

Lasers in Medicine

A/Prof Lee Collins
Medical Physics Dept
Westmead Hospital, Sydney

How we got here....

- From the realisation of the laser in 1960, medicine has found many uses – some ill conceived and short-lived, others profoundly influencing treatment
- What is it about a laser which makes it so important?
 - Pure “colour” (monochromatic)
 - Collimated or parallel beam
 - High intensity
 - Wide variety of modes of operation

Laser interactions

● Heat

- Most laser effects in tissue involve heat, ranging from $\sim 60^{\circ}$ to well over 1000° C
- Non-thermal effects (O⁻ production, resonant effects)

● Interaction with tissue components

- Haemoglobin, melanin and water, and exogenous materials such as tattoo pigment, absorb certain wavelengths more than others

Thermal effects

● $<100^{\circ}\text{C}$

- Protein denaturation, coagulation

● $\sim 100^{\circ}\text{C}$

- Water evaporation (tissue shrinking)

● $\sim 300^{\circ}\text{C}$

- Tissue ablation
- Smoke plume

● $>\sim 600^{\circ}\text{C}$

- Carbonisation

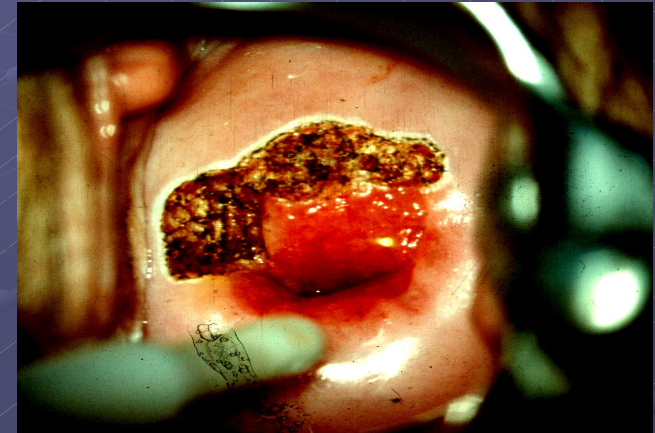
Tissue Interactions

- We can **“target”** certain tissues such as the retina or prostate (haemoglobin), use the varying **absorption of water** in the infrared region (cutting, epidermal or some dental treatments), create **shock waves** (lithotripsy), create **microbubbles** (LASIK corneal flap preparation), or **use totally harmless intensities** to react with natural or introduced agents (photodynamic therapy, low level laser therapy)

Thermal Application Examples

- Cervical intra-epithelial neoplasia (CIN)

- CO₂ laser



- Facial resurfacing

- CO₂ or Er:YAG laser

- Dental

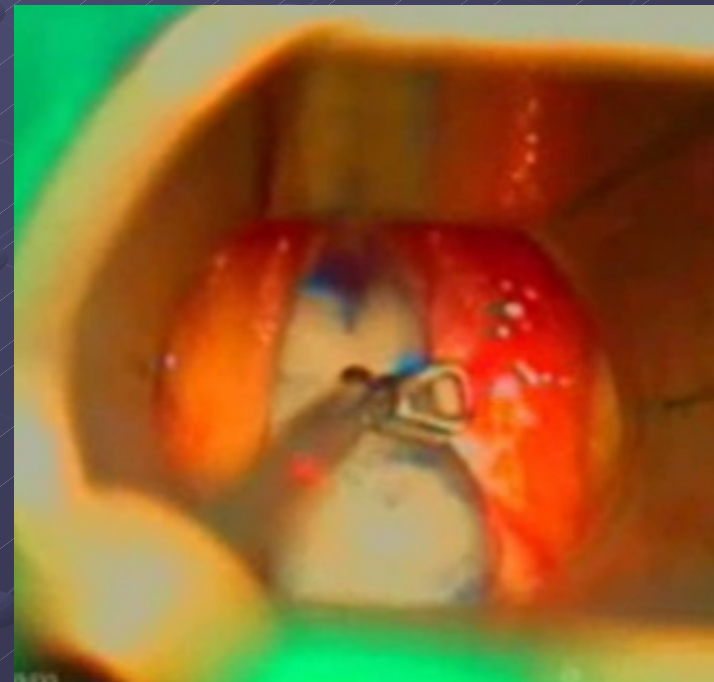
- Caries removal, soft tissue

● Prostate removal

- Green lasers – prostate ablation
- Ho:YAG (HoLEP or HoLAP)

● Excision of laryngeal tumours

- CO₂ laser



Vascular

● Endovenous laser therapy

- Varicous veins
- Thermal coagulation of vein wall with surrounding tumescent anaesthesia
- Vein and content collapse and are absorbed

Shock Wave Effects

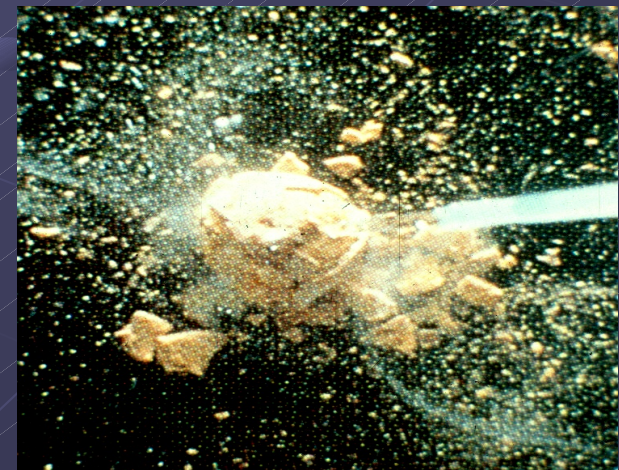
● Tattoo removal

- Pulsed Nd:YAG laser + others



● Renal lithotripsy

- Pulsed Ho:YAG laser



Low level laser therapy

- No thermal or other frank effects – entirely cellular or light-mediated chemical effects
 - Wound healing
 - Acupuncture
 - Photodynamic therapy (PDT)
 - Pain relief
 - Dental eg. anaesthesia

Chemical or Cellular Effects

● Pain relief, acupuncture, wound healing, photorejuvenation

- Various visible and near-visible, low power lasers

● Photodynamic therapy – cancer, AMD, scars, fungi

- Various lasers or other light sources, targeting absorption in an introduced (or natural) chromophore to induce chemical changes

Ophthalmology

● Probably greatest laser success story

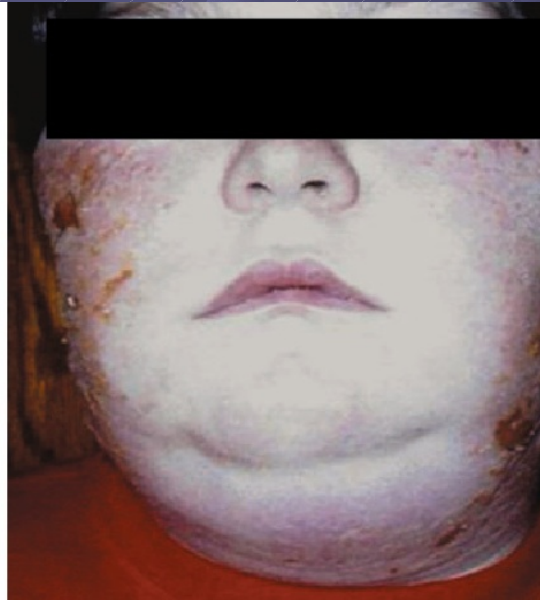
- Posterior capsulotomy (post IOL implant) – Nd:YAG
- Iridotomy, trabeculotomy – Nd:YAG +
- LASIK/PRK – excimer, near infrared (corneal flap)
- Retinal welding – green
- Retinal photocoagulation - green

Cosmetic

- Largely, but not entirely, thermal
- Facial resurfacing
- Superficial vascular lesions (port wine stains, rosacea, etc)
- Hair removal
- Wrinkle treatment
- Blephoroplasty
- Acne scarring
- Wide range of wavelengths and lasers/IPLs

..the downside

- In the wrong hands, things CAN go wrong
 - Mainly lack of understanding of tissue effects
 - OR poor equipment
- Proper training and accreditation essential



Non-laser devices

● IPL – intense pulse light sources

- Can be an effective replacement for lasers
- Not (yet) internationally standardised
- More adverse effects than from lasers (but this is mostly a training or equipment issue)
- Bypass regulatory controls (but this is changing)

The message

- Lasers have a definite and long-term place in therapeutic medicine
-and I haven't even considered diagnostic applications
- Must be used with care, by trained and qualified persons
- Patient and staff risks are real, but very low incidence.....however....!



Thank you!!