
LASER IN UROLOGY -MADE EASY...



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"This book is not meant to be a reference, it is simply the book that i wanted to read when i started my journey with laser in urology.

Keeping my faith in ALLAH as well as in the value of continuous updating and conveying the knowledge to others, gave me the power to fight all the disappointments in my way."

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August, 2015
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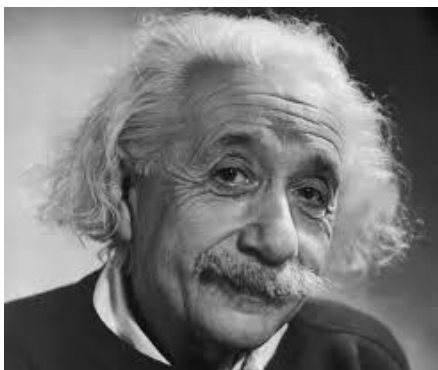
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Laser (Basic principals)

The word is an abbreviation that stands for Light Amplification by Stimulated Emission of Radiation (**L A S E R**).

When laser came to public, it was described as ***“A solution eagerly looking for a problem to solve.”***

“Albert Einstein” proposed its concept (1917) when he suggested the theory of stimulated emission by packs of excited “Photons”.



(Albert Einstein, 1879-1955)

In 1954, MASER (Microwave) was invented . And then came the LASER in 1960 by “Maiman” who built the Ruby laser.

“Parsons” was the first to use it in urology in 1966.

Since then, urology has been influenced by the laser applications, especially after the marked advances in producing the fibro-optics and small diameter instruments.

Physiology of light and laser

The main source of light on earth is the sun. But other sources, whether natural or artificial, are also available.

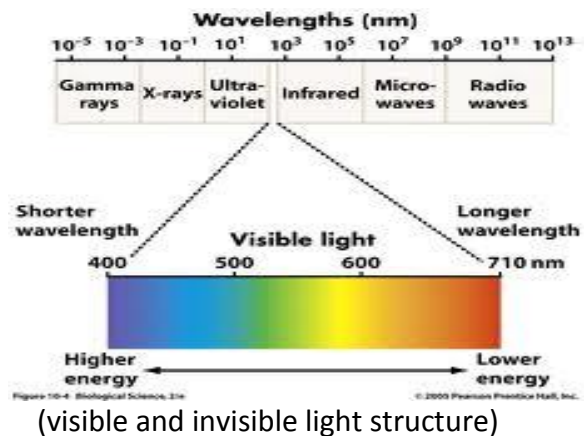
Light is a form of electromagnetic radiation in the form of photons that has a spectrum of wave lengths

depending on the amount of power used. The eye can identify only the range of 400 to 700 nanometers (between infrared and ultraviolet).

• Light is a form of energy



Laser is basically a monochromatic single wavelength of well packed and energized kind of light. The "Principle of conservation of energy" states that (***energy cannot be created nor destroyed but it can change from one form to another***). Based on this, producing laser is just changing the form of energy stored in the stimulating current and the lasing medium to a high energy light beam.



The wave length of which may fall within or around the range of visible light, hence it gets a visible color. Or, It may fall away from that and be invisible (colorless).

Measurements

To understand laser power measurement we have to keep in mind the definitions of work, energy and power that say "work is applying a force to make a change and its unit is Newton/meter or Joule", "energy is the ability to do work and measured in Joule as well", and "power is

the rate of energy transfer and is measured in Joule /second or Watt"

So the energy produced is measured as power that refers to the rate of energy expenditure.

It is measured in Joules per second, that is also called Watt ($1\text{J/s} = 1\text{ watt}$). In some machines, the control screen shows a window for energy and another for rate and as you set them a third window of power is automatically calculated. A power of 180 watt is the maximum reached by the machines nowadays. To know the difference we need to know that the world's most powerful laser on earth is 411 **TRILLION** watt that lasted for 23 **BILLIONTHS OF A SECOND**. But a 180 watt would be enough for the

delicate human tissues we are dealing with.

Flounce describes the amount of energy delivered per unit area (J/cm^2).

Irradiance refers to the intensity of laser beam, that is measured in watt per square centimeter ($\text{J}/\text{time/area unit}$)

laser machine

The machine is a sealed container with one aperture. It contains a lasing medium surrounded by both fully and partially reflective mirrors, and attached to a power source.

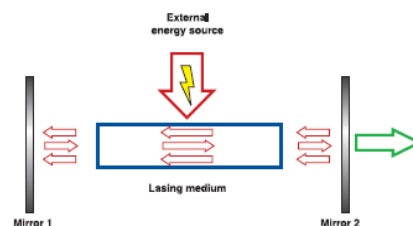
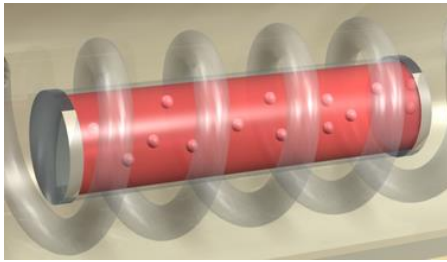


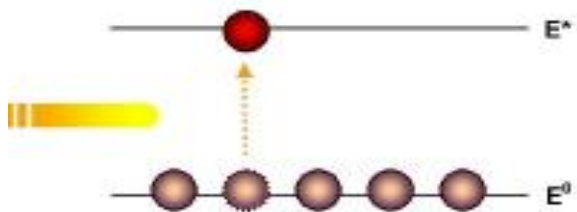
Figure 6A-1 A standard laser consists of a lasing medium, energized by an external energy source such as a flashlamp. Light oscillates between the mirrors, increasing in energy with each passage. Mirror 2 is partly transparent and the laser beam emerges as a high-quality beam of intense light energy.

Atoms in the lasing medium are in the resting state with energy level of E^0 .



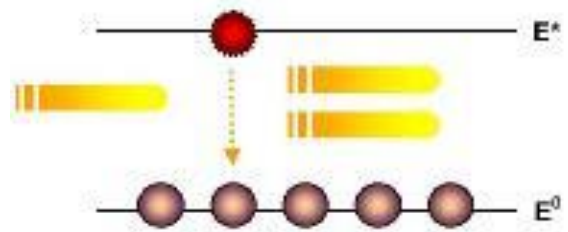
Once stimulated by a power source, they acquire energy and move to higher level of energy (E^1 , E^2 , E^n).

ABSORPTION

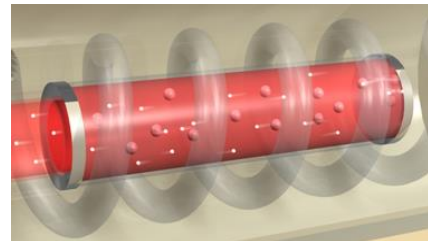


Soon they lose that energy in the form of photons and get back to E^0 .

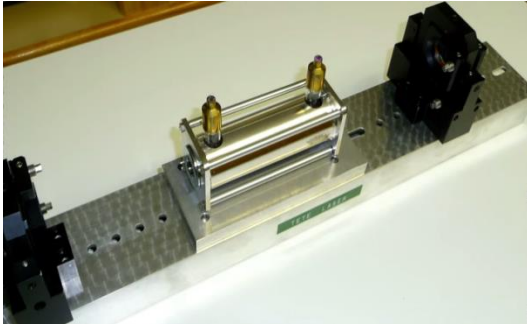
STIMULATED EMISSION OF RADIATION



The photons jerk between the mirrors until they come out of the definite aperture in the form of a pack of high energy parallel rays of light.



In their way out, they start pumping into other particles resulting in more and more energy (Amplification).



(the original laser machine model)

“Ruby” was the first crystal to be used as a lasing medium and it produced a red color laser. Since then, laser light beam is always drawn as red.



Different types of lasing media: solid (neodymium),

liquid (dye solutions), or gas (CO₂) are used for providing the atom to produce laser.

Coloring medium may be added to differentiate laser and to act as a guide during use.

Releasing the laser beam

The produced Laser beam can be released in either:

- continuous form (CW).
- interrupted form (PW).

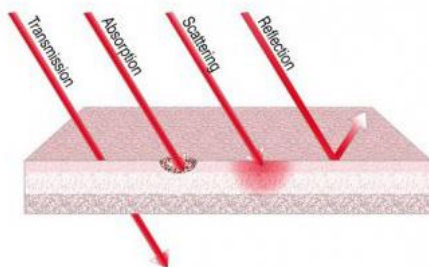
Interrupted form is controlled by interrupting the power source or the outlet of the laser beam. It has the advantage of higher power peak (bursts), shorter duration, less lateral heat conduction to the tissues e.g. Q-switched mode.

CW gives better interaction with the tissues but needs higher power

output to get the same effect of lower energy PW.

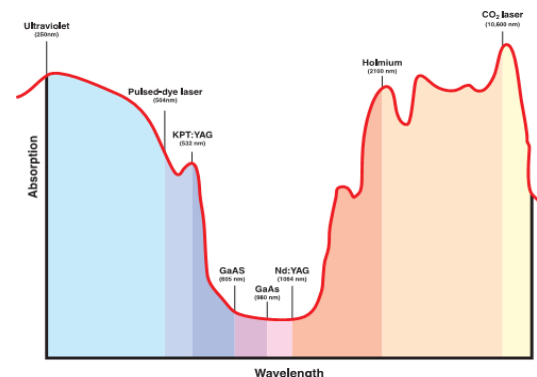
Patho-physiology

The interaction of laser with tissues depends mainly on absorption of this energy by the body chromophores or other tissue elements e.g., blood, water, and melanin. Other types of interaction are : Reflection, scattering (diffusion), and transmission. These pathways are not desired as they cause losing of energy as well as uncontrolled side effects.



(laser reaction on application to soft tissue)

The element affecting absorption and related to the laser itself is the wave length of that beam.



(absorption is inverse of penetration)

Absorption of that energy leads basically to heating up the tissues that causes coagulation or vaporization. Depending on the amount of heat produced, the effect will be different. At 100 C, protein denaturation and coagulation occurs followed over time by sloughing of these tissues. When the produced heat reaches up to 300 c, cavity formation occurs due to boiling and vaporization of the soft tissue component. According

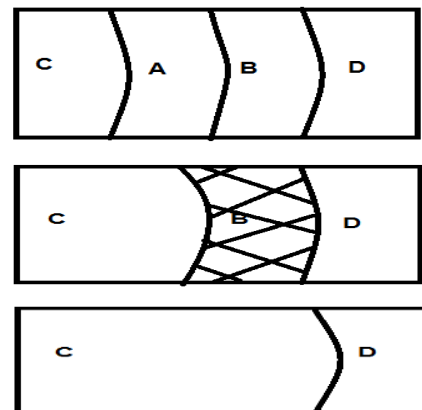
to this understanding companies are continuously trying to build up machines with higher energy output for more impressive immediate effect.

The tissue penetration of that energy is another important factor that determines which type of laser to be used in which tissue or lesion. The depth of penetration is basically related to absorption in an inverse relation.

Zonal effect:

When the laser energy is applied to a tissue mass(e.g., prostate) part of it is absorbed to that tissue giving an immediate cavity formation effect (zone A). Another part of that energy, lower intensity, penetrates more to the next layer of tissue and causes coagulation due to heat

production that is not enough to evaporate these tissues (zone B). That part (zone B) necrotizes and sloughs later leading to the characteristic ***burning sensation*** or more seriously, bleeding. Zone effect is differs in thickness of layers according to wave length and penetration feature of the applied laser.

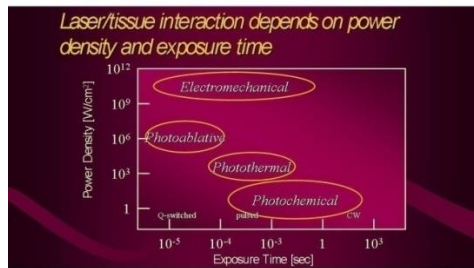


zonal effect (c=cavity, A=zone A, B=zone B, D=no effect zone)

Generally speaking, the laser effect at the body tissues is :

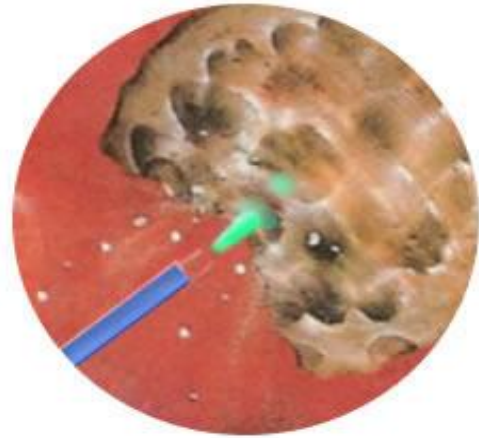
- Thermal by raising the tissue temp.
- Mechanical by the bursting air bubbles.

- Chemical initiating chemical reactions by the heat effect that changes tissue's nature.



(laser- tissue interaction)

effect through the disrupting plasma bubbles.



(air bubbles causing ESWL-like effect)

Tissue welding effect is another, completely different, type that takes place when the laser energy at special wave length induces collagen cross-linking.

Laser stone fragmentation effect is still one of the area of argument.

Two kinds of effect were suggested: Photo-thermal drilling effect creating cracks due to boiling and vaporization of the minute water content, and SWL like

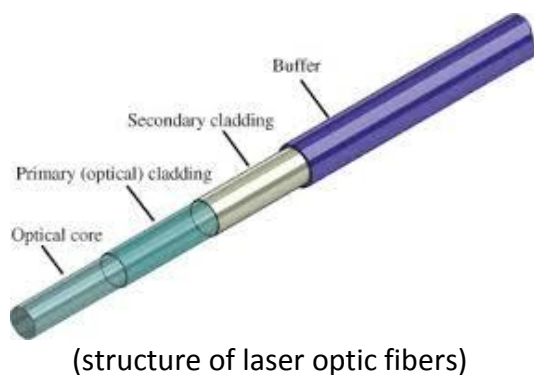
It seems that it starts by the thermal effect until surface fissures appear, then the SWL effect follows.



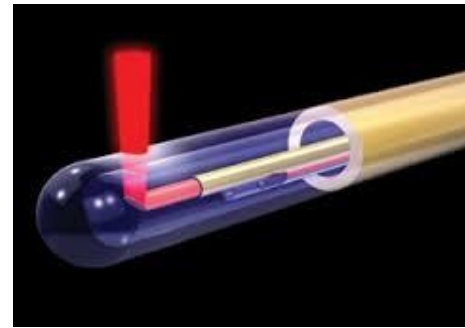
(mechanical laser fragmentation effect)

Laser fibers

They are fibro-optic fibers that transmit laser beam from the laser machine to the target tissue. The fiber consists of a core that transmits the laser energy covered by different layers that have the function of collimation and prevention of energy distraction before reaching the tip.



Transmission at the tip is either end -fire or side-fire fashion.



(side-firing fibers using a mirror)

Optic fibers were first made using the molten silica substance but the fibers were brittle and attenuating the transmitted energy. Later, other chemical additives were added to modify its specifications. finally, it could be made of different other substances as Silicon, Carbon, Germanium, and Phosphorus Oxychloride. Water free-silica fibers are used for Hol:YAG laser.

Some fibers are used once as the high temperature produced destroys the fiber ,or because of the tip-mounted accessories as in the PVP (Photo-selective Vaporization of Prostate)

fibers of Holmium: YAG machine.

It comes in different sizes e.g. size of 200, 360, 550, and 1000 micrometer (for Versa pulse, Lumenis).

Smaller diameter fibers have no advantage but fitting in small caliber endoscopes and smaller area of exposure with more density.

Dealing with laser fibers needs good awareness with the instructions. single use fibers is easier as it needs no preparation for use. But, still some advices should be followed. Gentle handling is important specially on unpacking or coiling. Avoid blood to come inside the tip of the side firing fiber as it affects the efficiency greatly, and when stained clean it. Using a single use fiber for a second time is not advisable

as the mirror is already ,partially or completely, damaged.

Dealing with reusable fibers is more tricky as it needs re-sterilization, preparation, gentle handling. Re-sterilization is best done by plasma sterilization machine, if not, using Cidex is accepted. Preparation is done by using the specialized "striper" to strip out the last one cm of the buffer or (collimating) sheath.



(striper, Lumenis)

preparing the tip of the fiber is done using the ceramic scissor by cutting the

lacerated peripheral part. Testing for a good cut tip is done by having a smooth rounded red spot light at the non-shiny machine surface while the machine is in standby mood.

Again, the colored light coming from the fiber while the machine is in standby mood is the guiding light not the laser beam.



(ceramic scissor)

Inside the endoscope, smooth movement under vision should be maintained. Distance between tip of the fiber and the tissue as well as intensity determines the effect:

- making incision → tissue contact with concentrated laser power dose.

- vaporizing → high laser power dose with slightly defocused beam (little away).

- coagulation → longer distance from the tissues.

The everlasting tips when using the optic fibers are: short time contact or better non-contact as it char the tip with loss of fiber efficiency, and don't apply laser where you can't see the tip as it is dangerously harmful.

Commonly used laser types in urology

- Nd:YAG: WL 1064 that penetrates up to 10mm as it is not absorbed by Hb or water. Coagulates vessels up to 5mm. Using it was plagued with bleeding.

-Hol:YAG: WL 2140nm with 2mm penetration.

Low(80) and High(100 and 120) power YAG laser that is most appropriate for stone fragmentation and prostate enucleation as well as tumor fulguration.



(KTP, Green light laser)

Holmium laser 20W machine for stone fragmentation are also available.



(Versa pulse, Lumenis)

-KTP (Green) laser: WL 532.

Basically, it is a double frequency half WL Nd:YAG by KTP crystal. So, it has less penetrating (0.5 mm).

-Carbon dioxide laser: It has the longest WL (10600nm) with the least penetration and highest charring effect, making it more suitable for superficial lesion ablation.



(OEM Pixel fractional CO2)

-Alexandrite laser:
Absorbed by melanin and

colored molecule, used for stone fragmentation.



(Candela-Syneron, GentaLASE PRO)

-Thulium:YAG (Tm:YAG): it has a 2000nm WL with a 250 μ m tissue penetration making it more suitable for vaporization purpose.



(MultiPulse, Jenasurgical)

-Lithium Triborate (LBO): WL 532 and 3mm penetration. It has the same

WL of KTP laser but with higher power (120 W) making it more efficient for faster and safer vaporization of the prostate and UB masses.



(GreenlightXPS, AMS)

-Diode laser: it is a wavelength modifiable laser with WL between 630 and 980nm. This is needed for use with different photosynthesizing substances that are used for PVP as well as other uses.

Laser application in urology

***Stone fragmentation:** by creating bubbles that rupture to give ESWL like effect.

***Tissue coagulation** e.g. UB tumors, by to 60c.

***Tissue vaporization:** strictures, prostatic vaporization, and prostatic enucleation by vaporizing the tissues in a line (cutting).

***Tissue welding:** by forming a tissue bond using the altered protein structure.

When laser was used in urology, some advantages were gained as: safety for patients taking anticoagulants and limitless size for resection as it uses normal saline for irrigation so fluid overload due to intravascular leakage is avoided. On the other hand, some disadvantages were expected as: no specimens for histopathology if vaporization or ablation are done. Not to mention the high expenses that limited its availability.

Dealing with the laser machine

When you have a laser machine, it is very important to know how to treasure such a valuable thing. Reading the manufacturer manual is first step. Keeping the machine in a safe, dry, well protected place is the second one. Being operated by a trained technician or a nurse is also so important. It is also of great value to know how to avoid abusing it as well as keeping it in a proper temperature if it has a manual cooling system as we definitely expecting that such an energy producing machine will get hot.

Cooling system

laser machines produce a big amount of heat , specifically from the laser

tube. Such heat should be cooled down to avoid tube damage and affection of machine performance. Laser machines are all using water or air cooling system. The water cooling system includes a chilling unit the cools the water injected to the tube. It needs to be always checked for the water level and chiller efficiency. In the other hand, it is characterized by producing minimal noise. Air cooling system uses fans to withdraw the hot air around the tube away. It is less expensive but produces more noise and after all you need to put the machine in cool dry environment.

How to select a laser machine

Professionals going to choose a laser machine

should justify and evaluate their goals before purchasing a one. Different types of laser modalities and machines have different capabilities and hence uses.

The main uses of laser in urology nowadays are: prostate surgeries, tumor tissue ablation, stricture cutting, and stone disintegration. Regarding these four uses and different specifications we can decide what to choose.

Laser	Stone Fragmentation	Prostate Coagulation	Prostate Incision	Urethral Strictures and UPI Stenosis
Pulsed-dye	++	N/A	N/A	N/A
Nd:YAG free beam	N/A	+++	N/A	+ (small fiber)
Nd:YAG with contact fibers and probes	N/A	+++	+++	+++
Semiconductor diode with contact fibers	N/A	+++	+++	+++
KTP Nd:YAG	N/A	+	+++	+++
Holmium:YAG	+++	+	+++	+++

N/A = not applicable; UPI = ureteropelvic junction; + = fair; ++ = good; +++ = excellent.

Smith Textbook of endourology, 2006.

So, If you want to get a machine for:

* stone → holmium.

*prostate and tissue coagulation→ thulium or KTP.

*prostate and tissue cutting→ holmium.

*all purposes→ dual form machine (Thulium and Holmium).

For the time being, I personally believe that the machine Revolix Due 200 (LISA laser) is the most justifiable as it is the only machine giving the chance for using two kinds of wave length laser to deal with all purposes.

Laser hazards



(The approved icon for laser energy warning)

The main laser hazards is the eye trauma, but skin injury is known as well (Beam related).

Other kinds of hazards are (Non-beam related):

- atmospheric contamination.
- collateral radiation.
- electrical and fire hazards.

Biological effects of laser:

- *photo-thermal.
- *photo-chemical.
- *photo-mechanical.

Invisible laser is mostly absorbed at the cornea level.

Visible laser is mostly focused at the retina level.

A 10 °c increase causes irreversible destruction of the photoreceptors.

Less than a blink is enough for high power laser, especially if the laser beam is invisible (<400 or >700), to harm the eye.

Visible laser seems more dangerous as it is focused at the retina giving more irreversible harm.

Wavelength range	Pathological effect
180–315 nm (UV-B, UV-C)	photokeratitis (inflammation of the cornea, equivalent to sunburn)
315–400 nm (UV-A)	photochemical cataract (clouding of the eye lens)
400–780 nm (visible)	photochemical damage to the retina, retinal burn
780–1400 nm (near-IR)	cataract, retinal burn
1.4–3.0µm (IR)	aqueous flare (protein in the aqueous humour), cataract, corneal burn
3.0 µm–1 mm	corneal burn

(common eye complications)

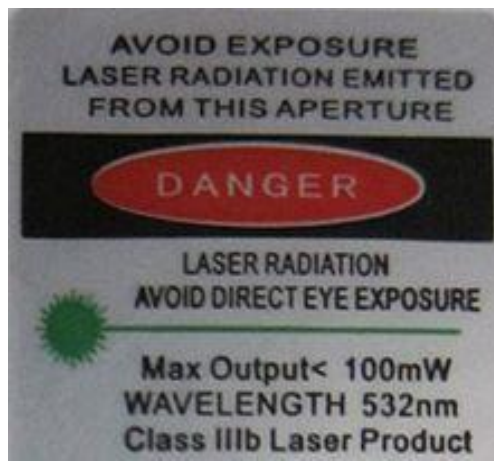
Parameters for laser safety are:

AEL (Accessible Emission Limit).

MPE (Maximum Permissible Exposure).

NOHD (Nominal Ocular Hazard Distance).

- ANSI (American national standards institute)



(the standardized specification patch, ANSI)

machine safety classes:

-class I: safe under all conditions.

-class II: safe unless stared at the laser beam.

IIM is unsafe if looked at through highly magnifying lenses.

-class III: harmful with eye exposure.

IIIR avoid DIRECT exposure.

IIIB avoid DIRECT or SHINY SURFACE REFLECTED exposure.

-class VI: unsafe even with scattered laser beam around the environment.

Most of laser machines are class III R and B.

KEEP IT SAFE:

*Don't be there if you don't have to be there.

*Hazards awareness.

*Loose all the shiny objects (hand watches, jewels, shiny eye glasses, etc).

*Machines should be operated by an experienced person.

*Eye protection: eye goggles (to show the invisible beam and absorb the reflected radiations).

OD (optical density) is the unit of function evaluation of the goggles e.g. OD 3 attenuates the beam power to a factor of 1000.

OR design

*Matt surfaces.

*Automatic-shutdown sensors connected to doors and machines to stop the machine on any failure.

*Fire extinguishing devices.

*Proper electric connections and appliances.

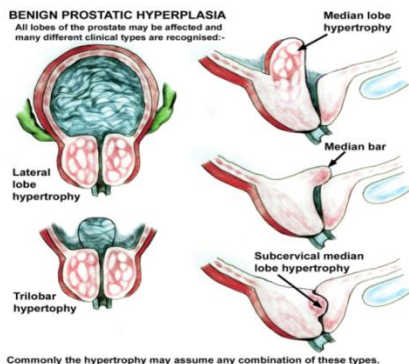
Benign prostatic hyperplasia

BPH is one of the most common male urologic disorders affecting even the males between 40-49ys old (8.4%).



(Benign Prostatic Hyperplasia)

It is clinically significant in almost 50% of males having BPH.



Most of them seek medical advice to solve the problem with the least complications.

Managing these patients starts with good history taking, and ends with choosing one of the known and approved lines of treatment nowadays :

1-Watchful waiting..

Reassurance.

Periodic monitoring.

Education.

life style changing.

2- Medical treatment..

α -blockers.

5 α -reductase-inhibitor.

Combination therapy.

Plant extract.

antimuscarenic drugs.

3- Surgical management..

>Open/ lap prostatectomy

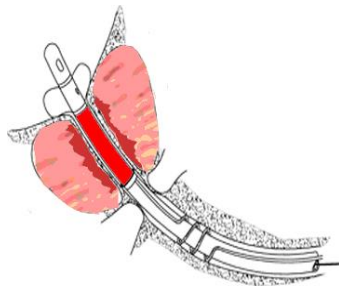
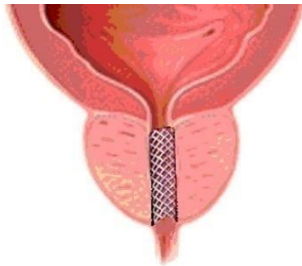
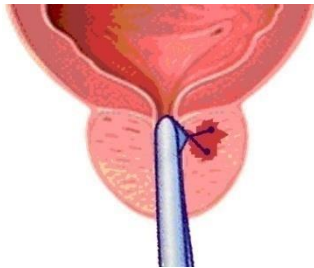
>TURP(mono or bipolar).

> TUIP, TUVF

>Laser surgery.

>TUNA, thermotherapy,
TUMT, HIFU.

>Stents, balloon dilation.



TUMT, Stent, Thermotherapy.

Open prostatectomy

It is described as the "ever-standing surgical solution" for the difficult

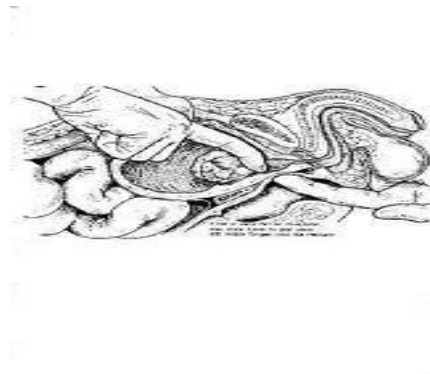
situations, as well as the sensible indications, applied only in 5% of cases nowadays.

-large prostate (size is debatable among resectionist).

-associated diverticulum.

- large associated stone.

-non applicable lithotomy position.



(Transvesical enucleation)

The operation has been always plagued by:

*Large abdominal incision.

*Maximum loss of blood.

*Highest incidence of Retrograde ejaculation, erectile dysfunction, urine incontinence.

*Expensive (hospital stay & back to work wise).

In the other hand, the operation is also described as being:

The fastest, ever available, widely known, least equipment, most impressive result technique.

Open prostatectomy was gradually replaced by the TURP that avoids most of the disadvantage but lacking the bright advantages of the open prostatectomy.

TURP

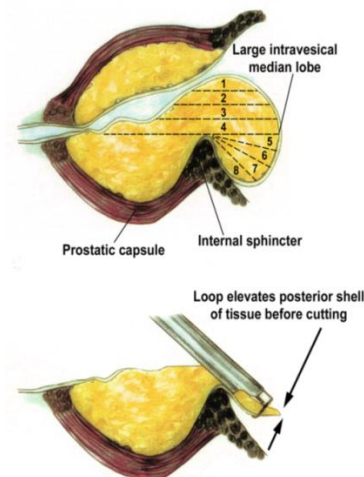
The technique was rapidly evolving with the advantage of:

*Less invasive with less blood loss.

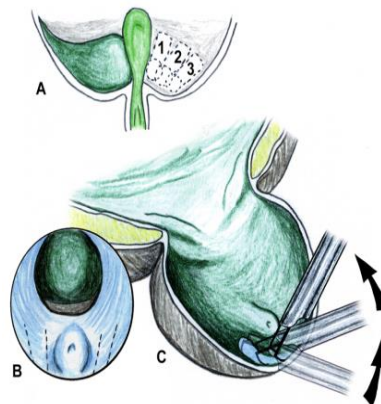
*Treats some of the associated pathology.

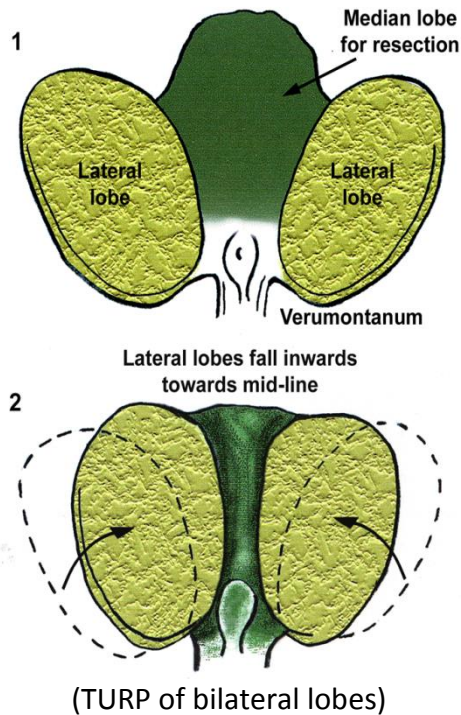
*Better results for small (<40gm) prostate.

It, soon, became the GOLD STANDARD for prostatectomy and Soon the resectoscope was available everywhere.



(TURP of the middle lobe)

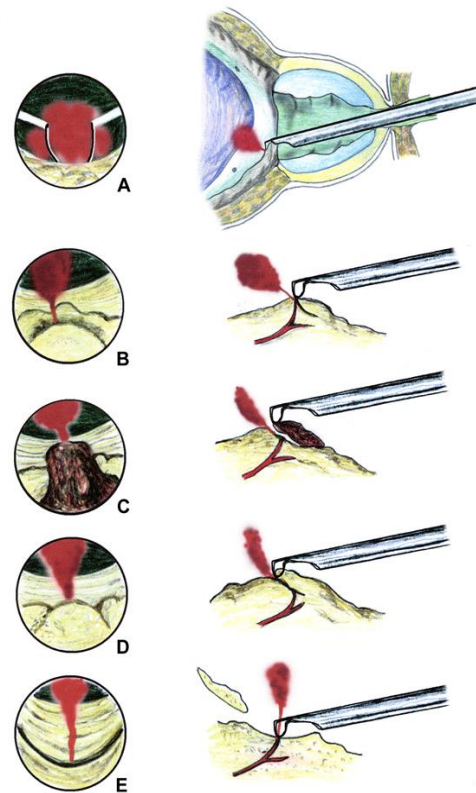
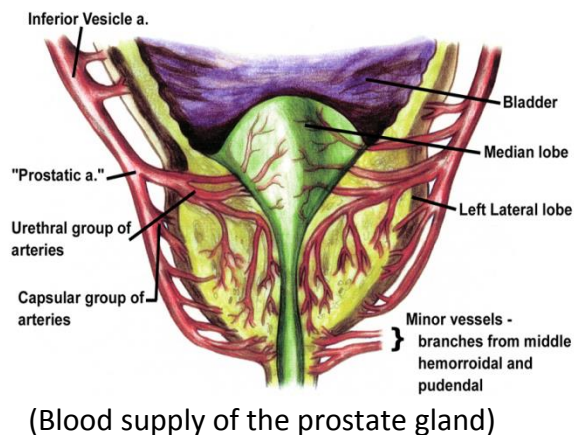




The procedure was basically a repeated steps of cutting part of the prostate followed by stopping the resulting bleeding.

Most of times it ends up with a pool of bloody fluids in the collecting bucket and the floor.

Knowing the details of the blood supply of the gland as well as its branches and tributaries, hemostasis was something that could be done but with some difficulty.



(hemostasis during TURP)

In spite of the invention of the bipolar resectoscope (plasma) that uses normal saline as an irrigation fluid (to avoid TUR-syndrome), the TURP is still a *boring* technique that takes a long time with unpleasant postoperative period.

It also causes considerable bleeding (5% transfusion) with easily misleading field.

An estimated incidence of repeated endoscopic intervention was almost 14.7%



(Old diathermy machine and resectoscope sheath, Urologica Historica))

Over the last 2 decades everybody , while practicing TURP, was dreaming of an alternative procedures with comparable results of TURP but without its disadvantage.

A procedure that has the bright advantage of open prostatectomy would be much attractive if any.

Laser prostatectomy

Different techniques of laser management for prostatic pathology are used as:

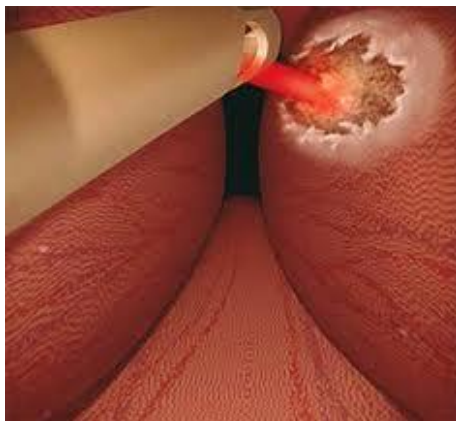
- *Photo-selective vaporization(PVP).***
- *Vaporization (ablation).***
- *Enucleation.***
- * Resection.***

PVP:

KTP is considered the best in such a process using the "painting while sweeping

out" non-contact technique. PVP is a process done only by KTP laser, but can be replaced by **Vaporization** that is done by Lithium triborate (LBO) that comes next to KTP followed by Holmium for prostatic tissue ablation having the disadvantage of less hemostatic ability.

PVP works by having the prostatic chromophores that is suitable for selective absorption of the KTP WL.



(laser prostatic vaporization)

A cavity is seen immediately. Still some necrosis with sloughing and

fall out of tissues occurs over the following days and weeks creating the famous laser "burning sensation". This effect is more pronounced in the VLAP (visual laser ablation of prostate) that was once practiced.

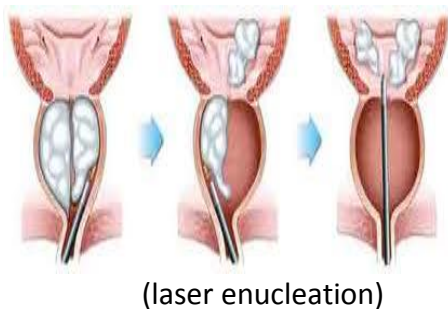
Resection:

Laser prostatic resection is another technique for cutting the prostatic tissue in a way of cutting small pieces (as in TURP) that can be extracted without the need of a morcellator but takes longer time. It has the advantage of being non-bloody, using Normal Saline (not Glycine as in TURP), and beginners-friendly. Holmium laser is the kind of energy used for such a purpose.

Enucleation:

Holmium:YAG laser has many advantages making it the best for BPH enucleation.

It is characterized by having absorption depth in the prostate of only 0.4 mm, creating a high energy density sufficient for vaporization.



Dissipating heat causes simultaneous coagulation of small blood vessels to a depth of about 2 mm.

This enables precise, char-free and virtually bloodless incision in prostatic tissue.

The process resembles open enucleation, but under vision using the laser fiber instead of the finger. The enucleation is done in two or three lobes fashion depending on the size of the middle lobe and the surgeon preference. While creating

an incision between the lobes to free them out, gentle jerking (right and left) movements are done to widen it for good space and proper dissection. Adenoma freeing should be done under clear vision in, usually, a retrograde fashion starting from the level of the V M.

Endoscopic instruments used for these purposes are similar to those for TURP, but differ in having certain parts that enable the control of the laser fiber from outside.



(top: laser urethrocystoscope for laser vaporization fiber. bottom: working element for end-fire fiber)

At the end of the enucleation procedure, the prostatic tissue masses in the UB are morcelated (chipped)

and sucked out using the "Morcellator". It is a machine that is introduced to the UB through the straight working channel of the offset eye nephroscope. It gets in contact with the prostatic tissue mass by sucking some fluids, then biting and sucking out the pieces at the same time.



(tissue morcellator, Versa Cut)

The estimated amount of blood loss, in several studies, ranged from 40 to 150ml.

The irritative symptoms are much less than vaporization, especially when meticulous resection is followed.

The process follows the same steps of open prostatectomy but adenomata should be morcelated and sucked out of the bladder.

A urethral Foley's catheter is fixed for 24-48 hours with optional use of UB irrigation.

HoLEP has been reported to be safe and effective for the treatment of patient with urinary retention, patients who are clinically ill, and those with bleeding disorders or those who are receiving anticoagulants.

Moreover, HoLEP can be used to simultaneously treat urinary bladder obstruction, with bladder or upper urinary tract stones.

Interstitial laser ablation (ILA) is another technique for laser prostatic ablation by

applying fine needles through the prostatic tissue endoscopically or transperineally and using laser for producing the needed heat to affect the prostatic tissues. The advantage of keeping the integrity of the urethral mucosa was not enough to outweigh the disadvantage of creating a non predictable effect in a blind spot.

Bipolar TURP

It is a newly invented technique for tissue ablation and cutting that depends of the idea of having a near-by both poles (cutting pole and grounding one) at the tip of the loop. This creates a vapor (plasma) layer at which the tissues are evaporated. It needs no Glycine, only Saline thus

avoiding a lot of the side effects of TURP technique.



(Bipolar loops)

The technique is compared to HoLEP when using of the bipolar spatula of the plasma resectoscope to enucleate the prostatic adenoma.

The technique has comparable results of being fast, non-bloody, safe, short non-eventful post-operative period.

COULD THE HoLEP BE THE DIAMOND STANDARD..!!!

This question was a title for several discussions between fans of new technologies as well as minimally invasive surgeries, and those who tend to use

the more reliable methods. The discussion is never finalized till the facilities are available widely in cheap prices for urologists to practice and master. An argument that resembles the one for starting the use of laparoscopy in urology two decades ago.

Another basic question was "which laser technique is better, PVP or enucleation". This specific question was answered by laser-pioneer urologists who preferred enucleation and pointed at using PVP or vaporization as a less preferred option for special situations only.

These arguments were also settled by international well known urology association as "European Association of Urology" that produced solid guidelines for using laser in urology (<http://uroweb.org/wp-content/uploads/Herrmann->

Th.-et-al-Eur-Urol-2012-614783-EAU-Guidelines-on-laser-technologies.pdf)

Learning such a technique is not so difficult as long as you are a good endoscopist and resectionist. It takes you almost 10 to 15 cases under supervision of a will-practicing urologist to get the proper sense of using the laser energy instead of the electricity to cut the prostate. When you do, you will find it rewarding to your patient and hospital in all aspects including expenses. It was found to be almost 9.5% less expensive than open prostatectomy and as expensive as TURP when considering the hospital stay in the equation.

Stones

The first trial of ureteroscopy was carried out using a cystoscope in 1912. In 1964, a flexible scope was introduced through an open ureterotomy. Over the last 20 years, major efforts were done producing small size ureteroscopes to be minimally invasive to the ureter.



(X-Flex, Storz)

Using small diameter optic laser fiber was a corner stone in these efforts. That small diameter is also an advantage for keeping the

flexibility of the ureteroscope.

Different methods were used to help the urologist breaking the stones during endoscopic procedures including: ultrasound based machines (Sonotrod), air pressure based machines (pneumatic Swiss lithoclast), electro-hydraulic based machines, and simple mechanical breaking using the stone crushing forceps.

laser for stone management

Laser energy was suggested and used in that issue successfully. It was very impressive to have such a way of breaking all kinds of stones including the hardest as well as the softest. The more attractive is using a multi-purpose machine that

can be used in soft tissue ablation as well.

Pulsed dye laser was one of the earliest types of laser energy to be tried in stone fragmentation. Later came the Nd:YAG followed by the Alexandrite that had no fans due to its restricted use for other purposes. FREDDY laser (freq doubled double - pulse Nd:YAG) was an a very good mixed type of laser to brake efficiently the stones without traumatizing the surrounding tissues. It consisted of a mix of Nd:YAG 80% and KTP 20%. the main problem for it was the inability to brake the hard stones as well as the non-pigmented ones.

Breaking the stone

On breaking the stone, we start usually with the lowest amount of energy that can affect it. A start with a total power of 10 watt will be fine as recommended by a lot of experts.



(cracking through a stone)

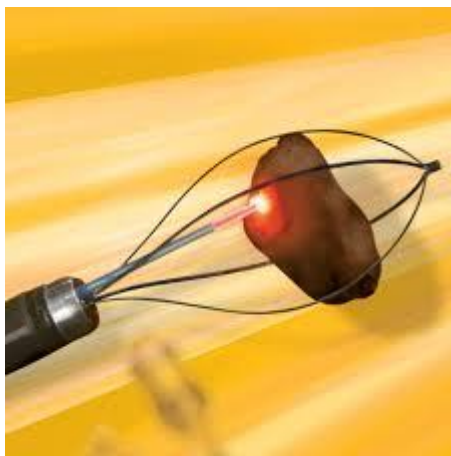
An increase of energy would be justified to increase the effect if not sufficient. An increase or decrease in rate is done to control the stone migration, especially the proximal one, under the laser effect. As the stone is confronted, a "painting" or "cracking" maneuvers can be used. "Painting" is usually used for

the large controlled stones followed by cracking it.

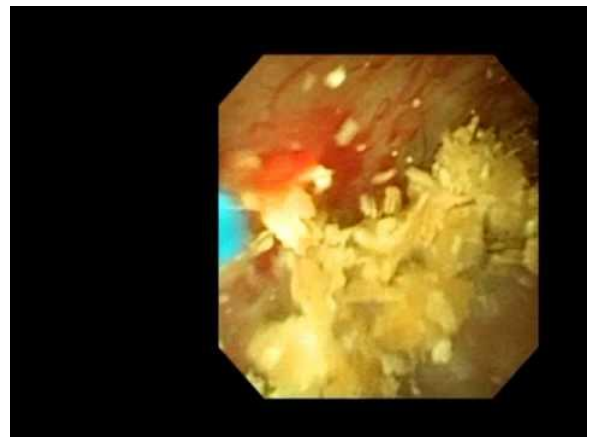


(large created crack)

Cracking by fixing the tip in contact at the same place for long time is very tricky as it leads to loss of laser breaking efficiency due to charring and destruction of the fiber or its insulator sheath, as well as tissue unavoidable complications. A Dormia basket may be used for fixing the stone while lasing it.

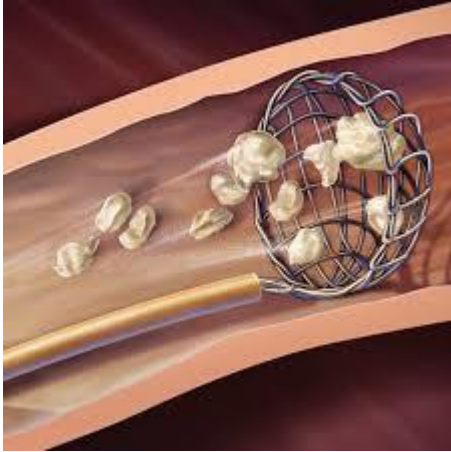


Another maneuver is the "Popcorn effect" that is used for a stone in a closed cavity or a calyx. The fiber tip is kept away from the stone and the laser is fired continuously, so the stone starts jumping and breaking around like a Popcorn in a pan.



(Popcorn effect)

At the end, the fragments can be retrieved using a stone cone, Dormia basket, forceps, or even left to pass with urine stream if the ureter is dilated enough and the gravels are small enough.



(using N-Trap, Cook, for preventing fragments migration)

machine or the fibers. But it is still an impressive idea to have a machine that can be used for the purpose of stone fragmentation as well as tissue ablation. Holmium: YAG was that solution, especially when the 120W machine was invented.

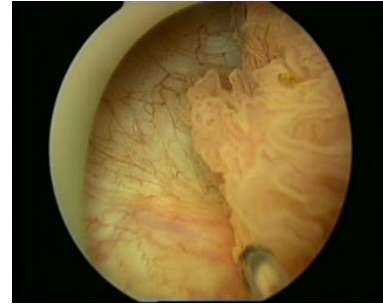
One major advantage for using the laser in breaking stones is efficiency against all kinds of stones of any size and in any place, especially after the invention of flexible ureteroscopes (6.5 Fr) as well as small size fibers (200 microns) and ureteral-access sheath. Even the lower renal calyceal stones are now accessible by the RIRS (retrograde intra-renal surgery).

The main disadvantage of using laser is the soft tissue side-effect and the high expenses, whether the

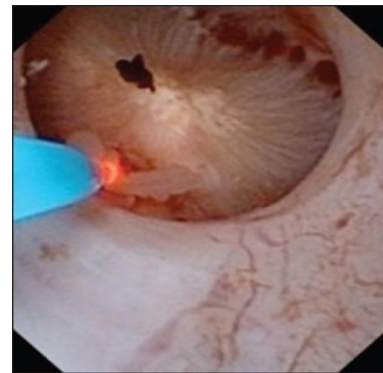
Other uses

Laser, as described by being a solution eagerly looking for a problem to solve, has been tried and used efficiently for different other purposes.

Transitional cell carcinoma of the UT was successfully ablated by laser. A superficially penetrating type of laser would be more safe in the issue, but a less superficial will be better for assuring hemostasis. Also the size of the tumor is considered as a factor to choose the type of laser to be used. urologists had used Ho:YAG for the small tumors in the ureter or UB, and Nd:YAG for the larger masses (5-10mm penetration).



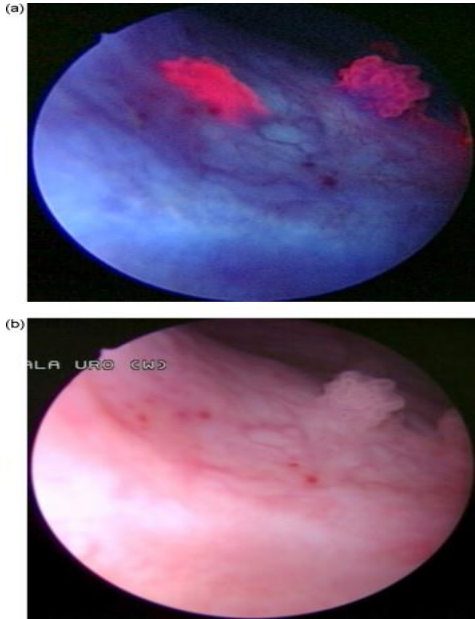
(Laser ablation of UB mass)



(Laser ablation of intracalyceal TCC)

Photodynamic therapy is another use of laser in urinary neoplasm where a special wavelength laser is applied to cells that is already sensitized by special light sensitive drugs (also called "photo-sensitizers"). Photofrin is an example of these drugs that is characterized by being cytotoxic. Diagnosis is obtained by the glowing of

the sensitized malignant cells, and therapy is accomplished when these cells are destroyed by the activated cytotoxic drug.



(Photodynamic therapy, the mass is glowing when exposed to laser after being sensitized by the drug)

Strictures of the upper and lower urinary tract were treated since 1978 by argon laser but high recurrence rate (70%) was disappointing. Recently, Ho:YAG was used efficiently in this subject. The laser is used as a replacement of the

cold knife taking care of the depth of the affection.



(laser stricture ablation)

Laser tissue soldering, or tissue welding has been starting since 1995 (solder is the alloy used in joining the parts in an electric circuit). CO₂, diode, or even Nd:YAG is used on albumin to produce a temperature enough to form well ceiled anastomosis in a speed of one minute /one cm of the wound. Hypospadias repair was one of the fields of success in using that modality.

Penis carcinoma and Genital skin lesions were treated successfully by laser

application, namely CO2 and to lesser extent Nd:YAG.

prostate carcinoma is another pathology that can benefit from using the laser energy as interstitial laser coagulation to get rid of the mass.

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