Presentation Abstracts

INTENSIVE CARE UNIT ELECTROENCEPHALOGRAPHY (ICU EEG)

Indications for CEEG - Seizure Identification

Adults

Saurabh R. Sinha, MD, PhD

Seizure detection is the most common indication for ICU EEG monitoring. The incidence of seizures in this population is high: ranging from 10-30% depending on the underlying diagnosis and patient selection. Moreover, most seizures in this population are non-convulsive with no or only subtle clinical manifestations. This means that without EEG, they would commonly be missed. Routine EEGs also miss a substantial portion of these seizures, but 24-48 hours of continuous EEG will capture most. The relevance of detecting these seizure is somewhat less certain. The use of ICU EEG to detect or rule out seizures has a significant impact on clinical decision-making. Furthermore, clinical and pre-clinical evidence suggests that seizures in patients with neurological insults leads to poorer outcomes. In this presentation, we will discuss the specific indications for ICU EEG in adult patients, emphasizing the likelihood of seizures and the impact this has on outcome.

Neonates

Courtney J. Wusthoff, MD

This session will critically review the evidence basis regarding the use of CEEG to identify seizures in neonates. We will identify why neonatal seizures are unique from seizures in older children and adult patients. Data regarding which neonatal groups are at highest seizure risk will be synthesized into suggested practice algorithms. Recent studies of neonatal seizures during therapeutic hypothermia and in preterm infants will be included. The ACNS Guideline on EEG monitoring in the neonate will be examined, along with the evidence supporting these recommendations.

Pediatrics

Nicholas S. Abend, MD

Electrographic seizures refer to seizures evident on electroencephalographic (EEG) monitoring, and they are common in critically ill children with acute encephalopathy. Most electrographic seizures have no associated clinical changes; EEG monitoring is required for identification. In current clinical practice, most clinicians monitor for 1-2 days when screening for seizures. Some clinical predictors have been identified, and recent work has developed seizure prediction models which may help guide use of limited EEG monitoring resources. A number of recent studies have addressed the test characteristics of various quantitative EEG modalities, and while imperfect implementation may improve EEG monitoring efficiency.

Indications for CEEG - Other

Prognosis – Adult

Suzette M. LaRoche, MD, FACNS

For decades, routine EEG has been an important tool to assist in the determination of prognosis, particularly for patients with anoxic encephalopathy following cardiac arrest. The 2006 AAN practice parameter for prediction of outcome in comatose survivors of cardiac arrest suggested that burst- suppression or generalized epileptiform discharges predicted poor outcomes but with insufficient prognostic accuracy (Level C). However, this recommendation was based upon literature review of studies that predominantly evaluated brief, routine EEGs and prior to the era of therapeutic hypothermia. Today, with expanding utilization of continuous EEG monitoring beyond mere seizure detection and treatment, there is growing evidence for the value of cEEG in assisting in prediction of prognosis; not only for patients following therapeutic hypothermia after cardiac arrest but also for patients suffering from other primary brain injuries as well as status epilepticus. Current knowledge regarding cEEG findings predictive of prognosis in various disease states in adults will be discussed.

Prognosis - Neonates and Children

Courtney J. Wusthoff, MD

CEEG is often used in children and neonates not just for seizure detection, but also for prognostication. Assessment of EEG background features, seizures, and interictal abnormalities can provide real-time information about neurologic function for use in short-term decision making, and also in understanding expected outcomes for children and neonates with acute brain dysfunction. This session will evaluate how CEEG may best be used for prognostication in critically ill children, with an emphasis on similarities and differences between prognostic features in pediatric patients and adults. Special attention will be given to neonatal patients, and how CEEG can be used to prognosticate in neonatal encephalopathy.

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CEEG Interpretation

Background

Saurabh R. Sinha, MD, PhD

Most ICU EEG monitoring is performed for the purposes of seizure detection and management. However, careful interpretation of ICU EEG can provide additional important information to aid in the management of these patients. Like routine EEGs, the background activity can suggest the presence of focal and diffuse disturbances in cerebral function as well as the potential for epileptic seizures. In addition, there are other background patterns frequently seen in ICU EEG (both due to the patient population and the prolonged recording period) such as periodic discharges, rhythmic activity, and stimulus-induced activity that are less common in routine EEGs. In prolonged recordings, it is also important to note changes in the background over time. Changes in background EEG over time can supplement the clinical exam and inform the ICU team about the patient's condition and the impact of manipulations on cerebral function. It can be an indicator of worsening function, like delayed cerebral ischemia in patients with subarachnoid hemorrhages. In certain clinical situations, for example postcardiac arrest, the background EEG and how it changes with time/manipulation can aid in prognosis. In this presentation, I will review important aspects of the background EEG in adult patients, including terminology, and the implications of specific patterns.

Seizures and Periodic Patterns

Lawrence J. Hirsch, MD, FACNS

Nomenclature for periodic patterns has recently been standardized by the ACNS. Periodic patterns (PDs) are simply divided into lateralized (LPDs) and generalized (GPDs), with descriptions of frequency, morphology (including triphasic morphology), sharpness, stability (static, fluctuating or evolving), etc. LPDs (previously known as PLEDs) are seen with any acute epileptogenic process (most commonly stroke) and are highly associated with seizures in the acute illness (about 75% overall). LPDs are occasionally unequivocally ictal (e.g., when they have a clinical correlate, or when treatment leads to immediate neurologic improvement). In general, treatment is to prevent definite seizures rather than to obliterate the LPDs. If and when LPDs themselves cause neuronal injury remains unclear. Bilateral independent PDs (BIPDs) are similarly associated with seizures, but more associated with coma and worse prognosis than LPDs. GPDs are also associated with seizures in the acute illness (about 50% overall in the one large controlled study), but not as highly as LPDs, and GPDs are most associated with nonconvulsive seizures/status. GPDs are somewhat associated with worse outcome (varies between studies). When and how aggressively to treat GPDs remains unclear, but we typically treat the GPDs themselves only when they reach >2 Hz or have a clinical correlate. Whether characteristics of the GPDs themselves can help determine whether they are seizure-related or not remains unclear; there are group differences, but this determination is very difficult in a given patient given extensive overlap and fluctuations over time with prolonged recordings. PDs (and seizures) are commonly elicited or exacerbated by alerting stimulation in the critically ill; this does not help determine whether or not the pattern is ictal or whether or not to treat them. An acute IV antiepileptic drug treatment trial can occasionally prove that a pattern with PDs is ictal by leading to rapid neurologic improvement, but there is no known method to prove a pattern is not ictal.

Neonatal

Courtney J. Wusthoff, MD

Neonatal EEG is often considered particularly challenging by neurophysiologists and trainees. At the same time, the use of CEEG in Neonatal Intensive Care Units is expanding rapidly. This session will use the ACNS Guideline on Neonatal EEG Terminology and Classification as a framework for approaching interpretation. We will focus on high-yield features to identify in those neonates most likely to undergo CEEG, with an emphasis on the practical implications of each finding. Normal and abnormal background for term and preterm neonates will be illustrated. Seizures and interictal abnormalities will be reviewed. Common pitfalls in neonatal EEG will be identified, with discussion of how to evaluate tricky patterns.

Seizure Management

Adults

Aatif M. Husain, MD, FACNS

Seizures most commonly seen in critically ill patients are either status epileptic (SE) or nonconvulsive seizures (NCS). SE can either be generalized convulsive (GCSE) or nonconvulsive (NCSE). GCSE is readily recognized and is treated aggressively as it is a neurologic emergency. NCSE and NCS are more difficult to diagnose, and their contribution to neurologic morbidity is less clear. Usually the same antiepileptic drugs (AEDs) and the same treatment algorithm are used to treat GCSE and NCSE/NCS. However, it is unclear whether NCSE/NCS should be treated as aggressively as GCSE. Clinicians are more reluctant to use anesthetic agents for the control of seizures in NCSE/NCS than GCSE. Other AED options are available and may be appropriate in NCSE/NCS. These issues will be explored in this presentation.

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Quantitative EEG

Utility

Cecil D. Hahn, MD, MPH, FACNS

This presentation will provide an introduction to available techniques for quantitative EEG (QEEG) trending. I will review the concepts underlying various methods of quantitiative EEG transformation, and discuss the potential applications of a variety of QEEG trends for seizure identification and ischemia detection. I will review available data on the sensitivity and false positive rates of QEEG trends for seizure identification by expert neurophysiologists and ICU bedside caregivers. Finally, I will discuss how QEEG trends may be incorporated into a ICU EEG monitoring program to complement both live and post-hoc EEG review.

Administrative Issues

Equipment, Networking and Electrodes

Saurabh R. Sinha, MD, PhD

The equipment and software needed for a successful ICU EEG program share many similarities with the equipment needed for long-term monitoring and event routine EEGs. The actual recording machine today is almost always a digital EEG system with video capabilities. Appropriate networking infrastructure is needed to allow for obtaining recording in different parts of the hospital while ideally allowing review of the data continuous and even from remote locations. Beyond routine EEG collection and review software, software for quantitative analysis of the EEG is often desirable. Standard cup metal electrodes are often used; however, the clinical, safety and practical concerns often dictate the use of special electrodes such as disposable, needle or MRI/CTcompatible electrodes. Although there are concerns about the quality of such recordings, the need for rapid application of the electrodes and application by personnel who are not trained EEG technologists have led to the use of templates for electrode placement to exploration of reduced montages or simplified electrode placements. In this presentation, we will review specific considerations and requirements for equipment, networking infrastructure, electrodes and electrode montages as they relate to ICU EEG.

Staffing, Personnel, Workflow and Logistics

Cecil D. Hahn, MD, MPH, FACNS

This presentation will provide an overview of strategies for staffing a successful ICU EEG monitong program. I will review data on current EEG technologist and physician staffing practices for electrode application, troubleshooting and EEG interpretation across North America, including various solutions for after-hours coverage. I will illustrate the benefits of developing a team approach with educational outreach to ICU nurses and physicians in order to facilitate collaborative multidisciplinary care.

Billing and Coding

Marc R. Nuwer, MD, PhD, FACNS

Coding, billing, and adhering to regulations are necessary for Continuous ICU EEG practice. Coding CPT for procedures depends on whether the monitoring was continuously supervised, whether video was used, and for how long monitoring continued. The reading physician can be at a distance, but needs to be available to interpret during the recording so as to recommend changes in medical care during the monitoring and to determine when the recording can end. The main codes themselves inherently include digital spike and seizure detection, so those automated features cannot be separately coded. Diagnostic ICD coding can determine whether a service is paid, by setting the medical justification for the service. ICD also determine the Hierarchical Condition Categories (HCC), which affect the patient's acuity level for payment purposes. In each case, chart documentation should justify the CPT and ICD codes chosen. Careful coding facilitates correct regulatory and payment processes. They are important parts of system-based practice.

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Other Topics

Impact of Seizures - Bench Studies

Gregory L. Holmes, MD, FACNS

Major co-morbidities of epilepsy include cognitive impairment and behavioral dysfunction. The type and degree of these co-morbidities is dependent upon age, seizure type and seizure frequency. The hippocampus and prefrontal cortex appear particularly vulnerable to seizure-induced dysfunction. Rodent studies allow investigators to understand the cellular basis for both the cognitive and behavior disturbances seen following prolonged or recurrent seizures. Cognitive impairment and behavioral disturbances are devastating co-morbidities of epilepsy, and may be far more impairing than the seizures themselves. While the etiology of the seizures is the most important determinant of outcome, there is now unequivocal data that prolonged or recurrent seizures can result in cognitive and behavioral deficits. A number of morphological changes can occur with repeated seizures including cell loss, synaptic reorganization and changes in neurogenesis. Likewise seizures can result in electrophysiological changes including changes in excitatory and inhibitory currents, alterations in brain oscillation strength and coordination, and impaired single cell firing patterns. Paralleling these morphological and physiological changes, rats subjected to seizures have considerable cognitive deficits including deficits of spatial cognition in the Morris water maze, impairment of auditory discrimination, altered activity level in the open field and reduced behavioral flexibility as well as behavioral abnormalities.

A major challenge is to determine which, if any of these morphological and physiological changes following seizures relate to life-long cognitive and behavioral deficits. Epilepsy is a disorder that affects neuronal networks, and cognitive and behavioral deficits related to seizures are due to the pathological interactions between many components of the developing and adult brain function. Recent studies have suggested that the cascade of morphological and molecular changes occurring after seizures result in a disturbance of hippocampal oscillations. Oscillations in brain structures provide temporal windows that bind coherently cooperating neuronal assemblies for the representation, processing, storage and retrieval of information. Both theta (4-10 Hz) and gamma oscillations (30-100 Hz) are critically involved in mnemonic function of the hippocampus. Seizure-induced changes at the molecular level will almost certainly affect the fine tuning of oscillatory activity. Accordingly, small errors in oscillation coordination can propagate swiftly across complex networks, and may even become amplified by cross-rhythms of cortical structures. These changes in hippocampal and prefrontal oscillation can lead to widespread deficits in behavior and cognition.

Impact of Seizures – Clinical

Nicholas S. Abend, MD

Electrographic seizures are associated with worse outcomes in critically ill children and neonates. In part, seizures may serve as biomarkers of more severe brain injury. Additionally, however, there is increasing evidence that high electrographic seizure burdens are associated with worse clinical outcomes after adjustment for brain injury etiology and severity, indicating that a high electrographic seizure burden may independently contribute to secondary brain injury. This presentation will review the available data addressing associations between electrographic seizures and outcome, with a focus on studies which have included multivariate analysis to adjust for brain injury type and severity.

ICU EEG Guidelines

Suzette M. LaRoche, MD, FACNS

Since the era of evidence based medicine and the prioritization of cost effective, quality healthcare, standardized guidelines have become increasingly important across many areas of medicine. Development of consistent standards to guide patient selection as well as technical and clinical protocols is especially important when new technologies are being developed, especially those that are resource intense such as continuous EEG monitoring. Recent surveys have shown that although the practices of continuous EEG monitoring for critically ill patients in growing rapidly, a wide variety of practices exist amongst practitioners and institutions. Although still an emerging technology, guidelines have been published to address a variety of relevant issues pertaining to the practice of ICU EEG monitoring for both neonatal and adult populations. These guidelines will be discussed in addition to recently proposed ACNS guidelines for ICU EEG monitoring of the adult population.