

The role of protons and neutrons in cancer prevention and detection

Sujata Shree

Shree S. The role of protons and neutrons in cancer prevention and detection. *J Cancer Metastasis Res.* 2023; 5(2):95-97.

in simple terms, understanding how and when they can be utilized.

Key Words: Prognosis; Gastrointestinal; Chemotherapy; Cancer; Tumors

ABSTRACT

Cancer, a devastating disease affecting millions worldwide, requires comprehensive strategies for prevention and early detection. While protons and neutrons may not be the first things that come to mind when discussing cancer, these particles play vital roles in certain aspects of cancer prevention and detection. Let's delve into their significance

INTRODUCTION

One of Proton therapy has emerged as a highly effective treatment option for cancer in radiation oncology. Compared to conventional photon therapy, proton therapy offers superior dosimetric advantages for various treatment sites. Despite the initial investment required to establish proton therapy facilities, there has been a significant increase in the number of proton therapy centers worldwide, and providing more patients with access to this advanced treatment. However, it is crucial to carefully select patients who can benefit the most from proton therapy's advantages.

One area where proton therapy excels is in treating lesions inside the head. The precision of proton irradiation, combined with accurate positioning and immobilization of head and neck patients, makes it a crucial indication for protons. One of the main advantages of clinical proton therapy is the ability to conform the dose to the target volume. Protons have a finite range and deliver a low entrance dose proximal to the target, resulting in a considerably smaller irradiated volume and integral dose compared to photon therapy. Numerous treatment planning studies and measurements have confirmed these benefits.

Pediatric patients, in particular, can greatly benefit from proton therapy. Due to their smaller structures and shorter distances to

organs at risk, pediatric patients are at a higher risk of developing late effects. Therefore, a smaller integral dose, which is achievable with protons, is highly beneficial for them. Late effects, such as radiation-induced second primary cancers, are a concern in both proton and photon therapy. However, the lower integral dose and irradiated volume in proton therapy directly translate to a lower risk of late effects compared to photon therapy.

It is important to note that comparing the effects of neutrons in proton and photon therapy requires careful consideration. Neutrons are mainly produced by proton interactions with the treatment delivery system and the patient, resulting in a whole-body neutron dose exposure in proton therapy. In photon therapy, neutrons are only produced above a certain energy threshold, and their contribution to neutron-induced late effects is negligible. The risk of late effects due to secondary neutron dose appears to be lower for photons based on these factors. However, it is essential to be cautious when comparing neutron effects in both therapies, as there are various complexities to consider.

Since the early days of clinical proton therapy, it has been known that neutrons are produced by proton beam interactions. The absorbed dose from neutrons in proton therapy has been recognized as relatively small, but concerns about neutron exposure arise due to

Department of Biotechnology, Graphic Era University, Dehradun, India

Correspondence: Sujata Shree, Department of Biotechnology, Graphic Era, University, Dehradun, India, Email cancerrech@eclinicalinsight.com

Received: 04-May-2023, Manuscript No. *pulcmr-23-6566*; Editor assigned: 09-May-2023, PreQC No. *pulcmr-23-6566*; Reviewed: 20-May-2023, QC No. *pulcmr-23-6566*; Revised: 24-May-2023, Manuscript No. *pulcmr-23-6566*; Published: 28-May-2023, DOI: [10.37532/pulcmr-2023.5\(2\).95-97](https://doi.org/10.37532/pulcmr-2023.5(2).95-97)



This open-access article is distributed under the terms of the Creative Commons Attribution Non-Commercial License (CC BY-NC) (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits reuse, distribution and reproduction of the article, provided that the original work is properly cited and the reuse is restricted to noncommercial purposes. For commercial reuse, contact reprints@pulsus.com

whole-body irradiation and the higher biological effectiveness of neutrons compared to photons. Previous studies on neutron biological effectiveness and radiation quality factors have yielded varying results, leading to uncertainty regarding the importance of neutron contribution to late effects risk in proton therapy patients.

Several research articles have addressed this topic. In 2008, presented an extensive assessment of neutron dose in external-beam radiation treatment, emphasizing the need for consistent dosimetry methodology and organ-specific absorbed doses in future studies. Schneider et al., in 2015, discussed the controversy surrounding the impact of neutron dose in proton therapy and highlighted the contributions of new epidemiological studies to understanding this issue. The American Association of Physicists in Medicine (AAPM) Task Group 158 published findings in 2017, covering the measurement and calculation of doses outside the treated volume from radiation therapy and addressing concerns related to non-target radiation, including radiation-induced second cancers.

As radiation therapy continues to achieve success in cancer treatment, understanding the non-target dose, including neutron doses, has become a significant topic of investigation. Ongoing studies, utilizing computational phantoms and Monte Carlo simulations, are vital for further advancing our knowledge in this field. Accurate dose reporting, particularly for neutron doses, and the development of systematic dosimetry approaches are essential in ensuring the safe and effective application of proton therapy.

Proton therapy

Proton therapy is an advanced treatment approach that employs special particles called protons to target tumors with precision. By directing these charged particles directly at the tumor, radiation can be delivered to kill cancer cells while minimizing damage to healthy tissues nearby. This accuracy allows for effective tumor control and reduces the risk of side effects typically associated with traditional radiation therapy. Proton therapy is used for specific types of cancers, and its suitability is determined by factors such as tumor location and size.

Neutron therapy

While less common than proton therapy, neutron therapy holds its own place in cancer treatment. Neutrons, known for their deep tissue penetration capabilities, are utilized in treating certain types of cancers, including sarcomas and salivary gland tumors. Neutron therapy delivers high doses of radiation to the tumor, but it carries a higher risk of side effects compared to other radiation therapies. Therefore, it is selectively employed based on the characteristics of the cancer and the patient's condition.

Proton and neutron imaging

In addition to treatment, protons and neutrons have applications in imaging techniques that aid in cancer detection. Proton radiography employs high-energy protons to create detailed images of tumors. These images provide valuable insights for treatment planning and allow healthcare professionals to determine the best course of action. Neutron imaging, on the other hand, can be used to detect and visualize specific types of cancer, such as lung and breast cancers, by highlighting the differences in tissue composition. These imaging techniques are utilized when cancer is suspected or when further information about a tumor is required.

Primary methods for cancer prevention and detection

It is essential to understand that the role of protons and neutrons in cancer prevention and detection is limited to specific applications. The primary methods for cancer prevention include regular screenings such as mammograms, Pap tests, colonoscopies, and genetic testing. These screenings enable the early detection of cancer or precancerous conditions, increasing the chances of successful treatment. Additionally, lifestyle modifications, such as adopting a healthy diet, engaging in regular exercise, avoiding tobacco, and limiting alcohol consumption, can significantly reduce the risk of developing cancer. Vaccinations, such as the HPV vaccine, are available to prevent specific types of cancer. Estimates Based on Dose Comparison: Using simple comparisons of radiation doses to estimate cancer risk can be unreliable for two reasons. Firstly, the decrease in dose from the edge of the treatment area is not linear but exponential, or even more rapid. This means that the dose close to the target area may be significantly different from the dose further away. For example, in techniques like IMRT with photons, the dose far away from the treatment area may be higher compared to traditional 3DCRT. However, the dose close to the treatment area's edge is lower with IMRT due to less scattering. Secondly, analyzing only specific components of the dose, such as neutron dose, doesn't provide a complete picture of the 3D-dose distribution. To accurately estimate risk, the energy deposited by all components of radiation must be studied, considering the characteristics of different radiation qualities. Comparisons should be made under the same conditions for all treatment types, whether through measurements or simulations.

Estimates Based on Risk Models: Simple models for predicting radiation-induced cancer risk in radiotherapy doses are based on conventional radiation protection concepts. These models rely on linear approximations of risks observed in atomic bomb survivors and use effective dose, which considers the weighted sum of equivalent doses in various tissues, for risk estimation. These models incorporate dose and dose-rate effectiveness factors to account for low dose-rates. However, the linear model is only valid for doses up to around 1-2 Gy and is generally not applicable to complete radiotherapy dose distributions.

Radiation protection models can be safely applied to scatter radiation doses but not to the in-field dose distribution. The linear model is applied to very low doses with a threshold of around 100 mSv, representing the maximum scatter dose in a typical radiotherapy treatment. Applying radiation protection concepts in this manner results in an estimated increase in cancer risk for modern radiotherapy techniques due to higher scatter, leakage, and neutron doses compared to conventional techniques. However, this approach neglects the in-field dose distribution (>100 mSv), which contributes significantly to cancer risk. Only a small percentage of radiation-induced malignancies (around 20%) are found far away from the treated area.

To obtain more accurate cancer risk estimates, semi-empirical models that consider the complete 3D-dose distribution (in- and out-of-field) can be used. These models account for dose fractionation and

provide a better representation of the dose-response relationships. However, uncertainties still exist due to limited knowledge about the induction processes of specific types of cancer, time patterns of cancer development, population-specific dependencies, and organ-specific cancer rates. When comparing treatment plans for individual patients, a precision of around 10% can be achieved. These models have been used to estimate cancer risk in prostate radiotherapy, considering the complete 3D-dose distribution, including stray doses. In certain cases, such as proton radiotherapy, the additional neutron dose is balanced by the advantages of proton beams, resulting in slightly lower predicted risk compared to photon 3DCRT.

Simple dose comparisons for risk estimates and radiation protection models should be used with caution in radiotherapy. They may not account for the complex 3D-dose distribution and can only predict a fraction of observed second malignancies. Semi-empirical models that consider the complete dose distribution offer a more accurate estimation of cancer risk, but uncertainties still exist. Precision in risk estimation can be achieved when comparing treatment plans for individual patients.

CONCLUSION

While protons and neutrons play important roles in cancer prevention and detection, their direct involvement is primarily observed in specific treatment modalities and imaging techniques. Proton therapy and neutron therapy are employed for precise and targeted radiation treatment, whereas proton and neutron imaging provide valuable insights into tumor detection and visualization. However, it is crucial to remember that the primary methods for cancer prevention and detection revolve around regular screenings, lifestyle modifications, and vaccinations. Consultation with medical professionals and adherence to recommended guidelines are paramount for effective cancer prevention and detection strategies.

It's important to note that while protons and neutrons have specific applications in cancer treatment and imaging, the primary cancer prevention and detection methods typically involve other approaches. These include regular screenings, such as mammograms, Pap tests, colonoscopies, genetic testing, lifestyle modifications, vaccination (e.g., HPV vaccine), and early intervention strategies. Consultation with medical professionals and adherence to recommended guidelines are crucial for effective cancer prevention and detection.