Current status of Quantitative Electroencephalography

Essay submitted for partial fulfillment of the Master Degree in Neuropsychiatry

Presented by:

Ayman Abdel Samae Amin Al Asrag

M.B.Bch. Menoufia university

Under the supervision of:

Prof. Dr.: Mohamed Yasser Metwally

Professor of Neuropsychiatry,

Faculty of medicine, Ain Shams University

Dr.: Yousry Aboelnaga Abdel Hamid

Assistant Professor of Neuropsychiatry,

Faculty of medicine, Ain Shams University

Dr.: Ahmed Ali Ibrahim Al Bassiouny

Lecturer of Neuropsychiatry,

Faculty of medicine, Ain Shams University

Faculty of medicine

Ain Shams University

2013

ACKNOWLEDGEMENT

First and foremost thanks to Allah, most merciful, without his help I would never have been able to complete this work.

I want to express my heart appreciation and deep gratitude to: **Prof. Dr.: Mohamed Yasser Metwally**, Professor of Neuropsychiatry, Faculty of medicine, Ain Shams University, under his supervision I had the honor to do this work and who devoted so much of his precious time and effort. He really helped me by his precious opinions and contributive comments that served much in the construction of this work.

I want to express my profound and sincere thanks to: **Dr.: Yousry Aboelnaga Abdel Hamid**, Assistant Professor of Neuropsychiatry, Faculty of Medicine, Ain Shams University, for giving me the honor of working under his supervision and for his great support throughout the whole work.

Also, I am indebted to: **Dr.: Ahmed Ali Ibrahim Al Bassiouny**, Lecturer of Neuropsychiatry, Faculty of Medicine, Ain Shams University, for his generous supervision, valuable instructions, great support.

Finally, I would like to extend my recognition to my parents who are behind each fruitful step in my life with their wisdom encouragement and tender guidance.

Contents

Abbreviations

AAN	American academy of neurology
AD	Alzheimer's disease
ADL	Activity of daily living
aEEG	Amplitude-integrated electroencephalography
AP	Absolute power
ApoE	Apolipoprotein E
ATP	Adenosine triphosphate
CBF	Cerebral blood flow
CDSA	Color density spectral array
cEEG	Continous electroencephalography
CT	Computerized tomography
DAR	Delta to alpha power
DEEG	Digital electroencephalography
DSM-IV	Diagnostic and statistical manual of mental disorders
DWI MRI	Diffusion-weighted magnetic resonance images
EEG	Electroencephalography
FFT	Fast-Fourier transformation
fMRI	Functional magnetic resonance imaging
GCS	Glasgow coma score
Hz	Hertz
ICU	Intensive Care Unit
MCA	Middle cerebral artery
MF	Mean frequency
MRI	Magnetic resonance imaging
MRS	Magnetic resonance spectroscopy
NIHSS	National institutes of health stroke scale
PET	Positron emission tomography
QEEG	Quantitative electroencephalography
RP	Relative power
SAH	Subarachnoid hemorrhage
SD	Standard deviation
SEF	Spectral edge frequency
sLORETA	Standardized Low Resolution Brain Electromagnetic Tomography analysis
SPECT	Single photon emission computed tomography
SVD	Subcortical vascular dementia

List of figures

List of tables

List of tables | Page

Introduction

Quantitative electroencephalography (QEEG) is the mathematical processing of digitally recorded EEG in order to highlight specific waveform components, transform the EEG into a format or domain that elucidates relevant information, or associate numerical results with the EEG data for subsequent review or comparison.Several QEEG techniques are commonly called EEG brain mapping **(Nuwer, 1997)**.

Digital electroencephalography (DEEG) techniques have grown rapidly in popularity for recording, reviewing, and storing electroencephalography (EEG).Digital EEG recordings are flexible in the way they display the EEG tracings, unlike analog paper EEG. Montage, filter, and gain settings can be changed retrospectively during record review. Quantitative EEG analysis techniques can provide additional measurements or displays of EEG in ways not available with analog paper EEG recordings. Although much scientific literature has been produced after decades of research in this field, there remains controversy about the clinical role of quantitative EEG analysis techniques. This assessment is meant to help the clinician by providing an expert review of the current clinical usefulness of these techniques **(Nuwer, 1997)**.

Quantitative EEG commenced 70 years ago when Dietsch (1932) applied Fourier analysis to seven records of EEG. Fourier analysis remains one of the most popular analysis techniques in this field, though hardly alone. Fourier analysis is a very accurate spectral analysis technique so it is often used offline, for assessment, when time is not an issue **(Kaiser, 2005)**.

Certain quantitative EEG techniques are considered established as an addition to digital EEG in: 1)Epilepsy:For screening for possible epileptic spikes or seizures in long-term EEG monitoring or ambulatory recording to facilitate subsequent expert visual EEG interpretation.2)Intensive Care Unit (ICU) and operating room monitoring: For continuous

EEG monitoring by frequency trending to detect early acute intracranial complications in the ICU or operating room, and for screening for possible epileptic seizures in high-risk ICU patients. Certain quantitative EEG techniques are considered possibly useful practice options as an addition to digital EEG in: 1) Epilepsy: For topographic voltage and dipole analysis in presurgical evaluations. 2) Cerebrovascular Disease: quantitative EEG in expert hands may possibly be useful in evaluating certain patients with symptoms of cerebrovascular disease whose neuroimaging and routine EEG studies are not conclusive. 3) Dementia: routine EEG has long been an established test used in evaluations of dementia and encephalopathy when the diagnosis remains unresolved after initial clinical evaluation.Quantitative EEG remains investigational for clinical use in postconcussion syndrome, mild or moderate head injury, learning disability, attention disorders, schizophrenia, depression, alcoholism, and drug abuse **(Nuwer, 1997)**.

Clinical quantitative EEG is a complex speciality that may include not only standard EEG but also digital EEG, topographic mapping, spectral analysis, spectral coherence, significance probability mapping, and discriminant function analysis. There are three basic clinical uses: non-specific detection of organicity; as encephalopathy, specific categorization of disease or clinical condition, and epileptic source localization **(Duffy;et al., 1994)**.

Long-term EEG monitoring increases the scope of EEG techniques and improves the diagnostic value of standard EEG recordings providing up to 90% positive diagnostic information. Allowing quantification of epileptic activity recorded in real-life situation, useful information not available by means of standard EEG recordings can be obtained **(Logar;et al., 1994)**.

The results of Clemens;et al., 2007 raised the possibility that some quantitative EEG changes indicating EEG normalization might be markers of seizure control as predicted for the antiepileptic drugs. Parallelism between neuronal synchronization, presence of generalized spike-wave paroxysms, and cortical excitability is the theoretical basis for this possibility. The relationship between them was supported by human studies.

Both color density spectral array (CDSA) and amplitude-integrated EEG (aEEG) demonstrate acceptable sensitivity and false-positive rates for seizure identification among critically ill children. Accuracy of these tools would likely improve during clinical use, when findings can be correlated in real-time with the underlying raw EEG. In the hands of neurophysiologists, color density spectral array and amplitude-integrated EEG displays represent useful screening tools for seizures during continuous EEG monitoring in ICU **(Stewart;et al., 2010)**.

Improving quantitative EEG software is helping to make it feasible for continous EEG (cEEG) to provide continuous information about changes in brain function in real time at the bedside and to alert clinicians to any acute brain event, including seizures, ischemia, increasing intracranial pressure, hemorrhage, and even systemic abnormalities affecting the brain, such as hypoxia, hypotension and acidosis **(Friedman;et al., 2009)**.

Quantitative EEG is capable of reflecting changes in blood flow and metabolism in as little as 28-104 seconds.Clinically, QEEG correlates with stroke severity, radiographic findings, and response to treatment. Several parameters correlate with initial stroke severity as measured by the National Institutes of Health Stroke Scale (NIHSS) in both the acute and subacute periods.Sensitive techniques are needed to detect cerebral ischemia, for example, in vasospasm-associated delayed cerebral ischemia after subarachnoid haemorrhage (SAH). Early evidence suggests that QEEG may be sensitive enough to allow pre-clinical detection of delayed cerebral ischemia from vasospasm **(Foreman and Claassen, 2012)**.

Visual EEGs and QEEGs could be used in addition to the differential diagnosis between Alzheimer's disease and subcortical vascular dementia, but only selected parameters of QEEG could be useful in differentiating between Alzheimer's disease and subcortical vascular dementia subgroups with the same degree of dementia **(Gawel;et al., 2009)**.

The Parkinson disease patients present diffuse slowing in the QEEG as compared with age-adjusted normal controls.QEEG analysis is not only useful as a tool for studying pathophysiological findings but also as a predictive biomarker for dementia in parkinson disease **(Kamei, 2012)**.

Quantitative EEG-guided neurofeedback appears to be dramatically effective in abolishing or significantly reducing headache frequency in patients with recurrent migraine **(walker, 2011)**.

Quantitative EEG results suggest that the duration of physiological recovery after concussion may extend longer than observed clinical recovery **(McCrea;et al., 2010)**.

Interventions for improvement of cognitive problems in patients with traumatic brain injury include electroencephalography biofeedback, also known as neurofeedback. Deviations in QEEG patterns from the normative group are the basis for an intervention plan. While QEEG patterns, obtained under an eyes closed, resting condition, provide information about deviations at rest, QEEG patterns obtained while the patient engages in cognitive tasks reflect specific deficiencies in brain functioning **(Thornton and Carmody, 2009)**.

Basal instability in cortical arousal, as reflected in measures of QEEG, is common in most of the anxiety disorders. A statistically significant difference of spectra power in alpha band between left and right hemisphere was obtained **(Demerdzieva and Pop-Jordanova, 2011)**.

In comparison with healthy subjects, patients with schizophrenia show increased delta, theta, and beta activity and decreased alpha activity. The Similar occurs in patients with depression, but in fewer regions. Interhemispheric asymmetry is found in patients with schizophrenia and healthy subjects, but not in patients with depression **(Begić;et al., 2011)**.

AIM AND STUDY OF THE WORK :

To review the current status of quantitative EEG and its value in certain neuropsychaitric disorders.