Booklet

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Artificial Intelligence In Radiation Therapy

For Radiologic Technicians and Technologists, Biomedical Scientists, and Nurses.

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Nuclear and Energy Research Institute (IPEN)
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Presentation

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This booklet was developed to provide information about the fascinating application of artificial intelligence in radiation therapy. With a special focus on Biomedical Scientists, Nurses, and Radiologic Technicians and Technologists, our objective is to clearly and accessibly present the applications, benefits, and challenges of this innovative technology.

We hope this material offers valuable information that contributes to expanding your knowledge of this highly relevant and rapidly growing topic in healthcare. Enjoy your reading!

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1 Introduction

What is Radiation Therapy?

Radiation therapy is a therapeutic modality that uses ionizing radiation to treat malignant tumors and certain benign conditions. This radiation has sufficient energy to interact with cells, causing DNA damage and preventing uncontrolled cellular replication.

The primary goal of radiation therapy is to eliminate or reduce tumor cell growth while preserving surrounding healthy tissues as much as possible.

DIVISION OF RADIATION THERAPY:

Radiation therapy is classified into two main modalities:

- **External Beam Radiation Therapy (Teletherapy):**

  The most common form, in which radiation is generated by an external device positioned at a certain distance from the patient. It uses X-ray or electron beams produced by Linear Accelerators (LINACs), or gamma rays emitted by cobalt-60 sources (telecobalt therapy).

- **Brachytherapy (Internal Radiation Therapy):**

  Small radioactive sources are placed inside or near the tumor, delivering radiation directly to the treatment area.

Linear Accelerator
(teletherapy)

Afterloader
(a computer-controlled machine)
(brachytherapy)

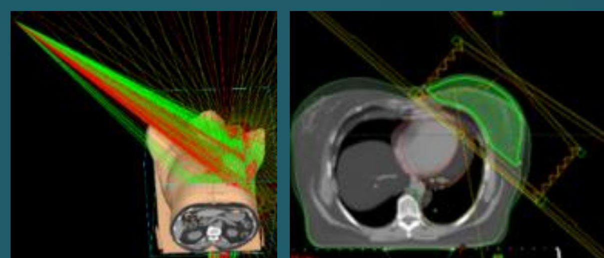
Main Treatment Modalities

Conventional Radiation Therapy (2D)
A basic technique based on two-dimensional images obtained from conventional radiographs.

Radiation fields are planned with less precision compared to modern techniques.

Two-dimensional radiographic images in conventional treatment planning

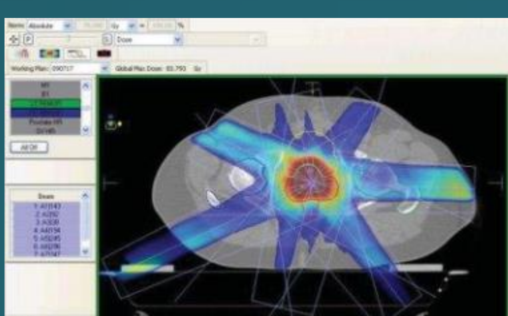
Three-Dimensional Conformal Radiation Therapy (3D-CRT):
Uses computed tomography (CT) images to create a three-dimensional tumor model, allowing better conformity of radiation beams to the tumor shape and reduced dose to surrounding healthy tissues.



3D Treatment Planning
Computed Tomography (CT)

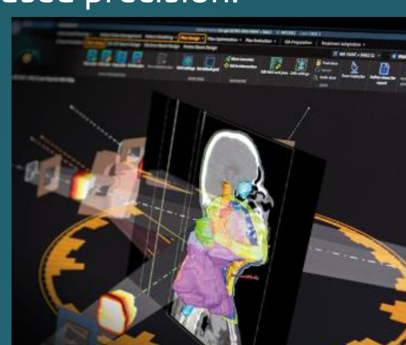
Intensity-Modulated Radiation Therapy (IMRT):

A technique that modulates beam intensity across different tumor regions. It uses CT and magnetic resonance imaging (MRI) to better define treatment volumes.



Radiation Therapy Treatment Planning – IMRT

Volumetric Modulated Arc Therapy (VMAT):
An evolution of IMRT in which radiation is delivered through rotational movement of the linear accelerator around the patient, allowing faster delivery and increased precision.



VMAT Planning

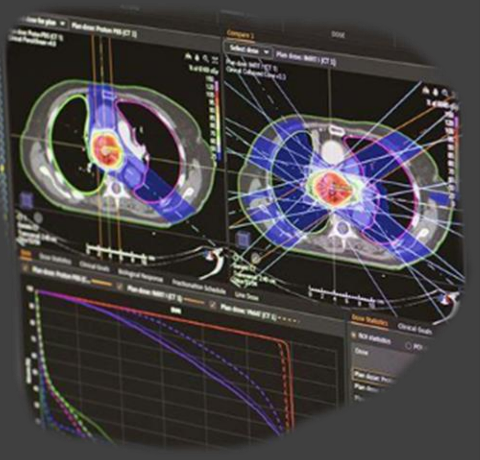
Simulation and Treatment Planning in Radiation Therapy

Simulation is the first step in radiation therapy treatment. Its objective is to accurately define and reproduce patient positioning across all treatment sessions, ensuring precise radiation delivery to the target.

Simulation can be performed in two main ways:

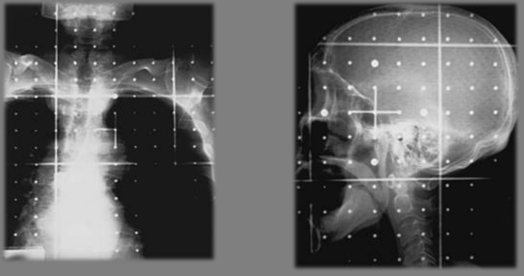
- **Computed Tomography (CT) Simulation:**

The most modern and accurate method. Images provide detailed anatomical slices, enabling three-dimensional (3D) treatment planning and precise localization of tumors and organs at risk.



- **Conventional Simulation:**

Uses an X-ray–based simulator to reproduce radiation fields with two-dimensional images. This method is older and has largely been replaced by CT simulation.



Images acquired using the conventional simulator for lung and head and neck treatments

This technique is older and has been progressively replaced by CT-based simulation.

In specific cases, **magnetic resonance imaging (MRI)** or **PET-CT** may be used as complementary imaging modalities.

Patient Support and Immobilization Devices Used in Radiation Therapy

Immobilization:

Refers to the use of devices and techniques to maintain correct patient positioning during treatment.

Prevention of undesired motion:

Involves strategies to eliminate or reduce voluntary and involuntary movements that could compromise dose delivery accuracy.

Common devices include:

- Thermoplastic masks
- Support blocks and wedges
- Headrests and head supports
- Body molds (Vac-Lok systems)
- Thigh, knee, and foot supports
- Velcro straps for patient immobilization
- Belly boards for prone positioning

Note:
There are also breast boards, abdominal compression devices, hand supports, and several other types of immobilization devices.

Example of a patient positioned in the supine position on a board on the examination table, with head support, arm support, abdominal compression device, and supports for the thighs, knees, and feet.

Linear Accelerator (LINAC)

Main Components

•**Gantry:** Rotating structure that houses the accelerator head, allowing beam movement around the patient.

•**Treatment Head:** Where radiation is generated and shaped before reaching the patient. Contains the collimator, filters, and beam monitoring systems.

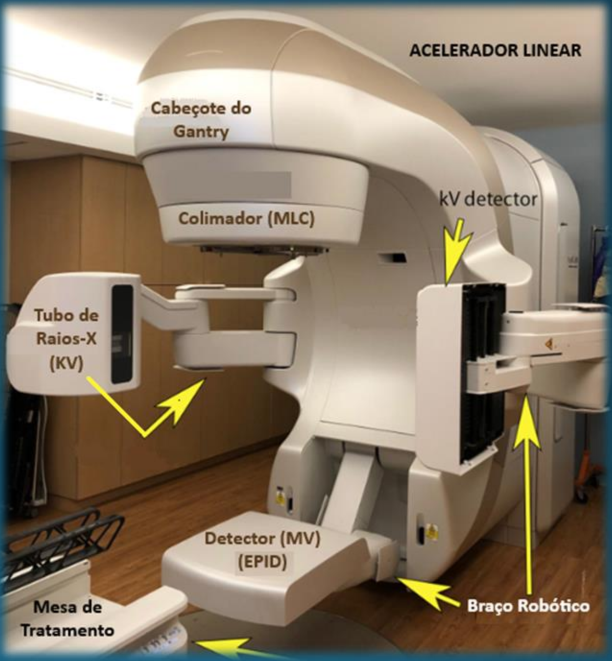
•**Multileaf Collimator (MLC):** A set of movable leaves that shape the radiation beam to conform to the tumor contour.

•**Treatment Couch:** Adjustable platform for patient positioning, with electronic control of height, rotation, and tilt.

On-Board Imager (OBI) and Electronic Portal Imaging Device (EPID):

OBI: kilovoltage (kV) X-ray–based imaging system used to acquire images prior to treatment. It allows verification of patient and tumor positioning with greater accuracy, enabling adjustments as needed.

EPID: electronic portal imaging device that uses megavoltage (MV) X-rays generated by the linear accelerator itself to acquire images during treatment. It is used to verify patient positioning and assess the quality of radiation beam delivery.



NOTE: Both are part of Image-Guided Radiation Therapy (IGRT), ensuring that radiation is delivered to the exact target location.

The Importance of the Multidisciplinary Team in Radiation Therapy

Radiation therapy is a cornerstone of cancer treatment, and its success depends on coordinated work by a multidisciplinary team. Each professional plays a critical role in ensuring treatment safety, precision, and humanized patient care.
From planning to the final session, the team integrates technical expertise, advanced technology, and patient-centered care.

From treatment planning through the final session, this team works in an integrated manner, combining technical expertise, advanced technology, and patient-centered care.

- Radiation Oncologist
- Medical Physicist
- Dosimetrist
- Radiation Therapy Technologist / Technician
- Nursing Team
- Biomedical Professional
- Pharmacy Professional
- Psychology Professional
- Nutrition
- Social Work
- Dentistry
- Clinical Engineering
- Maintenance Team
- Reception and Administrative Staff
- Residents / Interns
- Hygiene and Cleaning Team

They are involved in multiple stages of treatment to ensure that radiation is delivered safely, accurately, and efficiently. They serve as the link between technology and patient care, operating advanced equipment and ensuring the correct implementation of the treatment plan.

Practice Across Different Areas of Radiation Therapy

Simulation and Treatment Planning: They participate in initial patient positioning, assist with image acquisition, and collaborate with the dosimetry team to ensure that the treatment plan is correctly followed.

Dosimetry: They may work directly in dosimetry, assisting in the calculation and validation of treatment parameters, always under the supervision of the medical physicist and the radiation oncologist.

Treatment Rooms: They are responsible for operating linear accelerators, positioning patients, and ensuring that the radiation beam is delivered exactly to the planned target area.

Accelerator Console Operation: They monitor and adjust the parameters of each session, review IGRT (Image-Guided Radiation Therapy) images, and perform the necessary adjustments to achieve maximum treatment precision.

Patient Care: In addition to technical responsibilities, they support patients throughout the treatment sessions, provide guidance regarding the treatment and possible side effects, and contribute to a more humanized care experience.

Note: Professionals working in this field are typically radiology technicians or technologists with specialization in radiation therapy. In addition, biomedical professionals have also been increasingly prominent in this area.

The Role of Biomedical Professionals in Radiation Therapy

Biomedical professionals, upon obtaining the appropriate qualifications through recognized specialization programs, may work at various stages of the radiation therapy process, contributing significantly to treatment accuracy and safety.

Practice Across Different Areas of Radiation Therapy:

Equipment Operation: Biomedical professionals may operate radiation therapy equipment, such as linear accelerators, ensuring proper patient positioning and accurate radiation dose delivery.

Dosimetry: With specialization in dosimetry, biomedical professionals are responsible for the calculation and planning of radiation doses to be administered. They work in collaboration with medical physicists and radiation oncologists to ensure treatment effectiveness. The dosimetrist plays a fundamental role in radiation therapy, being responsible for ensuring accuracy and safety in radiation dose delivery to patients.

Technical Supervision: They may serve as technical supervisors, overseeing all stages of the simulation and treatment processes, ensuring the quality and consistency of radiation therapy procedures.

Team Management: Biomedical professionals are qualified to manage radiation therapy technologist teams, coordinating schedules, training activities, and the development of safety and quality protocols.

Research and Development: There are opportunities for biomedical professionals to engage in research and development of new technologies and protocols in radiation therapy, contributing to the continuous advancement of the field.

Imaging and Diagnostics: In the field of medical imaging, biomedical professionals may perform diagnostic imaging examinations, such as computed tomography (CT) and magnetic resonance imaging (MRI), supporting treatment planning and follow-up. Biomedical imaging specialists may work across multiple areas of radiology and diagnostic imaging, including nuclear medicine and radiopharmacy.

The Role of Nurses in Radiation Therapy

In radiation therapy, the role of nurses is essential to comprehensive patient care. They play a crucial role in patient monitoring, education, and support throughout the entire course of treatment, as well as in the prevention and management of treatment-related side effects.

Practice Across Different Areas of Radiation Therapy:

Patient Support and Education: Nurses establish a therapeutic relationship with patients, providing detailed information about the treatment, clarifying questions, and offering guidance on specific skin and mucosal care. They also address potential side effects related to the treated area, preparing patients for the different phases of treatment.

Monitoring and Assessment: Nurses perform regular assessments, identifying and monitoring side effects such as mucositis and radiation dermatitis. They apply the Nursing Care Systematization (SAE) to plan, implement, and evaluate necessary interventions, ensuring a personalized and effective approach.

Management of Side Effects: They are involved in the non-pharmacological management of adverse effects, providing guidance on relief and comfort measures. When necessary, they refer patients to the physician for further evaluation and possible pharmacological treatment.

Care Coordination: Nurses act as a communication link between the patient, the medical team, and other healthcare professionals, ensuring that all patient needs are addressed in an integrated and efficient manner.

Nursing Consultation: They conduct nursing consultations to identify health issues, plan interventions, and promote health, prevention, and rehabilitation actions, strengthening self-care and treatment adherence.

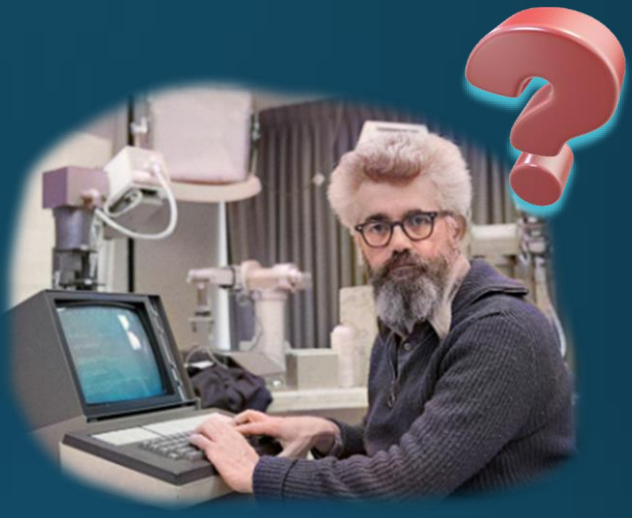
Health Education and Promotion: Nurses educate patients and their families about the treatment, home care, and preventive measures, using the nursing consultation as a tool to convey essential information and promote health.
Management and Leadership: In some settings, nurses assume management roles, coordinating nursing activities in radiation therapy, organizing work schedules, promoting training programs, and developing safety and quality protocols.

2 ARTIFICIAL INTELLIGENCE (A.I.)

Introduction to Artificial Intelligence (A.I.)

- Definition of AI and its application across different sectors:

Did you know that the term "artificial intelligence" (AI) was first coined in 1956 by John McCarthy, one of the pioneers in the field?



John McCarthy defined **Artificial Intelligence (AI)** as ***"the science and engineering of making intelligent machines."*** Since then, AI has been understood as the ability of machines to perform tasks that would normally require human intelligence. These tasks include learning, reasoning, problem-solving, pattern recognition, and decision-making.

Artificial Intelligence is a revolutionary technology that enables machines to perform activities that previously required direct human intervention. The term *artificial intelligence* was first coined in 1956 by John McCarthy, one of the pioneers of the field.

At its core, AI allows computational systems to **imitate human** behavior and perform activities autonomously.

Its application spans a wide range of sectors, standing out particularly in **healthcare, finance, retail, transportation, and manufacturing.**

In the **healthcare field**, AI has played a fundamental role in supporting medical diagnosis, medical image analysis, development of personalized treatments, and prediction of disease outbreaks.

In **the financial sector**, AI is used for fraud detection, risk analysis, market trend prediction, and investment management. In retail, AI personalizes product recommendations, optimizes pricing, forecasts demand, and enhances customer experience through virtual assistants.

In the **transportation industry**, AI supports autonomous navigation systems, traffic management, and predictive vehicle maintenance.

In manufacturing, it is applied to automation processes, quality control, and supply chain optimization. **Across all these sectors**, AI not only automates processes and optimizes operations but also extracts valuable insights from large volumes of data. **Collaboration between AI systems and humans is essential**, as their combined capabilities allow problems to be solved more efficiently, highlighting the transformative potential of this technology in modern society.

- **Overview of Fundamental AI Concepts:**

Within artificial intelligence, one of the most prominent and exciting areas is **Machine Learning**. In this section, we explore how computers can learn from data and improve over time, using a simple analogy.

"Imagine teaching a pet to perform a trick!"

At first, you show the pet what to do repeatedly and reinforce the desired behavior. Over time, the pet learns to associate the action with a reward.

In artificial intelligence, machine learning works in a similar way. Instead of a pet, we train **computer algorithms** using large amounts of data, such as images, measurements, or clinical records. These algorithms are encouraged to identify patterns, such as distinguishing between different anatomical structures or identifying abnormalities in medical images.

With experience, the algorithms become increasingly accurate and capable of making predictions or decisions based on the data provided.

"A More Formal Explanation of Machine Learning!"

Formally, machine learning models are trained using datasets and optimization algorithms that adjust internal parameters to minimize the error between predicted outcomes and real data.

*"If you are wondering what an **algorithm** is?"*

It can be understood as a step-by-step set of instructions that guides a computer in performing a specific task. Machine learning systems can be implemented using various platforms, including **open-source libraries**, which are collections of free software tools developed by programming communities. These libraries provide ready-to-use functionalities that facilitate the development of applications.

In addition, **frameworks** are collections of tools and libraries that provide an infrastructure for developing and deploying machine learning models more efficiently. They streamline model training, testing, and implementation in real-world applications.

3. Use of Artificial Intelligence in Radiation Therapy

- How is artificial intelligence being integrated into radiation therapy treatment processes?

Radiation therapy is one of the main weapons in the fight against cancer and is undergoing a silent revolution with the help of artificial intelligence (AI). But what exactly does AI bring that is so special to the field of radiation therapy? Let's explore together! The integration of AI into radiation therapy treatment processes is occurring across multiple fronts to improve the precision, efficiency, and safety of procedures.

Here are 6 examples of possible applications:

Example 1
Personalized Treatment Plans

Imagine that each patient is unique, like a fingerprint. Artificial intelligence helps physicians and medical physicists create customized radiation therapy treatment plans for each individual by analyzing detailed images, such as computed tomography (CT) scans and magnetic resonance imaging (MRI), to identify the tumor location and determine which parts of the body need to be protected. As a result, the radiation dose is precisely directed to the tumor, minimizing damage to the surrounding healthy tissues.

*"An example of this is the company **Brainlab**, in partnership with **Therapanacea**, which has integrated artificial intelligence (AI)–based solutions to optimize the contouring of organs at risk (OARs) and lymph nodes. The use of AI enables rapid and reliable delineation of more than 200 structures, reducing manual tasks and ensuring standardized and consistent contouring".*

Source: https://www.therapanacea.eu/

- **Research highlights the advantages of these technologies:**

Recently, Chan et al. (2022) compiled data from multiple centers to apply the automated MC-PRIMA system (Medical Care – Planning & Radiotherapy Intelligent Multi-modality Automation). This study, which included 24 centers and 5 metastases, demonstrated improvements in plan quality and a significant reduction in variability. Treatment plans generated using the MBM (Multi-Baseline Method) achieved scores equivalent to or higher than those produced by conventional treatment planning systems (TPS – Treatment Planning Systems).

Chan (2023) conducted a multicenter study demonstrating that automated planning helps standardize the quality of stereotactic radiosurgery (SRS) plans, both in the United Kingdom and in international institutions. This finding shows that automation not only improves consistency across outcomes but also maintains or enhances the quality of care.

Example 2 – Real-Time Adjustments During Treatment

Sometimes tumors can move slightly, especially due to patient breathing. AI plays an important role in this context as well. During treatment, it continuously monitors imaging data and makes real-time adjustments to ensure that radiation is delivered to the correct target, even if the tumor shifts slightly. An example of this is the solution developed by Vision RT, which offers a motion-tracking tool with instantaneous response. Tumor motion can result in unnecessarily large target volumes and unacceptable irradiation of surrounding normal tissue.

https://visionrt.com/applications-for-sgrt/sbrt/

The AlignRT system by Vision RT can help mitigate these risks through real-time patient tracking and automatic beam hold during radiation delivery.

Example 3 – Detection of Issues During Treatment

Like an attentive assistant, AI closely monitors the treatment process and verifies that everything is proceeding as planned. It analyzes data in real time to detect any issues or errors that may arise, ensuring that the patient receives the required treatment in the safest possible manner.

Example 4 – Decision Support for Physicians in Treatment Planning

Radiation oncologists must consider many factors when determining the most appropriate treatment plan for each patient. AI plays an important role once again by providing additional information and insights based on clinical and scientific data, such as predictions or estimates of future outcomes. Based on patient-specific data—such as tumor type, disease stage, and genetic characteristics—AI can help predict how a tumor will respond to radiation therapy. This supports radiation oncologists in further personalizing treatment plans to increase the likelihood of successful outcomes.

Source: https://www.philips.com.br

"**Philips Healthcare**, through its healthcare innovation division, has implemented remote monitoring solutions that use AI to analyze vital data such as blood pressure and glucose levels. This approach has enabled continuous monitoring of patients with chronic diseases, resulting in a significant reduction in hospital readmissions and improved long-term management of health conditions".

Tempus uses artificial intelligence to analyze large genomic and clinical datasets from cancer patients. This approach enables the identification of specific patterns, allowing for more personalized and effective treatments.

Source: https://www.tempus.com/about-us/tempus-tech/

Source:
https://www.tempus.com/?srsltid=AfmBOooDaBYb52eNeQuk55Vf1R86xWAfYRPLp1r5f2B8VKvURkweND_k

Example 5 – Remote Patient Monitoring

Sometimes patients may experience unexpected side effects during treatment. AI can assist radiation oncologists in remotely monitoring patients by analyzing reported symptom data and medical images. This enables early intervention if problems arise, ensuring that patients receive the necessary support.

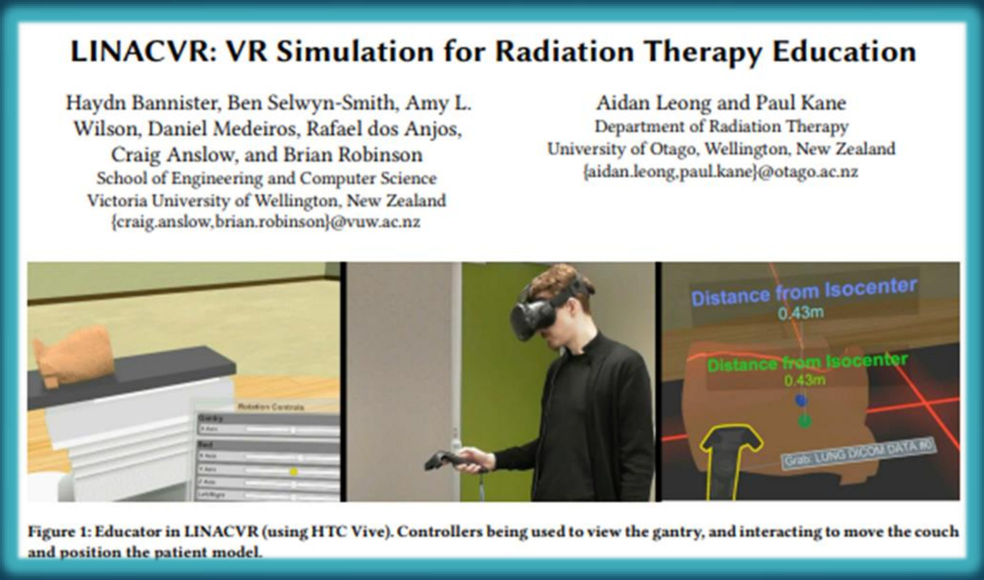
Source: https://wecancer.com.br

"The **WeCancer** a brazilian app is a tool designed for cancer patients that enables remote monitoring of their health. It records personal data, medications, symptoms, and daily activities, as well as indicators of physical and emotional health. The medical team can track treatment progress through graphical data visualizations".

Patients receive reminders to take medications, can access informational content about cancer, record symptoms and physical activities, and manage their appointment and examination schedules. They can also ask questions to the healthcare team via chat during business hours.

Example 6 – Enhancement of Education and Training

Last but not least, AI also plays an important role in the education and training of radiation therapy professionals. It provides realistic simulations and interactive case studies, allowing students and professionals to practice techniques and procedures in a safe and controlled environment.



LINACVR: VR Simulation for Radiation Therapy Education

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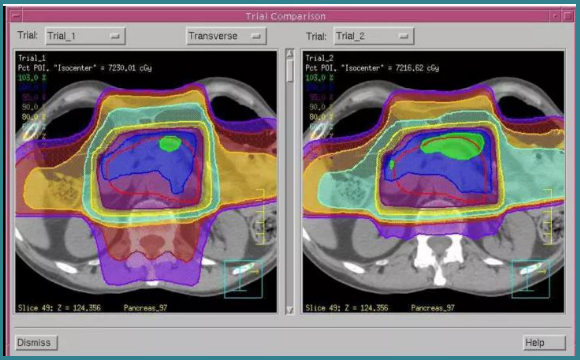
Figure 1: Educator in LINACVR (using HTC Vive). Controllers being used to view the gantry, and interacting to move the couch and position the patient model.

For example, the study entitled **"LINACVR: VR Simulation for Radiation Therapy Education"** explores the application of virtual reality (VR) simulations in the training of radiation therapy professionals, highlighting how this technology can enrich education by allowing students to practice treatment techniques in a safe and controlled environment. The authors discuss the development of a simulation platform that replicates the operation of a linear accelerator (LINAC), offering an immersive learning experience that can improve understanding of clinical procedures and increase student confidence. The results suggest that integrating VR into the radiation therapy curriculum can significantly contribute to the training of more competent professionals who are better prepared to face the challenges of clinical practice (Bannister et al., 2024).

There are also software applications that allow the simulation of radiation therapy treatments, in which users can practice defining treatment fields, calculating doses, and evaluating radiation therapy plans.

Examples include Varian Eclipse and Philips Pinnacle³.

Source: https://www.varian.com/pt-br/products/radiotherapy/treatment-planning/eclipse



Source: https://www.philips.com.br/healthcare/product/HCNOCTN135/pinnacle3-sistema-planejamento-radioterapia

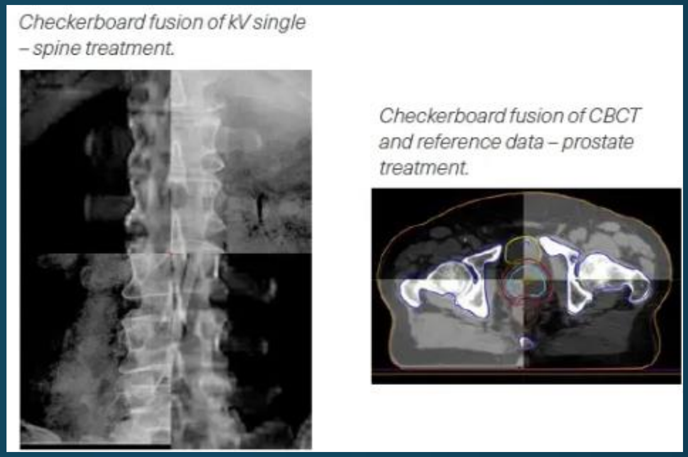
- **AI algorithms used in treatment optimization and anomaly detection.**

"Have you ever stopped to think about how artificial intelligence (AI) can help ensure the safety and effectiveness of radiotherapy treatments?"

Next, we will explain it in a simpler way!

Supervised Machine Learning: Imagine you are taking a photo and, when developing it, you notice that something is wrong. It's like AI is a friend who examines the photo with you and points out anything that's out of place.

"In radiotherapy treatment, AI can analyze treatment verification images and radiation dose records to detect any issues, such as the patient not being in the correct position or errors in delivering the radiation dose."



Source: https://www.abdosimetristas.com.br/igrt/

Typically, the pre-treatment image is acquired and compared with a reference image, where the anatomical positions of bones and soft tissues are analyzed. This analysis aims to quantify any variations, in millimeters, between the positions of organs in the acquired image and those in the reference image (which is the planning image).

Convolutional Neural Networks (CNNs): Now, think of a facial recognition program on social media. AI is trained to identify faces in photos and tag them automatically. Similarly, CNNs are used in radiotherapy to analyze medical images, such as CT scans or MRIs, and detect any anomalies or changes in the patient's anatomy during treatment.

A practical example of this would be during a treatment session: if the patient moves slightly or the treatment machine encounters any difficulty, AI can detect these changes and alert healthcare professionals so they can take immediate corrective action, ensuring the treatment is delivered accurately and safely.

4 Future Perspectives on the Use of AI in Radiotherapy

• **Trends and forecasts for the future development of AI in the field of radiotherapy:**

In recent years, artificial intelligence (AI) has gained prominence in the healthcare field, and radiotherapy is one of the areas benefiting from these advances. An article published by Chan et al. (2020) in the journal *Frontiers in Artificial Intelligence* explores how AI and machine learning (ML) are being integrated into quality assurance (QA) in radiotherapy, as well as their potential future applications.

QA in radiotherapy is essential to ensure that equipment functions correctly and treatments are delivered accurately. Currently, this process often requires manual checks and accessory setups, which can be time-consuming.

However, AI is helping to automate and enhance QA. Chan et al. (2020) highlight that machine learning can predict QA pass rates and analyze the performance of radiotherapy machines, such as linear accelerators, over time. A practical example mentioned in the article is the use of AI to predict the symmetry of radiation beams in linear accelerators, which is crucial for treatment accuracy.

A machine learning model was trained to analyze five years of daily quality control data and predict the performance of the linear accelerator with greater accuracy than traditional techniques (LI apud CHAN et al., 2020).

With AI-driven automation, professionals will have less need to perform manual checks. AI will be able to predict when a machine requires maintenance or adjustment, ensuring treatments are delivered more safely and efficiently, minimizing errors, and reducing equipment downtime.

- **Potential impacts on clinical practice and patient outcomes:**

Another major benefit of AI in radiotherapy is its ability to predict clinical outcomes. Chan et al. (2020) note that machine learning can be used to forecast treatment accuracy and QA pass rates based on previous data. For example, in VMAT (Volumetric Modulated Arc Therapy), machine learning models have been trained to predict discrepancies in the positioning of multileaf collimator (MLC) leaves during treatment delivery, helping ensure that the radiation dose is administered correctly (OSMAN apud CHAN et al., 2020).

In the future, AI systems may be able to predict each patient's response to radiotherapy based on previous treatment data and individual characteristics. This will allow healthcare professionals to adjust treatment parameters more personally, increasing precision and reducing side effects.

5 New Research and Innovations in AI and Radiotherapy

- Overview of recent and ongoing research related to AI and radiotherapy.

Radiotherapy treatment planning is a complex task, typically carried out by physicians, medical physicists, and dosimetrists, who adjust parameters to ensure that the radiation precisely targets the tumor while protecting healthy tissues. AI is already being used to improve treatment planning, and Chan et al. (2020) provide practical examples of this application.

"One example cited is the use of convolutional neural networks (CNNs) to predict QA pass rates in IMRT (Intensity-Modulated Radiotherapy) treatments. CNNs analyze fluence maps (planned radiation distributions) directly, without the need for human intervention to design beam features."

This AI model was compared to a traditional Poisson regression model, showing that the CNN was able to make predictions as accurate as previous methods, but much faster and more efficiently (INTERIAN apud CHAN et al., 2020).

Highlights of new technologies and promising approaches:

Chan et al. (2020) also emphasize the need for multi-institutional validation of AI models. To ensure that a model performs well across various clinics and contexts, it is important to test its predictions on different types of machines and workflows. This helps establish quality standards that can be applied in different locations.

An interesting example cited in the article is the use of AI to predict QA outcomes in proton therapy machines. In this study, over 1,700 proton fields with different configurations were used to train a machine learning model capable of predicting output factors (SUN apud CHAN et al., 2020). This approach helped significantly reduce the time needed to set up the machines and adjust treatment parameters, which is a major advantage in the clinical setting.

6 The New Role of the Radiology Technologist – Radiotherapy Specialist

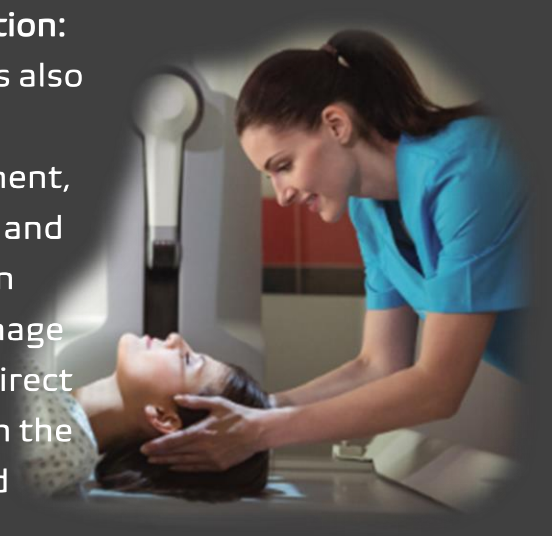
• Necessary adaptations for radiotherapy professionals in light of the growing integration of AI.

"Although AI can assist in certain stages of the radiotherapy process, such as treatment planning and setup, there are aspects of the radiotherapy professional's work that require human skills and sensitivity, such as patient interaction and the ability to respond to unforeseen situations."

The integration of AI in the field can complement the work of these professionals, but it cannot fully replace their presence and essential role in caring for oncology patients, such as:

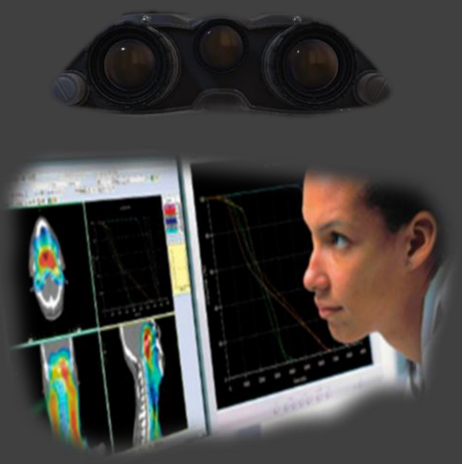
Equipment Preparation and Adjustment: The radiotherapy technologist is responsible for preparing and adjusting the equipment, loading the treatment plan, and positioning accessories for each treatment session. Although AI can assist in automating certain processes, such as the initial equipment setup, continuous supervision and verification during treatment require human presence and intervention.

Patient Positioning and Immobilization: The radiation therapy technologist is also responsible for positioning and immobilizing patients during treatment, ensuring they are correctly aligned and remain still throughout radiation delivery. While AI can assist with image analysis and positioning planning, direct interaction and communication with the patient require human skills and sensitivity.



Monitoring and Response to Unexpected Events

"During treatment, technologists closely monitor both patients and equipment, responding promptly to unexpected movements or technical issues. This real-time decision-making capability is difficult to replicate through AI alone."



Patient Support and Guidance

"Beyond technical responsibilities, radiologic technologists play a crucial role in providing emotional support, answering questions, and guiding patients throughout the treatment process. Empathy and human care are essential elements of patient-centered oncology care".

However, professionals must be attentive to the direction of these changes and recognize that, as AI takes on tasks previously performed by humans—such as the interpretation of medical images and treatment planning—radiotherapy technologists face the need to adapt and develop new skills to work collaboratively with AI systems. This requires a delicate balance between trust in technology and the preservation of patient-centered care.

Let's talk about some important things we need to understand about this:

New Roles in Healthcare:

With AI assisting in many tasks, such as treatment planning, radiotherapy technologists need to learn new skills. It is as if we have new tools in our work kit, and we must learn how to use them in the best possible way to help our patients.

Changes in the Workplace:

As AI automates certain tasks, some job roles may change. For example, some tasks may no longer need to be performed manually, while new procedures and roles will emerge in areas related to AI, such as maintenance and programming. It is like a dance: some steps change, but the music keeps playing.

In summary, although AI can assist in certain stages of the radiotherapy process, such as treatment planning and setup, there are aspects of the radiotherapy professional's work that require human skills and sensitivity, such as patient interaction and the ability to respond to unforeseen situations. The integration of AI in the field can complement the work of these professionals, but it cannot fully replace their presence and essential role in caring for oncology patients.

7 Conclusions:

Should we be afraid of AI and automation?

The answer is not simply "yes" or "no." It is important to address this question from a balanced and well-informed perspective. First and foremost, it is crucial to understand that AI and automation are not intended to completely replace radiotherapy professionals, but rather to complement and enhance their skills. Below are some important points to consider:

- **Improved precision and efficiency:** AI can help reduce human errors and increase treatment accuracy, directly benefiting patients.
- **Focus on higher-value tasks:** With the automation of repetitive tasks, professionals can devote more time to activities that require human judgment, empathy, and personalized care.
- **New career opportunities:** The integration of AI creates new areas of specialization, such as AI system management and advanced data interpretation.
- **Continuous learning:** Technological evolution encourages ongoing learning, keeping professionals up to date and relevant.

- **Better patient outcomes:** The combination of human expertise with the precision of AI can lead to improved treatment outcomes and better quality of life for patients.
- However, it is natural to have some concerns:

- **Need for adaptation:** Professionals will need to adapt and acquire new skills, which can be challenging.

- **Ethical and accountability issues:** It is important to establish clear guidelines regarding the use of AI and responsibility for decisions and outcomes.

- **Technological dependence:** Maintaining a balance between the use of technology and the preservation of essential human skills is crucial.

In conclusion, rather than fear, it is more productive to adopt an attitude of curiosity, adaptability, and continuous learning. AI and automation are powerful tools that, when used appropriately, can significantly improve the quality of patient care and the efficiency of radiotherapy practice.

The future of radiotherapy is not about machines replacing humans, but about an effective partnership between skilled professionals and advanced technology. By embracing these changes with an open and proactive mindset, radiotherapy professionals can position themselves at the forefront of a new era in oncology care, delivering more precise, personalized, and effective treatments for their patients.

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