

**INSTRUMENTATION IN  
NEUROSURGERY  
(COAGULATORS, DRILLS, CUSA AND  
RETRACTORS)**

# Coagulators

# History

- ▣ Thermal energy for hemostasis dates back to pharaonics
- ▣ The earliest known surgical records - in papyrus documents from Egypt dated as early as 3000 B.C. called fire drill – a device which when turned rapidly produced heat along
- ▣ Hot iron
- ▣ Bovie and Cushing in 1920s
- ▣ Lasers in 1960s

# Electrocautery

- ▣ Variety of electrical waveforms
- ▣ A constant waveform, - This produces heat very rapidly, to vaporize or cut tissue.
- ▣ An intermittent waveform, produce less heat. Instead of tissue vaporization, a coagulum is produced.



## EFFECT OF TEMPRATURE ON CELLS

>40 DEG	REVERSIBLE CELL DAMAGE
>49 DEG	DENATURATION(IRREVERSIBLE CELL DAMAGE)
>70 DEG	COAGULATION (COLLAGEN CONVERT TO GELATIN)
>100 DEG	DESICCATION(CELLS DRY AS WATER VAPORISES, GELATIN BECOMES 'STICKY')
>200 DEG	CARBONISATION, ESCHAR FORMATION (PATHOLOGICAL 4 <sup>TH</sup> DEG BURNS)

# Monopolar Coagulators

- ▣ Electrical energy in the range of 250000 to 2 million Hz
- ▣ Heating effect Depends upon the density of current
- ▣ Size of electrode should be as small as possible
- ▣ Fat, bone and air have low water content and hence high resistance
- ▣ Ground electrode must have a large area of contact to ensure low current density
- ▣ Healing is slower by 2 days, with wound having less tensile strength and larger scar (Vs scalpel cut)
- ▣ Increased susceptibility to wound infection

- The active electrode is in the wound.
- The patient return electrode is attached somewhere else on the patient. The function of the patient return electrode is to remove current from the patient safely.
- The current must flow through the patient to the patient return electrode.

# Pad Site Location

**Choose:** Well vascularized muscle mass

**Avoid:** Vascular insufficiency  
Irregular body contours  
Bony prominences

**Consider:** Incision site/prep area  
Patient position  
Other equipment on patient

**Return Electrode Monitoring**, actively monitor the amount of impedance at the patient/pad interface and deactivate system

# Modalities

cut	Coagulation	blend
Continuous wave	pulsed	Continuous, with resting period
yellow	blue	blue



Endo cut: fractionated cutting under water

# Variables Impacting Tissue Effect

- ▣ **Waveform**
- ▣ **Power Setting**
- ▣ **Size of Electrode**, The smaller the electrode, the higher the current concentration
- ▣ **Time**
- ▣ **Manipulation of Electrode**
- ▣ **Type of Tissue**
- ▣ **Eschar**

# Safety measures

- ▣ Start up self check
- ▣ Return electrode continuity monitor
- ▣ Contact quality monitoring
- ▣ Return current feedback monitor
- ▣ High frequency leakage monitor
- ▣ Earth leakage monitor
- ▣ Output error monitoring
- ▣ Smoke filtration
- ▣ Activation time limit alarm
- ▣ Do not activate the generator while the active electrode is touching or in close proximity to another metal object

- ▣ Power output should be sufficient to achieve the desired surgical effect but should not be too high, Power requirements vary according to the desired surgical effect, the active electrode size and type of tissue to be treated



# Bipolar Coagulators

- ▣ Greater precision and less damage to tissue
- ▣ Less power needed
- ▣ Current flows through one blade and out through other
- ▣ Only the tissue grasped is included in the electrical circuit
- ▣ More predictable and less stimulating muscles and nerves
- ▣ More effective for coagulating tissue under a layer of fluid
- ▣ Radionics vs malis bipolar instruments
  - sensing device ,no need of irrigation, chances of inadequate coagulation

- ▣ Optimum distance between electrodes
- ▣ Continuous irrigation with saline
- ▣ Charred tissue should be wiped off with moist clothes ,avoid blade to scrape

Tip diameter	use
1.5,2 mm	Large vessels and scalp bleeders, fascia ,muscles
.7-1mm	Dura and brain surface
.5 mm	Tissue close to blood vessels,nerves,and brainstem

Shaft length	
8cm	Brain surface to depth of 2 cm
9.5 cm	Deeper regions
10 cm	TNTS, posterior third ventricle

	micro	macro
Power range	0.1 – 9.9 watts	1-50 watts
adjustability	0.1 watts	1 watt
	Precise point coagulation	Universal use

- ▣ Shafts of different length available
- ▣ Self irrigating forceps, pre irrigation and post irrigation function
- ▣ Jet irrigation systems in haematomas
- ▣ Transistorized coagulator system, equipped with thermocontrol system( sugita and tsugane)
- ▣ Ohta et al, irrigation on when forceps is close
- ▣ PTFE coated forceps

# Complications

- ▣ Formation of coagulum
- ▣ Adherence of the blood vessel to the tip of the forceps
- ▣ Penetration of aneurysm
- ▣ Undesirable regional tissue damage due to grounding of current through the body


# General principles

- ❑ Current flow should not be started till the desired bleeder is reached
- ❑ Current setting should be reduced when changing to fine tipped forceps
- ❑ Coagulation should be done in a small pool of water
- ❑ When irrigated it should not be flooded
- ❑ When using on a vessel forceps should be pulsated
- ❑ Current should be set as low as possible
- ❑ Should be cleaned immediately after use

# Argon-Enhanced Coagulation & Cut

- ▣ Decreased smoke, odor
- ▣ Noncontact in coagulation mode
- ▣ Decreased blood loss, rebleeding
- ▣ Decreased tissue damage
- ▣ Flexible eschar

# Harmonic scalpel

- ▣ leading ultrasonic cutting and coagulation surgical device
- ▣ using lower temperatures than those used by electro surgery or lasers
- ▣ vessels are coapted (tamponaded) and sealed by a protein coagulum
- ▣ Coagulation occurs by means of protein denaturation when the blade couples with protein  denatures to form a coagulum that seals small coapted vessels



- ▣ control of harmonic Scalpels coagulation rate & cutting speed depends on time & force applied to the tissue by the end effector.
  
- ▣ The Harmonic Scalpel uses ultrasonic technology, & energy that allows both cutting & coagulation at the point of impact.
  
- ▣ As compared to electro surgery
  - ↓
  - 1) fewer instrument exchanges are needed
  - 2) less tissue charring and desiccation occur
  - 3) visibility in the surgical field is improved.

# Laser coagulators

- ▣ Types :

  - CO<sub>2</sub> laser,

  - Nd : YAG Laser,

  - Argon Laser,


  - KTP laser

- ▣ Principle : Photocoagulation

- ▣ Explosive tissue vaporization

- ▣ Coagulation, vapourization, haemostasis, Cutting

# DRILLS IN NEUROSURGERY

- ▣ Development of early tools  trephination to latest motor powered microdrills
- ▣ Records of neurosurgery from 3000 BC shows  
1st evidence of trephination  
hand operated drill in dentistry- 100 AD
- ▣ First powered instrument devised by George f. green,  
English dentist in 1869
- ▣ Sir Heneage Ogilve 1st air powered drill & osteotome
- ▣ Robert m hall forest c barber developed modern high  
speed drills

# Pneumatic high speed drill system

System comprises of

- 1) Motors
- 2) Pneumatic control unit with regulator & various connectors
- 3) Various attachments & dissecting tools
- 4) Lubricant/diffuser

# Mechanism

- ▣ Vane type is the hallmark
- ▣ Rotor spindle housed in rotor housing
- ▣ Vanes are incorporated on lengthwise slots on the rotor spindle
- ▣ Speed ranges from 65000 to 100000 rpm
- ▣ Speed more than 25000 – bone melts away easily  
- no tactile sensation

# Advantages

- ▣ Great precision
- ▣ Hands are free for the control
- ▣ Time saving
- ▣ If used properly it is the safest, for both patients & surgeon

# Instructions

- ▣ Stable body
- ▣ Microscope should be positioned in a comfortable operating position
- ▣ All loose materials should be removed from the field
- ▣ Hand piece should be of light weight & should be held in pen holding position



## ▣ Drilling underwater :

1) It allows the neurosurgeon to visualize prospective structures through bone, which becomes semitransparent when adequately hydrated

2) Underwater drilling protects key neuroanatomical structures from thermal injury

3) Irrigation serves to constantly wash the head of the drill bit

## ▣ Visualizing critical structures through bone

## ▣ Drilling parallel to underlying structures

The movement of the drill bit should proceed along the axis of the underlying structure being exposed. the sigmoid, means a predominantly superior-inferior motion, whereas for the middle fossa dura, the motion is in an anterior-posterior plane.

- ▣ Drilled part should be in the form of a saucer rather than in the shape of cup ■

It provides the neurosurgeon with increased visualization & working angles, smaller potential space in which a pseudomeningocele can develop & decreases the sharp bony edge that may result in skin tightness and possible wound breakdown.

- ▣ Burr should always rotate away from the critical structures
  
- ▣ Choice of drill bit
  - 1) Cutting burrs work more efficiently when removing large amounts of bone
  
  - 2) Diamond burrs are used
    - when working close to, or potentially close to, critical neurovascular structures.
    - for hemostasis when used briefly without irrigation at a site of bleeding.
  
  - 3) The size of the drill to use the biggest one the working space safely allows

# Applications

- ▣ Craniotomy
- ▣ Correction of craniosynostosis,
- ▣ Craniofacial anomalies
- ▣ Laminectomy,laminoplasty
- ▣ Foraminotomy
- ▣ Removal of osteophytes,iliac crest grafting etc.
- ▣ Excision of odontoid in TOO
- ▣ Removal of ACP

# Complications

- ▣ Direct penetrating injury
- ▣ Transmission of heat
- ▣ magnetic imaging metal artifacts
- ▣ Noise pollution
- ▣ Transmission of prion diseases

# Electric Drill

- ▣ More powerful than pneumatic
- ▣ Improved overall system weight and balance - cable lighter, more flexible than pneumatic hose
- ▣ Reversible direction
- ▣ Cable design prevents incorrect connection and assembly

# RETRACTORS

Adequate exposure of the target organ represents a laudable prerequisite of every successful operation.

- ▣ Hand held
- ▣ Self retaining



# Hand held retractors

## ▣ Disadvantages:

- Slipping from the desired position
- Excessive retraction
- Obscuring vision and light
- Inability to maintain in same position for long time

# Self retaining retractors

- ▣ Mechanical retractor mounts for neurosurgery in 1930s
- ▣ Earliest skull mounted system (Demartel, Malis, Heifetz, edinburgh, hamby etc.)
  - Mounted on burrhole, craniotomy edge
  - Inadequate bone strength, obscuration of the field
- ▣ Soft tissue/muscle mounted and pillar and post devices ( house and urban, weitlaner)
  - less stable, less flexible

- ▣ Skull mounted flexbar devices (Dohn and Carton, Apfelbaum) especially useful in Posterior fossa surgery
  
- ▣ Leyla retractor, Yasargil
  - adjustment difficulties, extreme length of the flexible arms
  
- ▣ Table mounted flexbar devices
  - Modification by Yasargil and Fox
  - Kanshepolsky, U shaped bar
  
- \* head or retractor movement independent of each other

- ▣ Headrest mounted flexbar system  
Sugita, Greenberg,
- ▣ Fukushima and Sano ,4 arms on clamp secured to mayfield headrest

# Leyla self retaining retractor

- ▣ Yasargil
- ▣ Self retaining, no assistance needed
- ▣ Uniform holding, no pressure irritations
- ▣ Upto 5 flexible arms can be used simultaneously
- ▣ No obstruction to operative vision
- ▣ No restriction of operating area – critical when using microscope

# NEW JERSEY Retractor system

## Advantages:

- Unique fixation clamp allows unlimited positioning of the retractor arm along the body of the retractor
- Attaches to virtually all self-retaining retractors
- Two retractor blade supports are available ,allowing the use of both flat and round shaft retractor blades
- Provide improved exposure on Posterior Fossa Craniotomies
- Excellent for nerve root retraction during laminectomy procedures

# Brain Retraction Injury

- ▣ The incidence of contusion or infarction from overzealous brain retraction is probably 10% in cranial base procedures and 5% in intracranial aneurysm procedures.
- ▣ Brain retraction injury is caused by focal pressure (the retractor blade) on the brain leading to
  - 1) Reduction or cessation of local perfusion
  - 2) Direct injury to brain tissue

# Retraction Injury

- ▣ Depends upon
  1. shape
  2. number of the retractors
  3. the pressure
  4. duration of the retraction
- ▣ The retraction pressures used are usually in the range of 20 to 40 mm Hg
- ▣ Use of two small retractor blades may provide exposure equivalent to one large blade with a lower retraction pressure



# Retraction



Constant pressure retraction involves readjusting the retractor blade as necessary to keep the pressure constant , this type of retraction is naturally suited to retraction pressure monitoring

Constant exposure retraction entails setting the retractor blade once without further adjustment. The brain is allowed to adjust over time to the fixed retractor blade

# CUSA

- ❑ The original ultrasonic aspirator was developed in 1947 for the removal of dental plaques.
- ❑ Field of eye surgery in 1967 ,based on the principle of phaco-emulsification.
- ❑ First developed in 1976 in the US
- ❑ Suction device with a tip that vibrates at ultrasonic speed
- ❑ Sonic energy disrupts and fragments
- ❑ Diluted and aspirated

- A console and handpiece
- Console has the ultrasonic generator- 2 types

electrostriction,	magnetostriction
piezoelectric ceramic crystals	change in dimensions of a magnetostrictive transducer
crystals decay	not subject to decay

- vibration level
- small amplitude - disruptive effect restricted to tissue immediately in contact with the tip

- ▣ Hand piece,  
straight vs Angled  
short Vs Long  
internal vs external coaxial irrigation system  
different frequencies
- ▣ Irrigation system  
to suspend the fragmented tissue, to  
cool the transducer and to prevent the blockage  
of suction system

# Mechanism

- ▣ Simultaneously fragment, emulsify and aspirate parenchymal tissue rapidly
- ▣ Vacuum effect
- ▣ Cavitation
- ▣ Rupture
- ▣ Susceptibility depends upon-  
water content  
sensitivity to vibration

Fat and brain easily disrupts Vs vessel and nerves

- ▣ Tissues with weak intracellular bonds, such as tumors and lipomas, are easy to fragment, whereas tissues with strong intracellular bonds, such as nerves and vessel walls, are difficult to fragment

- ▣ Low frequency → high amplitude  
Useful in hard and partially calcified tumors
- ▣ High frequency → low amplitude  
useful while working near vital structure

adjustments of the vibration energy, irrigation rates and the suction pressures along with the use of appropriate hand piece optimizes the use

# Advantages

- ▣ Minimizes,  
mechanical manipulation  
Traction on adjacent tissue
- ▣ Avoids thermal injury of cautery
- ▣ Clear and less crowded operative field
- ▣ Vs laser UA are faster ,good visualization of tumor brain interphase. Laser is more precise
- ▣ Suitable for HPE as they are not significantly distorted



# Complications

- ▣ Penetrating injury
- ▣ ? Transmission of ultrasonic energy to adjacent vital structures through bone
- ▣ Reports of multiple cranial nerve palsies

*“Winning is overrated. The only time it is really important is in surgery and war.”*

*Thank you*