

Therapeutic applications of CO₂ laser

Dr. Umesh Naiknaware,
Medical Officer, RRCAT

Dr. Z B Mirza,
I/C Medical Officer, RRCAT

Introduction

- The carbon dioxide (CO₂) laser was invented by C.Kumar N Patel in 1964.

Kumar Patel, CO₂ laser, Bell Labs, 1964



1967 photo, higher power CO₂

KUMAR PATEL

- C. Kumar N. Patel was born in Baramati, 1938.
- Bachelor's from Poona University at the age of 19 (1958)
- MS (1959) and PHD (1961) Stanford University.
- Hired by AT&T Bell Labs, in 1961, discovered laser action in carbon dioxide (1963)
- invented the nitrogen carbon dioxide (CO₂) laser (1964).

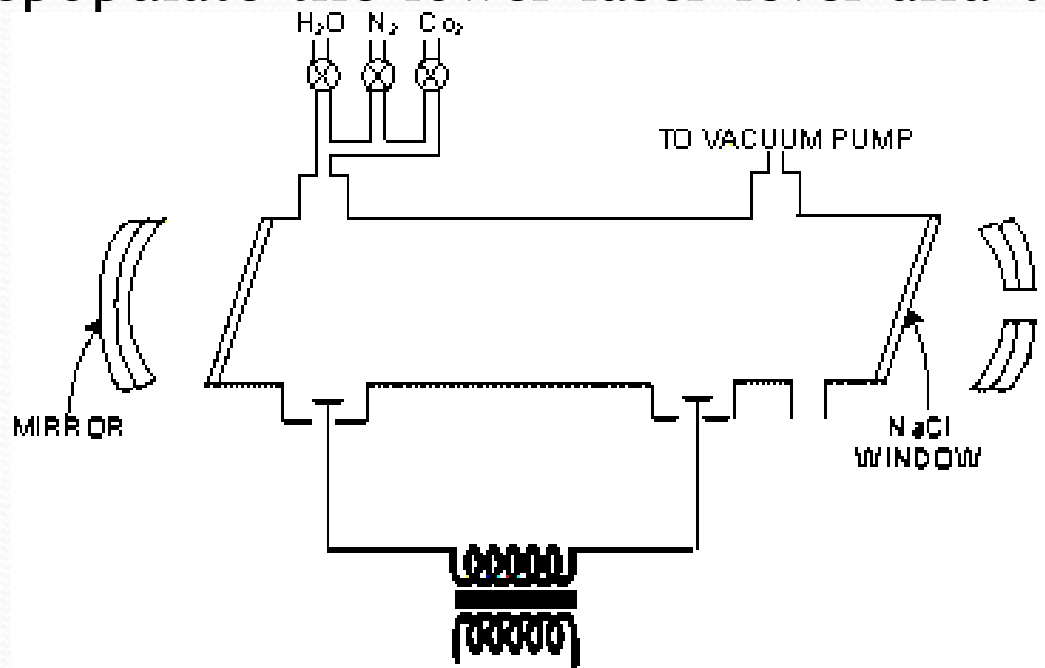
CO₂ laser

- It was invented in 1964.
- It was approved by the U.S. Food and Drug Administration (FDA) in 1984.
- The CO₂ laser is a gas laser which is a mixture of carbon dioxide (CO₂), helium (He), nitrogen (N₂), water vapour and/or xenon (Xe) and sometimes hydrogen (H₂).
- The gas mixture acts as a gain medium . *Such a* gain medium is required in a laser to compensate for the resonator losses

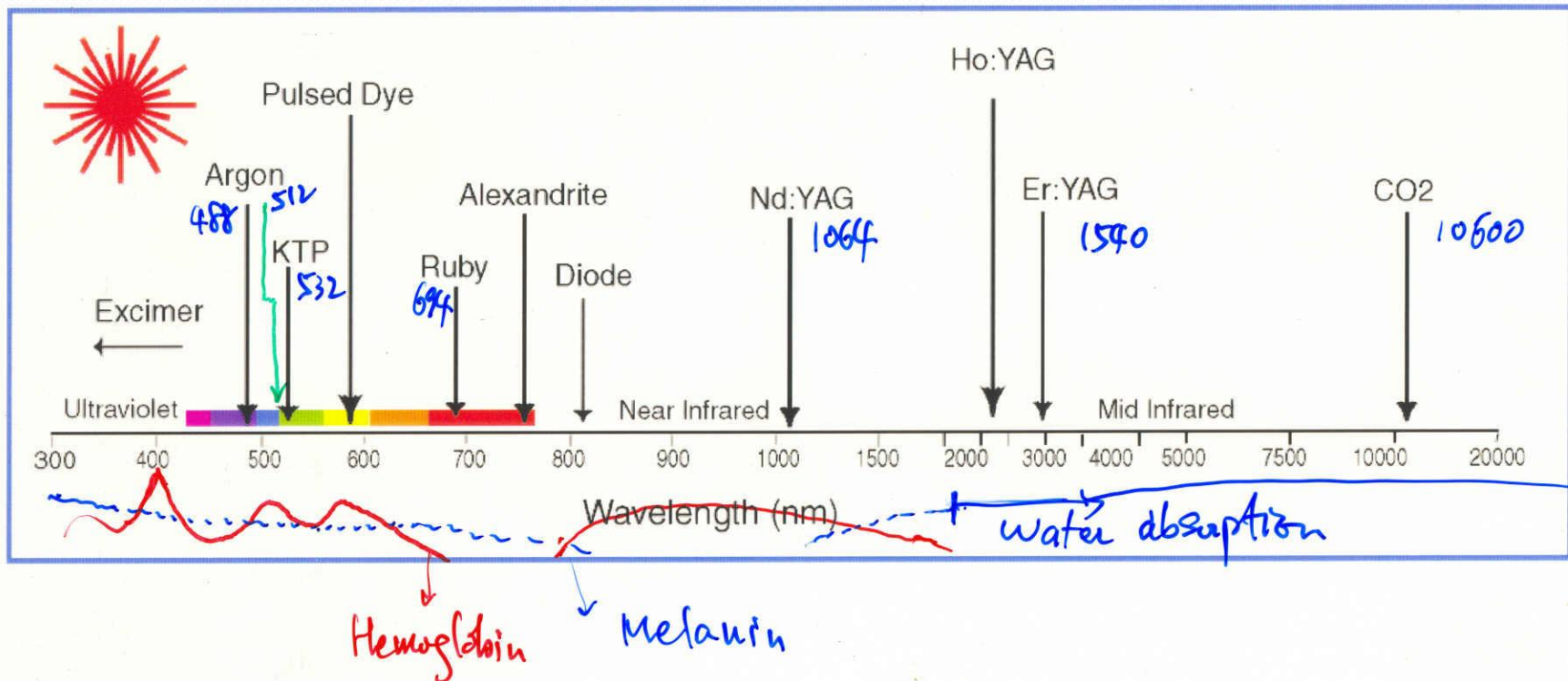
Properties of CO₂ laser

- It is pumped through an electrical discharge. During electrical discharge, the nitrogen molecules are excited to their metastable vibrational state, and collide with the CO₂ molecules to transfer their energy.
- Helium serves to depopulate the lower laser level and to remove the heat.

Constituents such as H₂ or water vapour helps to reoxidize CO to CO₂



Properties of CO₂ laser



It produces a beam of infrared light with the principal wavelength bands centering at 10,600 nanometers

Benefits offered by CO₂ laser

- **Less bleeding:** As it cuts, the CO₂ laser seal lymphatic and small blood vessels less than 0.5-mm wide and helps in reducing intra-operative bleeding and prevents post-operative swelling.
- **Less pain:** The penetration depth of CO₂ laser is 0.03mm which is considered very safe resulting in sealing of small peripheral nerves, thus alleviating post operative pain.
- **Reduce risk of infection:** The CO₂ laser has a sterilizing effect as it kills the bacteria in its path thus reducing the risk of infection.

Therapeutic Applications of CO₂ laser

- **Dermatology**
- **Surgery**

Skin Lesions

- Nevus cell nevus or mole on the cheek, seborrheic keratosis, burn scars, leukoplakia, xanthelesmas and decubitus ulcers can be treated with laser dermabrasion.
- Skin tags excision is done by applying traction to the tag and focussing the CO₂ laser at its base.



Verrucous epidermal nevus involving left cheek and neck



Verrucous epidermal nevus cleared with mild post-inflammatory hypopigmentation and scarring.

Skin Lesions



Melanocytic nevi before laser



Healed melanocytic nevi without scarring after laser



Earlobe keloid before laser



Earlobe keloid after laser



Pre-treatment rhinophyma



Healed rhinophyma with mild residual surface irregularity after ablation

Anti-aging

- High-energy, pulsed, and scanned CO₂ laser has been successful in reducing and removing facial wrinkles, acne scars and sun-damaged skin. Hence it is generally considered the gold standard against which all other facial rejuvenation systems are compared.
- Typically a 50% improvement is found in patients receiving CO₂ laser treatment.
- The aim of the full face ablative resurfacing is to ablate the epidermal layer completely, leaving the partially-coagulated dermal layer so that collagen formation can take place resulting in remodelling.



Side Effects

- If the coagulation remained incomplete then instead of wound healing necrotic sloughing takes place. This is known as residual thermal damage (RTD).
- The introduction of CO₂ fractional laser in 2006 has enabled to treat safely epidermis and dermis as it focuses partially only on a fine area due to its high energy .
- Secondary skin infection including reactivation of herpes is also a potential problem until healing occurs.
- Extreme caution is needed when treating darker skinned individuals as permanent loss or variable pigmentation may occur long term.

Warts

- ▶ Different sizes can be easily and effectively vapourized by CO₂ laser.
- ▶ **Precautions should be taken during vapourization of warts by using a special laser mask to filter wart particles during vapourization in order not to inhale the particles, which may cause infection to the surgeon.**
- ▶ The surface of the wart is shaved before laser vaporization to remove the dry hyperkeratotic surface, which requires much high energy because of its lower water content.
- ▶ **Peri ungual warts** can be vaporized and if the lesion is extending beneath and around the nail , the overlying nail can be evaporated to avoid nail avulsion.



Toe nail disease

- Diseases of the toenail like onychodystrophy is treated by irradiating the nailbed.
- Ingrown toe nails is treated with a CO₂ laser wedge resection, removing the outer edges and the involved tissue enbloc.



Source: New trends in laser application in dermatology, Shaza Mohd. Yousuf

Surgery

- CO₂ laser is used in practically all type of surgeries where the anticipated blood loss would be significant.
- In orthopaedic and plastic surgeries where large excisions are involved. e.g mastectomies, lipectomies.
- In highly vascular areas of body like tongue e.g partial or total glossectomies.
- Highly vascular tumors like cavernous haemangioma, Kaposi Sarcoma and haemangiosarcoma the need of hypotensive anesthesia and ligation of feeding arteries are best avoided by the use of CO₂ laser.

Spine surgery: In disc herniation, microdiscectomy is done by exactly focusing CO₂ laser on the target disc material which in turn evaporates.

Similar technique is used in extraforaminal lumbar disc herniation (EFLDH) and recurrent lumbar disc herniation (rLDH)

Neurosurgery: Removal of brain tumours by evaporation where the surgical approach of the tumour site is difficult like in cases with skull base, ventricular, brain stem and spinal cord tumours. e.g meningioma, low grade glioma.

Otorhinolaryngology: Laryngeal diseases such as laryngeal nodule, Reinke's edema. Laryngeal cyst, granuloma, papilloma, tonsillectomy, adenoidectomy etc

Ophthalmology: CO₂ laser is used especially in eyelid surgeries like blepharoplasty, entropion, ectropion and ptosis correction.

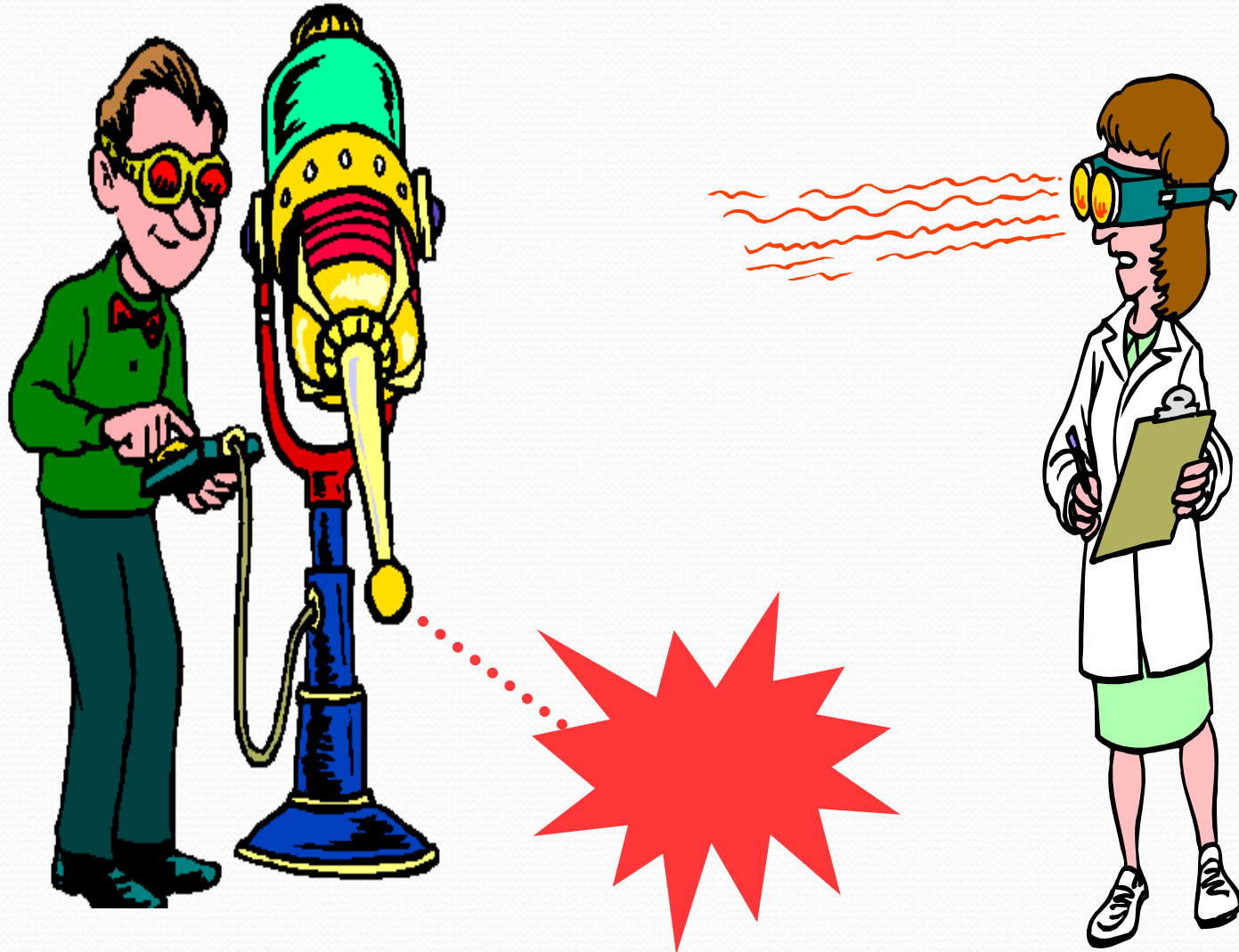
In ocular surgeries like enucleation, evisceration, squint correction.

In glaucoma treatment as CO₂ laser assisted sclerotomy surgery (CLASS).

Gynaecology: Benign tumors of vagina & uterine cervix.

Laparoscopic procedures such as adhesiolysis and the treatment of endometriosis and follicular cysts.

Laser Hazards



Hazards & Safety of CO₂ laser

- **Fire protection:** The main hazard with the CO₂ laser is accidental fire.
- It is advised to avoid supplemental O₂ during laser surgeries especially eyelid surgeries.
- If it is absolutely necessary to deliver the O₂ to the patient, it should be delivered through an intranasal tube covered by wet gauze or laser impermeable material like aluminium foil as there is no CO₂ reflection with them.

Eye protection

CO₂ laser is absorbed by water within the upper 200µm of tissues. Cornea is composed of >75% water and measures about 500-600µm at its centre.

Eye protection for the patient, surgeon and other operation theatre personnel is must with PPEs.



Protective goggles and eyewear with side shields for protection against the CO₂ laser beam



Metallic corneal shield in pts for protection against CO₂ laser ocular injury. A shield is placed in each eye with a rubber suction cup applicator.

Respiratory protection

- CO₂ laser ablates tissue by cell vapourisation and as the tissue contains mainly water it leads to water vapourisation and steam formation.
- The residual cell membrane undergoes carbonisation mixes with the steam forming a smoke plume which gets deposited in respiratory tract,
- Smoke evacuator and special laser filtration masks are used.

Source: HJK Ophthalmol Vol 16, no.1



(a) CO₂ laser smoke plume evacuator tubing and (b) CO₂ laser smoke plume masks with filtration efficiency to 0.1 μ m

Conclusion

- CO₂ laser due its properties which results in less pain and bleeding and due to the fact that it uses water as a chromophore is extensively used in medicine for various surgical purposes.
- It is also been developed to be used for rejuvenation of skin and other dermatological problems.
- In the years to come it will get more advanced and can be used for more medical applications than today.
- It is also important to keep in mind its potential hazards and take appropriate safety measures while handling CO₂ laser.

Acknowledgement

- Sincere thanks to Dr S K Majumder, Head, Laser Biomedical Application Section, RRCAT, Indore for his guidance and support.



Thank you