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Quality Assurance of Brachytherapy System (Physical Aspects)

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1. Introduction

Brachytherapy may be performed by inserting sources into the external surface molds or into the tissue(interstitial therapy) or into a natural body cavity(intracavitary therapy) or into a tubular organ(intraluminal therapy). In these cases the active sources may either be inserted directly or using afterloading methods.

The quality of the application can be assured more easily when afterloading methods are used the position of inactive guides or applicators can be checked by radiography. If, in addition, dummy sources are used, irradiation of the staff can be avoided. Afterloading methods(manual and remote) are strongly recommended.

Even though the need for quality assurances in brachytherapy increases, there are no generally acceptable protocols.

It is the purpose of this paper to suggest procedural policies for the development of a quality assurance program.

2. Sources

At present, the most commonly used sources are :

- miniaturized caesium-137 or cobalt-60 sources for intracavitary procedures using afterloading methods,
- cobalt-60 for high-intensity sources in remote afterloading devices used in so-called "high-dose rate" brachytherapy techniques,
- iridium-192 in wire or seeds for removable interstitial implants,
- iodine-125 seeds for permanent interstitial implants.

(1) Calibration of sources

Discrete sources with long half-life and with high activity should be clearly marked and a calibration certificate should accompany each new source purchased.

It is important to have a check procedure in place which does not solyrely on the calibration supplied by the manufacturer. The exact geometry of a source or of a train of miniaturized sources may be checked by means of an X-ray radiograph of the source, an autoradiograph of the source is a simple and cheap means of checking the homogeneity

of the activity to a first approximation.

The most commonly used device is a well type ionization chamber. The second alternative is to use cylindrical ionization chamber to measure the radiation intensity at some distance from the source.

It is essential to be able to accurately reproduce the positioning of the source. For such measurment it is obvious that the relative distance from the source to the center of the chamber must be maintained

(2) Source inventory

This should be carried out in association with each brachytherapy procedure and a general source inventory should be carried out at least every month.

For long half-life sources, the correction for radioactive decay, both up to the time of intended use and during treatment, should be part of the treatment planning.

Inventory system includes; a documented procedure for recieving, storing, distributing, returning, and disposing of sources.

(3) Source integrity

At present, NRC recommend that sources be leak tested every 6 months. The tools which are used to prepare Iridium sources should be tested for contamination twice a year.

The physical integrity of the sources shoud be checked when they are recieved from the manufacturer, and on a regular basis for long-lived sources.

(4) Source handling

A shielded area for source handling should be avaiable. This facility should include instruments and barriers which permit viewing and handling of the sources with minimum exposure to personnel. A storage area should be maintained for the sources. The sources should be clearly labeled, and stored in such a manner that minimzes confusion.

Sources should be transferred by appropriately trained personnel. The number, type, and date of removal of the sources from the safe should be documented in a log book. The souces should be transferred safely in a shielded carrier. Any unused sources should be returned to the shielded safe, recorded in a log book, and the inventory of the used sources should be checked.

3. Monitoring

After the sources have been loaded in the patient, the patient's room must be surveyed, and local shielding added, if necessary. The patient must be in a private room with a radiation caution sign on the door. After removal of the last source in a temporary implant, the patient must be surveyed to assure that all sources have been removed form the patient.

4. Training of personnel

It is important to train personnel involved in caring for patients with radioactive sources. It is required that a program be in place which instructs personnel on; the size and appearance of sources, safe handling of sources, procedures to be followed if a source is dislodged, procedures for patient control, procedures for visitor, and procedures for notifying the radiation safety officer in case of an emergency.

5. Emergency procedures

A set of procedures should be in place to handle any number of emergencies which would include; loss of sources, spills and contaminations, cardiac or respitory arrest, emergency surgery, death, autopsy, cremation, embalming, and fire. An emergency call list should be available for personnel involved in caring for patient and source handling.

6. Quality control of treatment

Before the active sources are positioned, dummy sources should be used to check the source position within the inactive guides or applicators with respect to the anatomical structures concerned.

A pair of radiographs, generally in the anteroposterior and lateral planes, perpendicular to one another and taken under well defined conditions, is necessary in order to reconstruct the source geometry so as to be able to compute the dose distribution and compare it with the planned treatment. For this purpose, rigid film holers are required in order to ensure orthogonality. The distances (X-ray tube source-film) must also be known so that the magnification can be calulated.

When the above conditions cannot be met, a pair of radioraphs taken in the anteroposterior and lateral planes are, at least, required to check whether the source positions are acceptable.

7. Remote controlled afterloading systems

These systems require special consideration with regard to their use.

(1) Source position

① Daily should be conducted to verify the operational condition of devices which indicate source location, e. g., light indicators on the control panel and a radiation moniter within the treatment room.

② The reproducibility of physical positioning of the source within the catheter should be whithin ± 1mm and checked daily. This check may be done with an autoradiographic techique.

③ The treatment position of the source must be verified to be at the prescribed position position for each treatment course. This is normally done by conventional X-ray localization.

(2) Treatment time

① Timer accuracy must be verified monthly. The timer should not result in an error greater than 1% of the desired dose to be deivered.
② The error in dose due to source travel time after occurrence of timer ON, and for complete return after timer OFF, should be determined initially and semi-annually. This correction should be used in all instances where an error of more than 1% might be introduced into the delivery of the prescribed dose.
③ In those cases where a back-up timer is not a standard feature of the irradiator, an accessory back-up timer should be provided.
④ The calculation of the treatment time should be verified independently before the start of treatment.
⑤ The dose prescription may have to be modified because of the higher dose rate.

(3) Treatment confirmation

① At the time of each treatment during the course of therapy, radiograph or fluoroscopic confirmation of the applicator position should be taken. In vivo dosimetric confirmation is also recommended.
② Constant patient viewing from the control console must be available.

(4) Emergency procedures

Each installation must have a permanently posted operation plan for emergency source retraction should power or mechenical failure of the apparatus require such action. In all such installations, a person who has been trained for and has practiced the required action should be on duty whenever this apparatus is used for patient treatment.

References

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근접방사선치료 시스템의 QA(물리적 측면)

지영훈
원자력병원 방사선물리생물실

근접방사선치료는 방사성동위원소를 종양에 밀착시키거나 또는 종양내에 직접 삽입하여 치료하는 방법으로서 종양에는 일시에 많은 선량을 주는 반면 주위 정상조직에는 선량을 최소화시킬 수 있는 장점이 있다. 따라서 근래에 들어 종양치료에 있어서 외부방사선치료와 병행하여 근접방사선치료를 시행하는 병원이 증가하고 있다. 그러나 근접방사선치료는 방출 방사선의 에너지가 낮고, 대부분 짧은 반감기를 가지며, 소형의, 수 mCi에서 수Ci 정도의 방사능을 가진 방사성동위원소들을 인체에 직접 삽입하는 것으로 정확한 선량분포를 위해서는 방사성동위원소의 방사능량, 위치, 분포 등의 정확성 확보가 절실히 요구된다. 따라서 이 논문은 근접방사선치료시스템의 QA프로그램 개발을 위하여 작성하였다.