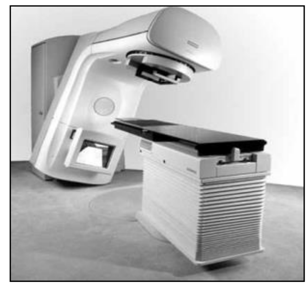
# Malignant Diseases Treatment Centres Part 2

Prof (Col) Dr RN Basu



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

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## Conformal Radiation Therapy

- The goal of *Conformal radiation therapy is:*
  - To deliver a high dose to a volume that closely conforms to the shape of patient's tumour volume
  - At the same time minimize the dose to any neighbouring sensitive organs
- This involves:
  - Accurately identifying exact shape and location of the tumour

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## Conformal Radiation Therapy

- This development allowed use of the maximal applicable tumour doses, but
  - without increasing radiation-induced complication for the patients
- This requires:
  - good imaging,
  - accurate radiation dose calculation,
  - computer-optimized treatment planning and
  - computer-controlled delivery of precisely directed radiation beam

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## Conformal Radiation Therapy

- Conformal radiation therapy became possible due to certain recent techniques.
- Tumours usually have an irregular shape
  - Capability is now available shaping the targeted volume exactly to the size and shape of the tumour
- Some of the most effective tools and techniques are:
  - The multileaf collimators (MLCs)
  - Intensity modulated radiation therapy (IMRT)
  - Adaptive radiation therapy (ART)
  - Image-guided radiation therapy (IGRT )
  - Stereotactic radiosurgery (SRS), and
  - Tomotherapy

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## Multileaf Collimators (MLCs)

- Radiation therapy may cause unnecessary irradiation of healthy tissue
- Collimation and shaping techniques were used to conform to tumour shape
- Metal such as tungsten is used to shape the X-ray field into rectangular shapes of different sizes
  - These collimators (referred to as jaws) remain stationary during treatment
- Additional beam shaping is accomplished through use of combination of these jaws

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## Multileaf Collimators (MLCs)

- MLCs consist of a large number of collimating shielding blocks or leaves
  - These can be driven automatically to generate a field of any shape
  - Beams can conform to each patient's tumour
- Thus normal tissues are spared
- More number of less wide leaves help accurately shape the beam to tumour shape

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## Intensity-Modulated Radiation Therapy (IMRT)

- Computer-controlled MLC is an essential tool to modulate X-ray beams for IMRT
  - This is a means of providing dose distributions that conform to target volumes
- IMRT is capable of delivering radiation dose to:
  - The areas that need it, and
    - Reduce radiation to specific sensitive areas
  - In IMRT, the radiation beam can be viewed as if it is broken up into many beamlets
  - Intensity of each beamlet can be adjusted individually

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## Adaptive Radiation Therapy (ART)

- The position of the tumour and its shape can change during a patient's radiation therapy
- Some of the sources of variations are:
  - Tumor shrinkage
  - Weight loss or gain
  - Change in hollow organ or cavity filling
  - Respiratory motion of the lung and adjacent organs



## Adaptive Radiation Therapy (ART)

- ART is basically a closed-loop process
  - In this the treatment plan can be modified using a systematic feedback measurements
  - These feedback help in determining accurate position of target tissues
  - This is done by
    - the implantation of *fiducial markers, or*
    - Use of imaging techniques such as CT and MV or KV X-ray imaging
  - It is also important to verify the actual delivered dose of radiation in each session



## Adaptive Radiation Therapy (ART)

- There are multiple RT delivery systems that combine the imaging with radiation
- ART allows the oncologist
  - To increase the amount of radiation that can be delivered to the tumour, and
  - Reducing the risk of excess radiation of tissues surrounding or near to the tumour
- Two examples are:
  - Accuray's Hi-Art® Tomotherapy system, and
  - CyberKnife® system



## Image-Guided Radiation Therapy (IGRT)

- The success of cancer radiation therapy delivery depends on:
  - Maximising the radiation dose to the tumour, and
  - At the same time minimising the effects of radiation on the surrounding tissue
- This becomes more critical when the tumour is sarrounded by sensitive tissue such as eye, spinal cord or lungs
- To achieve this objective, dose delivery must be accurate

## Image-Guided Radiation Therapy (IGRT)

- Improved accuracy and precision can be achieved by the newer technique of IGRT
- Radiation therapy for most patients involves a series of RT sessions
  - Typically these sessions are five days per week for as long as five or six weeks
- During this period the patient may gain or lose weight
  - Also during treatment sessions patients positioning may vary
  - Patients may move on the treatment couch due to pain or other reasons
- IGRT is a technique that is used in combination with other methods including CRT and IMRT
  - This improves the accuracy of treatment and compensates for variation in tumour positioning

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## Image-Guided Radiation Therapy (IGRT)

- Different techniques are used to implement IGRT effectively
- Two recently developed examples are:
  - Tomotherapy ® unit – Hi-Art ®
  - CyberKnife ®
- Tomotherapy is a term derived from tomography and therapy
  - Tomotherapy machines combine the precision of CT and capabilities of IMRT

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Hi-Art® system manufactured by Accuray Inc

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## Robotic Radiosurgery Cyberknife

- CyberKnife® is a radiosurgery system designed to treat well-defined tumours
- Used most often malignancies located in brain, spine, head, and neck
  - More recently it is used to treat tumours at different parts of the body
- It uses image guidance and a robot to achieve the precision of delivery
  - It is useful for treating tumours that is close to critical structures

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Accuray's CyberKnife System®. (Courtesy of Accuray.)



## Cyberknife

- The systems X-ray cameras monitor movement during treatment
  - This is done by tracking small markers implanted in the tumour, or
    - By tracking body's skeletal structures
- The robotic arm is fitted with a linac
  - This can aim many small radiation beams at the tumour from multiple different angles
- The oncologist is able to give high dose to the tumour sparing the surrounding tissue
- The linac in this system is smaller



## Stereotactic Radiosurgery (SRS)

- This is also known as stereotactic radiotherapy
- In this, radiation beam can be focused precisely to destroy certain types of tumours
- It delivers high doses of radiation to small tumors with well defined edges
  - Fewer sessions are required in SRS
- SRS units use extremely accurate image-guided tumour targeting and precision positioning system
  - Immobilisation devices such as head frame are used for brain tumours
  - Examples: Cyberknife, Gamma Knife



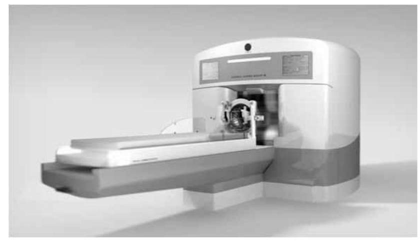
## Gamma Knife Radiosurgery

- Gamma Knife is typically used for treating brain tumours
  - High-intensity gamma radiation is used
  - The beam is accurately focused to converge on the targeted tumour
- Each individual beam is of relatively low intensity
  - This low intensity radiation does not affect the intervening brain tissue
  - The beam is concentrated on the tumour itself
  - This machine typically contains 201 cobalt 60 sources placed on a circular array in a heavily shielded assembly

## Gamma Knife Radiosurgery

- The patient wears a special helmet that is surgically fixed to the skull
  - Brain tumour remains stationary at the target point of the gamma rays
  - Thus, the tumour receives a substantial dose of radiation
  - Surrounding brain tissues are relatively spared





Elekta's Gamma Knife™



## Intraoperative Radiation Therapy

- Intraoperative radiation therapy is a special technique to deliver radiation dose during operative procedure
- Radiation dose is delivered in a single session to surgically exposed tumour bed after removal of the tumour
- The procedure allows the delivery of high radiation doses to the extent of 10 Gy



## Intraoperative Radiation Therapy

- Nearby normal tissue is spared
- Tiny tumour fragments may remain after surgery and recurrence may take place
- RT may destroy these remaining fragments
- Before delivery of radiation, normal tissue is shielded or displaced out of RT field
- As the target area is exposed, electron beam radiation is more suitable for IORT than X-ray radiation

The Mobetron, an IORT unit by IntraOp Medical Corporation (Santa Clara, CA).

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## Shielding

- Shielding
  - Adequate structural shielding shall be provided for the walls, ceiling and, where appropriate, the floor of the treatment room,
  - Radiation doses outside the room must not exceed the dose limits specified in appendix-iv. (AERB)
  - The shielding for the radiation therapy installation shall be arrived at, taking into account:
    - The patient workload, use factor of the radiation beam and occupancy in the vicinity.
  - The entry to the treatment room shall be of indirect type (maze) so as to minimise the shielding requirement at the entrance door

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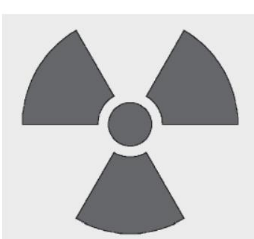
## Radioactive Material Symbol



**TREFOIL details**
For inner circle of radius R, the inside radius of the blades is 1.5R and the outer radius of the blades is 5R. The blades are separated by 60°.

These are magenta or black propellers on yellow background.

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## Personal Protective Equipment

- Hazard to workmen should be eliminated or controlled by engineering methods rathar than use of PPE
- Use of PPE is an important and necessary consideration in the development of safety programme
- Quality of PPE
  - To provide absolute and full protection against possible hazard
  - To be so designed and manufactured out of such material that it can withstand the hazard against which it is intended to be used

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## Personal Protective Equipment

- Selection of PPE
  - Following needs to be considered
    - Nature and severity of hazard
    - Type of contaminant, its concentration and location of contaminated area with respect to the source of respirable air
    - Expected activity of workman and duration of work
    - Comfort of workman when using PPE
    - Ease of maintenance and cleaning
    - Conformity to standards and availability of test certificates

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## Personal Protective Equipment

- Categories of PPE
  - Non-respiratory
    - These are used for protection against injury from outside the body
      - For protecting head, eye, face, hand, arm, foot, leg and other body parts
  - Respiratory
    - These are used for protection from harm due to inhalation of contaminated air

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## DOSE LIMITS

- Dose Limit
  - The limits on effective dose apply to the sum of effective doses
    - from external and internal sources
    - This will exclue the exposures due to natural background radiation and medical exposures
  - The calendar year shall be used for dose limitation purposes.
- Workers
  - The occupational exposure of any worker shall be so controlled that the following limits are not exceeded:
    - an effective dose of 20 mSv/y averaged over five consecutive years (calculated on a sliding scale of five years);

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## DOSE LIMITS

- an effective dose of 30 mSv in any year;
- an equivalent dose to the lens of the eye of 150 mSv in a year;
- an equivalent dose to the extremities (hands and feet) of 500 mSv in a year
- an equivalent dose to the skin of 500 mSv in a year;

- limits given above apply to female workers also.
  - However, once pregnancy is declared the equivalent dose limit to embryo/fetus shall be 1 mSv for the remainder of the pregnancy

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## DOSE LIMITS

- Public
  - The estimated average doses to the relevant members of the public shall not exceed the following limits:
    - an effective dose of 1 mSv in a year;
    - an equivalent dose to the lens of the eye of 15 mSv in a year; and
    - an equivalent dose to the skin of 50 mSv in a year.

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## Radiotherapy Workflow and Concept Design

- Integration of Cancer Treatment
  - It is becoming more integrated with all or some of the other disciplines, such as:
    - Surgery
    - Chemotherapy (medical oncology)
    - Radiotherapy
    - Paediatric Oncology
    - Nuclear Medicine
    - Diagnostic Services
    - Allied medicine: physiotherapy, oncology social work, counselling, dietetics, palliative supportive care, emergency care etc

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## Radiotherapy Concept Design

- It is preferable in new facilities to expedite multidisciplinary solution
- The possibility of future changes to the facilities should be considered at the planning and design phases
- Patient, visitor and staff circulation should be considered when planning and designing
  - If possible, the routes should be separated whenever possible

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## Radiotherapy Concept Design

- A typical facility should consist of five main functional areas:
  - Reception, administration and waiting areas
  - Clinical consulting area
  - External beam radiotherapy (EBRT)
  - Brachytherapy
  - Imaging and treatment planning

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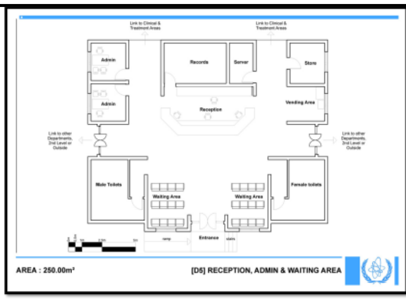


Typical Layout of the main reception area

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## Radiotherapy Concept Design

- Reception, Administration and Waiting Areas
  - The reception and main waiting area should be located at the main entrance to the department
  - This acts as a distribution point for all the different sections of the department
  - Number of reception staff should be sufficient to service the number of oncologists and medical officers for new and follow-up patients
  - A typical ratio should be one per team of two cxlinicians

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## Radiotherapy Concept Design

- Administration consists of separate offices for financial matters
  - This area is generally more private and where matters can be discussed more confidentially
- Retention period of records varies in different countries
  - As a general guideline, every paediatric record should be kept till the child is 21 years old
  - Or, for at least 10 years after the last contact

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## Radiotherapy Concept Design

- The ten year rule may also be considered  for adult
- Files could be kept separate from images as a double safety measure
- Sufficient space need to be allocated to accommodate the anticipated number of records
- Sufficient parking should be made available for ambulances, staff and patients
- Ideally, the patient should be allocated parking closest to the department

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## Radiotherapy Concept Design

- Waiting areas
  - Where appropriate, may be designed with separate enclosures to meet cultural requirements
  - The size of the main waiting area in reception does not need to cater for all patients attending the facility daily
    - Sub-waiting rooms should be provided in all the functional areas
  - Provision need to be made for stretcher bays
    - Ideally a seperate side or rear entrance should be used near the treatment facilities



## Radiotherapy Concept Design

- Clinical consulting area
  - Sub-waiting at various clinics for consultations need to be provided
  - The size of the clinical consultation rooms should be adequate to house a desk and two or three visitors' chairs
    - Should include a screened or separate examination area with a wash hand basin (WHB)
  - The total number of consultation rooms should be related to the number of radiation oncologists, medical officers and trainees in the department
  - Nurses, dieticians, social workers and other allied health workers may also need to be provided with consultation room/office within the facility

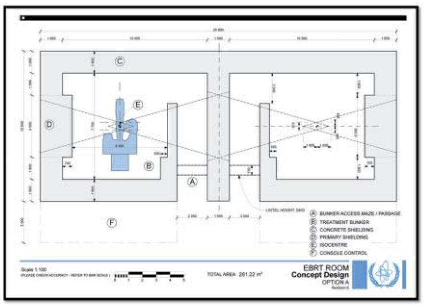



Typical Layout of a radiotherapy clinical consulting area



## Radiotherapy Concept Design

- External Beam Radiotherapy
  - It is advisable to place bunkers above ground, together with rest of the facility
  - This will facilitate natural lighting and ventilation
  - Waterproofing and drainage may be an additional challenge in underground bunkers
  - Construction of *fully shielded underground bunkers may also be required if future for* adjacent facilities are not known
  - Facilities are ideally designed with adjacent bunkers to reduce costs by sharing the primary shielding structures
    - This will reduce the footprint and the total volume of shielding material needed

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## Radiotherapy Concept Design

- EBRT (contd.)
  - Safety and security assessment may require that a door be installed
  - The door would be for restricting access by providing a physical barrier only and not for shielding against radiation.
  - Access during radiation can be prevented with a combination of light sensors and/or push gates or barriers that are interlocked to the control panel.
  - Modern megavoltage photon teletherapy units have a gantry with a maximum source–axis distance of 100 cm.

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## Radiotherapy Concept Design

- The gantry and the patient treatment table are engineered to rotate around an isocentre.
- The minimum recommended inside room dimensions are 7 m × 7 m
- Modern megavoltage photon teletherapy units have a gantry with a maximum source–axis distance of 100 cm.
- The minimum structural room height should be 4 m, including along the maze.
- The isocentre to be positioned approximately in the centre of the room.
  - These room dimensions provide space for the structure of the teletherapy unit and for the maximum longitudinal extension of a typical patient treatment table.

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# Layout Radiotherapy
(As per AERB)

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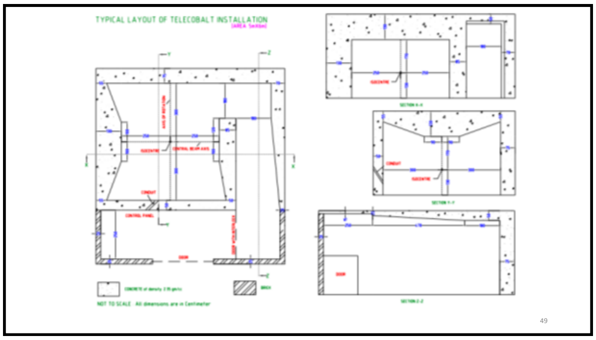
TYPICAL LAYOUT OF TELECOBALT INSTALLATION
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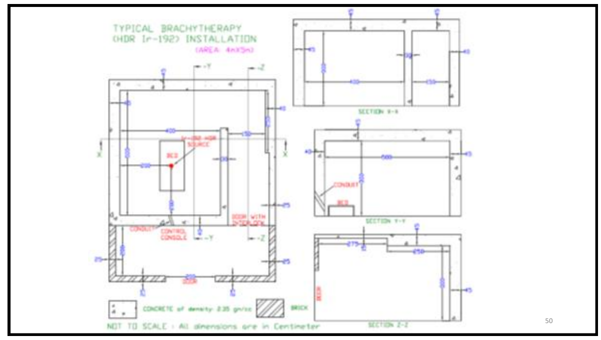
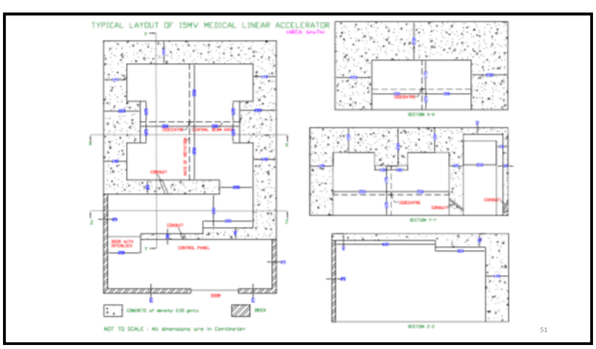

TYPICAL BRACHYTHERAPY
(HDR Ir-192) INSTALLATION
(AREA: 4mX5m)
SECTION X-X
SECTION Y-Y
SECTION Z-Z
CONCRETE of density 2.35 gm/cc
BRICK
NOT TO SCALE : All dimensions are in Centimeter
50


TYPICAL LAYOUT OF 15MV MEDICAL LINEAR ACCELERATOR
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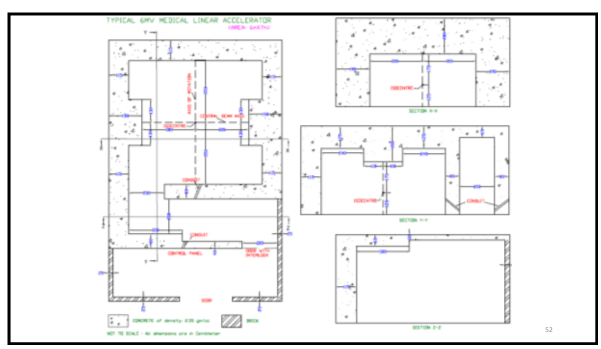
TYPICAL 6MV MEDICAL LINEAR ACCELERATOR
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## Principles of Surgical Oncology

- Surgical oncology is the specific application of surgical principles to the oncology setting
- These principles have been derived by
  - adapting standard surgical approaches
  - to the unique situations that arise when treating cancer patients
- The surgeon is often the first specialist to see the patient with a solid malignancy



## Principles of Surgical Oncology

- Surgical oncologist is often the first specialist to see a case with solid tumour
- The surgical oncologist may be called upon to provide diagnostic, therapeutic, palliative and supportive care
- Surgical oncologist should be knowledgeable about all the modalities of cancer treatment
  - This will enable the surgeon to explain to the patient the various treatment options
  - The communication should be done in such a way that it should not interfere with any future treatment option



## Principles of Surgical Oncology

- No touch technique
  - There is a theoretical possibility of local implantation and embolization of tumour cells when the tumour mass is manipulated
  - The metastatic potential of the primary lesion would be enhanced by the extrusion of tumour cells into local lymphatic and vascular spaces
  - There may be some validity to this theory with respect to tumours that extend directly into venous system
  - Example:
    - Renal cell tumours with extension to the vena cava



## Principles of Surgical Oncology

- Palliation
  - Aspects of palliation, or the reduction of suffering are delegated to the surgeon
  - Examples are:
    - Venous access
    - Surgical relief of ascites
    - Fixation of pathological fractures
    - Placement of feeding tubes to deliver food and drug
  - Risks and benefits need to be discussed with patients , family and referring physicians

## Oncology Operating Theatre

- Attention to be paid to the need for:
  - Mobile C-arm, or
  - Image intensifier access and use
  - Special storage facilities for catheters, guide wires etc will be needed
- These should be within or immediately adjacent to the operating room
- Where laser is used, adequate safety measures are to be adopted
- For radiation therapy, appropriate shielding of OR to be done

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## End of Life Care

- Dying patients are cared for in many settings:
  - These setting includes ICU, hospital wards, hospice facilities, aged care facilities and the home
- Principles
  - Primary goal of medical care is preservation of life
  - There are occasions when medical science is of no avail to reach this goal and death becomes inevitable
  - When the patient cannot make decision about the life sustaining treatment, ethical consensus among care givers need to be built about what is the best for the patient

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## End of Life Care

- The guiding principles are:
  - Respect for life and care in dying
  - The right to know and to choose
  - Appropriate withholding and withdrawal of life-sustaining treatment
  - The collaborative approach to care
    - Healthcare professionals have an obligation to work together to make compassionate decisions for patients lacking decision-making capacity

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## End of Life Care

- Transparency and accountability
  - The decision making process and its outcomes should be clear to the participants
  - This is to be accurately recorded
  - All these are necessary for sustaining trust in medical profession
- Non-discriminatory care
  - The decisions at the end of life should be non-discriminatory
  - This should be based only on that are relevant to only patient's medical condition

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## Hospice

- Concept
  - Hospice is a concept of caring derived from medieval times
  - This symbolises a place where travelers, pilgrims and a sick, wounded or dying could find rest and comfort
  - The contemporary hospice offers a comprehensive programme of care to patients and families facing a life threatening illness
  - Hospice is primarily a concept of care , not a specific place of care

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## Hospice

- Hospice emphasises palliative rather than curative treatment
  - The dying are comforted
  - Professional medical care is given and sophisticated symptom relief provided
- The patient and family are both included in the care plan
  - Emotional, spiritual and practical support is given based on the patient's wishes and family's needs
  - Trained volunteers can provide respite care for family members as well as meaningful support to the patient

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The Strasburk Hospice, Prague, Czech Republic, founded in a donated former residence on the edge of a large psychiatric hospital dating from the late nineteenth century. It is located in a suburb of Prague

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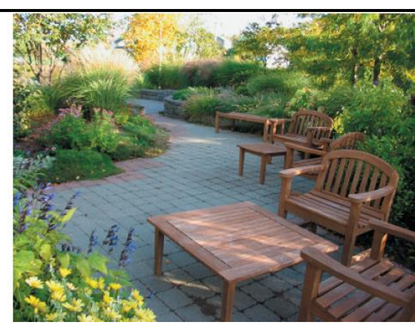

Hospice Japanese Garden

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**Thank you**

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