PIPADOR REVISION

MRCOG Part 1 Revision Notes

Electrosurgery

MEDICAL PHYSICS • LECTURE 514

VISUAL EXAMINATION REVISION NOTES

2026 Edition

514

MRCOG PART 1 REVISION NOTES | MEDICAL PHYSICS

Electrosurgery

Physics of electrosurgery, monopolar and bipolar circuits, waveforms, hazards and advanced energy devices

> 100 kHz	Monopolar	Bipolar	Capacitive coupling
Avoids nerve/ muscle stimulation	Return pad required	Current between the tips	Laparoscopic hazard

■ KEY FACTS: Learning objectives

- Define electrosurgery, current density, monopolar and bipolar circuits, and cutting and coagulation waveforms.
- Explain the physics of tissue heating and the tissue effects of different waveforms.
- Describe complications (return pad burns, insulation failure, direct and capacitive coupling, fire, smoke, implanted devices) and their prevention; compare advanced energy devices.

514.1 Key definitions

Term	Definition
Electrosurgery (diathermy)	Use of high-frequency alternating current passing through tissue to cut or coagulate by heating
Electrocautery	Heating a metal wire with current and applying it to tissue (current does not pass through the patient) — different from electrosurgery
Current density	Current per unit area — high at a small active electrode (tissue effect), low at a large return electrode (no burn)
Monopolar	Current passes from active electrode through the patient to a dispersive return pad
Bipolar	Current passes only between two electrodes in the instrument jaws
Duty cycle	Proportion of time the current is flowing (cut ≈ 100%; coag ≈ 6%)
Fulguration / desiccation	Spray coagulation with sparks over a surface / contact coagulation drying tissue
Capacitive coupling	Transfer of current through intact insulation to adjacent conductors (capacitor effect)

■ IN PLAIN ENGLISH: Electrosurgery

Electrosurgery uses very fast alternating current — too fast to stimulate nerves and muscles — to **heat tissue where the current is concentrated**. Concentrated current at a fine tip cuts or seals; spread over a large pad, it causes no harm. Burns happen when current concentrates somewhere unintended.

514.2 Physics

■ KEY EQUATIONS

Heat produced ∝ $I^2 \times R \times t$ (Joule heating) — I = current, R = tissue resistance, t = time

Current density = current ÷ area — tissue effect ∝ (current density)²

Frequency > 100 kHz (typically 300 kHz–3 MHz) avoids the faradic effect (neuromuscular stimulation occurs below ≈ 10 kHz)

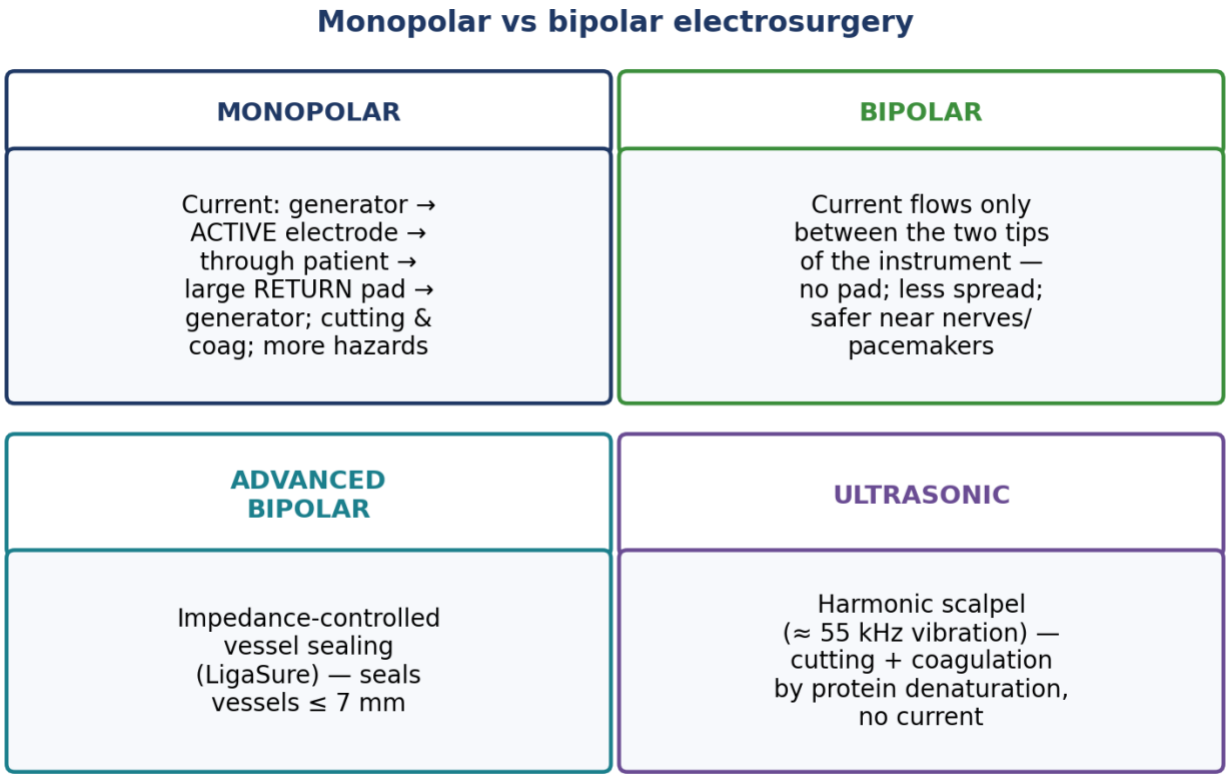


Figure 514.1 — Monopolar vs bipolar and other energy devices

514.3 Waveforms and tissue effects

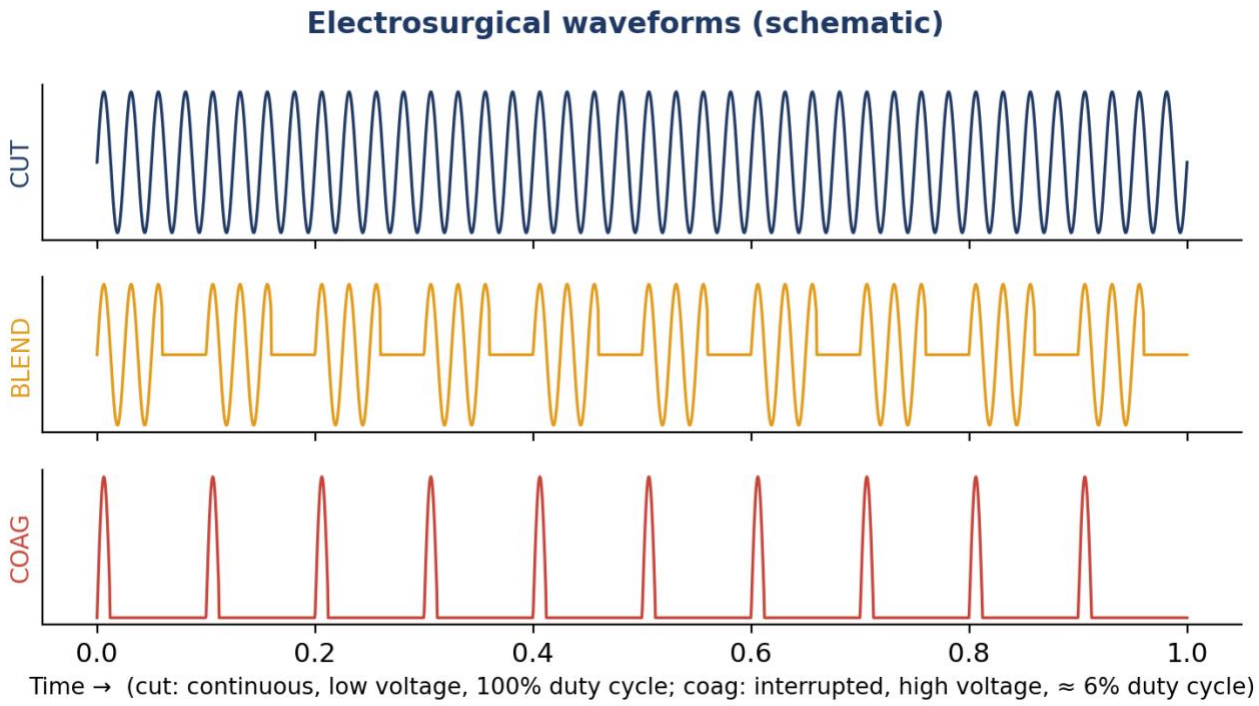


Figure 514.2 — Electrosurgical waveforms

Mode	Waveform and effect
CUT	• Continuous, low-voltage sine wave (100% duty cycle) — rapid heating > 100 °C → cellular vaporisation • Held just off tissue • Minimal haemostasis, little lateral spread
COAG	• Interrupted, high-voltage bursts (≈ 6% duty cycle) — slower heating → protein coagulation/desiccation • Fulguration (spray) with sparks • More lateral thermal spread and capacitive coupling risk
BLEND	Intermediate duty cycles — cutting with some haemostasis
Bipolar	• Low-voltage desiccation between the jaws — precise haemostasis • No return pad
LLETZ	Monopolar loop in cut/blend mode, then ball diathermy coagulation of the base

514.4 Hazards and prevention

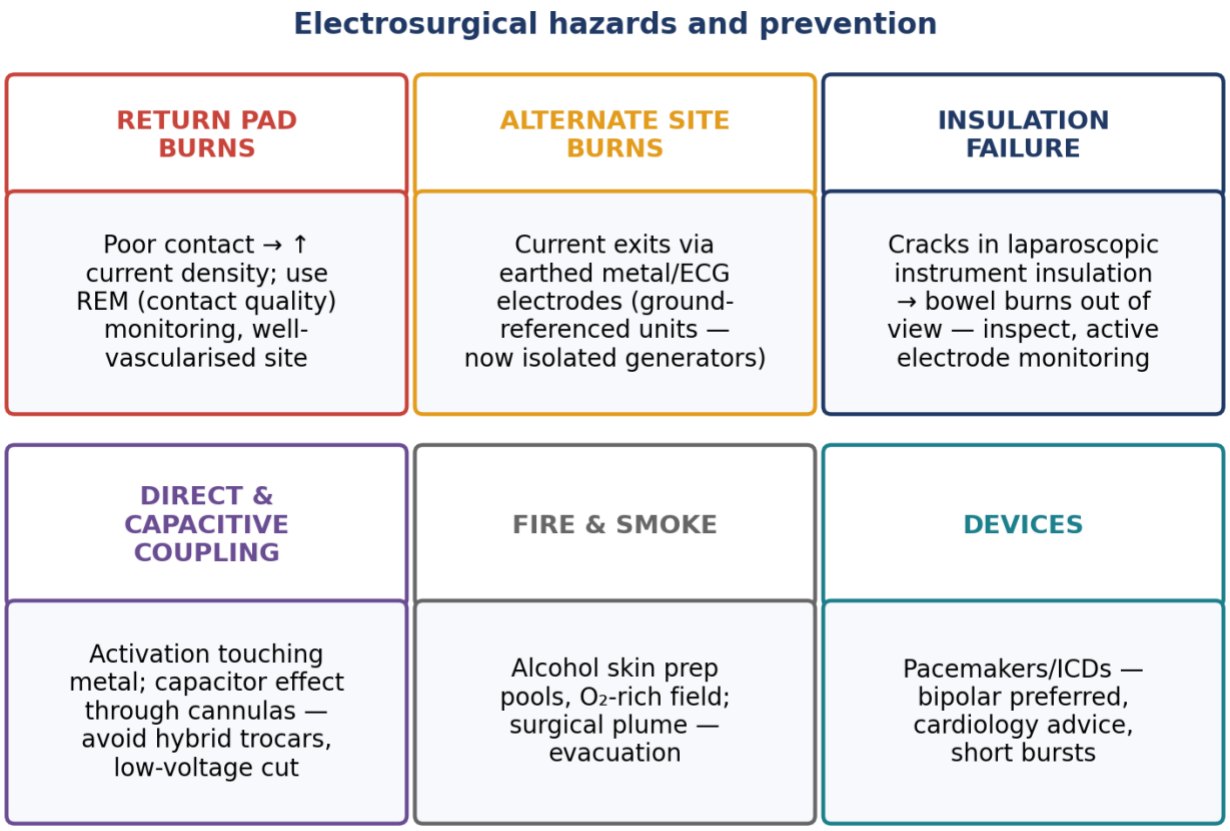


Figure 514.3 — Hazards and prevention

- **Return electrode (pad)**: full contact on clean, dry, hairless
  - Well-vascularised muscle mass close to the operative site
  - Away from bony prominences and metal implants
  - **REM (return electrode contact quality monitoring)** stops output if contact is poor.
- **Laparoscopy**: inspect insulation (cracks)
  - Use active electrode monitoring
  - Avoid activating when not touching target tissue ('open circuit')
  - Avoid contact with other instruments (direct coupling)
  - Avoid hybrid metal/plastic trocars (capacitive coupling)
  - Use the lowest effective power and cut waveform where possible
  - Unrecognised bowel burns present days later with peritonitis.
- **Fire**: allow alcohol-based skin prep to dry, avoid pooling; caution with oxygen near the field; bowel gas.
- **Implanted devices**: pacemakers/ICDs — prefer bipolar, short bursts, return pad positioned so current path avoids the device
  - Cardiology input (ICD deactivation)
  - Cochlear implants and neurostimulators — manufacturer advice.
- **Surgical smoke**: contains toxic chemicals and viable particles — local smoke evacuation.

514.5 Advanced energy devices

Device	Principle and use
Advanced bipolar (vessel sealers, e.g. LigaSure)	• Feedback-controlled bipolar energy + pressure → collagen/elastin fusion • Seals vessels up to 7 mm

Device	Principle and use
	• Laparoscopic hysterectomy, oophorectomy
Ultrasonic (harmonic scalpel)	• Blade vibrates ≈ 55,500 Hz → friction, protein coagulation at lower temperatures (< 100 °C) • No current through patient • Less smoke
Argon plasma coagulation	Monopolar energy via ionised argon gas — superficial coagulation (radiation proctitis)
Comparison	• Advanced devices reduce instrument exchanges and blood loss • All generate heat — lateral thermal spread remains a risk (ureter, bowel)

■ **COMMON PITFALLS**

Placing the return pad over bone, scar or metal implant.

Using coag (high voltage) near bowel in laparoscopy when cut would suffice.

Activating monopolar diathermy in a woman with a pacemaker without precautions.

514.6 Must-know summary

■ **EXAM TIP**

- High-frequency AC (> 100 kHz) avoids neuromuscular stimulation; heat $\propto I^2Rt$; effect depends on current density.
- Monopolar: active → patient → return pad (REM monitoring); bipolar: between jaws, safer (pacemakers, delicate areas).
- Cut: continuous low voltage (vaporisation); coag: interrupted high voltage (coagulation, more spread); blend in between.
- Hazards: pad burns, alternate site burns, insulation failure, direct/capacitive coupling, fire, smoke, implants; advanced bipolar and ultrasonic devices.

■ **MNEMONIC / MEMORY AID**

Laparoscopic diathermy injury — 'IDC': Insulation failure, Direct coupling, Capacitive coupling.