomes. The integration of AI technology with imaging data facilitates the optimisation of surgical strategies for minimally invasive procedures, thereby enhancing surgical outcomes.

2.3. Surgical Navigation and Robot-Assisted Surgery

2.3.1. Surgical navigation system

In the domain of oncology surgery, the surgical navigation system is a pivotal instrument that enhances surgical precision, mitigates risks, and augments the efficacy of surgical interventions. The advent of Artificial Intelligence (AI) has precipitated the emergence of AI-driven navigation systems as a pivotal technology, thereby augmenting the precision of oncology surgeries. These navigation systems facilitate the precise localisation of tumours, surrounding vital tissues, and blood vessels through automated image processing, real-time data analysis, and intelligent algorithms, thereby enabling personalised surgical procedures [10]. The integration of 3D image fusion with Augmented Reality (AR) technology facilitates the projection of diverse imaging data (e.g. CT, MRI, ultrasound) onto the surgical field, thereby enabling real-time modification of the surgical plan. Moreover, AI's capacity to analyse real-time data enables the prediction of complications or risks, the issuance of early warnings, and the facilitation of preventive measures by medical professionals.

Intuitive Surgical’s da Vinci Surgical System with AI-based Navigation. The da Vinci robotic surgical system is one of the most widely used robotic surgical platforms. Combining AI technology, the da Vinci system can achieve high-precision surgical navigation, especially in tumor resection surgery, where AI technology can assist doctors in precise path planning to avoid important organs and blood vessels. Widely used in minimally invasive surgeries for urology, gynecology, and gastrointestinal tumors. The system combines imaging data, real-time sensors, and machine learning algorithms to help doctors perform precise operations in complex tumor resection processes.

Brainlab’s AI-based Image-Guided Surgery (IGS). The AI-based Image Guided Surgery (IGS) system developed by Brainlab uses deep learning and image analysis technology to assist surgeons in precise tumor localization and removal. The system integrates various imaging data sources such as CT, MRI, and ultrasound to provide real-time navigation information. Used in complex tumor removal surgeries such as brain tumors and spinal tumors, it can provide surgeons with real-time imaging support and navigation, helping achieve high-precision tumor removal.

Siemens Healthineers’ AI-powered Surgical Navigation System. Siemens Healthcare has launched an AI-powered surgical navigation system that combines real-time 3D imaging, deep learning and AI algorithms to provide precise tumour localisation and navigation during surgery. This system is able to assist surgeons in developing personalised surgical plans by comparing real-time imaging data with the patient's anatomical information. Widely used in tumour surgeries for liver cancer, lung cancer and other parts of the body, especially in minimally invasive and robotic surgeries, the AI navigation system can help surgeons improve the precision and efficiency of removing tumours.

2.3.2. Robot-assisted surgery

The application of Robotic-Assisted Surgery (RAS) in oncology surgery, especially when combined with artificial intelligence (AI) technology, is significantly improving the precision, stability, and patient recovery speed of surgeries. Robotic-assisted surgery systems (such as the da Vinci surgical robot) combine robotic arms, high-definition 3D visual systems, remote control, and minimally invasive surgical techniques, allowing surgeons to perform precise operations from a console. By inserting surgical instruments through small incisions, robots can provide higher precision, flexibility, and control than traditional surgeries. In oncology surgery, especially in minimally invasive surgery, robotic technology enables precise operations in very small areas, helping reduce damage to surrounding tissues, improve postoperative recovery speed, and decrease complications. Similar clinical cases have been validated in multiple studies. For example, Rocco et al. (2020) demonstrated through a multicenter study that performing lung lobectomy with a robotic-assisted surgery system significantly improves surgical precision and postoperative recovery speed, with a lower complication rate [11]. Cerfolio et al. (2019) also proved the feasibility and advantages of robotic-assisted lung lobectomy in a study involving 1000 consecutive cases, particularly in reducing postoperative complications, shortening hospital stay, and enhancing patient quality of life [12].

2.4. Postoperative Monitoring and Follow-up

2.4.1. Patient data analysis

With the continuous advancement of artificial intelligence (AI) technology, the application of AI in the field of surgical oncology is not only limited to preoperative planning and assistance during surgery, but also plays an increasingly important role in postoperative monitoring and follow-up. The core of postoperative monitoring and follow-up lies in the comprehensive and accurate assessment of patients' postoperative health status. These assessments include not only the patient's physical signs and imaging results, but also multi-dimensional information such as biomarkers and genomic data, etc. AI can help process and analyse these complex data to unearth potential early warning signals of disease and help doctors intervene in a timely manner. One study used AI to analyse imaging data and biomarkers of post-surgical lung cancer patients, successfully predicting patients at high risk of disease recurrence and making timely adjustments to their treatment plans. The AI system combined the patient's CT images with tumour marker data and calculated the risk of recurrence through a deep learning model, with an accuracy rate of more than 80% [13].

Another study applied an AI system to analyse possible postoperative complications in oncology patients, including bleeding, infection, etc. By analysing the patients' postoperative physiological data, the AI successfully predicted possible complications and notified healthcare professionals in advance through the electronic health record system. The study showed that the AI achieved more than 90% sensitivity and specificity in predicting postoperative complications [14].

2.4.2. Prediction Model

In the field of oncology surgery, postoperative recurrence and survival rate prediction are crucial to improving long-term survival and enhancing treatment decisions. With the continuous development of Artificial Intelligence (AI) technology, especially the application of Machine Learning (ML) algorithms, the prediction of postoperative recurrence and survival rates has significantly improved. Machine learning models can analyze large amounts of complex patient data to identify potential patterns and provide personalized prognostic predictions for each patient based on historical data.

A study using support vector machine (SVM) model combined with clinical data, imaging data, and genomic data of lung cancer patients successfully predicted the risk of postoperative recurrence. The study found that the accuracy of the model was as high as 85%, and could provide effective personalized follow-up plans for lung cancer patients [15]. Another study employed random forest (RF) algorithm to predict the risk of postoperative recurrence in breast cancer patients. By integrating clinical data (such as tumor stage, age, hormone receptor status, etc.) and imaging data (such as MRI images) of patients, researchers established a precise postoperative recurrence prediction model [16].

2.4.3. Remote Monitoring and Intelligent Follow-up System

With the development of artificial intelligence (AI) technology, the application of remote monitoring and intelligent follow-up systems in the field of oncology surgery is increasing. These technologies provide personalized and precise treatment plans for cancer patients, helping doctors to timely grasp the health status of patients, especially in postoperative monitoring, prediction of recurrence, and management of survival rates.

Remote monitoring technology utilizes various smart devices and sensors to collect patients' health data and transmit the data to healthcare platforms through the network, enabling real-time monitoring of patients' health status. For cancer patients, especially during the postoperative recovery period, remote monitoring can effectively track patients' physiological indicators, changes in vital signs, promptly detect and address abnormal conditions, and reduce the risk of recurrence.

A study developed a remote monitoring system for postoperative lung cancer, collecting patient's data such as temperature, heart rate, blood oxygen saturation through intelligent wearable devices and mobile health applications, and using AI to analyze and predict the risk of recurrence. The study found that patients received timely medical intervention through the system, leading to a significant 17% reduction in the recurrence rate [17]. Another AI-based intelligent follow-up system for postoperative colorectal cancer, by collecting patients' physiological data and quality of life assessments, intelligently predicts the patient's recovery status and provides intervention suggestions. The application of the system significantly improves the quality of life of patients and reduces the occurrence of complications [18].

3. Challenges of Artificial Intelligence in the Application of Tumor Surgery

3.1. Data Privacy and Security

The application of artificial intelligence (AI) technology in tumor surgery has greatly promoted the progress of personalized treatment, precision medicine, and patient management. However, as AI is widely used in the medical field, data privacy and security issues are increasingly becoming a key challenge. The privacy protection and security of medical data are the foundation for the successful application of AI technology, especially in the field of tumor surgery, which involves large amounts of sensitive patient data, including genomic data, imaging data, and clinical records. How to ensure the privacy of this data and prevent data leaks, misuse, and improper use is an important issue that urgently needs to be addressed in the current application of AI in the medical industry [19], [20].

3.2. Algorithm performance and clinical validation

The application of artificial intelligence (AI) in tumor surgery is gradually transitioning from laboratory research to clinical practice, becoming an important tool in areas such as assisting diagnosis, treatment planning, and prognosis prediction. However, the promotion and popularization of AI in clinical applications face many challenges, one of which is the validation and standardization of algorithm performance. In tumor surgery, AI models need to handle complex and diverse medical data, such as imaging data, genomic data, and clinical records. Therefore, ensuring the efficiency and accuracy of AI algorithms, and passing through rigorous clinical validation processes, becomes key to the successful application of AI in tumor surgery [21], [22].

3.3. Interdisciplinary Collaboration

The successful application of artificial intelligence, especially in the field of oncologic surgery, depends on the close collaboration between various disciplines. Disciplines involved in oncologic surgery include oncology, surgical procedures, radiology, pathology, radiology, computer science, data science, etc. These disciplines play different roles in AI applications and need to collaborate closely to ensure the effectiveness and applicability of AI systems in clinical practice. There are significant differences in language, ways of thinking, and work methods between medicine and computer science. Doctors and AI engineers need to find a common language to fully understand each other's needs in research and development. The development of AI technology is usually based on certain theoretical assumptions or experimental data, but these technologies may be influenced by various complex factors in clinical applications. For example, differences in imaging equipment, individual patient variations, different medical environments, etc., may affect the performance of AI models. Therefore, AI systems need to be continuously adjusted and optimized to meet clinical needs, requiring close collaboration between technology developers and clinical physicians [23], [24].

4. Conclusion

The utilisation of artificial intelligence (AI) in the domain of tumour surgery has demonstrated considerable potential, particularly in enhancing surgical precision, optimising treatment plans, and improving patient prognosis. By leveraging deep learning and sophisticated image processing methodologies, AI can facilitate crucial support in the diagnosis, preoperative planning, surgical simulation, intraoperative navigation, and postoperative evaluation of tumours. The integration of virtual reality (VR) and augmented reality (AR) technologies further enhances the capabilities of AI, particularly in the domains of tumor localization and surgical path planning, contributing to an enhancement in surgical accuracy and safety, especially in complex surgical procedures.

The advantages of AI in tumor surgery are manifold. Primarily, AI can automate the processing and analysis of large-scale medical imaging data, thereby significantly enhancing the efficiency and accuracy of image interpretation, and reducing human errors, especially in the early identification of tumors and the detection of minute lesions. Secondly, AI-assisted preoperative planning can accurately simulate the relationship between tumours and surrounding tissues through three-dimensional modelling, providing doctors with a variety of surgical options, especially in dealing with complex anatomical structures, effectively avoiding the limitations of traditional planning, and improving the scientificity and feasibility of surgical plans. Additionally, AI technology supports real-time navigation during surgery, helping surgeons accurately locate tumours and key tissues by overlaying virtual information, thus optimising the surgical process and reducing operational risks. Postoperative, the potential of AI to dynamically assess patients' recovery status, assist in developing personalised rehabilitation plans, and further improve patients' prognoses is significant.

Notwithstanding, the implementation of AI in tumour surgery remains encumbered by numerous challenges. Primarily, AI systems are contingent upon substantial quantities of high-quality medical data for training; however, in clinical practice, the incompleteness and heterogeneity of data serve as the primary impediments to the widespread adoption of these systems. Secondly, although the potential of AI in image diagnosis and surgical planning is widely acknowledged, many AI algorithms have not yet undergone large-scale, multi-centre clinical validation, thus restricting their generalisability across different hospitals and patient populations. Furthermore, although AI can provide decision support, its data-driven model cannot completely replace the experiential judgment of surgeons in complex clinical situations, especially when facing variable pathologies or special anatomies. The auxiliary role of AI still requires comprehensive evaluation and judgment by doctors.

In contemplating the future of AI in the domain of tumour surgery, a plethora of opportunities emerge. The relentless pursuit of algorithmic optimisation, the escalating capabilities of computing technology, and the integration of multimodal data are poised to usher in a new era of precision in disease prediction and personalised treatment plan design. The advent of AI systems capable of incorporating a vast array of clinical data, encompassing genomic information, molecular imaging, and physiological parameters, signifies the imminent convergence of precision medicine across diverse disciplines. Furthermore, the integration of AI with robot-assisted surgical techniques holds considerable promise, as it promises to enhance the precision of surgical procedures, reduce trauma, improve surgical efficiency, and enhance the quality of postoperative recovery for patients.

In conclusion, despite the challenges that AI faces in its application in oncologic surgery, its potential to improve surgical quality, optimize treatment plans, and enhance patient outcomes is indisputable. As technology advances and clinical experience grows, AI is poised to assume an increasingly pivotal role in the domain of oncologic surgery, propelling cancer treatment towards more personalised and precise outcomes.

References

[1] Bandyopadhyay, S., et al. (2019). Deep learning-based computer-aided detection for mammography: Diagnostic performance in dense breast tissue. European Journal of Radiology, 116, 11-19. doi.org/10.1016/j.ejrad.2019.04.010

[2] Wang, J., et al. (2021). Detection of lung cancer in low-density pulmonary nodules using a deep learning-based computer-aided detection system in CT images. Radiology, 299(3), 587-595. doi.org/10.1148/radiol.2021202023

[3] Zhou, T., et al. (2020). Deep learning in medical image analysis: A survey. Medical Image Analysis, 64, 101724. doi.org/10.1016/j.media.2020.101724

[4] Zhao, Y., et al. (2020). Lung nodule detection and segmentation in CT images using U-Net deep learning architecture. Journal of Healthcare Engineering, 2020, 8892674. doi.org/10.1155/2020/8892674

[5] Zhang, Y., et al. (2019). Artificial intelligence-based 3D visualization of liver tumors and blood vessels for precise resection planning. Journal of Hepatology, 70(2), 332-338. doi.org/10.1016/j.jhep.2018.09.016

[6] Liu, Y., et al. (2021). Artificial intelligence-based 3D visualization and surgical planning for brain tumor resection: A preliminary study. Neurosurgery, 89(1), 23-30. doi.org/10.1093/neuros/nyab182

[7] Zhou, Y., et al. (2020). Artificial intelligence-based three-dimensional reconstruction for preoperative planning in lung cancer surgery. European Journal of Radiology, 129, 109038. doi.org/10.1016/j.ejrad.2020.109038

[8] Liu, Y., et al. (2020). Virtual reality and augmented reality in cancer surgery: Current applications and future perspectives. Journal of Surgical Oncology, 122(4), 607-618. doi.org/10.1002/jso.26016

[9] Strother, C. M., et al. (2021). Virtual reality and augmented reality in neurosurgery: Current status and future potential. Neurosurgical Review, 44(4), 1245-1253. doi.org/10.1007/s10143-021-01396-x

[10] Ribeiro, A. J., et al. (2019). Intraoperative neuronavigation in brain tumor surgery: A systematic review and meta-analysis. Journal of Neurosurgery, 131(1), 1-9. doi.org/10.3171/2018.10.JNS181457

[11] Rocco, G., et al. (2020). Robot-assisted lobectomy for lung cancer: A multicenter study. Journal of Thoracic and Cardiovascular Surgery, 159(1), 284-290. doi.org/10.1016/j.jtcvs.2019.04.048

[12] Cerfolio, R. J., et al. (2019). Robotic Lobectomy: A 5-Year Experience with 1,000 Consecutive Cases. The Annals of Thoracic Surgery, 108(3), 937-943. doi.org/10.1016/j.athoracsur.2019.02.038

[13] Yang, C., et al. (2021). AI-based analysis for predicting postoperative recurrence in lung cancer patients. Journal of Thoracic Oncology, 16(5), 716-725. doi.org/10.1016/j.jtho.2021.01.033

[14] Wang, H., et al. (2023). AI-driven prediction of postoperative complications in oncological surgery: A machine learning-based approach. Annals of Surgical Oncology, 30(1), 228-236. doi.org/10.1245/s10434-023-12679-4

[15] Wang, J., et al. (2020). Postoperative recurrence prediction in non-small cell lung cancer using machine learning algorithms. Journal of Thoracic Oncology, 15(3), 556-565. doi.org/10.1016/j.jtho.2019.12.015

[16] Chen, Y., et al. (2021). Prediction of postoperative recurrence in breast cancer patients using machine learning-based models. Cancer Research, 81(5), 1143-1152. doi.org/10.1158/0008-5472.CAN-20-2212

[17] Lee, J. K., et al. (2021). Remote monitoring and AI-based prediction of postoperative recurrence in lung cancer. Lung Cancer, 162, 12-18. doi.org/10.1016/j.lungcan.2021.07.004

[18] Wang, H., et al. (2022). AI-based intelligent follow-up system for colorectal cancer patients: A prospective study. Cancer Medicine, 11(12), 2319-2328. doi.org/10.1002/cam4.4602

[19] Bi, W. L., et al. (2019). Artificial intelligence in cancer imaging: Clinical challenges and applications. CA: A

Cancer Journal for Clinicians, 69(2), 127-157. doi.org/10.3322/caac.21552
[20] He, J., et al. (2019). The practical implementation of artificial intelligence technologies in medicine. Nature Medicine, 25(1), 30-36. doi.org/10.1038/s41591-018-0307-0
[21] Park, S. H., et al. (2020). Implementation of artificial intelligence in medicine: Status analysis and future directions. Journal of Korean Medical Science, 35(14), e115. doi.org/10.3346/jkms.2020.35.e115
[22] Nagendran, M., et al. (2020). Artificial intelligence versus clinicians: systematic review of design, reporting standards, and claims of deep learning studies. BMJ, 368, m689. doi.org/10.1136/bmj.m689
[23] Kann, B. H., et al. (2020). Artificial intelligence in oncology: Current applications and future directions. Nature Reviews Clinical Oncology, 17(11), 683-701. doi.org/10.1038/s41571-020-0399-6
[24] Bi, W. L., et al. (2019). Artificial intelligence in cancer imaging: Clinical challenges and applications. CA: A Cancer Journal for Clinicians, 69(2), 127-157. doi.org/10.3322/caac.21552