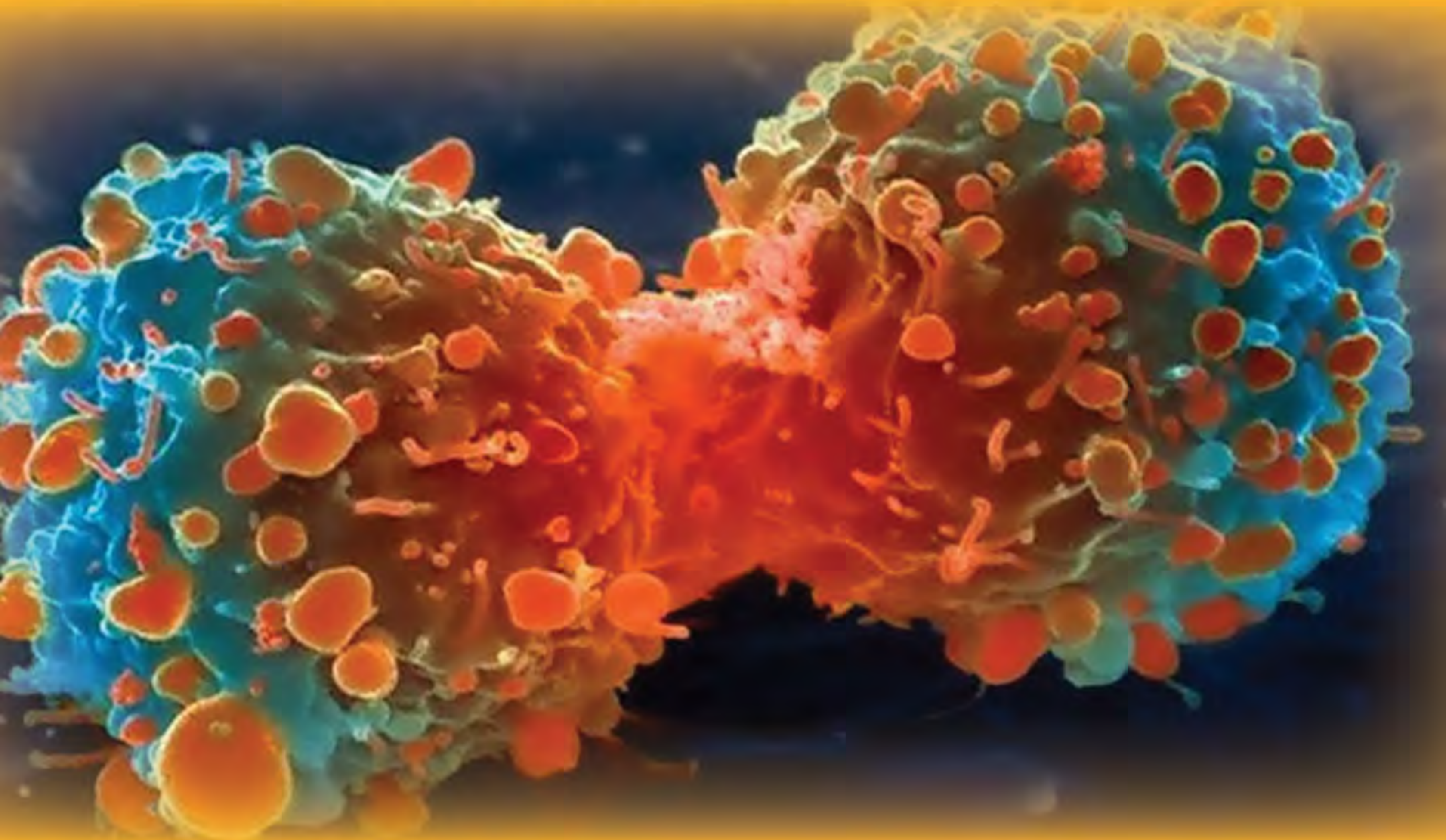
Principles and Management of Cancer



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CHAPTER

Brachytherapy

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INTRODUCTION

Brachytherapy has been variously called as "curietherapy", "internal therapy" or "endocurietherapy". The term "brachytherapy" is derived from the Greek word "brachy" meaning short, based on the distance between the target and the therapeutic radiation source. It is a method of delivering radiation at short distances by placing a sealed radiation source inside or in close contact to the tumor/target area. Unlike external beam therapy where the radiation source is at a distance from the patient and the radiation travels from outside to the deep seated target after traversing the intervening normal tissues, with brachytherapy the radiation source is inside the target and radiation travels from inside to outside. On account of rapid dose fall off, the adjacent normal tissues are preferentially spared. This way large dose can be delivered to the tumor. Inherent to the practice of brachytherapy is precise target localization to achieve treatment accuracy. Brachytherapy can be used in treatment of several cancers and forms an integral form of treatment for some of them.

HISTORY

The year 1895 marked the discovery of a "new kind of radiation" by WC Roentgen. The following year, 1896, was marked by the discovery of natural radioactivity by AH Becquerel. In 1898, Marie Curie successfully announced the discovery of a radioactive element, radium.[1] Within 5 years, brachytherapy was used to successfully treat two histologically proven cases of basal cell carcinoma of the face and an American surgeon, Robert Abbe had used radium applications using a primitive afterloading system to treat cancer in 1905.[2] The term brachytherapy was coined by G Forssell in 1931, he also made considerable contributions in terms of treatment of uterine cancer (Stockholm technique), time-dose fractionation (Strandqvist method) and radiation protection issues.[3] The first 5 decades of the 20th century saw a rapid surge in the use of radium for treatment of cancer. This period saw an equally rapid progress in physics and radiobiology of brachytherapy. During this period dosage systems were formulated and tested for calculation of radiation within a tumor. Next few decades saw rapid developments in use of brachytherapy for gynecological and genitourinary cancer treatments.

PRINCIPLES OF BRACHYTHERAPY

The advantage of brachytherapy lies in delivery of localized dose as compared to external beam therapy. It is feasible only for small localized targets. The radiobiological advantage at cellular level derives from the continuous irradiation of the tumor resulting in a delivery of a much higher biologically effective dose (BED) as compared to the teletherapy. The BED is considered to be 10–20% higher than teletherapy when compared dose for dose.[4]

The correct selection of cases is important. Thus, results of any brachytherapy application depend on the proper placement of the sources within or close to the target area. Since the doses are localized around the source itself, it is mandatory to ensure accurate placement of the source within the area of interest. Several models had been developed governing the distribution of sources within the target volume. It is important to mention the exact model used for placing the sources and for dose calculation, along with the duration of treatment. The source being used needs to be calibrated accurately as per standards of a national or international standard laboratory in order to have consistent dose delivery enabling comparison of outcomes.

CLINICAL APPLICATIONS OF BRACHYTHERAPY

The clinical applications of brachytherapy are given in Table 1.

Table 1 Clinical applications of brachytherapy

Site	*Use of brachytherapy*
Prostate cancer, localized	As primary treatment with implantation of radionuclides with short half-lives emitting low energy photons in range of 30 keV (Iodine 125 or Palladium 103, Gold 198)—permanent implants Can be used for delivering boost doses after a fractionated course of external beam radiotherapy using HDR machines, with Iridium-192 temporary implants
Gynecologic cancers	Intracavitary as part of radical treatment in carcinoma cervix Interstitial implants used for residual/recurrent disease SORBO cylinders or ovoids used for postoperative cases for vault irradiation Radical treatment for early stage vaginal/vulval lesions
Eye plaques	Intraocular melanomas. Usually Iodine-125 seeds (activity 1mCi) are loaded on to plaques of diameters 12–20 mm and placed on surface of the eyeball. Recently, beta-emitting sources like Strontium-90/Yttrium-90/Ruttenium-106 have been used
Head and neck cancers	For early stage oral cavity lesions (lip, tongue, buccal mucosa, floor of mouth). In experienced hands, certain oropharyngeal primaries can also be taken up for boost treatment Certain recurrent head and neck cancers
Breast cancers	As boost treatments in cases of breast conservative surgery along with fractionated external beam radiotherapy As the sole treatment for selective group of patients as accelerated partial breast irradiation
Soft tissue sarcomas	For postoperative treatments—as sole radiation or as boost along with external beam radiotherapy
Anorectal cancers	As boost along with fractionated EBRT or in cases of residual/recurrent disease as role modality of treatment
Lung	Permanent implants placed preoperatively for treatment of early stage tumors Intraluminal brachytherapy can be used as palliation for advanced cases with endobronchial disease
Esophagus	Intraluminal brachytherapy for dysphagia palliation
Hepatobiliary malignancies	For maintaining patency of intraluminal stents placed to relieve biliary obstruction due to disease
Intravascular	Used to delay/prevent restenosis of intravascular stents Radionuclides usually used are Iridium-192, Yttrium-90, and Strontium-90 for afterloading techniques. In case of inflatable balloons, Xenon-133, Rhenium-186 and Rhenium-188 are used In case radioactive stents are placed then the radionuclide used is Phosphorus-32 or Vanadium-48.

Abbreviations: HDR, high-dose-rate; EBRT, external beam radiation therapy.

CLASSIFICATION OF TYPES OF BRACHYTHERAPY

The classification on the types of brachytherapy is given in Table 2.

PROPERTIES OF AN IDEAL SOURCE

- Gamma ray emission energy should be high enough to avoid photoelectric effect-induced energy deposition in bones and prevent scatter while being low enough to have minimal radiation protection requirements
- High specific activity
- Source itself should be available in a nontoxic insoluble form. It should not be in powder/liquid form to avoid spillage in case of breakage of the source capsule
- Charged particle emission should be negligible or be easily screened
- It could be manufactured in various shapes and sizes

Table 2 Types of brachytherapy

Type of implant	• Temporary • Permanent
Placement of sources	• Interstitial • Intracavitary • Intraluminal • Intravascular • Surface molds
Dose rate	• Low-dose rate: 0.4–2 Gy/hr • Medium-dose rate: 2–12 Gy/hr • High-dose rate: greater than 12 Gy/hr • Ultra low-dose rate: 0.01–0.3 Gy/hr • Pulsed dose rate
Source loading	• Hot loading • Afterloading
Emitted rays	• Gamma ray emitter • Beta ray emitters

- Half-life should be long enough to avoid decay correction during treatment duration
- Decay products should not be gaseous
- Should not get damaged during the process of sterilization.

RADIONUCLIDES AND THEIR PROPERTIES

Each radionuclide has certain distinctive properties on the basis of the inherent physical properties. These physical properties are:

- *Radioactive decay:* Type of radiation depends on the radioactive decay scheme of the particular radionuclide, i.e. whether it is a photon or beta particle or neutron emitting source and this in turn determines the possible form and general design of the source.
- *Half-life:* Time taken for the source to decay to half strength (half-life) determines whether it can be used as a temporary implant or a permanent implant. Duration of half-life has economic implications also, as it determines the number of times source renewal is needed in any department. Half-life and maximal specific activity are inversely related.
- Specific activity determines the maximal dose rate and also the extent of miniaturization of the source physically.
- Energy basically refers to the energy of the emitted radiation, which in turn determines linear energy transfer (LET) value, the biological effectiveness, the depth of penetration in the tissues and thus the amount of shielding required. Thus, energy too has economic implications for any department.
- Density and atomic number determines the radiographic visibility of the source and also the extent of attenuation and absorption within the source, thus affecting the isotropy of the dose distribution.

Brachytherapy sources in clinical use are given in Table 3.

Radium

This was the first radioactive source to be used for brachytherapy. It is naturally occurring and emits 49 photons with energies varying from 0.184 to 2.45 MeV. The average energy of an encapsulated radium source (filtered with 0.5 mm Platinum) is 0.83 MeV. The high energy beta and alpha particles emitted are stopped by the encapsulation material.

Cesium-137

It is a gamma ray emitting radioisotope with energy 0.662 MeV. It has a long half-life and requires less shielding than radium. It is available in the form of insoluble powders or microspheres. The beta rays and characteristic X-rays are absorbed by the stainless steel container.

Iridium-192

It is used as a temporary implant radioisotope with a half-life of 73.8 days and has a complex gamma ray spectrum with an average energy of 0.38 MeV. It is available in the form of thin flexible wire and series of tiny seeds (3 mm long, 0.5 mm diameter) contained in nylon ribbon. It is used for high-dose-rate (HDR) brachytherapy.

Iodine-125

It is used for permanent implants and emits gamma rays of energy 35.5 keV.

Palladium-103

It is used for permanent prostate implants and decays by electron capture with emission of characteristic X-rays in energy range of 20–23 keV and Auger electrons.

Table 3 Brachytherapy sources in clinical use

Radionuclide	*Half-life*	*Photon energy [MeV]*	*Half-value layer (mm Pb)*	*Tenth-value layer (cm of concrete)*
Ra-226	1600 years	0.047–2.45 (0.83 avg)	12.0	Approx 25.0
Rn-222	3.83 days	0.047–2.45 (0.83 avg)	12.0	Approx 25.0
Cs-137	30.0 years	0.662	5.5	Approx 15.0
Co-60	5.26 years	1.17, 1.33 (1.25 avg)	11.0	Approx 20.0
Ir-192	73.7 days	0.136-1.06 (0.38 avg)	2.5	14.7
I-125	59.4 days	0.028 avg	0.025	Approx 2.0
Pd-103	17.0 days	0.021 avg	0.008	< 1.0
Au-198	2.697 days	0.412	2.5	Approx 14.0

Abbreviations: Avg, average; Approx, approximate.

TYPES OF SOURCES

Brachytherapy sources are sealed sources in contrast to the nonsealed ones like Iodine-131, Phosphorus-32, Strontium-89, Yttrium-90, etc. that can be ingested or administered intravenously. The double encapsulation of sources provides rigidity to the source; prevents leakage of radioactive materials and absorbs alpha rays and beta rays. A brachytherapy source can produce gamma rays (through gamma decay), characteristic X-rays (electron capture and internal conversion), characteristic X-rays and bremsstrahlung from the source capsule.

These sealed sources can be further classified on the basis of the type of emission, viz.:

- Predominantly photon sources emit gamma rays and characteristic X-rays: Cobalt-60, Cesium-137, Iridium-192, Iodine-125, Palladium-103
- Beta sources emit electrons: Strontium-90, Yttrium-90
- Neutron source emit neutrons following spontaneous nuclear fission: Californium-252.

Selecting the appropriate photon emitting radionuclide depends on the photon energy and its penetration depth, the half-life of the radiation source, specific activity and source strength. Apart from the clinical considerations, the radiation safety requirement also depend on the photon energy, half-value layer of shielding materials and the inverse square fall off of dose with distance.

Photon emitting brachytherapy sources are available in various physical forms, viz.:

- Cesium-137: Needles, tubes, pellets
- Cobalt-60: Pellets
- Iridium-192: Wires, seeds
- Palladium-103, Gold-198
- Iodine-125: Seeds

ROOM SHIELDING

Shielding requirements for the general public, the limit is 0.1 rem (1 mSv) in 1 year and for occupational exposure, the limit is 5 rem (50 mSv) in 1 year. Less than 2 mrem (20 mSv) in any 1 hour in any unrestricted area.

DOSIMETRY UNITS AND SOURCE SPECIFICATION

Early brachytherapy was practiced with Radium-226 and its daughter product Radon-222. Till early 1950s, the source strength was specified in terms of mass of radium in mg (mgRa). Time factor was not specified as it was regarded to be unnecessary given the long half-life of radium, thus mass specification rectification was not needed during a period of approximately less than 20 years, i.e. during normal working life of the source. Dosimetry at that time was in terms of milligram-hours (mgh) for Radium or millicuries-destroyed (mcd) for radon.

With advent of artificial nuclides, source strength was defined in terms of activity content expressed in mCi. However, this was limited by the fact that there was autoabsorption and filtration of emitted gamma rays by the source and its sheath.

To overcome these shortcomings, the concept of apparent activity was introduced. Apparent activity was defined as the activity of a hypothetical ideal point source that had no self-absorption or attenuation and had the same radionuclide that delivered the same exposure rate in air at the specified distance equal to that of the actual source under consideration. The distance was to be large enough to enable the source to be considered as a point source (taken to be 1 m). Apparent activity took into account effects of attenuation, filtration, self-absorption and production of bremsstrahlung X-rays in the source and its capsule.

The vast experience available with radium and the availability of dosage and dosimetry charts was helpful when using radium substitute nuclides. Thus, the term milligram-radium equivalent (mgRa equivalent) was formulated. Radium equivalent mass was defined as the mass in milligram of radium filtered by 0.5 mm Platinum resulting in the same exposure rate as that from the source at a distance of 1 m in air.

These terms were adequate to specify the source itself, but for reporting dose rates in tissue there was a need for a unit that could link the radiation output to the activity. The term specific gamma ray constant and exposure rate constant were thus coined. However, these quantities were characteristic of the radionuclide itself, but not for the source and did not take into account self-absorption or filtration due to encapsulation.

SOURCE SPECIFICATION

Gamma ray sources can be specified in terms of reference air kerma rate in air, air kerma strength, exposure rate in air, air kerma rate in air. Gamma ray sources are specified in terms of reference air kerma rate in air at 1 meter, corrected for air attenuation and scattering. The reference point is perpendicular to the length of the source at its central point. The SI unit for reference air kerma rate is Gy/s.

Beta ray sources can be specified in terms of reference absorbed dose rate in water at a reference distance from the source. The reference distance can vary with type of source however; it is generally between 0.5 mm and 2 mm from the source.

Exposure rate constant is defined as the exposure rate at a distance "d" from a point radioactive source of activity "A". Exposure is the total charge of ions of same sign produced in air when all electrons liberated by photons in air of mass are completely stopped in air. Unit is R and $1R = 2.58 \times 10^{-4}$ C/kg of air (Table 4).

Table 4 Exposure rate constant for various sources

Source	*Exposure rate constant ($R\ cm^2/mCi\ h$)*
Ra-226, Pt-filtered	8.25 $R\ cm^2/mgRa\ h$
Co-60	13.07
Au-198	2.35
Ir-192	4.69
Cs-137	3.26
I-125	1.46

DOSE RATES

Initially radium was the only isotope available for brachytherapy. The dose rate was low and the treatment time was measured in terms of days. Much later, with development of technology, the International Commission of Radiological Units (ICRU) proposed well-defined criteria for dose rates, viz. low-dose-rate (LDR) as 0.4–2 Gy/hour, medium-dose-rate (MDR) as 2–12 Gy/hour, and HDR as more than 0.2 Gy/minute.

IMPLANT DOSIMETRY SYSTEMS

Treatment planning entails determining the type and distribution of radioisotopes to achieve an optimum dose distribution so as to provide the planned dose distribution in the irradiated volume. Many dosimetric systems have been formulated in the past for interstitial implant treatment planning. These systems were formulated in the era when computers were not available for routine treatment planning and tables were provided with details of total dose delivered as a function of area or volume to be treated. This information was then used to plan the procedure by manually calculating the required number of sources and their arrangement so as to achieve the desired treatment. Two of these, Paterson-Parker and Quimby system were the most commonly used ones. These systems were developed for radium sources (unfiltered) in air. Tables were also available for 0.5 mm and 1.0 mm Platinum filtered sources. Oblique filtration, photon scattering and attenuation in tissue were not taken into account. They were applicable for radioactive sources emitting photons of energy more than 200 keV.

With availability of computers, isodose distributions could be calculated for each patient individually, thus, allowing greater degree of freedom for planning brachytherapy. These systems are used today as guiding principles for implanting sources.

Manchester System

This system was envisaged to deliver a uniform dose (within ± 10%) to a plane or volume. There were rules for source distribution so as to achieve a uniform dose, and dosage tables were provided for dose calculation. The tables were designed to provide milligrams-hours per 1,000 roentgens (mg-h/1000R) for implants. Patterson-Parker roentgens in tables could be converted to cGy in tissue after correction (using exposure rate constant and roentgen-cGy factor 0.957). Apart from gynecological treatments, three different types of implants were described: molds, interstitial planar and volume implants.[5,6]

Molds

Radioisotopes were positioned outside the patient, usually at a distance "d" from the patient's skin called the treatment distance. Dose prescription is to the plane at a distance "d" from the sources and dose within this plane was supposed to be ± 10% accurate. Sources could be arranged either in circles (preferable) or squares. Loading of source activity was dependent on the ratio of the circle diameter to the treatment distance, while in case of squares it was dependent on the ratio of the side of square to the treatment distance.

Planar Implant

Dose uniformity was achieved in parallel planes at a distance of 5 mm from the plane of implantation and within the area bounded by the peripheral needles. Depending on the size of the implanted area, the ratio of radium in periphery versus the area varied. The space between needles was not to exceed 1 cm and if the ends of the implant were not crossed by a needle then the effective area of dose uniformity was reduced by 10% for each uncrossed end. For multiplane implants the planes were supposed to be parallel to each other.

Volume Implants

When 3D distribution was akin to a cylinder, sphere or cuboid, then the distribution rules were different from those of a planar implant. The distribution for cylinder was—4 parts in belt, 2 parts in core, 1 part on each end; for sphere—6 parts in shell and 2 parts in core while for cuboid it was 1 part for each side and 2 parts in core. For uncrossed ends of volume implants, deduction of 7.5% volume was done for table reading.

Quimby System

Basically, Quimby system was an adaptation of the Manchester system. It was formulated to overcome the problem faced by radiation oncologists in fulfilling the requirement of lower linear source strength in the center of implants as mandated in Manchester system. The distribution rules were relaxed so that uniform linear source strength sources could be used and the activity be uniformly distributed. Although the dose homogeneity was not as good as Manchester system, the inhomogeneity was considered clinically acceptable.

Therefore, uniform strength needles were used throughout the implant and the desired activity was achieved by increasing the source separation in the center of the implant. Rules were same as those of Manchester for uncrossed ends.[7-9]

Paris System

This system was designed for modern radioisotopes, especially Iridium-192, that were flexible, had narrow diameter and may be formulated in any desired length. Sources were distributed as per specified rules, over a predefined treatment volume and dose was calculated at specified points (basal dose rate points) within the target volume. Calculating 85% of the average basal dose rate denoted the isodose that would encompass the target volume. The sources were implanted equidistantly and in parallel to each other. Ideally, centers of all linear sources were supposed to be in a single plane that bisects the sources perpendicularly, called the central plane. The source separation for short wires (≤ 50 mm) to be in the range of 8–15 mm and 8–22 mm for longer lengths (≥ 70 mm). The reference air kerma per unit length of source was constant for all sources within the implant.[1,10,11]

Gynecologic Cancers: Manchester System

Cancer Cervix

It was initially formulated for radium tubes and was later adapted for afterloading systems also. Within the system rules specify the spatial distribution of sources, the relative activity and the points for dose calculation. The applicators were specially designed for the purpose of intracavitary applications and consisted of a central tandem that could be inserted into the uterine cavity with an outside flange that abuts against the cervix and a pair of ovoids that were placed in both fornices. Different sizes of tandem and ovoids were available and the key feature was the uniform dose rate that could be achieved at point A with any combination. Point A defined as a point situated 2 cm cranial to the lateral fornices in the plane of the uterine tube and 2 cm lateral to the center of the uterine canal. Doses were prescribed to point A.[12]

Uterine Body Cancers

Similar applicator, with a uterine tube (1 cm diameter) and ovoids were used in conjunction. The loading patterns were different from intracavitary cervix ones and higher dose was delivered by the uterine sources.

Computerized Treatment Planning

Historically, treatment planning in brachytherapy involved use of systems that specified source distribution and provided lookup tables for dose calculation. This was quite empirical and deviations from the system rules resulted in major uncertainties. With availability of computers, the resultant isodoses could be visualized in three dimensions. Additionally, the dose distributions could be evaluated by means of dose volume histograms and not visual display alone. Use made of uniform strength sources that were spaced uniformly at a distance of 1–1.5 cm. The active length of sources kept at 30–40% longer than the target length as the ends were uncrossed. The target volume was defined prior to the procedure and the appropriate length of needles and spacing decided beforehand. Dose prescription based on the isodose surface that completely encompassed the target volume.

The major steps involved in computerized treatment planning were:

- Source localization: Source localization to be done by any of the three available methods; orthogonal imaging method, stereo-shift method or recently by use of CT scan
- Dose calculation around sources
- Evaluation of target volumes, critical organs and dose distributions in 3D format
- Dose optimization
- Plan evaluation using dose volume histograms.

Interstitial Brachytherapy

Alexander Graham Bell first suggested implanting radiation sources into tumor tissues for treatment. The technique involves directly implanting sealed radioactive sources into the tumor in specified fashion, the geometric distribution dictated by the existing dosimetric systems. Interstitial brachytherapy could be either temporary or permanent implants. Usually, Paris system rules are used for interstitial implants.

This can be further classified as "hot loading" when sources are directly implanted into the tissues or "afterloading" when hollow tubes/needles are implanted into the target tissue initially and then these are connected to remote afterloading machines that load the hollow tubes and needles. Remote afterloaders could be LDR, HDR or pulsed dose rate (PDR). Remote afterloaders entail use of a safe housing assembly for storing the radioisotopes, a system that controls the source and the driving mechanism remotely, a source transfer tube and treatment applicators that are hollow and source can be placed inside them. The entire assembly is controlled by a remote operating console and the treatment plans are generated on a dedicated treatment planning computer. Radiation exposure to personnel is negligible when using the afterloading technique.

The usual radionuclides used in remote afterloaders are Cobalt -60, Cesium-137 and Iridium 192; of these, Iridium-192 is used most widely because of its medium gamma ray energy (400 keV) and its high specific activity.

DOSE SPECIFICATION AND REPORTING

As per ICRU report 38 and 58, recommendation is made for use of uniform and standardized methodology for dose reporting so as to enable data comparisons between different centers. The following needs to be reported for all implants:

- Implant description
- Volume of interest
- Prescribed dose
- Delivered dose
- Reference air kerma rate in air (cGy/h at 1 m).

For gynecological brachytherapy treatments, ICRU 38 mandates reporting of the following:

- Description of technique
- Description of reference volume and its dimensions
- Dose at reference points
- Time and dose
- Reference air kerma rate in air (cGy/h at 1 m).

For interstitial implants, as per ICRU 58, the following parameters need to be reported:

- Clinical target volume
- Type of source, technique and treatment time
- Prescribed dose and achieved dose distribution
- Mean central dose and minimum dose required for tumor control
- Description of the low dose (regions receiving less than 90% of the peripheral dose) and high-dose regions (regions receiving more than 150% of the mean central dose) and indices of dose uniformity
- Dose volume histogram data
- Reference air kerma rate in air (cGy/h at 1 m).

ADVANCES IN BRACHYTHERAPY

Image-Assisted Brachytherapy

Imaging is used to acquire 3D volumetric information of the target. The imaging modalities in use are CT scans, MRI scans, USG, PET CT scans. This information enables generation of a provisional treatment plan prior to procedure. This same information is used to place the sources appropriately. Subsequent imaging enables generating a 3D dose distribution and accuracy can be ensured during treatment delivery. This can be subdivided as follows:

Image-based Brachytherapy

Information from imaging modalities is incorporated into assessment of target volume and for planning volumetric dose delivery.

Image-Guided Brachytherapy

Imaging techniques are used for guiding placement of the radiation sources and for planning volumetric dose delivery.

Electronic Brachytherapy (AXXENT)

It comprises of a 30–50 KV miniature X-ray tube that is attached to a high voltage cable and the assembly is retractable and flexible akin to HDR source assembly.

Pulsed Dose Rate Brachytherapy

Continuous LDR brachytherapy had been in use for cancer cervix for many decades and the results have been outstanding. At the time of conversion to HDR brachytherapy, for the ease of delivery to patient and personnel as well as better radiation safety profile, several trials were conducted against the "gold standard" LDR treatment. Only when the outcomes were reported to be equivalent, HDR brachytherapy became routine practice in most hospitals. Given the excellent results of LDR and the ease of delivery of HDR, it was envisaged to combine the advantageous points of both dose rates and hence PDR was derived. The PDR system uses a single stepping Iridium-192 source, which has a lower activity (37–74 GBq at installation) as compared to about 370 GBq activity of a HDR source at installation. The technique involves delivering a "pulsed" dose for about 10–40 minutes every hour, so that a fraction of the total prescribed dose is delivered in pulses every hour over a 48-hour time period. This imitates the biologic effectiveness of classical LDR treatments while improving the delivery technique by using computerized optimization.

Gliasite Radiation

It is a liquid source brachytherapy system used for treating intracranial metastatic or recurrent tumors. It is a balloon-shaped device filled with "lotrex", i.e. liquid iodine (I-135), that is implanted into the tumor cavity and can deliver radiation doses to the wall of the cavity. The catheter at the other end of the balloon is implanted outside the cranium into a distal inflatable balloon. Lortex can be delivered in several small doses or as a single dose into the balloon.

Accelerated Partial Breast Irradiation

With acceptance of breast conserving surgery (BCS) as a standard of care in cancer breast, whole breast radiotherapy (WBRT) followed by local boost became established as an integral part of treatment protocol. Results of BCS + WBRT + boost were equivalent to those of mastectomy. Accelerated partial breast irradiation (APBI), as radical treatment in place of WBRT + boost, has been found to have comparable outcomes with limited toxicity in select group of patients.

CONCLUSION

Brachytherapy is the most conformal treatment that can be delivered. It requires expertise at all steps and with proper application and planning, it has contributed toward improving local control rates at many sites. Modern brachytherapy utilizes the currently available imaging modalities and such a practice has resulted in dramatic improvements in treatment of cancer cervix and prostate. Careful handling of the radionuclides and proper disposal of these sources is the need of the hour. Stringent rules and regulations have been formulated to ensure that radiation accidents do not occur. The major impediment for widespread use of brachytherapy is the rising cost of the radionuclides. With availability of superior linear accelerators that can deliver highly conformal treatments that are nearly comparable to brachytherapy, the high maintenance cost of brachytherapy needs to be addressed, in order to ensure that the practice of brachytherapy continues to be in use.

Specific brachytherapy techniques have been described in the specific chapters.

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Principles and Management of

Cancer

Principles and Management of Cancer tries to bridge the gap in the practices of cancer treatment in a holistic manner.

Oncology, or the study of cancer, includes cancer genomics, cell biology, tumor pathology, staging, investigations, and treatment of patients suffering from cancer. The approach of the book is to arrange the chapters according to different sites and to present a supportive literature on surgical principles, radiation-therapeutics, and chemotherapeutic management of cancers. The book provides an insight into the radiobiological principles of radiation therapy, newer techniques of laser and minimally invasive surgery, critical organ sparing treatment delivery in radiation therapy, nutritional support for a cancer patient and guidelines on pain management. Acute emergencies have been dealt with as a separate chapter without any attempt to cover the critical care of such cases.

The chapter on clinical trials is a guideline on such a complex subject and gives a clue to the drug development process. The need for multimodality treatment to cure cancers and minimizing toxicity is emphasized throughout the book.

Radiation therapy is the principal method of treating cancer patients and this book highlights the stages of cancers where radiation can provide optimal benefit alone or as an adjunct to surgery and/or antineoplastic agents.

The book aspires to serve as a ready reference for the students of oncology, practitioners, clinicians, general physicians and oncologists. We hope it finds a space on the book shelf of the healthcare givers reaching out to cancer patients.

Tejinder Kataria MD DNB CCST FIMSA is the Chairperson, Division of Radiation Oncology, Medanta Cancer Institute, Medanta—The Medicity, Haryana, India. She is an alumnus of Indira Gandhi Medical College, Shimla, Himachal Pradesh and Postgraduate Institute of Medical Education and Research, Chandigarh, India. She has had her advanced training at Cookridge Hospital, Leeds, West Yorkshire, England; Royal Marsden Hospital, London; Christie and Holt Institute, Manchester; German Cancer Research Venter (DKFZ), Heidelberg, Germany; Mannheim Klinik, Mannheim, Germany; Klinik und Poliklinik fur Strahlentherapie, Universitatsklinikum, Wurzburg, Germany, and Brigham and Women's Hospital, Harvard University, Boston, MA, USA.

Dr Kataria has brought the finer technique of radiation delivery to her country of origin and established these techniques for patient care in the last 19 years. Her intent towards minimizing the radiation toxicity for curative purpose in cancer made her learn brachytherapy, conformal techniques, intensity modulation, image guidance and stereotaxy. She has an excellent clinical acumen besides a humane approach towards patients.

Dr Kataria has been the recipient of FICCI Aadhi Abadi Women Achievers Award in 2014 and National Excellence Award in 2003.

Hemant Singhal FRCSED FRCSC MBA is a graduate and postgraduate of All India Institute of Medical Sciences, New Delhi, India. He was trained in General Surgery and Surgical Oncology at the Royal Marsden Hospital, London and St Georges' Registrar rotation. He was a Fellow at Cornell University, New York, USA and a Lecturer in Surgical Oncology at The University of Western Ontario. He completed his specialist training in Breast and Reconstructive Surgery, at the Cardiff Breast Unit. Dr Singhal was Clinical Lead for North-West London Hospitals Breast Service and Senior Lecturer at Imperial College, London prior to taking a sabbatical to set-up a state-of-the-art Breast Service at Medanta—The Medicity, Haryana, India.

Dr Singhal is a part of the multidisciplinary team and works to establish a firm diagnosis and personalizing breast cancer treatment. He is an accomplished and recognized breast cancer specialist who has been instrumental in setting up the Sentinel Node Program in North-West London. He is passionate about breast conservation with an oncoplastic approach and the early diagnosis of breast cancer. At present, he is working in London and has keen interest in early diagnosis of breast cancer, screening of women at high-risk family history, treatment of all breast diseases, sentinel node biopsy, breast conservation and oncoplastic breast surgery and personalizing breast cancer treatment.

Dinesh Chand Doval MBBS MD has an illustrious career in oncology since the past twenty-five years during which he has made an outstanding contribution in the field of cancer research. He is an acclaimed clinician and a teacher of repute who has mentored numerous medical oncologists, who are practicing in the eminent institutes both in India and abroad. He has participated over 100 clinical trials and has more than 110 publications to his credit out of which 80 are in peer-reviewed high-impact factor journals. He has been bestowed upon with many awards and recognitions during his career, that are DMA Chikitsa Rattan 2014, Americare Clinical Excellence (runner-up) 2012, Chikitsa Siromani ISS Delhi 2007, and Wockhardt Medical Excellences. His present commitment at RGCI and RC has won him many accolades. The institute under his leadership has achieved a pinnacle in imparting cancer care. For his unfathomable contribution, the institute has conferred upon him an Excellence in Clinical Research Award 2011 and Outstanding Contribution Award 2014.

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