Radiation Therapy

Types of radiation

- Gamma radiation: radiation that originates from the decay of an atomic nucleus
- X-ray: radiation that originates outside of the atomic nucleus and is emitted when high energy charged particles (electrons) bombard a suitable target such as tungsten

Radiation units

The deposition of energy by radiation exposure is called radiation-absorbed dose – and it is measured in rads.
1 rad ≈ deposition of 100 erbs of energy into each gram of the irradiated object = 1 Joule/kg
1 rad = 1 cGy

Fractionation ≡ division of total radiation dose into several interval doses
Radiocurability ≡ elimination of tumor at the primary or metastatic site that is due to a direct effect of radiation.
Radiosensitivity ≡ response of tumor to irradiation that can be measured by the length of time of regression.

- The higher the hypoxic content of tumor cells, the less responsive the tumor to radiation.
- Hypoxic cells are three times more resistant to the effects of radiation than are cells with normal pO_2.

The limiting factor with regard to radiocurability is the inherent toxicity to normal tissue by increasing doses of radiation.
Approximate tolerance of tissues to radiation therapy:

Bladder	6000-7000 cGy
Rectum	6000-7000
Vaginal mucosa	7000
Bowel	6000
Cervix	>12,000
Kidney	2000-2300
Liver	2500-3500

Effects of Radiation on Fetus

Peak incidence of gross malformations occurs when the fetus is irradiated during the early organogenesis period (10-40 days of gestation).

Radiation Techniques

- Teletherapy (external beam) – Two opposing beams (e.g. anteroposterior and posteroanterior) usually produce a relatively homogeneous distribution of dose within the intervening tissue with some sparing of the skin surface. Two different radiation treatment techniques have been used for abdominal radiation.
  - Whole abdomen: large portals are used and a dose of 2500-3000 cGy is delivered during a 4-5 weeks period. The kidneys and right lobe of liver are shielded to limit the dose to 2000-2500 cGy.
  - Moving strip technique: The abdomen is divided into 2.5cm contiguous segments. Both back and front are treated every day and the treatment field is expanded by one strip every 2 days until 4 strips (10 cm) have been treated. The 10 cm segment is moved up 2.5 cm every 2 days until the last strip is reached. The field is then reduced one strip at a time and on the last 2 days of treatment, a single 2.5cm strip is irradiated. Again, the kidneys and liver are shielded. A tumor dose of 2600-2800cGy can be delivered safely.
  - Both techniques usually end with a pelvic boost of 2000-3000 cGy.
- Brachytherapy (Local irradiation) – placement of radioactive source within the body. Most commonly, intrauterine or intravaginal applicators are used loaded with ^{137}Cs, ^{226}Ra, ^{192}Ir.
  - Conventionally, brachytherapy has been delivered at a low dose rate (LDR), usually at 40-60 cGy/hr
  - High dose rate (HDR) treatment may offer practical advantages because it can be performed outpatient with dose fractionation. Dose fractionation schemes used for HDR therapy have tumor control and complication rates equivalent to that of LDR therapy.
  - Interstitial implants – radioactive sources are placed within tissues. Permanent implantation of ^{125}I or ^{198}Au seeds is sometimes used to treat pelvic or aortic lymph nodes, especially recurrences after irradiation. ^{192}Ir can be temporarily delivered via Teflon catheters to treat tumor bed disease.
- Intraperitoneal isotopes
  - ^{32}P has largely replaced ^{198}Au due to its longer $t_{1/2}$ (14.3 days), pure β decay, and a higher mean energy (0.698 MeV) result in slightly longer exposures, fewer radiation protection problems, and deeper tissue penetration.
  - The pattern of energy deposition within the abdomen and the dose delivered beneath the peritoneal surfaces depend upon
    1. physical character of isotopes used
    2. energies of its decay products
    3. distribution of the isotope in the peritoneal cavity

Clinical Uses

- Cervical cancer
  - Typical external beam fields are designed to include primary tumor, paracervical tissues, and the iliac and presacral lymph nodes, all with 1.5 to 2.0 cm margins. For most patients with locally advanced disease,

initial course of treatment is given with Teletherapy for 4-5 weeks with total dose 4000-4500 cGy. The dose to the central tumor is then supplemented with one or two LDR intracavitary treatments over with a variable number of HDR treatments.
    - Point A ≡ 2 cm lateral and 2 cm superior to external cervical os in the plane of the implant. The total dose (external beam and LDR) believed to be adequate to achieve central disease control is usually between 7500 cGy (Stage IA) to 9000 cGy (locally advanced).
    - Point B ≡ 3 cm lateral to Point A. The prescribed dose to point B is 4500 to 6500 cGy, depending on the extent of parametrial and sidewall involvement.
    - Studies have demonstrated improvement in pelvic disease and survival when cisplatin and possibly 5-flourouracil are used as radiosensitizers.
    - For patients with IB and IIA disease who undergo radical hysterectomy, adjuvant external beam radiation is recommended for positive lymph nodes. If nodes are negative, large tumor size (≥ 4 cm), deep stromal invasion (> 2/3), or lymph vascular space invasion predict an increased risk for pelvic recurrence. Postop radiation portends a RR 0.53 (p=0.008) for pelvic recurrence.
    - External beam therapy for recurrent disease and for palliation related to bony metastases and paraaortic nodal disease.
- Uterine cancer
    - adjuvant treatment to prevent pelvic recurrence after hysterectomy and BSO
        1. usually not necessary for Stage 1 Grade 1 or minimally invasive Grade 2
        2. some clinicians recommend vaginal intracavitary radiation for Grade 2
    - preoperative treatment for extensive cervical stromal involvement
    - curative for some patients with medical comorbidities that preclude surgery
    - curative for isolated vaginal or pelvic recurrence
    - palliative for massive pelvic or metastatic recurrence
- Ovarian cancer - Transperitoneal spread is the most common route of dissemination so radiation fields that encompass the whole peritoneal cavity are more likely to be curative than those which treat only the pelvis or lower abdomen
- Vulvar cancer

Sources

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3. Practical Gynecologic Oncology, 3rd edition. Berek JS and Hacker NF, eds. Lippincott, Williams, and Wilkins, Philadelphia, 2000: 117-58.