Review article:

Use of Quantitative Electroencephalography Biomarker in Characterizing Mild Cognitive Impairment in Malaysian Elderly

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Abstract:

The elderly population rising rapidly in Malaysia and contributes to the increasing number of cognitive problems including mild cognitive impairment (MCI). However, due to limited information regarding this problem which may progress towards severe neurologic degeneration, this problem rarely diagnosed and left untreated. Hence, the use of electroencephalography (EEG) biomarker is seen to be important with the spectral power, coherence and synchronization between the both halves of brain explain the pathophysiology underlined. This method is becoming popular for its capabilities in quantifying changes in brain electrical activity and provide early signs of brain impairment. This paper reviews the incidence of mild cognitive impairment in elderly as an early cognitive deterioration signal. It continues with the role of quantitative EEG analysis in providing the physiological meaning of their brain. This paper also provides the information about neurochemical changes which associated with MCI. In addition, this paper proposes an idea of study towards examining physiology, neurochemicals, diet and lifestyles to promote healthy lifestyle in elderly.

Keywords: Elderly, mild cognitive impairment (MCI), multivariate analysis, quantitative electroencephalography (qEEG).

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Introduction

The pace of population aging is dramatically increasing worldwide inflicting in various social, economic and health implications. Malaysia is predicted to achieve the status of aging nation by 2030 with an estimated of 15.3% of its population comprising elderly with Terengganu and Kelantan win the race, by which is classified as one of the fastest nation to achieve aged country status within 20 years[1].The rapid growth of elderly people (65 years above) increase the incidence of aging disorders such as mild cognitive impairment (MCI).

Aging is a physiological process affecting all body tissues, hence, in relating to brain and cognition, aging is associated with cognitive decline such as attention, memory and other cognitive domains inflicting in delay of cognitive processing such as input and coding, central processing and decision making[2]. Areas of orientation, concentration and functioning and self-care had objectively dysfunction as well,whereasmales significantly greater than females, in Indian population[3].

Mild Cognitive Impairment in elderly

MCI is a condition characterized by a reduction in memory and other cognitive process. However, this cognitive decline is not sufficiently severe to be diagnosed as dementia. MCI is an intermediate state lying between normal cognition and progression towards dementia with 50% of MCI

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elderly will subsequently develop dementia in upcoming five years[4]. Elderly with MCI progress to Alzheimer Disease at a rate of 10-15% per year, while healthy normal elderly convert at a rate of 1-2% only[5,6].

MCI is a common cognitive problem but not get attention since it does not obviously exhibit clinical symptoms those interfering with daily life, subsequently it is left untreated. Roughly, 60% of people diagnosed with MCI progressed with worse neurological and cognitive degeneration inflicting in dementia and Alzheimer's disease which incur higher costs for their management. Hence, early detection and interventions are vital. But, since the information of MCI related to physiology, biology, biochemistry and such are limited, MCI rarely diagnosed, leaving them worsening.

Quantitative Electroencephalographic potential

EEG is a non-invasive measurement that generates EEG waveforms signal. It is analysed quantitatively by transforming the waveform into the digital signal data through specific algorithms such as Fast Fourier Transform, it could explain wider aspects such as cognitive and emotion which represents the underlying physiology of the elderly.

Quantitative EEG (qEEG) analysis provides information on physiologically meaningful frequency components, dynamic alterations and topography of EEG signal generators, i.e. neuronal signaling. Numerous studies have shown that qEEG measures can detect disruptions in activity, topographical distribution and synchronization of neuronal (synaptic) activity such as generalized EEG slowing, reduced global synchronization and anteriorization of neuronal generators of fast-frequency resting-state EEG activity in elderly[7].

Recent study also found that topographic EEG revealed the increase of beta 2 power over the right anterior region in comparison with normal healthy aging which distinguished their anxiety level. Both the healthy and MCI groups exhibited a predominant distribution of theta and alpha at the frontal region. But the theta are highest at the parietal and temporal areas[8] indicating of cognitive decline among the MCI elderly, which is a qEEG characteristic of atrophy as well as memory deficit in MCI elderly[9]. A reduction of delta power at the prefrontal area (F3, Fz and F4) and the central regions (C3, Cz and C4) explained the cognitive decline in healthy elderly[8].

EEG coherence measures the cortical connection functionality and quantify cortico-cortico or cortico-subcortical connection. Coherence can also be used to quantify the linear correlation and detect synchronization between two channels. A decrease in coherence is interpreted as a reduction in linear function connection and function coupling in the cortical area[10]. The former index recorded that the higher the coherence, the higher the synchrony while higher synchrony reflects a functional linkage between the brain regions of interest. Some studies have found that MCI exhibited a reduction in coherence[11].

Neurochemical changes in MCI

The causes of cognitive decline can arise through neurochemical changes. Neurotransmitters are essential neurochemicals that maintain synaptic and cognitive functions by transmitting signals across synaptic neurons. Default in cognitive function contributes to the onset of age-related dysfunctions and diseases' development, thus, measuring neurochemical messengers releases that regulate the brain function is crucial. In fact, researchers suggest that the brain generates less chemical messengers with aging, which showed a decreased level of most neurotransmitters such as acetylcholine, glutamate, dopamine, serotonin and norepinephrine activity[12-15] that could play a role in declining cognition and memory.

Acetylcholine isproduced in acetylcholinergic neurons that is an essential neurotransmitter in the central and the peripheral nervous system. It also is the only neurotransmitter in the motor function of the somatic nervous system. In the peripheral nervous system, acetylcholine activates skeletal muscles as well as smooth muscle and cardiac muscle function. While within the central nervous system, it acts as a neuromodulator for the cholinergic system, which causes excitatory actions that is involved with plasticity, excitability, arousal, and reward. Acetylcholine release and signalling's disturbance can have a profound impact on neurological function[16-18]. Decreases in motor control has been postulated among a major factor leading to the decline of autonomy

capacity and quality of life in elderly populations worldwide[19].

While the most plentiful neurotransmitter found in the nervous system is glutamate, where it plays a major role in cognitive functions such as memory and learning. It also appears to be involved in motor behaviour function which change with age[20,21]. Glutamate abnormalities may disturb brain function by which dysregulation of it leads to cognitive impairment and neurodegeneration that plays a role in a number of neuropsychiatric diseases, apart from normal aging process. Hence, neurotransmitter can be a potential plasma biomarker in early diagnosis of neurodegenerative diseases, such as Alzheimer disease[22,23].

Diet and lifestyles

In addition, poor diets and passive lifestyle practicing and cultural engagement in the elderly also is associated with a remarkable loss of many neurological functions and cognitive decline through the ageing process. Other potential contributors to non-pathological cognitive ageing also includes cardiovascular disease, sleep, smoking and alcohol[24].

It is expected that there are differences in MCI elderly's brains and healthy in terms of alpha, beta, theta, delta and gamma oscillations. Moreover, the alpha-beta ratio and alpha-theta ratio which show the cognitive decline are expected to change. Furthermore, the lifestyle, nutrition and spiritual practices would give impacts on brain activities as well as cognitive performance. By uncovering the biomarker of MCI in elderly, it gives hope to provide detail explanation of MCI in Malaysian elderly in physiological, biochemical and lifestyle perspectives.

Conclusion

Through our study, we put a hope to contribute a new knowledge about the electroencephalographic information and neurochemicals as well as lifestyle those contributes to the development of MCI in elderly. Perhaps, this research will provide insights for prevention and healthy lifestyles for elderly.

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