PIPADOR REVISION

MRCOG Part 1 Revision Notes

Ionising Radiation and Radiotherapy

MEDICAL PHYSICS • LECTURE 511

VISUAL EXAMINATION REVISION NOTES

2026 Edition

511

MRCOG PART 1 REVISION NOTES | MEDICAL PHYSICS

Ionising Radiation and Radiotherapy

Radiation types and units, radiobiology, radiotherapy techniques in gynaecological oncology and UK regulations

Gray (Gy)	Sievert (Sv)	≈ 2.7 mSv/yr	5 Rs
Absorbed dose	Effective dose	UK background	Fractionation

■ KEY FACTS: Learning objectives

- Define ionising radiation, its types and the units of absorbed, equivalent and effective dose.
- Explain radiobiology: DNA damage, radiosensitivity, the oxygen effect and the rationale for fractionation.
- Describe external beam radiotherapy, brachytherapy and chemoradiation in gynaecological oncology, and UK radiation protection regulations.

511.1 Key definitions

Term	Definition
Ionising radiation	Radiation with enough energy to remove electrons from atoms — X-rays, gamma rays, alpha and beta particles, neutrons
Absorbed dose (Gray, Gy)	Energy deposited per unit mass: 1 Gy = 1 J/kg
Equivalent dose (Sievert, Sv)	Absorbed dose × radiation weighting factor (X-rays/gamma = 1; alpha = 20)
Effective dose (Sv)	• Sum of equivalent doses to each organ × tissue weighting factors — reflects overall stochastic risk • Used for diagnostic imaging
Radiotherapy	Use of ionising radiation to treat cancer (curative, adjuvant or palliative)
Fractionation	Dividing total radiotherapy dose into many small daily doses (e.g. 1.8–2 Gy per fraction)
Brachytherapy	Placing a radioactive source inside or next to the tumour (e.g. intracavitary for cervix/vaginal vault)
Radiosensitiser	Agent increasing tumour radiation response (e.g. cisplatin)

■ IN PLAIN ENGLISH: Radiation and radiotherapy

Ionising radiation damages DNA. Rapidly dividing cancer cells are less able to repair this damage than normal tissue — giving radiation in **small daily doses** lets normal tissues recover between treatments while the tumour is progressively destroyed.

511.2 Types and units

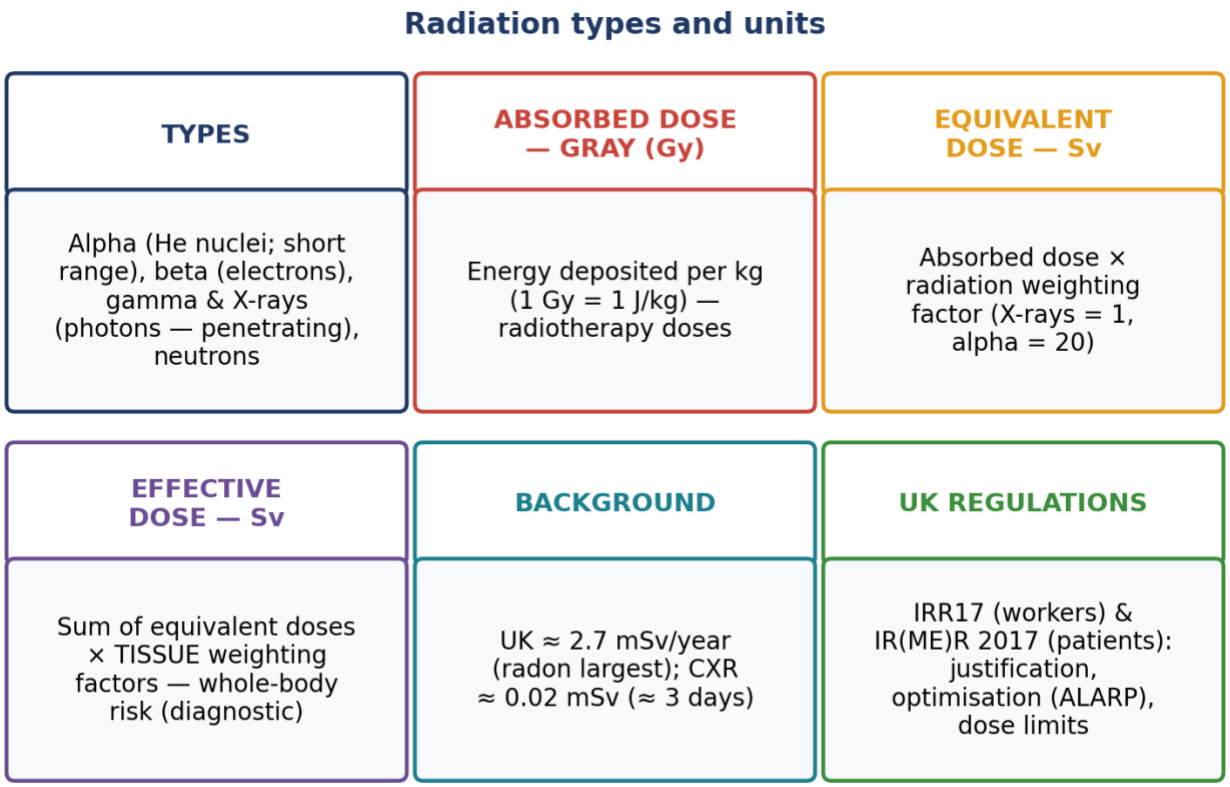


Figure 511.1 — Radiation types and units

Source / exam	Approximate effective dose
UK natural background	≈ 2.7 mSv per year (radon ≈ half)
Transatlantic flight	≈ 0.08 mSv
Chest X-ray	≈ 0.02 mSv
Mammogram	≈ 0.5 mSv
CT abdomen/pelvis	≈ 10 mSv
Radiotherapy (cervix)	≈ 45–50 Gy EBRT + brachytherapy to tumour (absorbed dose — not comparable with diagnostic effective doses)

511.3 Radiobiology

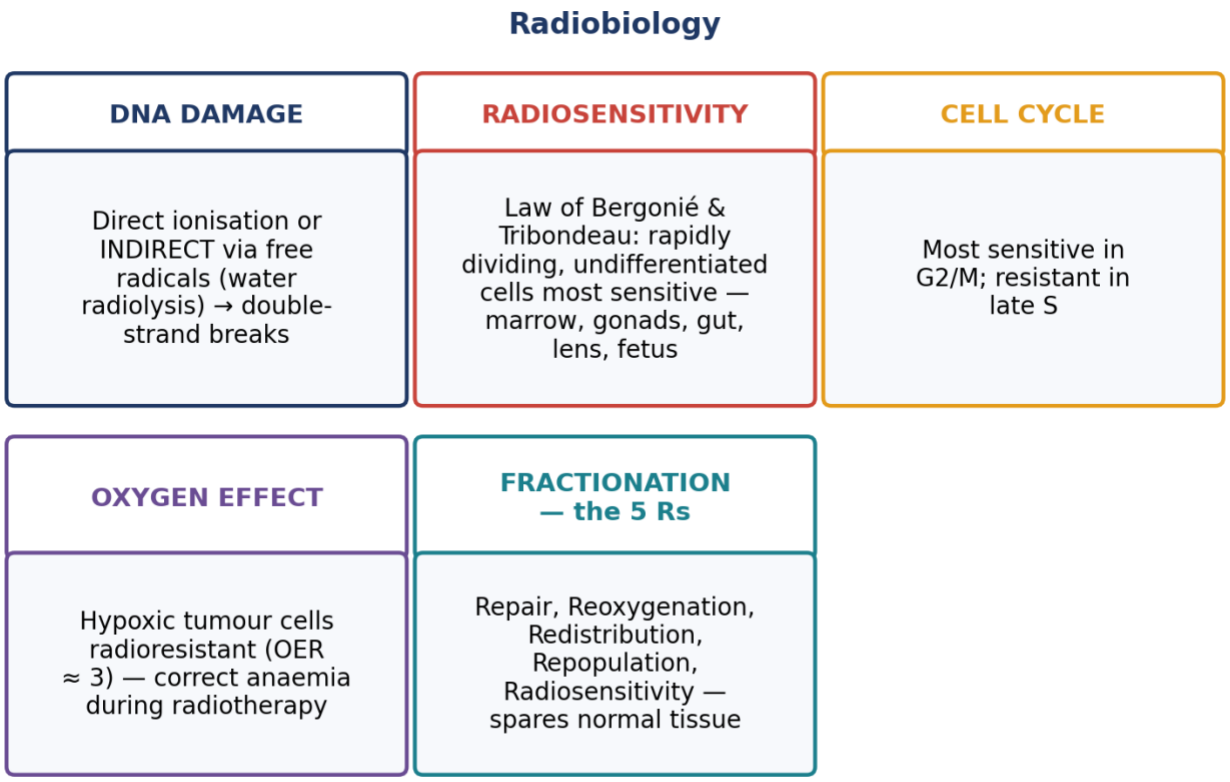


Figure 511.2 — Radiobiology

- **Direct action**: radiation ionises DNA
  - **Indirect action** (≈ 2/3 for X-rays): radiolysis of water produces hydroxyl free radicals that damage DNA — double-strand breaks are lethal if unrepaired (mitotic catastrophe, apoptosis).
- **Oxygen fixes** radiation damage — hypoxic tumour cells are 2–3 times more resistant (oxygen enhancement ratio) → maintain Hb > 100–120 g/L during cervical cancer radiotherapy.
- **The 5 Rs of fractionation**: Repair of sublethal damage in normal tissue
  - Reoxygenation of hypoxic tumour
  - Redistribution into sensitive phases (G2/M)
  - Repopulation (tumour regrowth — avoid treatment gaps, complete within ≈ 8 weeks for cervix)
  - Intrinsic Radiosensitivity.
- Early-reacting tissues (skin, mucosa, marrow) vs late-reacting tissues (bowel, bladder, connective tissue — sensitive to large fraction size).

511.4 Radiotherapy in gynaecological oncology

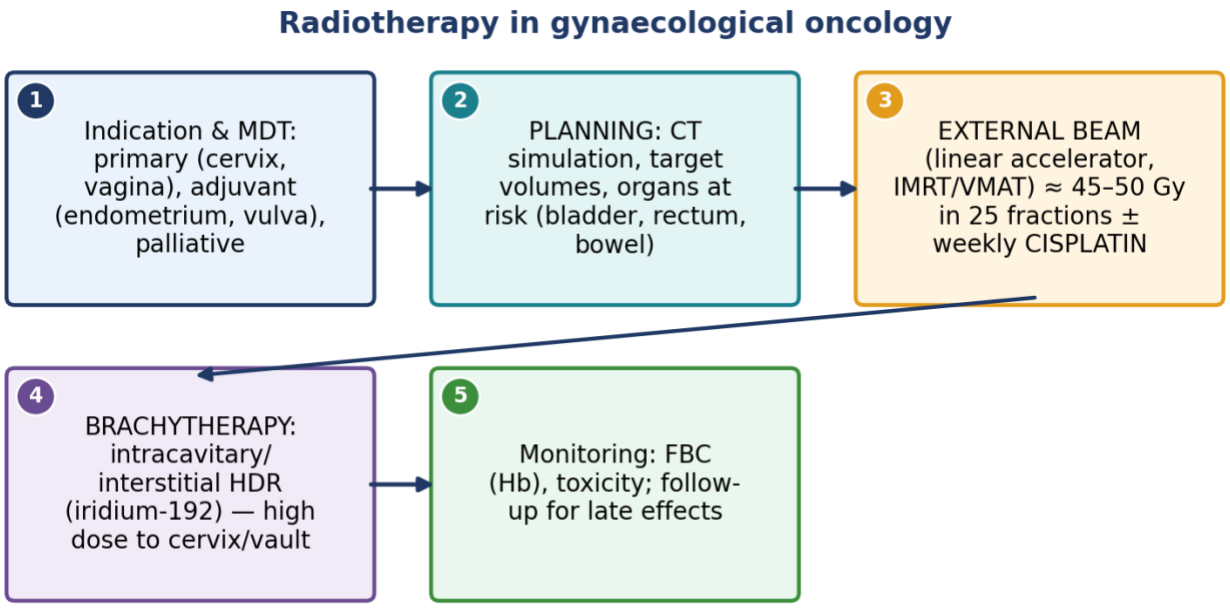


Figure 511.3 — Radiotherapy pathway

Indication	Typical approach
Cervical cancer (IB3–IVA)	• Primary chemoradiation: EBRT ≈ 45–50.4 Gy in 25–28 fractions with weekly cisplatin 40 mg/m², then image-guided HDR brachytherapy • Overall time ≤ 8 weeks
Endometrial cancer	Adjuvant vaginal vault brachytherapy (intermediate risk) or EBRT ± chemotherapy (high risk)
Vulval cancer	• Adjuvant groin/pelvic RT for positive nodes or close margins • Primary chemoradiation for locally advanced
Palliative	Short courses for bleeding, pain, bone metastases
Techniques	• Linear accelerator (megavoltage X-rays), IMRT/VMAT (shape dose, spare bowel/bladder), image guidance (IGRT) • Brachytherapy with iridium-192 HDR afterloading

511.5 Radiation protection (UK)

Regulation / principle	Key points
IRR17 (Ionising Radiations Regulations 2017)	• Protects workers and public: dose limits — employees 20 mSv/year • Public 1 mSv/year • Equivalent dose limits (lens 20 mSv) • Pregnant worker: fetal dose ≤ 1 mSv for the remainder of pregnancy once declared
IR(ME)R 2017	• Protects patients: JUSTIFICATION (benefit > risk) • OPTIMISATION (ALARP/ALARA), referral criteria • Duty holders (referrer, practitioner, operator) • Pregnancy enquiry for women 12–55
Practical protection	• Time, distance (inverse square law), shielding (lead aprons, screens) • Dosimetry badges

Regulation / principle	Key points
	• Controlled/supervised areas • Radiation Protection Adviser/Supervisor

■ **COMMON PITFALLS**

Confusing Gray (absorbed dose) with Sievert (effective dose/risk).

Allowing treatment gaps during cervical radiotherapy (repopulation).

Not correcting anaemia during radiotherapy (hypoxia).

511.6 Must-know summary

■ **EXAM TIP**

- Gy = J/kg (absorbed); Sv = weighted dose (equivalent/effective); background ≈ 2.7 mSv/yr.
- DNA damage via free radicals; radiosensitive: dividing, undifferentiated cells (marrow, gonads, gut, fetus); oxygen enhances effect.
- Fractionation 5 Rs: repair, reoxygenation, redistribution, repopulation, radiosensitivity.
- Cervical cancer: EBRT 45–50 Gy + weekly cisplatin + HDR brachytherapy within 8 weeks; IRR17 and IR(ME)R 2017 regulations.

■ **MNEMONIC / MEMORY AID**

Fractionation — 'The 5 Rs: Repair, Reoxygenate, Redistribute, Repopulate, Radiosensitivity'.