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Principles of Electrosurgery

Quick Reference Guide

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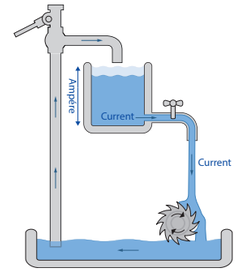
Principles of Electricity

Electric current (measured in Ampère)

- Electric current is the **flow of charged particles per time.**
- Current is ‘lazy’ and prefers the path of least resistance and needs a circuit to flow.
- The electric current I is measured in ampere [A]*.

*1 A = 6.24*1018 ions/s , 1mA = 6240 giga-ions/s (1015)

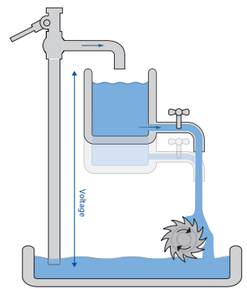
A



Voltage U (measured in Volts)

- Voltage is the **driving force that “pushes” electrons/ions** to flow through resistances.
- The higher the voltage the more “aggressive”.
- The voltage U is measured in volts [V].

V



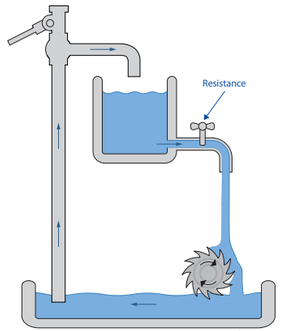
Principles of Electricity

Resistance = R (Ohms)

- Opposition to the flow of current is called resistance.
- A resistance can convert power into heat.
- The resistance R is measured in ohms [Ω].

Note: When tissue dries (coagulates), its resistance increases.

Ω



Resistance of Body Tissue

Vascular	Muscle	Fat	Skin	Bone	Metal:
~ 160 Ω/cm	~ 250 Ω/cm	~ 3.300 Ω/cm	~ 3.500 Ω/cm	~ 250.000 Ω/cm	~ 0.000001 Ω/cm

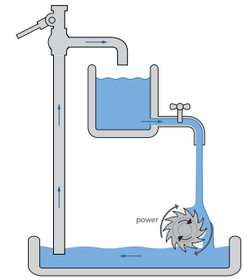
Principles of Electricity

Power (P, measured in watts W)

- Charged particles **can do work**. The more power they have, the more work they can do.
- P = U · I

Note: The higher the power level, the more the tissue is heated.

W



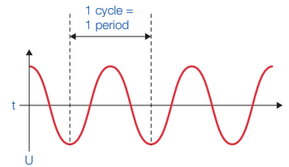
Frequency (f)

- Number of cycles of an oscillation
- (Change in direction of the electric current per unit of time)
- **1 Hertz (Hz) = 1 oscillation/sec.**

Energy (E, measured in Joule)

- The tissue effect is reached by electric energy that is converted to thermal energy in the tissue
- The "amount" of energy applied to the tissue is dependent on power and application time (E = P · t)

Hz



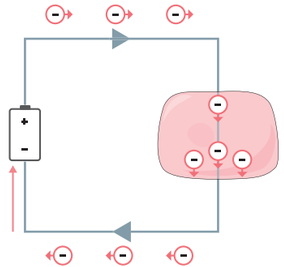
Principles of Electricity

Direct Current (DC)

The electric charges flow in the same direction (e.g. battery).

Direct current is **not suitable** for electrosurgical procedures because it also generates an **undesirable electrolytic effect,** producing acids and alkalis at the electrode poles.

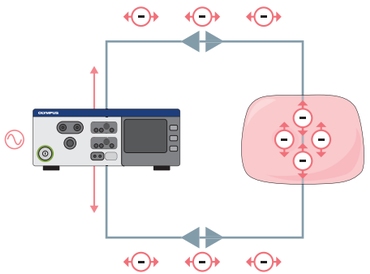
Danger of corrosive/acid burns!



HF Alternating Current (AC)

- The electric charges do not "flow" but oscillate around a single spot according to the frequency of electric current.
- In electrosurgery only alternating current is used.

One alternation per second is 1 Hz: “It has a frequency f of 1 Hz”.



Principles of Electricity

What Happens to a Cell Treated with HF* Alternating Current ?

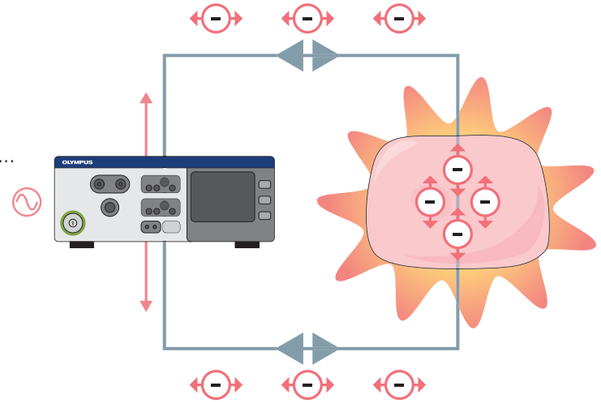
Charged particles in the cell (ions) are oscillating because of electrical current.

Movement of charged particles creates frictional energy and ...

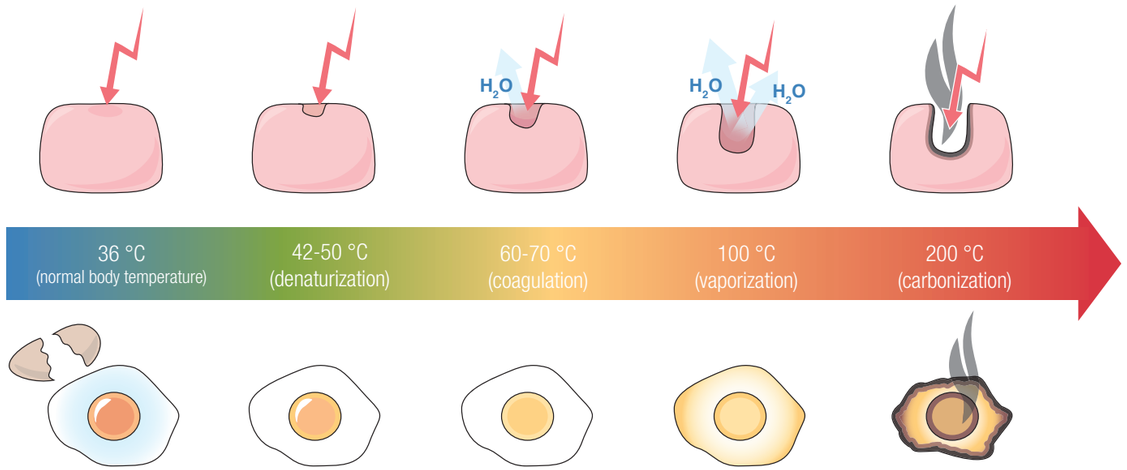
... thereby induces heat generation in the tissue.

The rising temperature inside the tissue leads to coagulation (from 60°C) or also to cutting (100°C).

* HF = high frequency



Cells and Temperature

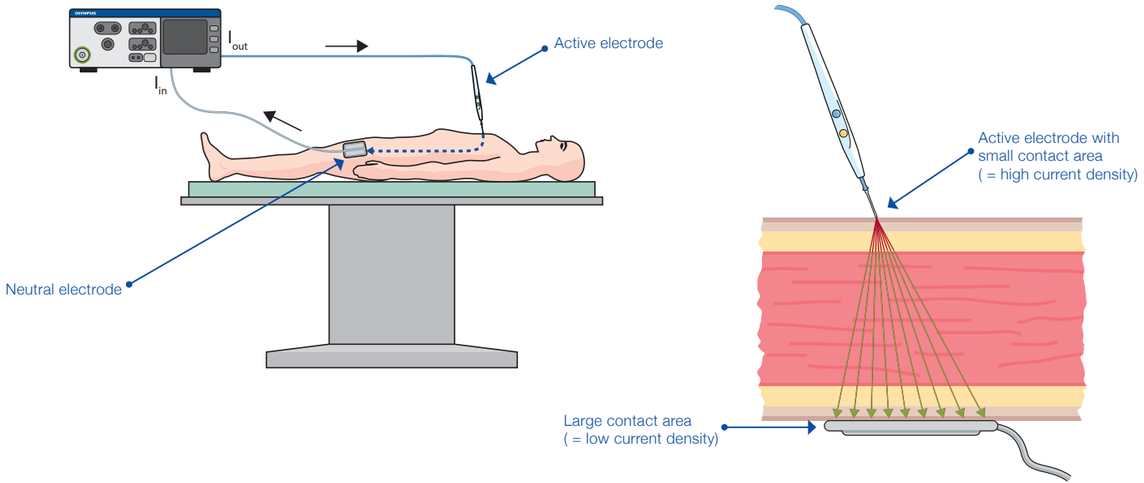


Overview of the Terminology

Parameter (Symbol)	Unit (Symbol)	Formula	Explanation
Voltage (U)	Volt (V)	U = R x I	Voltage is the driving force to move charged particles.
Current (I)	Ampere (A)	I = (n x e)/t I = U / R	Movement or flow of charged particles.
Resistance (R)	Ohm (Ω)	R = U / I (Ohm's law)	Resistance is an obstacle against the flow of charged particles (current).
Power (P)	Watt (W)	P = U x I	Power is responsible for heat generation in the tissue.
Frequency (f)	Hertz (Hz)	f = 1/t	Number of oscillations per second.
Energy (E)	Joule (J)	E = P · t	Electrical energy is transported by electrical current and transformed into thermal energy (heat) in the tissue.

Electrosurgical Modalities

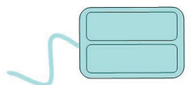
Monopolar Electrosurgery



Current flows between the active electrode and the neutral electrode/patient plate.

Electrosurgical Modalities

Patient Plates for Monopolar Electrosurgery



Split type

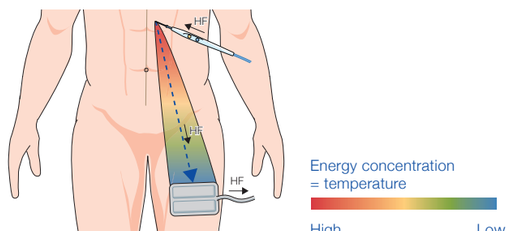
- 2 electrodes
- Warning if P plate detaches from the patient's body. → **Safer!**

Non-split type

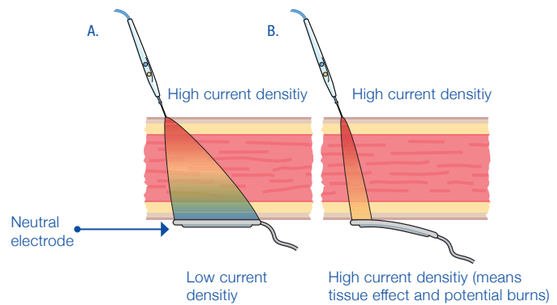
- 1 electrode
- No warning if P plate detaches from the patient's body.

Positioning of the neutral electrode

- Use well vascularized muscle close to the surgery site.
- Optimum: thigh (alternative: back or arm)

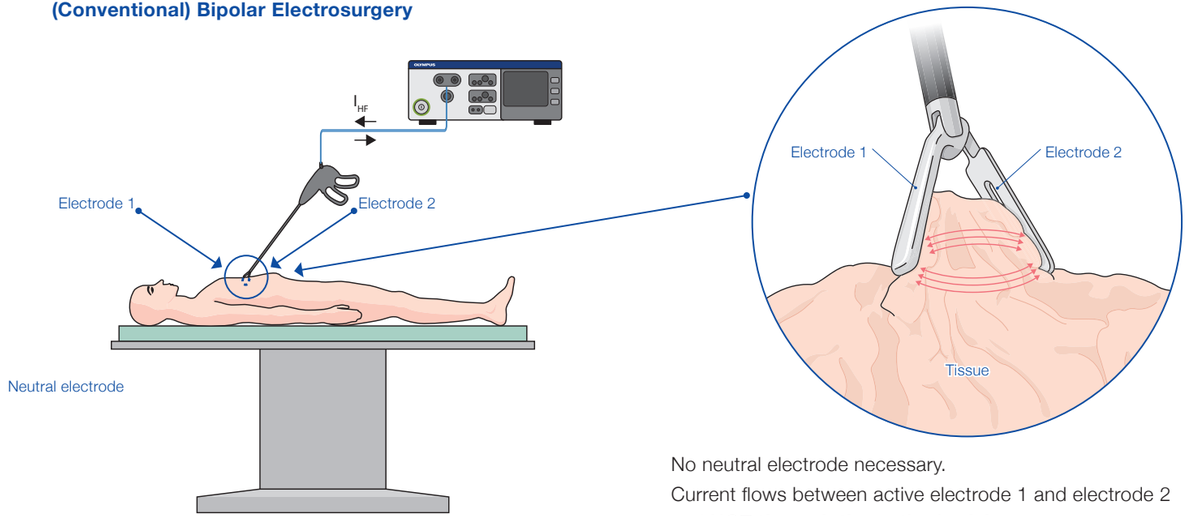


Wrong application (b) or malfunction of the neutral electrode can cause burns!



Electrosurgical Modalities

(Conventional) Bipolar Electrosurgery



No neutral electrode necessary.
Current flows between active electrode 1 and electrode 2 and **NOT through the entire body!**

Please note: **advanced** bipolar electrosurgery refers to vessel sealing instruments such as the PK cutting forceps (see differences on the next page).

Electrosurgical Modalities

Pros & Cons

Monopolar Technology

Pro	Contra
■ Widely accepted technology ■ Rapid cut and coagulation ■ Low cost accessories	■ HF current flows through the patient ■ Neutral electrode required ■ Wide thermal spread ■ High risk of carbonization ■ Lots of smoke (surgical plume) ■ No reliable hemostasis ■ Imprecise ■ Limited safety ■ For simple procedures

Conventional Bipolar Technology

Pro	Contra
■ Proven technology ■ HF current flows only locally ■ Good coagulation capabilities ■ Reliable hemostasis ■ Increased safety	■ Limited energy introduction into tissue ■ No dedicated sealing algorithm ■ Smoke (surgical plume) ■ Limited cutting ■ Insufficient vessel sealing ■ Limited applications

Advanced Bipolar Technology

Pro	Contra
■ Dedicated sealing algorithm* for controlled energy delivery** ■ Mechanical cutting capability ■ Reduced thermal spread ■ Reliable vessel sealing ■ Reliable hemostasis	■ Time-consuming -> two-step sealing and cutting action due to the mechanical blade ■ Limited dissection capabilities ■ Smoke (surgical plume) ■ Limited applications ■ Slower dissection

*(E.g. pulsed energy application) **(Including constant measurement of tissue resistance)

Factors of Influence in Electrosurgery

1. Generator settings (mode, power, effect)
2. Type of tissue (resistance, patient condition, e.g. obesity, arteriosclerosis)
3. Electrode design (surface area defines current density)
4. Handling of the physician (speed, pressure, duration of application)

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