Understanding and safe use of energy modalities in urologic surgery

충북의대 김용준

사랑의 교육, 창의적 연구, 감동의 진료로 건강한 삶을 선도한다.

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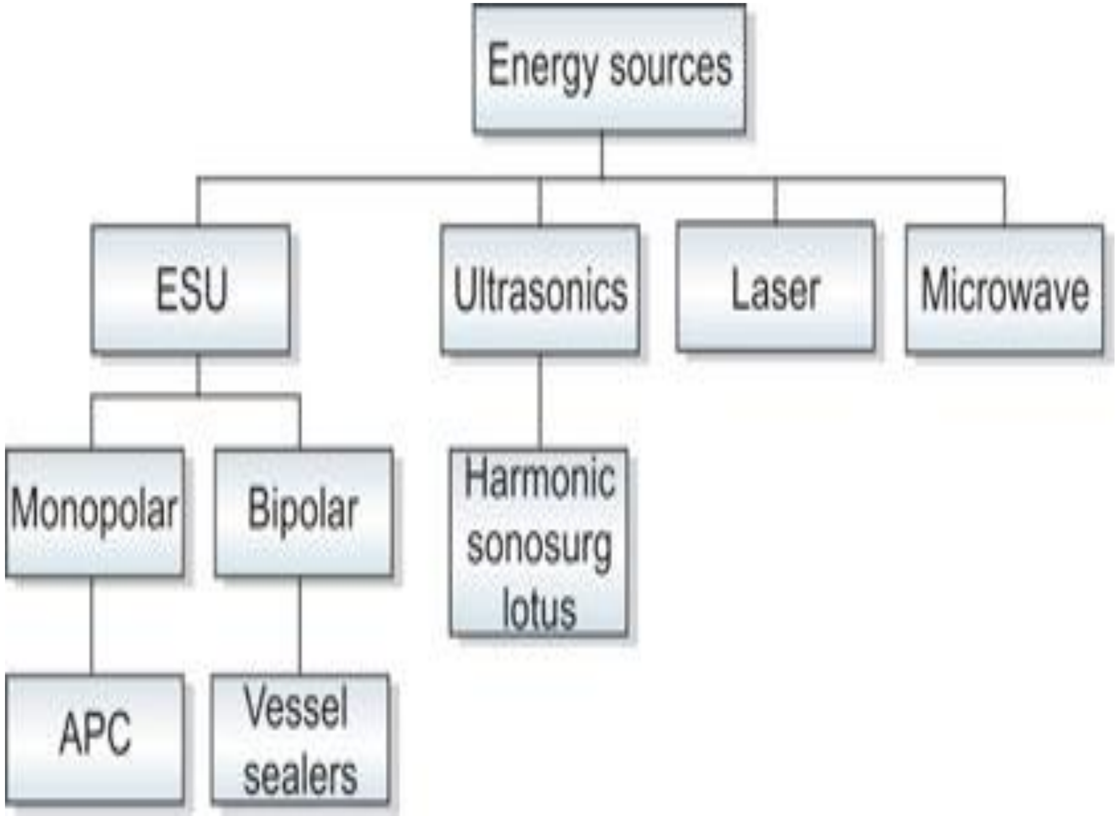
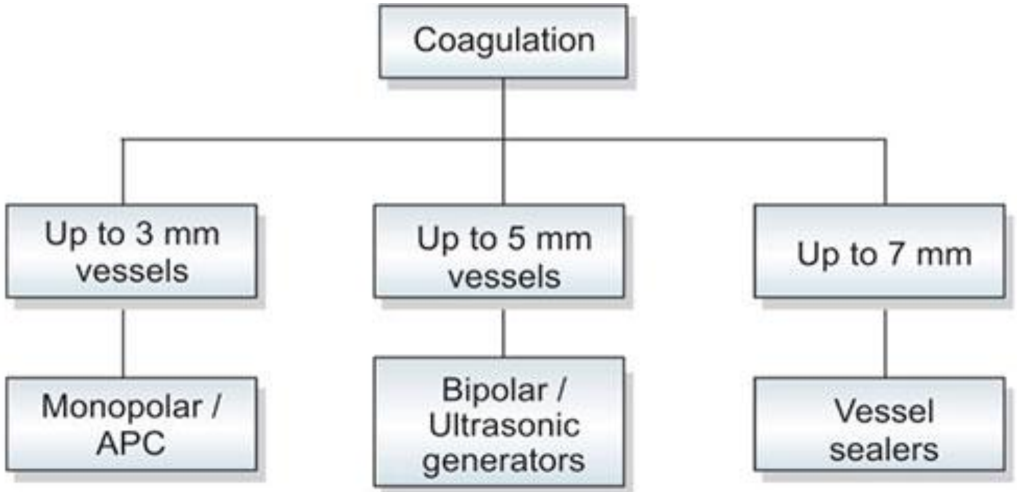
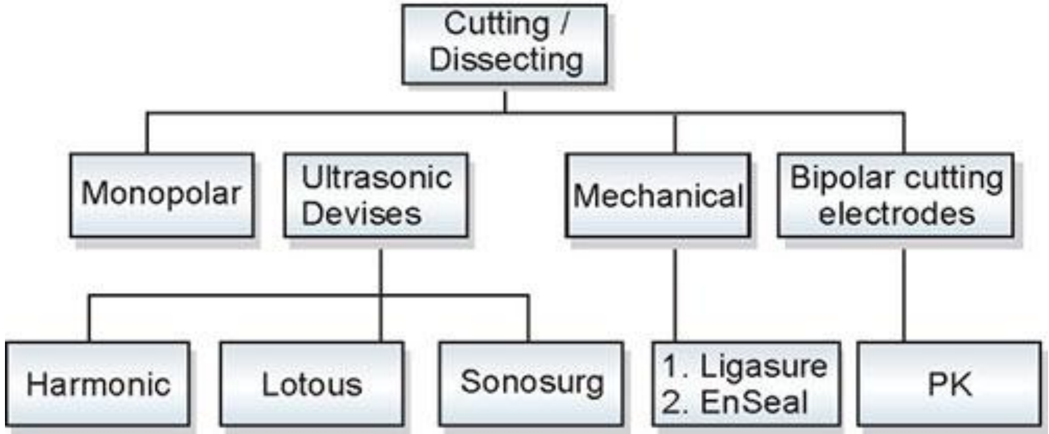
Basic Energy Modalities in Urologic Surgery

- TISSUE DISSECTION AND CAUTERIZATION
  - Electrosurgery
  - Ultrasonic Instrumentation (High-Frequency Vibratory Device)
  - Laser Instrumentation: Soft-Tissue Applications
- INTRACORPOREAL LITHOTRIPTERS
  - Electrohydraulic Lithotripsy
  - Pneumatic Lithotripsy
  - Ultrasonic Lithotripsy
  - Laser Lithotripsy

Tissue Dissection & Cauterization

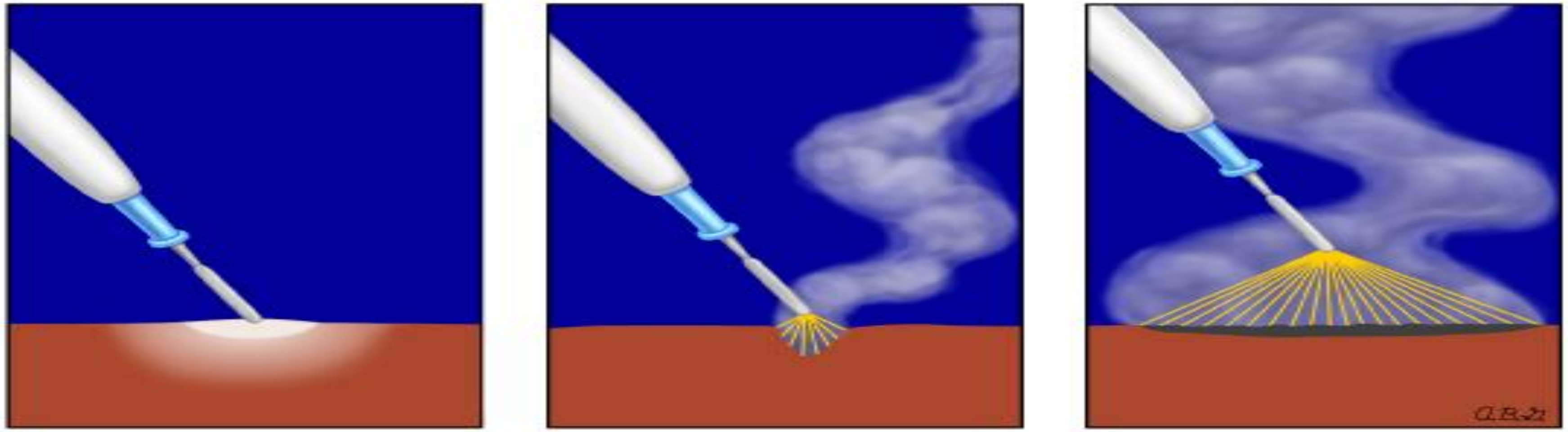






Electrosurgery

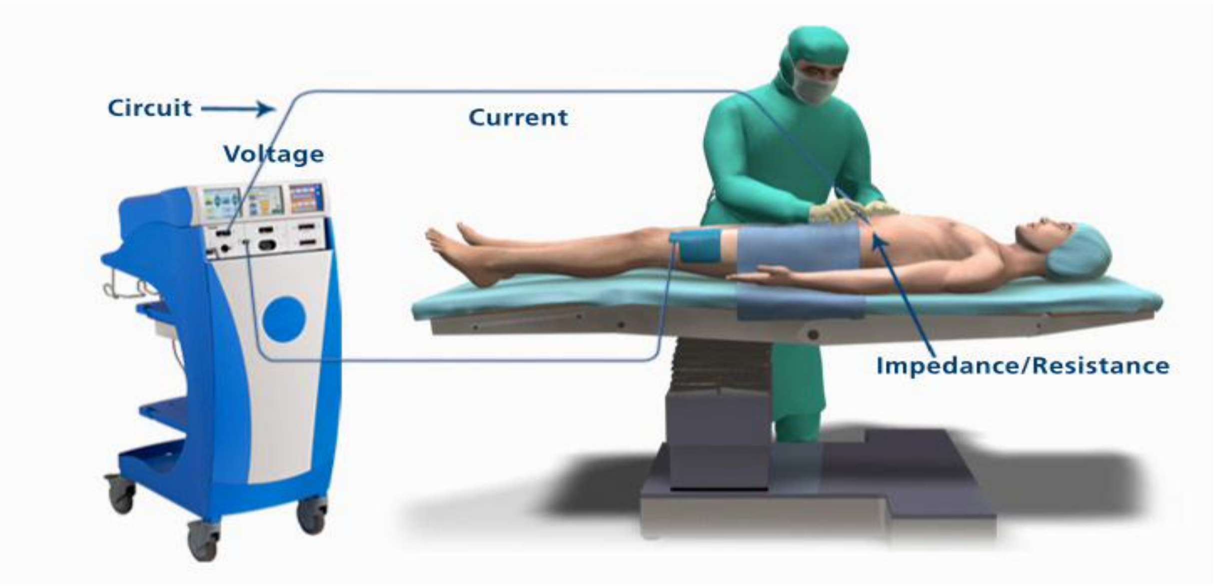
- Surgical application of high-frequency electricity
  - Thermal tissue effects: vaporization, desiccation, coagulation, fulg

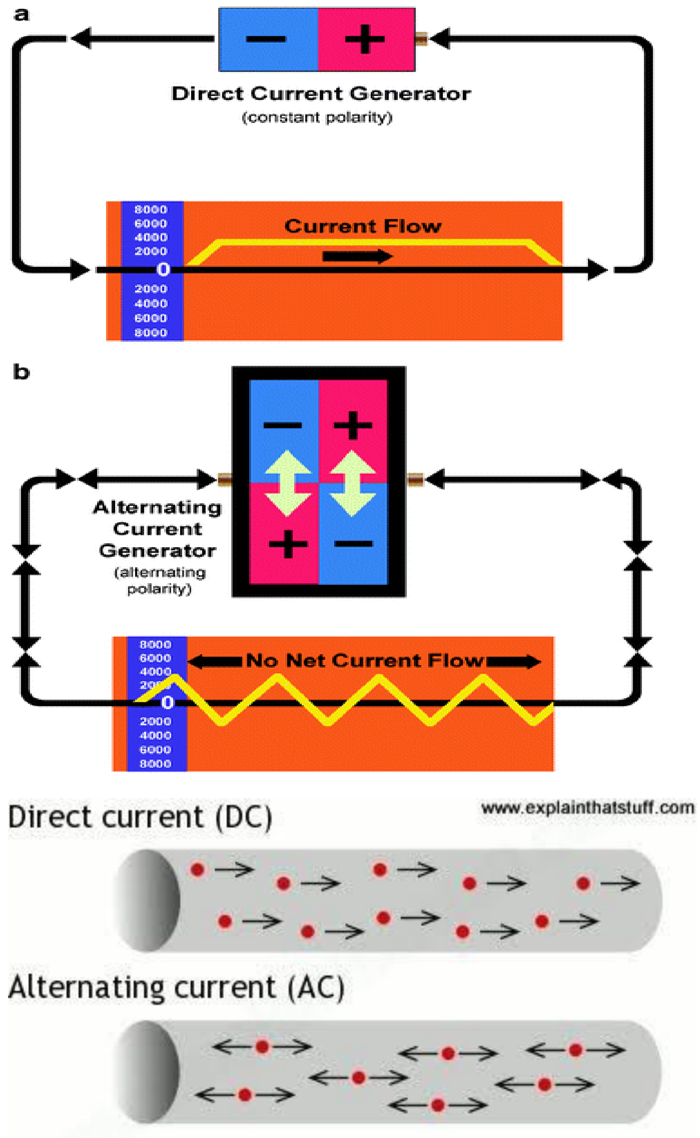


- **Ohm's law: current (I) = voltage (V)/resistance (R)**
- Power (P) = Voltage (V) × Current (I) or $P = V^2/R$
  - high voltage → increased electrosurgical Cxs

How electrosurgery works

- Back and forth movements of the high-frequency alternating current make the cellular ions oscillate to create frictional heat.
- Electrical energy is converted to mechanical then to thermal energy intracellularly.



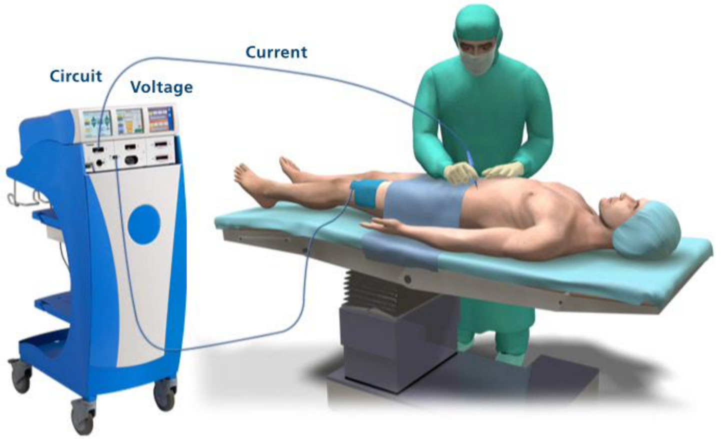


Monopolar vs. Bipolar

Monopolar

Active electrode : 수술 부위에 존재

Return electrode : 환자의 몸에 부착되어 존재



전류는 환자의 몸을 통해서 흐름

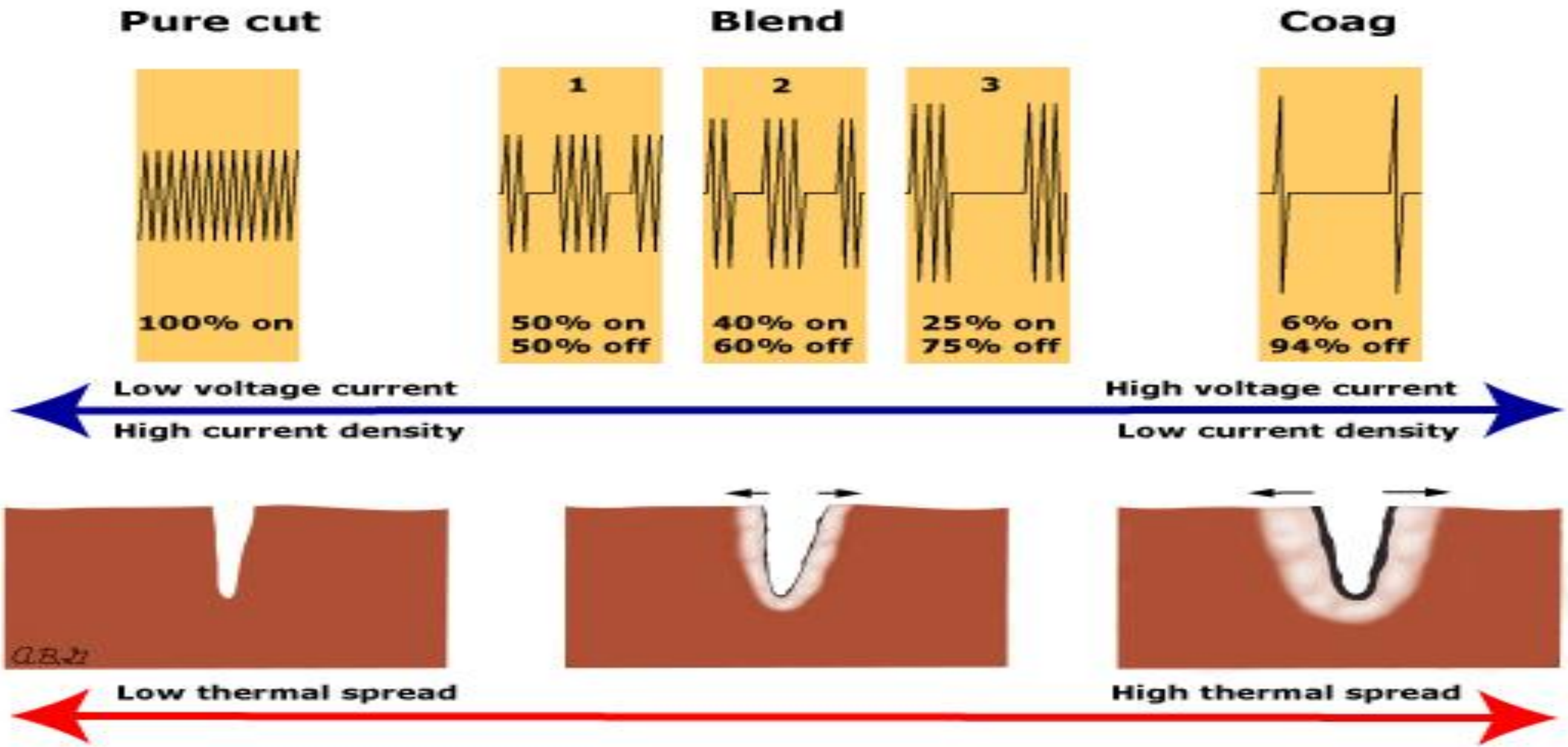
Biopolar

한 기구에 active electrode와 return electrode가 모두 존재

두 전극 사이의 조직에서 전류가 흐름

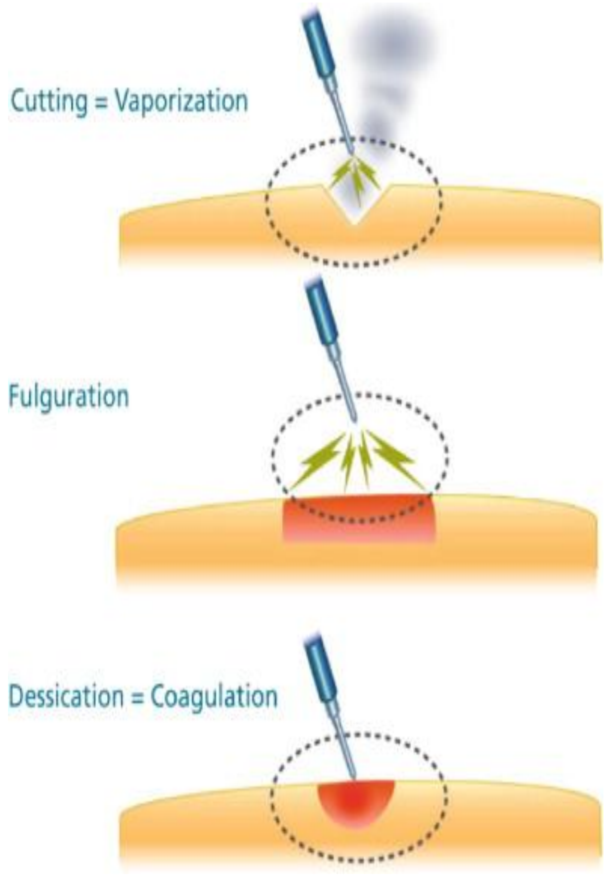
Three fundamental current waveforms

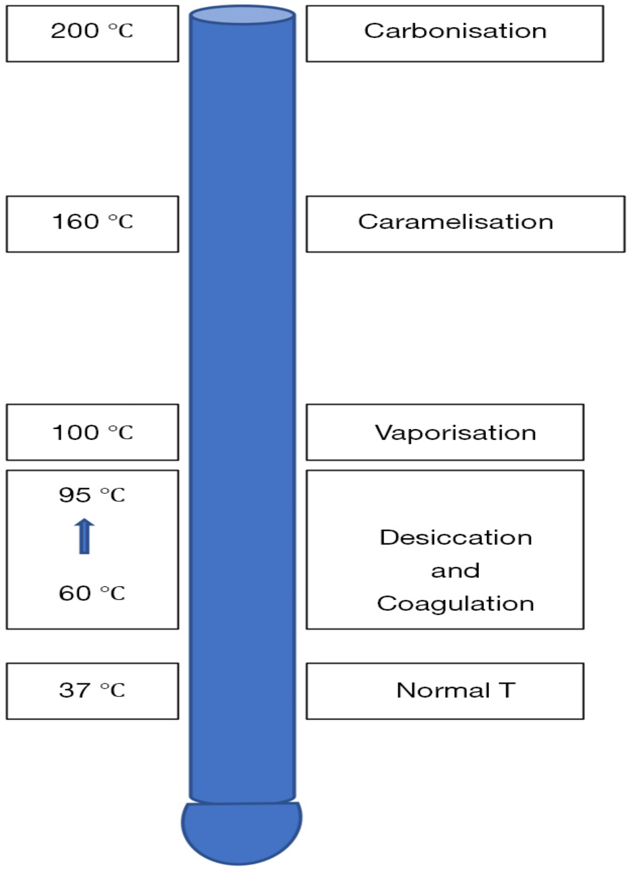
충북대학교병원



Thermal tissue effects

	Electrosurgical coagulation	Electrosurgical cutting	Electrosurgical fulguration
Tissue temperatures	60-95 ℃	100 ℃	>200 ℃
Tissue effect	White coagulation	Vaporization	Black coagulation
Best achieved with	Cut output	Cut output	Cut output
Electrode position	Contact	Near contact	None or near contact
Electrode shape	Wider	Needle	Needle





Variables: modify tissue effects

- Generator mode (current waveform)
- Power setting
- Active electrode shape (current density)
- Dwell time
- Electrode-tissue interface
- Tissue factors
- Eschar
- Electrosurgical technique

Clinical Use - Monopolar Electrosurgery

- Cutting (low voltage) or coagulation (high voltage) mode.
- To minimize unwanted effects
  - Use lowest possible power setting
  - Use a low voltage waveform (cut)
  - Use brief, intermittent activation
  - Do not activate in open circuit
  - Do not activate in close proximity or direct contact with another instrument
  - Use bipolar electrosurgery where appropriate
  - Use an all-metal or all-plastic cannula system (not metal-plastic hybrids)
  - Use a return electrode monitoring system
  - Use active electrode monitoring to eliminate concerns regarding insulation failure and capacitive coupling during laparoscopic electrosurgical procedures

Clinical Use - Bipolar Electrosurgery

- Generally performed at low voltage (cutting mode) since tissue impedance is relatively low due to the proximity of the two electrodes.
- Less effective for cutting tissue d/t adequate vaporization is difficult to achieve
- Ideal managing vascular areas: blood vessels 3 - 7 mm
- To minimize unwanted effects
  - Terminate current at the end of vapor phase
  - Apply current in pulsatile fashion
  - Avoid the use of an in-line ammeter
  - Alternate between desiccation and incision

Thermal Spread

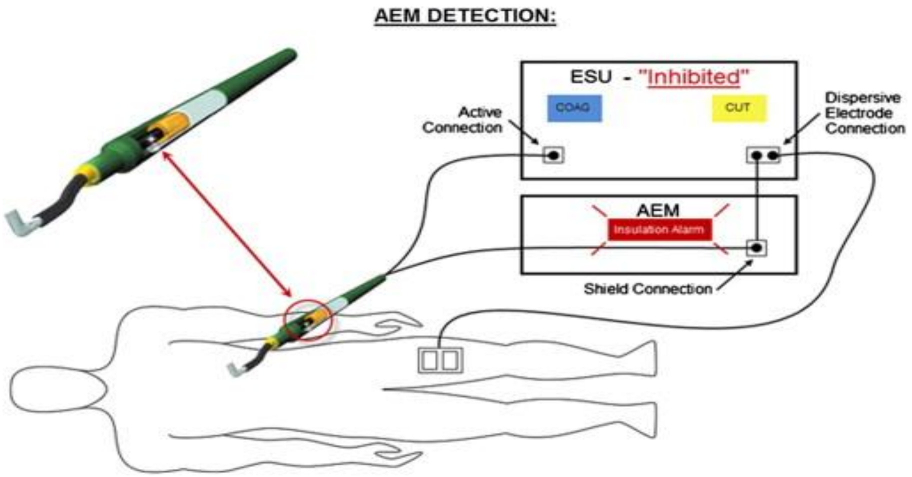
- **Thermal spread**
  - Tissue necrosis: delayed healing and postoperative recovery
  - Injury to adjacent organs (eg, ureter, bladder, or bowel)
- Expected thermal spread
  - Monopolar: highest temperatures & greatest degree of thermal spread
  - Traditional bipolar device: 2 ~ 22 mm
  - Ultrasonic device: 0 to 3 mm (Harmonic Scalpel)
  - Vessel sealing devices:
    - ✓ EnSeal Tissue Sealing and Hemostasis System: 1.1 mm
    - ✓ LigaSure device: 1.8 mm (10 mm device), 4.4 mm (5 mm device)
    - ✓ Gyrus Plasma Trissector: 6.3 mm

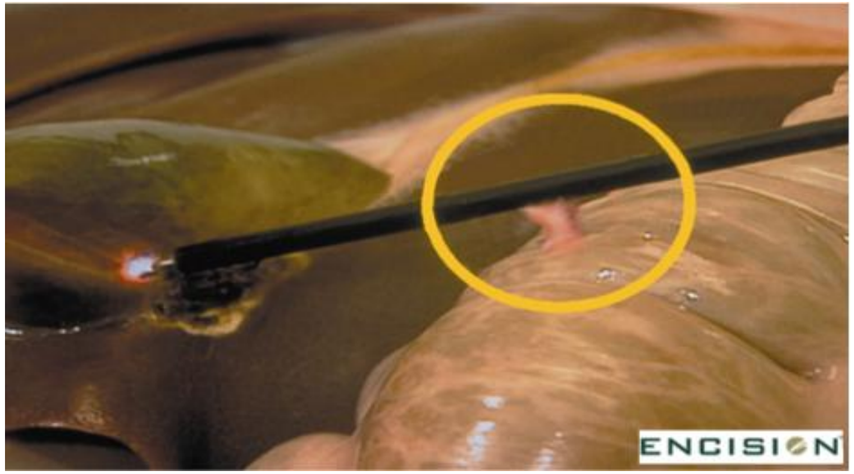
Hazards of Electrosurgery

- Lateral thermal spread
- Residual heat
- Inadvertent activation
- Direct thermal extension (pedicle effect, funnelling)
- Dispersive electrode burns
- Direct coupling
- Capacitive coupling
- Antenna coupling
- Insulation failure
- Alternate site burns
- Electrical shock and glove burns
- Surgical smoke
- Explosions
- Surgical fires
- Electromagnetic interference (EMI) with other devices

Improving Safety

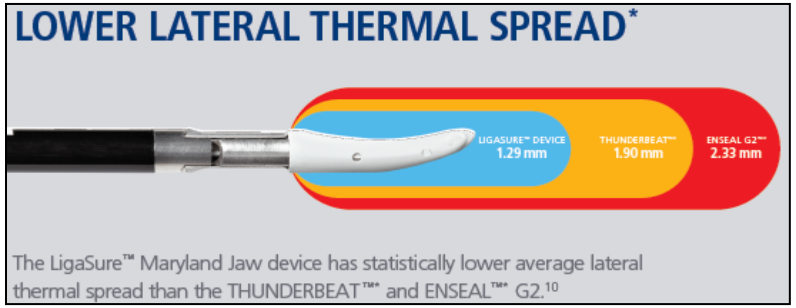
- Active Electrode monitoring (AEM)
- Inspect for faulty insulation
- Avoid skin contact with metals
- Avoid electromagnetic interference
  - Cardiac implantable devices (CIED;) that use electric current may be affected by the use of electrosurgery
  - Damage to the device, inability of the device to deliver pacing or shocks, lead-tissue interface damage, etc.





Advanced Electrosurgical Devices – bipolar

- **LigaSure device** (bipolar vessel sealing system)
  - Mechanism: bipolar energy & pressure → fuse collagen and elastin
  - Seals vessels: up to 7 mm
  - thermal spread: approximately 2 mm

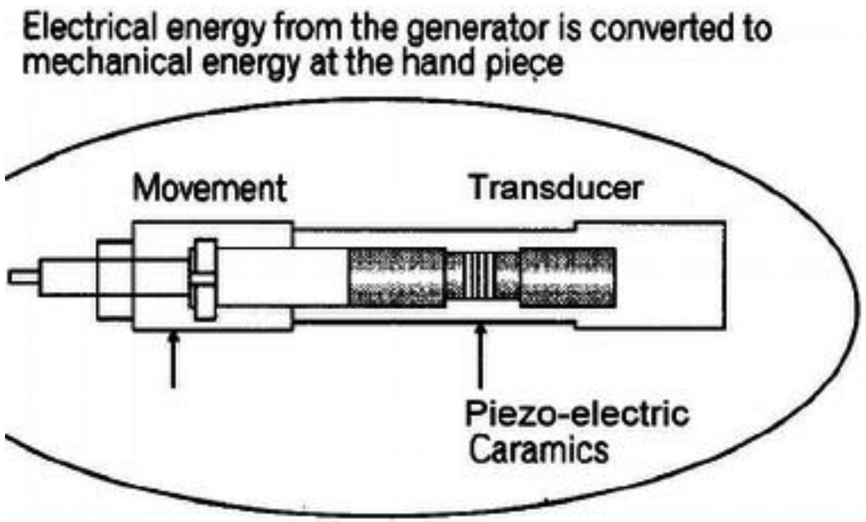


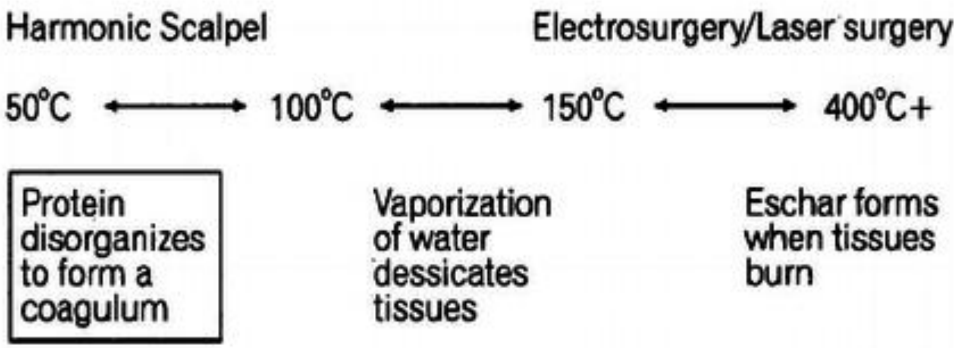
- **EnSeal**
  - Mechanism: compression mechanism & thermal energy control
  - Seals vessels: up to 7 mm
  - thermal spread: approximately 2 mm

- **PlasmaKinetic tissue management system**
  - Mechanism: pulsed bipolar energy → allowing intermittent tissue cooling
  - Limited lateral thermal spread & tissue sticking

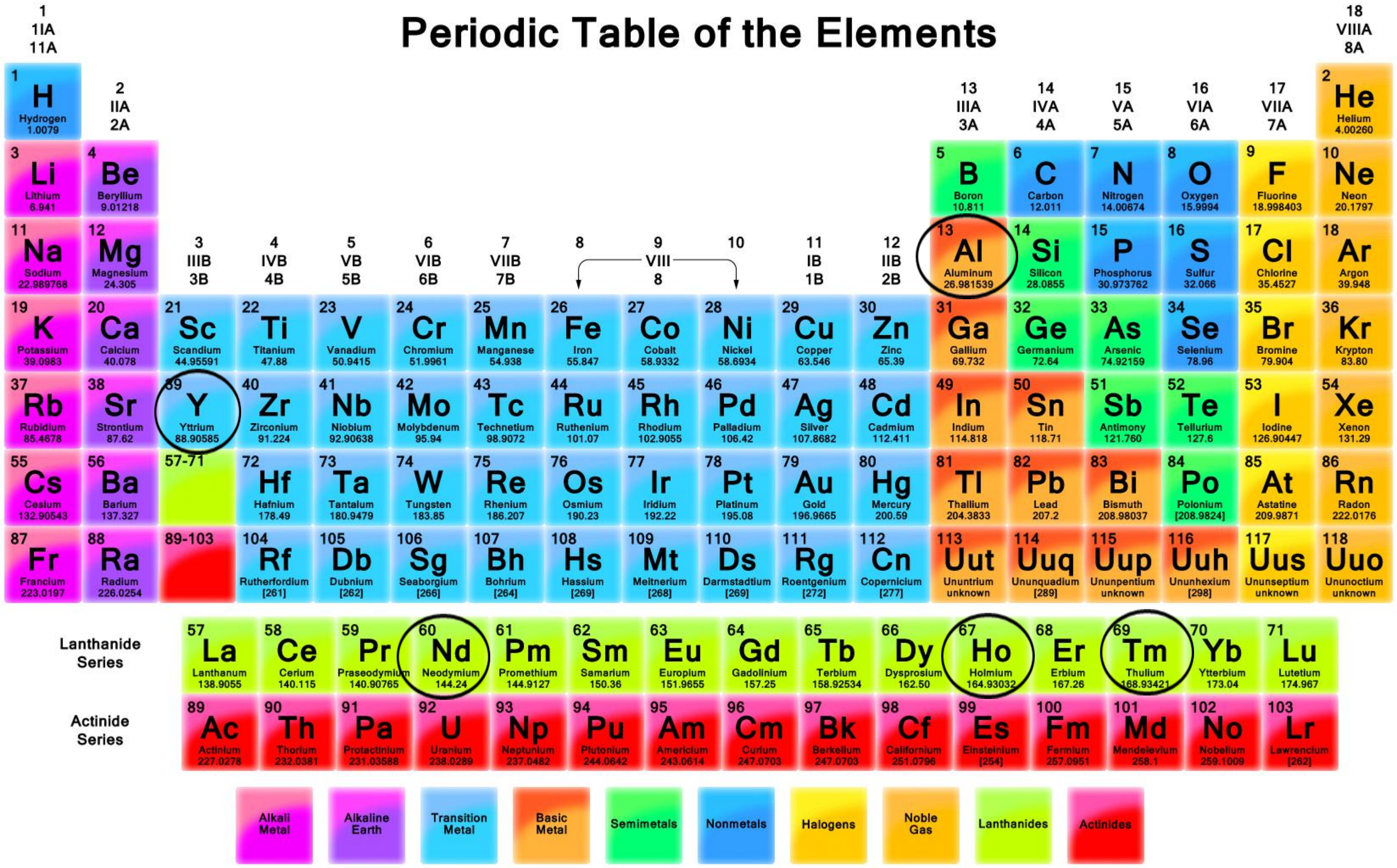
Advanced Electrosurgical Devices - Ultrasonic

- **Ultrasonic cutting and coagulating device**
  - Harmonic Scalpel, Sonocision, Thunderbeat
  - Limited ability to coagulate vessels larger than 3 to 5 mm
  - Potential for extensive thermal spread at high energy levels for more than five seconds





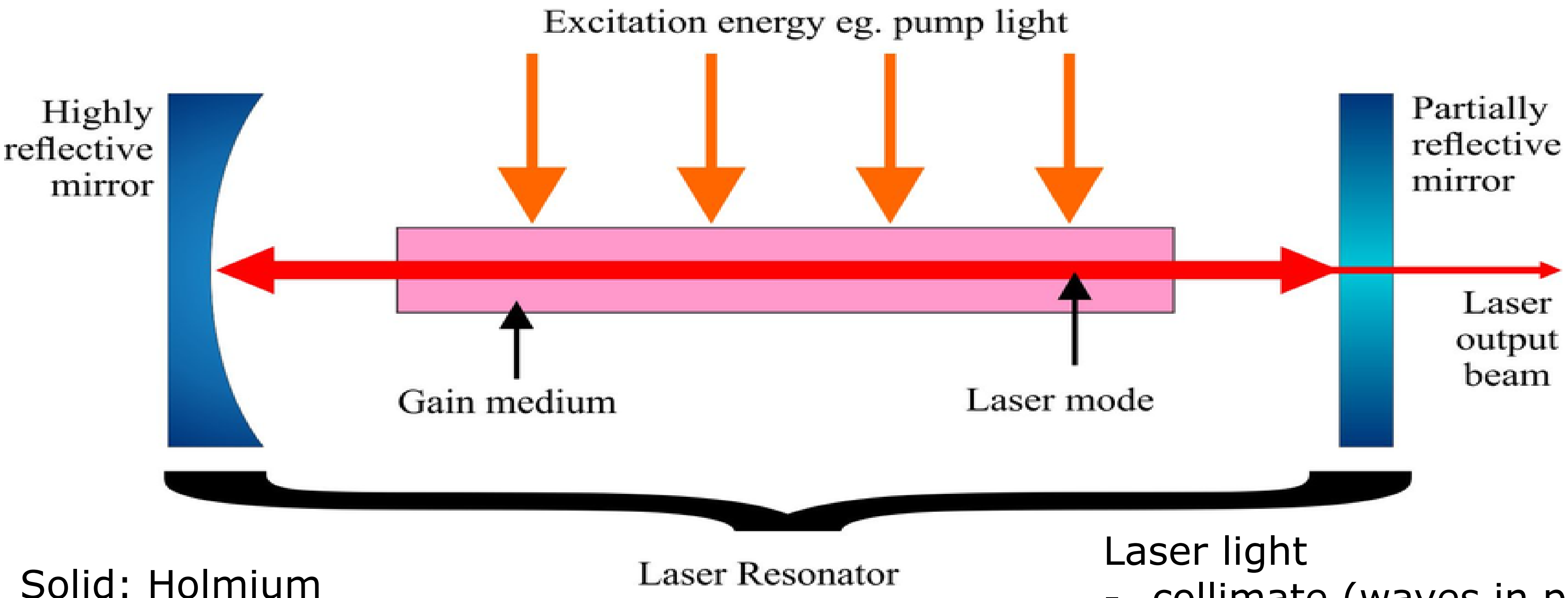
Lasers



Periodic Table of the Elements
1 1IA 11A
2 IIA 2A
3 IIIB 3B
4 IVB 4B
5 VB 5B
6 VIB 6B
7 VIIB 7B
8 9 VIII 8 10
11 IB 1B
12 IIB 2B
13 IIIA 3A
14 IVA 4A
15 VA 5A
16 VIA 6A
17 VIIA 7A
18 VIIIA 8A
1 H Hydrogen 1.0079
2 He Helium 4.00260
3 Li Lithium 6.941
4 Be Beryllium 9.01218
5 B Boron 10.811
6 C Carbon 12.011
7 N Nitrogen 14.00674
8 O Oxygen 15.9994
9 F Fluorine 18.998403
10 Ne Neon 20.1797
11 Na Sodium 22.989768
12 Mg Magnesium 24.305
13 Al Aluminum 26.981539
14 Si Silicon 28.0855
15 P Phosphorus 30.973762
16 S Sulfur 32.066
17 Cl Chlorine 35.4527
18 Ar Argon 39.948
19 K Potassium 39.0983
20 Ca Calcium 40.078
21 Sc Scandium 44.95591
22 Ti Titanium 47.88
23 V Vanadium 50.9415
24 Cr Chromium 51.9961
25 Mn Manganese 54.938
26 Fe Iron 55.847
27 Co Cobalt 58.9332
28 Ni Nickel 58.6934
29 Cu Copper 63.546
30 Zn Zinc 65.39
31 Ga Gallium 69.732
32 Ge Germanium 72.64
33 As Arsenic 74.92159
34 Se Selenium 78.96
35 Br Bromine 79.904
36 Kr Krypton 83.80
37 Rb Rubidium 85.4678
38 Sr Strontium 87.62
39 Y Yttrium 88.90585
40 Zr Zirconium 91.224
41 Nb Niobium 92.90638
42 Mo Molybdenum 95.94
43 Tc Technetium 98.9072
44 Ru Ruthenium 101.07
45 Rh Rhodium 102.9055
46 Pd Palladium 106.42
47 Ag Silver 107.8682
48 Cd Cadmium 112.411
49 In Indium 114.818
50 Sn Tin 118.71
51 Sb Antimony 121.760
52 Te Tellurium 127.6
53 I Iodine 126.90447
54 Xe Xenon 131.29
55 Cs Cesium 132.90543
56 Ba Barium 137.327
57-71
72 Hf Hafnium 178.49
73 Ta Tantalum 180.9479
74 W Tungsten 183.85
75 Re Rhenium 186.207
76 Os Osmium 190.23
77 Ir Iridium 192.22
78 Pt Platinum 195.08
79 Au Gold 196.9665
80 Hg Mercury 200.59
81 Tl Thallium 204.3833
82 Pb Lead 207.2
83 Bi Bismuth 208.98037
84 Po Polonium [208.9824]
85 At Astatine 209.9871
86 Rn Radon 222.0176
87 Fr Francium 223.0197
88 Ra Radium 226.0254
89-103
104 Rf Rutherfordium [261]
105 Db Dubnium [262]
106 Sg Seaborgium [266]
107 Bh Bohrium [264]
108 Hs Hassium [269]
109 Mt Meitnerium [268]
110 Ds Darmstadtium [269]
111 Rg Roentgenium [272]
112 Cn Copernicium [277]
113 Uut Ununtrium unknown
114 Uuq Ununquadium [289]
115 Uup Ununpentium unknown
116 Uuh Ununhexium [298]
117 Uus Ununseptium unknown
118 Uuo Ununoctium unknown
Lanthanide Series
57 La Lanthanum 138.9055
58 Ce Cerium 140.115
59 Pr Praseodymium 140.90765
60 Nd Neodymium 144.24
61 Pm Promethium 144.9127
62 Sm Samarium 150.36
63 Eu Europium 151.9655
64 Gd Gadolinium 157.25
65 Tb Terbium 158.92534
66 Dy Dysprosium 162.50
67 Ho Holmium 164.93032
68 Er Erbium 167.26
69 Tm Thulium 168.93421
70 Yb Ytterbium 173.04
71 Lu Lutetium 174.967
Actinide Series
89 Ac Actinium 227.0278
90 Th Thorium 232.0381
91 Pa Protactinium 231.03588
92 U Uranium 238.0289
93 Np Neptunium 237.0482
94 Pu Plutonium 244.0642
95 Am Americium 243.0614
96 Cm Curium 247.0703
97 Bk Berkelium 247.0703
98 Cf Californium 251.0796
99 Es Einsteinium [254]
100 Fm Fermium 257.0951
101 Md Mendelevium 258.1
102 No Nobelium 259.1009
103 Lr Lawrencium [262]
Alkali Metal
Alkaline Earth
Transition Metal
Basic Metal
Semimetals
Nonmetals
Halogens
Noble Gas
Lanthanides
Actinides

Laser Physics

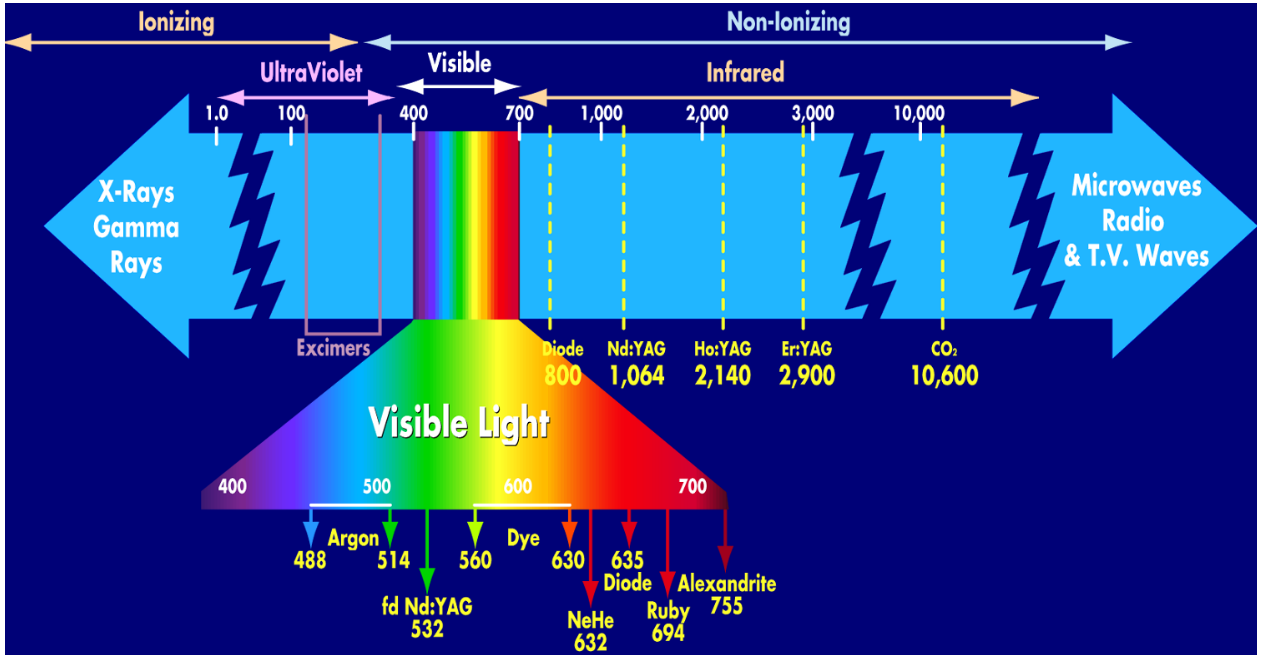
- Light amplification by stimulated emission of electromagnetic radiation (LASER)

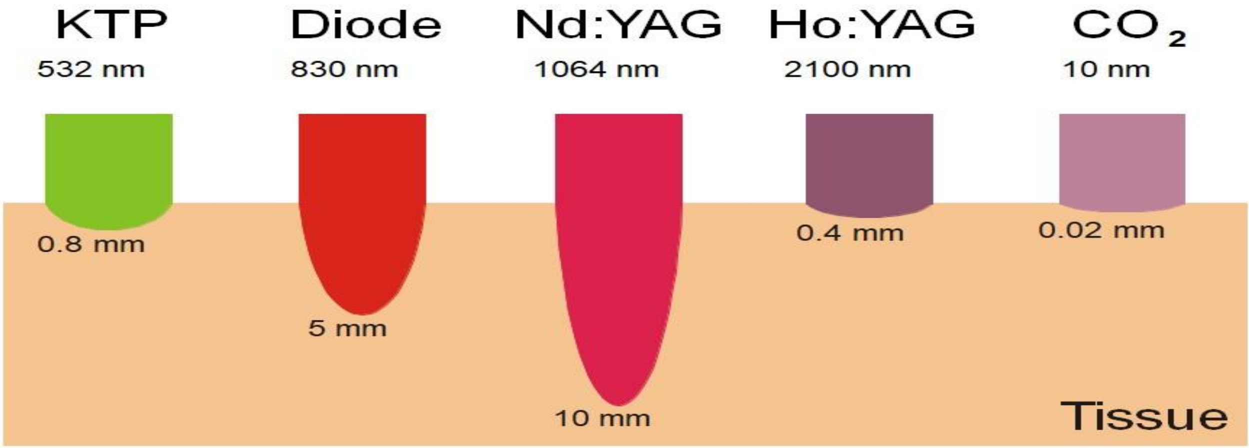


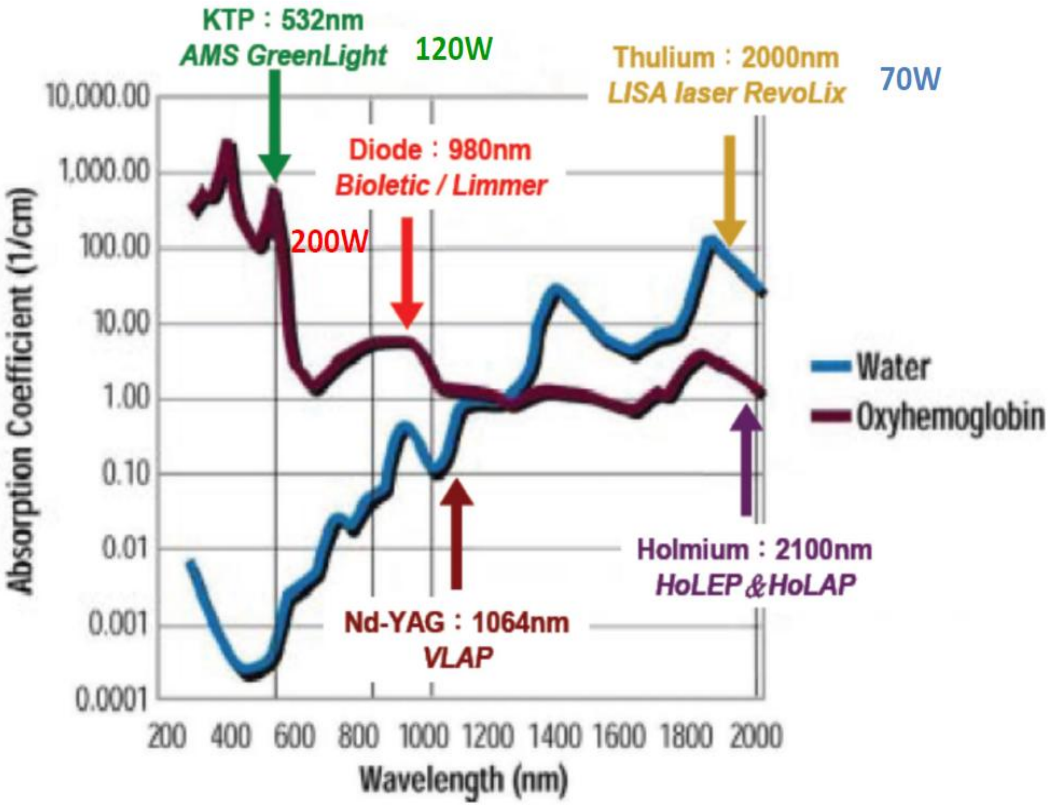
Solid: Holmium
GAS: CO_2
Liquid: dye
Semiconductor: diode

Laser light
- collimate (waves in parallel)
- Monochromatic (same wavelength)
- coherent (waves travel in phase)

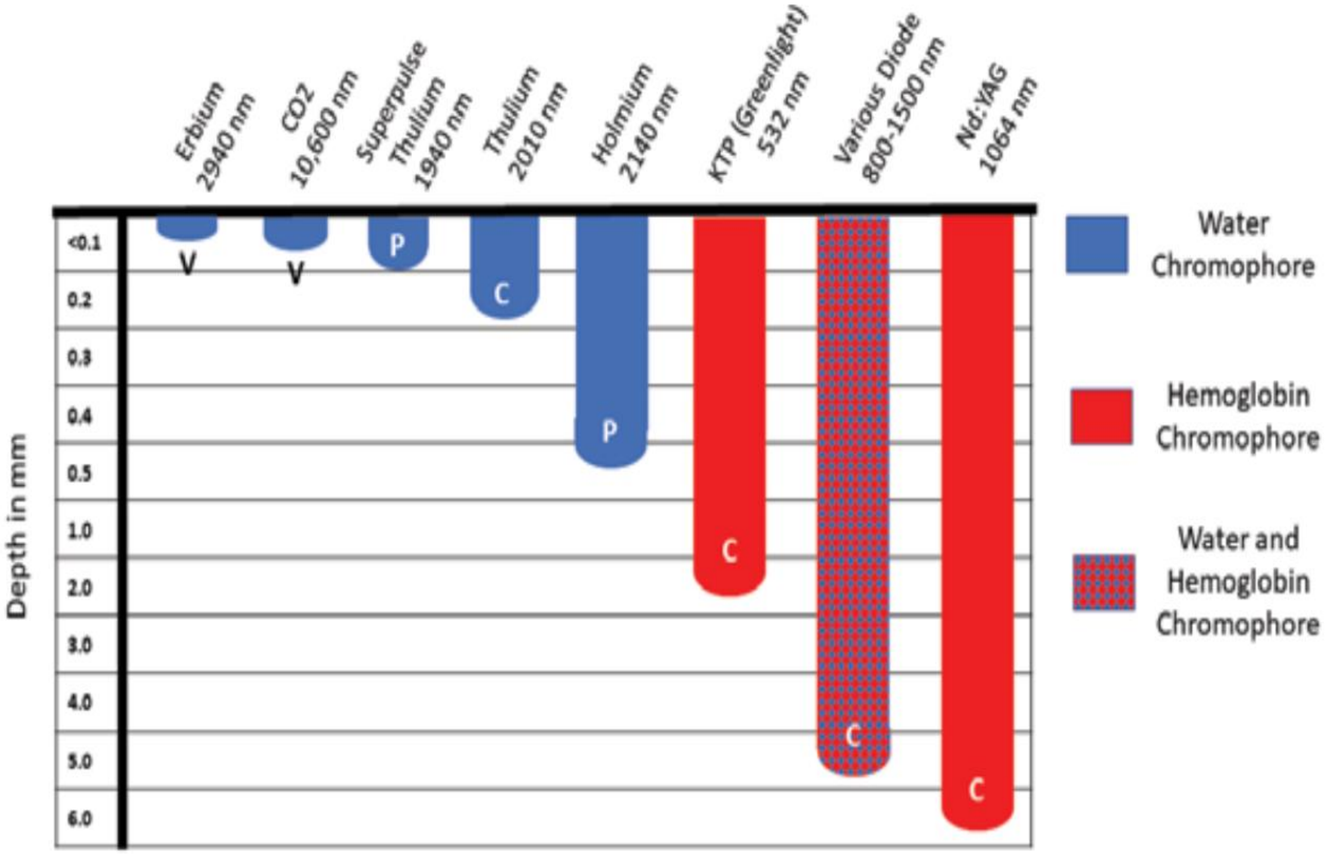
Laser Wave Length & Tissue Effects



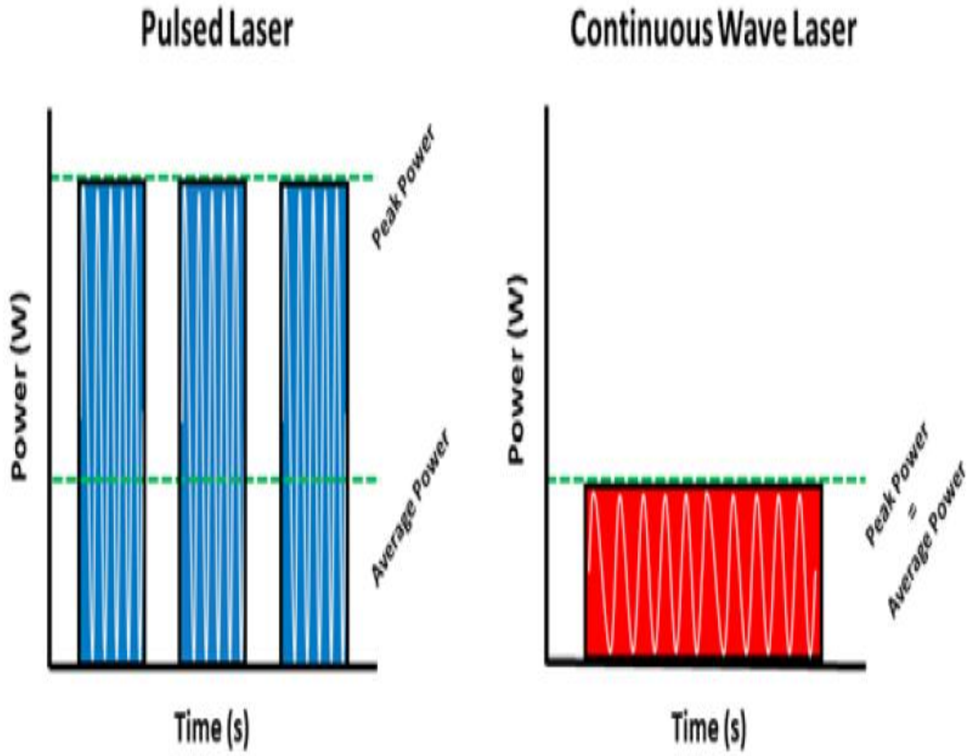




Laser/Tissue Interaction



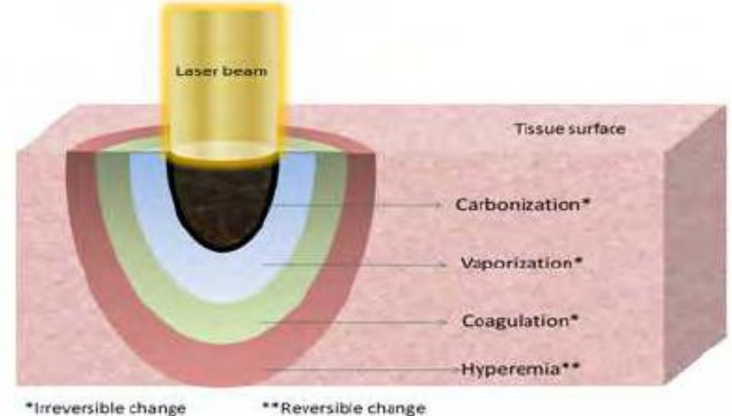
C = continuous, P = Pulsed, V = variable mode options
Many laser energies can be modified to deliver energy in various modes



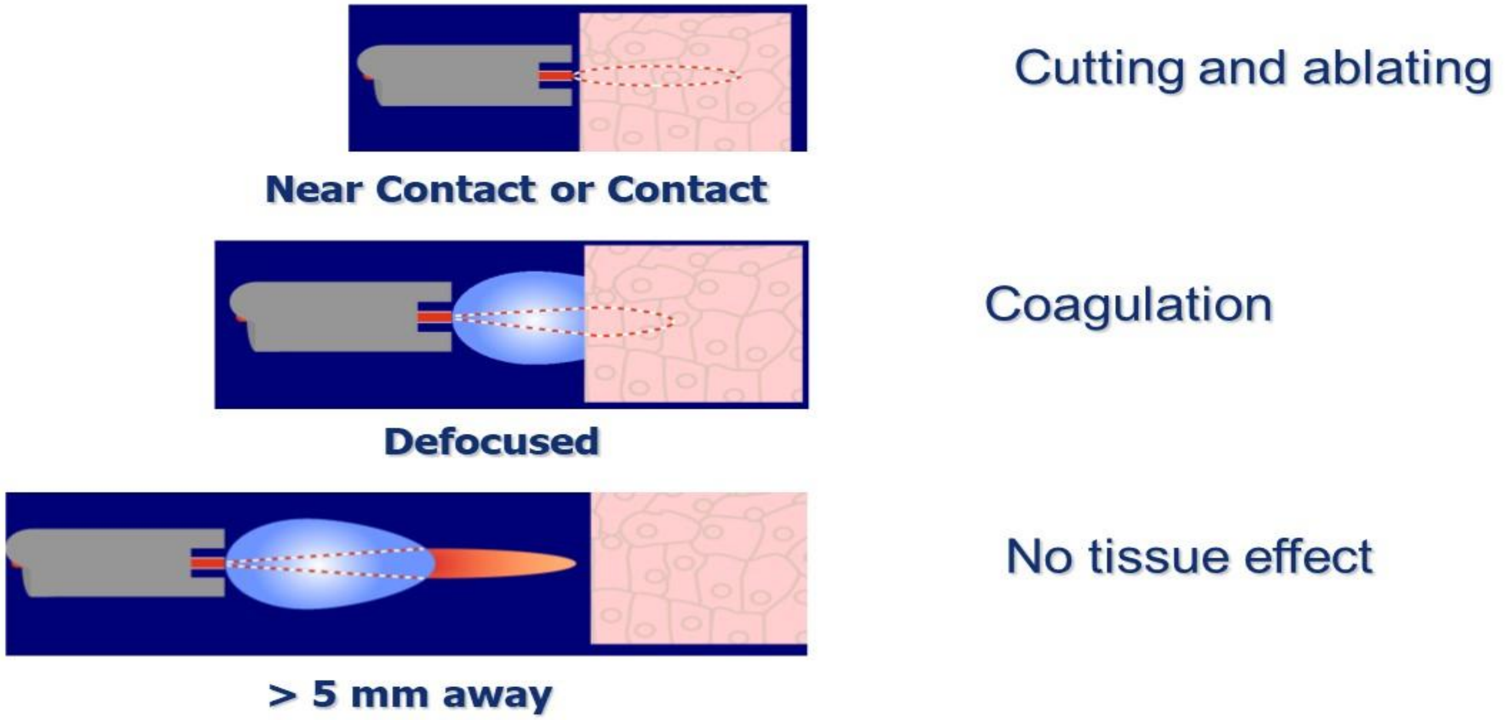
Laser/Tissue Interaction

Photothermal effect at tissue temperatures

Temp (℃) Threshold	Biological Effect
37	Body temperature
45	Hyperthermia
60	Coagulation (near tissue)
100	Vaporization/cutting (in contact with tissue)
150	Carbonization
300	Melting



Adjusting distance of fiber from tissue will achieve different tissue effects



Safety

- Most medical lasers: class 4
  - Cause eye or skin damage via direct or scattered exposure
  - Protective, wavelength specific eyewear for all those working with the fiber is recommended.
  - For the patient, the degree of protection is dictated by the nominal ocular hazard distance
  - Regular inspection and maintenance of the machine
  - The laser unit/resonator: cool environment & free from moisture

Laser type	Power (W)	NOHD (m)
CO2 (10,600nm)	60	175
KTP (532nm)	180	33.9
Nd:YAG (1064nm)	100	9.8
Holmium (2140nm)	120	1.6
	100	1.9
	50	1.9
	20	1.1
Diode (1470nm)	100	1.63
Thulium (~2000nm)	150	1.08

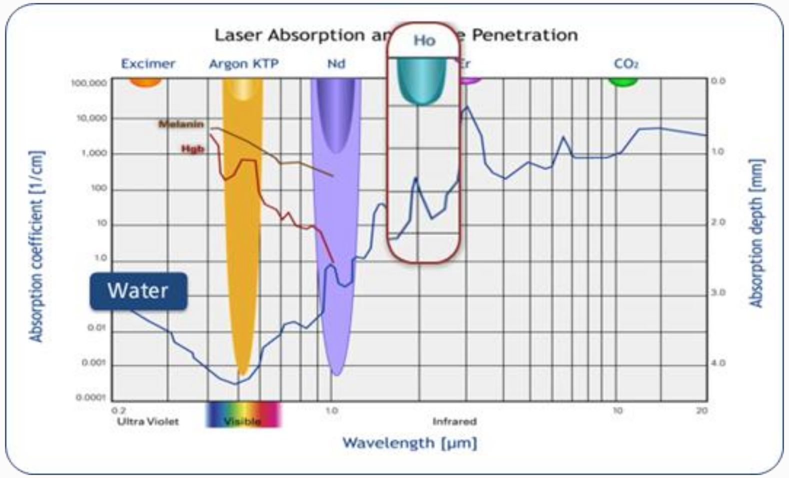
* NOHD: Nominal Ocular Hazard Distance

Usages

	CO2	Diode	Erbium	KTP	Holmium	Thulium	Nd:YAG
Bladder Ca					0	0	
Prostate ablation		0		0	0	0	
Prostate enucleation		0		0	0	0	
Radiation cystitis				0			
Skin warts	0	0			0		
Stone disease					0	0	
Trans perineal prostate ablation		0					
Upper tract cancer					0	0	0
Urethral stricture				0	0	0	
Ureteral stricture					0		
SUI, UTI	0		0				

Holmium Laser

Holmium characteristics



- **Good absorption in water**
  Efficient energy absorption in water-filled targets (soft tissue & stones)
  Less risk to surrounding tissues
- **Minimal penetration depth (0.4mm)**
  Controlled and precise incisions
- **Pulsed Solid state**
  Minimized risk of tissue charring

Factors influencing Laser's impact

Energy

- The **energy** of each pulse, measured in **Joules**
- As energy in use increases, the impact on the target grows

Frequency

- The **frequency** at which pulses are emitted, measured in **Hz**
- **Higher frequency** allows to emit **more pulses** in a set time

Distance

- The closer the target is to the fiber tip – the more impact it will absorb

Power (Watt) = Energy (J) x Frequency (Hz)

Usages – Prostate

BPH

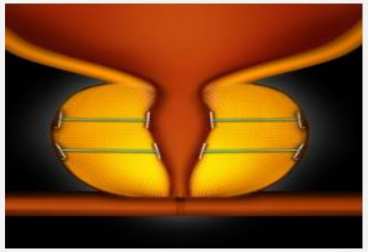
- **Non-invasive**
- **Surgical**

Open surgery

- Following an abdominal and prostate incision, the adenoma is directly removed from the capsule

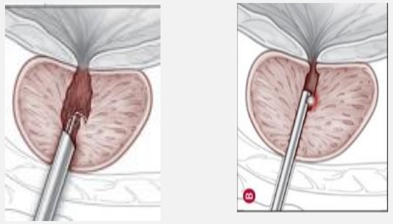
Lift and hold

- Mechanical solution witch lifts and holds the enlarged prostate tissue out of the way so it no longer blocks the urethra



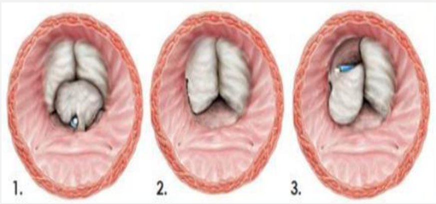
Resection / Ablation / Vaporization

- The adenoma is "polished-off" using various potential energy sources such as radiofrequency or laser energy



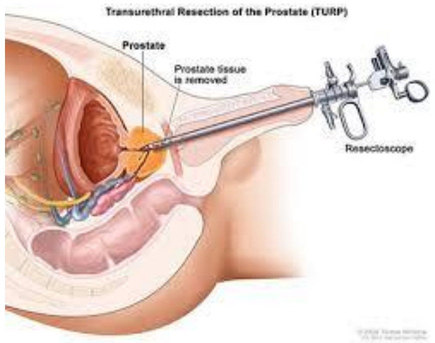
Enucleation

- The prostatic lobes are surgically separated from the capsule using various laser energy sources



Monopolar & Bipolar TURP

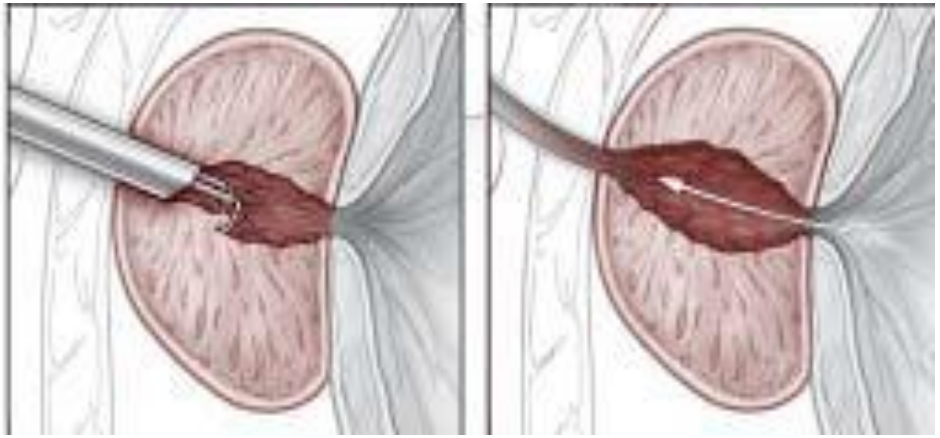
- **Monopolar TURP**
  - **Electrical current passes through the prostate from the active electrode (connected to the resectoscope loop) to a grounding pad attached to the patient.**
  - **Glycine used as irrigant**
  - **Potential risks:**
    - ✓ Nerve damage
    - ✓ Cardiac Pacemaker malfunction
    - ✓ Excessive heating of tissues
    - ✓ TUR Syndrome



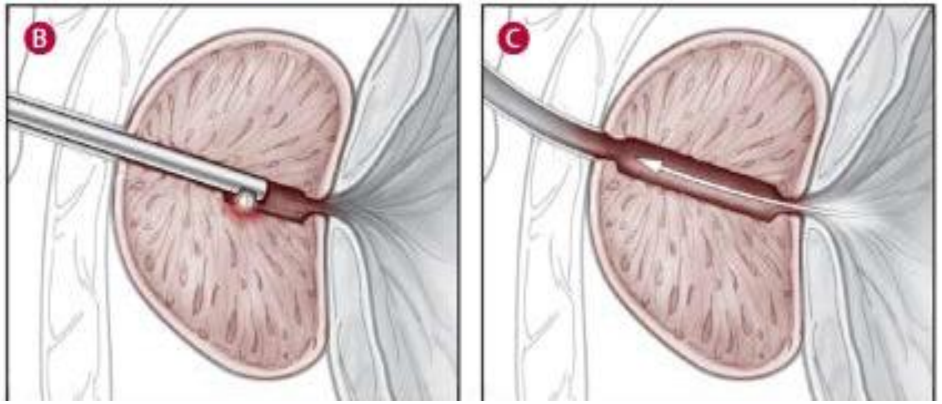
- **Bipolar TURP**
  - **Electricity runs between active & passive electrode**
  - **Forms a Vapor at tissue interface**
  - **Tissue Vaporization**
  - **Normal saline can be used**
  - **Risks:**
    - ✓ Blood Transfusion rate
    - ✓ Clot formation – Myocardial Infarction
    - ✓ Recurrence rates

Usages - Prostate disease

- Prostate enucleation, ablation/vaporization, etc.
- Laser: Holmium, thulium, KTP/GreenLight™, and various diodes
- No risk for TUR syndrome.
- **Holmium Enucleation: most widely used**
- **Thulium Enucleation**
  - **Continuous heat, vaporization**
  - **Better hemostasis c/w Holmium**
- **KTP (GreenLight™) Laser Enucleation**
  - **Continuous, Hb. Absorption**
- **Diode Laser Enucleation**
  - **DOP: 4-5mm, continuous, absorb by water & Hb.**

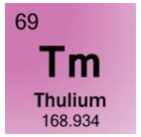
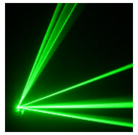
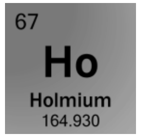


Resection



Ablation

Resection / Ablation / Vaporization

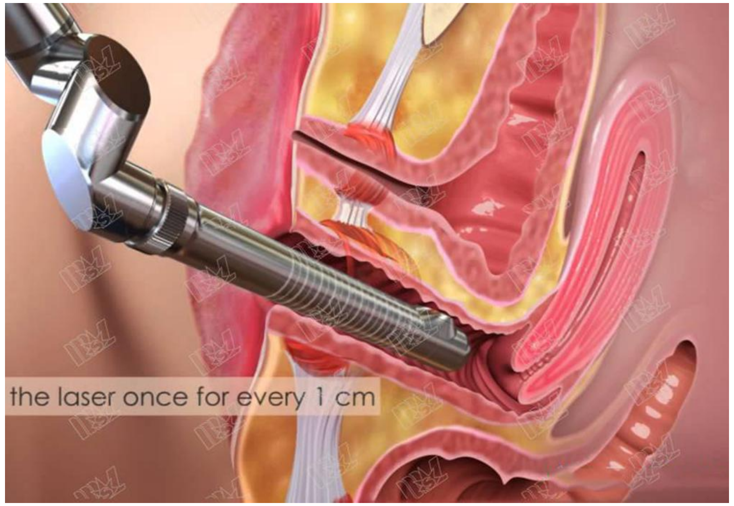
Procedure	Characteristics
Transurethral resection of the prostate (TURP) *Tissue is resected using radiofrequency loop*	• Significant bleeding • Inconsistent recurrence • Long hospitalization • TURP syndrome
 **Thulium laser ablation**	• Continuous wave – may cause charring and increase complication rate • Bubbles formation – low visibility • Ineffective for stones
 **KTP (Greenlight) laser**	• Continuous wave – may cause charring and increase complication rate • Higher depth of penetration as it is a wavelength observed by hemoglobin • Unable to have direct tissue contact which can also lead to higher recurrence rates • Special physician and operation room protection is needed • Ineffective for stones
 **Holmium laser**	• Full contact with tissue – maximum energy transmission • Solid pulse state – no charring • Clear visibility • High absorption in water and precise penetration rate, minimizing collateral risk to the surrounding tissues

Usages - Urothelial carcinoma

- Urothelial cancers: very water rich & vascular → well suited for laser therapy
- **Bladder Cancer**
  - **Nd:YAG**
    - ✓ Absorbed by Hb with a high DOP→ deeper & effective tumor ablation and hemostasis.
    - ✓ higher risk of bladder perforation & bowel injury
  - **Holmium**
    - ✓ minimizes risk of perforation d/t shallow penetration and lower thermal effect
    - ✓ En bloc resection (0.8 to 1.2 J at 10 to 20 Hz with a 550 μm end-fire fiber)
  - **Thulium**
    - ✓ more shallow DOP than holmium
    - ✓ En bloc resection - various levels of power (5 to 50 W) with a 550 μm fiber
- **Upper TCC**
  - Renal sparing surgery (low grade disease, solitary kidney or CKD, etc.)
  - **Nd:YAG, Holmium, Thulium**

Usages - Others

- Stricture
  - 70-90% success rate
  - Risk factor for recurrence: >2cm, mid ureter, impaired renal function, HN..
  - **Lasers:** holmium (m/c), thulium and KTP/GreenLight
- Radiation Cystitis
  - Lasers: KTP (High affinity for Hb), Diode & holmium (rare)
- GU syndrome of menopause
- Stress urinary incontinence
- Genital Warts
  - CO2, holmium, Diode
  - Low scaring, low recurrence

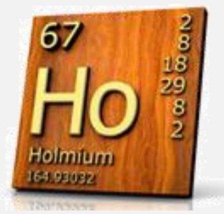


Usage - Lithotripsy

Stone treatment

- **Non-invasive**
- **Surgical**
  - **Ureteroscopy**
  - **Percutaneous Nephrolithotomy (PCNL)**

Holmium/Thulium



Ultrasonic

- Ultrasonic waves are produced, causing vibration of the probe that leads to stone breakage

Pneumatic

- Compressed air forces a metal projectile at the end of the probe to mechanically break stones

Electrohydraulic

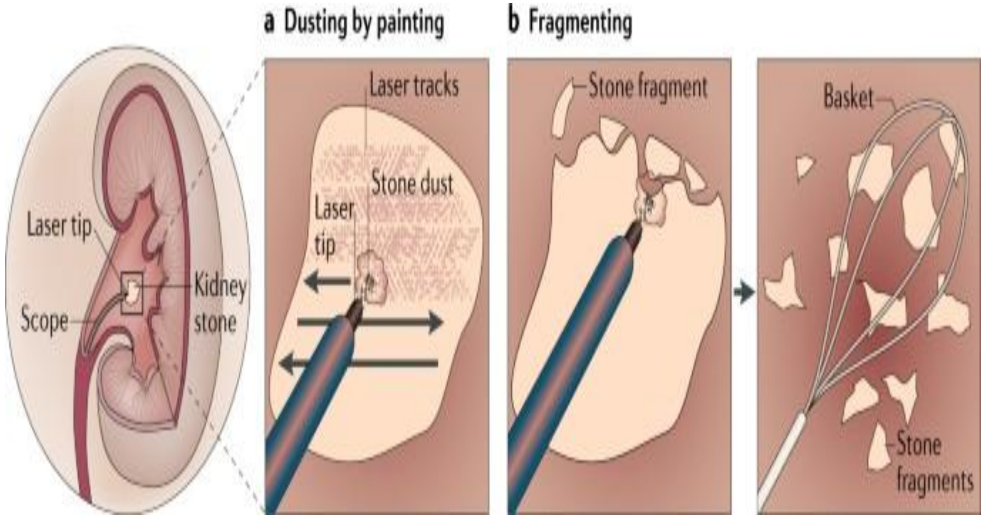
- An electric spark creates a shock wave in the water
- The shock wave breaks the stone

Characteristics of Commonly Used Intracorporeal Lithotripters

MODALITY	CONTACT	MECHANISM OF ACTION	TISSUE EFFECTS	ADVANTAGES	DISADVANTAGES
EHL	1 mm from Stone	Electric spark produces vapor bubble and subsequent cavitation bubble creates shockwaves that fracture stones	• >1 mm distance from mucosa <500 mJ—no injury • >1000 mJ— ureteric perforation	• Able to reach lower pole • Inexpensive	• Significant tissue damage at higher energy • Durability of probe tip
Ultrasonic	Direct Contact	Rapidly vibrating probe tip results in fragmentation, while simultaneous aspiration removes debris	• Mucosal stripping • No muscularis damage	• Most efficient single modality • In-line suction for simultaneous stone removal	• Reduced efficiency in hard stones
Pneumanic	Direct contact	Ballistic tip repeatedly strikes stone similar to jackhammer	• Focal areas of hemorrhage and mucosal erosions • Least traumatic of all intracorporeal lithotripters	• Least traumatic • Works well on harder stones • Least expensive	• Least efficient • Significant retropulsion
Ho:YAG laser	Direct contact	Photothermal energy transfer rapidly heats and disintegrates stone, producing fine fragments	• Thermal injury to depth of 0.5–1.0 mm	• Flexible enough to reach lower pole • Smallest fragment • Works on all stone compositions • Can be used for nonstone indications	• Mucosal injuries with 0.5-1 mm depth of penetration • Fiber breakage can damage flexible scope • High initial cost

Usages - Urolithiasis

- **Holmium laser**
  - **Various sized Laser fiber: 200 μm ~ 1000 μm**
  - **Short DOP (~0.4mm):** less likely to damage urothelial mucosa
  - **Moses effect:** efficiently break up stones
- **Thulium or TFL**
  - **Thin laser fiber: 150 μm (irrigant flow ↑)**
  - **DOP: ~0.2mm**
  - Efficiently break up stones



- **Dusting vs Fragmenting**
  - Dusting: higher frequency (50 to 80 Hz) & lower energy (0.2 to 0.4 J)
  - Fragmentation: lower frequency (4 to 10 Hz) & higher energy (1 to 2 J)

Ho:YAG & Thulium Fiber Laser

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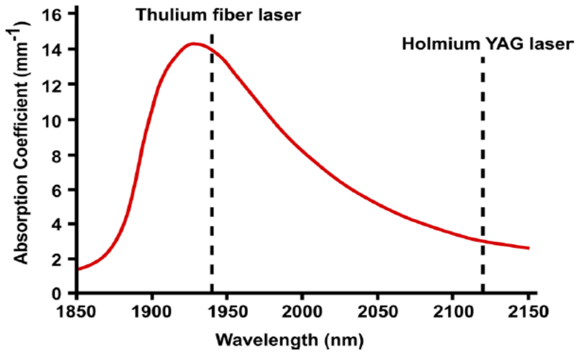
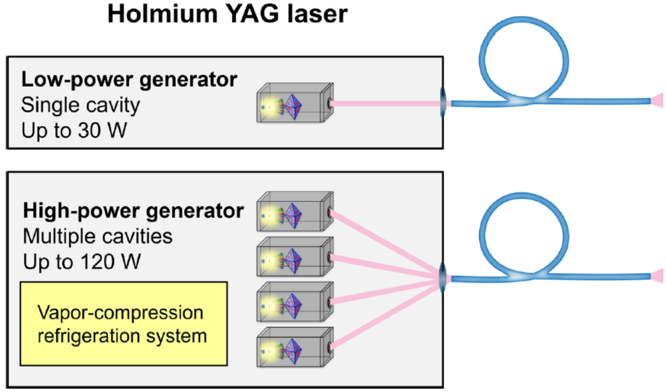
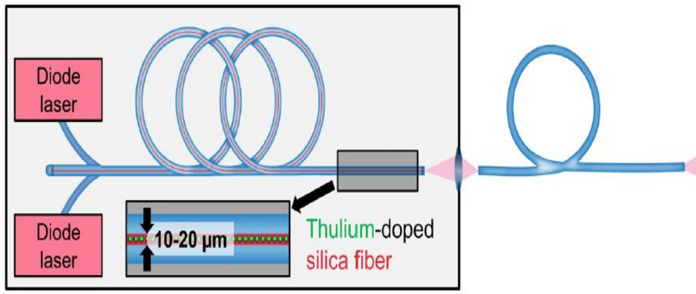
Laser specifications	Ho:YAG Laser	TFL
Peak power	N/A	500 W
Average power	120–140 W	50–60 W
Pulse energy	0.2–6.0 J	0.025–6.0 J
Pulse frequency	5–80 Hz	1–2400 Hz
Pulse duration	50–1300 μs	200 μs–50 ms
Pulse profile	Irregular spikes with rapid descent	Approximately square wave
Wavelength	2100 μm	1920–1960 μm
Minimum laser fiber diameter	200 μm	50 μm
Energy efficiency	1%	12%
Power supply required	High amperage power outlet	Standard power outlet
Energy source	Flash lamp	Laser diodes
Gain medium	Crystal rods containing holmium ions	Laser fiber core containing thulium ions
Cooling apparatus	Water	Air
Weight	245–300 kg	36 kg
Peak noise level	70 dB	N/A



Holmium YAG laser



Thulium fiber laser



Holmium Lithotripsy

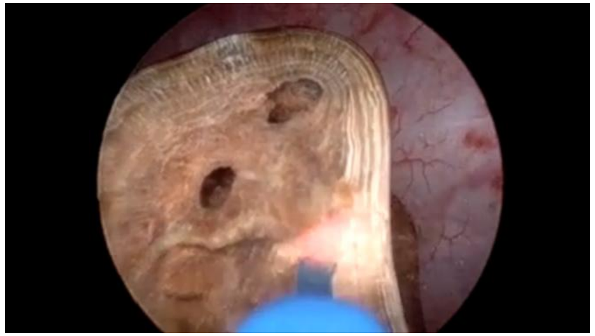
Fragmentation

- Usage of high energy and low frequency (>0.5J, <40Hz)
- Stone is fragmented to small pieces
- Retrieval device is utilized for stone fragments extraction

Dusting

- Usage of low energy and high frequency (0.2-0.5J, 50-80Hz)
- Stone is ablated into small debris = dust
- Stone dust is washed with irrigation or in the urine

Required	**Retrieval devices**	Not required
Higher	**Retropulsion**	Lower
Higher	**Intra op complication**	Lower
Higher	**Cost**	Lower
Higher	**Fiber degradation rate**	Lower

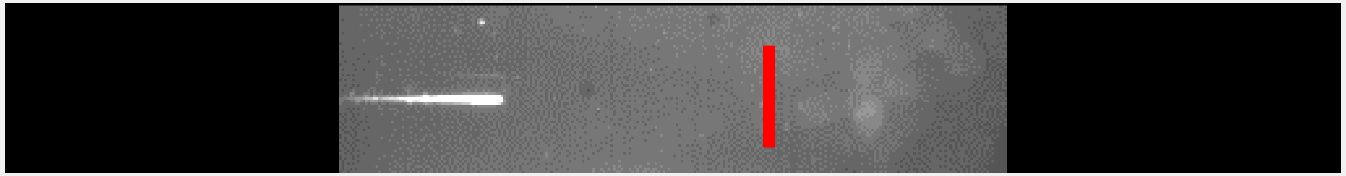


Holmium Lithotripsy

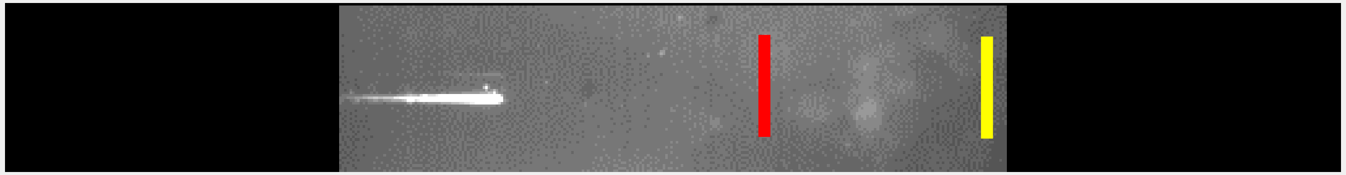
Challenges in Holmium lithotripsy	MOSES™
Reduction in energy transmission and high dependency on distance	✓ Maximized energy transmission

Utilizing the Moses fiber, the Moses technology modulates the laser pulse so that it first separates the water, and then delivers the remaining energy through the bubble and towards the target stone, thus less energy is lost

Regular



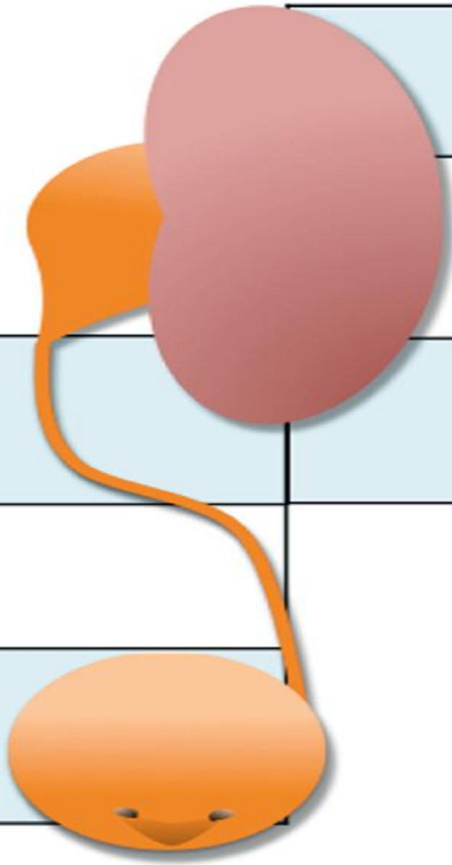
MOSES™



Stone-free rates in ureteroscopy

Kidney:

	EHL	PNM	USN	LSR
UPPER	87	ND	–	100
MID	87	ND	–	95.8
LOWER	92	ND	–	90



Ureter:

	EHL	PNM	USN	LSR
PROX	84	88.8	74	97
MID	66.6	92.5	76	100
DISTAL	94	98.4	89.4	100

Stone-free rates (percentage) for intracorporeal lithotripters used in ureteroscopy by anatomic region. *EHL,* Electrohydraulic lithotripsy; *LSR,* laser; *ND,* no data; *PNM,* pneumatic; *PROX,* proximal; *USN,* ultrasonic.

Complications & Prevention

- **Injuries result from**
  - equipment failure, technique errors, inadequate understanding of the properties of the particular laser and its thermal effects
- **Eye injury, Air embolism, Ureter & bladder perforation, skin burn ….**
- **Prevention**
  - Proper education and knowledge of the differences among the various laser energies
  - Movement of laser fibers (slow versus fast) varies depending on the laser wavelength and chromophore (different techniques is applied to different energies)
  - Improper use can lead to under/overtreatment of tissue and potentially lead to injury (long dwell times for certain lasers can cause deep tissue damage/injury).
  - Prolonged laser use → surgeon should be cognizant of overheating of the irrigant fluid that can lead to thermal injury of the urothelial mucosa

Long-term complications associated with lasers

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Prostate reduction surgery	Incomplete tissue removal which may require retreatment
	Irritative symptoms, sometimes severe, from thermal effect (more common with continuous lasers and deeper penetration)
	Erectile dysfunction
	Stress and/or urge incontinence
	Bladder neck contracture (likely d/t excessive coagulation instead of vaporization and prolonged heat delivery to the bladder neck)
	Damage to the ureteral orifices
	Severe thermal injury to the bladder from elevated temperature of irrigant (it is important to use irrigation at room temperature and avoid fluid warmer when performing laser prostate surgery, particularly with continuous laser energies)
Upper tract urothelial carcinoma/stones:	Aggressive lasering within the ureter can result in ureteral damage leading to perforation, scarring, fibrosis and stricture formation
	Pulsed modes and cool irrigation fluid reduce collateral collateral thermal damage
Bladder therapy:	Bladder perforation with extensive lasering (laser energy is best when applied to the surface of the bladder in short bursts)
	Distal ureteral injury
	Bowel injury from prolonged dwell time with Hb based lasers

Take home Messages

- Electrosurgery is a very useful surgical tool. Improvements in technology increased its safety and reduced complications.
- Electrosurgery facilitates surgery as a versatile tool but training is essential to understand its principles and reduce complications.
- Laser energies have been of significant benefit to patients and surgeons.
- The surgeon must be aware the differences of its characteristics to use the technology safely and correctly.

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감사합니다.