SINFONIA

Doses from medical exposure in radiation therapy and their impact on patient risk

INTRODUCTION

Cancer is a group of diseases affecting any part of the body. They are characterised by rapid growth of abnormal cells that can invade nearby tissues and also spread to other organs in a process called *metastasis*. The risk of developing cancer is modulated by several factors, including genetics, environmental and lifestyle factors; exposure to carcinogenic agents such as ionising radiation or some chemical products; and infections. People in developed countries have a risk of 25-30% of developing a cancer in their lifetime.

Cancer treatment is a multidisciplinary approach that aims to provide the best care to the patient according to the experience of the physicians involved and latest guidelines. Several treatment options are considered, including surgery, radiation therapy and chemotherapy. Radiation therapy is an effective treatment form for cancer diseases and also some benign lesions. It is estimated that approximately 50% of cancer patients receive radiation therapy as part of the medical management of their disease. Several treatment techniques and radiation types are available in radiation therapy. The majority of treatments are delivered with external beam radiation therapy which involves the irradiation of the intended target from an external source of radiation. Other forms of treatment make use of sealed sources inserted in the body (brachytherapy) or unsealed sources (radionuclide therapy). Radiation therapy with photons and electrons is the most common, but in recent years the use of accelerated particles (neutrons, protons and other ions) for radiation therapy has increased.

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Doses in radiation therapy

The purpose of radiation therapy is to deliver a high dose of ionising radiation to the treated target to prevent the growth and proliferation of cancer cells. The unit for radiation dose is the gray (Gy), but a sub-unit, the centigray (cGy), may also be used.

The specific dose prescribed for each treatment depends on the location, type and severity of the disease as well as on other treatment modalities employed in the multidisciplinary management of the disease. Radiation therapy is delivered with the prescribed dose divided into several fractions administered over several days or weeks. Typical total doses prescribed are of the order of several tens of Gy to the target. Dose prescription, including fractionation, is decided by the radiation oncologist, who is responsible for such therapeutic decisions.

Great efforts are made to avoid the irradiation of healthy tissue around the target while delivering the prescribed dose to the cancer cells, but in some cases irradiating a minimal part of the former is unavoidable. This may increase the risk for side effects. For this reason, treatment planning is one of the most important early steps in radiotherapy treatment, which aims to optimise the delivery of the prescribed dose to the target while keeping the doses and side effects in normal tissues at acceptable levels. The irradiation of healthy tissue may arise from limitations and uncertainties in treatment planning, secondary radiation produced during irradiation, or imaging procedures, which also contribute to increasing the dose.

Improvements in radiation delivery arrive continuously, and novel treatment modalities are rapidly rising. In addition, novel forms of radiation therapy such as proton or neutron therapy have also been developed and hold hope for improved results.

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Risk versus benefits in radiation therapy

The inclusion of radiation therapy in cancer treatment strategy is preceded by several factors such as risk versus benefit analysis of the treatment target, the available treatment options, and the optimisation of dose delivery to the target. As a result, the patient undergoes radiation therapy only if the benefits outweigh the risks.

Doses to normal tissues are usually kept below thresholds for many serious side effects so that the patient would have a good quality of life after treatment. Side effects may appear at various time intervals in relation to radiation therapy. Acute side effects usually appear under radiation therapy and are transient in nature. Late effects may appear a few months or even years after radiation therapy. Increased concerns have been recently raised regarding the risk of inducing a second cancer in irradiated normal tissues. Dose reduction is the key to reduce the severity of these effects, as they are dose dependent. Unfortunately, there is no threshold dose for the induction of secondary cancers, but risk is dose dependent: the higher the dose, the higher the risk. Therefore, doses to healthy tissue should be reduced as much as reasonably achievable. The risk of inducing a second cancer from radiation therapy is small for adults but greater for young patients and children. Nevertheless, the cancer risk from the irradiation of normal tissues in radiation therapy are at least one order of magnitude lower than the risk of spontaneous cancer development. An important aspect to bear in mind is that the induction of a second cancer is a very slow process that may take years, implying that the primary cancer has been successfully treated. And in many cases the risks from abstaining from radiotherapy are far greater than the risks for inducing a second cancer.

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