Predictive importance of Index of Asymmetry in recovery following stroke

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INTRODUCTION

Most frequent question after period of neurorehabilitation is how and how many recovery can expect patient who suffer a stroke. Many authors tried to answer on this question on the many ways. Usually they used comparative studies between different stroke scales and some visual and quantitative EEG parameters to predict recovery after stroke, usually in acute period. Explanation of this is confused for many physicians who interfere in neurorehabilinations and who follow up of patients in long-lasting period. It distinguish that many of patients who suffered the stroke, after the period of good recovery, have period of stagnation, state of worsening, repeated strokes or death.

We keep in sight of this and we tried to simplify methodology and to answer on that question, what can expect the patient in long-lasting period after the stroke. Most of the reports that was used QEEG technique were based on the Brains Symmetry Index (BSI). BSI is bottom on the connection in delta/theta and alpha/beta ratio between two hemispheres and correlations with different clinical scales. These reports mostly do not evidence rate of neurological and functional recovery in patients with brain damage. They are also of little bit help of physiatrists who carry neurorehabilitation to predict of long-lasting recovery in this patients. The BSI has found application in monitoring during carotid endarterectomy, acute stroke and focal seizure detection. Also the BSI were used in correlated with some scales, like modified Rankin Scale (mRS) score and National Institute of Health Stroke Scale (NIHSS) as a prognostic value after stroke. Also it was shown that the BSI can be used as a measure to monitor possible changes of brain function in patients with acute ischemic hemispheric stroke. The extended BSI was introduced to assist the visual interpretation of the EEG, in particular to quantify both the spatial (left/right) and the temporal characteristics. The revised
BSI has an improved sensitivity (about two times) to detect interhemispheric asymmetry and diffuse changes. The r-sBSI and r-tBSI is illustrated using random noise signals to stimulate various changes in the EEG. They were normalized in the range (0-1) with sensitivity of about 0.05 for a 10% difference in signal amplitude, either spatial or temporal. The baseline value of the sBSI show a modest dependence on the number of channel used. Since the beginning, from 2004th, there were many articles published about BSI. The modified expression of the tBSI is more compact and allows a more intuitive understanding than previously proposed. Asymmetries was observed after unilateral brain damage or in the split brain.

Also, there were reports of inter-hemispheric symmetry of electroencephalographic (EEG) post-movement beta-event-related synchronization (PMBS) after movements on a drawing board in acute stroke subjects with mild hemiparesis compare with normal subjects. This clinical investigation need to be carried out to evaluate relationship between recovery and PMBS symmetry.

**AIM**

We setted a goal to explore simplify method who can help us to detect the place of brain damage, but to predict recovery in post-stroke patients regardless of grade of neurological and functional impaired, using Index of asymmetry. That method must be used by physicians who involve in neurorehabilitation as prognostic value in longlasting recovery after stroke.

**METHOD**

Explore was performed on 86 healthy subjects who were standard to determine frontier of allowance for every derivation and every frequency band. We excluded persons who had diabetes, hypertension, disruption of function of thyroid gland and the other diseases who disrupt of function of brain function. Also, we excluded with neurological examination present of neurological disease.

We recorded EEG on digital 32 channel apparatus XLTEK in separate room wherein temperature was 19-21°C. Electrodes placed in 10-20 system. Filters had frontier value of 0,1 frequency and 60-70Hz for high frequency. Signal from electrode cup carried out on 32 channel Head box, then on the XLTEK Cyclobox preamplifier and then on the PC. Display was perform in Laplacian electrode montage. Recording was standard on 20 minutes. Processing data involved using program package Persyst Insight II (Persyst Development Corporation, 1060 Sandreto Drive, Suite E-2, Prescott, AZ 86305). Noise who derived from vertical and horizontal eyes movements was correct using Independent Component Analysis- ICA incorporated in program package. Selected segments was durability of 32 seconds in relaxation state with eyes closed and 32 seconds with eyes open. The recording was made during 4 per subject one-minute periods of quite rest under the eyes closed and eyes open condition. The choice of 32 seconds epochs in a session was based on the report that at least 20 seconds epoch were in 90% cases representative for the state of subjects studied. Selected segments was submitted by frequency analysis. For analysis we included further derivations: F7-aF7, T3-aT3, T5-aT5, F3-aF3, C3-aC3, P3-aP3, T5-O1, T5-O1, F8-aF8, T4-aT4, T6-aT6, F4-aF4, C4-aC4, P4-aP4, P4-O2, T6-O2 and frequency bands, from 0 to 20Hz with step of 1. Power of spectra (periodogram) was calculated as a mean value of algorithm Fast Fourier transformation (FFT). On the end, average spectrum was calculated for every derivation and for every frequency band. For a group we did frequency analysis for all frequency bands and for all derivations. in program package GraphPad Prys. We got normal distribution for all derivations and for all frequency bands with frontier of allowance of p=0,95 (95%) in the state with eyes closed and the state with eyes open. On the base of that we accounted the group of healthy subject in both states. If the value of average amplitude for determine derivation and for determine frequency band in border, account is 1, but if not, account is 0. Maximal account is 320 (20 frequency bands x 16 derivations). Using the accounts we calculated index of asymmetry using formula (left -right)/(left +right) x 100. We divided the brain on the four areas, front left
(FL), front right (FR), back left (BL) and back right (BR) and we calculated Index of asymmetry between that areas and for whole brain also.

Then we recorded EEG in post-stroke patients on admission in our Clinic in Department of neurorehabilitation, average one month after onset stroke, and after two months of neurorehabilitation. For every patient we calculated account of frontier of allowance and on the base of that we determined index of asymmetry on admission and after two months of neurorehabilitation. We must to accept that patients are controlled permanent in our clinic and followed up theirs functional and neurological state.

**RESULTS**

We did frequency analysis in normal subjects for all derivations and all frequency bands and got normal distribution with coefficient of variation less than 30%. We did that in program package GraphPad Prysm.

We determined frontier of allowance of p=0.95 (95%) in condition with eyes closed in normal subjects.

We also determined frontier of allowance of p=0.95 (95%) in condition with eyes open in normal subjects.

**Example 1.**

Patient, male, old 57 years, suffered infarctus temporoparieto-occipital in left hemisphere. Account of frontier of allowance were on admission, 315 with eyes closed and 307 with eyes open. After two months of neurorehabilitation accounts were 278 with eyes closed and 284 in the state with eyes open. There was increases of index of asymmetry after neurorehabilitation. He had poor recovery. After five months he had repeated stroke and after fourteen months he was dead. (Chart 1.)

**Example 2.**

Patient male, old 45 years, suffered intracerebral haemorrhage area in the left hemisphere. On admission account of frontier of allowance were 259 in the rest state when the eyes were closed and 263 when the eyes were open. After two months of neurorehabilitation account was 316 with eyes closed and 316 with eyes open. There was decreases of index of asymmetry after neurorehabilitation. He had good recovery. We follow up him almost four years and we noticed on every control better neurological and functional recovery. Now, he is independent in self establish and activity of daily living. (Chart 2.)

**DISCUSSION**

Long propounded a question and many methodologies first of all, clinical examinations and after that and quantitative EEG analysis who used many years ago, could not completely assigned the answer on permanent dilemma of percentage of long-lasting recovery in patients who suffered the stroke. Although the electroencephalography have a long history in clinical evaluations of cerebrovascular diseases, assessment of recovery after stroke becoming more important, particular with appearing new possibilities in studious of stroke and rehabilitation. A long while ago are known numbered EEG abnormalities who onset after stroke like enhanced slow delta activity, depression of voltage and epileptic changes. Using QEEG and its predictive value is most important in analyzing individual profile. In patients who have a best recovery, EEG spectrum becoming symmetrical above left and right hemisphere as a aspect who show good recovery in motion and activity of daily living. According of that, maintaining electrophysiological balanced between two hemispheres with decreasing of degree of asymmetry, predict better long-lasting recovery. We made curves of index of asymmetry on the beginning of rehabilitation and after two months of rehabilitation. With this we can better display electrophysiological recovery of the patient. Following up of that patient, we noticed that those who had low index of asymmetry had better long-life recovery with improvement of motion and activity of daily living and due of that, they had progress in quality of life. In those patients whose index of asymmetry remained equal, little bit smaller or greater than on the admission, we noticed worse outcome meaning in worsening motion and functional condition, repeated of stroke, even massive stroke with deadly result.

Neural plasticity refers to the capability of the brain to alter function or structure in response to a range of events and is a crucial component of functional recovery after stroke. Very complicated processes that take place the period of 3-4 weeks after the stroke and recovery is assigned of neuropsychological, reorganize of the brain in whom the motion function previously generated by ischemic area and downloading by the other particles of the equilateral or adverse brain areas. Activation of motor networks in the hemisphere who is not destroyed, increasing degree of activity of supplemental motor area. Because of that, recovery in patients with destroy of both hemispheres is slowly and worse. On the human and on the animal models was evidentially that due of recovery was onset the structural and functional neural plasticity in equilateral areas and in areas far away from destroyed area. Neuroplasticity was assigned by numbered of parallel arrange of neural traces, changes in synopsis number, sprouting of axons and generation of new synopsis, take over the functions by adverse and equilateral cortex and substitution of uncrossed neural traces.

We tested many patients after stroke and noticed that in this way we can prognosticate recovery in durable period. We illustrated that in two patients shown on chart 1. and 2.

**CONCLUSION**

Due of derived results of basic exploration and results who we have got, we conclude that this method show significant results in following up the state in patients after stroke. Also this is simplified method who can be used and read by the other specialists, not only by neurologists and neurophysiologist. Also it can be apply in the other brain diseases.
On the base of that, we did the software, whereby we can assess the statement of every patient, results of rehabilitation and to predict of long-lasting recovery, the most important question that asking by patients and by members of their families.

**SUMMARY**

**PREDIKTIVNI ZNAČAJ INDEKSA ASIMETRIJE U OPORAVKU NAKON MOŽĐANOG UDARA**

Cilj rada: Dokazano je da je kvantitativna elektroencefalografija (QEEG) moćno sredstvo koje se koristi u predikciji stanja rezidualne funkcionalne onesposobljenosti. Za prediktivnu vrednost QEEG najvažniji je individualni profil svakog pacijenta. Pokazano je da Indeks moždane simetrije (BSI) predstavlja specifičnu asimetriju snage spektra između dve moždane hemisfera i normalizovan je između 0 (savršena simetrija) i 1 (maksimalna asimetrija). Metod: U analizu je uključeno 86 zdravih osoba kod kojih je izvršeno EEG registrovanje. Uradjena je frekvencijska analiza spektralne snage korišćenjem brze Furijeove transformacije (FFT) za 16 derivacija i 20 frekvencijskih opsega, od 1 do 20 sa korakom od 1. Na osnovu tih podataka, dobijena je normalna raspodela sa koeficijentom varijacije manjim od 30%. Potom smo odredili ocene granica varijabilnosti za sve derivacije i sve frekvencijske opsege u stanju sa zatvorenim očima i stanju sa otvorenim očima kod zdravih. Maksimalna ocena za svako stanje je po 320. Na ovaj način smo odredili standard. Registrovali smo EEG kod svakog pacijenta na prijemu i posle dva meseca neurološke rehabilitacije. Izvršena je ista procedura kod svakog pacijenta i na osnovu standarda izračunat su ocene. Na osnovu izračunatih ocena, izračunat je indeks asimetrije prema formuli, \((l-d)/(l+d) \times 100\) i načinjeni grafikoni. Zakrivljenost krive u grafikonu i stepen odstupanja od 0, ukazuje na elektrofiziološko stanje mozga.

Rezultati: Indeks asimetrije kod pacijenata sa lošijim dugotrajnim oporavkom je veći, isti ili neznatno manji na kontroli, posle dva meseca rehabilitacije, u odnosu na onaj prijelom prijema. S druge strane, kod pacijenata sa dobrom dugotrajnim oporavkom dolazi do smanjenja indeksa asimetrije na kontrolnom pregledu.

Ključne reči: EEG, QEEG, moždani udar, rehabilitacija

**REFERENCES**


