STUDENTS CORNER

The Role of Electroencephalography in the Differential Diagnosis of Dementia

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INTRODUCTION

Dementia is a well-known condition that affects nearly 5.8 million people in the United States [1]. While people are most familiar with Alzheimer's dementia, other lesser-known forms of dementia, including Lewy body dementia, Creutzfeldt Jakob disease, and vascular dementia, account for 20-40% of dementia in today's population. More than 55 illnesses can cause dementia. Dementia is characterized by acquired loss of cognitive, behavioral, and emotional abilities to the extent that it impacts daily life [2]. Common dementia symptoms include memory loss, deficits in mental acuity, language impairments, impaired judgment, unstable mood, and motor deficits [3].

An electroencephalogram (EEG) records the summed electrical activity of pyramidal cells using electrodes placed on the scalp and graphed over time. It represents the amalgamation of excitatory and inhibitory postsynaptic potentials by measuring the difference in electrical potential between two scalp sites. EEGs play an important role in research and medicine. They are useful in monitoring brain activity for various functions, such as memory or sleep, and diagnosing numerous neurological disorders [10]. An EEG of a normal, alert individual typically has low-amplitude, high-frequency activity in alpha waves [9].

EEG is not routinely performed to diagnose people with dementia. Typically, the patient's family members will provide background regarding his or her condition, and mental status evaluations will be performed. However, EEGs may help identify certain biomarkers in cases of rapidly progressing dementia [2].

Alzheimer's Dementia

Alzheimer's disease (AD) accounts for approximately 70% of dementia cases. Its neurophysiological root lies in the degeneration of cholinergic synapses and the presence of amyloid plaques and neurofibrillary tangles made of tau protein [6]. Cognitive decline is typically progressive; the average survival after onset is 8-10 years. The characteristic *cognitive* features of AD are progressive memory impairment,

disorientation, language impairment, anomia, deficits in visual and spatial abilities, and apraxia. Other *non-cognitive* symptoms include personality changes, decreased emotional expression, increased stubbornness, decreased drive, delusions, and hallucinations. [2].

EEG Biomarkers

In patients with Alzheimer's, EEGs show a reduction of background activity, characterized by an intensification in the number of slow waves, such as theta and delta brain waves, and a decrease in alpha and beta wave activity [5]. This global "slowing" pattern at peak frequencies of 8-11 Hz is a notable biomarker for AD. Younger patients are more likely to have focal abnormalities than patients with late-onset Alzheimer's. However, in the early stages of dementia, the EEG may appear more normal. [4].

Discrimination from Other Dementias

Suppose a patient is showing clear signs of cognitive disturbances, but their EEG appears normal. In that case, it is more likely that they would be diagnosed with AD as opposed to Lewy body, vascular, or Creutzfeldt-Jakob dementia [4]. Additionally, patients with AD have patterns with lower mean frequencies than those with vascular dementia [5].

Vascular Dementia

Vascular dementia (VD), which is characterized by permanent cognitive impairment due to cerebrovascular disease (such as a stroke), accounts for about 10 to 20 percent of all dementia cases, and it is more prevalent in certain racial and ethnic groups, such as African Americans and Japanese people. Early markers of vascular dementia include gait disturbance and dysuria and more neurologic symptoms such as rigidity, mask-like facial expression, asymmetric reflexes, and Babinski's sign [2]. It can be difficult to differentiate between AD and VD due to similarities in clinical symptoms, such as slow progression, personality disorders, behavioral changes, and deficits in thinking [5].

EEG Biomarkers

Focal abnormalities associated with large-vessel infarctions and diffusely slowed background patterns are associated with subcortical ischemic vascular dimension [4]. Alpha waves decrease and slow delta waves increase [5].

Discrimination from Other Dementias

EEG patterns of VD patients show more focal abnormalities, spikes, and/or sharp waves than AD patients [8]. However, the intensification and number of slow EEG waves were like AD patients [5].

Lewy Body Dementia

Lewy body dementia (LBD) is named for the deposits of alpha-synuclein protein that can accumulate in the brain and affect chemicals that induce changes in cognition, motor activity, and behavior. An early onset of

extrapyramidal signs, such as rigidity and tremors characteristic of *parkinsonism*, often indicate the presence of Lewy bodies. LBD is a progressive disease with a survival of approximately five to eight years from onset. Cognitive symptoms of patients with LBD include visual hallucinations, changes in attention and alertness, and severe loss of thinking abilities [17]. At the early stages of the disease, the disease's clinical picture may overlap with that of AD, making it difficult to determine which form of dementia a patient has.

EEG Biomarkers

EEG patterns depict severe slowing in background rhythms with a 4-8 Hz peak frequency, characteristic of theta waves. This and strong frontal intermittent rhythmic delta activity (FIRDA) indicate LDB. A normal EEG or an EEG with mild abnormalities would strongly go against a diagnosis of LBD, as focal abnormalities are more likely to be present [4].

Discrimination from Other Dementias

The slowing in the background rhythm of patients with LBD is more severe than patients with AD, and FIRDA is uncommon in patients with other types of dementia [4]. Closing and opening eyes also cause more severe reactivity in EEG patterns [4].

Creutzfeldt-Jakob Disease

This disease is a rare and rapidly progressive type of dementia that owes its severity to *prions* or infection viral proteins. The disease usually lasts only one to two years [2]. At least two of the following symptoms are present in Creutzfeldt-Jakob disease (CJD): myoclonus, visual or cerebellar symptoms, extrapyramidal signs, and/or akinetic mutism (a decrease in goal-directed behaviors) [4]. Motor signs such as stiffness, incontinence, and parkinsonism are prominent, along with minor memory loss, mood changes, and apathy [13]. Despite its rarity, it is important to diagnose this type of dementia quickly due to its infectious nature and rapid decline in the affected person.

EEG Biomarkers

EEG patterns for CJD consist of intermittent periodic sharp wave complexes (PSWCs). These complexes typically last 100-600 ms and have intervals of 500-2000 ms [4]. There are also nonspecific patterns, such as diffuse slowing and frontal intermittent rhythmic delta activity (FIRDA), as seen in previously discussed types of dementia [11].

Discrimination from Other Dementia

Most other forms of dementia do not have sharp wave complexes, which differentiates CJD from other types.

Advantages and Limitations of EEG in the Differential Diagnosis of Dementia

EEGs are painless, non-invasive tests that do not require radiation or contrast agents, making it one of the safer methods of monitoring brain activity. EEGs and any imaging/detection tool allow for early disease detection, which is often crucial to treatment and longevity. EEGs also allow for continuous monitoring of disease progression to help modify dementia management.

However, EEG readings are not always the most specific to dementia. One study found sharp-wave complexes characteristic of Creutzfeldt-Jakob disease in patients with AD and Lewy body dementia, showing that EEG patterns may overlap between different diseases [15]. Furthermore, EEG patterns may vary from person to person, and it may be difficult to create a standard pattern for people with various types of dementia. Lastly, unlike other imaging devices, such as CT machines and ultrasounds, EEG machines are not commonly found in most healthcare settings, and the cost of using EEGs may make them inaccessible to patients.

Importance of Dementia Diagnosis

Dementia is one of the most expensive conditions in the United States. Approximately $215 billion is spent yearly to treat dementia, and this figure could double in 15 years as our elderly population increases [14]. Treatment of Alzheimer's disease and other dementias is typically most effective when it is diagnosed in the earlier stages [12]. If the onset of dementia were to be delayed by two years, then by 2040, we could potentially reduce the number of people living with dementia by 20 percent. [14].

Diagnosis is especially important for at-risk groups. According to the Population Reference Bureau (PRB) and the Centers for Disease Control (CDC), people who are most at risk of dementia include women, racial and ethnic minorities, people aged 85 and older, and individuals with less education. It is predicted that the numbers of Hispanic and African American people with dementia will increase 4-7 times as much from now to 2060 [1,18].

Future Studies

Early and accurate diagnoses are critical in treating dementia. EEG studies have shown that they may be useful in differentiating between different types of dementia. Other diagnostic methods, such as cognitive testing and motor evaluations, are necessary for dementia diagnoses, and simply doing EEGs may not prove useful for such a task. Still, they can certainly work to complement the evaluation in cases where symptomatic overlap is common. Further research is warranted to determine more standardized patterns to differentiate between dementia types using EEGs.

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