Research paper

Electrodiagnostic referrals and neuromuscular disease pattern in East Africa: Experience from a tertiary hospital in Ethiopia

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Abstract

Objective: We present a retrospective cross-sectional review of the electrodiagnostic (EDX) referral and diagnostic patterns in patients with suspected neuromuscular conditions at a tertiary hospital in Ethiopia.

Methods: Between 2016 and 2019, 313 patients were evaluated at the EDX lab in Tikur Anbessa Specialised Hospital, Addis Ababa, Ethiopia. In our patients, nerve conduction study and when appropriate needle electromyography was done. Demographic and clinical data were extracted from a digital registry.

Results: Polyneuropathy (19.8%), carpal tunnel syndrome (12.1%), and lumbosacral radiculopathy (9.9%) were the top three reasons for EDX referral in Ethiopia. Among them, polyneuropathy was the most frequent electrodiagnosis, where diffuse axonal and demyelinating subtypes accounted for 54% and 18.8%, respectively. Guillain-Barre syndrome was suspected in 18 patients and 15 had EDX confirmed motor axon polyneuropathy while three patients had demyelinating variant. Although a quarter (26.2%) of the referrals had a normal EDX, abnormal test results were significantly associated with weakness (95% CI: 3.29–7.04, p < 0.001), bound to wheelchair (95% CI: 1.86–2.87, p = 0.01) and having a specific diagnosis at time of referral (95% CI: 2.53–4.68, p = 0.007).

Conclusions: Diffuse and entrapment neuropathies were the main reasons for electrodiagnosis test referrals in Ethiopia. Also, motor axonal variant was the most common type of inflammatory polyneuropathy diagnosed with EDX.

Significance: Proper patient evaluation and documentation significantly improves the diagnostic yield and cost-effectiveness of EDX testing in a resource-poor countries like Ethiopia. This might be achieved through educating medical students, residents, and other care providers on the basics of EDX and its indications for correct use in the clinical care.

1. Introduction

Electrodiagnostic (EDX) studies, including nerve conduction studies (NCS) and needle electromyography (EMG), remain the most effective diagnostic tools in the evaluation of patients with suspected neuromuscular disorders (NMD). NCS and needle EMG studies are complementary and usually performed together, playing a vital role in assessing peripheral nervous system (Podnar, 2005).
ered by the Community-based Health Insurance. Despite the growing burden of neuromuscular disorders, there is a dearth of published data on the epidemiology of neuromuscular disorders in Ethiopia. To the best of the authors' knowledge, this is the first study to report on the NCS/EMG profile of Ethiopian patients. This study aims to review the clinical indications, and electrodiagnostic profiles among patients with neuromuscular disorders referred to the electrophysiology laboratory in TASH, Addis Ababa, Ethiopia. We believe this study lays the ground to facilitate further research and contribute to the current understanding of neuromuscular disorders in the region.

2. Methods and materials

2.1. Study area

The study was conducted at the electrophysiology laboratory of Tikur Anbessa Specialized Hospital, the largest tertiary level referral and teaching hospital, under the College of Health Sciences of Addis Ababa University (CHS-AAU) in Addis Ababa, Ethiopia. The hospital serves a large population of patients referred from every corner of the country for outpatient and inpatient care in multidisciplinary specialties (neurology, internal medicine, emergency, pediatrics, neurosurgery, and orthopedics). TASH is the only neurology training center in Ethiopia, and it has been providing comprehensive outpatient, in-patient, and emergency neurological services since 2012. In May 2016, under the leadership of the Department of Neurology, the EDX lab was renovated to provide NCS, EMG, Electroencephalogram (EEG), and Evoked Potentials (EP) services. It also serves as EDX referral center for Zewditu Memorial Hospital (ZMH), a CHS-AAU affiliated neurology training center under the Addis Ababa City Administration. Although the department lacks a neuromuscular or neurophysiology subspecialist, the nine neurologists at the department who co-authored this paper run the lab and performed all the EDX tests. The EDX lab also functions as one of the training sites for neurology residents.

2.2. Study design and study period

This retrospective, cross-sectional study was conducted by reviewing the electronic records of consecutive patients referred for the first time to the EDX laboratory at TASH between 2016 and 2019. Patients who had a repeat test and incomplete data were excluded.

2.3. Data collection

An excel sheet was prepared to extract all the necessary information from a structured referral form completed by the treating physician and approved by the attending neurologist at the time of EDX referral. We collected the socio-demographic data (age, sex, referral unit, and mobility), comorbidities, working diagnosis of the referring physician, and indication for EDX referral. Also, the final diagnosis from the electrophysiologic evaluation was documented.

One Neuropack X1 MEB-2300 (Nihon Kohden) NCS/EMG machine was used for the EDX assessment and different combinations of sensory and motor conduction studies, including F-wave and H reflex, were performed in common nerves in the limbs. For suspected cases of neuromuscular junction disorders, repetitive nerve stimulation (RNS) was done in addition to routine NCS. Needle EMG study using concentric needle was done in selected patients when the examining neurologist considered this test essential to exclude a competing diagnosis or confirm the suspected diagnosis based on his or her clinical judgments.

The World Federation of Neurology (WFN) Classification of Neuromuscular Diseases (Swash and Schwartz, 1997) was used to categories the referral diagnosis and the electrodiagnosis in a standardized form. Accordingly, neuromuscular disorders were classified as: 1) Spinal Muscular Atrophy (SMA) and other disorders of motor neurons, 2) Disorders of motor nerve roots, 3) Disorders of the peripheral nerves, 4) Disorders of neuromuscular transmission and 5) Disorders of muscle.

In the absence of local normative data, all test results were interpreted using normative data from standard published references (Preston and Shapiro, 2013) or in cases where side-to-side asymmetries found, intra-personal comparisons were taken. All test results and technical limitations were interpreted in the context of referral diagnosis, examiners’ clinical judgment, and any additional investigation results to reach the final diagnosis.

2.4. Statistical analysis

Cleaned and completed data from the excel sheet was exported to the Statistical Package for Social Science (SPSS, IBM, Chicago, IL, USA) Version 25 for data analysis. Descriptive statistics were summarized using mean, standard deviation (SD), and range for continuous data. Frequencies and proportions were utilized for categorical data. Pearson's Chi-square or Fisher's exact tests were used to evaluate the association between the electrodiagnosis and independent variables. Variables with p values < 0.05 were considered statistically significant.

2.5. Ethical approval and consent to participate

The study protocol obtained ethical approval from the Institutional Review Board (IRB) of the College of Health Sciences in Addis Ababa University (Protocol number: 003/20/Neuro). Waiver of consent was received due to the nature of the study.

3. Results

3.1. Demographic data and referral pattern

During the three- and a half-year period, 313 patients with presumed neuromuscular disorders were referred to the EDX lab in TASH for comprehensive EDX evaluation. Among them, the majority (93.9%) were referred by neurology, pediatric neurology, orthopedics, internal and emergency medicine physicians at TASH while the rest 6.1% were from the neurology outpatient clinic in ZMH. Males accounted for 57.5% of the referrals. Most of the electrophysiology tests (84%) were done for adult patients aged between 18 and 59 years, while children under 18 years represented only 7.3% of the referrals. The mean age (±SD) of participants was 39.3 (±15.6) years (Ranges: 2–85 years).

During the EDX lab visit, 90.4% (n = 283) of the participants were self-ambulating. Fifty-one (16.3%) patients had a documented comorbidity where diabetes and HIV infection were the most frequent ones at 31.4% (n = 16) and 25.5% (n = 13), respectively. Motor weakness (40.2%) was the main reason for referral followed by sensory complaints (29.7%) and trauma/iatrogenic complications (10.5%). Demographic, clinical, and referral characteristics of patients referred for EDX tests are summarized in Table 1.

3.2. Working diagnosis and electrodiagnosis for referred patients

More than half of the patients referred with sensory complaint or pain had a normal EDX result while two-third of the cases with
focal or diffuse motor weakness showed an abnormal EDX (Fig. 1). The commonest indications for EDX referral were disorders of the peripheral nerves (38.9%). Among them, (26.2%) had a clinical diagnosis of polyneuropathies followed by mononeuropathies (19.1%) at different anatomic sites. The second most common (18.8%) reason for EDX referral were disorders of the nerve roots including lumbosacral (9.9%) and cervical (4.2%) radiculopathy and brachial plexopathy (4.8%). Motor neuron disease was suspected in 7.7% of the patients. The least frequent causes of referrals were disorders of the muscle (5.4%) and neuromuscular transmission (2.2%). A quarter (26.8%) of patients were referred without a clear working diagnosis, but neurologic symptoms such as pain, numbness, and weakness were documented in the request form.

NCS was done for all patients and when appropriate, needle EMG was done in 33.8% of the participants. EDX abnormalities were documented in (73.2%) of the participants with variable degrees of severity. The most frequent (27.1%) electrodiagnosis were polyneuropathies with further categorization into axonal (11.8%) and demyelinating (5.1%) type based on an established criterion (5). Acute and chronic inflammatory polyneuropathies accounted for 5.8% and 1.3% of the referrals, respectively. In both conditions, the clinical and electrodiagnosis showed 100% congruency. Among the Guillain-Barre syndrome (GBS) cases, 15/18 (83.3%) met the EDX criteria for acute motor axonal polyneuropathy (AMAN) variant, while only 3 (1%) patients showed acute inflammatory demyelinating polyneuropathy (AIDP) features on their NCS. One (0.3%) case was consistent with multifocal motor neuropathy with conduction block (MMNCB).

A quarter (24.6%) of EDX referrals were for mononeuropathies. Among them, the majority 30 (9.6%) had carpal tunnel syndrome (CTS) with variable severity (mild 23.3%, moderate 26.6%, and severe 50%) and anatomic locations (unilateral: 60% and bilateral: 40%). Other less frequent focal neuropathies include peroneal neuropathy (4.8%), multifocal mononeuropathies (2.2%), and ulnar neuropathy at the elbow (1.9%).

NCS/EMG evaluation confirmed the diagnosis of amyotrophic lateral sclerosis (ALS) in all 24 (7.7%) patients suspected of motor

### Table 1

Demographic, comorbidity, and referral characteristics of patients evaluated at the EDX lab in TASH.

| Baseline demographic and clinical patterns | Frequency | Percentage (%)|
|--------------------------------------------|-----------|---------------|
| **Age (years)**                            |           |               |
| <18                                        | 23        | 7.3           |
| 18–59                                      | 263       | 84.0          |
| >60                                        | 27        | 8.5           |
| **Sex**                                    |           |               |
| Male                                       | 180       | 57.5          |
| Female                                     | 133       | 42.5          |
| **Referral unit**                          |           |               |
| TASH                                       | 294       | 93.9          |
| ZMH                                        | 19        | 6.1           |
| **Mobility**                               |           |               |
| Walking                                    | 283       | 90.4          |
| Wheelchair                                 | 30        | 9.6           |
| **Comorbidity**                            |           |               |
| Diabetes mellitus                          | 16        | 31.4          |
| HIV infection                              | 13        | 25.5          |
| History of malignancy                      | 10        | 19.6          |
| Chemotherapy                               | 8         | 15.7          |
| Others                                     | 12        | 23.5          |
| Not recorded                               | 262       | 83.7          |
| **Reason for referral**                    |           |               |
| Motor weakness                             | 126       | 40.2          |
| Sensory abnormality                        | 93        | 29.7          |
| Post-trauma/iatrogenic complications       | 33        | 10.5          |
| Lower limb radiculopathy                   | 29        | 9.3           |
| Upper limb radiculopathy                   | 15        | 4.8           |
| Others                                     | 17        | 5.4           |

**EDX:** Electrodiagnosis; **TASH:** Tikur Anbessa Specialized Hospital; **ZMH:** Zewditu Memorial Hospital.

![Fig. 1. The frequency of electrodiagnosis test outcomes based on main referral complaint.](image-url)
neuron disease with 100% congruence. Five had definite ALS, 13 probable and 6 possible ALS diagnosis based on the revised El Escorial criteria (Brooks et al., 2000). Seven patients suspected with myoneural junction disorders tested by NCS, EMG and RNS and four had the typical EDX features of myasthenia gravis (MG) (decremental response on RNS) but the rest three had normal studies.

Although 17 (5.4%) of the referrals were made for suspected muscle disorders, NCS/EMG studies identified thirteen inflammatory and twelve non-inflammatory myopathies based on the presence or absence of abnormal spontaneous activity on EMG. Besides, two (0.6%) patients had features of myotonic dystrophy. A quarter (26.8%) of the referrals had normal EDX tests. Fig. 2 summarizes the referral (suspected) diagnosis and electrodiagnosis categorized according to the WFN Classification of Neuromuscular Diseases.

3.3. Association between electrodiagnosis finding and patient variables

We hypothesized that patients who had a specific diagnosis at the time of referral and those with motor weakness will have a specific final EDX. Accordingly, we performed Pearson’s Chi-square or Fisher exact test to assess the correlation between abnormal electrodiagnosis findings and different clinical and demographic variables such as gender, age group, mobility, presenting symptom, and referral diagnosis. Patients presented with motor weakness (OR: 4.81, 95% CI: 3.29–7.04, p < 0.001), those who were wheelchair bounded at presentation (OR: 2.32, 95% CI: 1.86–2.87, p = 0.01) were significantly associated with abnormal EDX test results. Besides, patients referred with a completed forms mentioning a clear EDX indications and specific referral diagnosis were associated with congruent electrodiagnosis (OR: 3.44, 95% CI: 2.53–4.68, p = 0.007) as compared to those with incomplete form or without diagnosis. Gender and younger age group did not show statistically significant agreement with EDX test outcome (Table 2).

4. Discussion

In Ethiopia, due to the lack of widely available and affordable EDX service, patients presenting with neuromuscular complaints often remain underreported, misdiagnosed or untreated. In 2016, the department of neurology revitalized the electodiagnostic laboratory in TASH. Since then, we have noticed a growing number of patients referred for EDX evaluation. To the best of our knowledge, this is the first study to critically review the referral pattern and EDX profile of patients with neuromuscular symptoms who were evaluated in the electrophysiology laboratory of one of the largest public hospitals in Ethiopia, TASH, over a three-year period.

We found that polyneuropathy was the most common (26.2%) reason for EDX referral, and it was also the most frequently (27.1%) documented electodiagnostic abnormality. Similar results were reported from tertiary neurology referral centres in Serbia (Nikolic et al., 2016) and Zambia (Kvalsund et al., 2019), where polyneuropathies were the most common suspected and confirmed diagnosis among patients referred for EDX testing. However, other studies from Siena (Cocito et al., 2006; Mondelli et al., 2014; Podnar, 2005), Italy showed that carpal tunnel syndrome and upper/lower limb radiculopathies were the frequent cause of referral as well as EDX findings Also, a report from tertiary centre in the USA (Cho et al., 2004) reported that only 13% of the referral cases had a diagnosis of polyneuropathy. This gap might be explained by a shortage of skilled professionals and poorly equipped facilities noted at the primary care level in Ethiopia and other developing nations, leading to delay in diagnosis and referral of chronic conditions like polyneuropathies to tertiary centers. The opposite is true in the developed countries like the USA, where a higher percentage of such patients likely obtain proper care.

![Fig. 2. The frequency (%) of referral diagnosis and electrodiagnosis categorized according to the WFN Classification of Neuromuscular Diseases.](image-url)
nosis of MND patients in our lab is that most of our patients see a
explanation for 100% congruency between clinical and electrodiag-
ria evaluated three suspected cases of MND and only one of them
MND. Similarly, P.B. Adebayo and his colleagues from Ibadan, Nige-
-Nikolic et al., 2016) confirmed the diagnosis of MND in less than
-Nikolic and his colleagues
-a Zambian study reported a relatively higher frequency (11%) of
-NCS/EMG evaluation. All cases fulfilled the revised El Escorial diag-
-involvement are likely to get referred to a tertiary centre for EDX
-Setting where patients having severe weakness from axonal
-ods in our study can be explained by the study setting where patients having severe weakness from axonal involvement are likely to get referred to a tertiary centre for EDX evaluation unlike the milder forms noted with AIDP variants.

Twenty-four (7.7%) patients with suspected MND underwent NCS/EMG evaluation. All cases fulfilled the revised El Escorial diagnostic criteria for ALS diagnosis. Using the same diagnostic criteria, a Zambian study reported a relatively higher frequency (11%) of ALS cases among the 12% adults referred for MND evaluation (Kvalsund et al., 2019). In contrary, Nikolic and his colleagues (Nikolic et al., 2016) confirmed the diagnosis of MND in less than half of the patients who arrived to their EDX lab for suspected MND. Similarly, P.B. Adebayo and his colleagues from Ibadan, Nige-
-Table 2

| Variables                  | Final electrodiagnosis | \( \chi^2 \) test | OR [95% CI] | p-value |
|----------------------------|------------------------|-------------------|-------------|---------|
| Sex                        |                        |                   |             |         |
| Male                       | 44                     | 136               | 0.93        | 2.41 [1.66–3.5] | 0.34 |
| Female                     | 39                     | 94                | 1           |         |
| Age category               |                        |                   |             |         |
| < 18 years                 | 5                      | 18                | 1           |         |
| \( \geq 18 \) years        | 78                     | 212               | 0.29        | 0.75 [0.27–2.1] | 0.59 |
| Mobility                   |                        |                   |             |         |
| Wheelchair                 | 2                      | 28                | 1           |         |
| Walking                    | 81                     | 202               | 6.71        | 2.32 [1.86–2.87] | 0.01* |
| Presenting symptom         |                        |                   |             |         |
| Sensory abnormality        | 51                     | 76                | 1           |         |
| Motor weakness             | 32                     | 154               | 20.41       | 4.81 [3.29–7.04] | <0.001* |
| Referral diagnosis         |                       |                   |             |         |
| No specific diagnosis      | 31                     | 51                | 1           |         |
| Specific diagnosis         | 52                     | 179               | 7.27        | 3.44 [2.53–4.68] | 0.007* |

EDX: Electrodiagnosis; TASH: Tikur Anbessa Specialized Hospital. *Statistically significant; \( \chi^2 \) test: Chi-square test.
case-control studies are recommended to establish a normative data for our setting and additionally generate a local epidemiological knowledge.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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