I. Equipments for external beam radiotherapy

5 linear accelerators (LINACs):
- Varian TrueBeam  6, 10 & 18 MV photons, 6-18 MeV electrons, image-guided (IGRT) and intensity modulated radiotherapy (IMRT), gated radiotherapy, stereotactic radiosurgery (SRS) and stereotactic body radiotherapy (SBRT)
- Siemens Artiste  6 & 18 MV photons, 6-18 MeV electrons, IGRT, IMRT, gated radiotherapy
- Siemens Primus I  6 & 18 MV photons, 6-21 MeV electrons, 3D conformal radiotherapy (3D-CRT)
- Siemens Primus II  6 & 18 MV photons, 6-21 MeV electrons, 3D-CRT, IMRT, SRS, micromultileaf collimator (micro-MLC)
- Siemens Primus III  6 MV photon, 3D-CRT

All linear accelerators are equipped with multileaf collimator (MLC), and electronic portal imaging device (EPID). The Varian TrueBeam machine is mounted with a kV cone-beam CT, while our Siemens Artiste LINAC is using MV cone-beam CT and an „in-room” CT unit for high precision IGRT and IMRT.

- Theratron 780E telecobalt treatment unit
- Special cobalt unit for the delivery of total body irradiation (TBI) before bone marrow transplantation
- Gulmay (40-200 keV) ortovoltage X-ray therapy equipment
- Dermopan (50 keV) superficial X-ray therapy equipment

Accessories, treatment planning systems

- Treatment planning system (Philips Pinnacle 3D & Varian Eclipse)
- Conventional simulator (Siemens Simview NT)
- 2 CT simulators (Siemens Somatom Emotion 6 & Siemens Somatom Definition AS)
- „In-room” CT at Artiste LINAC (Siemens Sensation Open)
- MRI equipment (General Electric – 3 Tesla*)
- Record & Verify system – Simenes LANTIS & Varian ARIA

*Shared use with Diagnostic Radiology Department

II. Brachytherapy equipments

High-Dose-Rate remote controlled afterloading equipment (HDR-AL )
- Nucletron microSelectron

Accessories, treatment planning systems

- Treatment planning system (Nucletron Oncentra Brachy)
- Prostate HDR-brachytherapy (Nucletron SWIFT system)
- Prostate permanent iodine-125 LDR-brachytherapy (Nucletron SPOT & Bebig system)
- Rectal Ultrasound equipment (B&K Medical)
- C-arm, isocentric localization X-ray equipment (Siemens Arcadis Orbic)
**Linear accelerator**

An electron accelerator, specially developed for external irradiation of patients with cancer. The electrons are accelerated with high frequency electromagnetic waves, focused on the target where they lose energy, creating “bremsstrahlung” photons. The shape of the treatment field can be formed with the collimators integrated in the head of the accelerator. With the removal of the target, a high energy electron beam can be created. The gantry is the rotatable part of the accelerator, which gives the opportunity to irradiate from different angles without moving the patient. The rotatable couch gives more flexibility during treatment planning. For tumours next to the body surface electrons with the energy of 6-21 MeV are used. For tumours located deeper in the body photons with the energy of 6-18 MV are used.

**Cobalt unit**

Therapeutic machine used in external beam radiotherapy. A cobalt (Co-60) isotope is used as radiation source, which emits photons with the mean energy of 1.25 MV. A shielded container in the head stores the source while there is no need for radiation. An automatic mechanism moves the isotope into the treating position, when the beam is switched on, and returns it after beam is off.

**Therapeutic X-ray machine**

The kilovoltage (40-200 kV) machine mainly used for the treatment of skin cancer, tumours next to the body surface and benign cases (e.g. arthrosis, keloid).
Radiotherapy X-ray simulator

It is a special X-ray machine equipped with a kV source and an image intensifier. All patient position and treatment parameters can be set up for simulation, because it has the same configuration as the accelerators. The main advantage in the patient positioning is that better soft tissue contrast can be achieved with the kV system compared to the MV system installed on the accelerators.

CT-simulator

It is a standard multi-slice CT scanner equipped with movable lasers and has extended field of view because of the size of patient immobilizer systems. Beside the topometric CT scans for the treatment planning system, reference point marking and treatment fields can also be made.

Brachytherapy (afterloading equipment)

In brachytherapy the radioactive source is placed inside or directly next to the tumour. The isotope is stored in the shielded container of the afterloading machine, except when the catheters or applicators are placed in treatment position. Using this shielding the radiation protection of the staff and the patient can be provided. For the treatment the source is loaded into the treatment positions with an automatic remote control mechanism. The afterloader moves the isotope through the active source positions in each catheter. The microSelectron afterloader is equipped with an Ir-192 radioactive source, which emits gamma radiation with the mean energy of 360kV.
Radiotherapy treatment planning system

used for preparing the personalized treatment plans for the patients. Computers with high computing capacity are included into the system for dose calculation and 3D image reconstruction. Anatomical information of patients and physical, dosimetric parameters of accelerator are used for a treatment plan. The anatomical information can be collected with a CT scanner, dedicated for radiotherapy. On the CT slices the contours of the organs at risk and target volumes are delineated. Depending on the position of these volumes the angles and shapes of the fields are defined, and the dose distribution is calculated. The dosimetric and set up parameters of the treatment plan are sent to the simulator and accelerator.
Process of Radiotherapy step by step

Topometrical image acquisition

For treatment planning a dedicated CT image acquisition is performed. Small marks with tattoos or ink are signed on the patient skin helping reproducible daily positioning. Every radiotherapy machine is equipped with lasers for patient set up. The marks on the patient and the lasers must be synchronized. Different patient fixation devices are used for different localisations to minimize intrafractional motions. After the examination the CT scans are sent through the network to the treatment planning system.

Treatment planning

On each CT slice the planning target volume (tumour with safety margins) and the organs at risk (e.g. spinal cord, lungs, lens etc.) are delineated. Depending on the position of these volumes the angles and shapes of the fields are defined, and the dose distribution is calculated, and the plan quality is analyzed. The general purpose during treatment planning is to cover the target with the highest possible dose while sparing the dose to the surrounding normal tissues. The documentation of the treatment plan is printed, and sent to the simulator and to the accelerator.

Simulation

During the process of simulation the position of the isocentre is marked on the skin of the patient, and also the orientation and position of the treatment fields are verified. For this purposes the patient has to be positioned identically as previously (during the planning CT scan). For basic treatment techniques beam orientations and field sizes can be defined and can be marked on the skin of the patient in the simulator. If during the topometrical image acquisition a CT simulation was performed, there is no need for simulation.

Treatment

Overall treatment time of external beam radiotherapy is usually 1 to 8 weeks, usually with daily treatment sessions (or so called fractions) over 5 days a week. The process is painless and the daily treatment time is about 10 to 20 minutes. Usually the first treatment takes more time, because every treatment field and the patient positioning must be verified with the accelerator’s built in MV or kV portal imaging.