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Generate Synthetic Megavoltage Cone Beam CT Images for Enhanced Cardiac Pacemaker Contouring Accuracy

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Introduction

Cardiac pacemakers have revolutionized the treatment of heart rhythm disorders, providing a lifeline for millions of patients worldwide. These devices are implanted to regulate and stabilize the heart's electrical activity, ensuring that it beats at a consistent rate. However, accurate contouring of cardiac pacemakers within the body during radiotherapy procedures can be challenging due to the limitations of imaging techniques. This challenge has led to the development of novel solutions, one of which is the use of synthetic Megavoltage Cone Beam CT (sMV-CBCT) images to enhance contouring accuracy. In this article, we will explore the significance of cardiac pacemaker contouring accuracy, the limitations of traditional imaging methods, and the role of sMV-CBCT images in improving the precision of radiotherapy for patients with cardiac pacemakers. We will discuss the principles behind sMV-CBCT, its potential applications, and the advantages it offers in cardiac pacemaker contouring [1,2].

Description

Radiotherapy involves the targeted delivery of high-energy radiation to specific areas of the body to treat cancer. Ensuring the cardiac pacemaker is accurately contoured helps minimize radiation exposure to the device and surrounding tissues, reducing the risk of device malfunction and potential harm to the patient. Accurate contouring enables clinicians to plan and deliver radiotherapy with greater precision. This can improve the effectiveness of the treatment by maximizing the dose to the tumor while sparing healthy tissues, including the heart and surrounding organs. Knowing the exact location and geometry of the pacemaker within the patient's body is essential for developing a comprehensive treatment plan. This plan determines the optimal radiation beam angles and intensity to achieve therapeutic goals while minimizing side effects. Patients with cardiac pacemakers already face health challenges, and radiotherapy should not exacerbate these issues. Accurate contouring helps maintain a patient's quality of life by reducing the potential for complications or the need for additional medical interventions. Cardiac pacemakers are predominantly composed of metal, which can cause significant artifacts in conventional CT imaging [3,4]. These artifacts obscure the precise location and shape of the device, making it challenging to create accurate contours. Megavoltage portal imaging, while effective in verifying the positioning of radiation beams, does not provide detailed anatomical information. It is not suitable for the precise visualization of the cardiac pacemaker and its relationship to surrounding structures. During radiotherapy, patient movement can further complicate the localization of the pacemaker. It is essential to account for these movements and their impact on the device's position. Repeated CT scans or portal imaging sessions may expose patients to additional ionizing radiation. For individuals with cardiac pacemakers, minimizing radiation exposure is of paramount importance. sMV-CBCT is a cutting-edge imaging technique that addresses the limitations of traditional methods and offers significant advantages for cardiac pacemaker contouring. It combines principles from megavoltage imaging and cone beam CT to create synthetic images that provide high-quality anatomical information while minimizing metal artifacts [5,6].

Conclusion

Enhancing cardiac pacemaker contouring accuracy in radiotherapy is of paramount importance to ensure patient safety, treatment efficacy, and quality of life. Traditional imaging methods have inherent limitations, which are addressed by the innovative approach of synthetic Megavoltage Cone Beam CT (sMV-CBCT). This advanced imaging technique reduces metal artifacts, provides detailed 3D visualization, and offers real-time monitoring capabilities, making it an invaluable tool for cardiac pacemaker contouring. The application of sMV-CBCT in cardiac pacemaker contouring brings significant advantages, including enhanced accuracy, patient safety, optimized treatment plans, time efficiency, and increased patient satisfaction. As research and technology continue to evolve, sMV-CBCT is poised to become a standard in radiotherapy, contributing to improved outcomes and a higher standard of care for patients with cardiac pacemakers. In the coming years, ongoing research and clinical validation will further refine the implementation of sMV-CBCT, making it an indispensable component of the radiotherapy toolkit for the benefit of both patients and healthcare providers.

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