AMERICAN CLINICAL NEUROPHYSIOLOGY SOCIETY
Continuing Medical Education Committee
Professional Practice Gap Analysis
Revised January 2016

Sources of Data

- AAN Member reports 2004, 2009, 2010
- AAN Core Curricula in Clinical Neurophysiology
- American Board of Clinical Neurophysiology Candidate Exam Handout
- American Board of Electrodiagnostic Medicine Candidate Exam Booklet
- American Board of Psychiatry and Neurology Initial Exam Content Outline
- American Board of Psychiatry and Neurology Certification Statistics
- ACNS CME Committee Meetings 2014 and 2015
- ACNS Program Committee Meeting 2014
- ACNS Course Committee Meeting 2014
- ACNS CME Survey 2012
- ACNS Annual Meeting and Courses evaluation forms 2013, 2014, 2015
- ACNS Fall Course evaluation forms 2013, 2014, 2015
- Review of journal articles in *Journal of Clinical Neurophysiology*, *Clinical Neurophysiology*, and *Neurology*
- Results of ACNS In-Service Exam scores 2013, 2014, 2015

Gap #1 - Emerging Areas of Practice
Intraoperative monitoring, intensive care unit EEG monitoring and invasive evaluation for epilepsy surgery with Stereo EEG are new and growing areas of clinical neurophysiology. Few practicing neurologists have adequate training in these techniques. Adult and pediatric physicians as well as neurodiagnostic technologists with competence in these areas are in great demand. Without additional specialized training, neurologists will not be competent to conduct these types of monitoring. This practice gap has been identified in several ways:

Summary of Data

1. **Surveys of United States neurologists**
   In 2009, the American Academy of Neurology (AAN) surveyed 21,772 members, including 11,963 practicing US AAN neurologists (Neurologists 2009: AAN Member Demographic and Practice Characteristics). The Practice Profile Form (PPF) was sent to a 20% random sample (2,380). The response rates were 56% for the census and 41% for the PPF. The percent of respondents performing intraoperative monitoring was 8.5, with a median number of procedures per month of two. This area of practice is therefore much smaller than other areas of clinical neurophysiology (see general clinical neurophysiology below). The small number of studies performed monthly suggests that it is difficult for practicing neurologists to gain and maintain sufficient expertise in intraoperative monitoring by clinical practice alone. Continuous EEG monitoring in the intensive care unit was performed by 16.3% of respondents, with a median number of procedures per week of two. Again, this number is insufficient to gain and maintain appropriate expertise in this complex neurophysiologic technique.

2. **Availability and scope of training programs in clinical neurophysiology**
   Training in these new areas is not available in most neurology residencies. Clinical neurophysiology fellowship training programs provide 6 or more months of didactic and clinical experience in the major areas of clinical neurophysiology (electroencephalography, electromyography and nerve conduction studies, or polysomnography and assessment of disorders of sleep), but typically less clinical experience in other areas, such as intraoperative monitoring and analysis and evoked potential studies. Clinical neurophysiology fellowship training programs have updated curricula to include training in intraoperative monitoring, but this is usually only didactic education rather than practical experience. Only a few clinical neurophysiology fellowships offer a full 6 months experience in intraoperative monitoring. EEG and video-EEG monitoring in the intensive care unit setting are new areas of clinical neurophysiology which have not yet been formally incorporated into clinical neurophysiology training programs.

3. **A competency in Intraoperative Monitoring is now offered by the American Board of Clinical Neurophysiology Exam**
   At this time, few neurologists have been certified by this examination. A new track in EEG Monitoring in the ICU is being developed by the Board.

4. **Examination scores in the Intraoperative Monitoring sections of the American Board of Clinical Neurophysiology Exam and the American Clinical Neurophysiology In-Service Exam are lower than those in more established areas of clinical neurophysiology.**
   Percent correct responses in this area are 24-52%, compared to 53-68% in other areas of clinical neurophysiology. This gap in knowledge is present in all examinees: current clinical neurophysiology fellows, graduates of clinical neurophysiology training programs, and neurologists in practice.

5. **Number of downloads of guidelines for intraoperative monitoring from the ACNS web site.**
   New guidelines have been published in the past year for both intraoperative monitoring and continuous EEG monitoring in the ICU.

6. **Recent publications in the *Journal of Clinical Neurophysiology* (includes two full issues on advances in intraoperative monitoring), and number of publications on these topics downloaded from the journal web site.**
   Recent publications in *Epilepsia* shows that several larger epilepsy centers in the United States now perform 2/3 of their invasive recordings for epilepsy surgery through Stereo EEG rather than the traditional approach with subdural electrodes.

7. **Subjectively by participants in ACNS educational programs, based on the increasing number of requests for programs in these areas and attendance at course and symposia on these topics.**
   Several courses for Stereo EEG have been offered as free standing meetings and as symposia or breakfast courses during the ACNS Fall Courses 2014 and the Annual Courses 2015. The interest in those courses has been overwhelming.

Gap Analysis #1

Gaps in knowledge, competence, and performance in NEW clinical neurophysiology procedures, such as neurophysiological intraoperative monitoring (NIOM), the use of EEG in the intensive care unit (ICU EEG monitoring) and invasive exploration for epilepsy surgery using Stereo EEG (Stereo EEG).

- **Best Practice:** Clinical neurophysiologists should understand the pathophysiology of normal and abnormal patterns in NIOM, ICU EEG and Stereo EEG (knowledge), accurately perform and interpret studies (competence), and apply the results of these studies to timely and accurate diagnosis and treatment of patients at risk for neurologic deterioration in the operating room and intensive care unit (performance) or evaluated for epilepsy surgery as their best option for seizure freedom. New ACNS guidelines in NIOM and ICU EEG highlight the technical and clinical aspects of these new procedures. An invited review on the principles and clinical practice of Stereo EEG for the Journal of Clincial Neurophysiology is in preparation.

- **Current Practice:** Review of surveys of learners, the medical literature, and recent guidelines indicate that NIOM and ICU EEG are underutilized and often misinterpreted. There is a shortage of clinical neurophysiologists who have been trained in NIOM, ICU EEG and Stereo EEG. Most CN training programs have little didactic or practical training in these emerging areas of CN. Because these areas are new procedures, clinical neurophysiologists who completed training more than several years ago have little or no exposure to these techniques.

- **Resulting Gaps:** Practitioners performing clinical neurophysiology procedures have inadequate knowledge of the pathophysiology of normal and abnormal patterns in NIOM, ICU EEG and Stereo EEG, often do not possess the technical skills to accurately perform and interpret studies (competence), and are uncertain how to apply the results of these studies to the diagnosis and treatment of patients at risk for neurologic deterioration in the operating room and intensive care unit (performance). Gaps are present both for practitioners new to ICU EEG,NIOM and Stereo EEG, as well as those currently performing NIOM and ICU EEG and invasive exploration of epilepsy surgery because of rapid evolution of these techniques.

Gap #2 - General Practice of Clinical Neurophysiology

Clinical neurophysiology procedures are performed by a large proportion of practicing US neurologists, many of whom have little or no formal training in clinical neurophysiology. Many clinical neurophysiology procedures (e.g. evoked potentials, invasive EEG, advanced EMG procedures) are performed at low volume at many centers and a forum for review and hands-on interpretation are essential to maintain competence in these areas.

Summary of Data

Review of national neurology practice surveys indicate that clinical neurophysiology procedures are performed by a large proportion of practicing US neurologists. Many of these practitioners have little or no formal training (e.g. fellowship) in clinical neurophysiology. Many clinical neurophysiology procedures (e.g. evoked potentials, invasive EEG) are performed at low volume at most centers and a forum for review and hands-on interpretation are essential to maintain competence in these areas. A literature review was performed for new research and clinical findings in clinical neurophysiology, Several specific topics with significant gaps between current practice and ideal practice were identified via review of the literature, review of clinical neurophysiology fellowship curricula, discussions with experts in clinical neurophysiology, and surveys of ACNS members and Annual Meeting attendees.

The gap in acquisition and maintenance of expertise in clinical neurophysiology techniques was identified in several ways:

1. **Surveys of United States neurologists.**
   In 2009, the American Academy of Neurology (AAN) surveyed 21,772 members, including 11,963 practicing US AAN neurologists (Neurologists 2009: AAN Member Demographic and Practice Characteristics). The Practice Profile Form (PPF) was sent to a 20% random sample (2,380). The response rates were 56% for the census and 41% for the PPF. From the main survery, practice focus was EEG 32.6%, EMG 8.2%, Epilepsy 39.4%, and Neuromuscular disorders 25.7%.

Procedure	Percent of respondents who perform/interpret the procedure during the last 12 months						
	1991-92 (n=1,371)	1993-94 (n=1,235)	1997 (n=1,064)	1998 (n=1,230)	2000 (n=832)	2004 (n=947)	2010 (n=897)
Electrodiagnostic Services:							
Electroencephalography (EEG)	68.0	68.0	69.8	65.0	59.9	61.4	56.9
Electromyography (EMG/NCS) [a]	54.6	55.1	58.1	55.8	49.4	54.4	54.1
Evoked Potentials (EP)	43.5	44.2	46.1	43.7	34.3	32.5	25.6
Intraoperative Monitoring	12.5	13.7	14.5	14.5	11.1	9.8	8.5
Sleep Studies	12.5	11.2	14.7	12.0	10.2	12.0	14.0
Video EEG Monitoring	NA[b]	NA	NA	NA	NA	NA	17.9
Continuous EEG (cEEG)	NA	NA	NA	NA	NA	NA	16.3

Procedure	For those who perform the procedure, median number performed per month					
	1993-94	1997	1998	2000	2004	2010
Electrodiagnostic Services:						
Electroencephalography (EEG)	20	20	20	20	20	20
Electromyography (EMG/NCS) [a]	20	25	25	25	25	20
Evoked Potentials (EP)	5	5	5	4	4	2
Intraoperative Monitoring	2	3	4	1	3	2
Sleep Studies	5	5	10	5	15	11
Video EEG Monitoring	NA	NA	NA	NA	NA	2
Continuous EEG (cEEG)	NA	NA	NA	NA	NA	2

2. **Availability and scope of training programs in clinical neurophysiology.**
   The amount of training received by neurology residents in clinical neurophysiology is quite variable. EEG and EMG training are provided in 75% of neurology residency programs, ranging from 1-5 months. One quarter of neurology residency programs have no requirement for formal training in clinical neurophysiology. Fellowship training in clinical neurophysiology is available as a 5th year of subspecialization. Fellows have six or more months of didactic and clinical experience in the major areas of clinical neurophysiology (electroencephalography, electromyography and nerve conduction studies, polysomnography and assessment of disorders of sleep, or intraoperative neurophysiologic monitoring), and didactic training in other areas of clinical neurophysiology.

3. **Board certification statistics.**
   As of 2012, a total of 18,885 neurologists and child neurologists have been certified in Neurology by the American Board of Psychiatry and Neurology (ABPN) since 1935. Approximately 85% of currently practicing US neurologists (13,300) are board certified (approximately 11,305), Fewer than 20% (2,317) of practicing neurologists have ABPN certification in the Subspecialty of Clinical Neurophysiology. This is much lower than the percentage of neurologists who self-identify themselves as performing clinical neurophysiology procedures.

4. **The merger of ACNS with AACN necessitated the addition of content from the peripheral neurology area.**
   Members of the combined Society consist of three groups: those trained primarily in central neurophysiology; those trained primarily in peripheral neurophysiology; and those who were cross-trained or have otherwise gained competence in both areas. It should also be noted that the American Board of Psychiatry and Neurology Subspecialty exam for Clinical Neurophysiology incorporates both central and peripheral neurophysiology, but until the merger with AACN, there had not been a viable single group attempting to provide education in both areas.

5. **Survey responses of meeting attendees confirm that attendees identified these areas as their own practice gaps**.

Gap Analysis #2

EEG

- Basic EEG:
  - Identification of normal variants
  - Identification of artifacts
  - Clinical correlation
  - Update in technology
- Pediatric EEG:
  a. Neonatal EEG

Example Gap

- **Best Practice:** Seizures in neonates are rapidly identified and treated. Clinical neurophysiologists are skilled in neonatal EEG interpretation
- **Current Practice:** Neonatal seizures are commonly underdiagnosed or misdiagnosed resulting in delays in treatment and poor outcomes.
- **Resulting Gap:** Inadequate knowledge of risk factors for neonatal seizures, and inadequate competence in performing neonatal EEG and quantitative EEG analysis. Inadequate team approach to patient treatment, incorporating clinical neurophysiologists and neonatologists.
- **Educational Need:** Didactic lectures and discussion groups on neonatal seizures, quantitative EEG techniques, and new neonatal EEG guidelines.

Digital EEG processing:

- Quantiative EEG
- Trends for use in the intensive care unit

Source localization:

- EEG source localization
- Source coregistration with neuroimaging

Example Gap

- **Best Practice:** Patients with intractable epilepsy undergo efficient and accurate pre-surgical evaluation.
- **Current Practice:** Many potential surgical candidates do not undergo epilepsy surgery evaluation because their seizures are considered to be poorly localized.
- **Resulting Gap:** Inadequate knowledge of methods of seizure localization, and inadequate competence in source localization and co-registration techniques.
- **Educational Need:** Symposia and workshops on source location, co-registration, and clinical applications of above.

Magnetoencephalography
- Clinical indications
- New guidelines
- Role in surgical epilepsy
- Combined EEG-MEG source localization and imaging

Broad band EEG
- Ultrafast and ultraslow EEG

Functional Brain Mapping and Brain Machine Interface
- Neurophysiology of Brain Function
- Brain Mapping to guide surgical resection
- Emerging technologies

Video-EEG monitoring
- Invasive EEG
- New/next generation seizure detection algorithms

Example Gap
- **Best Practice:** Patients with intractable epilepsy are identified as potential surgical candidates early in their disease course, and undergo presurgical evaluation.
- **Current Practice:** Many potential surgical candidates are not identified at all or are identified only after many years of intractable epilepsy.
- **Resulting Gap:** Inadequate competence in recognizing potential surgical candidates, and in performing presurgical video-EEG monitoring. Inadequate incorporation of results of video-EEG monitoring into patient treatment plans.
- **Educational Need:** Workshops on video-EEG and invasive EEG

Ambulatory EEG
- Indication for EEG and Video EEG home recordings
- Quality Standards
- Guidelines

Intraoperative Neurophysiologic Monitoring:

Motor evoked potentials
- Guidelines and standards of care for NIOM (e.g. indications, cost effectiveness)
- Clinical Evidence

Evoked potentials:
- Current role of short-and long-latency EPs

Sleep:

- Neurophysiology of Sleep Disorders
  - Use of new scoring system, implications for patient care
  - Sleep in Neurologic Disorders (Epilepsy, Stroke, etc.)
  - Sleep and Coma

Example Gap

- **Best Practice:** Sleep evaluations should conform to recently published guidelines for polysomnography.
- **Current Practice:** Many practitioners are not familiar with new guidelines.
- **Resulting Gap:** Inadequate knowledge of optimal polysomnography techniques, inadequate competence in PSG techniques, and inadequate ability to incorporate guidelines into clinical practice.
- **Need:** Review of new sleep guidelines. Tools to incorporate new guidelines into sleep lab management.

Peripheral neurophysiology:

- Pediatric EMG
- Critical illness related neurophysiology
- Muscle ultrasound
- Electroneurodiagnostics of the pelvic floor

Example Gap

- **Best Practice:** Critical illness neuropathy and myopathy are rapidly identified and treated.
- **Current Practice:** Critical illness neuropathy and myopathy are often not recognized, and prolong the need for ICU care.
- **Resulting Gap**: Inadequate knowledge of risk factors for critical illness neuropathy and myopathy, and inadequate competence in performing EMG and nerve conduction studies in critically ill patients.
- **Need:** Didactic lectures and hands-on workshops on critical illness neuropathy and myopathy.

Other areas of Clinical Neurophysiology

- Neurophysiology of Brain and peripheral Nervous System Stimulation:
  Indication, safety, role in diagnosis and therapy
  - Transcranial Magnetic Stimulation
  - Deep Brain Stimulation
  - Responsive Neurostimulation

- Autonomic nervous system
  - Neurophysiologic Testing
  - Role of the autonomic nervous system in SUDEP

- Neurophysiology in psychiatry
  - Transcranial magnetic stimulation
  - Quantitative EEG
  - Deep brain stimulation
  - Non-epileptic seizures

- Practice Management in Clinical Neurophysiology
  - Healthcare models
  - Self-assessment
  - Patient safety and quality improvement
  - Billing and Coding
  - Educational techniques

- Neurophysiology of Movement Disorders
    - Spasticity
    - Use of botulinum toxin
    - Diagnosis and pathophysiology of non-epileptic seizures

- Neurophysiology of Trauma and Recovery
    - Neuroplasticity
    - Regenerative and rehabilitative strategies
    - Neurophysiology of Consciousness
    - Neurophysiology of sports injury and sports medicine
    - Neurophysiology of Cooling after Cardiac Arrest

- Neurophysiologic Mechanisms of Disease
    - Neurophysiologic Biomarkers
    - Channelopathies

- Clinical Research Methodology

- History of clinical neurophysiology