SNS COLLEGE OF TECHNOLOGY

(Autonomous Institution)

COIMBATORE-35

DEPARTMENT OF BIOMEDICAL ENGINEERING

19BME308 - Medical Radiation Safety

UNIT II - RADIATION SAFETY IN NUCLEAR MEDICINE AND RADIOTHERAPY

2.5 Radiation Protection in External Beam Radiotherapy

Introduction

External beam radiotherapy involves the delivery of high doses of radiation of up to about 80 Gy with the aim of curing a tumor by killing all the proliferating cells or of providing palliation by restricting the rate at which the tumor is spreading. To prevent adverse reactions from healthy tissue in the path of the radiation, radiotherapy is usually delivered with two or more beams each directed at the tumor from different angles, so that the total dose to the tumor is greater than that to any of the surrounding tissue. Also, tumor cells and normal tissue cells have a different capacity to recover from radiation damage. Radiation treatment aims to exploit this difference by delivering the radiation dose progressively over a period of up to 8 weeks, typically in 2 Gy fractions given five times per week. Although external beam radiotherapy covers a range of radiation-emitting equipment, with differing characteristics and radiation protection requirements, the basic principles of room design and safety remain applicable in all cases.

Figure 1 : A linear accelerator and treatment couch.

Radiation Surveys

As soon as possible after a new linear accelerator is capable of producing radiation, a detailed radiation survey should be conducted. This is especially important if the bunker is also new, because this will be the first opportunity to check whether the design constraints have been satisfied−both the design assumptions and the construction are being tested. It is best if the machines output for the reference conditions for each photon energy is set to be at least approximately correct prior to the survey, to avoid misleading survey figures. Equipment required includes the following:

- Two people, one to operate the linear accelerator and one to measure, with means of communication
- A photon survey meter, suitable for the energy range of the radiation measured, and with a calibration figure traceable to a standards laboratory
- If photon energies above 10 MV are to be measured, a neutron meter that reads directly in millisievert and millisievert per hour and which has a reliable calibration figure
- A plan of the bunker and surrounds (including the floors above and below if appropriate)
- A tape measure

If parts of the survey require access to occupied areas, it is prudent to arrange to conduct the survey after-hours. If this cannot be done (e.g., for a hospital ward), then be sure to liaise with the appropriate people regarding the timing of any reason for the survey. Particular care should be exercised with a new facility. When timelines are tight, the survey might have to be undertaken while building works continue around and sometimes within the bunker, and before all the standard safety features have been installed. On the positive side, performing a survey at this stage often allows for speedy and easy fixing of identified issues such as unshielded cable ducts or air vents that compromise the integrity of the treatment room. Close liaison and good communication with all personnel on site is essential, for both radiation safety and good industrial relations. Determine beforehand the appropriate points for survey readings to be taken, and for what beam geometries, concentrating on areas where the readings are likely to be highest, according to the design. The doorway or entrance to the maze, areas behind or near the primary barriers, and areas around wall penetrations are the most important. The surveyor should not be restricted to the predetermined points, though, as the measurements may reveal other points that warrant attention. When measuring the exposure through a wall or door, it is usual to hold the survey meter approximately 30 cm away from the barrier, at a height of about 1 m. This can be taken as an upper limit of exposure to a person standing or sitting in that vicinity.

Of course, other heights and distances from the wall can also be measured, considering children and tall persons, as appropriate. Apply common sense; for instance, in the treatment console area, the workbench may prevent close approach to the wall.

Readings behind primary barriers should be taken with the collimators set to their maximum, with the collimator rotated through 45°, and with no scattering material in the path of the beam. Conversely, readings through secondary barriers and at the maze entrance should be taken with a "full scatter" phantom (at least 30 cm^3) in the beam. A thorough survey will include measurements at gantry angles 0°, 90°, 180°, and 270°; however, the exposure through secondary barriers is not strongly dependent on gantry angle, so one angle will suffice where levels are very low. Depending on the bunker design, photon and neutron readings at the maze entrance are likely be highest when the gantry is pointing in the general direction of the maze, that is, gantry 90° or 270°. However, unlike photons, the neutron exposure is likely to be higher when the photon collimators are closed down. To establish this, it is best to measure for small, medium, and large field sizes at the maze entrance, then thereafter use the field size that gave the maximum neutron exposure.

Survey exposure rates should be entered into a spreadsheet and processed along with workload, use, and occupancy factors before establishing whether the facility is safe for long-term use. If a weakness in the design or construction is detected such that exposure is unacceptably high or borderline in some regions, act promptly to redress the situation. First double-check the measurements and calculations, then discuss possible solutions with the project manager. These might include thickening a wall with high-density blocks or steel plates, adding a door, converting an area from full occupancy to partial occupancy, or placing warning signs or a barrier so that an area can no longer be occupied at all.

Many jurisdictions require a formal detailed radiation survey report to be submitted before the equipment can be registered for ongoing operation.

Reference: *Jamie V. Trapp, "An Introduction to Radiation Protection in Medicine".*