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Review Article

Recent Progress in Radiation Oncology: The Impact of Artificial Intelligence.

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Abstract

Radiotherapy (RT) is very much a technology-driven treatment modality in the management of cancer. RT techniques have changed significantly over the past few decades, thanks to improvements in engineering and computing. We aim to highlight the recent developments in radiation oncology, focusing on the technological and biological advances. We will present state-of-the-art treatment techniques, employing photon beams, such as intensity-modulated RT, volumetric-modulated arc therapy, stereotactic body RT and adaptive RT, which make possible a highly tailored dose distribution with maximum normal tissue sparing. We will analyse all the steps involved in the treatment: imaging, delineation of the tumour and organs at risk, treatment planning and finally image-guidance for accurate tumour localisation before and during treatment delivery. Particular attention will be given to the crucial role that imaging plays throughout the entire process. In the case of adaptive RT, the precise identification of target volumes as well as the monitoring of tumour response/modification during the course of treatment is mainly based on multimodality imaging that integrates morphological, functional and metabolic information. Moreover, real-time imaging of the tumour is essential in breathing adaptive techniques to compensate for tumour motion due to respiration.

Finally, we will analyse the advancing field and technology in tumour targeting. Indeed, the effectiveness of RT has been improved not only by technological developments but also through the integration of Artificial Intelligence and virtual reality knowledge to produce more efficient and personalised treatment strategies.

Keywords*: Artificial Intelligence (AI), Adaptive Radiotherapy, Augmented Reality (AR), virtual reality(VR).*

Introduction

Oncology is a rapidly advancing field, and technology is playing an increasingly important role in its development. Some of the latest advancements and reality technologies in oncology include:

1. Precision Medicine: Precision medicine is a personalized approach to cancer treatment that takes into account the genetic makeup of the individual's cancer. This allows for more targeted and effective treatments, resulting in better outcomes for patients. Precision oncology uses genomic data to identify the specific mutations driving a patient's cancer, allowing for targeted, personalized treatment. One example is the use of targeted therapy drugs, such as trastuzumab (Herceptin) for breast cancer patients with HER2 positive tumours.

2. Artificial Intelligence: AI is being used in oncology to help with early detection, diagnosis, and treatment planning. AI algorithms can analyze large amounts of medical data to identify patterns and predict outcomes, leading to more informed treatment decisions. AI has been increasingly used in oncology to help with diagnosis, treatment planning, and predicting outcomes. For example, AI algorithms can analyze medical images and identify malignant tumours more accurately than human experts, leading to improved diagnosis and treatment. AI is being used to support oncologists in areas such as diagnostic imaging, treatment planning, and drug discovery. One example is the use of AI algorithms to analyze medical images and assist in identifying cancerous lesions.

3. Immunotherapy: Immunotherapy is a type of cancer treatment that harnesses the power of the immune system to fight cancer. This approach has proven to be particularly effective in treating certain types of cancer, such as melanoma and lung cancer. Immunotherapy is a type of treatment that harnesses the body's own immune system to fight cancer. This has been a major breakthrough in the field of oncology, as it has shown great promise in treating various types of cancer, including melanoma, lung cancer, and renal cell carcinoma.

4. Radiotherapy: Radiotherapy has been a mainstay of cancer treatment for many years, but recent advancements in technology have allowed for more precise delivery of radiation, leading to improved outcomes and reduced side effects. Radiotherapy has become more precise and effective in recent years with the development of new technologies such as proton therapy and stereotactic body radiotherapy. These technologies allow for higher doses of radiation to be delivered to cancerous tumors with fewer side effects.

5. Proton Therapy: Proton therapy is a type of radiation therapy that uses protons instead of photons to deliver radiation to the cancerous cells. This allows for a more targeted approach, reducing damage to surrounding healthy tissue and reducing side effects.

6. Telemedicine in Oncology: Telemedicine has become increasingly important in oncology due to the

COVID-19 pandemic and the need to maintain social distancing. Virtual consultations and remote monitoring of patients are being used to maintain continuity of care.

7. 3D Printing: 3D printing is being used to create personalized surgical tools and implants, as well as to help with planning and simulations for complex surgeries.

These are just a few examples of the ways that technology is changing the field of oncology. As technology continues to advance, it is likely that we will see even more innovative and effective treatments for cancer in the future

Technological advances

In the following, we will briefly present the high-precision RT techniques currently available in clinical practice together with the fundamental prerequisite to accurately localise the target volume during treatment planning and delivery. Finally, ART is introduced within the framework of personalised medicine.

Oncology is an area where Reality Technology, such as Virtual and Augmented Reality, are making a significant impact. These technologies are transforming the way cancer patients receive treatment, helping them to better understand their conditions, and improving their overall experience.

Reality technology has made significant advancements in the field of oncology over the past few years, with increasing discussions and studies exploring its use in diagnosing, treating, and managing cancer.

The use of reality technology in oncology has been a growing field in recent years, with numerous advancements and discussions taking place. One of the most promising areas of development has been the use of virtual and augmented reality for surgical planning and training. This technology allows doctors to simulate complex surgeries and plan the best approach before entering the operating room, reducing the risk of complications and improving patient outcomes.

Another area of advancement has been the use of virtual reality for pain management in cancer patients. Studies have shown that VR can be an effective tool for reducing pain and anxiety, particularly in patients undergoing procedures such as chemotherapy.

Another area of interest is the use of augmented reality in the treatment of cancer. Augmented reality has been used to help guide physicians during minimally invasive procedures, allowing them to see inside the body in real-time without the need for open surgery.

Additionally, virtual reality has also been used to enhance patient education and engagement. Patients can use VR to visualize their treatment plan, understand the side effects of their treatment, and participate in their care in a more interactive and engaging manner.

Overall, the use of reality technology in oncology is a rapidly developing field with numerous potential applications. While there is still much research to be done, the early results are promising and suggest that these technologies have the potential to greatly improve patient outcomes and the delivery of cancer care.

Virtual Reality (VR) is being used in oncology to help patients prepare for surgery, reducing anxiety and increasing patient engagement. For instance, preoperative VR simulations allow patients to understand the surgical procedure and become familiar with the operating room environment. In addition, VR can be used during radiotherapy treatment to help patients manage pain, reduce stress, and even distract them from the procedure. Virtual Reality (VR) technology is being used for pain management and distraction during cancer treatments such as chemotherapy and radiation therapy. This helps to reduce anxiety and stress levels in patients, making the process more tolerable.

Augmented Reality (AR) is being used in oncology to provide real-time information to physicians during complex surgeries. AR technology overlays a patient's MRI or CT scan with a 3D image of the tumor, allowing the surgeon to see exactly where to make the incision and avoid healthy tissue. This enhances the accuracy of the procedure and minimizes the risk of complications. Augmented Reality (AR) is being utilized in surgical procedures to provide real-time guidance to surgeons. AR displays provide important information such as anatomy and biopsy results, helping surgeons to make more informed decisions and reducing the likelihood of complications.

Mixed Reality (MR) is a combination of VR and AR technologies and is being used for simulation training for oncologists. MR allows healthcare professionals to practice complex procedures in a safe and controlled environment, without any risk to patients.

Artificial Intelligence (AI) is also playing a significant role in oncology by enabling early detection and improved diagnosis of cancer. AI algorithms analyse medical images and identify suspicious areas, leading to earlier and more accurate diagnoses the integration of reality technology in oncology has the potential to revolutionize the field and improve patient outcomes. However, it is essential to further explore and validate its use in clinical practice through rigorous scientific studies and clinical trials.

Reality technology has made significant advancements in the field of oncology in recent years. These

technologies are being used to create immersive environments for medical training, patient education, and therapeutic applications.

One of the most notable advancements in reality technology is the use of virtual and augmented reality (VR and AR) in medical simulations. Medical professionals can use VR simulations to practice procedures and surgeries in a safe and controlled environment, allowing them to develop and refine their skills.

Additionally, patients with cancer can use AR and VR technologies to better understand their diagnosis, treatment options, and how their bodies may change throughout the process. This can help them feel more informed and empowered in their healthcare journey.

In terms of therapeutic applications, VR is being used to distract patients during painful procedures and to help them manage symptoms such as anxiety, pain, and nausea. The immersive environment provided by VR can help patients cope with the physical and emotional challenges of cancer treatment.

There is also growing interest in using mixed reality (MR) in oncology. MR combines aspects of VR and AR to create a hybrid environment that can provide real-time feedback to users. This technology is being explored as a tool for medical imaging and visualization, as well as for patient engagement and education.

Despite the exciting potential of these technologies, there are still challenges to their widespread adoption in oncology. These include cost, accessibility, and the need for further research to establish the effectiveness of VR and AR in medical applications.

Overall, the integration of reality technology in oncology has the potential to revolutionize medical education, patient care, and treatment outcomes. As these technologies continue to evolve, it is likely that we will see even more innovative applications in the future.

Another area where Reality Technology is being used in oncology is in patient education. Interactive VR simulations can help patients understand their condition, the treatment options available, and the potential side effects. This leads to increased patient engagement and helps them make informed decisions about their care.

Conclusion

In conclusion, RT has undergone tremendous progress over the years, realising technological developments that have revolutionised its clinical use, but we must not forget the multifaceted nature of this discipline that makes it an interface between physics, chemistry, biology and medicine. Only by exploring all these aspects will we manage to produce individualised radiation therapy with better target delineation, avoidance of normal tissue, dose escalation, dose fractionation and better prediction of treatment response. Reality Technology is

becoming increasingly important in the field of oncology, offering new opportunities to enhance patient care and outcomes.

While these technologies are still in their early stages, the potential for further development and integration into clinical practice is huge. As the technology continues to evolve, it is likely that Reality Technology will play a significant role in the future of oncology and cancer care.

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