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Title Page

Title: Assessment of Clinical Skills in Electrodiagnostic Medicine

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Word Count: 1686

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Ethical Statement:

We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

Disclosures: BB and ZNL have no relevant conflicts of interest to disclose.

Key words: Electrodiagnostic, Education, Competencies, Feedback, Trainee

Proficiency in performing and interpreting electrodiagnostic (EDX) testing requires skills that are unique within the field of medicine. An EDX physician must generate a hypothesis based on the patient's presentation, gather specific EDX data to test that hypothesis, and continuously modify the study in an iterative fashion, all over the course of one clinical encounter. This distinctive framework of diagnostic reasoning requires integrating foundational knowledge of anatomy and electrophysiology with technical, procedural, and communication skills that are unique to the discipline.

One of the challenges of assessing competency in EDX is the diversity of experiences and requirements of learners, including physical medicine and rehabilitation (PM&R) residents, adult and child neurology residents, neuromuscular medicine fellows, and clinical neurophysiology fellows. Standards for training are set by the Accreditation Council of Graduate Medical Education (ACGME) and the medical board organizations that certify candidates in each of these fields, but the program requirements and milestones needed for different competency domains vary across disciplines[1-4]. For instance, the ACGME adult neurology program requirements do not even mention EDX and have no procedural minimums[1]. The ACMGE program requirements for PM&R, however, mandate participation in a minimum of 200 EDX evaluations, and the PM&R milestones include performing, documenting, and interpreting EDX studies[2]. Clinical neurophysiology and neuromuscular medicine fellowships require familiarity with uncommon studies that assess cranial nerve function, neuromuscular junction function, and late responses[3-4].

The educational needs of trainees are determined not only by the requirements set out by the ACGME, but by the content that trainees are expected to master for their respective board certification examinations. Certifications in neurology, child neurology, clinical neurophysiology and neuromuscular medicine are through the American Board of Psychiatry and Neurology (ABPN), while certification for PM&R is through the American Board of Physical Medicine and Rehabilitation (ABPMR). The level of detail and areas of focus vary among specialties. For instance, the content outline for the adult and child

neurology examinations mentions only electromyography (EMG), nerve conduction studies (NCS), and single fiber EMG[5-6]; while the content outlines for the clinical neurophysiology and PM&R examinations include anatomy, techniques for uncommon studies, interpretation of EMG and NCS waveforms, recognition of artifacts, and clinical correlations with disease[7-8]. The content outline for neuromuscular medicine certification does not directly mention EMG or NCS, other than to say that the examination includes questions about diagnostic testing for various neuromuscular disorders[9]. If graduates of any of these programs exceed the predetermined procedural minimums for supervised and unsupervised EDX studies, they may be eligible to sit for the American Board of Electrodiagnostic Medicine (ABEM) examination. Until 2014, the ABEM physician examination included an oral portion, in which candidates were asked to reason through mock cases, describe the technical set up of nerve conduction studies, and explain their diagnostic reasoning. Since 2014, this examination has been entirely multiple choice.

With so many different standards and requirements for EDX trainees, it is not surprising that the educational experience is variable across disciplines and institutions. In a 2017 survey of graduating adult neurology residents, 77% reported a lack of confidence in interpreting EDX results[10]. In another survey, neurology program directors thought that only 75% of graduating residents achieved the level 4 EDX milestone intended for a graduation goal, despite most residents reporting that the ability to interpret these results is important[11]. It is possible that inadequate clinical exposure to EDX during residency is one factor that leads to a poor learning experience, which in turn may be dissuading trainees from pursuing a career that involves EDX[10].

To fill this gap in EDX training, residency and fellowship programs rely on a variety of unvalidated supplemental resources, including textbooks, interactive web-based tools, and self-assessment examinations[12-15]. One freely available self-study EDX curriculum was shown to be associated with high neurology Residency In-Service Training Examination (RITE) subscores compared to the same cohort's scores in other domains, high resident rotation satisfaction, and high clinical

competency at a single institution[15]. This self-directed learning model is highly adaptable to training programs of all sizes and provides a guide for a graduated level of independence, but like most self-study tools, it focuses on medical knowledge.

To address other clinical competencies such as technical, procedural, and communication skills, there is a need to provide EDX trainees with actionable formative and summative feedback on clinical performance. Direct observation of either standardized or clinical encounters provides an opportunity for feedback, and workplace-based assessments have the additional advantages of productivity and oversight of patient care. Direct Observation Tools (DOT) have been developed to standardize this form of feedback and decrease its barriers to use.

DOTs have been developed and adopted across the spectrum of medical specialties, but only 31% of these tools have been validated against other assessments such as written examinations or clinical performance ratings[16]. The ABPN requirements for adult and child neurology include a minimum of five observed clinical skills examinations during residency training to demonstrate mastery of medical interviewing skills, neurological examination skills, humanistic qualities, professionalism, and counseling skills[17]; for which standardized assessment forms have been developed. One of these examinations must pertain to the evaluation of a patient with a neuromuscular disorder, but there is no specific EDX requirement. The first standardized DOT for the assessment of trainees in electromyography and nerve conduction studies was published in 2016[18]. It is a 14-item assessment in which attending physicians grade trainees on a 5-point competency-based scale, with a separate 5-item assessment to be used by technicians to provide feedback to trainees[18]. These tools, termed the EMG-DOT, were subsequently validated to map to ACGME Milestones for neurology, child neurology, and PM&R residencies, as well as clinical neurophysiology and neuromuscular medicine fellowships.

In this issue of Muscle & Nerve, Dr. Leep Hunderfund and colleagues studied the correlation between the EMG-DOT and other forms of assessment to determine if these tools are complimentary or redundant[19]. They compared the EMG-DOT in a workplace observational setting to patient experience surveys, end-of-rotation evaluations, American Association of Neuromuscular and Electrodiagnostic Medicine (AANEM) self-assessment examination scores, and the same DOT in simulated patient settings. They found no correlation between EMG-DOT and classroom-based evaluations such as the AANEM self-assessment examination scores and simulated patients. The authors suggest that this demonstrates the value of EMG-DOT, because it assesses performance in practice, and thus addresses higher level competencies than basic knowledge assessments. Certainly, the knowledge and skills needed to answer multiple choice questions correctly differs from that needed to navigate complex patient interactions. But this needs to be interpreted with caution. Showing a lack of correlation between two assessments addressing different competencies suggests that they are not redundant, but it does not prove that both have value.

The authors found that physician ratings (but not technician ratings) using EMG-DOT correlated with end-of-rotation evaluations. The simplest way to interpret this finding is that direct observation during training informs final evaluations and does so strongly enough to overcome recall bias. One could also interpret this to mean that summative feedback obviates the need for onerous mid-rotation observation and feedback. This may be true from the standpoint of gathering summative performance data, but it discounts potential unmeasured educational benefits of formative feedback.

Entrustable Professional Activities (EPAs) are the key tasks of a discipline that a trainee can be trusted to perform once sufficient competence has been demonstrated. Like DOTs, EPA assessment tools have been developed to grade a learner's level of autonomy from "observer only" to "independent" in a variety of clinical skills. EPA assessment tools have been designed for PM&R milestones.[20] The assessments pertaining to EDX are less structured and may be less time-intensive than

the EMG-DOT. Instructors and residents noted that this conceptual framework was useful at setting expectations, but only instructors reported that these EPAs added value in providing formative and summative feedback[21]. To date, EPAs specific to neurology residencies and fellowships have not been published or validated, but the PM&R EDX EPAs could be adaptable to different programs.

With few comprehensive curricular resources available, EDX training still relies on the apprenticeship model. Longitudinal hands-on experience and in-person guidance from qualified mentors are foundational for trainees to develop the attitudes, skills, and knowledge to be become the best physicians possible. Multi-faceted formative feedback at regular intervals has clear value in helping trainees and their instructors gauge areas of relative strength and weakness in their journey towards independent practice of EDX medicine. Standardized assessments that incorporate direct observation correlate with end-of-rotation summative feedback, but perhaps more importantly play an important role in creating opportunities for meaningful feedback to trainees. There are many factors that impact how supervision and feedback are provided, including the ratio of instructors to trainees, the educational culture of the program, the volume and complexity of patients, and the level of engagement with technologists and other learners. Thus, at this time it is unknown if EDX trainees uniformly benefit from formative feedback based on direct observation.

To address this, the medical boards that certify candidates in PM&R, neuromuscular medicine, and clinical neurophysiology should require observed clinical skills examinations during training, akin to the clinical skills examinations required during neurology and child-neurology residency, but specifically tailored to EDX medicine. This would assess technical skills, humanistic qualities, and real-time diagnostic reasoning in ways that written board examinations cannot and ensure that graduates have these skills. Using a structured observation tool could also help training programs recognize curricular gaps that may otherwise have gone unnoticed. This could allow these programs to better address ACGME program requirements and specialty-specific board certification content.

Of course, the gold standard for the value of a formative assessment tool in medical education is whether its use enhances patient care and clinical skills[16]. Neither the EMG-DOT nor the PM&R EDX EPAs have been shown to meet that threshold. Thus, neither assessment tool should be preferentially required by training or certification organizations in the absence of further study. If programs are intentional about their approach to formative assessment, they can benefit from a customized or blended menu of comprehensive standardized assessments like EMG-DOT or more loosely structured EPA assessments. Incorporating observation and feedback on clinical performance is an important step toward fostering greater competence and optimizing training across the spectrum of learners.

Abbreviations:

AANEM - American Association of Neuromuscular and Electrodiagnostic Medicine

ABEM - American Board of Electrodiagnostic Medicine

ABPMR - American Board of Physical Medicine and Rehabilitation

ABPN – American Board of Psychiatry and Neurology

ACGME - Accreditation Council of Graduate Medical Education

DOT – Direct observation tool

EDX – Electrodiagnostic

EMG – Electromyography

EPA – Entrustable professional activity

NCS – Nerve conduction studies

PM&R - Physical medicine and rehabilitation

RITE - Residency In-Service Training Examination

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