Brachytheraphy in head and neck cancers– An update

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Abstract

Head and neck cancers have become very prevalent all over the world and ranked 11th among all cancers worldwide. The mainstay for managing these oral cancers includes surgery, radiotherapy and chemotherapy or combination of these modalities. This article highlights the one of the type of radiotherapy which is mainly used in managing the head and neck cancers, that is brachytherapy. This review article enlights the dental surgeons about indications, types, mechanisms, limitations and advances about brachytherapy.

Keywords: Brachytherapy, Head and neck cancer.

Introduction

Oral cancer is a malignant neoplasm seen on the lip, floor of the mouth, cheek, gingiva, palate or in the tongue. It has been included in the top three among the different cancers seen in India.[1] The incidence of oral cancer is highest in India, south and Southeast Asian countries. Ninty to ninty five percent of the oral cancers in India is squamous cell carcinoma.[2] The international agency for research on cancer has predicted that India's incidence of cancer will increase from 1 million in 2012 to more than 1.7 million in 2035. This indicates that the death rate because of cancer will also increase from 6,80,000 to 12 million in the same period.[3]

The principle aim of treatment of H&N cancer is to cure the patient. The cell type and its degree of differentiation; the location, size; lymph nodal & bony involvement; the ability to achieve adequate surgical margins; the ability to preserve all functions such as speech, swallowing; the esthetics, mental load for the patient; a thorough assessment of the potential complications of each therapy; the experience of the surgeon and radiotherapist; and the personal preferences and cooperation of the patient are the key factors to decide the management of oral cancer.[4]

The complex anatomy of Head and neck region (H&N) makes it the most challenging sites of the human body for managing cancers affecting the same. While opting for the treatment of head and neck cancer, we need to bore in our mind about the restoration of various functions of that region such as speaking, hearing, seeing and swallowing, as well as smelling. Esthetics also plays a very important role in selecting the treatment modality especially for H&N cancers, as it mentally affects the individual's self esteem. Considering all these factors, the physician has to plan a treatment properly. It is never a one man show but it should be a team with interdisciplinary thinking.[5]

Surgery is the most commonly accepted in the treatment of oral cancer, followed by radiotherapy. Chemotherapy is an adjunct to the principal curative modalities of surgery and radiation.[4] Radiation therapy remains an important component of cancer treatment with approximately 50% of all cancer patients receiving radiation therapy during their course of illness; it contributes towards 40% of curative treatment for cancer. The main goal of radiation therapy is to deprive cancer cells of their multiplication (cell division) potential.[6]

What is radiotherapy?

Radiation therapy is also called as radiotherapy is a cancer treatment that uses high doses of radiation to kill cancer cells and shrink tumors.[7] It can be used as

curative modality or for palliative treatment. But most of the time it is used as combination therapy.

Principles of radiation therapy:[6,8]

Radiation is a physical agent, which is used to destroy cancer cells. The radiation uses the property of ionization thereby depositing its energy in the cells through which it passes. This deposited energy can kill cancer cells or cause genetic changes resulting in cancer cell death. It usually targets the deoxyribonucleic acid (DNA) of cells, therewith blocking its ability of cell division and proliferation. [8] It damages both normal as well as cancer cells, but the principle of using radiotherapy is to maximize the effect on cancerous cells as they are rich in DNA content and protecting the damage on the normal cells which are in the path of radiations.

Types of radiotherapy

Ionizing radiation may be administered as an

1. **External beam radiotherapy/ Teletherapy** - targeting the tumor by external radiation beam
2. **Brachytherapy** - directly implanting radioactive sources within the tumor

Teletherapy/External Beam Radiation:[10]

External beam radiotherapy is usually delivered in fractionated doses, which means that the total dose is delivered over time in smaller doses or fractions. Conventional fractionation schedules deliver treatment in single daily fractions of 1.8-2 Gy, 5 days/week, resulting in dose accumulation of approximately 10 Gy/week.[9]

This is the most common modality accounting for 90% of radiation therapy. It involves the delivery of electromagnetic radiation (e.g. X-rays, gamma rays) or particulate radiation (e.g. electrons, protons) from a linear accelerator or radionuclide source, such as 60cobalt kept at a distance away from the patient.

It is of two types depending on energy of rays, which are used for this purpose.

Kilovoltage Therapy

1. Superficial X-rays (50-150 kV)
2. Orthovoltage X-rays (150-300 kV)

Megavoltage Therapy

1. Cobalt gamma rays (1.17-1.33 mV)
2. Linear accelerators (4-25 mV) (1 mV = 1000 kV).

Brachytherapy

Definition

Brachytherapy is defined as the short distance treatment of cancer with a radioactive isotope placed on, in, or near the lesions or tumor to be treated.[11]

The National Council on Radiation Protection (1972) defined the term brachytherapy as a method of radiation therapy in which an encapsulated source or a group of such sources is utilized to deliver gamma or beta radiation at a distance of up to a few centimetres, either by surface, intracavitary or interstitial application.[12]

History

Dr G Forsell in 1931was first to coin the term brachytherapy.[13] Brachytherapy, as a definition, is derived from ancient Greek words for 'short distance' (*brachios*) and 'treatment' (*therapy*), and refers to therapeutic use of encapsulated radionuclides within or close to a tumor.

It is sometimes called Curietherapy (fr. *Curie*), and in many cases, an outpatient procedure used in a treatment of different types of cancer. Since the discovery of polonium and radium by Marie and Pierre Curie in the late 19th century,[14] and the first use of radium in the treatment of cancer in the late 19th century, brachytherapy (as it would eventually be called) is being used in focused and short treatment courses.

In 1901, Pierre Curie suggested to Danlos at St. Louis Hospital in Paris that a small radium tube may be inserted into a tumor, thus heralding the birth of brachytherapy. In 1903, completely independently, Alexander Graham Bell made a similar suggestion in a letter to the Editor of Archives Roentgen Ray. It was found in these early experiences that inserting radioactive materials into tumors caused cancers to shrink.[15]

In the early twentieth century, major brachytherapy work was completed at the Curie Institute in Paris and at Memorial Hospital in New York. Dr. Robert Abbe, the chief surgeon at St. Luke's Hospital of New York, placed tubes into tumor beds

after resection, and later inserted removable radium sources, thus introducing the afterloading technique as early as 1905. Dr. William Myers at Ohio State University developed several radioisotopes, including 198Au, 60Co, 125I, and 32Ph for clinical brachytherapy. These were implanted surgically by Drs. Arthur James (surgeon) and Ulrich Henschke (radiation oncologist).[15,16]

The radioactive material will be encapsulated within the non toxic and inert material like stainless steel or platinum. And these sources come in the form of small needles, wires, rods or spheres. Radium226, Cesium137, Iridium192 and Iodine125 are the most commonly used isotopes and are usually administer in a dose of 65 Gy over 6-7 days when it is used alone.

Types of brachytherapy:[16]

Brachytherapy can be classified into various types and as follows.

Based on the duration of the irradiation

1. **Permanent -** when the seeds (radioactive sources, radionuclides, isotopes) remain inside the body, and
2. **Temporary -** when the isotopes are inserted into a tumor or nearby, inside the body, and then removed.

Based by positioning of the radionuclides

1. **Interstitial brachy therapy:** radioactive sources are inside the tumor. For example, in carcinoma of tongue and buccal mucosa.
2. **Contact brachytherapy or plesiobrachy therapy:** radioactive sources are close to the tumor.

It is divided into four different kinds of brachytherapy:

1. Intracavitary,
2. Intraluminal,
3. Endovascular, and
4. Surface brachytherapy.

Based by the dose rate (ICRU definitions):

1. Low-dose-rate (LDR): 0.4-2.0 Gy/h,
2. Pulsed-dose-rate (PDR): 0.5-1.0 Gy/h,
3. Medium-dose-rate (MDR): 2-12 Gy/h,
4. High-dose-rate (HDR): > 12 Gy/h,
5. Ultra LDR (seeds, permanent implants): 0.01-0.3 Gy/h.

Techniques for Brachytherapy:[17]

Based on the loading it is classified as preload and afterload techniques.

Preload Technique

In the olden days, live radioactive isotopes are kept inside a body cavity. Usually 226 radium was used because of its long half life which was around 1620 years. But the staffs were handling this procedure directly thereby increasing the hazardous effect of the radioactive materials. But nowadays caesium is mostly used.

After Load Technique

This technique was introduced in early 1960s so as to overcome the disadvantage of preload technique. It may be conventional (manual) or remote (automatic).

Conventional (Manual) Afterloading

In manual method the radioactive source is introduced into the tumor through hollow metal or plastic tube, followed by radiography to confirm the postion which will be later sealed.

Remote (Automatic) Afterloading

In this technique machine is used to load a radioactive material in which the plastic tubes are positioned within the patient and then the radioactive material is transferedautomatically with the help of machine and once the treatment is finished, the source comes back into the machine.

High Dose Rate (HDR) Afterloading Equipment:

The HDR system tends to contain a single active source usually 192Iridium, which moves in steps to preprogramed positions. Typical active source is 1 mm in diameter and 4 mm in length. This is soldered to a stainless steel cable, which is mechanically driven in and out of the applicator.

Advantages[10]

1. A high dose of radiation can be delivered directly to the tumor sparing surrounding normal tissue.
2. Treatment time is short.

Disadvantages

1. It can be used only in selected cases especially in the early stage of disease at accessible sites.
2. It requires anesthesia and excellent expertise.
3. It is an invasive procedure.

Indications

Brachytherapy is most commonly used to treat prostate, breast, brain, and cervical cancers. It can, however, be used to treat many other cancers. In general, brachytherapy is an established treatment for prostate cancer. It is a clinically effective treatment for low and high-risk prostate cancer.[18]

Brachytherapy in head and neck cancers:[16,18,21]

Its use in treatment of head and neck cancer has limited clinical data and the oncologist are little reluctant to use brachytherapy as main mode for treating oral cancer probably because of its proximity to vital structures like carotid arteries, jugular veins, nerves and even brain sometimes.[16]

Lip, tongue, and floor of mouth cancers are treated by implantationof plastic catheters. They are inserted using hypodermic needles under general anesthesia. Usually, the needles are inserted in sequence and as parallel as possible to the tumor bed.[18]

Brachytherapy (BT) alone or in combination with external beam (EBRT) and chemotherapy helps in managing the H&N cancers very well. Modern BT is playing an important and successful role in the multidisciplinary treatment of head and neck cancer.

It can be used as a sole treatment for several T1/T2 cancers, and it is also effective in complementary to EBRT as a local dose escalation method, combined with surgery as a small volume radiation with high geo-graphic accuracy.

Major advantages of modern brachytherapy are the use of imaging in BT target definition, the implementation of stepping source technology with the potential for intensity modulation, and developments in medical and physics quality assurance (QA).[20]

Recent advances in BT:[10]

Newer imaging modalities, advanced software and new delivery system promises in improvement in BT for better management of head and neck cancers. The various newer techniques includes 3D Conformal Radiotherapy (3D-CRT), Intensity-Modulated Radiation Therapy (IMRT), Neutron Beam Therapy (Fast Neutron Therapy), Radioimmunotherapy, Intraoperative Radiation Therapy (IORT), Stereotactic Radiosurgery (Fig. 1).

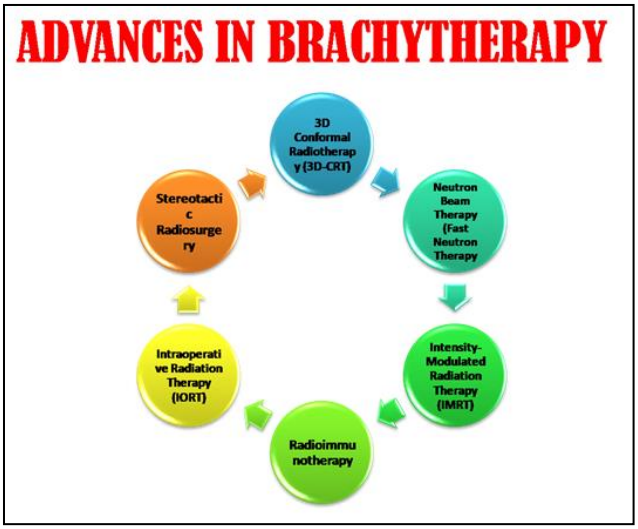

Fig. 1: Advances in Brachytherapy

Conclusion

Radiotherapy plays a major role in management of head and neck cancers alone or in combination with other modalities. The advances in brachytherapy have excelled in recent years thereby promising the future generation in better management of head and neck cancers, thereby reducing the death rates over a period of time.

Source of Funding

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Conflict of Interest

None.

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