INSTRUMENTATION IN NEUROSURGERY

(COAGULATORS, DRILLS, CUSA AND RETRACTORS)

Presented by : Noufal Basheer
Coagulators
• Thermal energy for haemostasis 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 temperature on cells

- >40°C: Reversible cell damage
- >49°C: Denaturation (irreversible cell damage)
- >70°C: Coagulation (collagens convert to gelatin)
- >100°C: Desiccation (cells dry as water vaporises, gelatin becomes ‘sticky’)
- >200°C: Carbonisation, eschar formation (pathological 4th degree burns)
Monopolar Coagulators

- Electrical energy in the range of 250 000 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.

\[
\text{BURN} = \frac{\text{CURRENT} \times \text{TIME}}{\text{AREA}}
\]

• The current must flow through the patient to the patient return electrode.
Low Current Concentration/Density

High Current Concentration/Density
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

<table>
<thead>
<tr>
<th>cut</th>
<th>Coagulation</th>
<th>blend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous wave</td>
<td>pulsed</td>
<td>Continuous, with resting period</td>
</tr>
<tr>
<td>yellow</td>
<td>blue</td>
<td>blue</td>
</tr>
</tbody>
</table>

Coagulation

Endo cut: fractionated cutting under water
Cutting

Contact Coagulation

Loop Excision

Spray Coagulation
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.
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

<table>
<thead>
<tr>
<th>Tip diameter</th>
<th>use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5,2 mm</td>
<td>Large vessels and scalp bleeders, fascia, muscles</td>
</tr>
<tr>
<td>.7-1 mm</td>
<td>Dura and brain surface</td>
</tr>
<tr>
<td>.5 mm</td>
<td>Tissue close to blood vessels, nerves, and brainstem</td>
</tr>
<tr>
<td>Shaft length</td>
<td>micro</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>8cm</td>
<td>Brain surface to depth of 2 cm</td>
</tr>
<tr>
<td>9.5 cm</td>
<td>Deeper regions</td>
</tr>
<tr>
<td>10 cm</td>
<td>TNTS, posterior third ventricle</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>micro</th>
<th>macro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power range</td>
<td>0.1 – 9.9 watts</td>
<td>1-50 watts</td>
</tr>
<tr>
<td>adjustability</td>
<td>0.1 watts</td>
<td>1 watt</td>
</tr>
<tr>
<td>Precise point coagulation</td>
<td></td>
<td>Universal use</td>
</tr>
</tbody>
</table>
• Shafts of different length available

• Self irrigating forceps, pre irrigation and post irrigation function

• Jet irrigation systems in haematomas

• Transistorized coagulator system, equipped with themocontrole system (sugita and tsugane)

• Ohta et al., irrigation on when forceps is close

• PTFE coated forceps
FULLY INSULATED TIP

PARTIALLY INSULATED TIP
Bipolar forceps with jet irrigation system
PTFE coated
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
• 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 denaturs 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.
The harmonic scalpel uses ultrasonic energy to both cut tissue and coagulate blood vessels.
Laser coagulators

- Types:
  - CO$_2$ laser,
  - Nd : YAG Laser,
  - Argon Laser,
  - KTP laser

- Principle: Photocoagulation

- Explosive tissue vapourisation

- 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
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
Angled instrumentation in neurosurgery
Dissecting tools

- Acorn
- Cylinder
- Ball
- Tapered
- Match Head

10/18/2008  instrumentation in neurosurgery
Bone mill
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
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 retracion
  - Obscuring vision and light
  - Inability to maintain in same position for long time
Dural Retractors
Self retaining retractor

- 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, Yasar gill adjustment difficulties, extreme length of the flexible arms

• Table mounted flexbar devices modification by Yasargill 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
Self Retaining Retractors
WEILMANER
BV101R – BV104R

BV101R
sharp/deep
3x4 prongs

BV104R
blunt/deep
3x4 prongs
Skull mounted Retractor System
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
Ball and socket joint for fixing holding rod to operating table
Fixing rod

coupler
Flexible arm

spatula
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
BUDDE Halo Retractor System
Greenberg Retractor System

50-1507 GREENBERG Primary Bar attaches to skull clamp. GREENBERG Retractor Kit (50-1500) is supplied with two primary bars.

50-1509 GREENBERG Long Retractor Arm attaches to floating secondary bars. GREENBERG Retractor Kit (50-1500) is supplied with four long retractor arms.

50-1513 GREENBERG Pattie Tray attaches to long or short arm (50-1509 or 50-1511).

50-1516 GREENBERG Floating Secondary Bar Attaches to Primary Bar (50-1506) or Secondary Bar (50-1509) or Short Coupler (50-1522). Can also be mounted onto a flat metal edge of up to 1/2” thickness incorporates a universal joint enabling conical adjustment of angle.

50-1522 GREENBERG Short Coupler should be used to mount the GREENBERG Handrest (50-1512) to the floating secondary at Level I.

50-1524 GREENBERG Large Instrument Holder is a flexbar arm used to support heavy instruments. The cantilever clamp holds instruments with shafts up to 1” in diameter.

50-1525 GREENBERG Universal Retractor System X-large Instrument Holder holds instruments up to 2” in diameter.
Lumbr retraction handle
Caspar retractor

double hinge retractors
- optimal intra-operative adaption
- basic retractor with tiltable butterfly screw

non-slip fenestrated Titanium blades
- firm yet gentle grip with secure fit
- better view and light weight
- semi-radiolucent to X-ray
- tissue protection due to less retraction forces
- color coded according to blade width
Retractors

**BW046R**
CCR counter retractor, preferably used for longitudinal retraction

**BW049R**
CCR basic cervical retractor, preferably used for transverse retraction, double hinge, tiltable butterfly screw

**BW047R**
CCR basic counter retractor, preferably used for longitudinal retraction, double hinge

**BW010R**
Handle for blades with side load attachment

**BW011P**
Depth gauge to determine the appropriate blade length
Crank frame Spinal Retractor System

Designed for posterior thoracolumbar surgeries
The BOOKWALTER Retractor.

Provides simple, multi-directional exposure for a broad range of surgical procedures
Tew Cranial/Spinal Retractor

* Capacity to simultaneously manipulate the spinal cord
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
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.
<table>
<thead>
<tr>
<th>Goal</th>
<th>Intervention</th>
<th>Advantage</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthesia</td>
<td>Isoflurane</td>
<td>Well studied</td>
<td>Hypotensive</td>
</tr>
<tr>
<td></td>
<td>Propofol</td>
<td>Intravenous administration,</td>
<td>Hypotensive, expensive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>reliable evoked potential recordings</td>
<td></td>
</tr>
<tr>
<td>Metabolic depression</td>
<td>Barbiturates</td>
<td>Well studied</td>
<td>Delayed recovery</td>
</tr>
<tr>
<td></td>
<td>Etomidate</td>
<td>Rapid recovery</td>
<td>? effective as barbiturates</td>
</tr>
<tr>
<td></td>
<td>Hypothermia (mild)</td>
<td>Probably quite effective</td>
<td>Mildly cumbersome, some delay in extubation</td>
</tr>
<tr>
<td></td>
<td>Hypothermia (deep)</td>
<td>Circulatory arrest</td>
<td>Very cumbersome, coagulopathy</td>
</tr>
<tr>
<td>Improve cerebral blood flow</td>
<td>Mannitol</td>
<td>Effective</td>
<td>? cerebroprotective value</td>
</tr>
<tr>
<td>Minimize Ca++ injury</td>
<td>Induced hypertension</td>
<td>Effective</td>
<td>Increased bleeding</td>
</tr>
<tr>
<td>Electrophysiological</td>
<td>Nimodipine</td>
<td>Probably effective</td>
<td>Hypotension, no intravenous form at present in U.S.</td>
</tr>
<tr>
<td>monitoring</td>
<td></td>
<td></td>
<td>Mildly cumbersome, some delay in extubation</td>
</tr>
<tr>
<td></td>
<td>Hypothermia (mild)</td>
<td>Probably quite effective</td>
<td></td>
</tr>
<tr>
<td>Electroencephalogram</td>
<td>Electorencedaphagram</td>
<td>Standardized monitoring</td>
<td>? sensitive to deep ischemia, limits anesthesia options</td>
</tr>
<tr>
<td>Evoked potentials</td>
<td></td>
<td>Sensitive to cortical and subcortical ischemia</td>
<td>Only certain regions of brain readily monitored</td>
</tr>
<tr>
<td>Goal</td>
<td>Intervention</td>
<td>Advantage</td>
<td>Comments</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------</td>
<td>----------------------------------</td>
<td>------------------------------------------------------------</td>
</tr>
<tr>
<td>Cerebral blood flow</td>
<td>Laser-Doppler</td>
<td>Relatively easy to implement</td>
<td>Local cerebral blood flow only, errors likely</td>
</tr>
<tr>
<td>monitoring</td>
<td>Thermal diffusion</td>
<td>Relatively easy to implement</td>
<td>Local cerebral blood flow only, errors likely</td>
</tr>
<tr>
<td></td>
<td>Transcranial Doppler</td>
<td>Relatively easy to implement</td>
<td>Large vessels only, difficult to monitor ipsilaterally</td>
</tr>
<tr>
<td>Increase exposure</td>
<td>Positioning</td>
<td>Practical</td>
<td>Limited application</td>
</tr>
<tr>
<td></td>
<td>Cerebrospinal fluid drainage</td>
<td>Relatively simple</td>
<td>Injury caused by intracranial shifts</td>
</tr>
<tr>
<td></td>
<td>Cranial base removal; osteotomy</td>
<td>Effective</td>
<td>Technically demanding, time consuming</td>
</tr>
<tr>
<td></td>
<td>Hyperventilation</td>
<td>Effective</td>
<td>Decreased cerebral blood flow, alkalosis</td>
</tr>
<tr>
<td>Minimize retraction injury</td>
<td>Brain retraction</td>
<td>No injury if appropriate</td>
<td>Safe limits variable</td>
</tr>
<tr>
<td></td>
<td>Brain resection</td>
<td>Effective</td>
<td>Destructive</td>
</tr>
<tr>
<td></td>
<td>Retraction pressure monitoring;</td>
<td>Effective</td>
<td>Mildly cumbersome</td>
</tr>
<tr>
<td></td>
<td>&lt;40 mm Hg</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intermittent retraction; &lt;15 min</td>
<td>Probably effective</td>
<td>Delays surgery, ? increased reperfusion injury</td>
</tr>
<tr>
<td></td>
<td>on, 5 min off</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Multiple retractors</td>
<td>Possibly effective</td>
<td>More cumbersome than fewer retractors</td>
</tr>
</tbody>
</table>
• 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

<table>
<thead>
<tr>
<th>electrostriction</th>
<th>magnetostriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>piezoelectric</td>
<td>change in dimensions of a magnetostrictive transducer</td>
</tr>
<tr>
<td>ceramic crystals</td>
<td></td>
</tr>
<tr>
<td>crystals decay</td>
<td>not subject to decay</td>
</tr>
</tbody>
</table>

• Titanium tip vibrates longitudinally at a speed of 23 to 35 khz ,
• amplitude of 100 – 300 microns ,function of setting the vibration level
• small amplitude - disruptive effect restricted to
• 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 disruptsVs 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