OVERVIEW of RADIATION THERAPY & ASSOCIATED TERMINOLOGY

AHEC

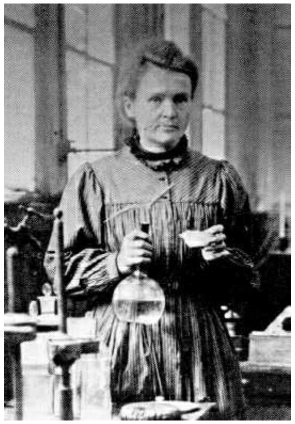
Objectives
Upon completion of this presentation attendees will be able to:

- Define Brachtherapy & Teletherapy
- Discuss the History of Brachytherapy
- Differentiate between interstitial and intercavity implants
- Differentiate between permanent and temporary implants
- Describe the various radionuclides and the special considerations applicable to their use.
- List one treatment advantage of Brachytherapy
- List one treatment advantage of Teletherapy

Associated Radiation Therapy Terminology
Upon completion of this unit attendees should be familiar with common terms utilized in teletherapy practice.

- Percent depth dose
- Dmax
- Isocenter
- SSD
- Isodose

Brachytherapy
History & Applications



In 1902, after fours years of work on tons of pitch blend ore, Madame Curie was able make the first decigram of Radium. This was the first radioactive substance used for cancer treatment.

Unaware of their peril, these technicians engaged in purifying radium are leaning, without protection, over open dishes of radium salts.

Radium was used in interstitial, intracavitary and mold treatments. The use of Radium in teletherapy was limited due to the unfavorable characteristics of Radium as a teletherapy source. Also, the high price of Radium ($150,000 a gram in 1903) limited the use of Radium. Despite these limitations, several teletherapy devices termed "Radium Bombs" were in use by the 1920's.

A radiation unit (the Curie) was established. One Curie was equal to the activity of one gram of radium. Radium dosage for cancer treatment was determined by the number of milligram hours of radium treatment. Since radium was the only radioactive substance available for treatment, the initial treatment experience gained was with dosage in "milligram hours" of Radium.

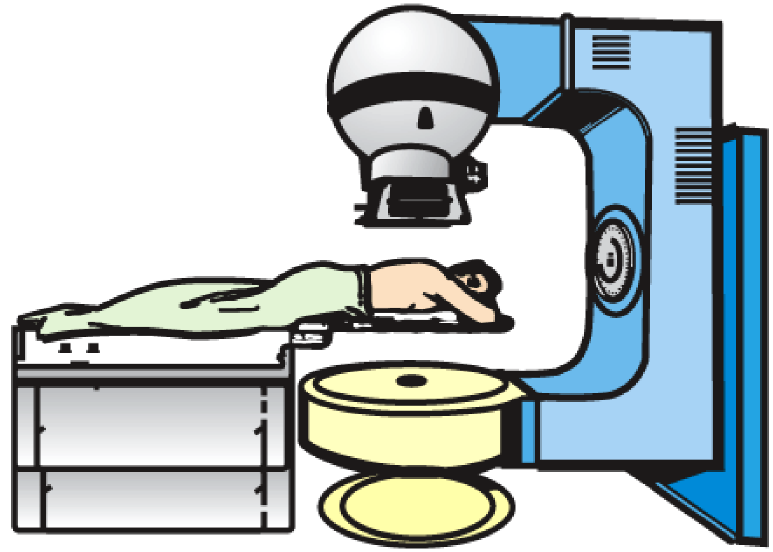
External beam treatment

Treatment from a source of radiation "external" to the patient's body.

Teletherapy - Treatment at a Distance

Teletherapy is the use of a large activity of high energy radionuclide to expose a patient at a great distance, so as to treat tumors at a depth The source is in a head, which contains lead or depleted uranium, with a port for treatment. The head is for shielding. Collimators of lead or depleted uranium are used to define the field size.

Figure 35 - Cobalt-60 Teletherapy Unit



Source: 3 to 12 kiloCuries of Co-60

Energy: 1.17 & 1.33 MeV (1.25 average MeV)

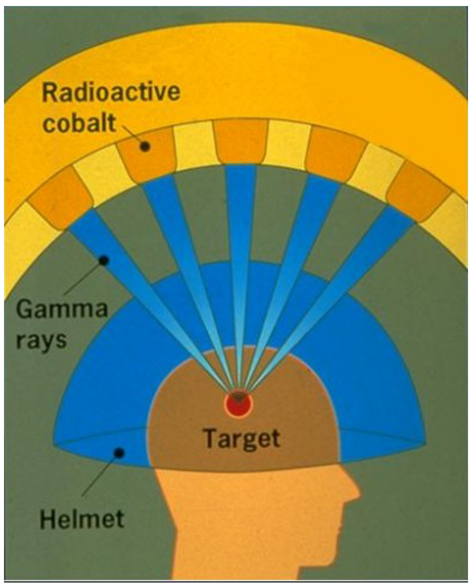
Treatment distance: 80 to 120 cm Source to Skin Distance (SSD)

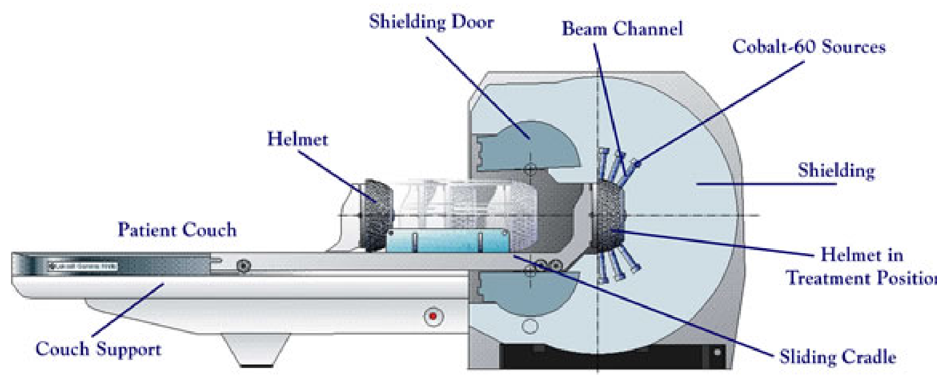
Output 50-200 rad/min.

Cs-137 Teletherapy

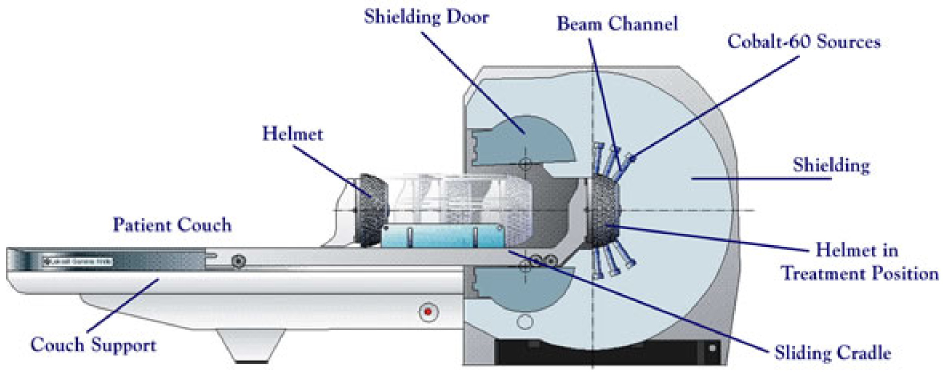
Cs-137 teletherapy units were formerly used by a few facilities. Few, if any, remain. The energy is not penetrating enough (662 keV).

Co-60 Gamma Knife

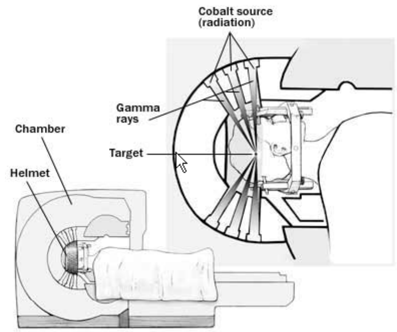


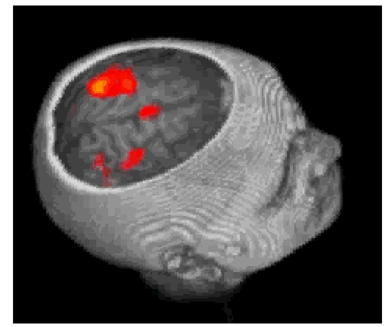


Cobalt 60 Gamma Knife - 201 small cobalt 60 sources are positioned so that their beams focus at one point. These devices are usually used for both malignant and benign intracranial tumors.


Shielding Door
Beam Channel
Cobalt-60 Sources
Helmet
Shielding
Patient Couch
Helmet in
Treatment Position
Couch Support
Sliding Cradle

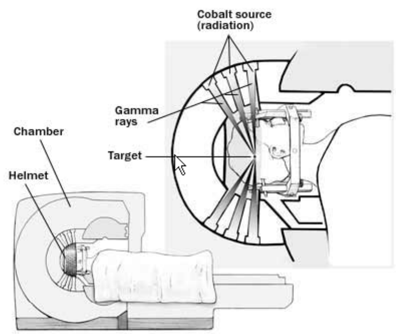
Stereotactic Radiosurgery

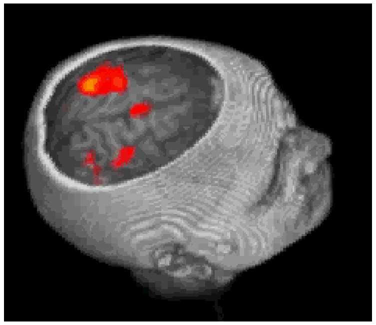




Stereotactic radiosurgery uses multiple beams of radiation converging in three dimensions to focus precisely on a small volume of tissue, such as a tumor, permitting intense doses of radiation to be delivered to that volume safely. These devices are usually referred to as a **gamma knife**. Treatment is fractionated over several days.

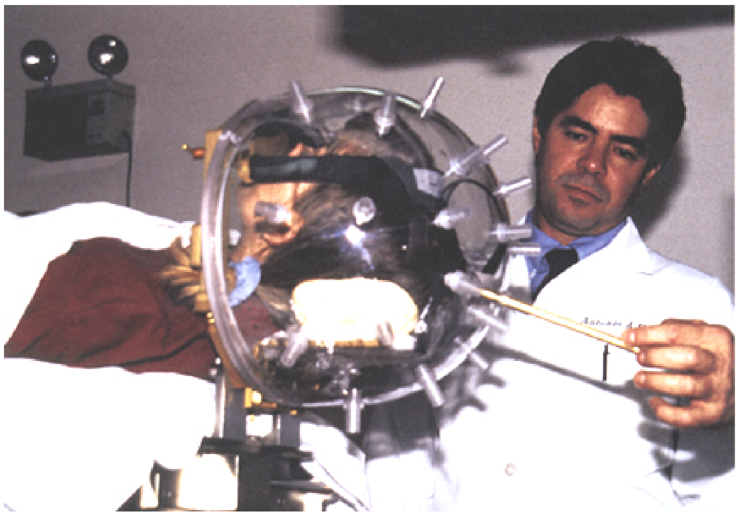
Stereotactic Radiosurgery

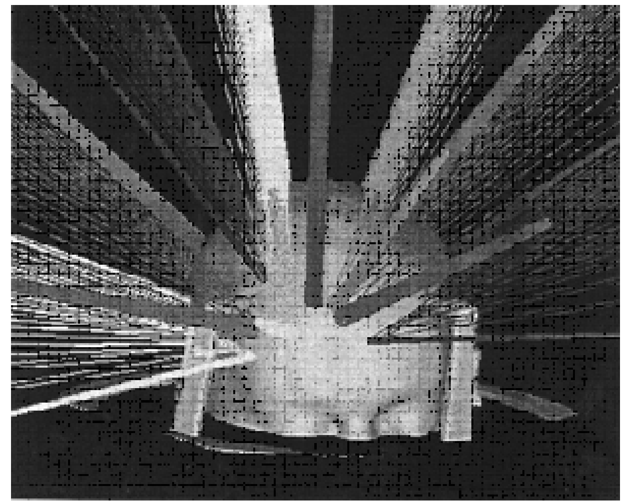




The patient is placed under local anesthesia while a special head frame that has three-dimensional coordinates built into it is attached to the patient's skull with four screws. Treatment planning is done via computer which has the ability to integrate information from CT, MRI, or a catheter angiogram.

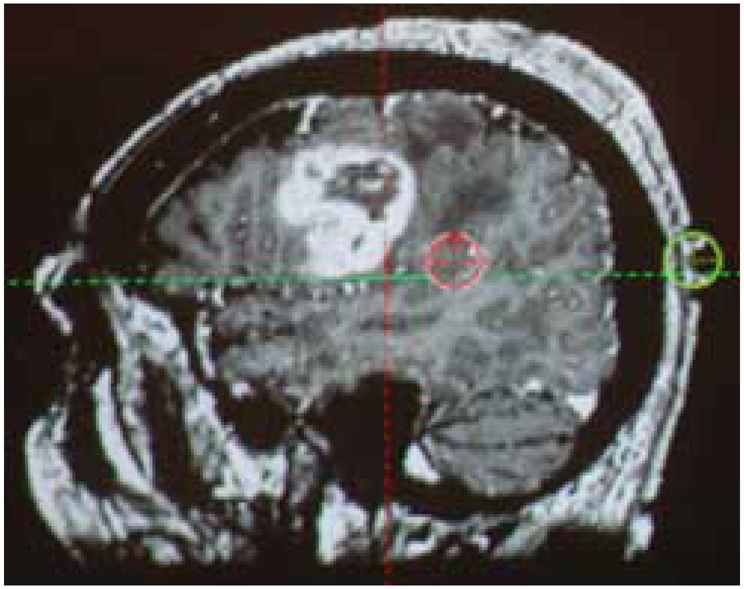
Stereotactic Radiosurgery

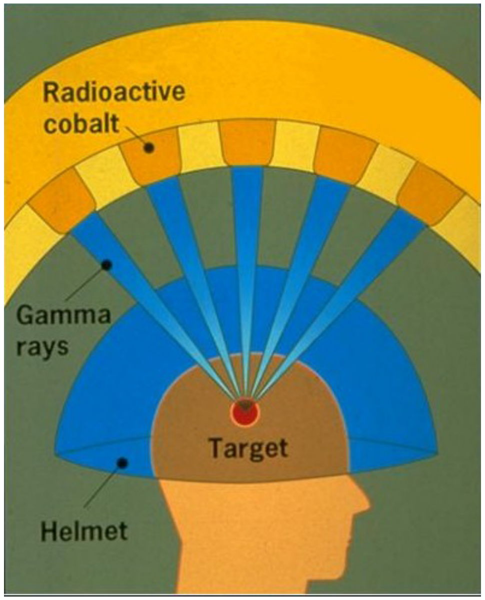




Multiple isocenters -Tumor targets are best treated by combinations of several aimings, commonly known as "shots", thereby producing an optimal treatment plan.

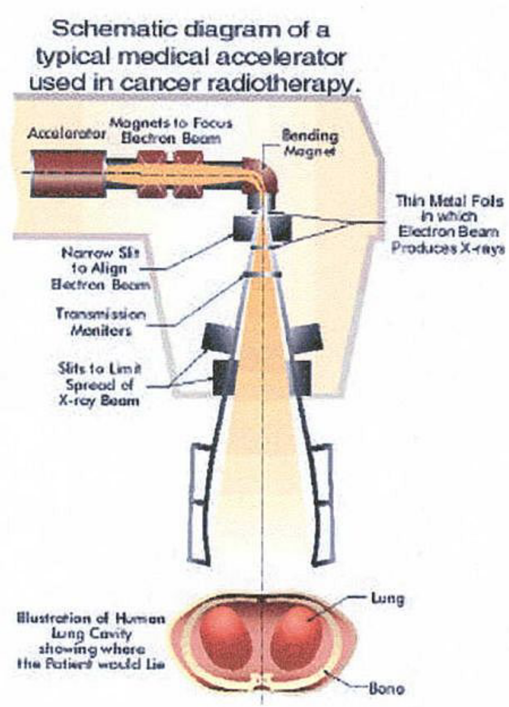
Stereotactic Radiosurgery



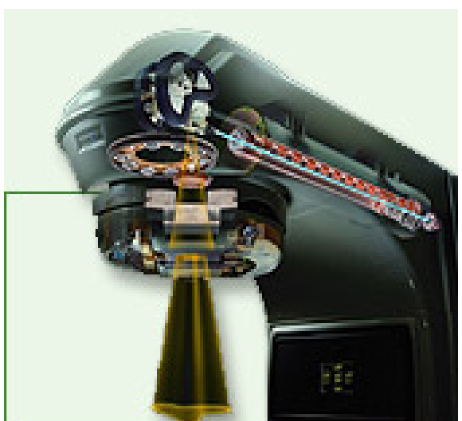


The gamma knife loses its ability to spare the surrounding normal tissue as the number of targets increases and it is not suitable for large targets (larger than 3 to 4 centimeters) and can not be used for targets outside the head.

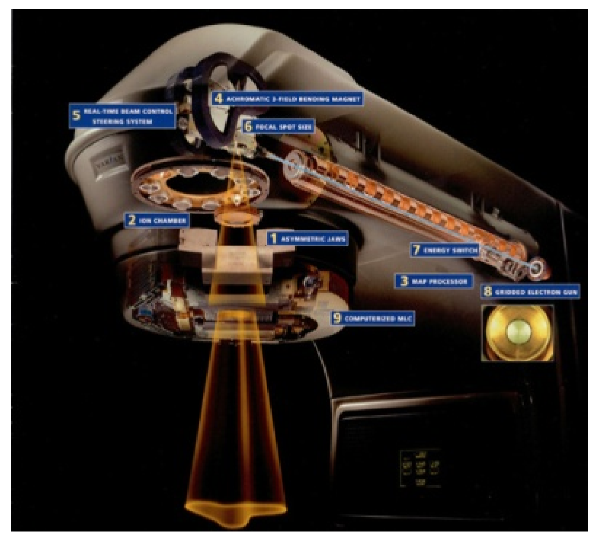
Linear Accelerator



Linear accelerators are replacing Co-60 units. The 4 MV accelerator is about the same energy as Co-60 but with higher output (100-300 rad/min). There is no concern for head leakage, leak tests, decay, source replacement or licensing. Higher energy accelerators are now being used (6 MV to 35 MV). These higher energy photons provide a greater dose at depth. Also, the high energy electrons may be used directly for treatment in some cases.



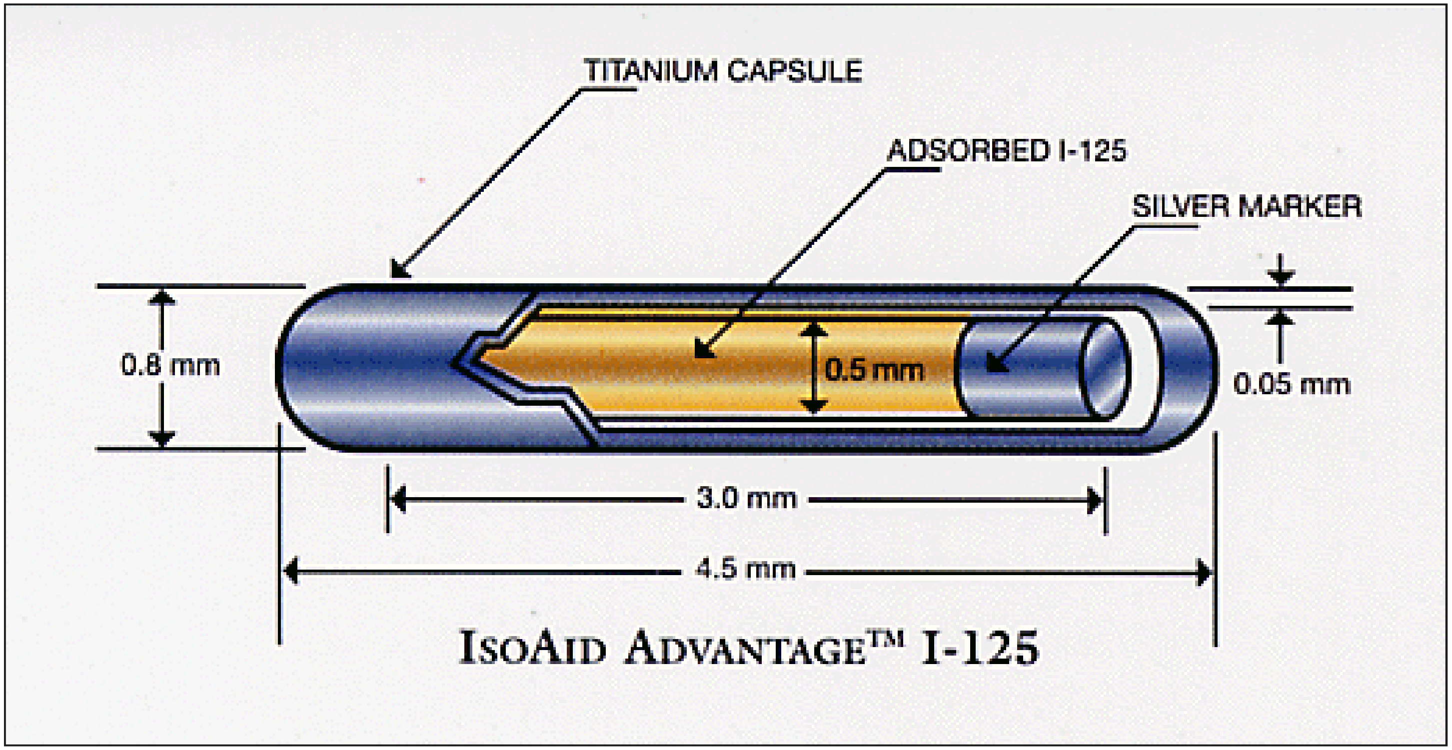
Linear Accelerator producing high-energy radiation beams.



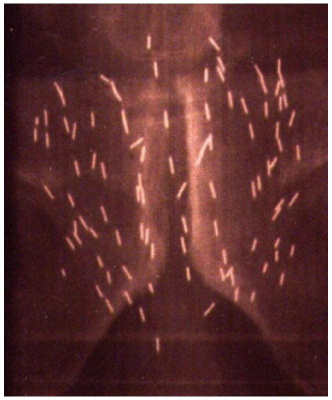
Advantages of External Beam Therapy

- Large areas of the body may be treated to an "even" dose.
- Both primary tumor and areas to which cancer may have spread (regional lymphatic's) may be treated at the same time.

Brachytherapy -"Short Distance" Therapy

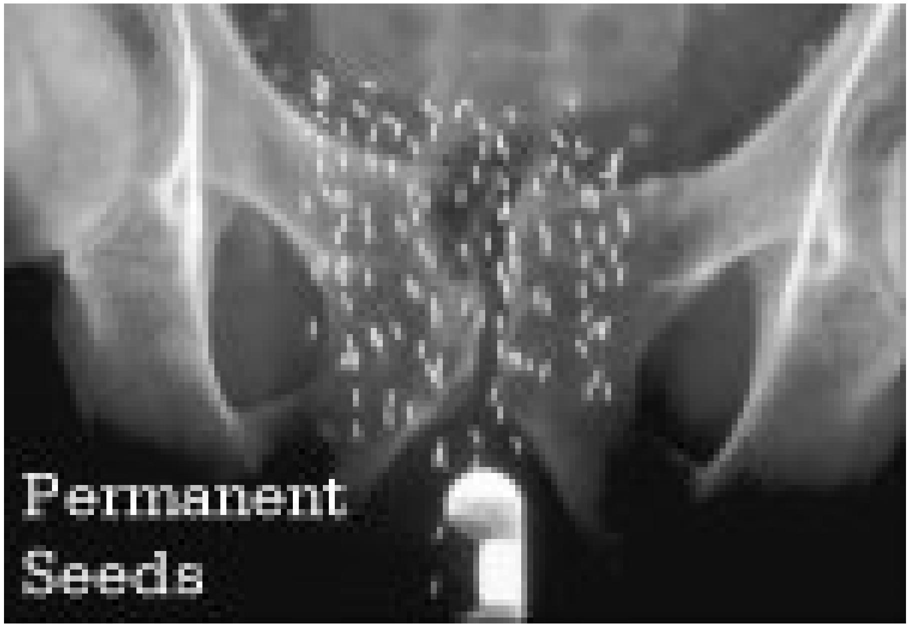


Brachytherapy



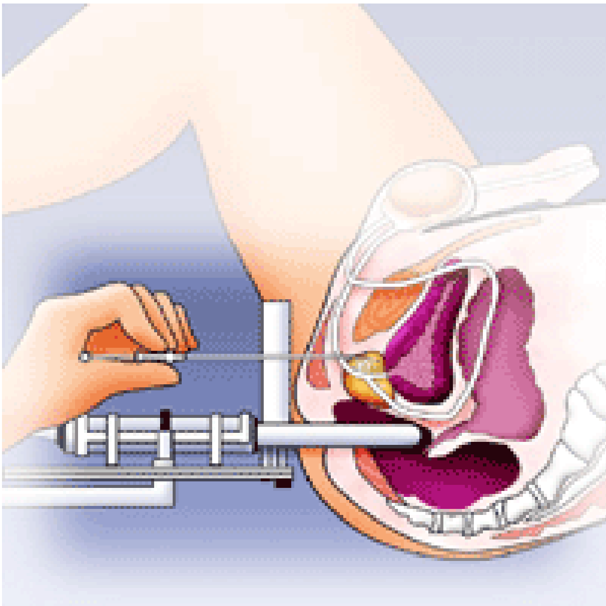
Brachytherapy is the use of small, sealed sources of radioactive material, inserted into a body cavity (so as to treat cancers of the cavity wall), directly into tissue (so as to treat tumor in the tissue), or into the lumen of a blood vessel. By placing the source of radiation close to a tumor, the tumor receives high doses, but other tissues receive lower doses.

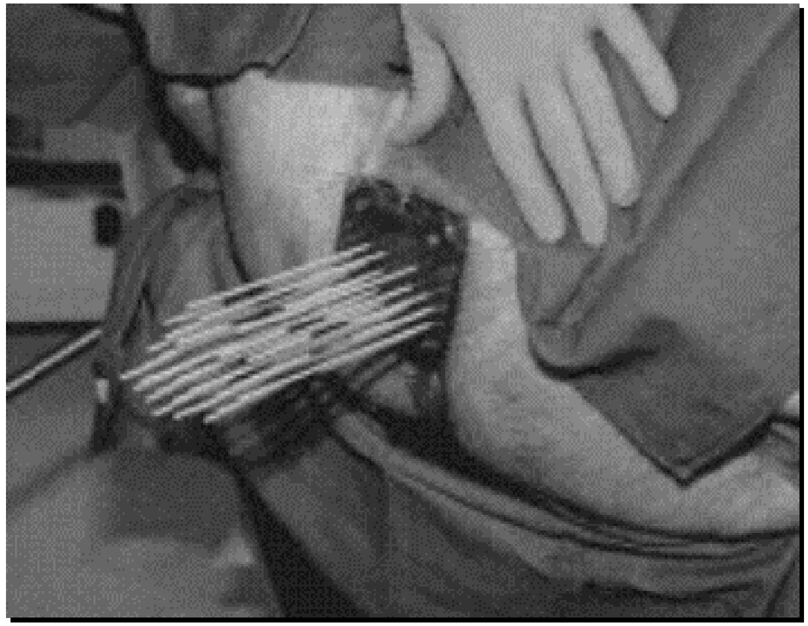
Implants may be Permanent or Temporary.



Permanent

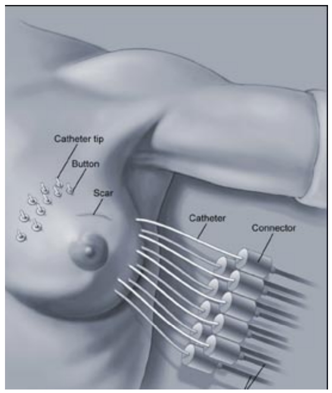
Implants may be Permanent or Temporary.

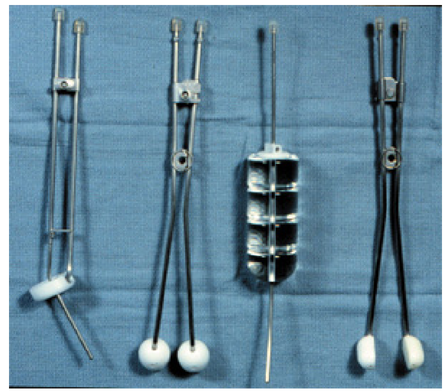




Temporary

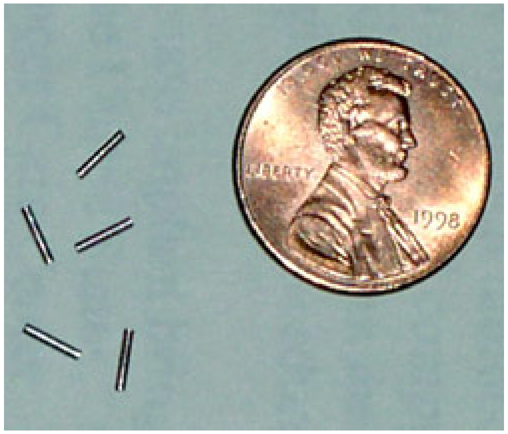
Temporary Implants



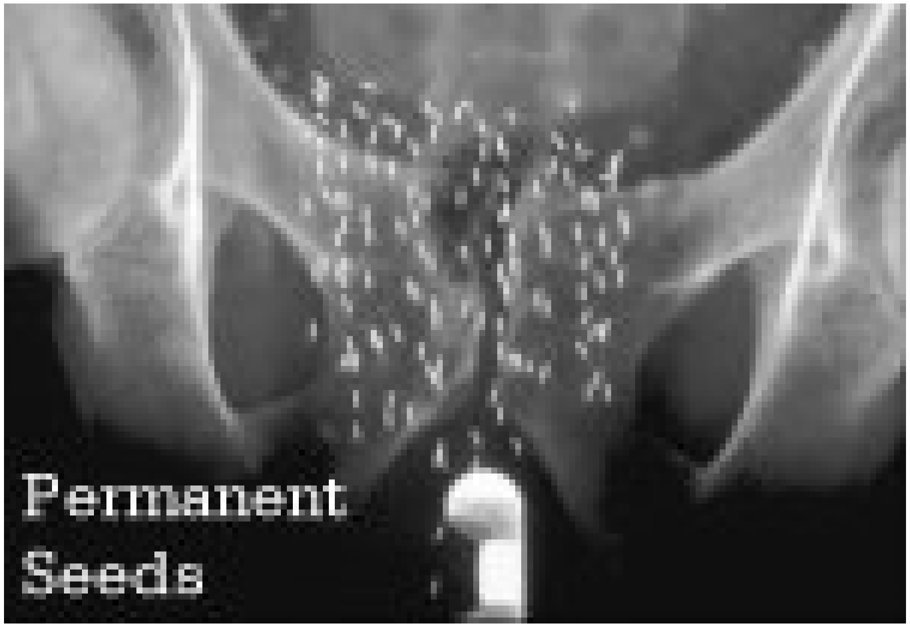


Temporary implants are removed at the end of treatment and may be reused depending on the source cavity. Applicators are used with temporary implants to hold sources in a fixed pattern.

Permanent Implants



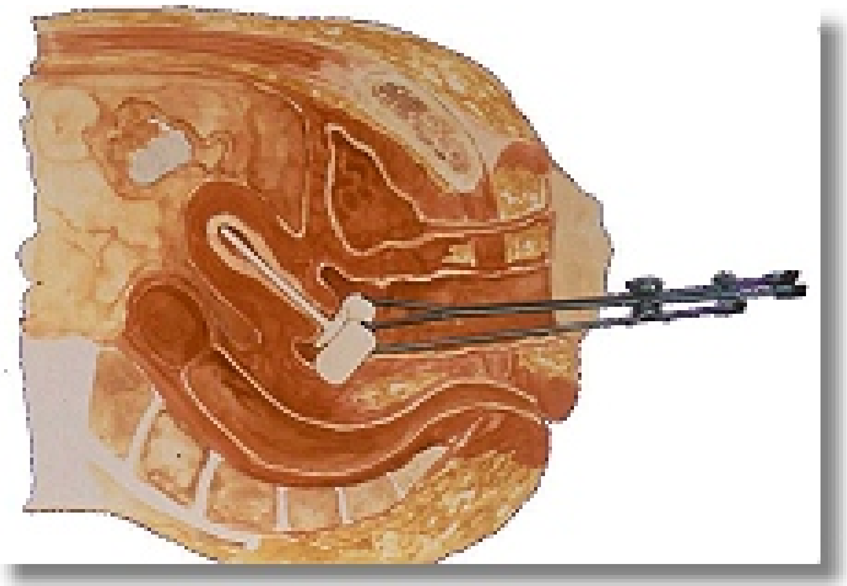
Permanent implants are generally short-lived material placed where they cannot easily be removed.

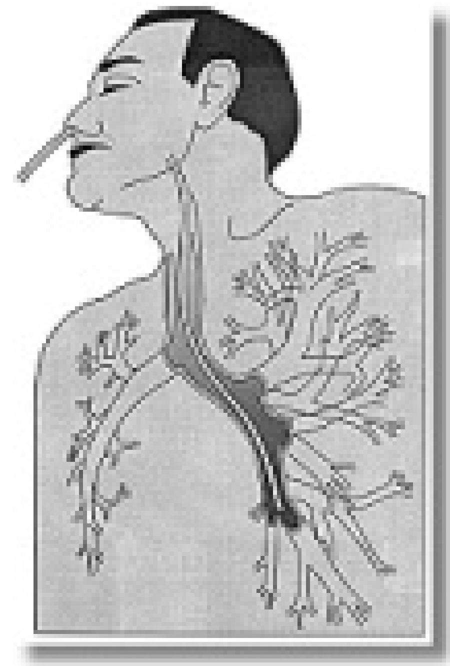


Major Division of Brachytherapy

- Intracavity
- Interstitial
- Intraluminal
- Topical

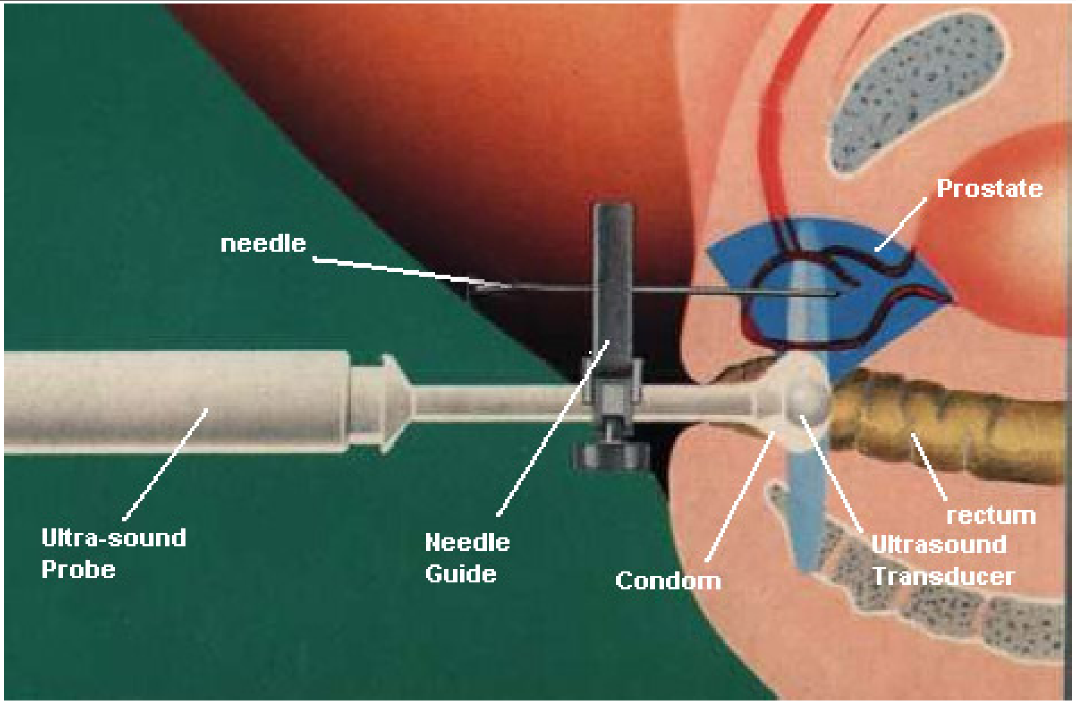
Intracavity





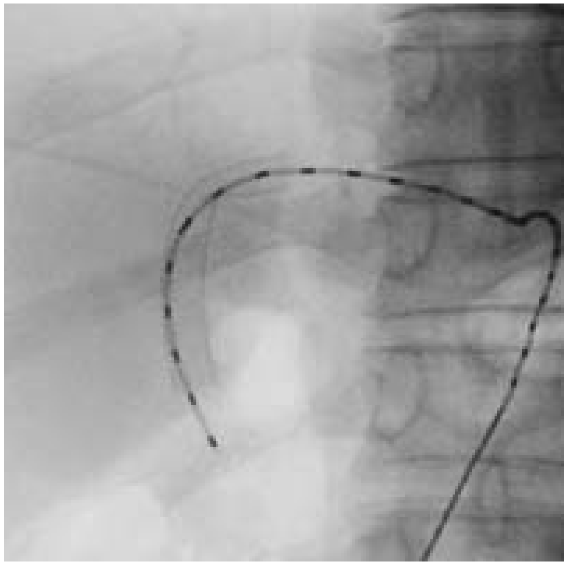
Intracavity - radioactive source is placed into an "applicator" and placed in a body cavity.

Interstitial



Interstitial - A radioactive source is placed directly into the patient's tissue.

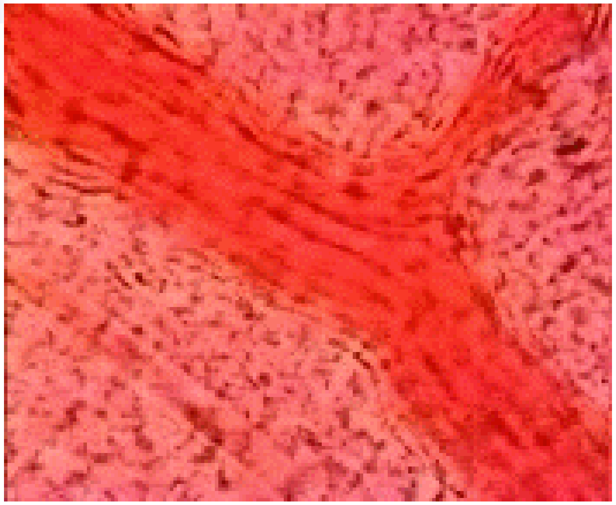
Intraluminal



Biliary duct

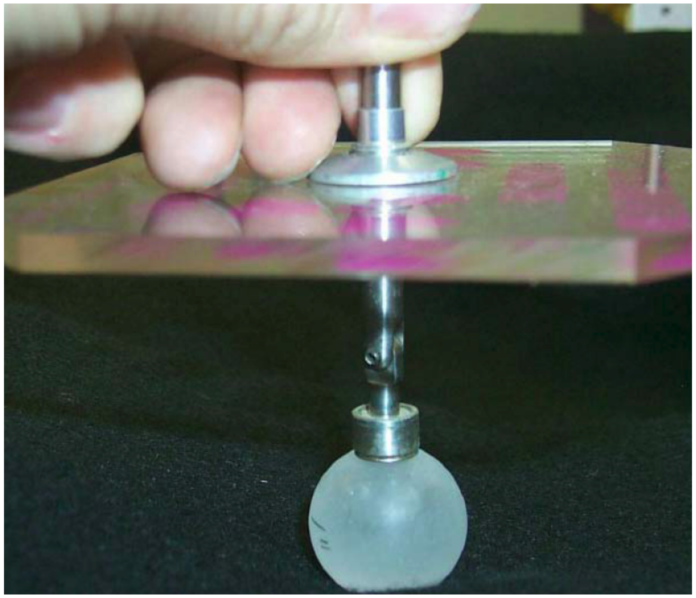
Intraluminal - A radioactive source is placed in the lumen such as esophagus, trachea, and ducts (biliary and salivary)

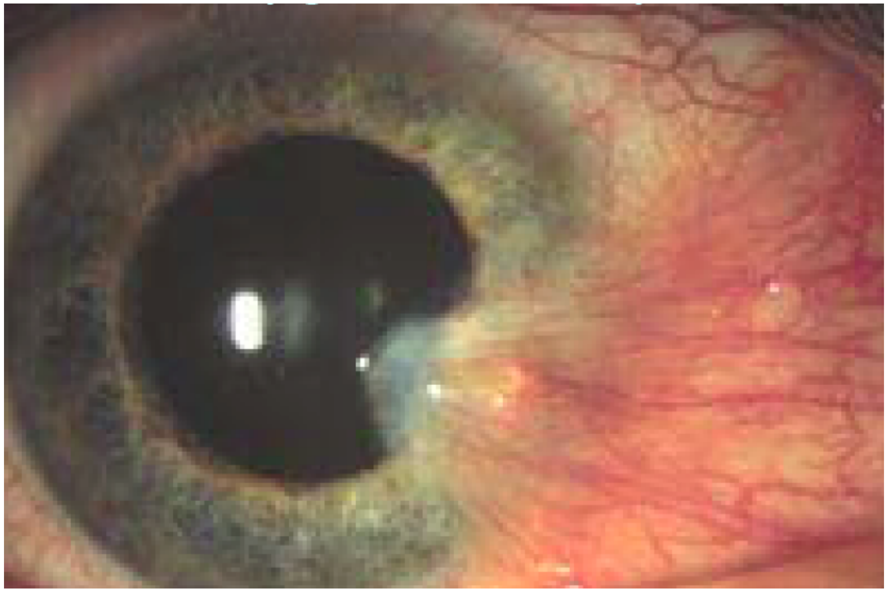
Intravascular



Intravascular - A radioactive source is placed in the lumen of a blood vessel.

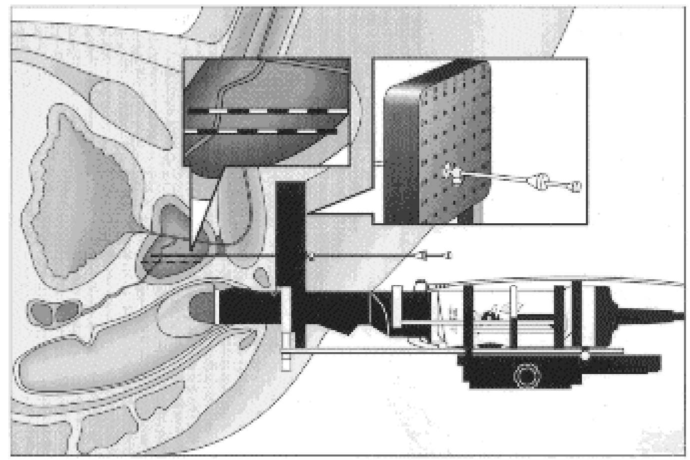
Topical





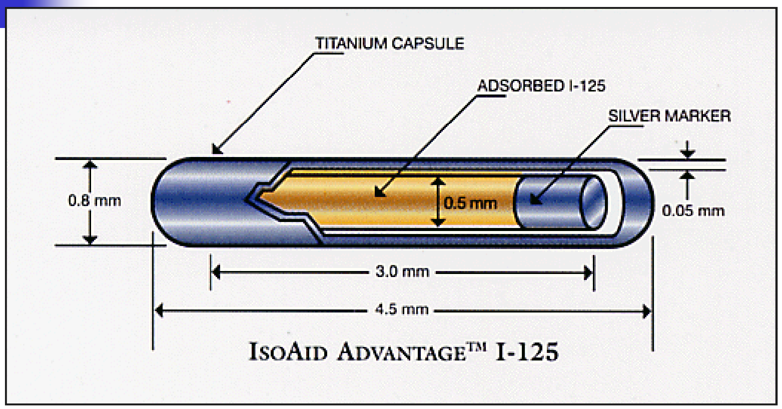
Direct Application

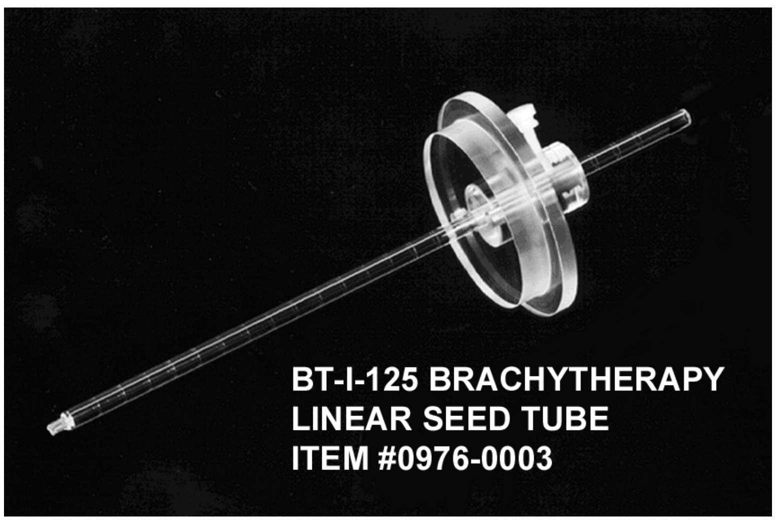
Advantages of Brachytherapy



The major advantage of Brachytherapy treatments is the ability to deliver a very high dose to a small area and lower doses to surrounding tissues. Another advantage is that the high dose volume may be made to "conform" to the tumor volume. (This is accomplished by placement of sources or precise movement of the source).

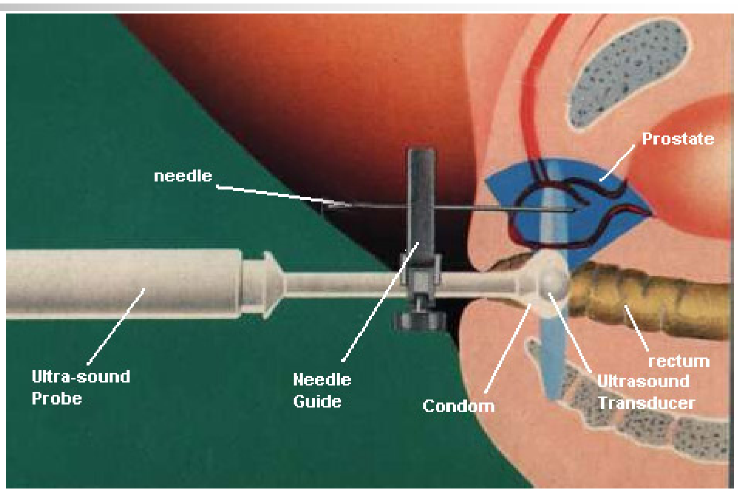
I 125 Seeds


TITANIUM CAPSULE
ADSORBED I-125
SILVER MARKER
0.8 mm
0.5 mm
0.05 mm
3.0 mm
4.5 mm
IsoAid Advantage™ I-125


BT-I-125 BRACHYTHERAPY
LINEAR SEED TUBE
ITEM #0976-0003


IODINE-125
Apparent Activity Range
Total Apparent Activity
Ref. Date
QTY: 50
CAUTION:
Radioactive Material

Applicators & Practical Applications



I-125 seeds are normally used for permanent implants. The most common implant site is the prostate wall. Approximately 20 seeds at 0.5-1.0 mCi each are used. Insertion is performed in surgery, and the patient is normally hospitalized a few days after implantation due to the surgery. A Foley catheter is normally used.

Applicators & Practical Applications

The patient is not an external radiation hazard. Very little radiation is emitted from the patient due to the low energy of the 28 keV photons. The patient is not hospitalized due to the exposure level.

Applicators & Practical Applications

Most of the Cs-137 safety precautions are not invoked. No film badges are needed for nurses and no visitor control is necessary. Warning signs on the bed and chart should be made. The safety instructions to nurses are abbreviated.

Brachytherapy Applicators

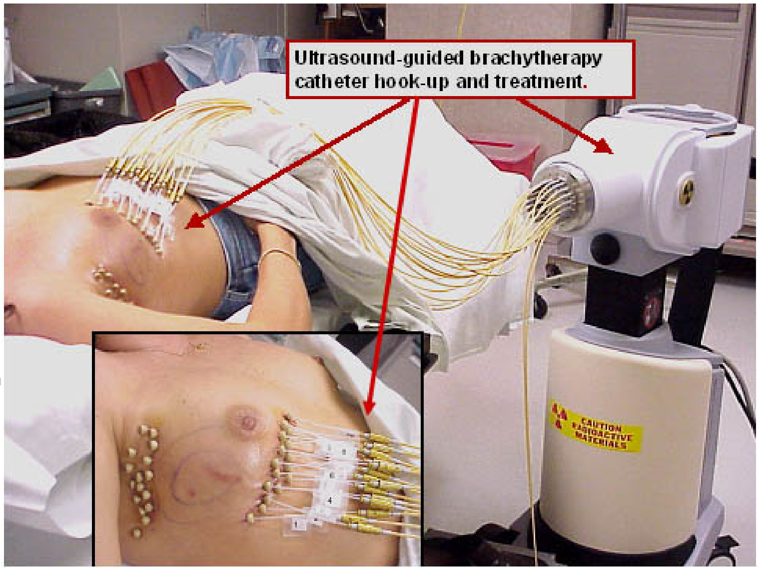
- Preload
- Afterload

Preload Applicators

- Preloaded applicators have the radioactive substance loaded prior to implantation (pre-loaded). This system then exposes all personnel in the operating room during implantation, as well as exposing x-ray personnel when localization films are produced. The material may need to be removed if the localization films show the applicators are in unacceptable positions. This results in all personnel involved receiving a second exposure. Recovery room personnel are exposed after the patient is moved from the operating room. The patent is also a source of exposure during transport to the patient's room. In general, the use of preloaded applicators is not a current practice.

After Load

With after-loading systems, the applicators are implanted in the patient in the operating room (OR) without the radioactive source.



Afterloading devices may be manual or remote. With the manual afterloading device, the sources are placed in the applicator manually with forceps (radioactive sources are never handled).

Remote afterloading devices store the sources in a shielded area. An applicator is carefully positioned in the patient and its location is verified. In the treatment phase the patient is repositioned in the treatment room.

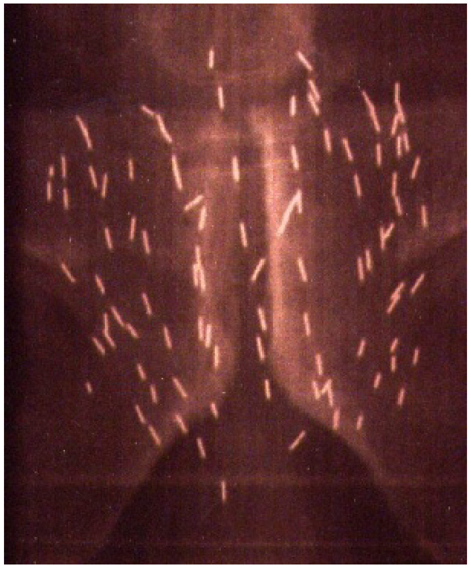
The applicator in the patient is attached to a tube or catheter. The catheter is attached to the afterloading storage device. During treatment, the patient remains in the shielded environment room and is observed. The radioactive sources move down the catheter into treatment position through remote control.

The main advantage of the use of afterloading devices is a reduced dose to the hospital staff.

Applicators & Practical Applications

The I-125 seeds may become dislodged and may then be excreted in the urine. These seeds will be held in the Foley catheter bag. These dislodged sources must be watched for.

Applicators & Practical Applications



I-125 seeds are easily lost due to their small size. Constant vigilance is necessary. Inventories are critical.

Applicators & Practical Applications

Localization films are taken. The films verify source distribution for dosimetry and the source count.

Applicators & Practical Applications

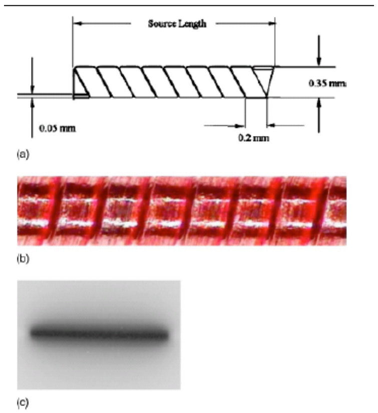
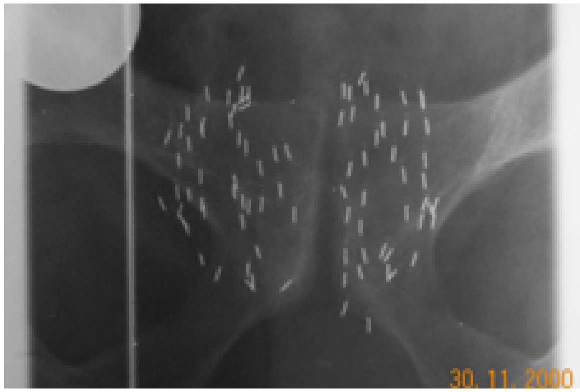
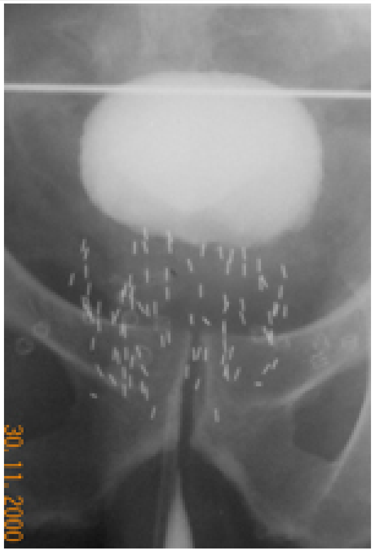


FIG. 1. (a) Schematic diagram of the RadioCoil™ ^{103}Pd linear source, showing a coiled structure; (b) a magnified view of a section of a RadioCoil™ source; (c) autoradiograph of a 3 cm RadioCoil™ source.





Palladium-103

Pd-103 seeds for interstitial therapy. Pd-103 is used as an alternative for I-125 seeds. The same precautions and procedures as for I-125 apply.

Applicators & Practical Applications

Radioisotope	Mean Energy	Half-Life
Iridium-192	400 kV	72 days
Gold-198	1.2 MV	2.7 days
Iodine-125	27 kV	60 days
Palladium-103	21 kV	17 days

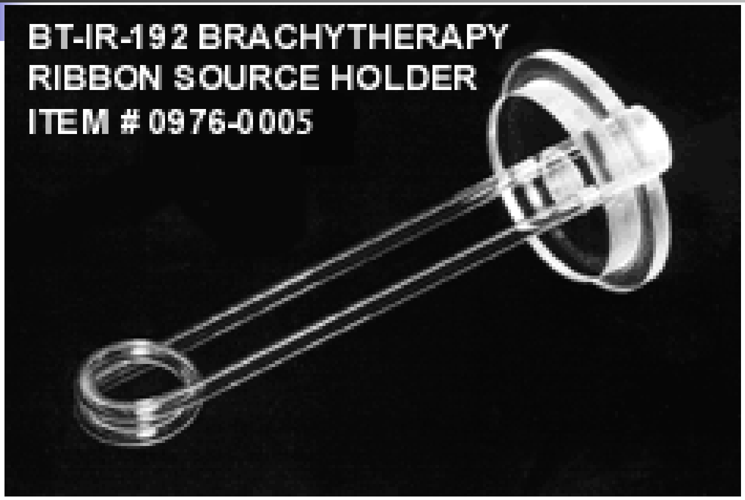
Gold-198
Au-198 has been used as an alternative to I-125. The short half-life (2.7 days) allows the dose to be delivered in a short time.

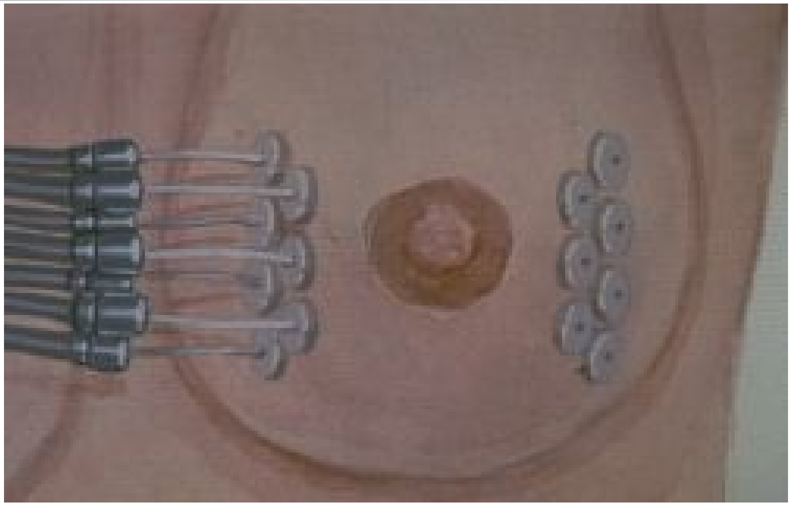
*** Note: Gamma and characteristic energies are usually specified as Kev and MV.**

Applicators & Practical Applications

Ir-192 Seeds in Nylon Ribbon - These sources are used for temporary implants. The most common is for breast implants. Occasionally, they are used for other sites, such as head and neck tumors. They may also be used intraluminally, such as bronchial or esophageal. Activities used are 0.2 to 5 mg.Ra.eq. per seed (1.65 mCi per mg. Ra. eq.), each 1 to 3 mm long, spaced at 1 cm center to center. 12 seeds per ribbon are common. The seed diameter is 0.5 mm. The ribbon diameter is 0.9 mm.

Applicators & Practical Applications



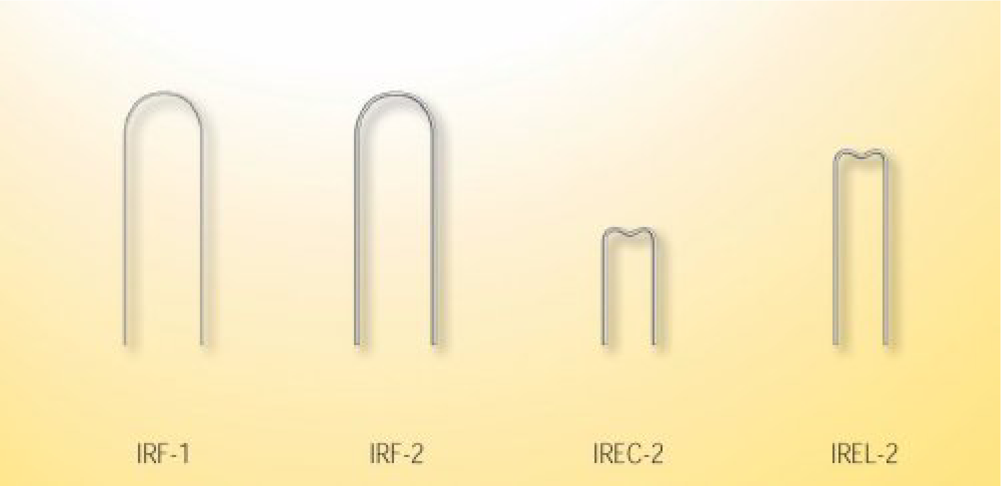


These sources may be after-loaded or implanted in surgery. For breast treatments, 5 to 10 ribbons are used at 5 to 10 seeds each or about 50 seeds total. (50 seeds x 1.5 mCi/seed x 0.5 mR/hr/mCi at 1 m = 37.5 mR/hr at 1 m). The implant times are 2-3 days. All the precautions used for Cs-137 must be used with Ir- 192.

Applicators & Practical Applications

Ribbons are cut for use. The seeds themselves are not cut. Accountability is critical. Inventories of individual seeds (not ribbons) are very important.

Applicators & Practical Applications



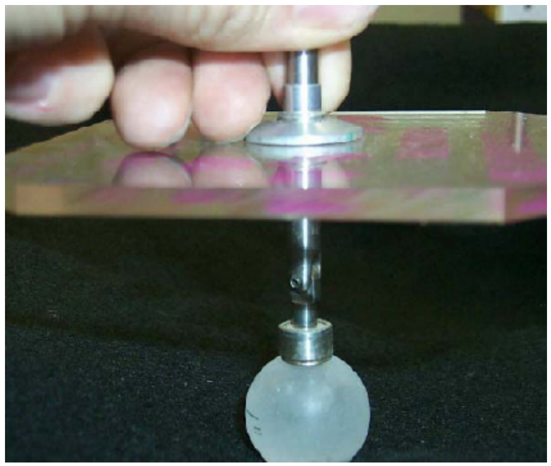
Ir-192 wire is not included in 35.400. The license must list the authorization for Ir-192 wire specifically. Ir-192 wire is used for temporary implants in the form of short lengths, hairpins or a long coil. Strengths are specified in activity per unit length - Ci/mm. Lengths of 1 to 10 cm are used. The wire is directly inserted into tissues in surgery. Treatment times of 2-5 days are used.

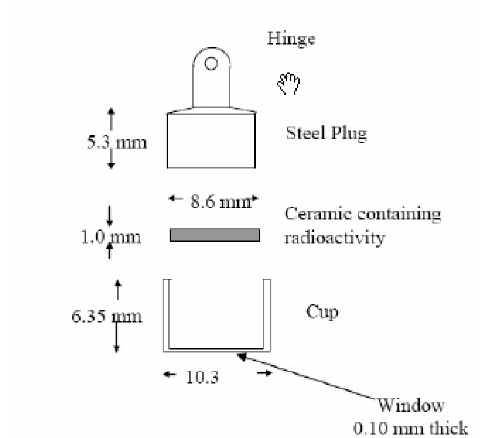
Applicators & Practical Applications

- The full Cs-137 precautions are used. There is a possibility of the sources becoming dislodged or breaking in situ.

- The wire may be cut to length. A special cutter is available from the manufacturer. Control of the cuttings is a concern. The licensee must limit those who can cut the wire to those specifically trained. These individuals may be listed in the license. The cuttings are returned to the supplier along with the wire after removal.

Applicators & Practical Applications





Sr-90 Applicator-This source is used for surface ophthalmic applications using the high energy betas. A typical source strength is 55 mCi of Sr-90, which produces a surface dose rate of 50 rad/sec. Treatment times are in seconds. The source is held in place by hand during treatment.

Plaques or Molds

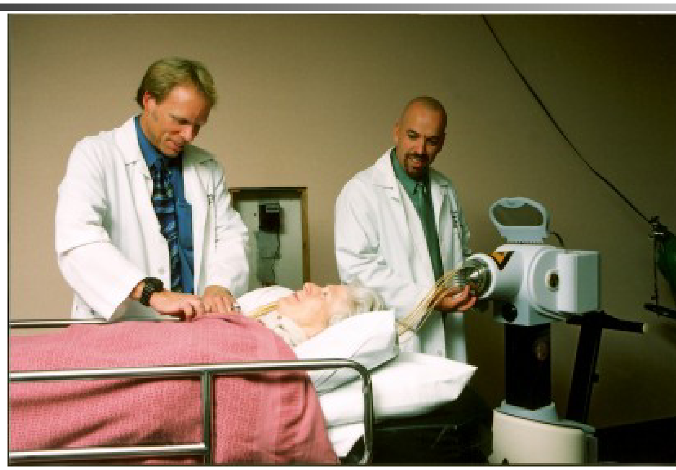
An eye plaque or a mold is a device that is used to hold radioactive sources in a geometric arrangement to optimize treatment. Mold therapy is usually performed for external structures or skin lesions. Molds can be either preloaded, afterloaded or remotely loaded.

Applicators & Practical Applications

Ra-226

Effective August 2005 discrete sources of Radium are regulated by the states, not the NRC. Its form, use and precautions are similar to Cs-137. Radium is harder to shield (HVL = 1.66 cm Pb vs. 0.65 cm Pb) than Cs-137. Radium presents a severe contamination problem if a source leaks. Rn-222, the daughter of Ra-226, is a gas. The gas dissipates and then decays. The Rn-222 daughters are then dispersed widely. The situation is made worse as these nuclides are alpha emitters.

Applicators & Practical Applications - High Dose Remote Afterloaders



High Dose Rate Remote Afterloaders -these devices use high activity sources to provide brachytherapy treatments in minutes rather than days. As a remote afterloader, personnel do not handle the source nor are they exposed directly to the source. The treatments can be performed on an outpatient basis in many cases. The source used is Ir-192. The initial activity is 10 Ci, which produces an exposure rate of 5 R/hr at one meter (33 R/min at 5 cm, 833 R/min at 1 cm).

Applicators & Practical Applications - High Dose Remote Afterloaders

Safety concerns for these devices are more like those of teletherapy

1. structural shielding is needed (15 to 18 inches concrete)
2. access control is necessary
3. emergency procedures are needed
4. calibration of source output must be measured
5. decay of the source must be calculated

Applicators & Practical Applications - High Dose Remote Afterloaders

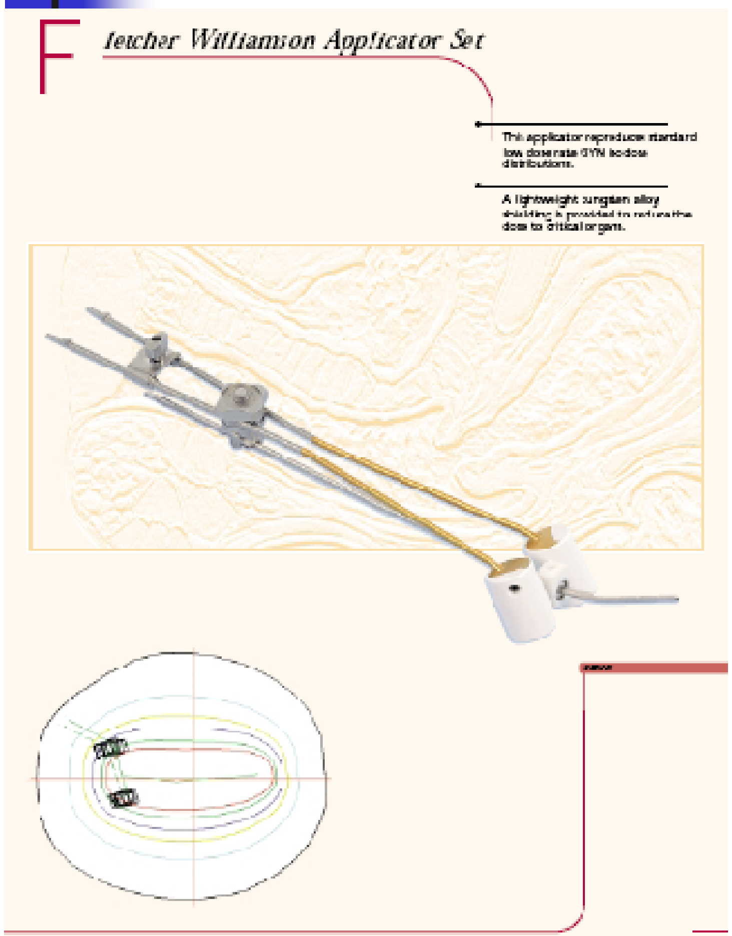
- The source is normally replaced at approximately 3-4 months. Leak testing is performed at that time, if necessary.

- Receipt and shipment considerations are significant. The source does not exceed Type A quantities: 10 Ci normal form, 20 Ci special form.

- Authorization for these units is through specific license condition.

- Treatments are delivered in several daily fractions.

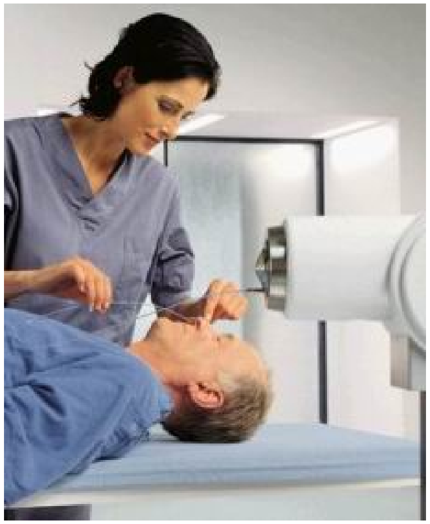
Applicators & Practical Applications- Low Dose Rate Manual Afterloaders



The Fletcher afterloading applicator was the mainstay of gynecological cancer treatment for over forty years.

Applicators & Practical Applications-Low Dose Rate Remote Afterloaders (Very Rare in U.S.)

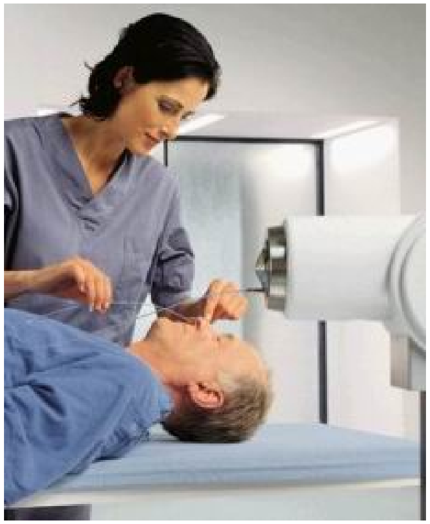
These units are similar to the high dose rate units except they use more than one source, each of lesser activity. The activities and treatment times are similar to those of standard brachytherapy implants. As the treatment times are several days, these therapies are performed on an inpatient basis.



Nucletron LDR

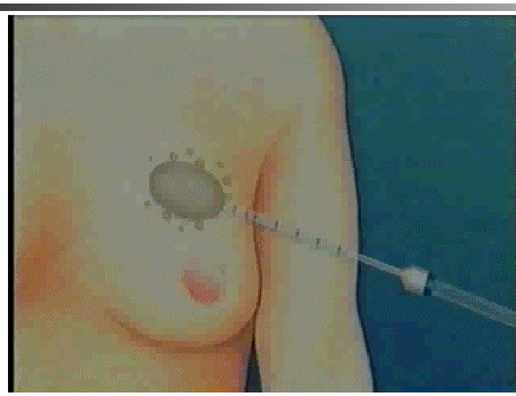
Applicators & Practical Applications-Low Dose Rate Remote Afterloaders (Very Rare in U.S.)

The advantage of these units over standard brachytherapy is that the sources can be removed from the patient when nursing personnel or visitors enter the patient's room. The sources are then reinserted when the visitor leaves. Another advantage is that personnel do not handle the source during implant or removal.



Nucletron LDR

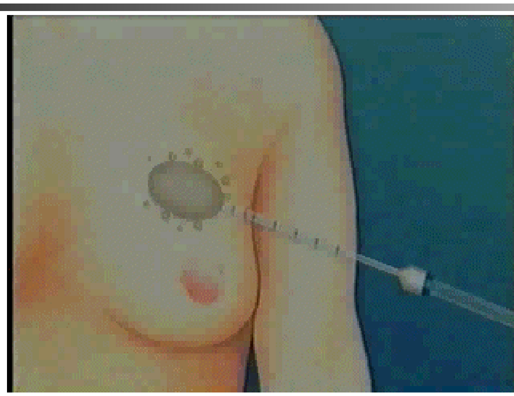
Applicators & Practical Applications-Mammosite



Mammosite Movie

- New minimally invasive method of delivering internal radiation therapy following a lumpectomy for breast cancer
- Single balloon catheter fits inside tumor resection cavity
- Iridium 192-high dose remote rate afterloader source inserted into balloon
- Delivers intended dose of radiation during time of treatment

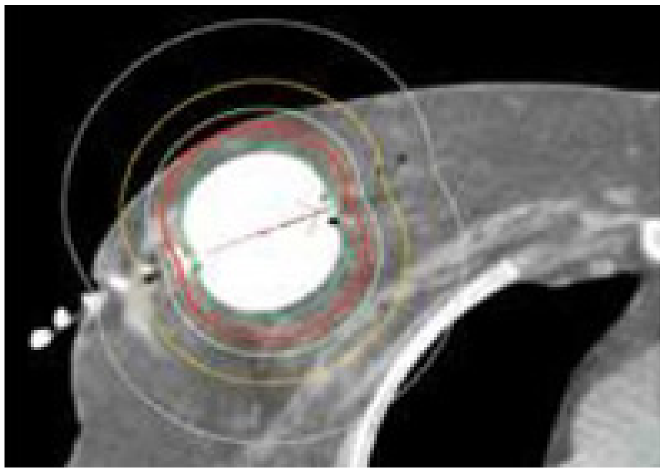
Applicators & Practical Applications-Mammosite

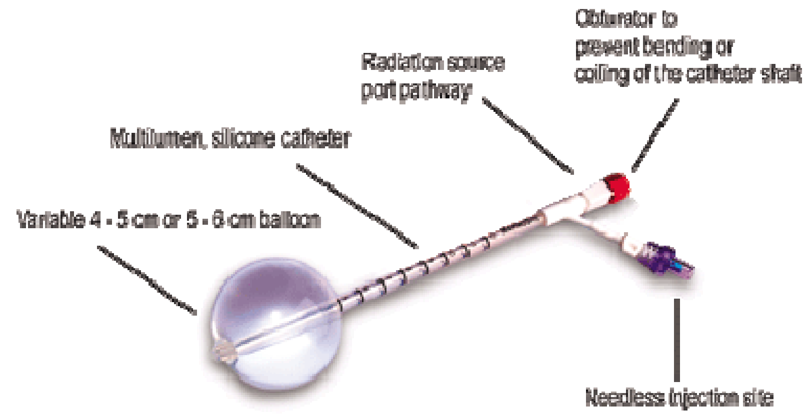


Mammosite Movie

- Retracted into afterloader
- Balloon filled with saline and contrast agent once in place
- May be inserted at time of lumpectomy or within 10 weeks thereafter

Applicators & Practical Applications-Mammosite



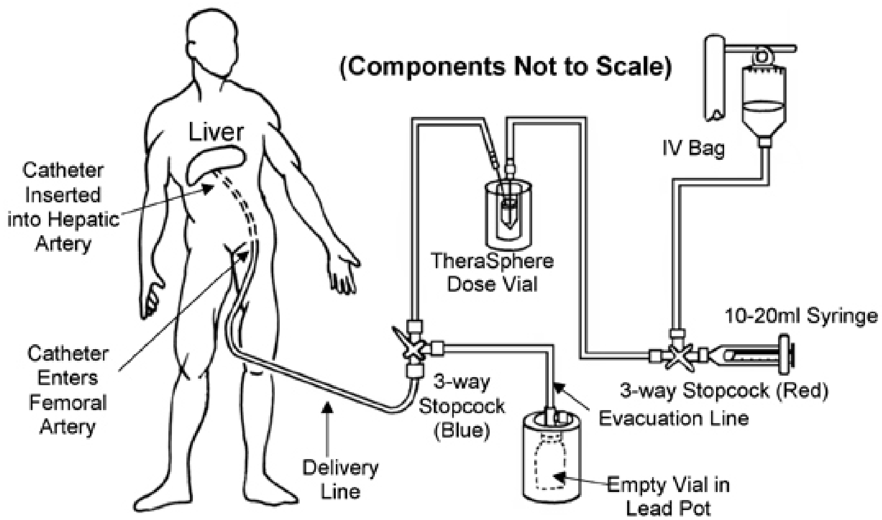


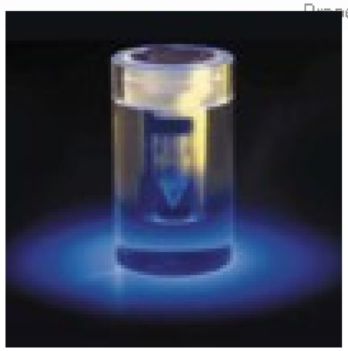
Once the therapy is concluded, the balloon is deflated and the catheter is removed. The advantages for the patient are the radiation therapy can be completed in 5 days and can be done on an outpatient basis. Radiation to healthy tissue is limited, reducing the potential for side effects. Partial breast irradiation treatment. It became available in 2002.

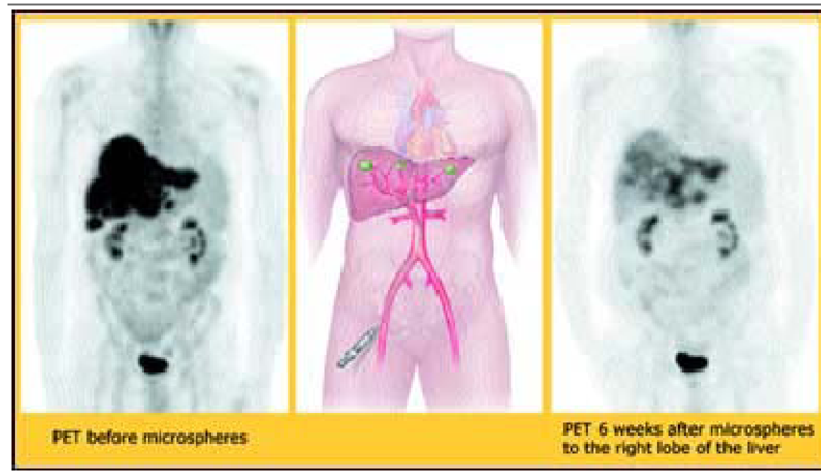
Applicators & Practical Applications-Microsphere

- Ceramic or glass microspheres contain yttrium-90, a beta emitter
- Manual brachytherapy sources
- Used for permanent brachytherapy implantation therapy
- Implanted using a syringe; travel via the blood stream
- Targeted treatment area is the liver
- Number or location of the tumors is not required; the microspheres irradiate it by a process know as Selective Internal Radiation Therapy (SIRT)
- This leads to destruction of the tumor while most of the normal tissue remains relatively unaffected

Applicators & Practical Applications-Microsphere





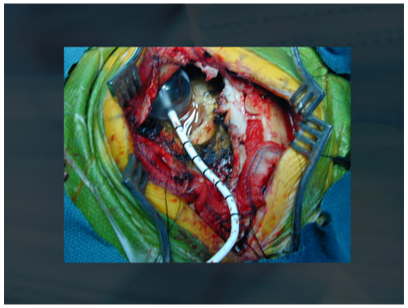


Left image is a PET scan of a patient with metastatic colon cancer in the liver prior to receiving 90Y-microspheres. The center drawing describes the procedure illustrating the catheter placed into the right hepatic artery for delivery of microspheres. The right image is a follow-up PET scan of the same patient 6 weeks after delivery of microspheres into the right lobe of liver only. There is significant clearing of tumor on PET in the treated right lobe, and persistent tumor in the untreated left lobe of liver.

Applicators & Practical Applications-Microsphere

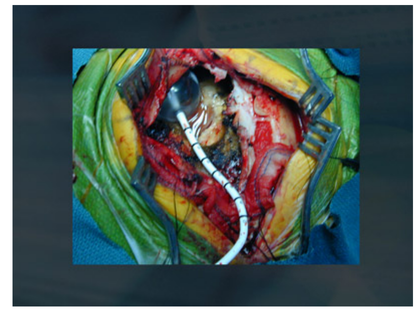
- Microspheres are available under the trade name of Theraspheres made by MDS Nordion and SIR Spheres made by Sirtex.

Applicators & Practical Applications-Liquid Brachytherapy



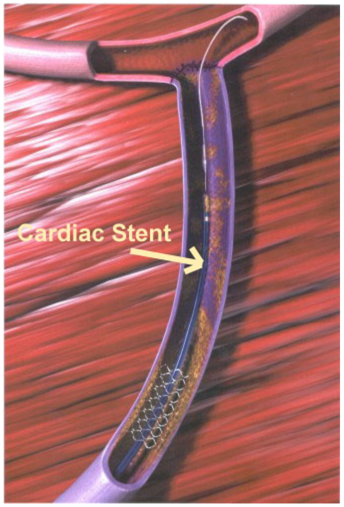
- I-125 Iotrex liquid brachytherapy sources-manual brachytherapy sources
- Used for temporary brachytherapy implantation therapy in GliaSite Radiation Therapy System made by Cytyc
- Combines a GliaSite balloon catheter with Iotrex liquid brachytherapy source

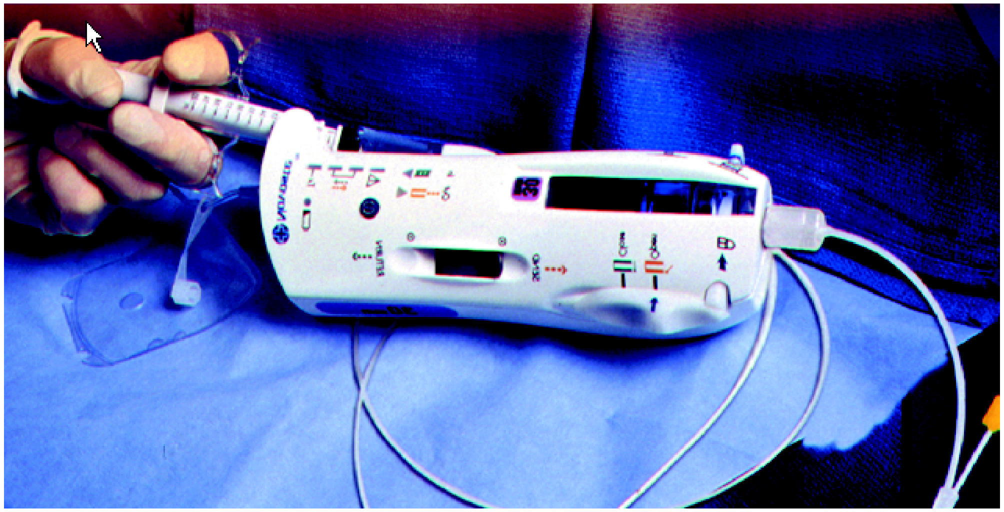
Applicators & Practical Applications-Liquid Brachytherapy



- Designed to treat newly diagnosed, metastatic and recurrent brain tumors
- Delivers radiation from within the cavity created by the surgical removal of the tumor

Applicators & Practical Applications- Intravascular Brachytherapy





The Beta-Cath is used in patients who have in-stent restenosis. In-stent restenosis is a re-blockage inside a coronary artery at the site of previous stent placement. A stent is an expandable metal tube placed inside an artery to keep it open at the site of narrowing (stenosis). The radiation can prevent scar tissue from forming which will cause another blockage of the artery.

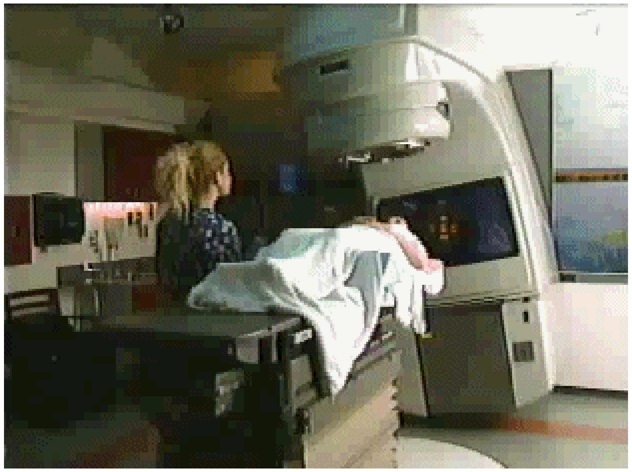
Concepts in Conformal Radiation Therapy

Conformal radiation therapy may be defined as the following:
Several external beams of radiation in which the shape of each radiation beam closely conforms to a 2-D outline of area targeted for treatment (treatment area). Each radiation beam may be directed at the patient from different gantry angles.

The goals of conformal radiation therapy may be stated as follows:

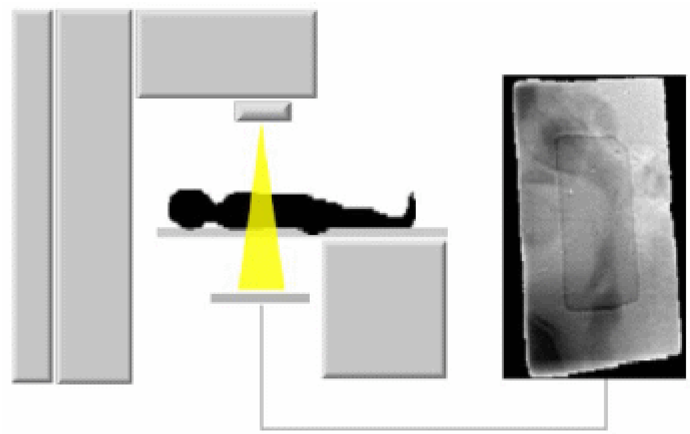
1. Increase cure rates by delivery of increased radiation dose to the treatment area.
2. Decrease complications rates by reducing the dose to normal tissues

Concepts in Conformal Radiation Therapy



The methods of treatment delivery in conformal radiation therapy can be divided into three separate segments. By combining these three types of treatment segments a conformal treatment is delivered.

Concepts in Conformal Radiation Therapy

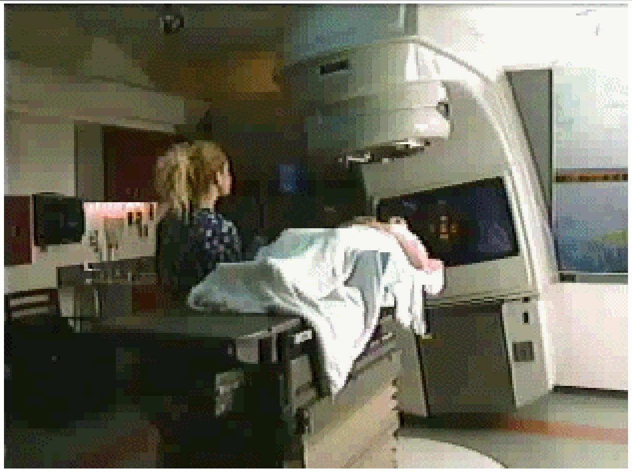


Static segments - The dose is delivered by using a stationary "fixed beam". This closely resembles most current radiation treatments

Concepts in Conformal Radiation Therapy

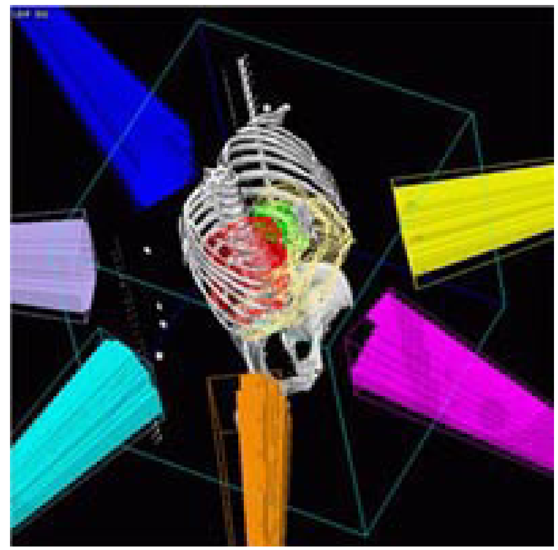
Move only segments -The treatment machine will move to a set of mechanical parameters without delivering radiation. This allows for set up for the next segment. (This may be performed automatically or with therapist intervention).

Concepts in Conformal Radiation Therapy



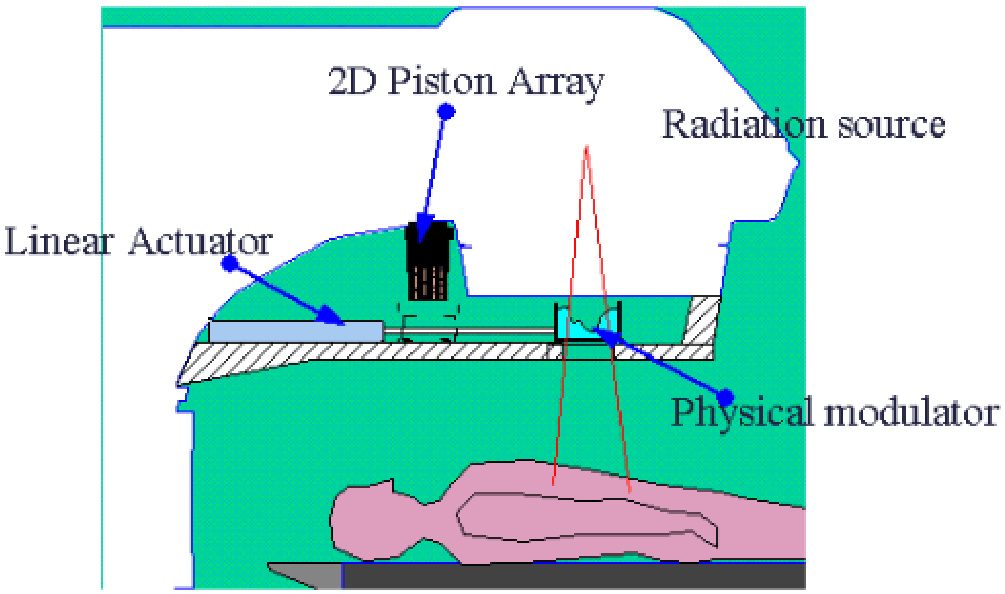
Dynamic segments - The treatment machine may vary one or several parameters while radiation treatment is being delivered. For example the gantry may rotate, the collimators may rotate and change size while the table on which the patient in lying on also moves.

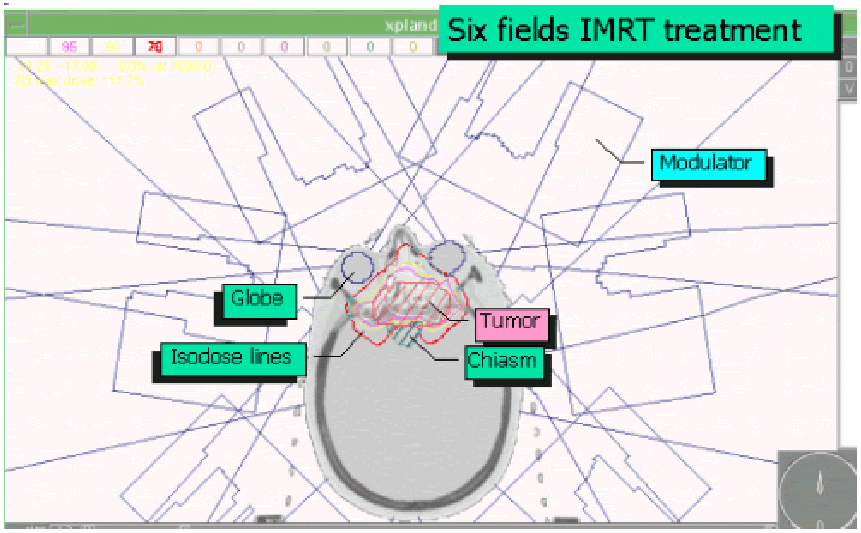
Intensity Modulated Radiation Therapy (IMRT)



Intensity **M**odulated **R**adiation **T**herapy (**IMRT**) may be defined as the use of small "pencil beams" of radiation of different intensities which produce a uniform dose distribution within the volume of tissue targeted for treatment. The dose at the edge of this treatment falls off sharply. In the past few years IMRT is an area of expanding technology in radiation therapy.

Intensity Modulated Radiation Therapy (IMRT)





Intensity Modulated Radiation Therapy (IMRT)