EANS/UEMS European examination in neurosurgery

Variants of questions with answers (compilation - Vyacheslav S. Botev, Department of Neurosurgery, M.Gorky Donetsk National Medical University)

EPILEPSY SURGERY

Questions

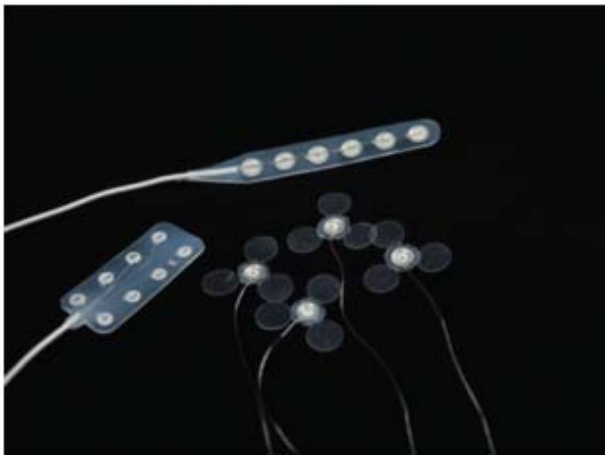
I. Pathophysiology: Seizure Focus

1. What are the characteristics of the three classes of neurons comprising an epileptic focus?

II. Preoperative Workup

2. What portion of patients with epilepsy are seizure-free on their first antiepileptic drug (AED)?
3. What portion of patients with epilepsy are seizure-free on their second antiepileptic drug (AED)?
4. What portion of patients with epilepsy are refractory to medical therapy?
5. Does the number of seizures that occurred prior to the initiation of therapy influence response to therapy?
6. What are the phases in preoperative workup of patients with epilepsy?
7. What imaging methods are useful in the characterization of the seizure focus?
8. What are the major limitations of surface EEG recordings (in comparison to invasive monitoring)?
9. What is the purpose of the Wada test, and who developed it?
10. What is another name for the Wada test?
11. What intervention is performed during the Wada?
12. What are some semiinvasive EEG recording electrodes?
13. What are the invasive electrodes used in EEG recording?
14. How are foramen ovale electrodes placed?
15. What is the purpose of foramen ovale electrode placement?
16. What are peg electrodes?
17. What are depth electrodes?
18. How are depth electrodes typically placed?
19. What are subdural strip electrodes?
20. What type of activity are subdural strip electrodes often used to monitor?

21. Where are subdural strip electrodes placed for monitoring of the temporal lobe?
22. How are subdural strip electrodes placed?
23. What electrodes are shown in figure below?



24. What electrodes are shown in figure below?

25. What are subdural grid electrodes?
26. What structures are often monitored with subdural grid electrodes?
27. How are subdural grid electrodes placed?
28. What are some of the drawbacks or risks of using subdural grid electrodes?
29. How may the drawbacks of subdural grid electrodes, as listed above, be mitigated?
30. What are some other complications of using subdural grid electrodes?

III. Intraoperative Recordings

31. When are intraoperative recordings performed?
32. What is this recording technique called?
33. What is the purpose of intraoperative ECoG recordings?
34. What are intraoperative recordings not useful for?
35. What information is provided by ECoG recording?

36. How does one determine the location of the central sulcus electrophysiologically?
37. What is the ideal line of resection?

IV. Surgical Principles

38. What three general types of surgical procedures are presently applied in the treatment of epilepsy?
39. What is the extent of resection of temporal lobe on the dominant and nondominant sides?
40. What is the objective of selective amygdalohippocampectomy?
41. What are the various approaches described to perform this procedure?
42. Describe the highlights of the technique for selective amygdalohippocampectomy employing an anterior (“proximal”) approach, including the (1) craniotomy type, (2) exposure approach, and (3) tissue removed.
43. What types of precision ablative surgery are effective in treating seizures?
44. What are the scales used to measure outcome?
45. Describe the first of these two scales.
46. Describe the more recent of these two scales.

V. Epilepsy Surgery: Neuromodulation

47. What was the first neuromodulatory therapy that was FDA approved for the treatment of epilepsy?
48. How effective is VNS in the treatment of epilepsy?
49. What other types of neuromodulatory stimulation therapies hold promise in treating epilepsy?
50. What are the major targets of open-loop neuromodulation that have shown some efficacy in treating epilepsy?
51. What is responsive neurostimulation (RNS)?
52. What is the origin and current status of RNS for epilepsy?
53. What is closed-loop neuromodulation (CLN)?
54. What is the origin and current status of CLN for epilepsy?
55. How effective is open-loop stimulation of the anterior nucleus of the thalamus in treating seizures?
56. What are the benefits of neuromodulation over resective or disconnective surgical techniques?
57. What is multiple subpial transection?

Epilepsy Surgery
Answers

I. Pathophysiology: Seizure Focus

1. Three classes of neurons (Talairach and Bancaud):

Class I neurons: intrinsically abnormal “epileptic neurons,” characterized by paroxysmal depolarization shift (PDS).

Class II neurons: labile neurons, which, depending on their “physiological occupation,” may dis charge with a normal pattern or an abnormal burst index. (They can be “recruited” by class I neurons to discharge abnormally. If occupied with appropriate physiological stimulus, they can resist recruitment into abnormal activity.)

Class III neurons: neurons with a normal burst index.

II. Preoperative Workup

2. 47% (seizure-free in this context is defined as having had no seizure in a 1-year period).

3. 13% (seizure-free in this context is defined as having had no seizure in a 1-year period).

4. 40%
5. Yes. Patients in whom ≥20 seizures have occurred are less likely to respond to AEDs.
6.
Phase I:
• Imaging
• Scalp EEG/video EEG (recorded video synchronized with EEG)
• Neurophysiological testing
Phase II:
• Invasive monitoring
• Subdural grids and strips
• Depth electrodes
• Wada test

7.

1. Interictal MRI: to assess abnormalities of brain structure. It is sensitive and specific for neoplasia, dysplasia, vascular malformations, and hippocampal sclerosis (gold standard for diagnosis and for quantifying volume).

2. Interictal proton magnetic resonance spectroscopy (MRS): to study reductions in N-acetyl-aspartate (NAA) as a measure of neuronal integrity (by comparing NAA levels with choline or creatine). A decreased NAA-to-choline ratio is found in lesions such as hippocampal sclerosis (HS).

3. Ictal/interictal single-photon emission computed tomography (SPECT): to characterize cerebral perfusion during and after a seizure, with subtraction of ictal-interictal images. It is sensitive for lateralizing seizure focus.

4. Interictal FDG positron emission tomography (PET):
a. With FDG (fluoro-2-deoxyglucose) to study metabolism. Anterior temporal lobe hypometabolism and extratemporal hypometabolism provide accurate lateralization in temporal lobe epilepsy (TLE).
b. With flumazenil to study density of central benzodiazepine receptors (cBZRs)

5. Magnetoencephalography (MEG): to detect small electrical currents produced by neurons. MEG is free of distortions caused by the scalp and cranium as well as by irregularities secondary to masses and previous surgery.

8.
1. Scalp EEG is less spatially precise than invasive monitoring.
2. Scalp EEG signals have a lower amplitude and bandwidth (filtered by skull, CSF, dural layers) and are less sensitive in the early detection of abnormal neural activity characterizing the onset of a seizure.
3. Scalp EEG recordings contain more noise, including muscle and movement artifact, each of which can obscure signals of interest.

9. The Wada test is used to assess language and memory localization. It was developed by Juhn Wada in 1949 to determine hemispheric dominance for language.

10. Intracarotid sodium amobarbital test (IAT).
11. Injection of sodium amobarbital into the ICA.
12. Semiinvasive chronic recording electrodes include:
1. Foramen ovale (FO) electrodes
2. Peg electrodes.

13.
1. Subdural strip and grid electrodes
2. Depth electrodes.

14. Foramen ovale electrodes are placed using the same techniques used for placement of a lesioning electrode in the treatment of trigeminal neuralgia.

15. Foramen ovale electrodes are used for recording from the mesiobasal temporal lobe (TL) and are therefore helpful in lateralizing seizure onsets to the mesial portion of the TL.

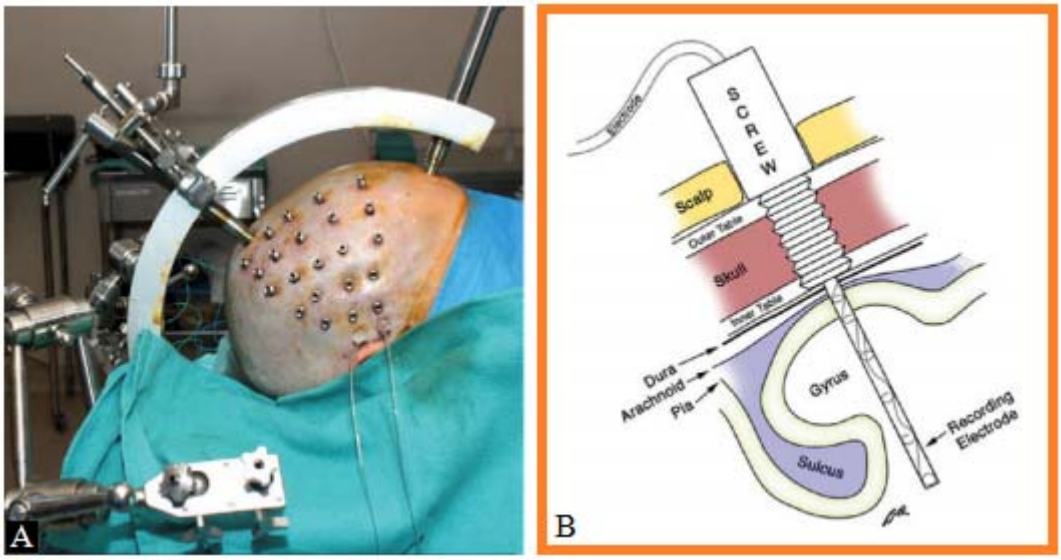
16.

Single contact epicortical electrode (below) and skull peg (above). The electrode fits inside the skull peg and is locked onto the peg with a screw cap. The electrode tip contacts the dura over a specific anatomical structure targeted with neuronavigation.

Peg electrodes are, as their name implies, peg-shaped electrodes that are inserted into holes in the skull. They provide epidural recordings and are helpful when the precise location of a focus is not yet determined and can be placed to further determine where to implant strip, grid, or depth electrodes. Peg electrodes may also be placed contralateral to these other conventional electrodes to rule out contralateral seizure activity.

17. Depth electrodes are cylindrical electrode arrays with a diameter of slightly more than 1 mm that are implanted into deep nuclei and structures, usually the amygdala and hippocampus.

18. Depth electrodes are implanted using stereotactic techniques through a burr hole. The hippocampus, a common recording target, is often approached laterally (orthogonally) via a burr hole in the temporal bone (more common) or posteriorly (longitudinally) via a burr hole in the occipital bone.



(A) The Free Guide is attached to the star-burst base of the C-clamp. In addition to two depth electrodes inserted to the mesial temporal structures, a grid pattern of hollow bone pegs are in place, each of which will hold an epicortical electrode.

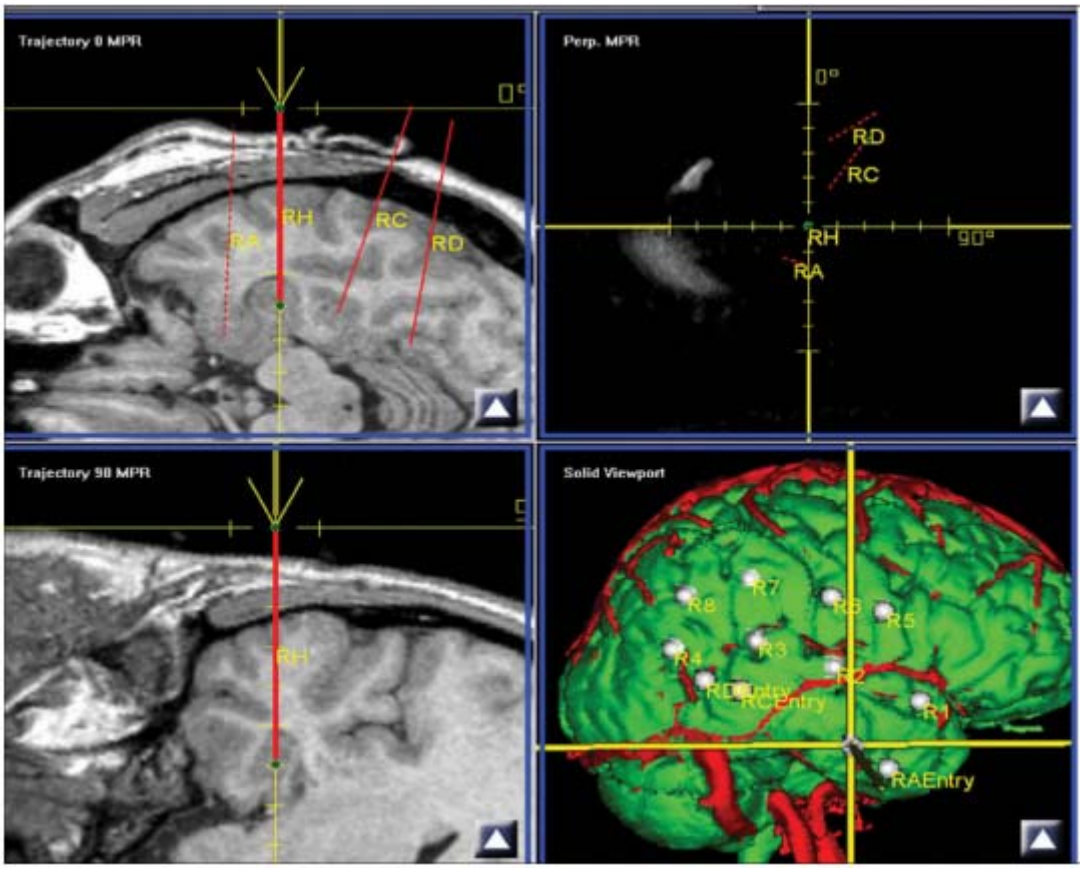
(B) A multicontact depth electrode is inserted through the bone peg to an intragyral target. The electrode is locked into the bone peg with a cap to prevent movement after insertion.

19. Subdural strip electrodes are linear arrays of electrodes embedded in a flexible silicone strip, with each electrode electrically connected to a wire that emanates as a conductor within a wire bundle from one side.

20. Subdural strip electrodes are used to monitor neocortical activity.

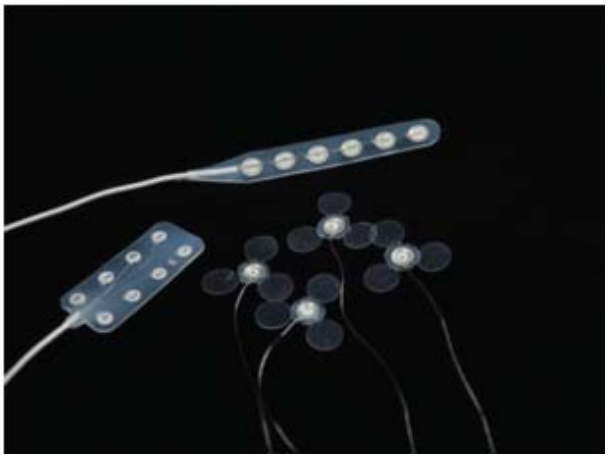
21. Three are often used:
1. An anterior temporal electrode is inserted such that the distal electrode curves around the tip of the temporal lobe.
2. A middle temporal electrode is inserted to curve along the inferior surface of the temporal lobe, with the most distal contact overlying the parahippocampal gyrus.
3. A posterior temporal electrode is inserted posteriorly to course along the middle temporal gyrus and to pass posterior to the end of the sylvian fissure.

22. Subdural strip electrodes are commonly placed using a burr hole. Stereotactic navigation may be used to guide electrode placement. They are advanced in the subdural space, and by virtue of the flexibility of the silicone, conform to the brain surface.



Neuronavigation plan for depth and surface electrode implantation. The MRI was acquired with double-dose gadolinium contrast. Both during creation of the implantation plan and prior to depth electrode insertion in the operating room, the neuronavigation virtual probe confirms an avascular pathway for insertion of the actual electrode.

23.



1. Subdural strip electrodes (top, 1×6 array)
2. Subdural grid electrodes (left, small 2×4 array)
3. Intraoperative (IOM) mapping electrode (bottom right, single electrode with cloverleaf tab design for stabilization during mapping).

24.

Depth electrodes (intracranial recording electrode array on bottom, connector array on top, plug shown attached on leftmost array).

25. Subdural grid electrodes are flat two-dimensional arrays of electrodes embedded in a flexible silicone sheet, with each electrode electrically connected to a wire that emanates as a conductor within one or more wire bundles.

26. Subdural strip electrodes are variably used to monitor activity of portions of the frontal, temporal, parietal, and occipital lobes. They are well suited for monitoring neocortex on the convexity of the cerebrum but are not easily placed on the basal surface of the temporal lobe.

27. Placement of subdural grid electrodes requires a craniotomy, and the flexibility of the grid allows the electrode array to assume a curvature that conforms to up to 10 cm 2 of the cortical surface of the convexity.

28. Drawbacks and risks inherent to subdural grids:
1. Their large size can exert mass effect on the brain.
2. The large size of the foreign material of a grid electrode presents a greater infection risk (>1%) than that of strips (1%).
3. Infection risk increases with surface area and with duration of implantation. Duration is limited to 4 weeks (or 30 days, the FDA-approved maximal duration).

29. Drawbacks and risks from subdural grids may be minimized by the following means:

1. Mass effect may be compensated by:
a. Administering mannitol prior to implantation

b. Creating a duraplasty (with extra intradural volume)
c. Loosely attaching the craniotomy bone flap with suture instead of with rigid craniofacial plating

2. The infection risk may be minimized by the following means:
a. Tunneling electrode leads subcutaneously as far from the implant as possible
b. Anchoring leads to skin using a purse-string suture (which also functions to seal the opening)
c. Clipping the entire head (helpful for postoperative hygiene during implantation periods, which may last up to 4 weeks)
d. Perioperative antibiotics

30. Other complications of subdural grids include:
1. Vascular injury (e.g., hemorrhage) (approximately 1%)
2. Neurological damage (<1%)

III. Intraoperative Recordings

31. During the planned craniotomy for resection.
32. Electrocorticogram (ECoG).
33.
1. To determine the extent of irritable cortex to be resected, which can be checked using stimulation followed by recording of “afterdischarges”
2. Determine boundaries of eloquent cortex.

34. Because of their short duration, intraoperative recordings are not useful for seizure recordings.

35.
• Location of primary focus
• Regions of secondary spread of seizure activity
• Eloquent cortical regions:
1. Motor and sensory areas
2. Speech areas

36. Using somatosensory evoked potentials (SSEPs). Specifically, an electrical stimulus may be delivered to a peripheral nerve, such as the median nerve. Signals are recorded over the presumed area of sensorimotor cortex. A phase reversal of signals recorded from adjacent electrodes signifies the location of the central sulcus.

37. An ideal line of resection includes the seizure focus as well as tissue that is found to be secondarily recruited into seizure activity but excluding eloquent cortex.

IV. Surgical Principles

38.
1. Resection or ablation (temporal lobectomy)
2. Disconnection (corpus callosotomy, subpial resection)
3. Neuromodulation (VNS is in widespread use; DBS and other forms of modulation are undergoing clinical trials)

39. As measured along the sylvian fissure from anterior tip:
1. Dominant temporal lobe (several strategies):
a. 4.5 cm of middle temporal gyrus, with less from superior temporal gyrus
b. 3.5 cm of middle temporal gyrus, with none from superior temporal gyrus
c. removal of suspected involved tissue, with a 2-cm border of spared tissue bordering eloquent areas
2. Nondominant temporal lobe: 5 cm.

40. Seizure freedom with an improved side-effect profile in comparison to traditional temporal lobectomy.

41.
1. Transcortical
2. Transinsular
3. Transsylvian-transcisternal
4. Subtemporal

42.
1. Craniotomy: pterional
2. Exposure: transsylvian (classically described by Yasargil, others have been described as well)
3a. Subtotal removal of the amygdala
3b. Removal of anterior two thirds of hippocampus and parahippocampal gyrus

43.
• Multiple subpial resection: used when seizure focus resides in unresectable cortex, usually in eloquent cortical regions (motor, sensory, speech, memory, vision)
• Corpus callosotomy

44.
1. Engel rating scale
2. International League Against Epilepsy (ILAE) rating scale.

45. Engel rating scale:

Class I: free of disabling seizures
A: Seizure-free
B: Nondisabling simple partial seizures only
C: Free of seizures for the last 2 years
D. Convulsions with AED discontinuation only

Class II: rare disabling seizures
A: Initially free, rare seizures now
B: Rare disabling seizures (RDSs)
C: RDSs during the past 2 years
D: Nocturnal seizures only

Class III: worthwhile improvement
A: Worthwhile seizure reduction
B: Prolonged seizure free periods, not <2 years

Class IV: no worthwhile improvement
A: Nonsignificant seizure reduction
B: No appreciable change
C: Seizures worse

(Note: the Engel scale is assessed at any given point in time. This time is not standardized, may vary among studies, and must be specified.)

46. International League Against Epilepsy (ILAE) rating scale:
Class 1: Completely seizure-free; no auras
Class 1a: Completely seizure-free since surgery; no auras
Class 2: Only aura, no other seizures
Class 3: One to three seizure days per year; may have auras
Class 4: Four seizure days per year or up to 50% reduction in seizure days from baseline; may have auras
Class 5: Less than 50% reduction in number of seizure days from baseline, or an increase in seizure days of up to 100% from baseline
Class 6: Increase in number of seizure days from baseline of more than 100%

V. Epilepsy Surgery: Neuromodulation

47. Vagus nerve stimulation (VNS) was approved in July 1997 as an adjuvant therapy in patients over age 12 with partial-onset seizures refractory to antiepileptic drugs.

48. A 50% reduction in seizure frequency is achieved in approximately one third to one half of patients (a greater than 50% seizure frequency reduction was found in 38% of patients at 14 weeks of VNS).

49.
- Open-loop stimulation
- Responsive neuromodulation
- Closed-loop neuromodulation.

50.
1. VNS
2. Stimulation of the anterior nucleus of the thalamus
3. Hippocampus stimulation

51. RNS is a form of stimulation in which electrical energy is delivered upon detection of a suspected seizure.

52. The RNS system is based on the notion of termination of after discharges demonstrated by Lesser in the 1990s. This technology is under clinical trials.

53. Closed-loop neuromodulation is a form of neuromodulation in which the delivered signal is a function of a measured parameter.

54. A predictive and closed-loop technology is being developed and is in clinical trials.

55. In investigational studies at 2 years postimplantation, bilateral stimulation of the anterior nucleus of the thalamus has been shown to cause a 56% median reduction in seizure frequency, and 54% of patients had a seizure reduction of at least 50%.

(Note: this is an investigational study and this method is currently not approved by the FDA.)

56. By its reversible nature, neuromodulation avoids the potential for permanent neurological deficit. In the case of temporal lobe epilepsy, neuromodulation offers the potential to avoid the risk of memory and speech deficits.

57. Multiple subpial transection is a disconnective technique described as a treatment for seizures arising from the sensorimotor cortex.