Malignant Diseases Treatment Centres

Prof (Col) Dr RN Basu

Overview of Treatment

- Overall treatment strategy for malignant diseases
  - The strategy may involve:
    - Surgery
    - Chemotherapy
    - Radiotherapy
  - With these strategy hormone therapy and tumour-suppressive drugs also may be used
  - Some patients may receive chemotherapy and radiotherapy concurrently

Overview of Treatment

- Chemotherapy and radiotherapy facilities are largely self-contained
  - They require good access to
    - Main diagnostic
    - Surgical
    - In-patient
    - Critical care
    - Accident and emergency, and
    - Rehabilitation facilities
  - Medical physics, Pharmacy and pathology facilities should also be there along with

Overview of Treatment

- Facilities that are essential are:
  - Wig fitting and prosthesis services
  - Information services, and
  - complementary services
- These services may be provided from the general outpatient department
- The OPD should be located close by
  - Else the oncology facility should have these facilities within the unit itself

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Chemotherapy

- Chemotherapy is the use of anti-cancer (or cytotoxic) drugs
  - These drugs destroy the cancer cells
- The type of chemotherapy used will depend on a number of factors
  - These factors include:
    - Primary. or
    - Metastatic

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Chemotherapy

- Many new chemotherapeutic drugs are now available
  – This has led to more widespread use of chemotherapeutic agents
  – More wider range of solid cancers are also being treated with these agents now than previously
- Patient-specific treatment protocols are prescribed
  – Drugs may be administered over a period of one or two weeks, or
  – Two or more drugs may be administered over a period of one day
  – A typical regimen may last over six months
    - The treatment is given in several sessions

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Chemotherapy

- The drugs are usually given by the intravenous route either as a bolus over minutes
  – This may be done on an outpatient basis, or
  – The drugs may be given as an infusion over hours (as a day case)
- Some drugs may also be prescribed to be taken orally in tablet or capsule form
- Some patients may be admitted as the drugs are administered over a long time, or
  – The regimen may be long
  – The patients would receive chemotherapy on the ward whether bolus or infusion

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Chemotherapy

- The patient will undergo
  - Regular imaging investigation, and
  - Pathology tests
- These tests are done to monitor the success of the treatment
- Oncologists now have higher levels of skill and skilled nursing is also available
  - As a result more patients are now being managed on OPD basis

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Chemotherapy Preparation Area

- The Chemotherapy Preparation Area
  - Should be in a dedicated clean room.
  - The clean room should include the following features:
    - An ante room or area, that is a clean area that precedes the buffer zone (where the BSC is located),
    - This area is used for donning of personal protective equipment

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Chemotherapy Preparation Area

- In the ante room/area, supplies and equipment are removed from shipping cartons
  - The cartons are wiped with a hospital-approved disinfectant
- If supplies are received in sealed pouches,
  - The pouches can be removed as the supplies are introduced into the clean room
  - In this case, there is no need to disinfect the individual supply items.
  - No shipping or other external cartons may be taken into the clean room

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Chemotherapy Preparation Area

- A buffer zone or room
  - this is the area in which the cleanest work surface Biological Safety Cabinet-(BSC) is located.
- This zone or room should be ventilated into the ante room/area to maintain a negative air pressure gradient difference
  - This would isolate biological and chemical contaminants within the clean room and buffer zone/room)
  - The buffer zone/room is used for
    - storage of bulk drug and diluent supplies,

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Chemotherapy Preparation Area

- assembly of materials for chemotherapy drug preparation and admixture,
- packaging of finished doses for transportation within the facility and
- Other activities associated with chemotherapy preparation.
  – This area contains hard, cleanable surfaces throughout (e.g. no porous flooring or ceilings, furniture),
- The Biologic Safety Cabinet (BSC) provides the critical area for preparing cytotoxic chemotherapy products.

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Radiotherapy

- This is the use of ionising radiation to damage or kill deceased cells
- Its main use is found in cancer treatment
  - It can be used with the aim of curing or for palliation, or
  - It can be used as part of wider treatment of cancer
    - Radiotherapy is also used along with surgery

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Radiotherapy

- Radiation exposure can damage cell DNA
  – This may lead to cell being unable to reproduce or to cell death
- Ability of healthy cells to repair itself from this kind of damage is more than the cancerous cells
- This repair mechanism of cells is taken advantage of for planning radiotherapy
  – Radiotherapy treatment is split into several fractions
  – Thus damage to healthy cells will be far less than to cancerous cells
  – The precise fractionation is the crucial part of radiotherapy

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Radiotherapy

- Individual patient treatment plans enable delivery of prescribed radiation doses to the diseased part
- The planning process involves some form of imaging
  – Various structures including the tumour are outlined
  – Organs close to the tumour are designated as “organs at risk”
  – These should receive low radiation doses to avoid long-term undesirable effects

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Radiotherapy

- Radiotherapy treatments are always a careful balance of clinical risk of probabilities
  - The probability is of controlling the tumour and the probability of causing harm to normal tissue
- The plan after production needs to be approved and verified
  - This can be done by further imaging
- After finalisation of the plan the patient can receive treatment

Radiotherapy Staff

- Staff in the radiotherapy department includes:
  - Doctors
  - Physicists
  - Dosimetrists
  - Radiographerts
  - Technologist, and
  - Support staff
- The technical staff must work together

Radiotherapy Staff

- Clinical oncologists
  - Take overall responsibility for the patient's treatment
  - They are involved in diagnosing and determining the staging of the cancer
  - Oncologists decide on a course of treatment and prescribing the radiation dose
  - The process of prescribing is complicated
  - It involves the definition of target volume, and
  - Determining the radiation dose to be delivered
  - They undergo a 3-year degree course in radiotherapy leading to MD in radiation medicine

Radiotherapy Staff

- Physicists
  - Develop and oversee the scientific infrastructure of the oncology centre
  - They are responsible for ensuring the proper commissioning and collaboration and calibration of radiation-producing equipment
  - They ensure safe use of radiation, protecting the patient, the staff and members of the public as per the safety regulation of AERB

Radiotherapy Staff

- The minimum qualification for Medical physicists
  - This is laid down in AERB safety code on Radiation Therapy Services, Equipment and Installation
  - (AERB/RF/MED-1 (rev.1), 2011)
- These are as follows:
  - A PG degree in physics
  - A post M.Sc diploma in radiological/medical physics, and
  - An internship of minimum 12 months in a recognised well-equipped radiation therapy department

Radiotherapy Staff

- Radiological Safety Officer (RSO)
  - Minimum qualification
    - PG degree in physics
    - Post M.Sc diploma in radiological/medical physics
    - An internship of minimum 12 months in a recognised well-equipped radiation therapy department
  - OR
    - A basic degree in science with physics
    - PG degree in radiological/medical physics, and
    - Internship of minimum 12 months in a well-equipped radiation therapy department
  - An approval from the competent authority to function as RSO

Radiotherapy Staff

- Dosimetrist
  - Minimum qualification
    - Qualification as required for a medical physicist
    - A minimum of 2 years experience in dosimetry in a recognised well equipped radiation therapy department
  - Responsiblities of Dosimetrist
  - Shall ensure that
    - The provisions of AE (RP) Rules 2004 are implemented

Radiotherapy Staff

- The responsibilities of Dosimetrist include
  - Carrying out necessary procedures to initiate treatment planning process in consultation with oncologist
  - Carrying out manual/computer generated dose calculations and participation in the review of patient chart
  - Maintaining accurate documentation of all facets of the treatment plan, and Communication of the same to the oncology team
  - Assisting the physicist in clinical dose measurement
  - Assisting in brachytherapy source loading
  - Assisting physicist in clinical dose measurements, machine calibration, quality assurance procedures and radiation protection surveys

Radiotherapy Staff

- Radiotherapy Technologists
  - Qualification requirement:
    - Ten plus two or equivalent examination with science subject from a recognised board
    - Must have undergone a two-year radiation therapy technologist course or equivalent
    - The course curriculum must have been approved by a competent authority
    - The candidate must have passed from a recognised institution with infield training in radiotherapy
    - The institution must have been assessed by the AERB

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Radiotherapy Staff

- Responsibilities of Radiation Therapy Technologist
  - To ensure that AE (Radiation Protection) Rules, 2004 or modified thereafter are implemented
  - Patient set-up in accoprdance with the prescription chart
  - Selection of treatment parameters on the machine and the treatment control panel as defined in the prescription chart
  - Delivery of correct dose to the planning treatment volume

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Radiotherapy Staff

- Stopping the treatment, when fault condition develops
- Intimating the licensee/RSO regarding the incident
- Ensuring that no further treatment is given to the patient unless the RSO certifies in writing
- The certificate should state that the fault condition has been rectified, and
  - It is safe to commence the treatment after resetting the parameters on the control panel
- Following the radiation safety instructions specified by the RSO from time to time

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Radiotherapy Staff

- Radiation Therapy Service Engineer
  - A radiation therapy service engineer shall have:
    - Basic degree/diploma in electrical/electronic/biomedical engineering from a recognised university, and
    - Certification from the competent authority for handling radiation therapy equipment
  - Competent authority
    - Any official or authority appointed, approved or recognised by the Government of India for the purpose of the Rules promulgated under the Atomic Energy Act, 1962

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Radiotherapy Staff

- Auxiliary staff
  - Nurse
  - Social worker
  - Dietician Physiotherapists
  - Occupational Therapists
  - Psychiatrist
  - Maintenance Engineer

Ionizing Radiation Measuring Units

- The amount of radiation delivered needs to be known
  - This is to determine possible harmful biological effects, and
  - To reach definite conclusions in studies that use ionizing radiation
- Specific units are required for radiation measurement

Murat Beyzadeoglu et al. Basic Radiation Oncology. Springer, London

PIONEERS


W.K. Rontgen


H.Gray


M. Curie


H. Becquerel


R. Sievert

Ionizing Radiation Units

- Units of radiation measurement have changed dramatically over the years
  - Some units have been completely abandoned
  - Some units have been introduced
- The measured quantities can be summarised as follows:
  - Source ➔ a ctivity units
  - The first interaction point ➔ Kinetic Energy released in the matter (KERMA)
  - Matter ➔ absorbed dose

Ionizing Radiation Units

- Activity unit
  - This is the number of spontaneous nuclear disintegration (*N*) per unit time *(t)* as measured in becquerels.(A = N/t)
- Radioactivity
  - This is the transition of an unstable nucleus to a steady state through the emission of particulate or electromagnetic radiation from the nucleus
- Curie (Ci)
  - This is an activity of 3.7 X 10^{10} disintegration per second

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Ionizing Radiation Units

- Becquerel (Bq)
  - This is an activity of one disintegration per second
    - 1 Ci = 33.7 X 10^{10} Bq
    - 1 Bq = 2.7 X 10^{-11} Ci
- Kerma *(kinetic energy released in the medium)*
  - This is the sum of initial kinetic energies of all the charged particles liberated by uncharged ionizing radiation (neutrons, protons) in a sample of matter divided by the mass of the sample.
  - The kerma is measured in the same units as the absorbed dose (Gy)

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Ionizing Radiation Units

- The *reference air kerma* is used to define the visible activity. It is the dose delivered in one hour to air one meter away from a source with an activity of 1 MBq. Its units are:
  - 1 µGy^{-1}. m^2 = 1 cGy. H^{-1}.cm^2

- *Absorbed dose.* The basic quantity associated with radiation measurement in radiotherapy is the absorbed dose.
- This defines the amount of energy absorbed from a radiation beam per unit mass of absorbent material. It is measured in grays (Gy), although an older unit, the rad, is also still used

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Ionizing Radiation

- Rad
  - This is the amount of radiation that causes one erg (of energy) to be absorbed per gram of irradiated material (rad = radiation absorbed dose)
  - 1 rad = 100 erg/g
- Gray (Gy)
  - This is the amount of radiation that cause one joule to be absorbed per kilogram of irradiated material
    - 1Gy = 1 J/kg
    - 1 Gy = 100 cGy = 100 Rad

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Ionizing Radiation

- Equivalent dose
  - Since different radiations have different harmful effects on human tissues, the basic dosimetric unit of absorbed dose (Gy) is not sufficient for studies of radiation protection
  - Thus the absorbed dose in tissue must be multiplied by a radiation weighting factor that depends on the type of radiation employed
  - The resulting dose is called the equivalent dose and is measured in sieverts (Sv)
  - An older unit of rem (roentgen equivalent man) is also used

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Definitions

- Effective Dose
  - The quantity 'E' is defined as
    - a summation of the tissue equivalent doses, each multiplied by the appropriate tissue weighting factor:
    - E = Σ WT. HT T where 'HT' is the equivalent dose in tissue 'T' and 'WT' is the tissue weighting factor for tissue 'T'.

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Definitions

- Equivalent Dose ($H_{T,R}$)
  - The quantity $H_{T,R}$, is defined as:
  - $H_{T,R} = D_{T,R}.W_R$
    - Where
    - $D_{T,R}$ is the absorbed dose delivered by radiation type 'R' averaged over a tissue or organ 'T' and
    - 'W_R'is the radiation weighting factor for radiation type 'R'.
      - When the radiation field is composed of different radiation types with values of 'W_R',the equivalent dose is
      - $H_T = \Sigma_R W_R D_{T,R}$

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Radionuclides-Based Radiation Therapy

- There are two principle approaches for ionizing radiation to the tumour
- In the internal radiotherapy, a radiation source is placed inside or in close proximity to the targeted tumour
  - This is known as *brachytherapy*
- This is in contrast to *external beam radiotherapy*
  - This is known as *teletherapy*
  - In this, ionizing radiation originates from a machine outside the body

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Brachythyerapy

- In this mode of therapy, a high dose of radiation can be delivered locally to the tumour
  - Surrounding tissue gets much less dose
- Most of the sources used are artificially produced radioactive isotopes such as
  - cesium 137 (^{137}Cs), iridium 192 (^{192}Ir), gold 198 (^{198}Au)
- The implanted radionuclide can be removed after sometime or remain forever

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Teletherapy

- This is the most frequently used form of radiotherapy
- A radiation beam is generated by a machine source of radiation external to the patient and at a distance from the body
- Two most important characteristics
  - The localisation of the beam to the target volume,
  - The level of dose deposited in the tumour

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Teletherapy

- In the planning process
  - Radiation beams /sources are simulated in order to calculate and assess the optimum treatment geometry and dose delivery by the radiation
- Patients usually attend the radiotherapy unit on an out-/day patient basis

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Cobalt-60 Teletherapy Unit

- The well-known isotope of cobalt is unstable radioactive Co-60
- The isotope was discovered by Glenn Seaborg and John Livinghood at California Berkeley University in 1930
- Cobalt-60 is now produced commercially in nuclear reactors
  - The decay of Co-60 starts with a b^- decay and then two gamma emissions with energies of 1.17321 and 1.33247 MV are observed

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Cobalt-60 Teletherapy Unit

- The half-life of Co-60 is 5.27 years
  - For practical purposes it is considered harmless and inactive after ten half-lives
  - Thus Co-60 should be stored safely for approximately 53 years
- Co-60 teletherapy units have a cylindrical source 2 cm in diameter
  - The activity of the source is generally between 5000 and 15000 Ci
  - A source with an activity of less than 3000 Ci is replaced with a new one
  - This is necessary after 5-7 years of use

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Cobalt-60 teletharapy unit

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Cobalt-60 Teletherapy Unit

- Co-60 teletherapy units provide good performance for tumours with depths of <10cm
  - Thus the use of linac is recommended for more deeply seated tumours
- The leakage from the treatment head is not more than 2mR/h at 1 m
- The drive mechanism returns to its parked position spontaneously in emergencies (even during electric interruptions)
- The collimator system can move to any position when the gantry is rotated

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Linear Accelerators (linacs)

- The linear accelerator is the primary and mostly widely used treatment unit for radiotherapy
- Radiation beams are produced by accelerating electrons to a very high energies, and
  - Depending on the type of radiation beam required, directing the accelerated electrons onto a metal target

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Linear Accelerators (linacs)

- Linear accelerator is the primary and mostly widely used treatment unit for radioiotherapy
- Radiation beams are produced by accelerating electrons to very high energies, and
  - Depending on the type of radiation beam required, directing the accelerated electrons onto a metal target
- The radiation beams are shaped by collimators or applicators in the linac head
  - This achieves precisely defined radiation field
- Linac measures the radiation output in order to deliver precisely determined radiation dose

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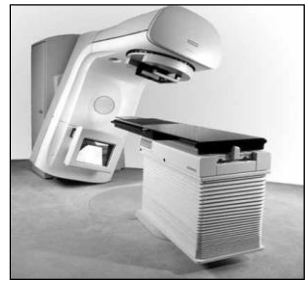

Example of an accelerator-based radiation therapy machine, the Primus™, *by* Siemens.

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End of Part 1