What is an epilepsy invasive evaluation?
Andreas Alexopoulos, MD

Welcome. This web cast is designed to describe some of the details of the pre-surgical invasive evaluation at the Cleveland Clinic Epilepsy Center.

The rationale for surgical management of epilepsies that are difficult to control with medications is to reduce or eliminate the tendency of the brain to generate uncontrolled seizures. Following successful removal of the epileptic focus patients are able to not only regain control of their seizures, but also of their independence employment and quality of life.

We know that the best surgical outcome is attained after precise localization of the seizure focus. When noninvasive electroencephalography (EEG) monitoring is insufficient, invasive EEG monitoring (by means of subdural grid or depth electrodes) is sometimes necessary.

Patients in whom epilepsy surgery is being considered undergo a number of tests. These include video-electroencephalography (video-EEG) monitoring, MRI and other neuroimaging (for example PET, SPECT) or neurophysiological testing (for example magnetoencephalography, MEG). Before considering epilepsy surgery or sometimes recommending an invasive evaluation our expert epileptologists, neurosurgeons, neuroradiologists, and other investigators carefully review the results of all these studies in our multidisciplinary patient management conference.

What are the indications for an invasive evaluation?
- to help localize the epileptic focus, when noninvasive tests do not adequately localize the area of interest or provide conflicting data
- to help localize the focus in patients with a normal MRI
- to define the focus in relation to certain structural lesions
- to define the relationship of the focus to essential functional areas of the brain (such as motor or sensory cortex)
- to help determine the dominant epileptic area in some patients, who have multiple abnormalities in more than one brain region

Broadly speaking there are two different techniques and types of electrodes being used to perform invasive recordings:

(1) Subdural electrodes provide coverage of large areas of neocortex and are ideally suited for evaluating certain patients with intractable epilepsy, and to functionally map critical cortex. Subdural grid electrodes can be used for recording as well as for stimulating brain tissue to identify the underlying function (e.g., language areas, sensation or motor function). Placement of these electrodes requires a craniotomy (i.e. surgical opening of the skull). The electrodes remain in place for several days and up to 1
to 2 weeks, as needed, to record seizures and map brain functions. They are then removed and epilepsy surgery is performed if the findings are favorable for such surgery. In some patients in whom invasive monitoring fails to locate the seizure focus, re-investigation with invasive electrodes (subdural or depth electrodes depending on the clinical scenario) can identify the origin of seizure and allow successful surgical treatment.

Brain Mapping with Electrical Stimulation Cortical stimulation entails delivering a short duration electrical current to the brain via the invasive electrodes to determine the function of this particular brain region that is being stimulated. Often patients are asked to perform a task such as speaking during cortical stimulation to see if stimulation interferes with the performance of that task. Functions that can be tested for using this technique include language, vision, movement, and sensation.

(2) Depth EEG Electrodes and stereo-EEG are those electrodes, which are placed within the substance of the brain. The neurosurgeon places depth electrodes through small “burr holes” and with great accuracy using a stereotactic frame. Utilizing this approach the neurosurgeon is able to place several depth electrodes in targeted brain areas, which are determined based on the results of all the presurgical noninvasive studies. Careful planning before placement of these electrodes is very important and requires a multidisciplinary discussion of the patient’s noninvasive findings involving epileptologists, neurosurgeons, radiologists, neurophysiologists and others. The recordings of the intracranial electrodes are then monitored continuously in the epilepsy-monitoring unit in order to precisely locate the seizure source, if possible. When the seizure onset is localized, a surgical resection and a good seizure outcome may be possible.

Invasive EEG monitoring with subdural grid or depth electrodes has its own limitations related to placement of the electrodes and interpretation of the recordings. Placement of these electrodes requires an additional surgery, and carries a risk for complications such as infection, bleeding and stroke – most of these complications are transient and do not result in long-lasting deficits.

With our patients in mind, our team of epileptologists, neurosurgeons, neuroradiologists and other investigators and researchers at the Cleveland Clinic Epilepsy Center strives to constantly improve our technology and expertise, and thus to better contribute to the care of our patients, the outcomes of our interventions and advancement of the field.
What is an invasive evaluation?

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Who is a candidate for epilepsy surgery?

• Patient history and response to medications
• Results of video-EEG evaluation
• Anatomic imaging (MRI, CT)
• Neurophysiological recordings (EEG, MEG)
• Functional imaging (PET, SPECT, fMRI, etc.)
• Neuropsychological testing
• Other tests
• Discussion in patient management conference

Why is an invasive evaluation necessary?
**Noninvasive EEG has limitations**

- It cannot evaluate several areas given their distance from recording electrodes.
- It can only “see” seizure activity when the seizure spreads to involve extensive areas of the brain.

**What are the indications for an invasive evaluation?**

1. to help localize the epileptic focus, when noninvasive tests do not adequately localize the area of interest or provide conflicting data.
2. to help localize the focus in patients with a normal MRI.
3. to better define the focus in relation to certain structural lesions.
4. to better define the relationship of the focus to essential functional areas of the brain (such as motor or sensory cortex).
5. to help determine the dominant epileptic area in some patients, who have multiple abnormalities in more than one brain region.

**From noninvasive to invasive recordings**

- The indication and planning for placement of invasive electrodes is based on results of all the presurgical testing and a thorough multidisciplinary discussion in patient management conference.
- There is a need for a solid, well-defined hypothesis derived from all non-invasive studies before placing these electrodes.
- There is a limit on what can be covered.
Subdural electrodes

Position of subdural grid electrodes

Cortical stimulation mapping of function
Advantages of subdural grid electrodes

• Sensitive to activities on the outer part of the brain
• Can map the extent of epileptic area
• Allow for functional mapping through electrical stimulation of the brain

Depth electrodes

Placement of depth electrodes
**Entry points of depth electrodes**

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**Identifying the epileptic area (contacts A5-7)**

**Advantages of depth electrodes including stereo-EEG**

- Able to record from deeper brain areas
- Allow exploration of anatomically distant regions, and from both hemispheres, if necessary
Limitations of the Invasive evaluation

• We cannot record from the entire brain
• Some recorded activities can be difficult to localize
• We cannot always achieve the goals of this evaluation
• Need for an additional surgery to place these electrodes
• Surgical risks including infection, bleeding and stroke
• Additional cost

Taking advantage of our technology and expertise
to constantly improve care and outcomes

THANK YOU FOR YOUR ATTENTION