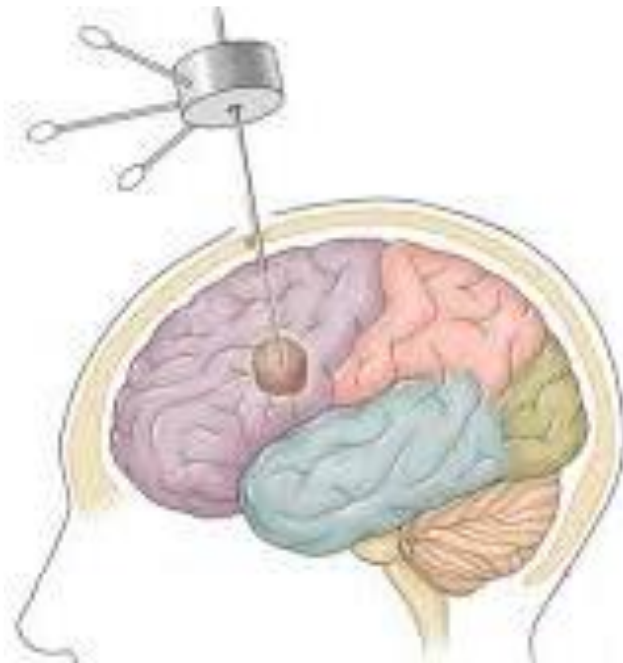


# FUNCTIONAL AND STEREOTACTIC NEUROSURGERY. PAIN, EPILEPSY, DYSKINESIAS AND PSYCHOSURGERY. NEURONAVIGATION. IMAGE- GUIDED SURGERY

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**34484 Pathology of the  
nervous system**

**Neurosurgery**

**Topic 23**

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# Key concepts to be developed

- **Functional neurosurgery: concept**
- **Susceptible pathologies**
  - Refractory chronic pain
  - Epilepsy refractory to medical treatment
  - Movement disorders (Parkinson's, dyskinesias, spasticity)
  - Psychosurgery
- **Advanced techniques in Neurosurgery**
  - STEREOTAXY
  - Neuronavigation
  - Image-guided surgery
  - Robotic neurosurgery
  - Neural prostheses



# FUNCTIONAL NEUROSURGERY

- Disruption of the neural circuits of the central, peripheral, or autonomic nervous systems to obtain a clinical benefit aiming to:
  - Recover lost function
  - Reset an altered function
  - Restore a new balance that improves conditions
- Aim
  - Diseases with an imbalance between excitatory and inhibitory centres that cause disabling symptoms unresponsive to medical treatment

Pain

Epilepsy

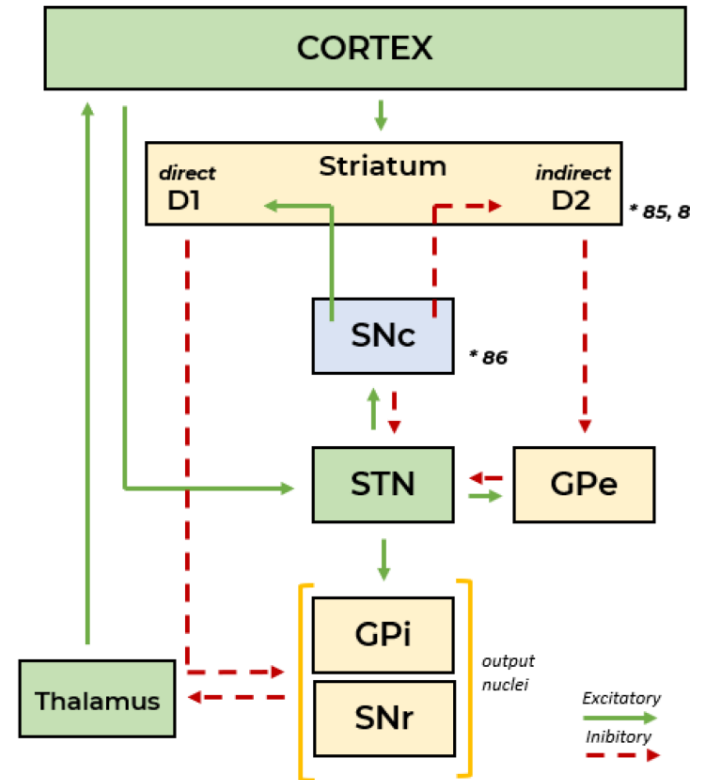
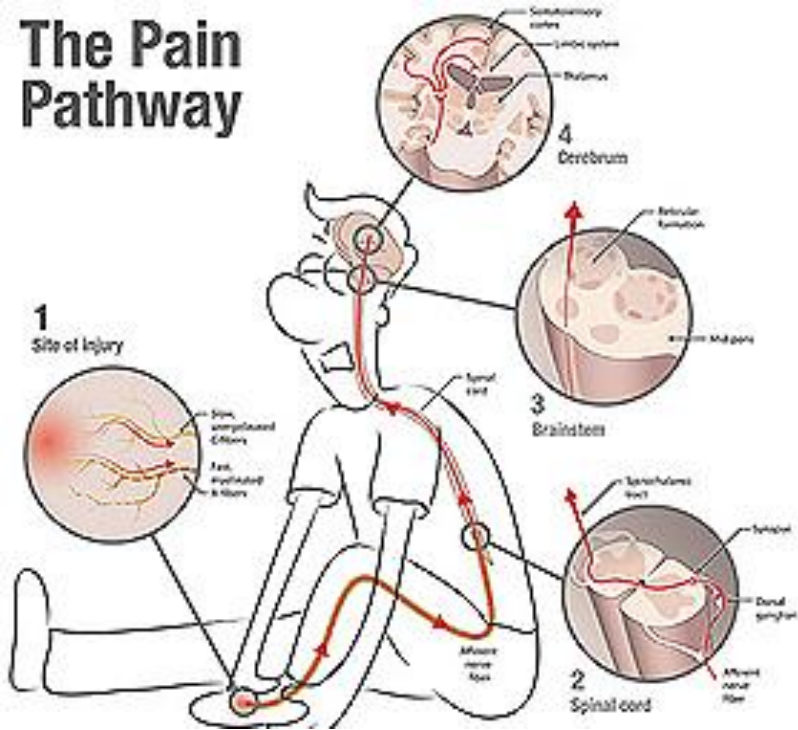
Movement  
disorders

Psychosurgery



# Functional neurosurgery

## The Pain Pathway



Pain

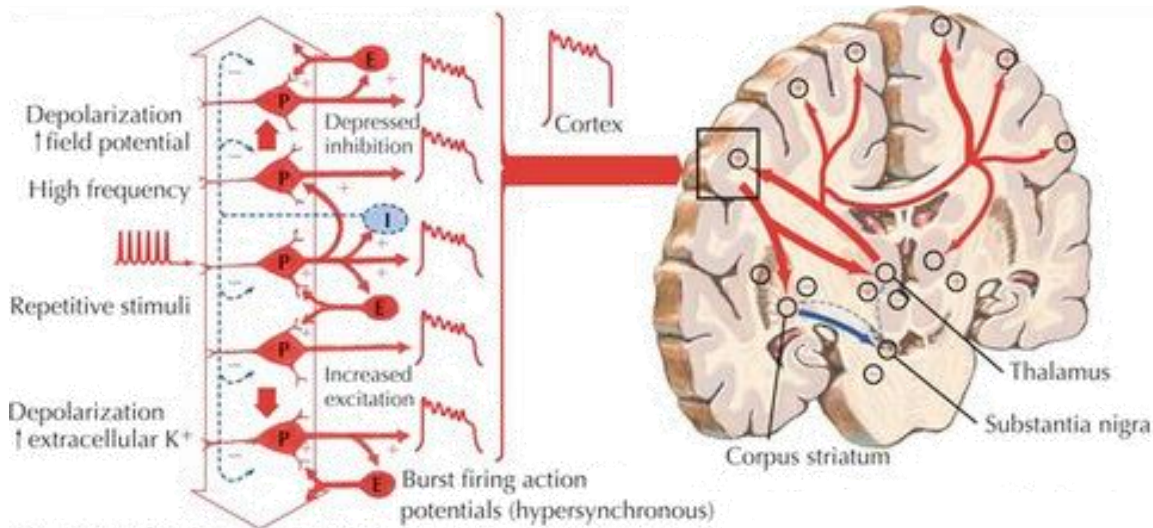
Epilepsy

Movement disorders

Psychosurgery



# Functional neurosurgery



Pain

Epilepsy

Movement  
disorders

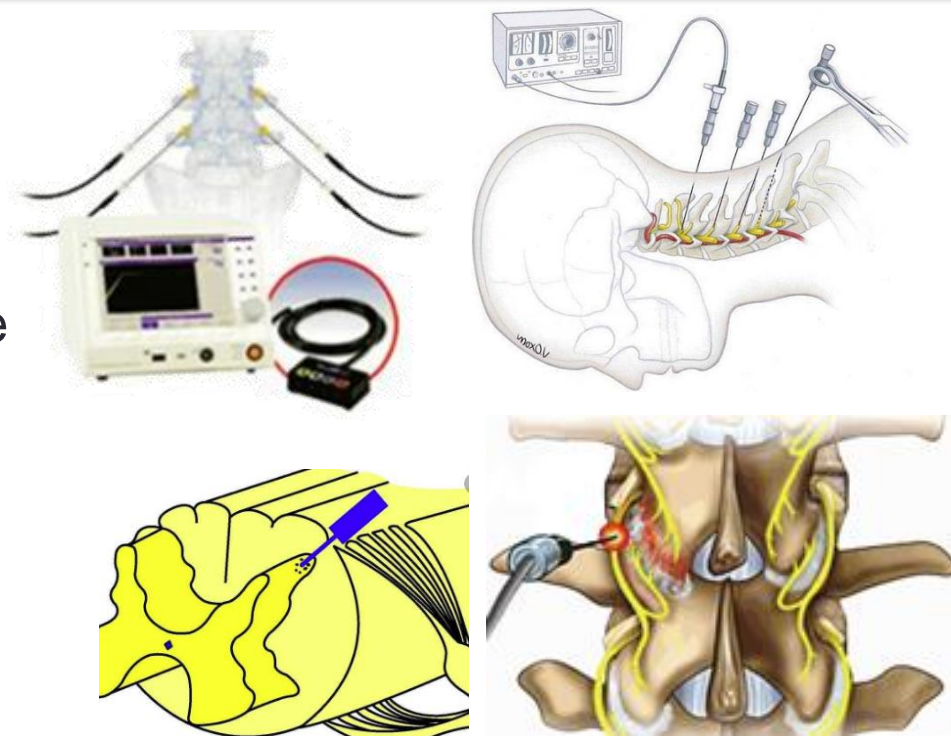
Psychosurgery



# Functional neurosurgery - techniques

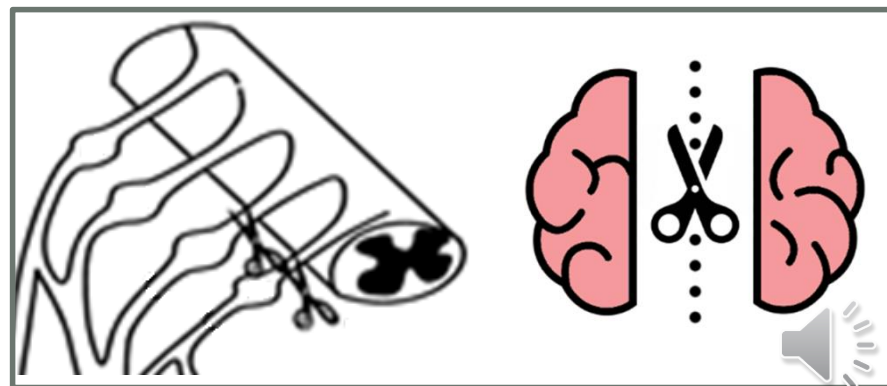
## • Ablation

- Destruction or elimination of a part of the nervous tissue to completely interrupt the nervous transmission at some point in the circuit
- Definitive lesion
- Irreversible both therapeutic + side effects
- Methods
  - *Radiofrequency ablation*
  - *Surgical ablation*



- Neurostimulation
- Drug infusion

**Neuromodulation**

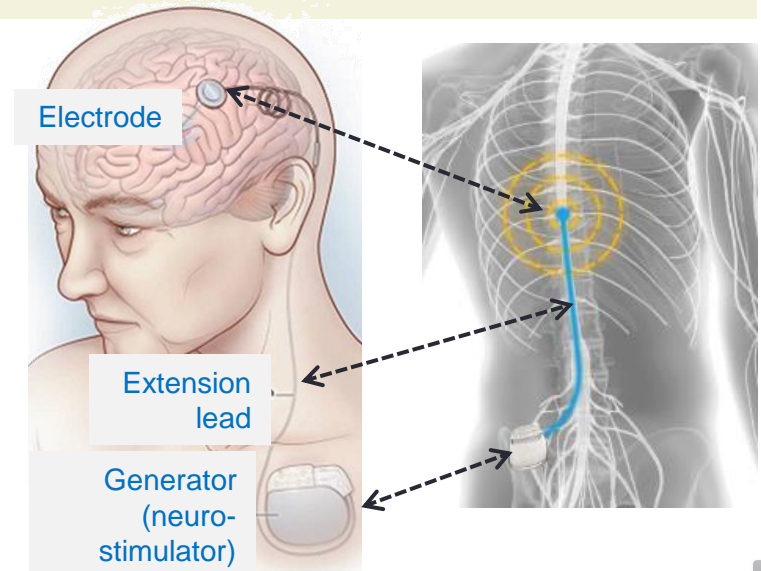


# Functional neurosurgery - techniques

- Ablation
- Neurostimulation
  - "Electrical neuromodulation" = Electrical stimulation without lesion
    - *Low frequency* → *excitatory effect*  $\oplus$
    - *High frequency* → *inhibitory effect*  $\ominus$
  - Adjustable action (intensity, voltage, and frequency)
  - Reversible on suspension of stimulation
- Drug infusion

"Neuromodulation = therapeutic alteration of the activity in the CNS, PNS, and ANS, whether **electrical or pharmacological**, by means of implantable devices"  
 (International Neuromodulation Society)

- Basic principle = change the ion permeability of neurons to increase or decrease the possibility of generation of an action potential.

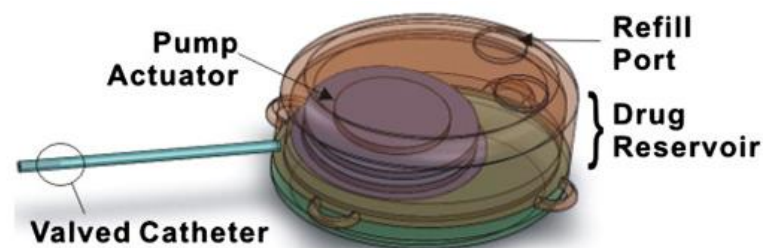
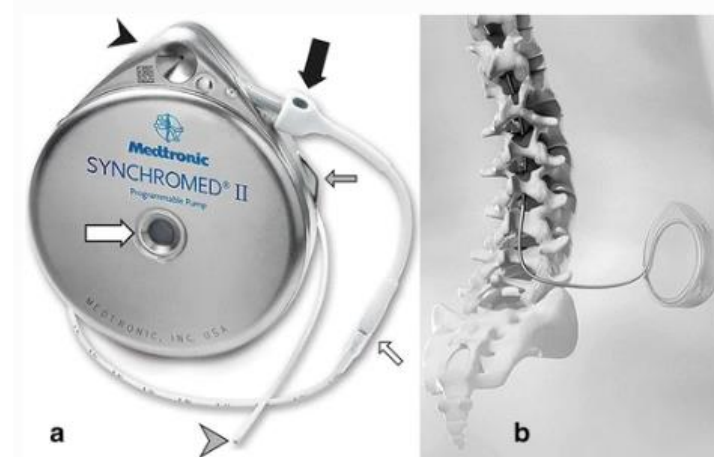


**Neuromodulation**



# Functional neurosurgery - techniques

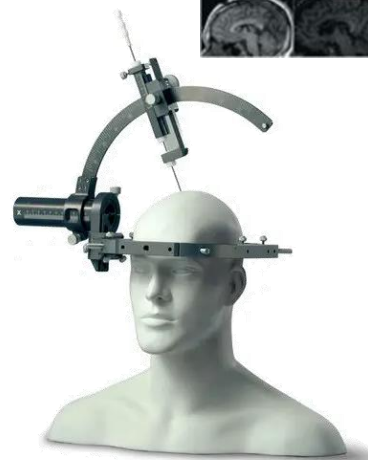
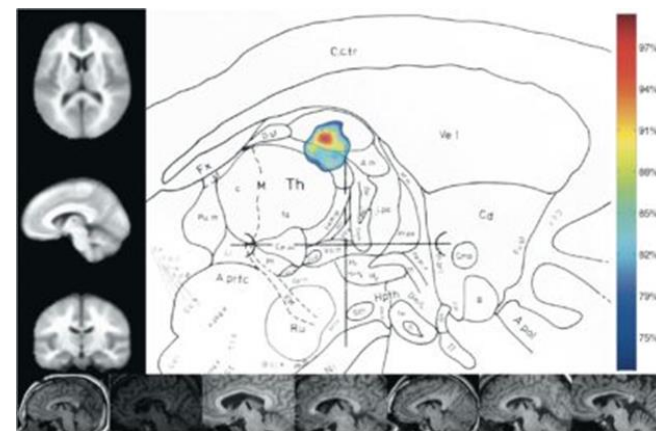
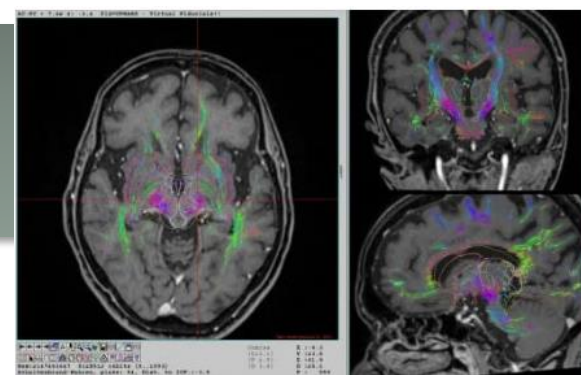
- Ablation
- Neurostimulation
- Drug infusion
  - "Pharmacological or chemical neuromodulation" = modification of nervous system activity by directly infusing drugs:
  - Implantable infusion pumps
  - Morphine or another opiate
  - Baclofen
  - Requires periodic drug refill





# Functional neurosurgery

- Location of circuits and target points
  - Especially important in techniques performed on a specific brain nucleus
  - **Stereotaxy** = integrates current anatomical landmarks and neuroimaging
    - *identification of a subcortical structure on MRI (previously on CT)*
    - *location using coordinates in three Cartesian axes*
    - *imaging systems in the operating room that integrate real anatomical landmarks with neuroimaging*

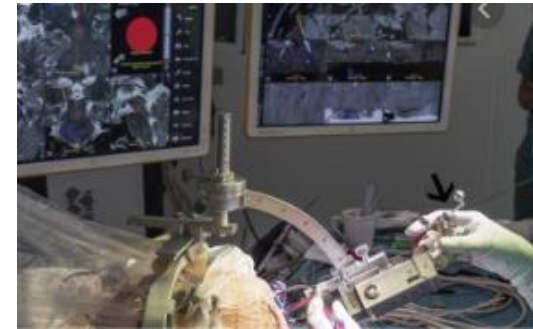


(We see it now)



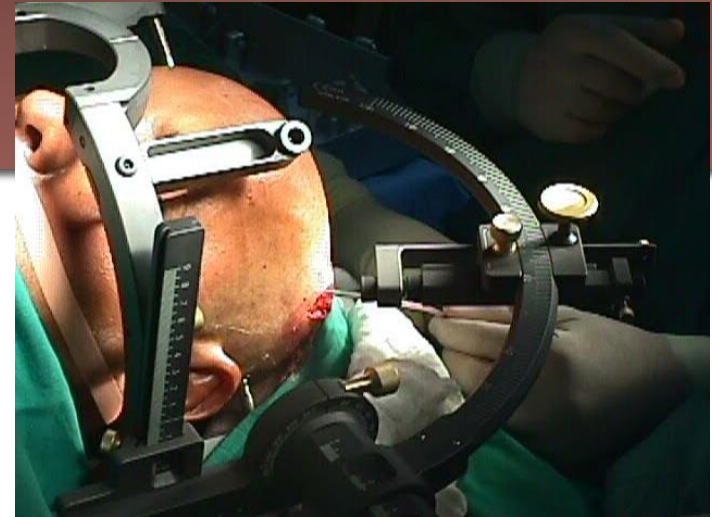
# STEREOTAXY

- “Capability to locate exactly a specific point or a lesion from two images with different angulation”
  - Millimetre location system using 3D coordinates
  - Allows procedures guided by image diagnostic techniques
- Stereotaxic radiosurgery
  - Radiotherapy technique that focuses high-power energy to a precisely identified point using stereotaxy
- Stereotaxic surgery
  - Minimally invasive surgical procedure that uses stereotaxy to locate small structures within the body, and to perform actions such as ablation, biopsy, lesion, stimulation, injection, or implantation of devices.

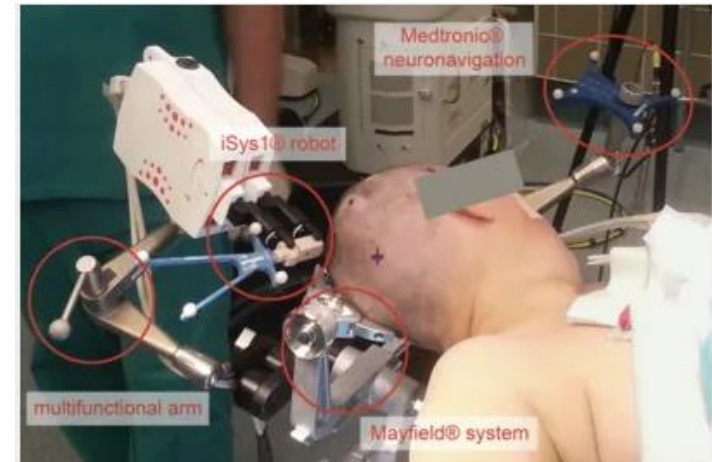


# Stereotaxy

- These are “advanced techniques” but the first systems similar to these – and using the square arc concept – appeared in 1949 (Lars Leksell, Sweden)
  - Initially for radiosurgery → Gamma Knife (today CyberKnife)
  - 70s - CT scan → First radiosurgery in Spain (Valencia 1975, JL Barcia Salorio, HCUV): carotid-cavernous fistulas, vestibular schwannomas, epilepsy.
  - 80s - MRI → New devices, linear accelerator (Madrid).
  - 90s - Minimal invasiveness
  - Since 2000 - Robotic Systems



*Traditional stereotaxy framework*



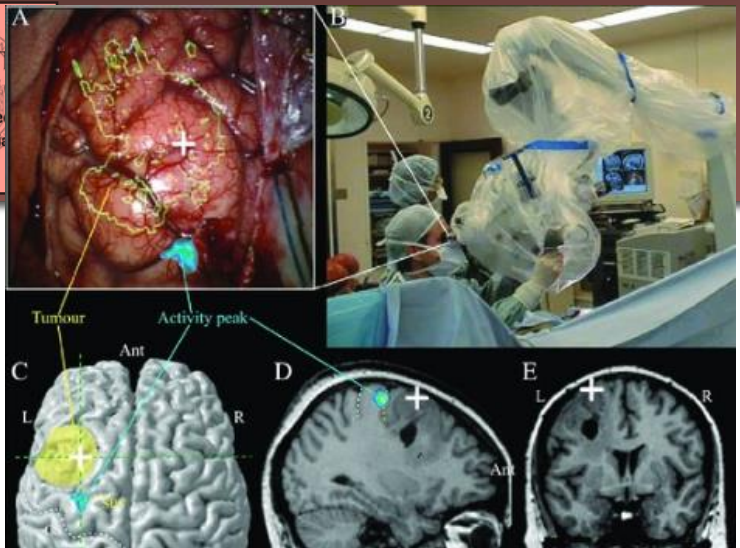
*Frameless stereotaxy and robotic navigation for deep brain electrode implantation*

# Stereotaxic neurosurgery

## • Indications

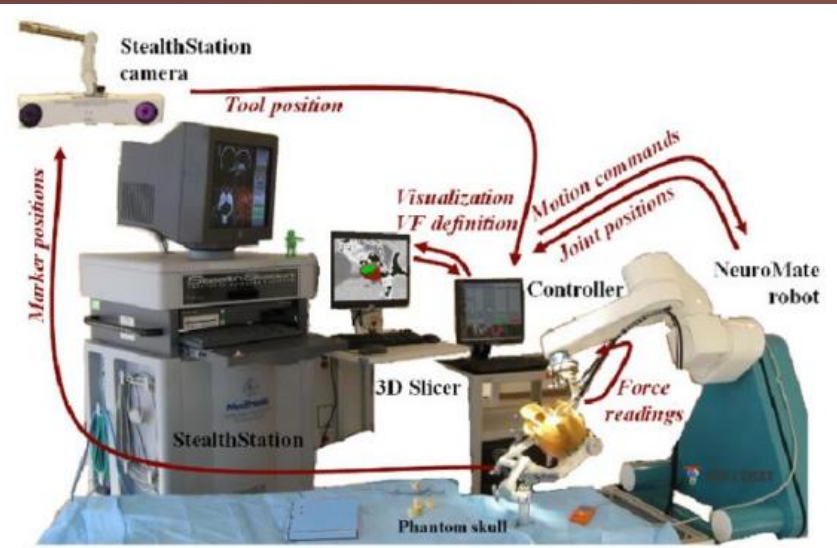
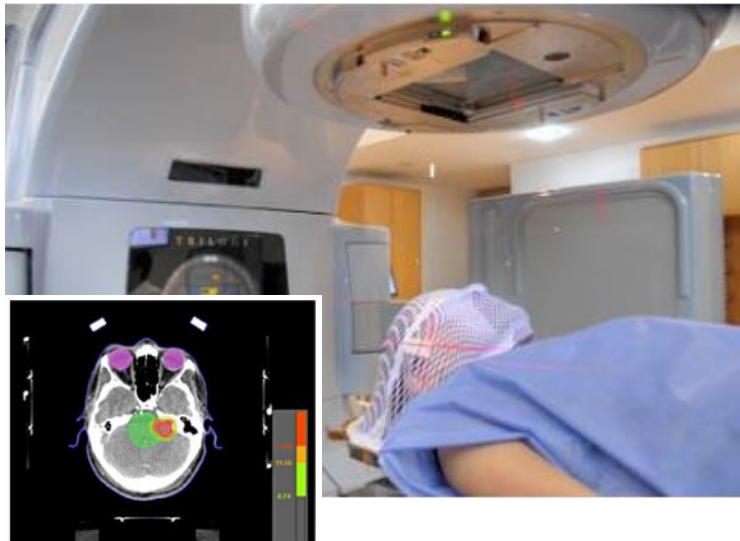
- Biopsy (brain) + resection of small lesions
  - *Tumours, abscesses, space-occupying lesions with unknown origin, inflammatory processes*
- Deep electrode implantation
  - *Parkinson's disease, dystonia, pain, epilepsy*
- Surgical lesions in deep brain areas
  - *Psychosurgery*
- As a localization system for other non-surgical techniques
  - *Stereotaxic radiosurgery (today with CT-scan and integrated position and movement detectors) → High doses of radiation to a specific target*
  - *High intensity focused ultrasound (HIFU), MRI-guided focused ultrasound (MRgFUS) → Ultrasound from multiple focuses for ↑ temperature of a specific target, guided by MRI.*





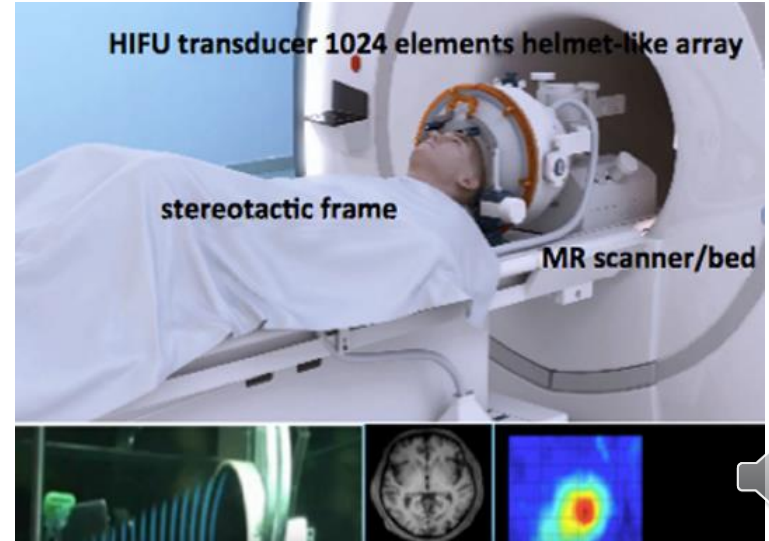
*Neuronavigation for lesion localization in eloquent brain areas*

*Planning and execution of stereotactic radiosurgery*



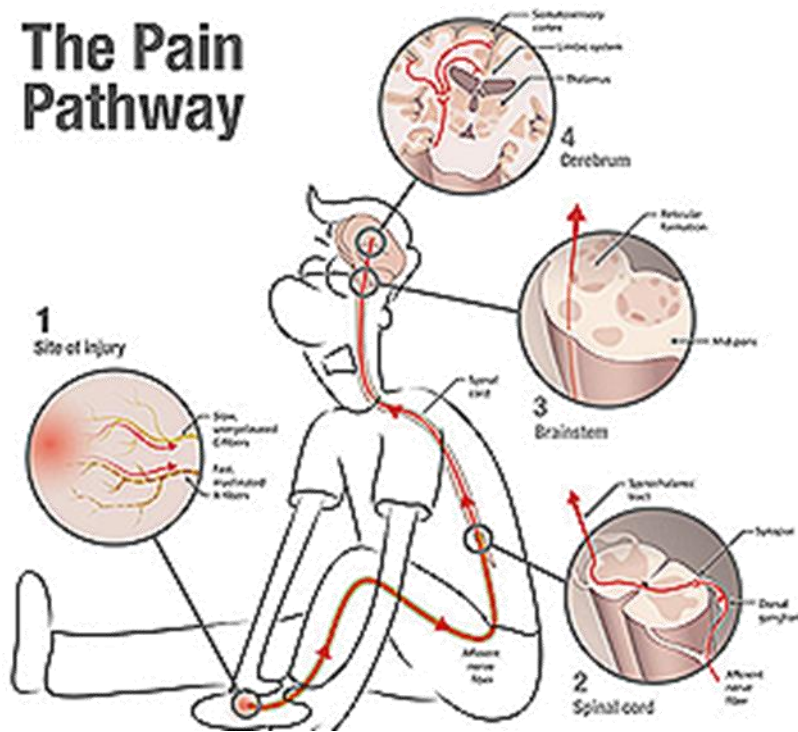
*Image and neuronavigational integration in robotic surgery*

*High intensity focused ultrasound (HIFU, MRgFUS)*



# PAIN

## The Pain Pathway



## • Pain

- **Acute** - benign - nociceptive (nociception excess )
  - Resolved when its cause disappears (inflammation → NSAIDs)
  - Mediated by endorphins → controlled with opiate administration
  - Treatment = to control its cause
- Chronic

Pain

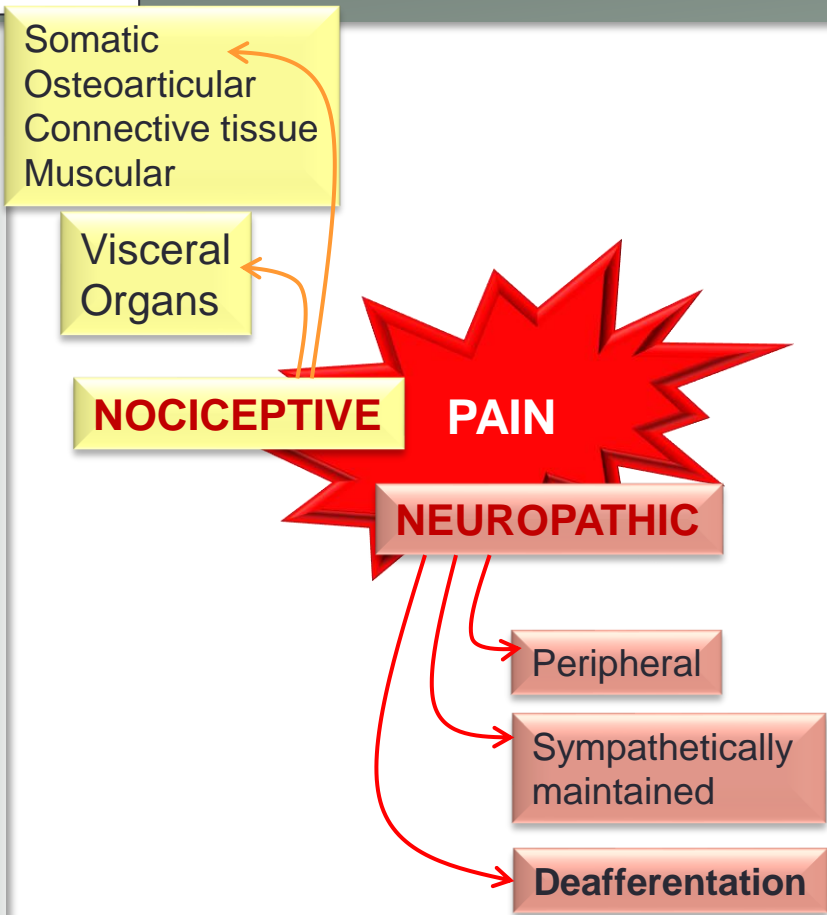
Epilepsy

Movement disorders

Psychosurgery



# PAIN



## • Pain

- Acute
- **Chronic** - malignant - neuropathic (deafferentation)
  - *Imbalance of sensory inputs (nervous pathways)*
    - ↓ sensory input + ↑ painful input
  - *Pain as a disease: persists despite having resolved the cause that started it → pain units*
  - *Treatment = increase sensory input*

Pain

Epilepsy

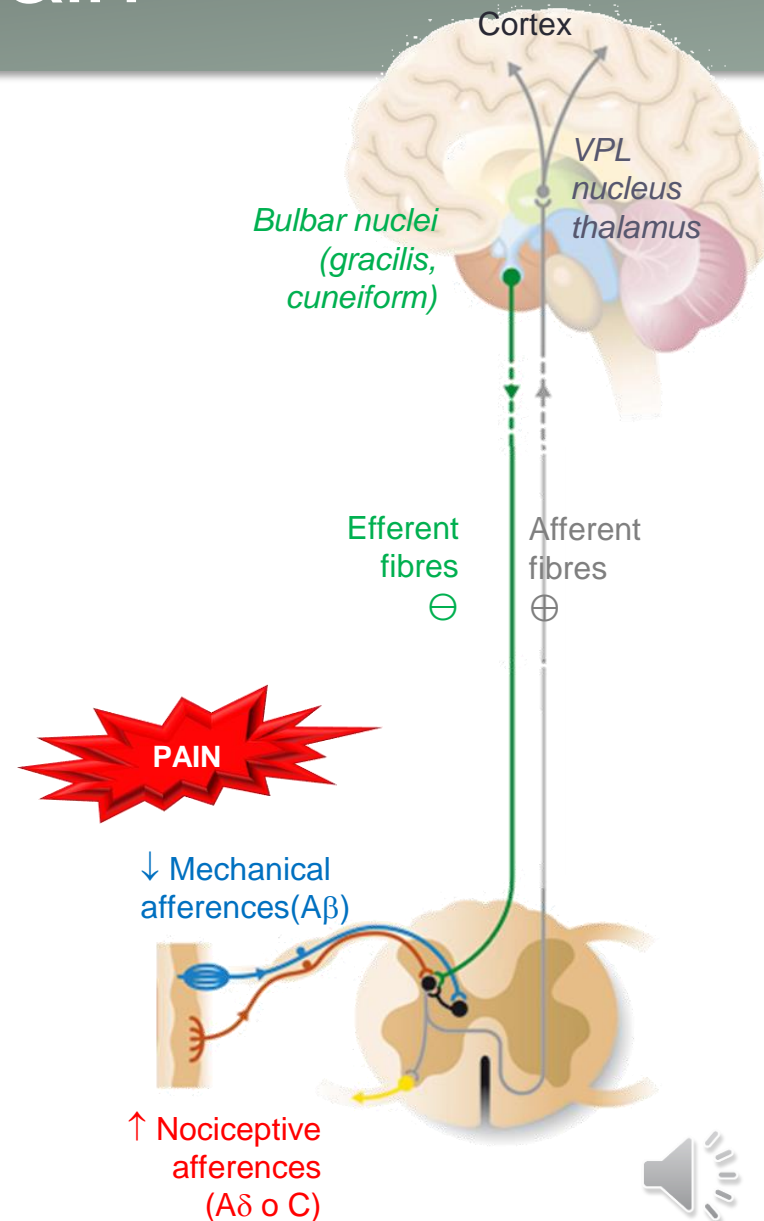
Movement  
disorders

Psychosurgery

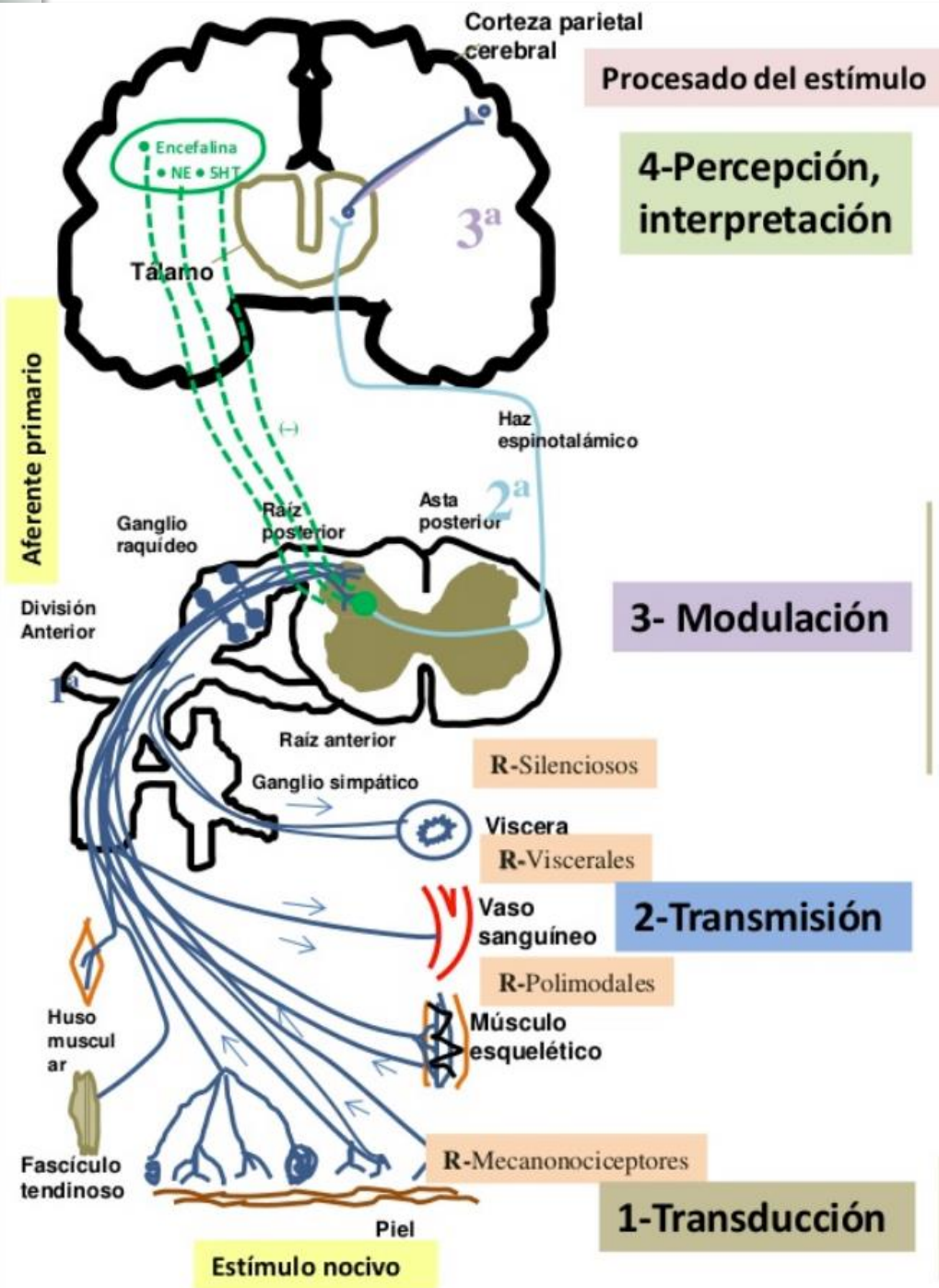


# Chronic refractory pain

- Definition: pain lasting > 6 months in which medical treatment has failed
- Treatment
  - Acupuncture, cognitive therapy, meditation, therapeutic massage ...
  - Non-opioids > weak opioid > strong opioid ( $\pm$  adjuvants in all cases)
    - Morphine, hydromorphone, transdermal fentanyl, oxycodone, methadone
    - Adjuvants: corticosteroids, antidepressants, anticonvulsants ...
    - Different routes of administration
    - NO MEPERIDINE (normeperidine metabolite  $\rightarrow$  epileptic seizures)







- Opiáceos sistémicos
- Ketamina, N<sub>2</sub>O
- Anestésicos locales
- Anticonvulsivantes
- Neurolepticos
- Glucocorticoides
- Antihistamínicos
- Alfa 2 agonistas

- Estructuras:**
- Vías descendentes (-)
  - Actividad segmentaria
  - Péptidos
- Modulación:**
- Sensibilización
  - Fatiga

- Analgesia espinal
- Epidurales
- Intradurales
- Crioanalgesia
- Alfa 2 agonistas

- Activación:**
- Directa
  - Mediadores

# Chronic refractory pain

- Neurosurgical treatment possibilities
  - **Benign chronic pain** (in case of long life expectancy)
    - *Anesthetic blocks*
    - *Epidural morphine*
    - *Neurostimulation*
  - **Chronic malignant pain** (oncologic, short-life expectancy)
    - *Anesthetic blocks*
    - *Epidural or intrathecal morphine pumps*
    - *Ablative treatments*
    - *Others*
  - **Neuropathic pain**
    - *Do not increase deafferentation lesioning peripheral nerves, nerve roots, or neuronal pathways!*
    - *Neurostimulation (helps with pain control)*

Neuro-  
stimulation

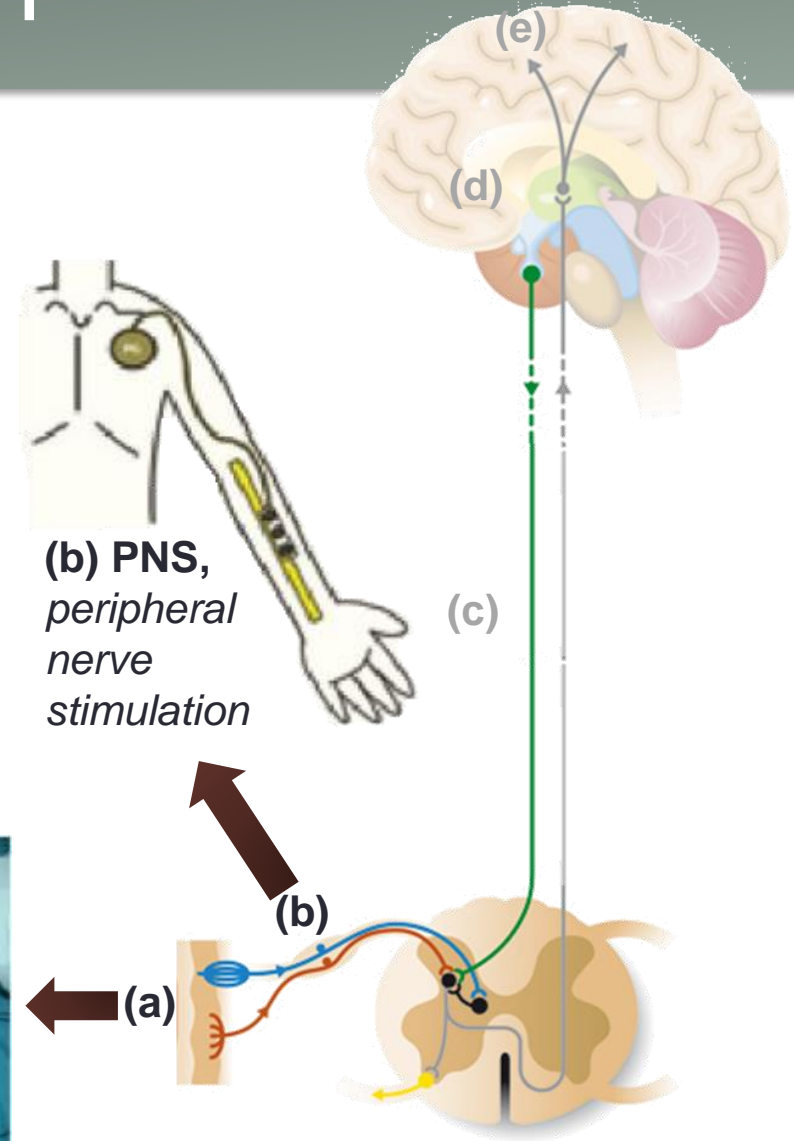
Ablative  
techniques

Facial  
neuralgia



# 1. Neurostimulation

- a) Receptors (TENS)
- b) Peripheral nerves (PNS)
- c) Posterior spinal cord stimulation
- d) Deep brain stimulation
- e) Cerebral cortex stimulation



**(b) PNS,**  
*peripheral*  
*nerve*  
*stimulation*

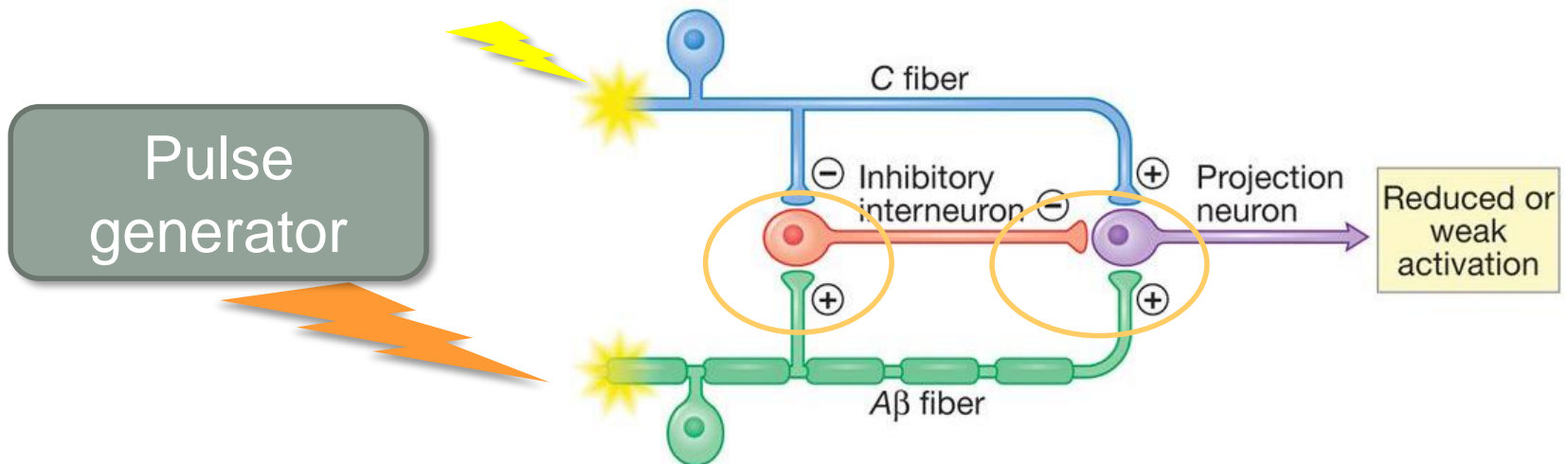
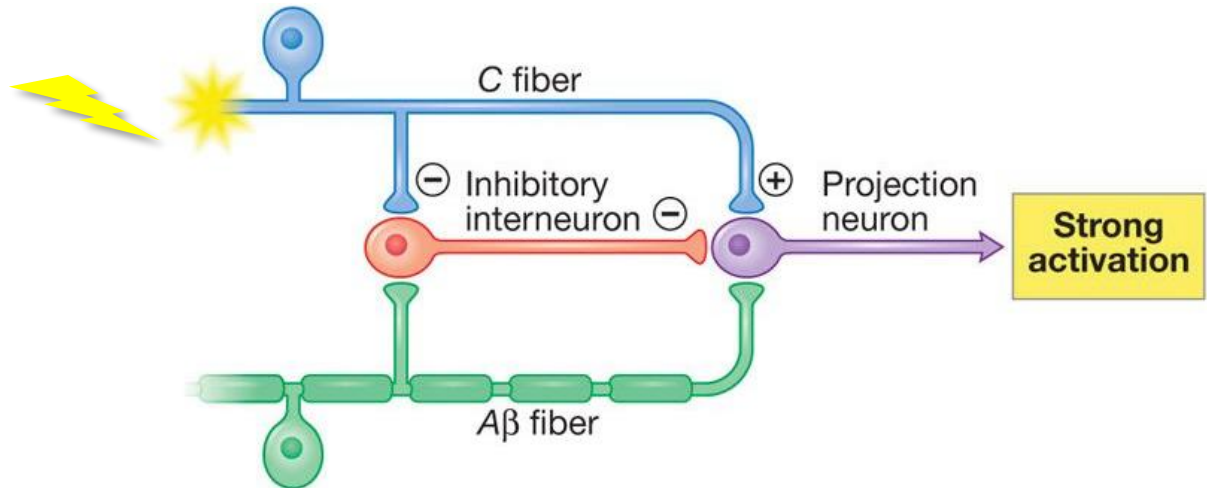
(c)

**(a) TENS,** *transcutaneous*  
*electrical nerve stimulation*



# 1. Neurostimulation

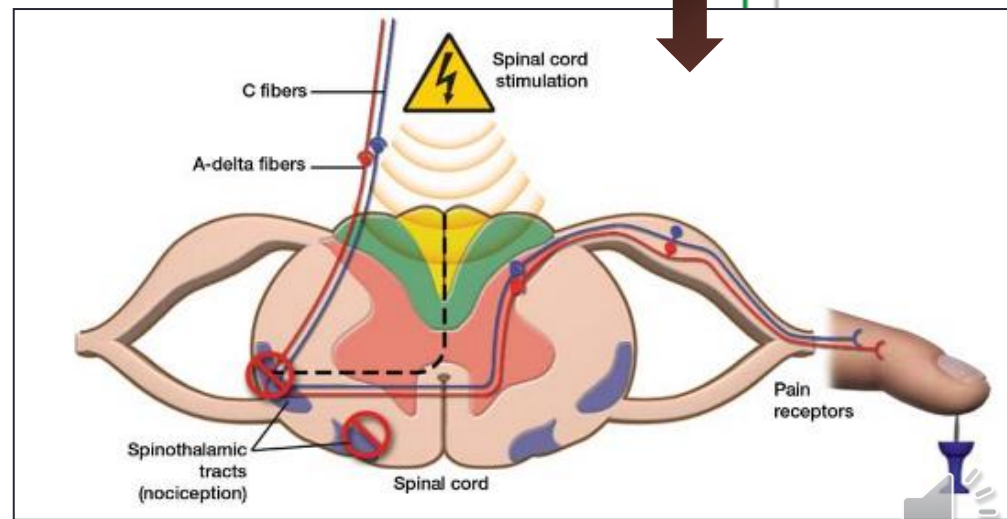
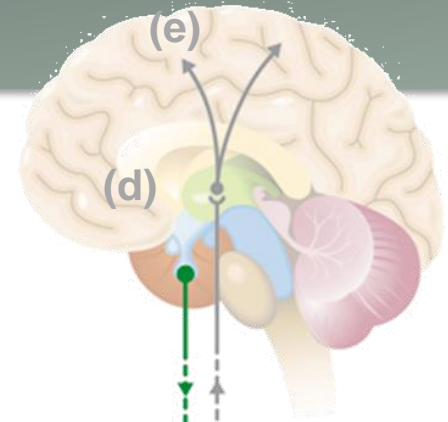
PAIN STIMULI  
(true or false)



# 1. Neurostimulation

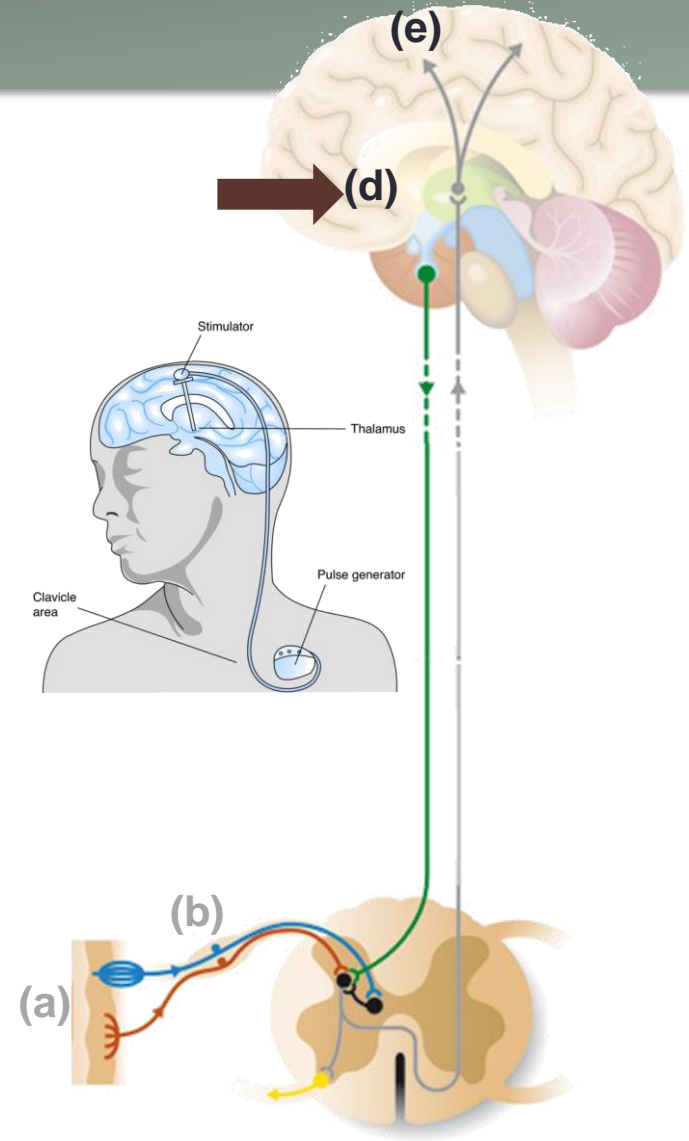
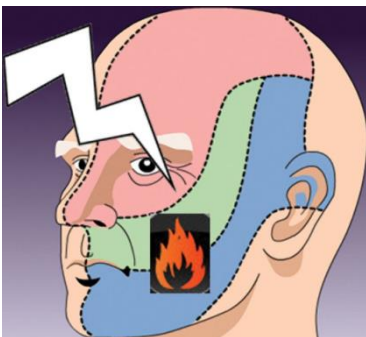
## c) Posterior spinal cord stimulation (SCS, spinal cord stimulation)

- Epidural electrodes inserted at spinal level
- ⊕ antidromic posterior cords
  - spinothalamic conduction block
  - ↑ posterior spinal cord horn endorphins
- Deafferentation pain
  - persistent lumbosciatica (failed back syndrome)
  - reflex sympathetic dystrophy
  - phantom limb pain
  - brachial plexus avulsion
- Ischemic pain (angina)
  - produces vasodilation
  - angor pectoris
  - vascular claudication



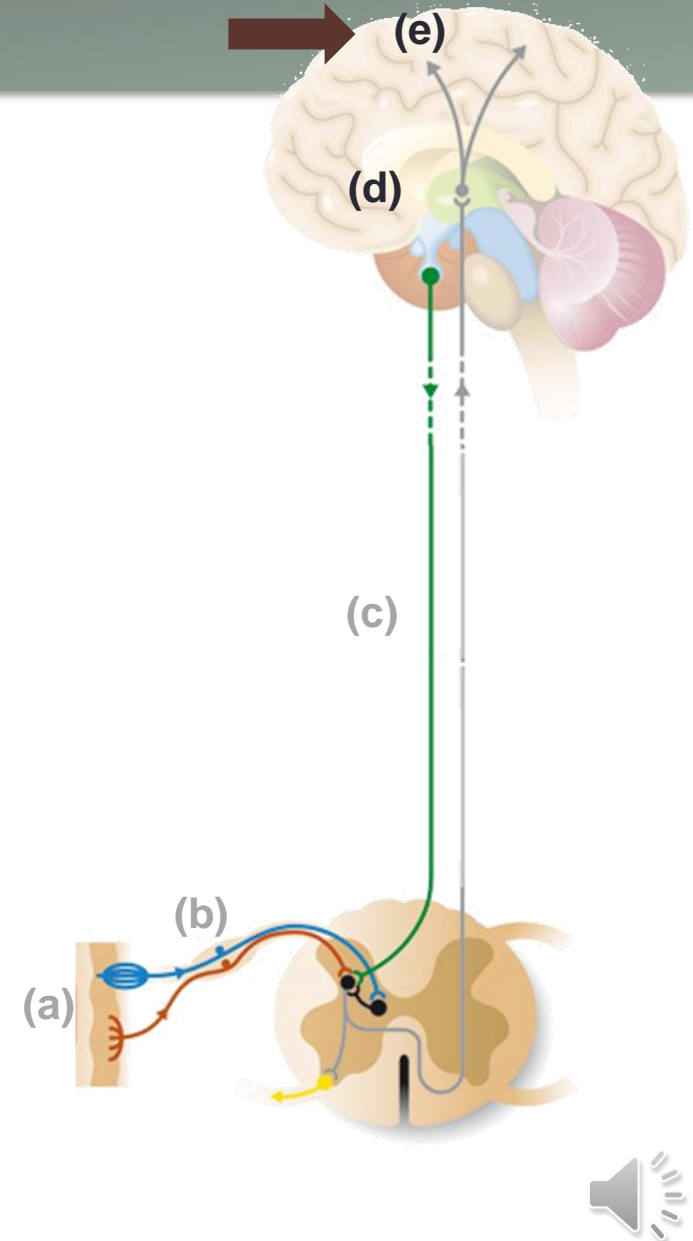
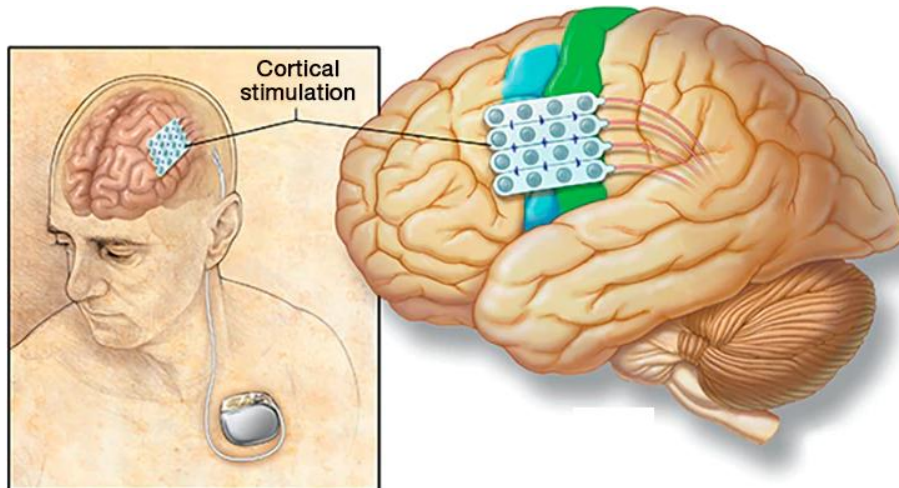
# 1. Neurostimulation

- d) Deep brain stimulation (DBS)
- *Little used (difficulty and risky)*
  - *Chronic deafferentation pain*
  - *(Neuropathic, trigeminal pain)*
  - *VPM nucleus and VPL nucleus of the thalamus*
    - somatosensory subcortical areas
    - posterior arm internal capsule
    - chronic nociceptive pain
  - *Periaqueductal and periventricular grey matter*



# 1. Neurostimulation

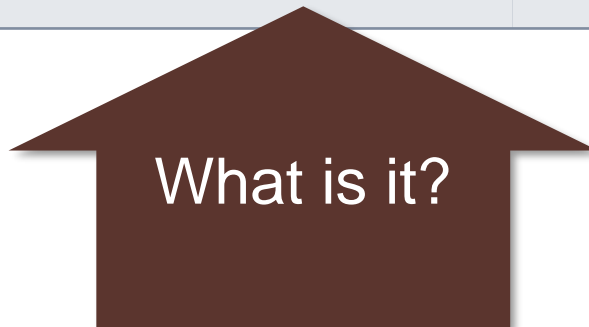
- d) Deep brain stimulation
- *Motor cortex stimulation*
  - *Subdural space electrodes (brain)*
  - *Indications*
    - Facial neuralgia
    - Post-infarction thalamic pain
    - Nerve and plexus injuries
    - Phantom limb pain




# 2. Ablative techniques

- Pathway section or nuclei lesion:

	<b>Radiofrequency</b>	<b>Alcohol / phenol</b>	<b>Surgery</b>
<b>Nerve roots, ganglia, or plexuses</b>	Sympathectomy	Sympathectomy	Sympathectomy
<b>Neuromas</b>	-	-	Neurectomy
<b>Articular nerves</b>	Rhizotomy	-	-
<b>DREZ</b>	DREZotomy	-	DREZotomy
<b>Spinal tracts</b>	-	-	Cordotomy



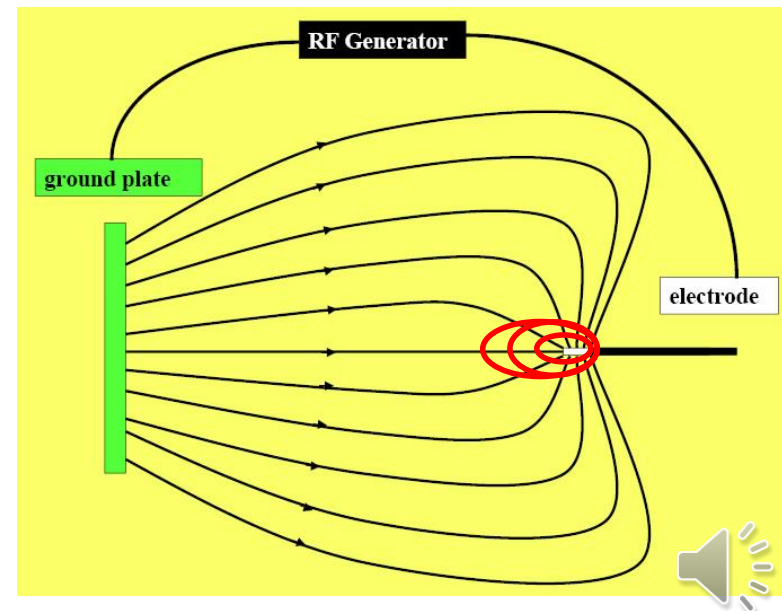
*Absolute alcohol = ethanol > 96 %*  
*Phenol = C<sub>6</sub>H<sub>6</sub>O*




# Radiofrequency (RF)

- Radiofrequency

- Electric current between active tip electrode and conductive plate (passive electrode) → friction of water molecules → ↑ local temperature → cell lesion
  - 42 - 90 °C, for 15 - 120 sec depending on the target
  - *DO NOT reach boiling point!*



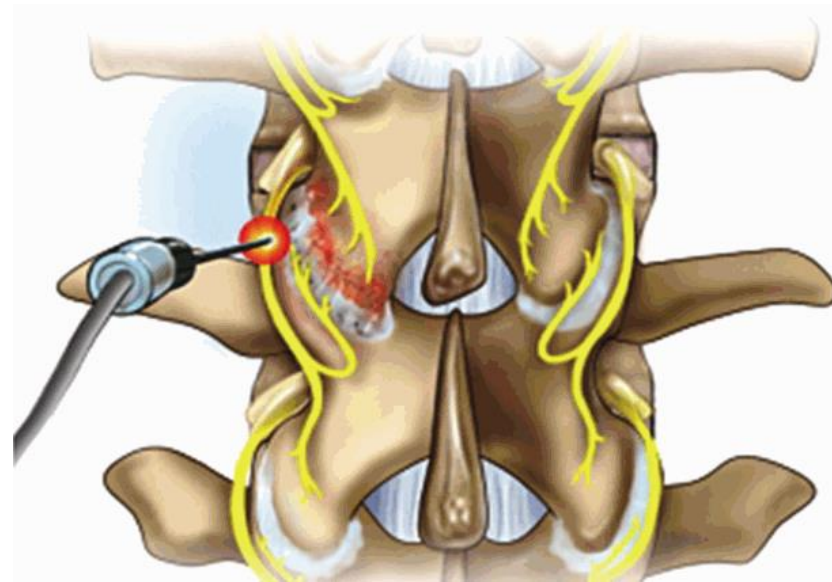
# Radiofrequency (RF)

- Types

- Thermal → irreversible lesion to the treated nerve
- Pulsed → modulates nerve transmission without nerve damage

- Indications

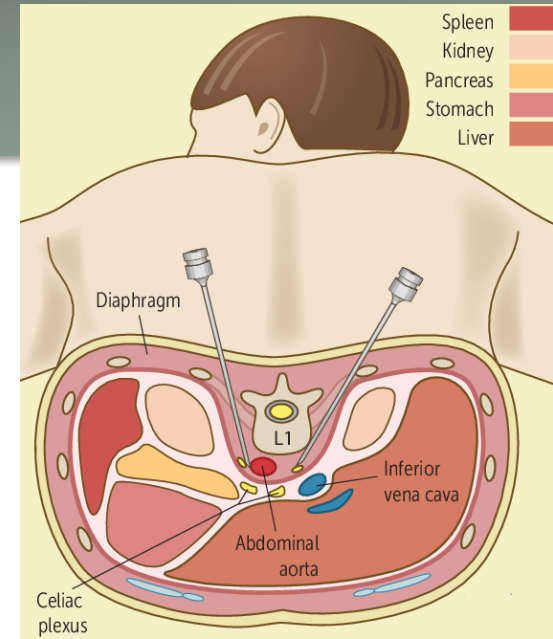
- injury to sensory nerves, especially articular nerves
- lumbar, cervical, hip, knee pain
- trigeminal neuralgia
- lumbar sympathectomy, DREZotomy



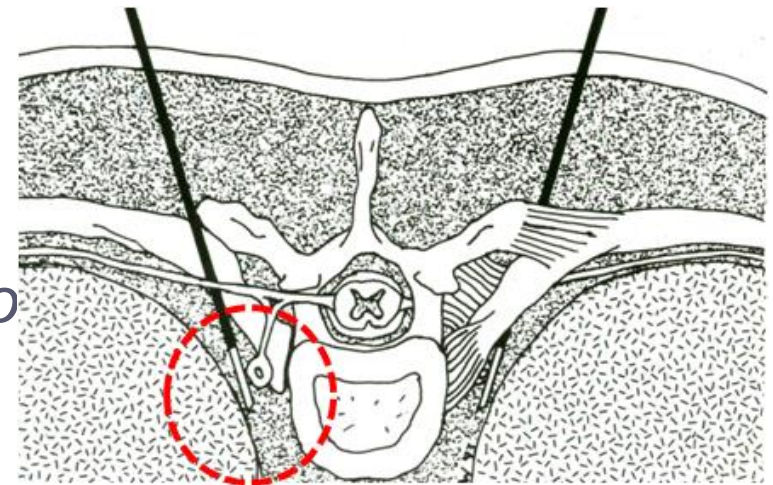
# 2. Ablative techniques

## a) Sympathectomy

- Sympathetic chain block
- Indications
  - *reflex sympathetic dystrophy*
  - *angor pectoris*
  - *lower limb vascular disorders*
  - *visceral cancer pain*
- Techniques
  - *local infiltration of ethyl alcohol*
  - *radiofrequency*
  - *surgical section*



*Ethyl alcohol infiltration*



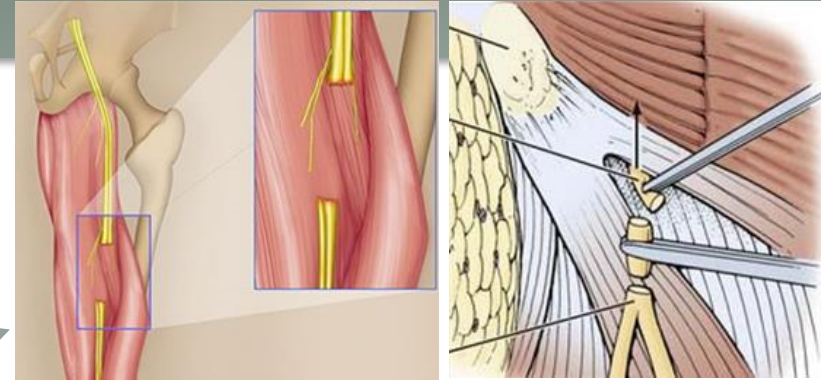
*Radiofrequency sympathectomy*



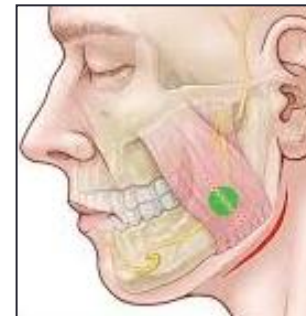
# 2. Ablative techniques

## b) Neurectomy (surgical)

- Excision-avulsion of the neuroma
- Discontinued technique
- Indications
  - *meralgia paresthetica*
  - *neuralgia terminal branches - fifth cranial nerve*



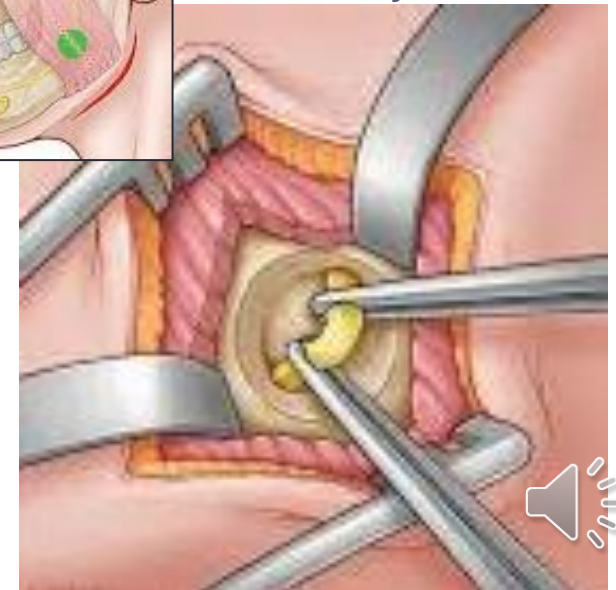
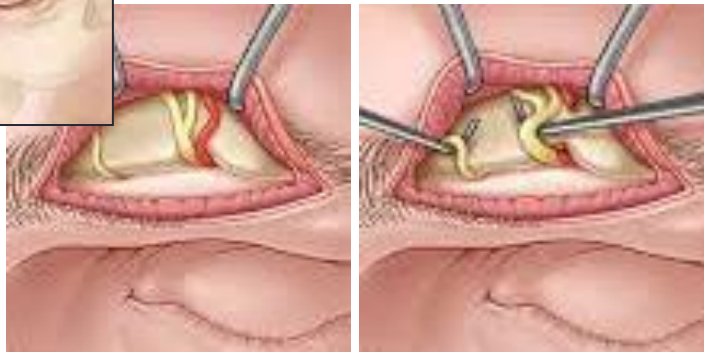
*Femorocutaneous nerve neurectomy*



*Fifth cranial nerve  
mandibular branch  
neurectomy*

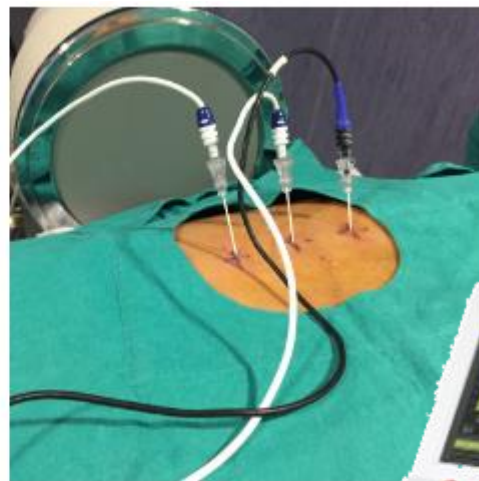
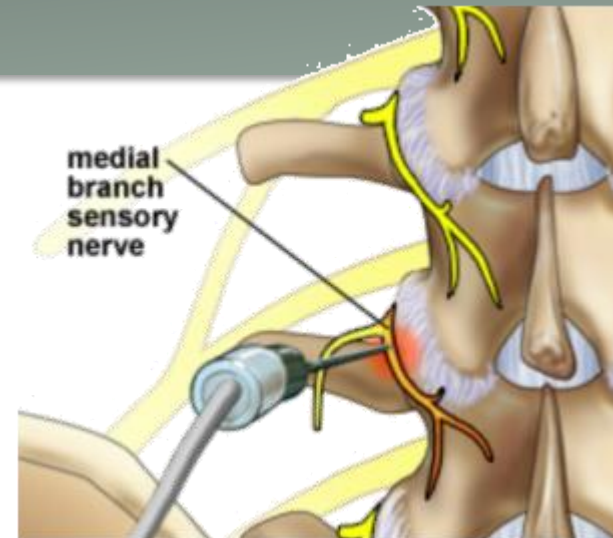


*Supraorbital nerve  
neurectomy*



# 2. Ablative techniques

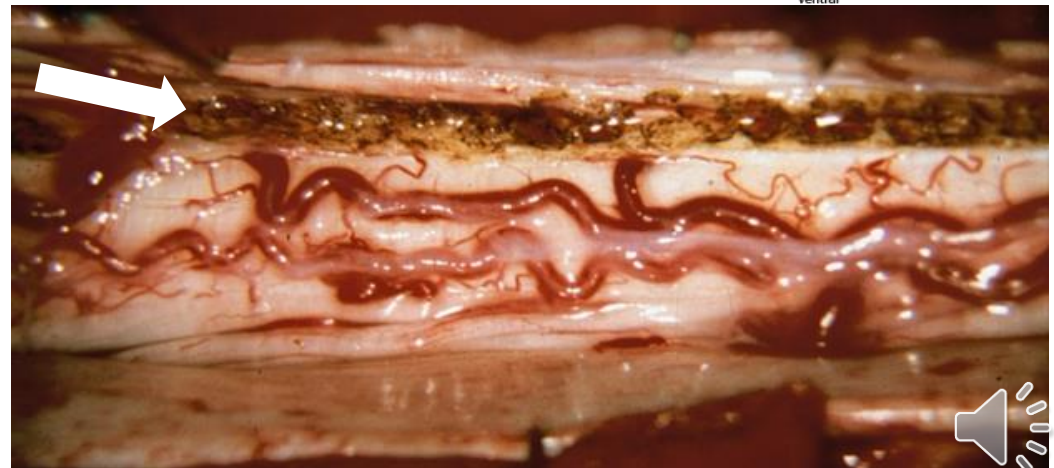
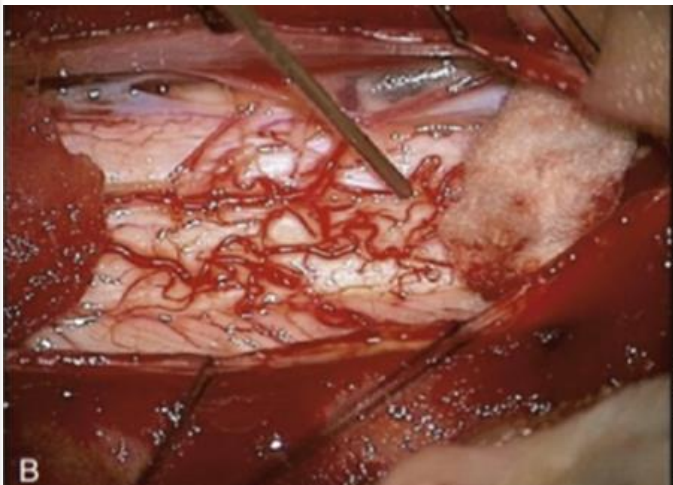
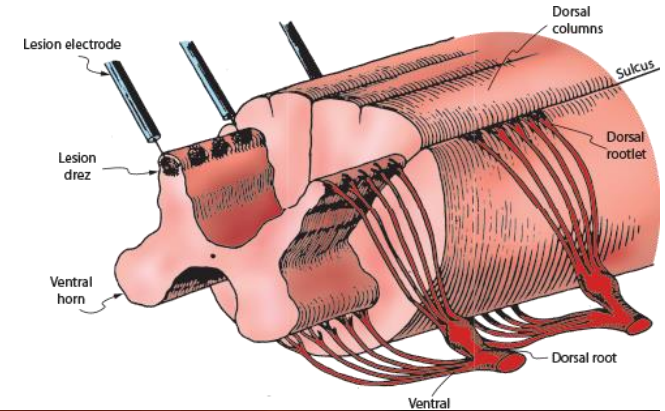
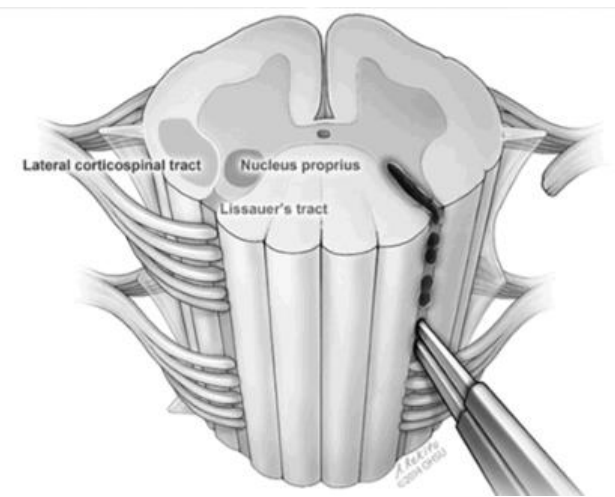
- c) Lumbar and cervical rhizolysis with radiofrequency
- Radiofrequency lesion of posterior branches of spinal nerves
  - Indications
    - *chronic back or neck pain of facet origin*



## 2. Ablative techniques

### d) DREZotomy

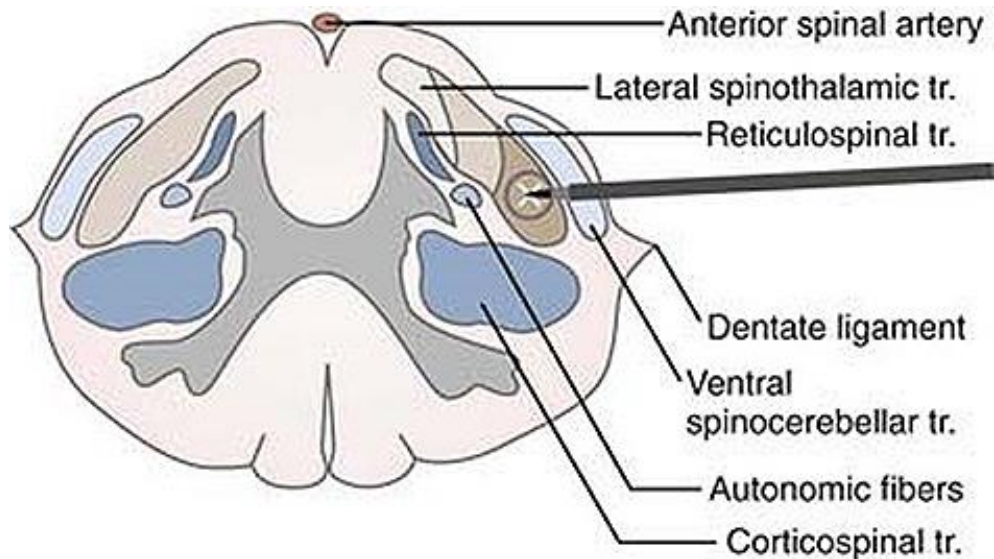
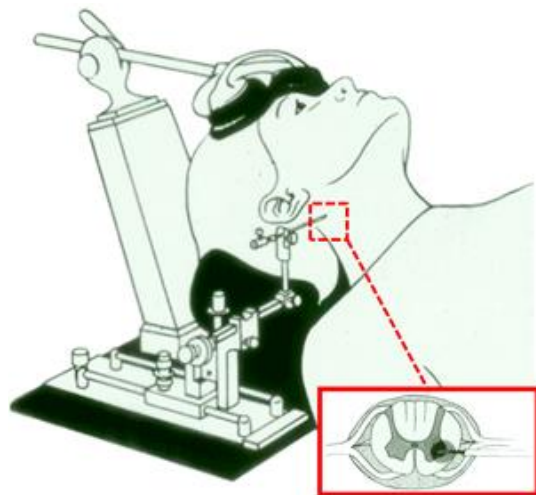
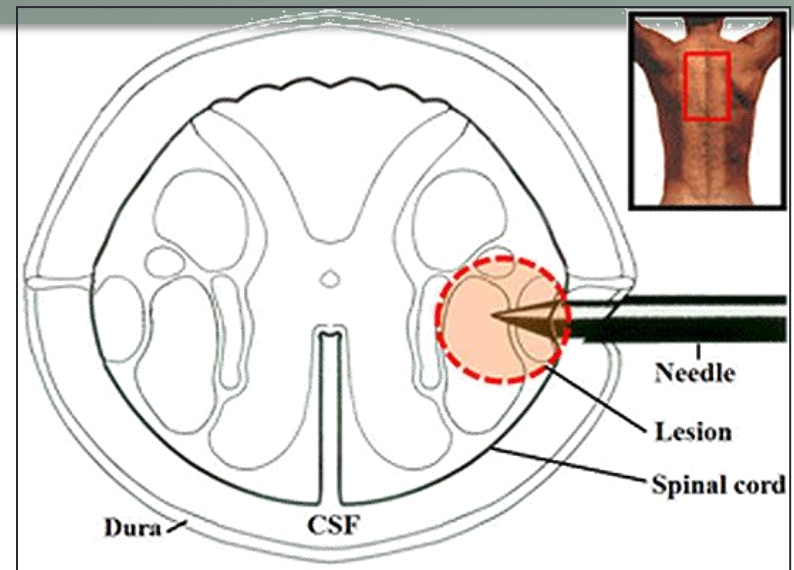
- DREZ (dorsal root entry zone) lesion in the spinal cord
- Radiofrequency >>> micro scissors
- Indications
  - *Brachial plexus avulsion*
  - *Phantom limb pain*
  - *Cancer pain*



# 2. Ablative techniques

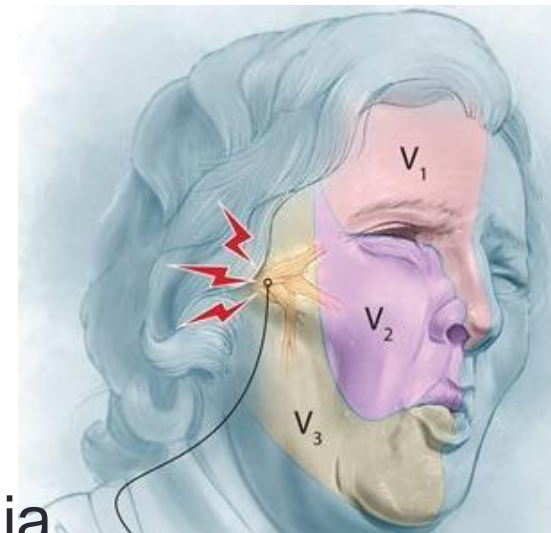
## e) Cordotomy

- Surgical lesion of the spinothalamic tract (usually at C<sub>1</sub>-C<sub>2</sub>)
- Open or percutaneous
- Thoracic or cervical cord level (C<sub>1</sub>-C<sub>2</sub>)
- Indications
  - *Cancer pain*



# 3. Trigeminal Neuralgia

- Fifth cranial nerve function
  - Sensation of the face and nasal and oral mucosa → Gasser's ganglion
  - Mastication (masseter & pterygoid)
  - Lesion = mouth deviated to the injured side
    - *The healthy side predominates*
  - Corneal reflex afferent pathway
- Unilateral, paroxysmal, brief & lancinating facial pain = tic douloureux, typical neuralgia
  - Spontaneous or after sensory stimulus (trigger areas)
  - Typical = women > 55 years (♀:♂ is 2:1)
  - DO NOT wake up the patient at night
  - Branches V2-V3 (42%) > other combinations > V1 (4%)
  - NORMAL motor and sensory neurological examination



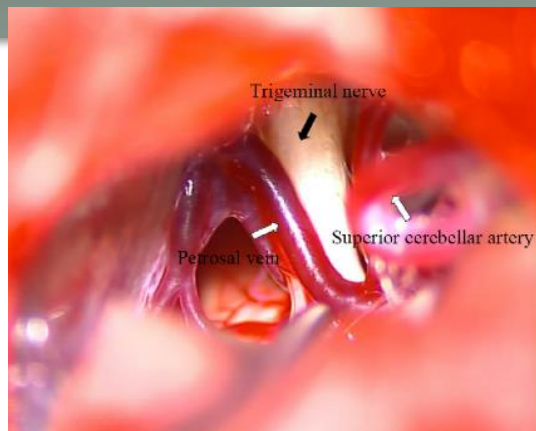


# 3. Trigeminal neuralgia

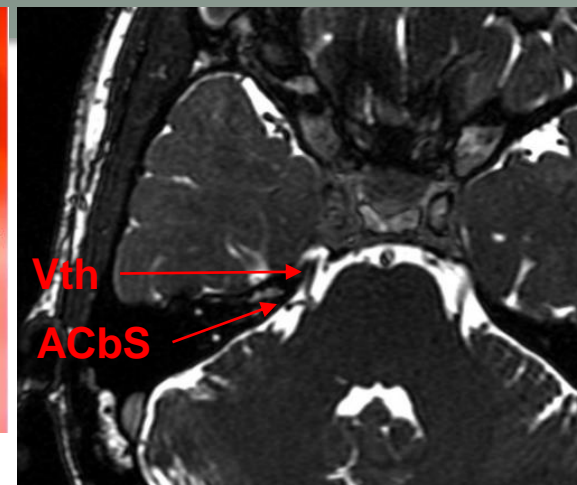
## • Cause

### – Idiopathic

- ↑ *frequent*, ♀ > 40 years
- *vascular compromise (cerebellar artery, petrous vein ...)*



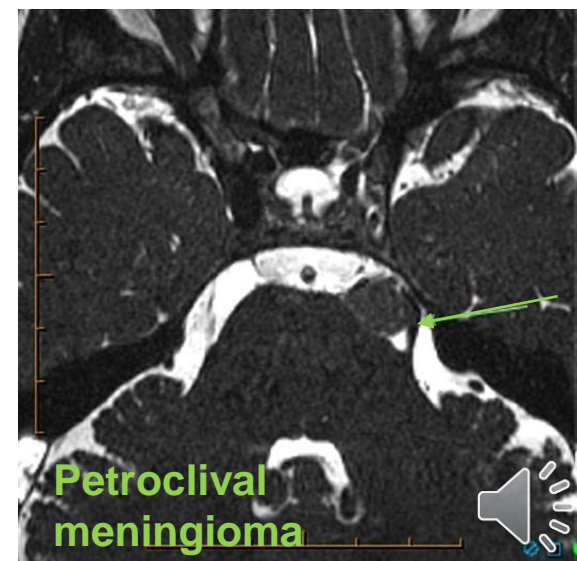
*Compression by the petrous vein*



*RM T2 axial fatsat.  
Compression by the superior cerebellar artery*

### – Secondary

- *accompanied by neurological deficit or ongoing pain*
- *pontocerebellar angle tumours*
- *demyelinating disease (Multiple sclerosis), inflammation, infection*
- *affects fifth cranial nerve nucleus*



*RM axial T2. Petroclival meningioma compressing V<sup>th</sup> cranial nerve*

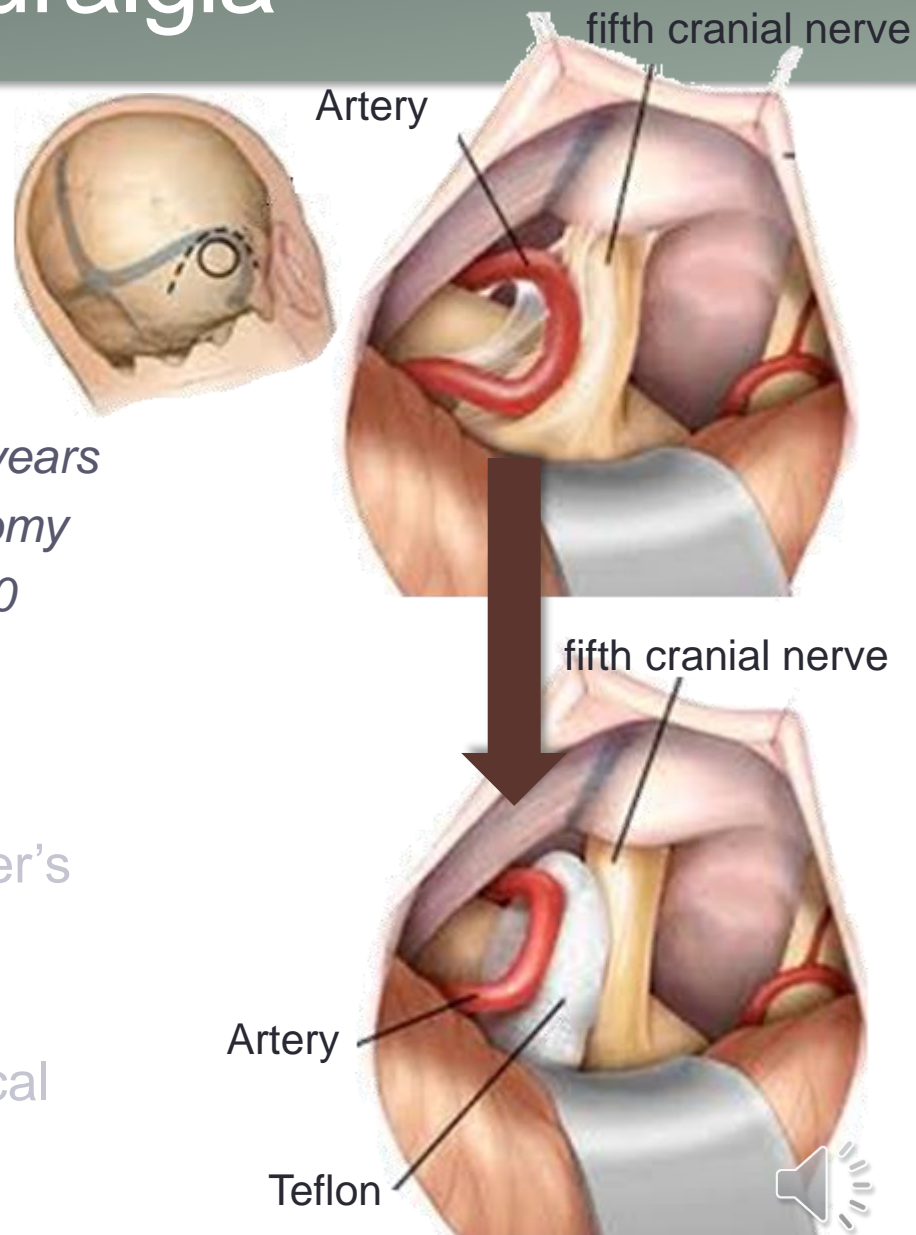
**Petroclival meningioma**



# 3. Trigeminal neuralgia

## • Treatment

- Carbamazepine
- Microvascular decompression (Jannetta 1965)
  - *patients with life expectancy > 5 years*
  - *suboccipital retromastoid craniotomy*
  - *long-term improvement (70% > 10 years)*
  - ↓ *incidence of facial anesthesia*
  - ↓ *mortality (<1%)*
- percutaneous techniques (Gasser's ganglion)
- radiosurgery
- other techniques: cortical electrical stimulation



# 3. Trigeminal neuralgia

## • Treatment

- Carbamazepine
- Microvascular decompression
- Percutaneous techniques (Gasser's ganglion)

### • *Indication*

- refusal of the patient to have surgery
- high anesthetic risk patient
- unresectable intracranial tumours
- multiple sclerosis, hearing loss
- life expectancy <5 years

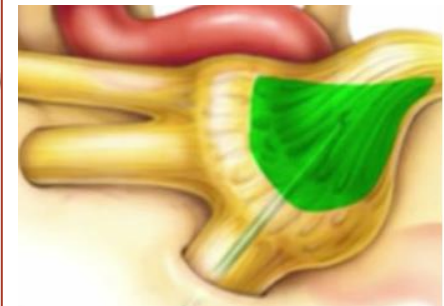
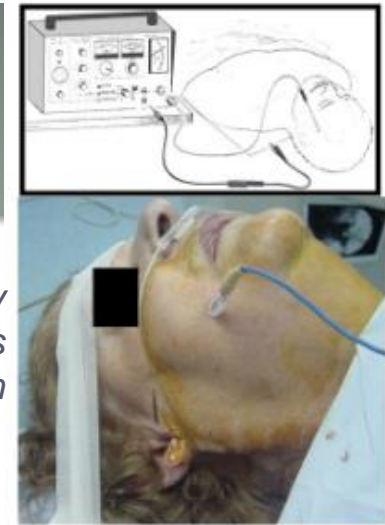
### • *Techniques*

- radiofrequency, glycerol injection, percutaneous balloon compression (Mullan)

### • *Outcome*

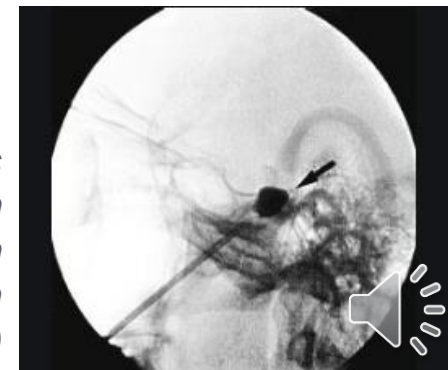
- relieves pain > 90%
- recurrence in 2 - 5 years
- paresthesias, dysesthesias

Radiofrequency  
Gasser's  
ganglion



Glycerol injection

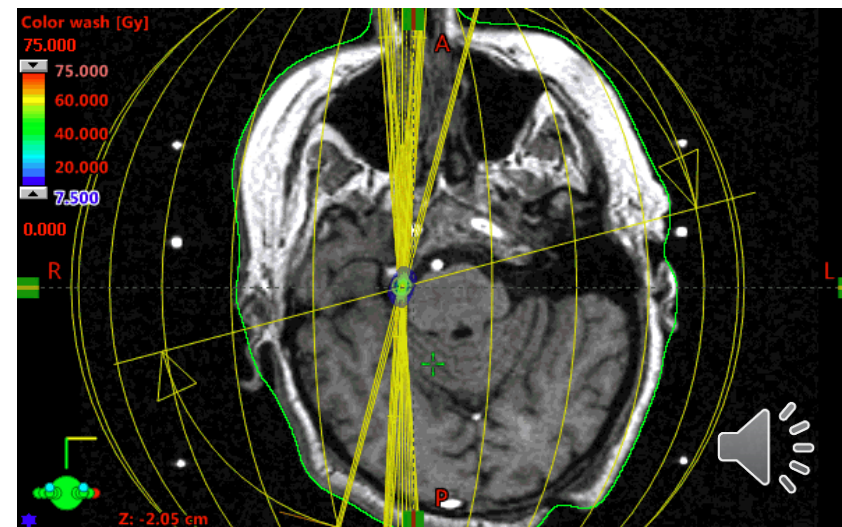
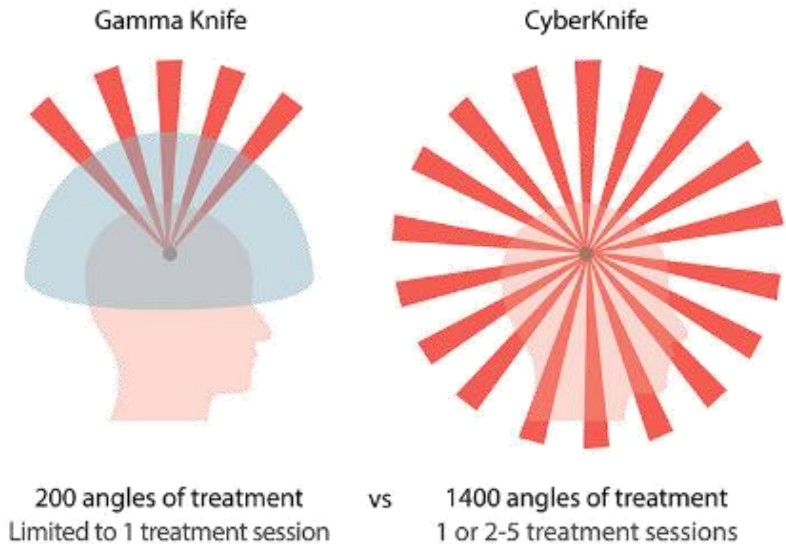
Percutaneous  
balloon  
compression  
(Mullan  
technique)



# 3. Trigeminal neuralgia

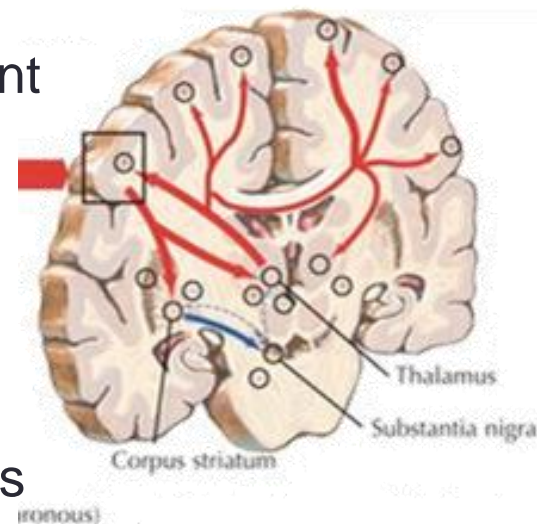
## • Treatment

- Carbamazepine
- Microvascular decompression
- Percutaneous techniques (Gasser's ganglion)
- Radiosurgery
  - *little invasiveness*
  - *high-risk patients only*
  - *pain relief 60% (latency 3 months)*
  - *hypoesthesia 20%*
  - *frequent relapses*
    - *32% need to repeat treatment*
  - *others: cortical stimulation*
  - *infrequent use*



# EPILEPSY SURGERY

- Drug-resistant epilepsy (epilepsy units)
  - Criteria for refractoriness:
    - *no seizure control ( $\geq 1$  seizure per month) with 2 - 3 first-line antiepileptic drugs*
    - *if epileptic seizures are less frequent but affect quality of life (psychological, interpersonal, and work function)*
  - Candidates for surgery = only 10-20% drug-resistant epilepsy
- Objective (curative or palliative):
  - Lesion-epileptogenic complex
  - Epileptogenic zone = originates the focus
  - Lesion zone = structural lesion stimulating the focus



Pain

Epilepsy

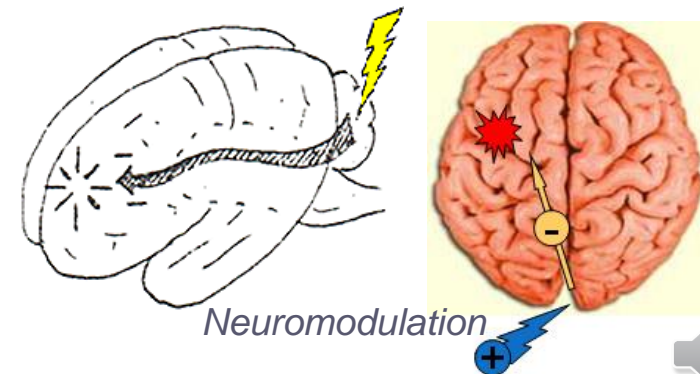
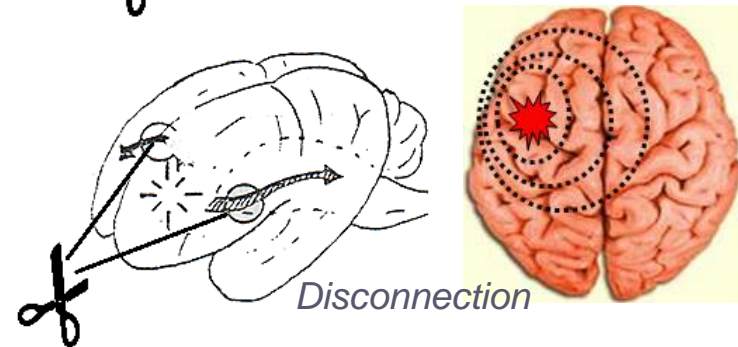
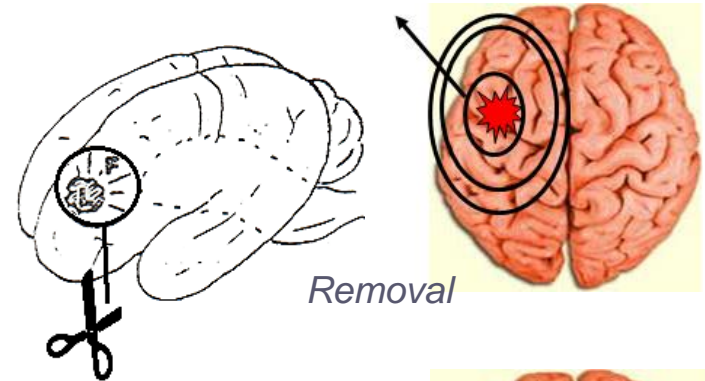
Movement  
disorders

Psychosurgery



# Epilepsy surgery

- Diagnostic procedures
  - Deep brain electrodes
- Treatment options
  - Removal of focus
    - *Resective surgery*
    - *Radiosurgery*
  - Disconnection of propagation pathways
    - *Palliative surgery = disconnection techniques (callosotomy)*
  - Inhibition (neurostimulation)
  - Neuromodulation



# Epilepsy surgery

## • Patient selection

- Correct diagnosis
- Drug-absolute resistance
- Seizures interfere with quality of life
- Motivated and collaborative patient
- Surgery with adequate risk / benefit
- Special cases: patients with severe intellectual impairment and / or generalized epilepsies

Deep brain electrodes?

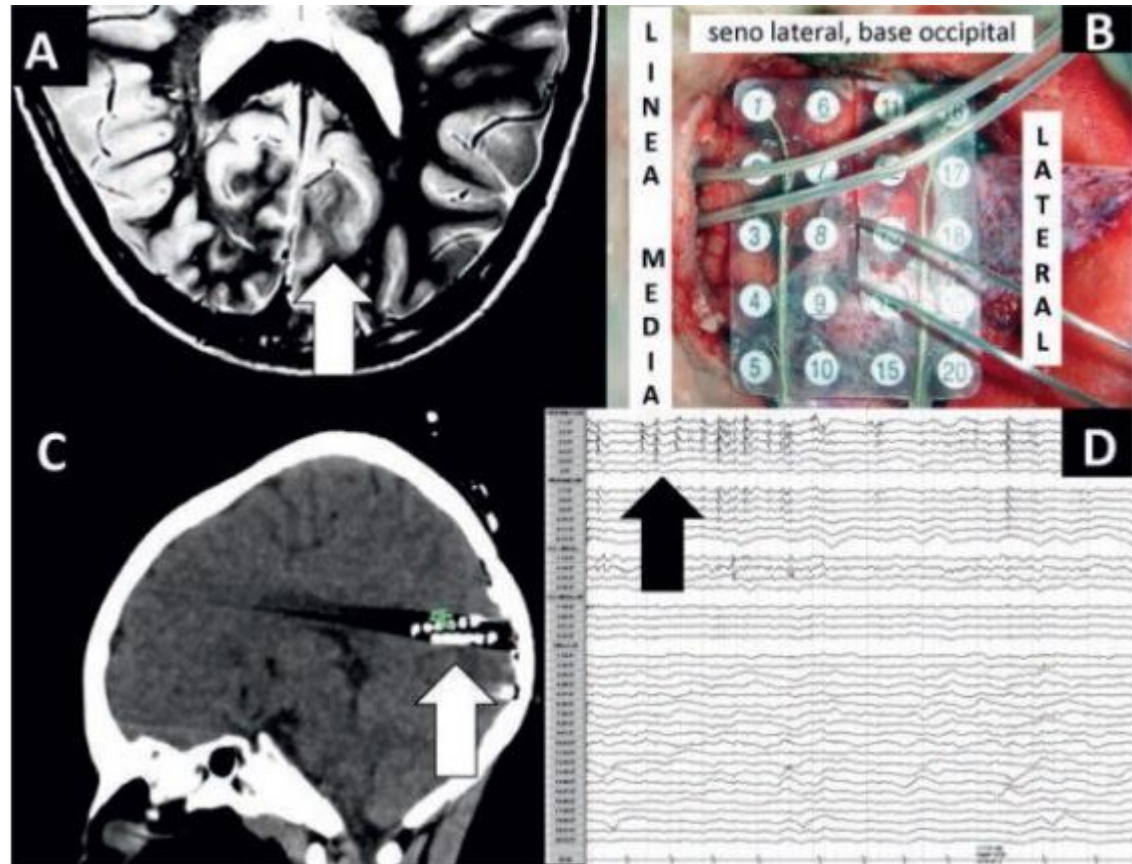
- ▶ *Electroclinical study (medical history)*
- ▶ *Prolonged video-EEG monitoring*
  - Anatomico-functional localization
  - *Neuroimaging*
  - MRI, SPECT, PET, brain electrical activity maps, functional MRI and spectroscopy, ...
- ▶ *Neuropsychology*
  - Cognitive and functional assessment
  - Dominance in memory and language
  - Prediction of surgery effects on family and social



# Diagnostic procedures

- Deep and subdural electrodes

- MRI, left occipital lesion*
- Posterior and medial deep and subdural electrodes*
- CT confirms deep electrodes*
- Chronic electrocorticography: activity only on deep electrodes*





# Surgical techniques



Amigdalohipocampectomia selectiva



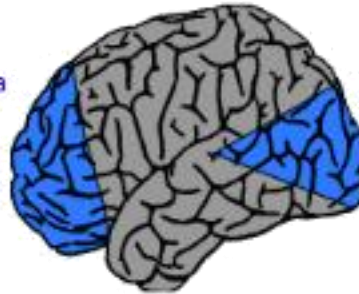
Reseccióndel Lóbulo Temporal



Topectomia



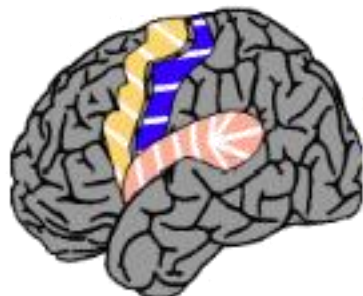
Hemisferectomia Funcional



Lobectomia aislada



Multi-lobectomia



Transecciones Subpiales Múltiples



Transecciones adicionales

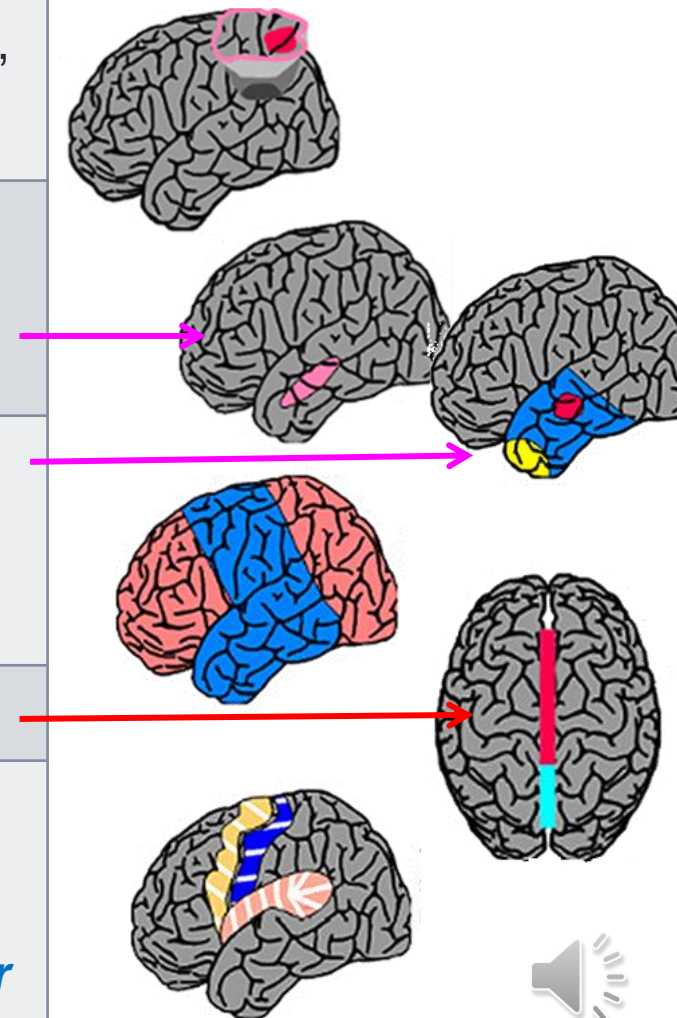


Callosotomia (2/3 - total)



# Surgical techniques

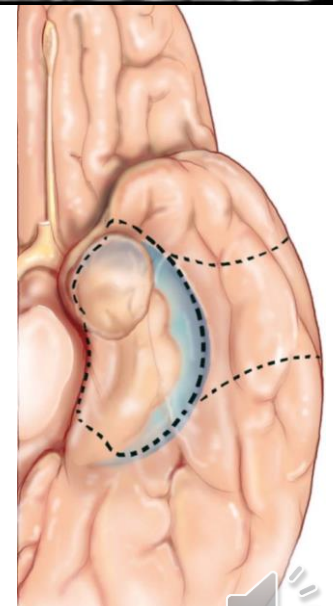
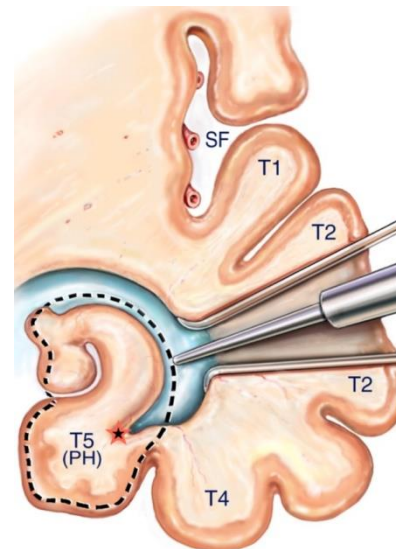
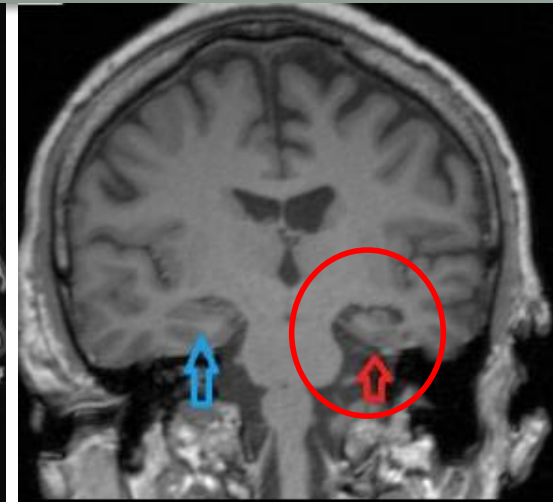
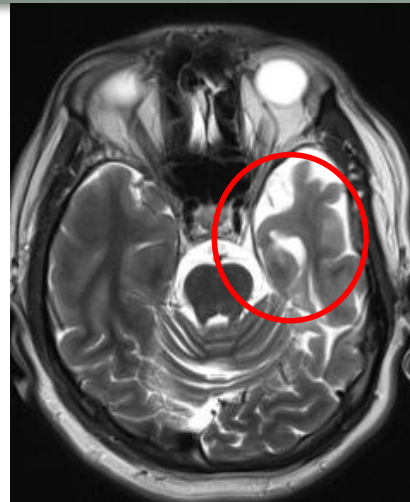
Known and resectable lesion or epileptic focus	Excision of the epileptic focus or lesion (cavernoma, cortical dysplasia)
<b>Temporal lobe epilepsy</b>	<ul style="list-style-type: none"> <li>• Selective amygdalo-hypocampectomy</li> <li>• Temporal lobectomy</li> </ul>
Diffuse hemispheric disease (Rasmussen encephalitis)	Functional hemispherectomy ± callosotomy
Drop attacks	Callosotomy
Unknown focus or not surgically removable	Palliative techniques (Multiple subpial transections) <ul style="list-style-type: none"> <li>• <b><i>Vagus nerve stimulator</i></b></li> </ul>



# Specific cases

## 1. Temporal lobe epilepsy

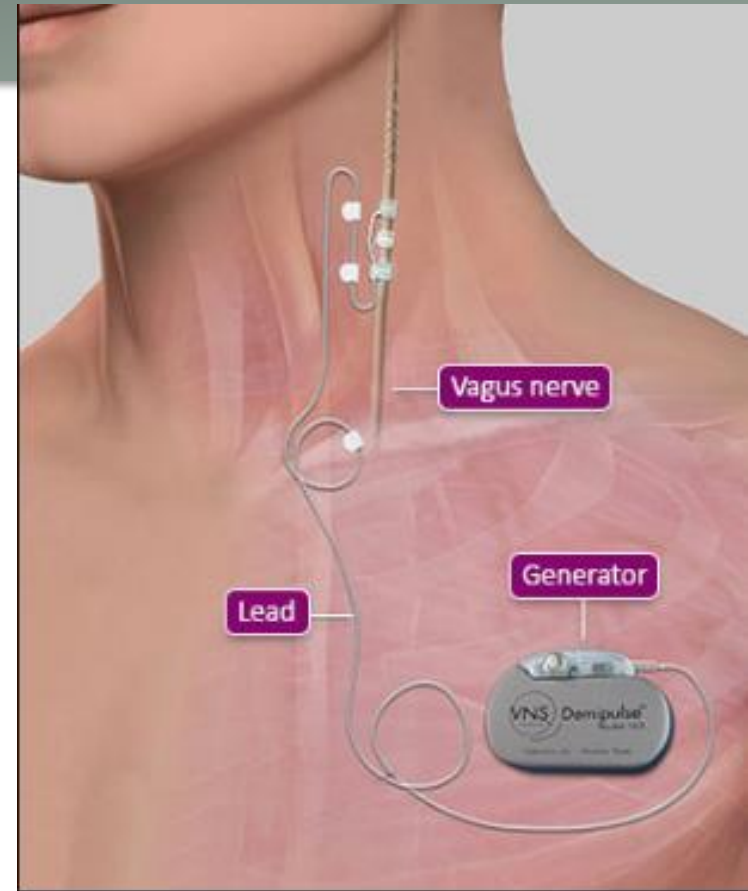
- 55 - 90% refractory to medical treatment
- Good response to surgical treatment (90 → 70%)
- Cause = mesial temporal lobe sclerosis
  - *Neuronal loss in amygdala and hippocampus*
- Removal of temporal lobe mesial part or temporal lobectomy
  - *Amygdala, hippocampus, parahippocampal gyrus ± temporal pole*



# Specific cases

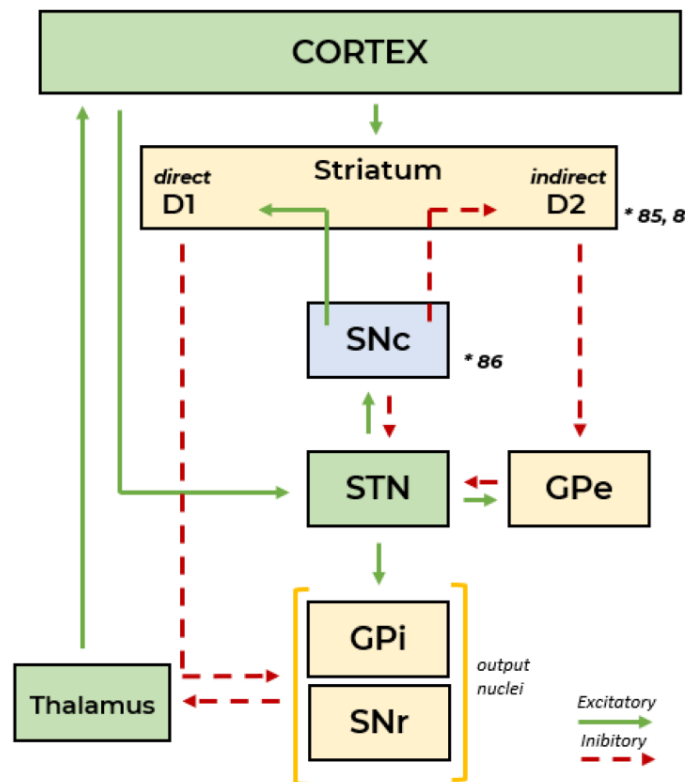
## 2. Vagus nerve stimulation (VNS)

- ↓ 50% seizure frequency in 50% patients
  - *Control seizures in <10% cases*
- Unknown or unresectable epileptic focus
- Low surgical aggressiveness, reversible
- Mechanism of action
  - *“Pacemaker for the brain” (sends regular pulses via vagus nerve)*
  - *Extra pulse via external stimulator*



# ABNORMAL MOVEMENTS

- Functional neurosurgery in movement disorders (abnormal extrapyramidal movements)
- Parkinson
  1. Dystonias
  2. Spasticity and movement disorders in diseases



Pain

Epilepsy

Movement disorders

Psychosurgery



# 1. Parkinson's disease

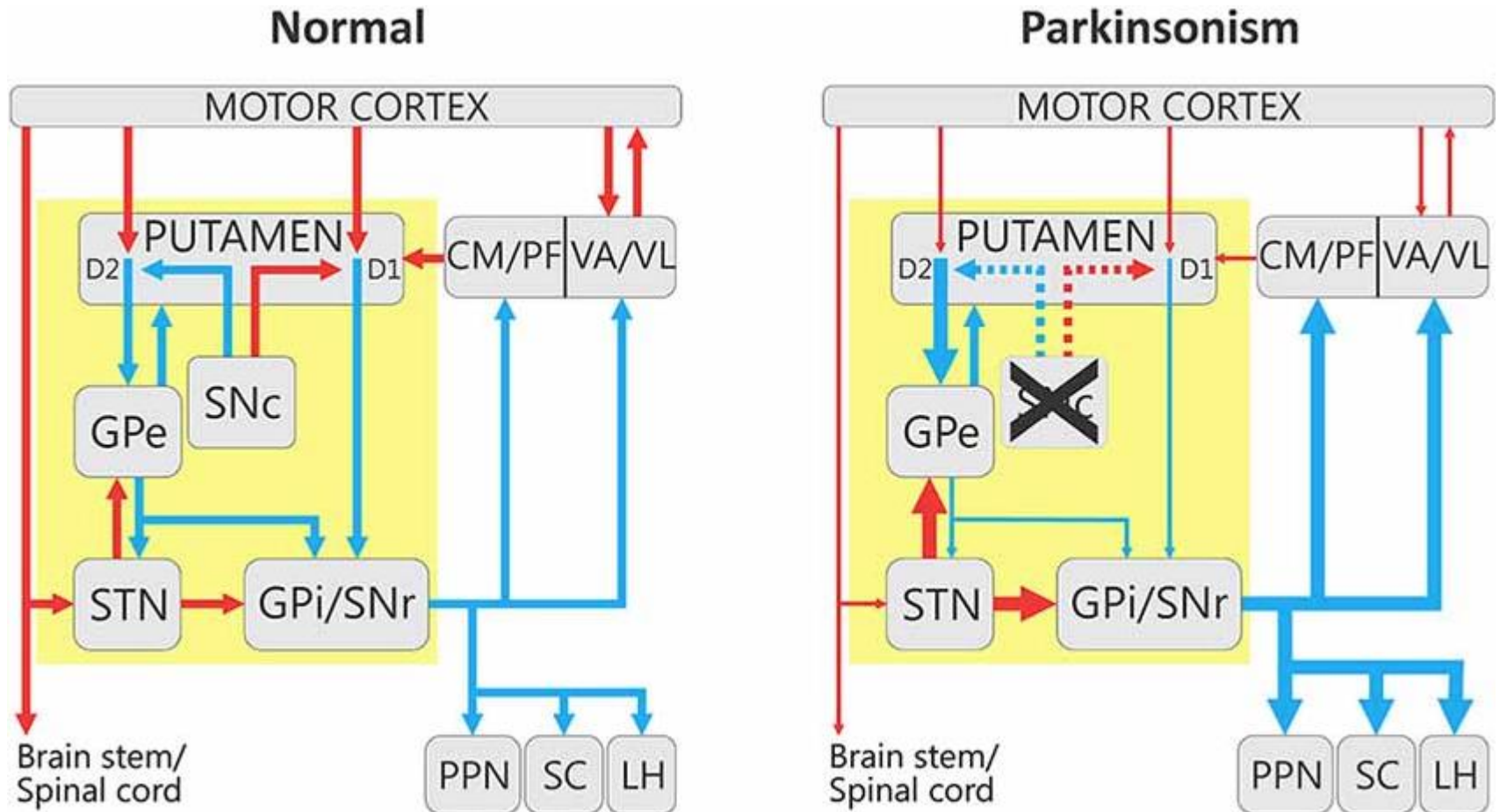
- Most frequent extrapyramidal disorder (prevalence 1% population > 50 years)
  - ↓ Dopamine + ↑ acetyl-choline in core nuclei (striated)
  - Medical treatment
    - *L-Dopa, ago-Dopamine, ⊖ Dopamine metabolism (Selegiline)*
    - *Anticholinergics (Biperiden)*
    - *Amantadine*
  - Neurosurgical treatment
    - *Ablative → Pallidotomy, thalamotomy*
    - *Deep brain stimulation, DBS (SUBTALAMUS, ventrolateral thalamus, internal globus pallidus)*

## OBJECTIVE:

↓ Inhibitory orders originating from extrapyramidal nuclei and blocking spinal motor nuclei and cortex



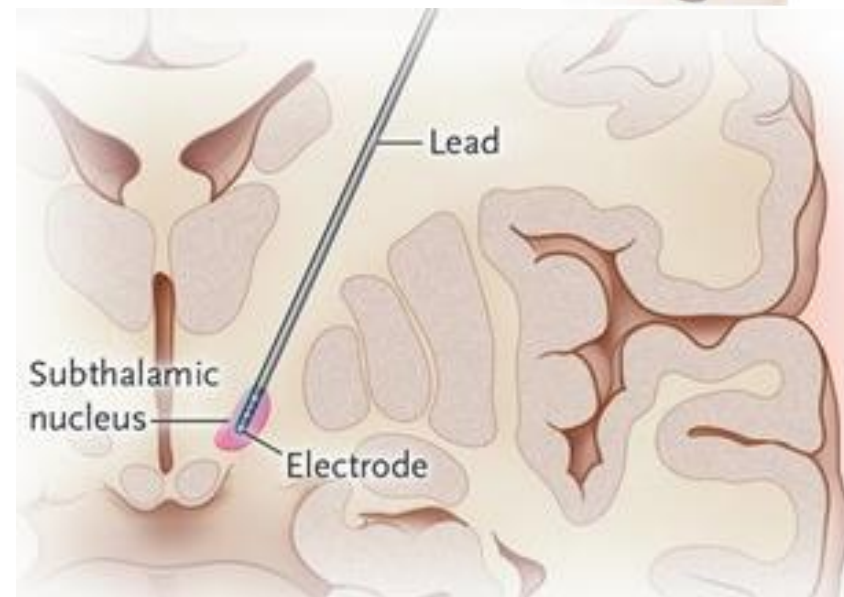
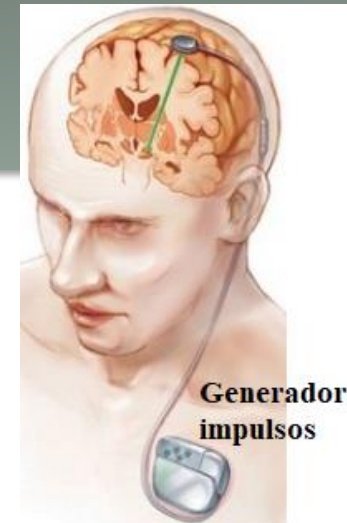
# 1. Parkinson's disease



*CM, centromedian nucleus of thalamus; D1 and D2, dopamine receptor subtypes; GPe, external segment of the globus pallidus; GPi, internal segment of the globus pallidus; LH, lateral habenula; PF, perifascicular nucleus of the thalamus; PPN, pedunculopontine nucleus; SC, superior colliculus; SNc, substantia nigra pars compacta; SNr, substantia nigra pars reticulata; STN, subthalamic nucleus; VA, ventral anterior nucleus of thalamus; VL, ventrolateral nucleus of thalamus.*

# 1. Parkinson's disease

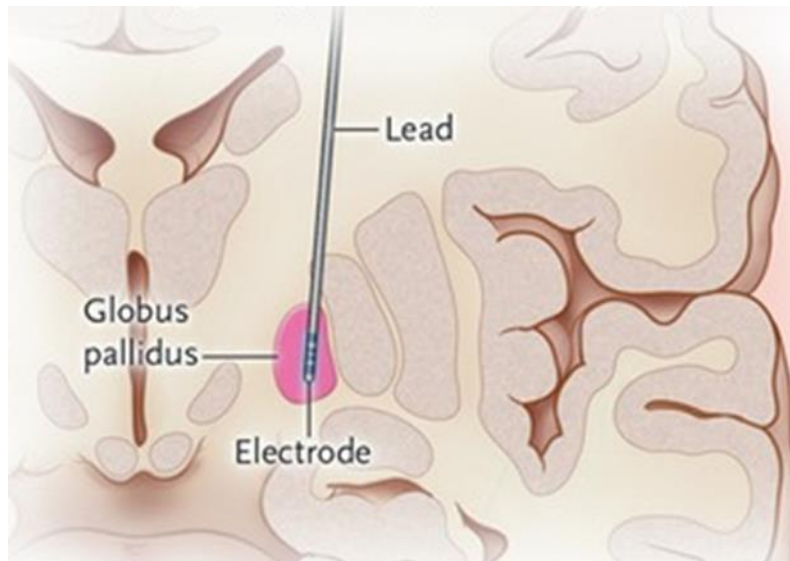
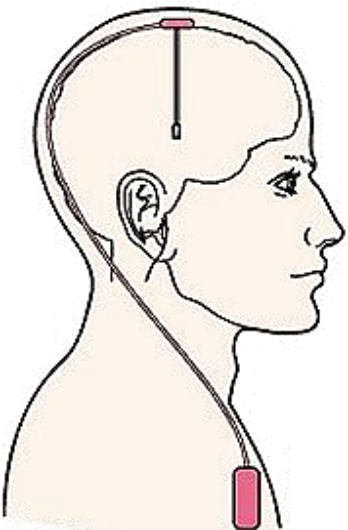
- Ablation
  - Pallidotomy, thalamotomy (ventrolateral nucleus)
  - Technique = thermal injury, radiosurgery, HIFU (ultrasound)
- DBS (deep brain stimulation)
  - Subthalamic nucleus (tremor, bradykinesia)
  - Candidates
    - *Good response to L-Dopa, with >5 years of evolution (to rule out other parkinsonism)*
    - *Absence of severe cognitive impairment*
  - Reversible, bilateral, adaptable to each patient and disease evolution





## 2. Dystonia

- Indication
  - Pain and severe motor symptoms refractory to medical treatment
- Neurostimulation (neuromodulation)
  - Bilateral stimulation of the GPi (internal globus pallidus)



*Dystonia = involuntary and sustained muscle contractions that result in repetitive twisting and movement*



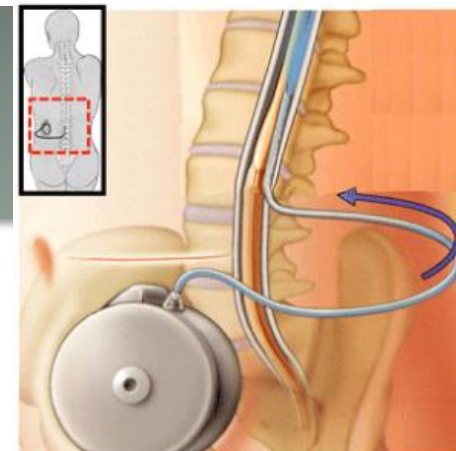
# 3. Spasticity

## • Indication

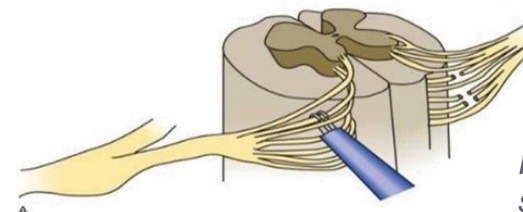
- Spasticity refractory to medical treatment
  - *When oral medication does not reach adequate levels in the CNS to relieve symptoms*

## • Therapeutic options

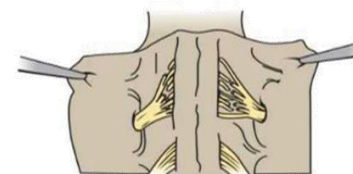
- Intrathecal space continuous infusion pump (Baclofen)
- Selective posterior lumbar rhizotomy
  - *Spastic diplegia*
- Selective neurectomy
- Section of motor branches of the nerve that causes painful muscle spasms



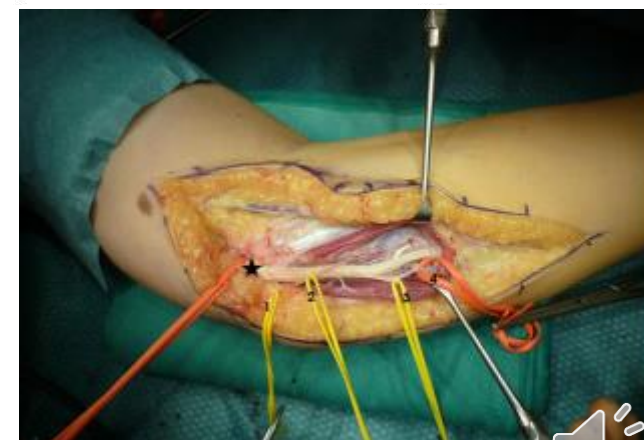
Baclofen pump



Posterior selective rhizotomy

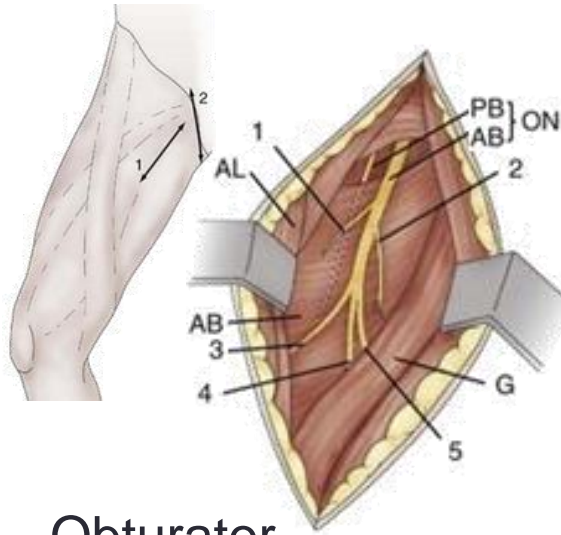


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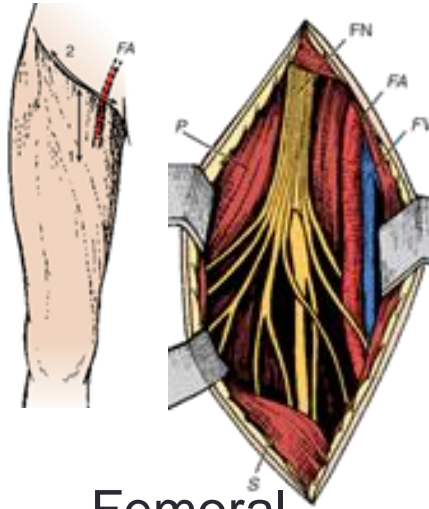


Microdissection of the four motor branches of the \*ulnar nerve (1-3 ulnar flexor branches of the carpus, four superficial flexor fingers)

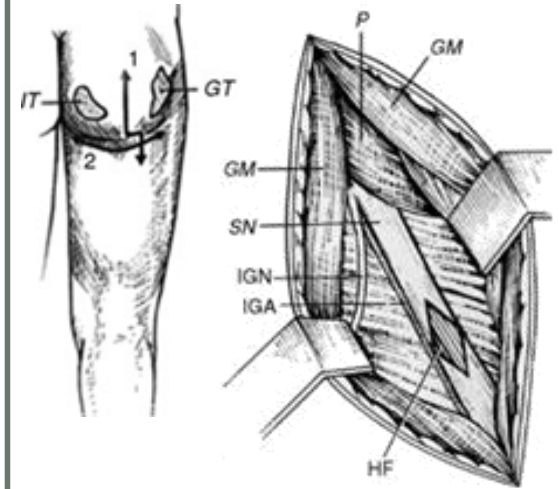
# Neurectomy



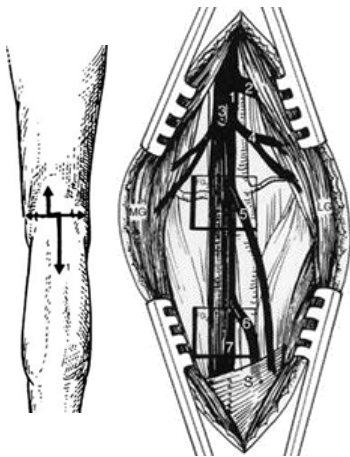
Obturator



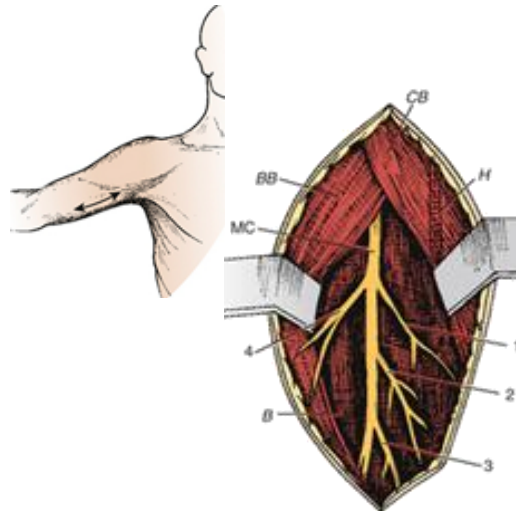
Femoral



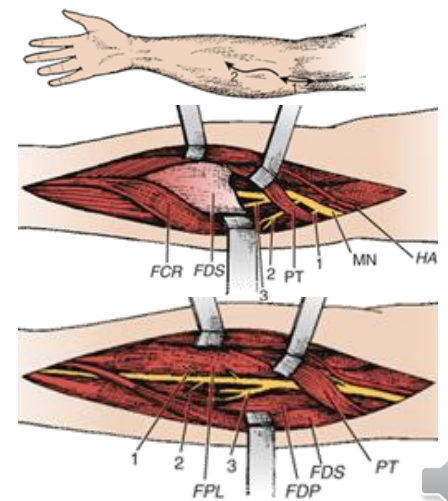
Sciatic



Tibial posterior



Muscle-cutaneous



Median



# PSYCHOSURGERY

- Indication: psychiatric patients with
  - ↓response to drugs
  - who pose serious problem for patient, family, caregivers
  - who will follow psychiatric treatment after surgery
- Techniques: can be applied to the same targets by either
  - Ablation
  - Stimulation



Pain

Epilepsy

Movement  
disorders

Psychosurgery



# Psychosurgery

- Ablation (injury)

- Thermocoagulation

- *Cingulotomy (obsessive compulsive disorder or OCD, depression)*
    - *Capsulotomy (OCD, depression)*
    - *Subcaudate tractotomy (OCD)*
    - *Limbic leukotomy (OCD)*

- Radiosurgery

- *Capsulotomy (OCD)*

- Stimulation

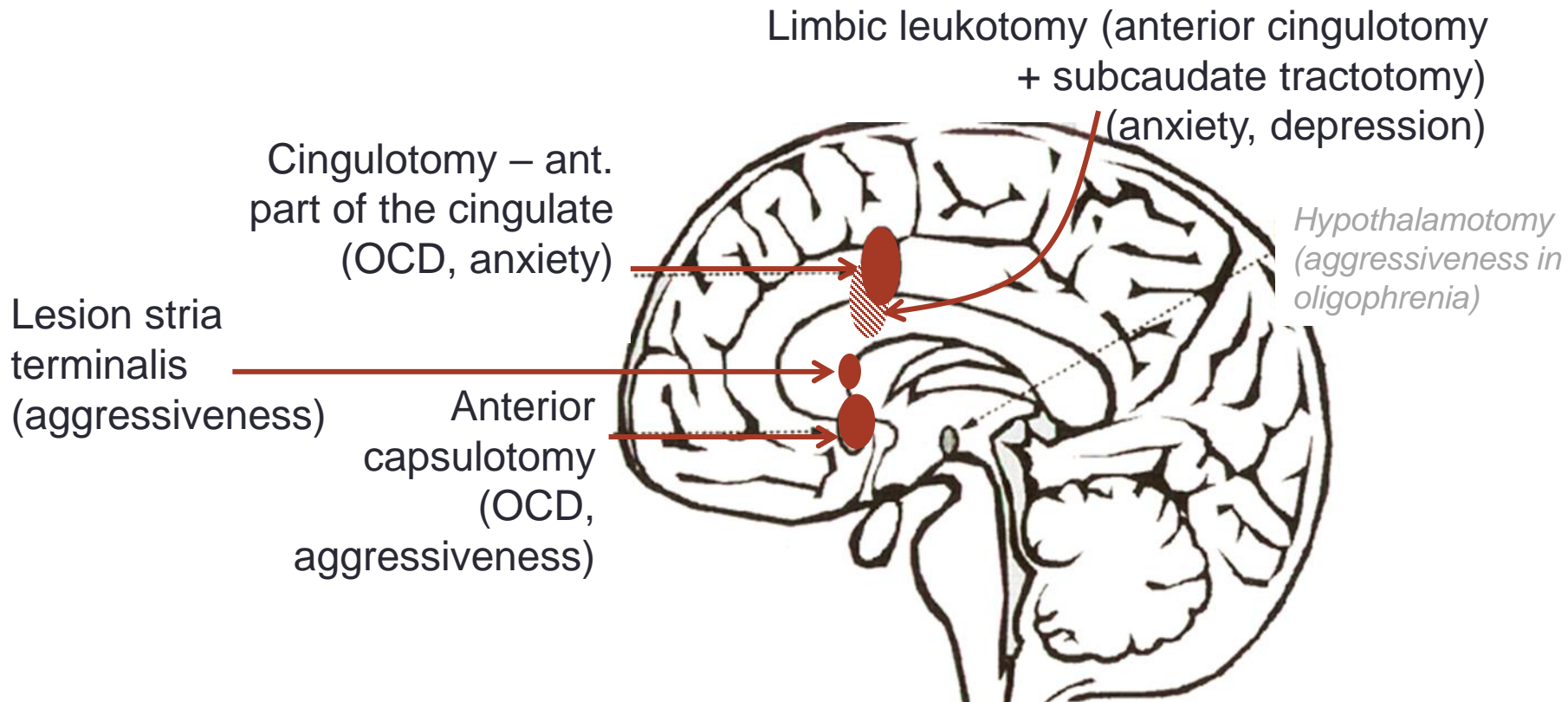
- Cortical and vagal stimulation (depression)

- Deep brain stimulation

- *Anterior arm internal capsule (OCD, depression, anorexia)*
    - *N accumbens (OCD, depression, anorexia, addiction)*
    - *Others*

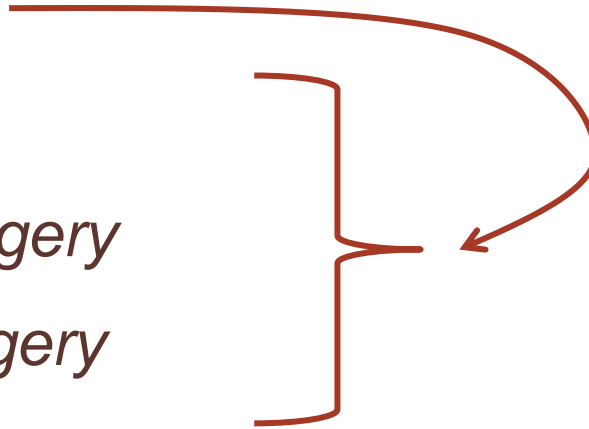


# Psychosurgery



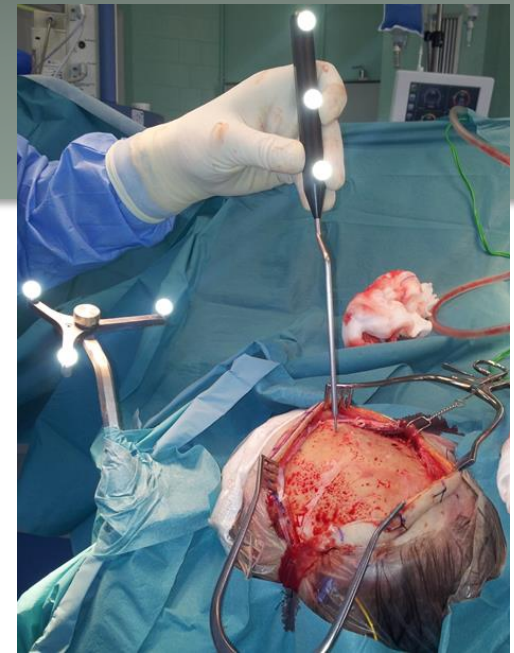
# NEUROSURGERY ADVANCED TECHNIQUES

1. *STEREOTAXY*
2. *Neuronavigation*
3. *Image-guided surgery*
4. *Robotic neurosurgery*
5. *Neural prostheses*



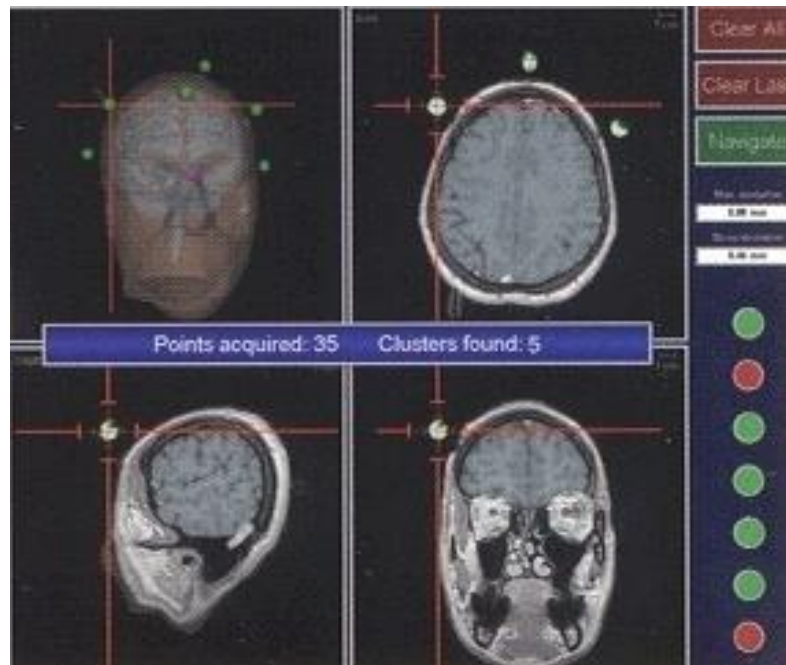
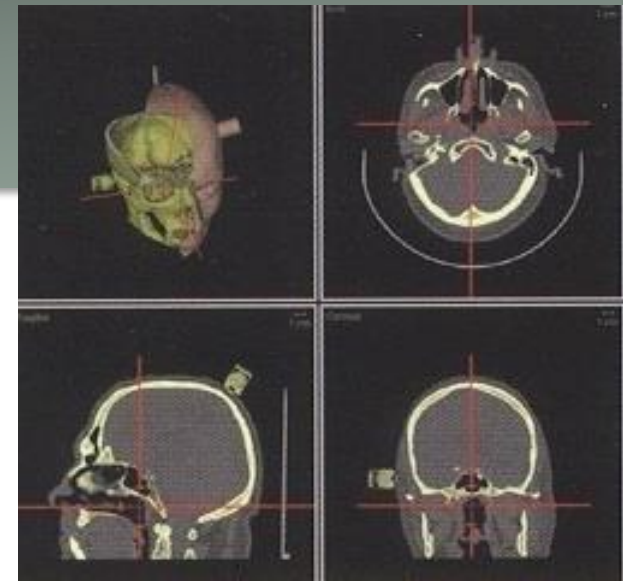
## 2. Neuronavigation

- Stereotaxy with no head frame
- Integrates neuroimaging studies with the movements of surgical microscope
- Demands specific equipment





# 2. Neuronavigation

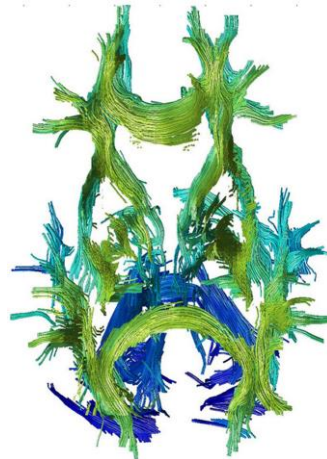
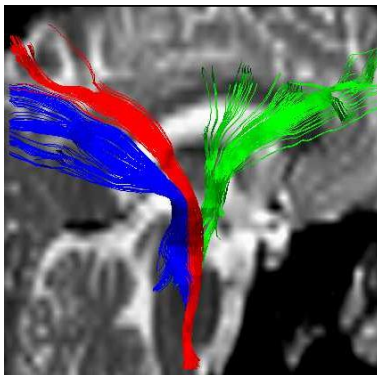
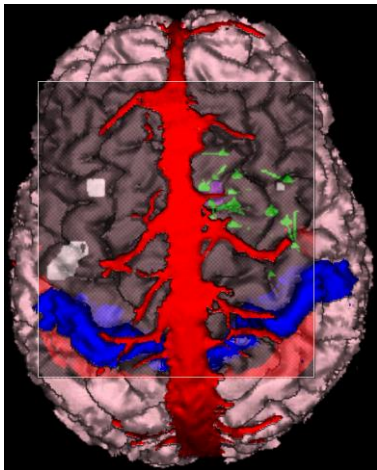


# 3. Image-guided surgery

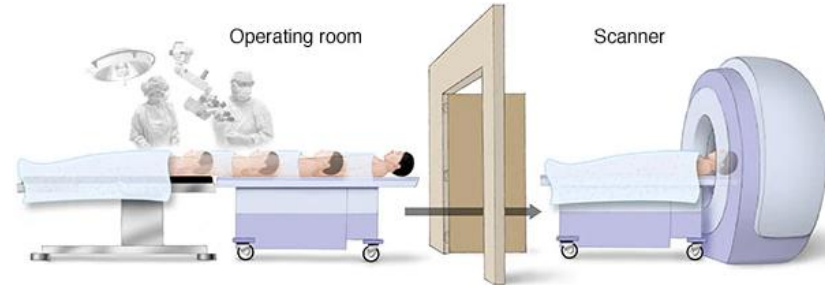
- Preoperative image
  - MRI → functional MRI and tractography



*Operative planning (lesion, pathways, tracts, eloquent areas)*

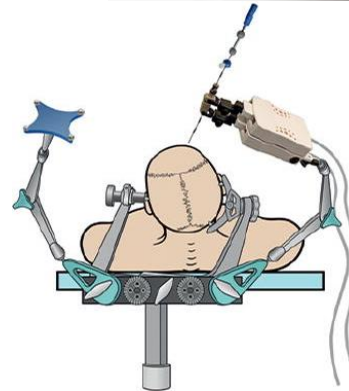
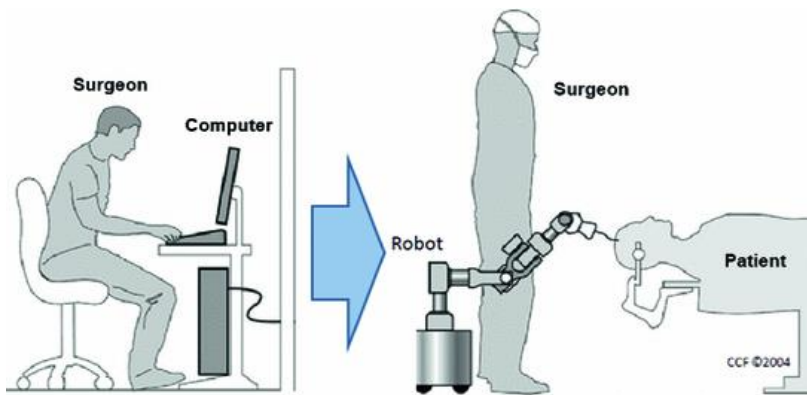


- Intraoperative imaging
  - Intra-op CT or MRI → control of surgical action → ↑Precision and degree of resection
  - Hybrid operating room



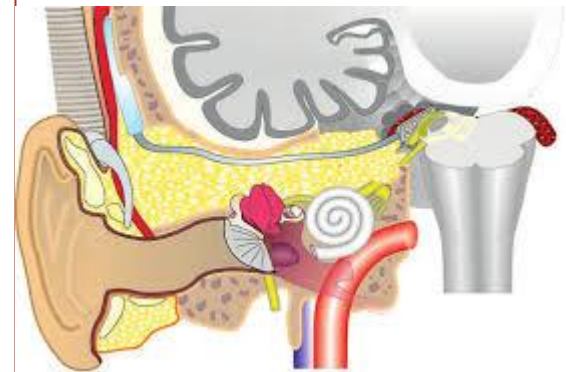
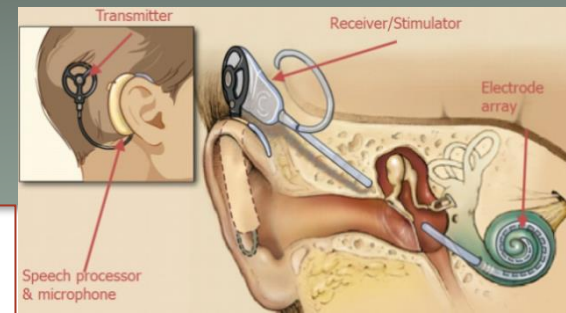
# 4. Robotic neurosurgery

- Increase precision (= reduce complications)
- Very costly
- Limited use
  - Epilepsy surgery
  - Abnormal movement surgery
- Future (NOT YET)
  - Telesurgery (army/navy/space travels)



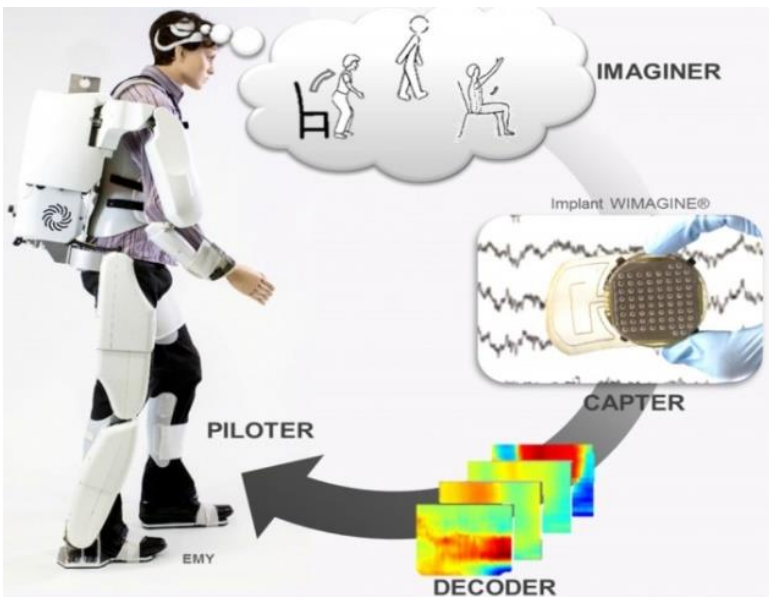
# 5. Neural prostheses

- Cochlear implant / brainstem
- Visual prosthetics
- Motor prostheses
  - Robotic prosthetics and smart implants
  - Exoskeletons (exist for rehabilitation and heavy load lifting)



Cochlear (top) and brainstem (bottom) auditory implants

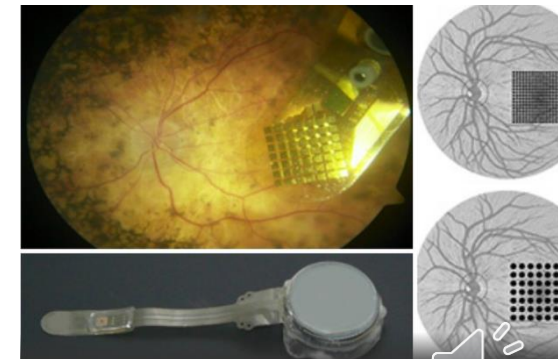
## Exoskeleton



## Robotic prostheses and smart implants



## Visual chip (retina)



# SUMMARY KEY CONCEPTS TOPIC 9

- Refractory chronic pain
  - Multiple options, but adjustable and reversible neurostimulation
  - Fifth nerve neuralgia → surgical decompression is the most successful
- Neurosurgical treatment for refractory epilepsy
  - Many options, mediocre results except in temporal lobe epilepsy
- Neurosurgical treatment movement disorders
  - Parkinson's disease → neurostimulation improves symptoms but does not stop progression
  - Dyskinesias → symptomatic relief and quality of life improvement
  - Spasticity → facilitates rehabilitation and functional recovery (gait)
  - Psychosurgery → only desperate cases
- Advanced techniques in neurosurgery
  - Stereotaxy → accuracy to reach targets in CNS
  - Neuronavigation → guide for surgeon and comfortable for patient
  - Image-guided surgery → safe and effective neurosurgery, but very expensive
  - Robotics → future, will allow precision and telemedicine
  - Neural prostheses → restoration of lost neural functions



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# QUESTIONS?



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