USE OF SURFACE ELECTROMYOGRAPHY AS A TOOLS TO PREDICT UPPER EXTREMITY RECOVERY FUNCTION AFTER STROKE

Written by:
Berthy Al Mungiza, dr.
132021210501

RESEARCH PROPOSAL

To fulfill the exam requirement to obtain a specialist degree in
Physical Medicine and Rehabilitation program

PHYSICAL AND REHABILITATION MEDICINE RESIDENCY
PROGRAM FACULTY OF MEDICINE PADJADJARAN UNIVERSITY
Dr. HASAN SADIKIN GENERAL HOSPITAL BANDUNG
2023

APPROVAL SHEET

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After being checked and observed this research proposal has fulfilled the qualifications to be examined.

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USE OF SURFACE ELECTROMYOGRAPHY AS A TOOLS TO PREDICT UPPER EXTREMITY RECOVERY FUNCTION AFTER STROKE

Vitriana B, Irma R.D, Lisda A, Nurvita T, Berthy A

INTRODUCTION

Study Background

In the past 3 decades, the disease pattern in 80% of developing countries is shifting from communicable to noncommunicable diseases, of which stroke is one of the most common debilitating diseases, the second most common cause of death, and the third most common cause of disability adjusted life years.[1] Compared to other countries in Southeast Asia, Indonesia has the highest age- and sex-standardized mortality (193.3/100,000) and disability-adjusted life years lost (3,382.2/100,000), which are caused by stroke.[2]

In the majority of stroke patients, the upper limb is more severely involved than the lower limb, as most strokes occur in the territory of the middle cerebral artery. Lawrence et al. found upper limb weakness in 77% of patients and lower limb weakness in 72%.[3,4] About half of all stroke survivors also report challenges in upper extremity motor function six months post-stroke, which can include hemiparesis, spasticity, co-contraction, pain, or other limitations which impact quality of life.[5]

Clinicians and patients struggle to determine if and when muscle activity and movement will return after a stroke. During the early weeks, movement can return rapidly and seemingly unexpectedly, which makes every twitch or sensation a potential positive sign.[6]

Prediction which applied early, and preferably within the first week after stroke onset are most useful for rehabilitation and discharge planning. Early prediction is also important when considering the constantly decreasing length of hospital stay and improved acute care. The median time in stroke unit was reported to be 7 days in Sweden and 2–8 days in Australia in 2019. These numbers point out the need to implement simple and informative prognosis indicators during the first days after stroke onset.[7]

In acute care, function-based clinical exams remain the standard for evaluating and monitoring muscle activity and movement. The Manual Muscle Test (MMT) and NIH Stroke Scale (NIHSS) are among the most common evaluation measures used in the United States. instructions. The Fugl-Meyer Assessment (FMA) also expands the repertoire of movements to evaluate synergistic or other inappropriate muscle activity. The FMA has shown promise for predicting recovery and future function of upper extremity in stroke patients.[6]

Individuals with no volitional movement, however, the FMA-UE or MMT alone cannot determine whether muscle activity is present. MMT score of 0 can indicate severe paresis with no muscle activity, that the muscle activity is below the level necessary to produce observable contractions, or that the patient was unable to fully participate in the assessment. Patients with an MMT of 0, this can be frustrating as the patient and their clinical team take a “wait-and-see” approach to determine whether muscle activity will return.[8]

Ongoing research continues to explore areas of brain plasticity, neural recovery mechanisms, and prognostication of stroke outcomes to maximize

recovery, while there has been simultaneous advancement in wearable sensor-based technologies that provide additional, non-invasive means of examining neuromuscular pathways and recovery processes following stroke.[5]

One of these wearable sensor-based technologies is surface electromyography (sEMG). Surface electromyography (sEMG) provides a non-invasive window into the nervous system that can be used to monitor muscle activity, but is rarely used in acute care. Steele et al have demonstrated that deploying sEMG in acute care is both feasible and useful. They found that current technology can be used to comfortably and non-obtrusively monitor muscle activity, even for patients with no detectable muscle activity by traditional clinical assessments. They perceive opportunities in using sEMG to inform prognosis, enable biofeedback training, and provide metrics necessary for supporting and justifying care for further research.[6]

Problem Statement

Nijland et al subsequently carried out a prospective study to determine if outcome in terms of upper limb function at 6 months after stroke can be predicted using clinical parameters measured within 72 hours after stroke in hospital stroke units. This study found that the probability of an ARAT score of at least 10 out of 57 at 6 months poststroke could be predicted by paretic finger extension (binarized at a score of 1 or more out of 2 on the UE-FMA) and paretic shoulder abduction (binarized at a score of at least 9 out of 33 on the Motricity Index) evaluated 2 days poststroke. The authors present a helpful table for making predictions for individual patients. The clinical usefulness of making this prediction, however, is unclear as

the range of functional abilities represented by an ARAT score between 10 and 57 is very wide, and neither model has been validated.[9]

Stinear et al combined clinical predictors and corticospinal tract biomarkers to predict 1 of 4 upper limb functional outcome categories at 3 months poststroke. The Predict Recovery Potential (PREP) algorithm was developed in a study of 40 participants and externally validated in a subsequent study of 157 participants. The PREP2 algorithm begins with the Shoulder Abduction, Finger Extension score (SAFE) determined within 72 hours of stroke. Each of these movements made with the paretic upper limb is evaluated with manual muscle testing and scored out of 5 with the Medical Research Council grades. The scores are summed to determine the SAFE score, and if the score is at least 5 out of 10, the patient's age is all that is required to predict either an Excellent or Good upper limb outcome, but if the SAFE score is <5 out of 10, then transcranial magnetic stimulation is needed to test the function of the corticomotor system. A good outcome is predicted if motor-evoked potentials can be elicited in the paretic upper limb. The NIHSS score is used to predict either a limited or poor upper limb outcome if motor-evoked potentials cannot be elicited. The PREP2 algorithm is accurate for 75% of patients, and using it in clinical practice increases therapist confidence, allows tailoring of upper limb therapy, and is associated with a reduced length of stay. A recent follow-up study found that PREP2 predictions remained accurate for most patients at 2 years poststroke. A major limitation of PREP2 is that transcranial magnetic stimulation is not readily available in many clinical settings.[9]

Adopting wearable sensors likes sEMG in acute care will ultimately require that these sensors provide unique and valuable insights that are not available with current methods. Beyond detecting muscle activity, longitudinal evaluations will determine the diagnostic and prognostic value of sEMG in acute care.[8]

Christina Papazian et al. study found that monitoring muscle activity with dual mode sensors of sEMG during acute care could detect contractions in the major arm muscles of stroke survivors, even among those who had no observable activity from clinical examination. In their exploratory analyses, they found modest correlations between contraction characteristics and future function for the participants with an MMT of 0.[8]

Regarding the accessibility of sEMG devices, Hachi et al found that its met predefined criteria of being portable, affordable, and easy to operate. This suggests that accessibility or price does not constitute in itself a barrier for the use of sEMG in the clinical practice.[10] Recently, clinicians have recognized the potential of sEMG as a prognostic tool, but there is limited study has explained correlation of sEMG parameters as a predictor of upper extremity motor recovery in adult acute stroke patients.

Research Question

More specifically, the following research question needs to be addressed :

Can sEMG parameters predict upper extremity motor function recovery in acute stroke patients?

Study Objective

The aim of the study are:

To know if sEMG parameters can predict upper extremity motor function recovery in acute stroke patients

Study Benefits

This study has numerous benefits, it can help us gain a better understanding of complex issues, develop new technique, determine discharge planning, improve outcome of rehabilitation program, and inform public policy.

The results of this study are expected to enrich our knowledge and become a base for future research. The results of this study are also expected to be an aid in determine prognostication to promote functional outcomes in stroke patients.

LITERATURE REVIEW

Upper Extremity Motor Impairment Post Stroke

Upper extremity weakness is the most common impairment of stroke patients, which plays an important role in motor function deficiency and has a detrimental effect on the quality of life.[11,12]

Upper extremity impairments after stroke are the cause of activity limitations, participation restrictions, and reduced independence in daily life with regard to use of the affected upper extremity after stroke, so a clear understanding of the underlying impairments is necessary to provide appropriate treatment. Understanding upper extremity impairments in any given patient is complex for two reasons:[13]

1) The impairments are not static, for example as motor recovery proceeds, the type and nature of the impairments may change, therefore the treatment needs to evolve to target the impairment contributing to dysfunction at a given point in time.
2) Multiple impairments may be present simultaneously, for example a patient may present with weakness of the arm and hand immediately after a stroke, which may not have resolved when spasticity sets in a few weeks or months later, hence there may be a layering of impairments over time making it difficult to decide what to treat first.

It is useful to review the progression of motor recovery as described by Twitchell and Brunnstrom to understand how impairments may be layered over time (Figure 1).[13]

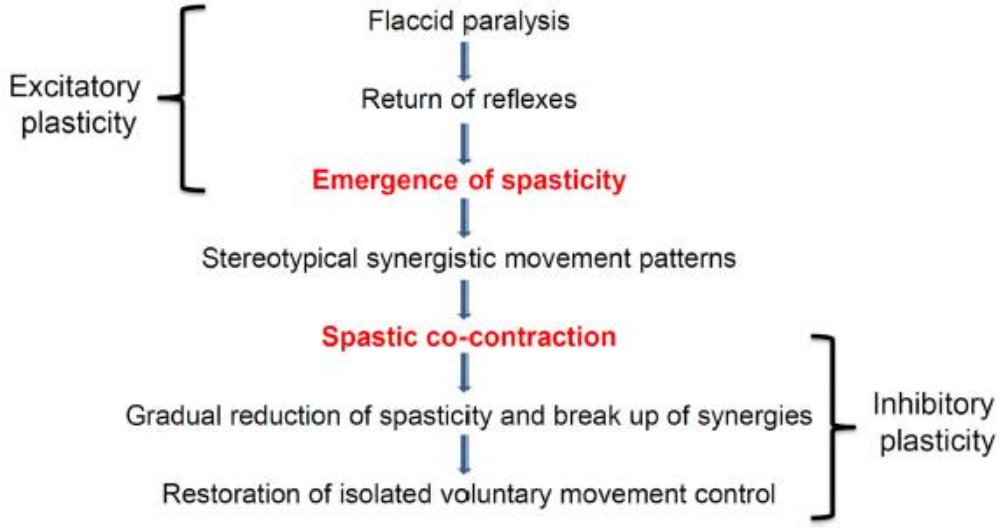

Figure 1. Sequential progression of motor recovery. Quoted from: Raghavan P. Upper Limb Motor Impairment After Stroke. Phys Med Rehabil Clin N Am. 2015;26(4):599-610

Prabhakaran et al. proposed a proportional recovery rule. According to this rule, the majority of stroke survivors are expected to recover approximately 70% of their maximum potentials at 3 months after a stroke.[14]

A rule of thumb in stroke recovery is that patients with mild deficits are more likely to make a good recovery than patients with initially more severe deficits (Figure 2). The most significant improvements occur in the first few week post-stroke, often reaching a relative plateau after 3 months with less significant recovery subsequently. After 6 months, spontaneous recovery is usually at its limit, leading to a more or less stable, for example, chronic deficit.[15]

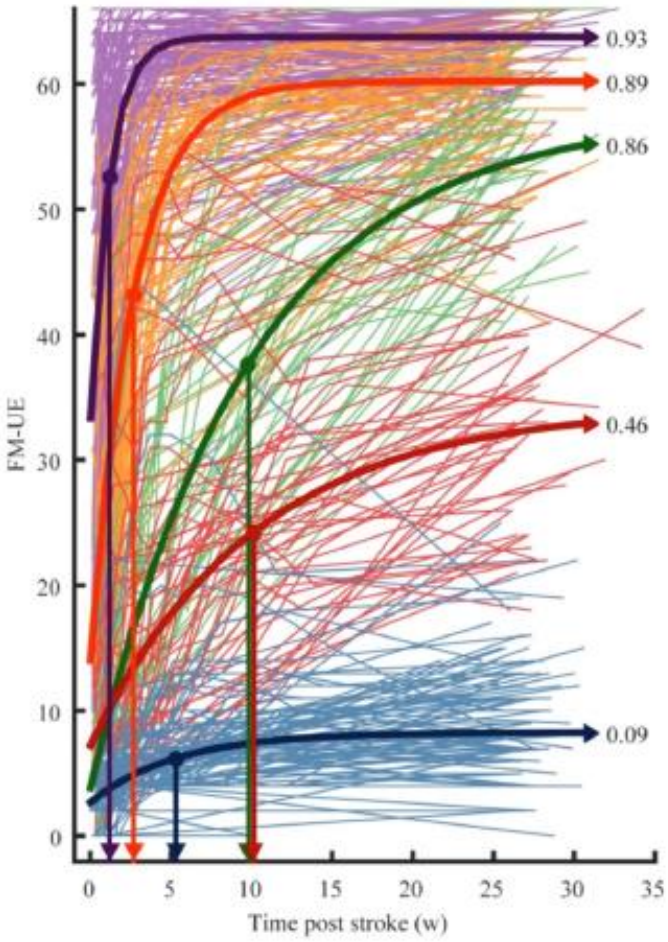

Figure 2. Motor recovery after stroke in a sample of n = 412 ischemic stroke patients based on the Fugl-Meyer upper extremity (FM-UE) score. Quoted from: Grefkes C, Fink GR. Recovery from stroke: current concepts and future perspectives. Neurol Res Pract.2020;2:17

Recent studies confirmed that the patient clinical features assessed at the baseline, predicted the final outcomes of the motor treatment.[16] Some of the following features have positive predictive value on upper extremity prognosis after stroke, and one of them is the presence of any muscle contraction when attempting to perform a movement.[17]

Ability to volitionally perform a movement of in individual's suffering stroke usually done through manual muscle testing (MMT). Manual muscle testing

is recommended for initial assessments because it is quick and provides standardized measures of motor function.[12]

MMT is performed with the hands of the therapist or physician. MMT use a five-point scale defined as normal, good, fair, poor, trace and zero, and assesses muscles that perform a joint motion, rather than individual muscles as described in Table 1.[18,19] The required assessment time is shorter, and at the same time, important information is provided about the patient's muscle strength.[18] Some MMT can be performed in the supine position.[20]

Table 1. Manual Muscle Testing Scoring System.

Grade	(%)	Qualitative value	Muscle strength
5	100	Normal	Complete range of motion (ROM) against gravity, with full resistance
4	75	Good	Complete ROM against gravity, with some resistance
3	50	Fair	Complete ROM against gravity, with no resistance
2	25	Poor	Complete ROM with a gravity omitted
1	10	Trace	Evidence of slight contractility, with no joint motion
0	0	Zero	No evidence of muscle contractility

Quoted from : Brown M, Hislop H, Avers D. Daniels and Worthingham's muscle Testing-E-Book: Techniques of manual examination and performance testing: Elsevier Health Sciences; 2013

Currently, besides MMT, patients with upper extremity motor impairment also assessed mainly by clinical scales, with the Fugl–Meyer test being one of the most commonly used measures of motor impairment after stroke to provide a more detailed description of the patient's clinical condition. The functional diagnosis

allows the medical practitioners to set the post-stroke patients' rehabilitation objectives, and can also provide a perspective on the future rehabilitation potential and prognosis, and on the necessary timeframe.[18]

Fugl-Meyer Assessment (FMA) is the first stroke-specific assessment tool that was developed on the basis of Brunnstrom's motor recovery stages. It is a feasible, well-designed, responsive, and efficient tool. The FMA is considered by many in the field of stroke rehabilitation to be one of the most comprehensive quantitative measures of motor impairment following stroke, and its use has been recommended for clinical trials of stroke rehabilitation.[21]

The FMA is based on the natural progression in post-stroke hemiparesis. The upper extremity subsection of FMA (FMA-UE) is commonly used as compared with other parts in post-stroke patients. The FMA-UE comprises 33 items related to the movements of proximal and distal upper extremity. The maximum motor performance score is 66 points for upper extremity. Scoring is done on a 3-point ordinal scale ranging from 0 (item cannot be performed) to 2 (items can be performed faultlessly) by the direct observation of the movement performance. The FMA-UE requires 10-20 min for its administration.[21]

The FMA-UE assesses the post-stroke subjects as per the sequential recovery stages. The items are hierarchically organized from synergistic to voluntary movements. Synergistic movement exhibits an abnormal stereotyped behaviour that does not allow the combination of different movement patterns, for example, an attempt to raise the arm results in elbow flexion, shoulder abduction and internal rotation. The components of flexor and extensor synergy are tested

before the movements combining synergies and out of synergy. Each item of FMA-UE subsection, further, has multiple components that allow an examination of the wide and complex motor changes.[21]

Surface Electromyography

Electromyography (EMG) is the recording of the electrical activity of muscles, and therefore constitutes an extension of the physical exploration and testing of the integrity of the motor system. It can be said that surface electromyography (sEMG), sometimes called kinesiological electromyography, is the electromyographical analysis that makes it possible to obtain an electrical signal from a muscle in a moving body.[22]

Surface EMG's is only requiring adequate electrode contact with the skin to function. This sensing capability does not require sophisticated hardware and can be made either in a benchtop or portable scale. It does not require dedicated personnel to operate, and can be constructed cost-effectively for a variety of applications.[23]

When the brain instructs the body to move, it sends an electrical impulse signal down the spinal cord and through an intricate network of peripheral nerves to the targeted muscle. This neuronal signal is transduced into a muscular contraction by numerous neurons known as motor units, each consisting of a motor neuron (anterior horn cell), its axon, and all the individual muscle fibres it innervates (Figure 3). Upon arrival of the electrical impulse from the brain, the motor units quickly depolarize the cell membrane space of their respective axon

terminals, leading to a propagating action potential wave that travels across the muscle fibres. Since an activation impulse from the brain can recruit multiple motor units, all the resultant motor unit action potentials (MUAPs) become superposed as their electrical signals radiate through the muscle. The resultant electrical signal can be sensed on the skin by the surface of electrodes, giving the characteristics EMG signal. Smaller muscle motions with fewer recruited motor units therefore exhibit low amplitude EMG signals, while large muscle motions conversely result in high amplitude EMG signals.[23]

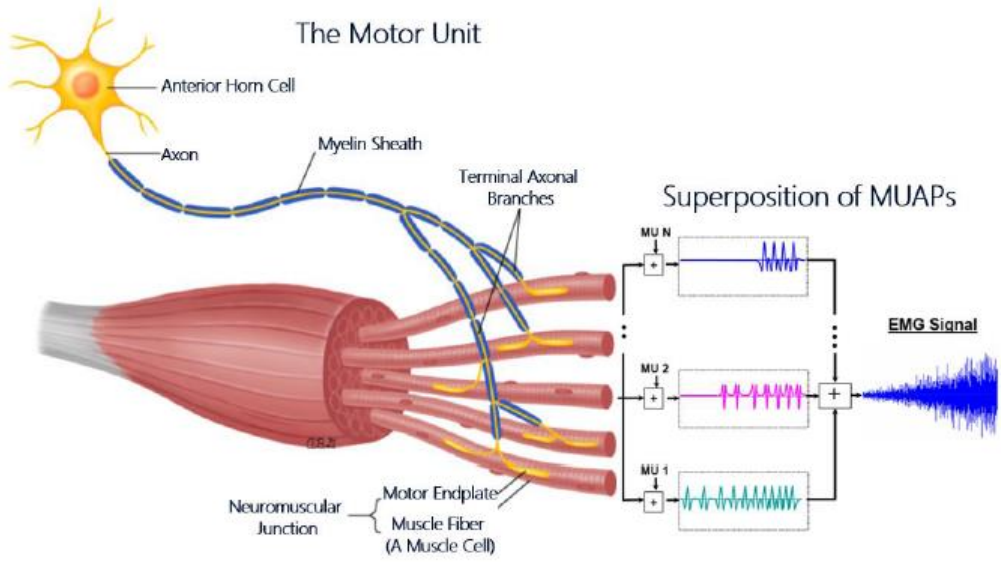

Figure 3. A single motor unit and the muscle fibers it innervates. Quotes from: Zheng M, Crouch MS, Eggleston MS. Surface Electromyography as a Natural Human–Machine Interface: A Review. IEEE Sensors Journal. 2022;22(10):9198-9214.

Steele et al. study showed that among 21 patients they were monitored, muscle contractions were detected from all five muscles (deltoid, biceps, triceps, wrist flexors, and wrist extensors) during a single four hours collection period

during standard care even for the 11 patients who had an MMT score of zero, indicating no voluntary movement or muscle activity detected via palpation. In the patients who were initially flaccid, they did find moderate correlations between early contraction characteristics and scores on the MMT at follow-up. These findings indicate that muscle activity is present during the first week after stroke, even among participants characterized as flaccid, and EMG can provide quantitative metrics that may have prognostic value for predicting future function.[6]

The use of sEMG involves three phases (the preparation phase, the recording phase and the processing phase) which are described below:[22]

1. Preparation phase
    a) Preparation of the individual and the provision of information in advance.

        It is essential to adequately inform the individual about the procedure to be followed during the recording session and about particular aspects of the study, such as its objectives, usefulness and possible applications. It is necessary to obtain the individual's informed consent in writing.

    b) Preparing the skin.

        The skin's impedance must be reduced so as to obtain a good quality electrical signal. It is advisable to shared and rub the skin with an abrasive gel to reduce the dry layer of the skin or dead cells, and to eliminate sweat by cleaning the skin with alcohol.

    c) Positioning the electrodes

        It is essential to position the electrodes correctly to obtain a good signal. The best position, provided it is possible, is on the mid line of the muscle

belly, between the myotendinous junction and the motor point. The published guides like Surface Electromyography for the Noninvasive Assessment of Muscles (SENIAM) guidelines can be used to ensure the methodology is followed correctly. It is very important to always use the same position on different individuals and for different recordings taken from the same individual, given that the signal recorded varies according to the area of the muscle on which the electrodes are positioned. It is also advisable to maintain an optimum distance between the electrodes. Each muscle is examined by positioning two electrodes on it, separated by a distance of one or two centimetres.

2. Recording phase

   Recording is the phase in which the electromyographic signal corresponding to the action or movement being studied is obtained

3. Processing phase

   Processing the signal is proses that the raw signal has to be prepared so that it can be easily observed and analysed. The type of processing will depend on the type of analysis we wish to make from the trace.

Many different quantitative parameters can be evaluated from sEMG data such as number of contractions, contraction magnitude, contraction duration, presence of synergistic activations, evaluations of spasticity, or measures of voluntary vs. involuntary contractions.[6]

Surface EMG's signal parameters related to muscle contraction include time analysis and amplitude analysis. The time analysis includes length of contraction. The length of contraction is a parameter for evaluating the period of muscle contraction from manually identified at start until end times.[8]

Papazian et al. successfully used the number of contractions, maximum amplitude, median amplitude, and duration from the manually identified start and end times the contractions to measured muscle activity in acute stroke patients. They also evaluated the correlation between the number of contractions, amplitude, and duration. The participants with an MMT of 0, individuals with more contractions had greater maximum amplitude and longer duration contractions.[8]

The primary advantage of sEMG along with its non-invasive nature, is that the signals are relatively straightforward to record and analyse (with some basic signal processing knowledge). It also provides an estimate of the overall activity of a muscle or group of muscles in contrast to the more selective nature of intramuscular recordings.[24]

Surface EMG, however, is only suitable for recording from superficial muscles and is not appropriate for recording deep muscle activity. Recording from small muscles without contamination from surrounding muscles can be difficult and signals can be prone to cross-talk, particularly over regions where there is substantial subcutaneous fat.[24]

Surface EMG's signal has complex nature, and the huge number of variables upon which it depends, so it is important to critically analyse the signal knowing the effects of these variables on its properties. Several years now, an

increasing number of methodological studies have been undertaken in order to clarify the role of certain experimental factors that can modify signal characteristics, thereby biasing their interpretation. These factors can be classified according to their level of influence on the signal:[25]

1. Technical level: environmental conditions (temperature, humidity, electromagnetic fields) and technical specifications of the equipment (electrodes, electrode-skin interface properties, amplifiers, filters, data acquisition card)
2. Experimental level: measurement procedure (skin preparation, electrode configuration, electrode localisation and orientation) and contraction conditions (ergometer utilised, contraction type, muscle length, contraction level, exercise duration)
3. Descriptive level: signal processing (digitisation, signal characteristics, chosen parameters, used parameter estimates), statistical data analysis (statistical tests)
4. Physiological level: physiological characteristics of the neuromuscular system, either structural (diameter of the active fibres, spatial organisation of fibres in the motor unit and of motor units in the muscle, filtering properties of the tissues, etc) or functional (myotypology, motor unit recruitment, fatigue, muscular coordination, etc.)

Conceptual framework

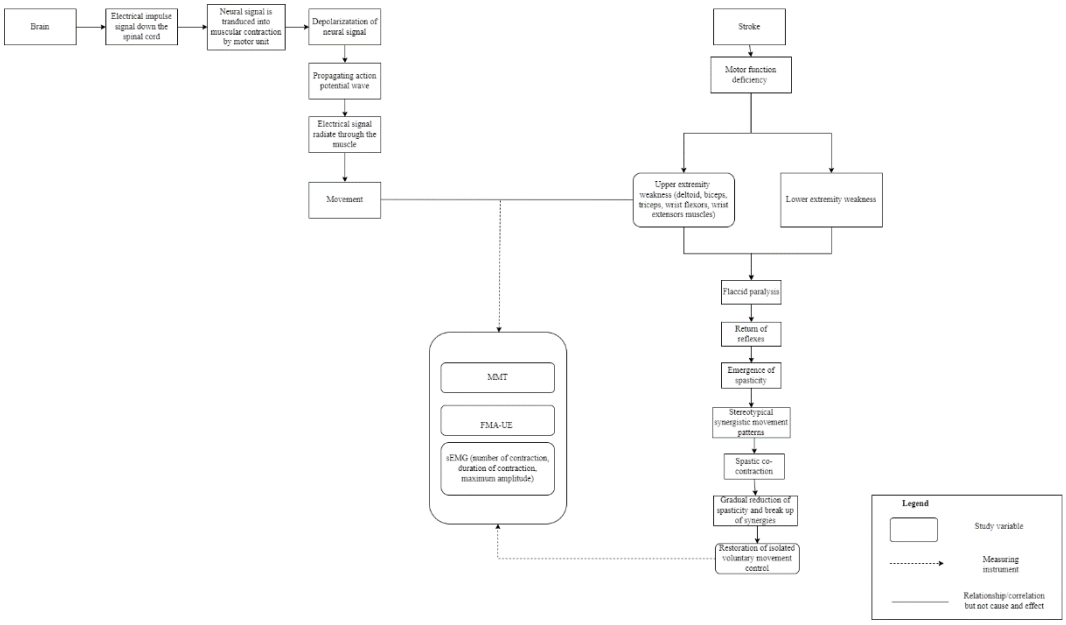

Figure 4. Conceptual framework

Premise

Based on the above frame of mind, several premises are compiled as follows:

Premise 1 : Upper extremity weakness is the most common impairment of stroke patients.[11]

Premise 2 : The most significant improvements of upper extremity motor function occur in the first few week post-stroke, often reaching a relative plateau after 3 months with less significant recovery subsequently.[15]

Premise 3 : The presence of any muscle contraction when attempting to perform a movement has positive predictive value on upper extremity prognosis after stroke.[17]

Premise 4 : Muscle contraction is present even among stroke patients characterized as flaccid.[6]

Premise 5 : Surface EMG is useful for the initial evaluation of muscle contraction even for the stroke patients who had an MMT score of zero.[6,23]

Hypothesis :

Based on the framework and premises above, the hypothesis is formulated as follows:

H0 : sEMG parameters cannot predicts upper extremity motor function recovery in stroke patients

H1: sEMG parameters can predicts upper extremity motor function recovery in stroke patients (premise 1,2,3,4,5)

MATERIAL AND METHODS

Study design and setting

This study is an analytic quantitative observational study, to analyse the quantification of MMT score, FMA-UE score and electrical signals of the anterior deltoid, biceps, triceps, wrist flexors and wrist extensors muscles based on contractions, length of contraction and amplitude parameters in patients with acute phase stroke. This study performed at Hasan Sadikin Hospital between February 2024 – July 2024.

Study participants

Potential participants will be recruited by the main researcher

Inclusion criteria:

1. Patients who are hospitalized with upper extremity weakness due to stroke on the same side which confirmed with computed tomography (CT) scan or structural magnetic resonance imaging (MRI), in the acute phase
2. Men and women aged more than 18 years old
3. Willing to participate

Exclusion criteria:

1. Cognitive impairment (MoCA-Ina score less than 26)
2. Impaired consciousness (GCS score less than 15)
3. Unstable medical conditions at time of hospitalization
4. Patients with pacemaker

5. Having other injury or dysfunction in the impaired side of upper extremity that caused restrictions on the range of joint movement and muscle weakness, such as fractures, periarthritis, or moderate-severe pain
6. Diagnosis of other neurological disease or disorders in addition to stroke (e.g., traumatic brain injury, neuropathy or radiculopathy)
7. Get treated in isolation room
8. Hypersensitivity to gel electrodes

Drop out criteria:

1. Unable to do 2 or more follow up session
2. Withdrawn by themselves

Confounding factor:

1. Stroke location
2. Stroke size
3. Spasticity
4. Rehabilitation program
5. Compliance rehabilitation
6. Stroke risk factor

Sampling Technique

The method of sampling based on consecutive samplings, that is, all stroke patients who meet the inclusion and exclusion criteria during the duration of the study.

Study Variable

Independent variables:

1. Type of stroke
2. Stroke severity
3. Recurrent stroke

Dependent variables:

1. MMT score
2. FMA-UE score
3. Electrical activity of deltoid muscle
4. Electrical activity of biceps muscle
5. Electrical activity of triceps muscle
6. Electrical activity of wrist flexors muscle
7. Electrical activity of wrist extensors muscle

Sample Size Determination

Samples are taken from research subjects that meet the inclusion criteria. The sample size to test the pair averages then the large determination of the sample, carried out on the basis of statistical calculations by setting the 95% confidence level of the two-way hypothesis and the power test 95%.

Sample determination for categorical numerical analytical research pairs using the formula:

$$n_1 = n_2 = \left(\frac{(Z_\alpha + Z_\beta)S}{X_1 - X_2} \right)^2$$

Where:

Z_{α} = alpha standard deviation

Z_{β} = beta standard deviation

S = combined standard deviation.

X_1-X_2 = average minimal difference that is considered significant

Type I error is determined as 5%, hence two-ways hypothesis Zα = 1,96

Type 2 error determined as 5%, hence Zβ = 1,64

Based on the formula, the value is entered into the sample size formula as follows:

$$n_1 = n_2 = \left(\frac{\left(Z_{\alpha} + Z_{\beta}\right) S}{X_1 - X_2} \right)^2$$

$$n_1 = n_2 = \left(\frac{\left(1,96 + 1,64\right) * 1}{1} \right)^2$$

$$= 12,96 \approx 13$$

The minimum sample size for the pre-post test group is 13 people. The minimum number of samples required is 13 samples. The minimum sample number is added to the 10% possibility of sample exclusion so that the minimum sample size is 13+1.3 = 14.3 ≈ 15 samples.

According to Gay and Diehl (1992), the sample must be as large as possible. This opinion assumes that the more samples taken, the more representative they will be and the results can be generalized. The sample size depends on the type of research:

1. The research is descriptive, so the minimum sample = 10% of the population
2. Correlational research, minimum sample is 30 units
3. Comparative causal research, the sample is 30 units per group
4. Experimental research, the minimum sample is 15 units per group

Based on the opinion of Gay and Diehl (1992), the minimum sample for this study for comparative analysis is 30 people. Based on the formula above, the minimum sample size for this research is adequate, so the minimum sample size is 30 samples.

Data Analysis

Before data analysis is carried out, the data is checked for completeness and accuracy, tabulated, coded, and entered into the computer. The next data analysis aims to describe the dependent and independent variables so that it can help further analysis in more depth. Apart from that, descriptive analysis is also used to determine the characteristics of the research subjects, who are the research samples.

Data analysis to see an overview of the proportions of each variable that will be presented descriptively can be broken down into descriptive analysis and hypothesis testing. Numerical scale data such as age and others are presented with a mean and standard deviation, a maximum value, and a minimum value. The sample characteristic data in the form of categorical data is presented in a frequency distribution table. Data is recorded in the research form that has been created, then editing, verification, coding, and data entry are carried out, and then data analysis

is carried out. Statistical analysis according to research objectives and research hypotheses Data are presented as percentages (%) for categorical variables and mean ± standard deviation (SD) for continuous variables. Statistical analysis begins with this normality test aims to find out whether the data is normally distributed or not. The statistical test used to test the data is normally distributed or not, with Shapiro Wilks (because n is less than 50). Numerical variables between pairs of two groups is compared using the paired T test if the data is normally distributed and the alternative Wilcoxon test. Numerical variables between pairs of more than two groups is compared using the repeated ANOVA test if the data is normally distributed and the alternative Fredman test. The McNemar and Marginal Homogeneity tests are used for paired categorical data. The significance of statistical test results is determined based on a p value of <0.05.

The data obtained was recorded in a special form and then processed using the SPSS version 24.0 for Windows program.

Ethics consideration

The study was conducted using human trials, patients with acute stroke treated in RSHS. The observation is a non-invasive procedure that is relatively safe to administer. The description of research ethics is as follows:

1. The research will be submitted to the Ethics Committee and obtain *Ethical Approval*.
2. The research began after obtaining a research permit from the hospital
3. All subjects were given an explanation of the purpose, benefits, and work of the research including the subject's discomfort.
4. Subjects who are willing to participate in the research are asked to sign a letter of consent to participate in the research or *informed consent.*
5. All data and information of the subject are kept confidential.

Dummy Table

Table 2. Dummy Table

Variable	In Hospital			Follow Up				Difference in change at 3 months
	3 days	Discharge	P-Value	1 Months	2 Months	3 Months	P-Value	
MMT score								
FMA-UE score								
Contraction								
Length of contraction								
Amplitude								

Note: For numerical data, the p value is tested using the paired T test if the data is normally distributed and the alternative Wilcoxon test if the data is not normally distributed. Then, to compare numerical variables between pairs of more than two groups using the repeated ANOVA test if the data is normally distributed and the alternative Fredman test, The significance value is based on a p value of <0.05. The * sign indicates a p value <0.05, meaning it is significant or statistically significant.

Table 3. Characteristic Table

Variables	p-Value
Sex	
Women	
Men	
Age	
Length of stay	
Stroke diagnosis	
Ischemic stroke	
Haemorrhagic stroke	
Stroke side	
Right hemisphere	
Left hemisphere	
Dominant Hand	
Right	
Left	
Stroke severity	
Minor stroke	
Moderate stroke	
Moderate to severe stroke	
Severe stroke	
Stroke risk factor	
Hypertension	
Diabetes Mellitus	
Heart disease	
Dyslipidemia	
Smoking	
Recurrent stroke	
Yes	
No	

Note: categorical data is presented in number, frequency, and percentage, while numerical data is presented in mean, median, standard deviation, and range.

Operational Definition

Table 4. Operational Definition of Research

Research Variables	Operational Definition	Measuring Instrument	Result	Measurement Scale
Sex	Sex corresponds which stated on the valid ID card	ID card Family card	Male Female	Nominal
Age	The age limit is stated in years according to the last birthday	ID card Family card	Years	Numerical
Length of stay	Clinical metric that measures the length of time elapsed between a patient's hospital admittance and discharge	Medical record	Days	Numerical
Stroke diagnosis	Acute episode of focal or global neurological dysfunction that persists for more than 24 hours	Medical record and imaging result (CT-Scan, MRI)	Stroke Ischemic Stroke Hemorrhagic	Categorical
Recovery upper motor function in stroke	Improvements of upper extremity motor function, occur in the first few week post-stroke, often reaching a relative plateau after 3 months	FMA-UE	≤25 : severe 26-45 : moderate 46-66 : mild	Categorical
Stroke side	Hemisphere (side) of blood cannot flow to in the brain	Medical record and imaging result (CT-Scan, MRI)	Right hemisphere Left hemisphere	Categorical
Dominant hand	Individual's preferential use of one hand	Medical record	Right Left	Nominal
Stroke severity	The extent of the impact caused by a stroke	NIHSS score	1-4 : Minor stroke 5-15 : Moderate stroke	Categorical

Stroke risk factor	The subject's risk factors for stroke	Medical record	15-20 : Moderate to severe stroke 21-42 : Severe stroke Hypertension Diabetes Mellitus Heart disease Dyslipidemia Smoking	Nominal
Recurrent stroke	The subject has had their brain deprived of oxygen at least twice, increasing the chances of possible damage to the brain	Medical record and imaging result (CT-Scan, MRI)	Yes No	Nominal
MMT score	Physical exam to testing muscle strength. Scoring use a five-point scale defined as normal, good, fair, poor, trace and zero	Medical record	0-5	Categorical
FMA-UE score	Stroke-specific assessment tool to assess motor functioning, balance, sensation and joint functioning. Comprises 33 items related to the movements of proximal and distal upper extremity. The maximum motor performance score is 66 points	Medical record	≤25 : severe 26-45 : moderate 46-66 : mild	Numerical
Electrical activity deltoid muscle	Electrical activity of the deltoid muscle recorded with a sEMG machine during muscle contraction	Flexcomp Infiniti sEMG	• Contraction (number/minute) • Length of contraction (millisecond) • Amplitude (mV)	Numerical
Electrical activity biceps muscle	Electrical activity of the biceps muscle recorded with a sEMG	Flexcomp Infiniti sEMG	• Contraction (number/minute)	Numerical

	machine during muscle contraction		• Length of contraction (millisecond) • Amplitude (mV)	
Electrical activity triceps muscle	Electrical activity of the triceps muscle recorded with a sEMG machine during muscle contraction	Flexcomp Infiniti sEMG	• Contraction (number/minute) • Length of contraction (millisecond) • Amplitude (mV)	Numerical
Electrical activity wrist flexors muscle	Electrical activity of the wrist flexors muscles recorded with a sEMG machine during muscle contraction	Flexcomp Infiniti sEMG	• Contraction (number/minute) • Length of contraction (millisecond) • Amplitude (mV)	Numerical
Electrical activity wrist extensors muscle	Electrical activity of the wrist extensors muscles recorded with a sEMG machine during muscle contraction	Flexcomp Infiniti sEMG	• Contraction (number/minute) • Length of contraction (millisecond) • Amplitude (mV)	Numerical

Outcome Measures

The investigator assessed the outcome measures. The outcome measures are MMT score, FMA UE score, sEMG parameters (contractions, length of contraction, and amplitude). It is measured at 3 days of stroke onset, the day of discharge from hospital, 1 months, 2 months and 3 months after stroke onset.

Research Work Procedure

This research collaborates with the ITB engineering team and the procedure of research is carried out as follows:

1. Selection of subjects according to the criteria of inclusion and exclusion.
2. Research subjects are given an explanation of the research procedure as well as signing informed consent to participate the research.
3. Research subjects who agree to participate in the study sign the informed consent
4. Data registration of the examination form in the medical record
5. Examination of vital signs to see contraindications for further examination. The subjects used a pulse oximetry during the subsequent examination.
6. Upper extremity function assessment is carried out using MMT and FMA UE.
7. Electrical activity recording of deltoid, biceps, triceps, wrist flexors and wrist extensors muscles is performed using sEMG is carried out as follows:
    a. The subjects are positioned sitting at 60-90 degrees during recording. Put an arm pillow below the impaired hand.
    b. Preparation of the sEMG (Biograph Infinity) machine for observation the contraction of muscles.
    c. Clean the skin first using alcohol swab to reduce skin impedance

d. Ground electrodes are attached to the bone structures in the elbow in the impaired side (olecranon)

e. Electrodes with diameter 50 mm are placed in impaired side at the anterior deltoid, long head of the biceps, lateral head of the triceps according to the Surface Electromyography for the Noninvasive Assessment of Muscles (SENIAM) guidelines standard placement procedures (Figure 5). Bony anatomical landmarks of the medial and lateral humeral epicondyles were used for standard placement of the subsequent electrodes the wrist flexor and extensor muscle groups, as SENIAM does not offer placement guidelines for these muscles

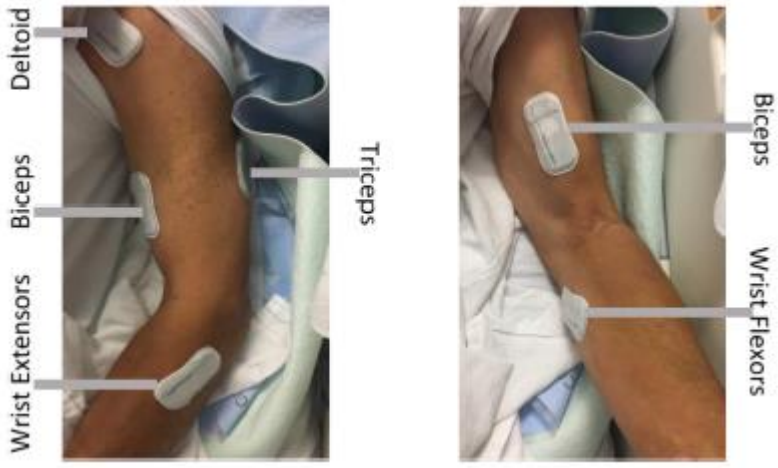

Figure 5. Electrodes/sensor placement

f. Each muscle is examined by positioning two electrodes on it, separated by a distance of one or two centimeters

g. The electrodes are fixed when the electrical activity is clearly visible on the monitor with minimal noise

h. Muscle signal data were collected for 30 minutes

i. During 30 minutes, the subjects do the protocol activity (Figure 6) as describe, for subjects with MMT 0, the researcher then performed a passive range of motion:

- 00:01:00 (shoulder flexion)
- 00:02:00 (rest)
- 00:03:00 (shoulder flexion)
- 00:04:00 (rest)
- 00:05:00 (shoulder flexion)
- 00:06:00 (rest)
- 00:07:00 (elbow flexion)
- 00:08:00 (rest)
- 00:09:00 (elbow flexion)
- 00:10:00 (rest)
- 00:11:00 (elbow flexion)
- 00:12:00 (rest)
- 00:13:00 (elbow extension)
- 00:14:00 (rest)
- 00:15:00 (elbow extension)
- 00:16:00 (rest)
- 00:17:00 (elbow extension)
- 00:18:00 (rest)
- 00:19:00 (wrist flexion)

- 00:20:00 (rest)
- 00:21:00 (wrist flexion)
- 00:22:00 (rest)
- 00:23:00 (wrist flexion)
- 00:24:00 (rest)
- 00:25:00 (wrist extension)
- 00:26:00 (rest)
- 00:27:00 (wrist extension)
- 00:28:00 rest
- 00:29:00 (wrist extension)
- 00:30:00 (rest)

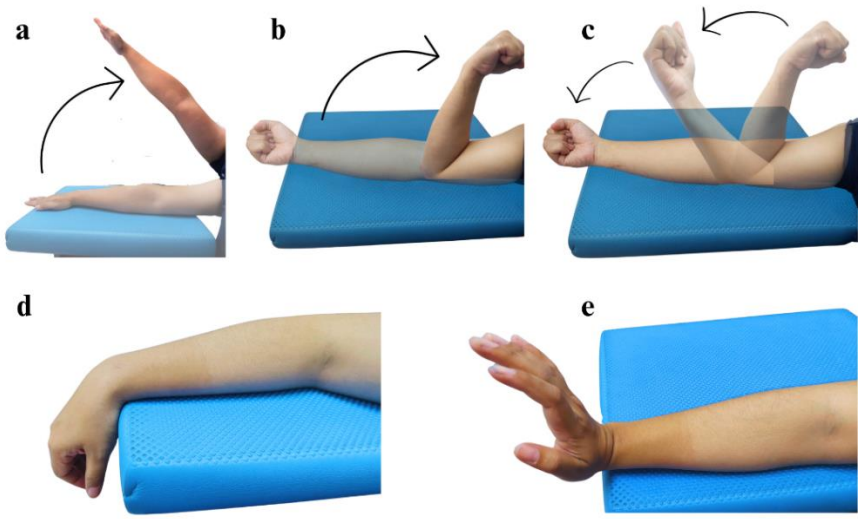

Figure 6. The five movements tested in the experimental setting. Shoulder flexion (a), elbow flexion (b), elbow extension (c), wrist flexion (d), wrist extension (e).

j. The electrodes are released and the scratch area is checked to see if there are any signs of irritation

k. The subjects are informed that the data collection has been completed, the sEMG engine cleaned up.

8. Surface EMG's signal recording results in digital form were submitted to the ITB Engineering team for the processing of the signal. The results of the electrical activity features of the muscle are contraction, length of contraction and amplitude will be analyzed.
9. All assessment (MMT, FMA UE and sEMG) is carried out at 3 days of stroke onset, the day of discharge from hospital, 1 month, 2 months and 3 months after stroke onset.

Research Flow

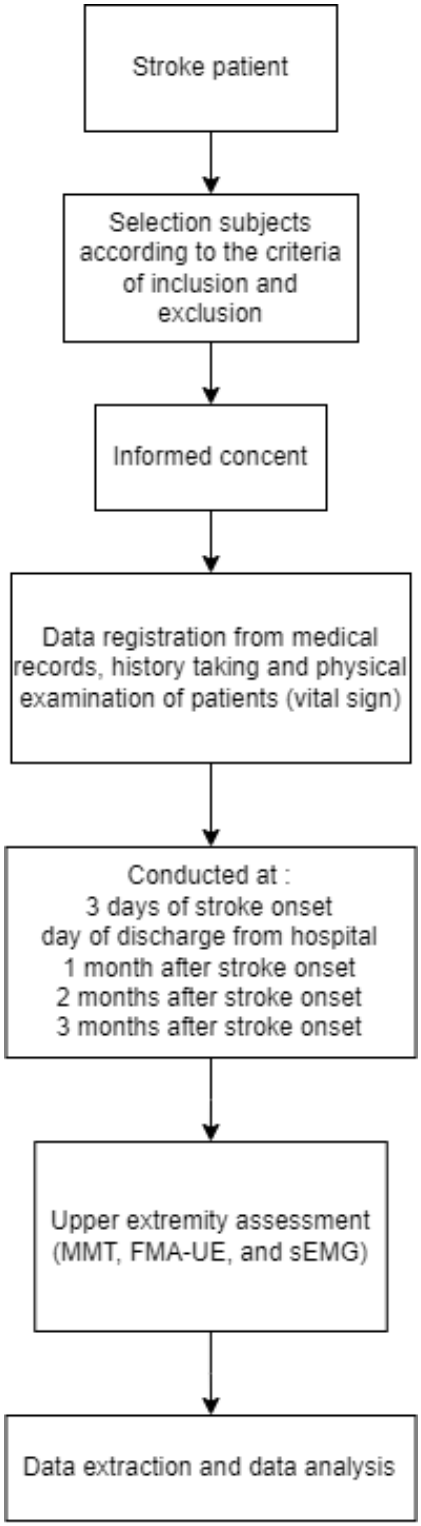

Figure 7. Research flow

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Lampiran 1 Formulir Pemeriksaan

RUMAH SAKIT UMUM PUSAT Dr. HASAN SADIKIN BANDUNG
Dr. HASAN SADIKIN GENERAL HOSPITAL BANDUNG
KOMITE ETIK PENELITIAN KESEHATAN
HEALTH RESEARCH ETHICS COMMITTEE
Jl. Pasteur No. 38 Bandung 40161

FORMULIR PEMERIKSAAN

No. Subjek :
Tanggal Pemeriksaan :
Tanggal Onset Stroke :
Keluhan :

Data Dasar

Nama	:	Lama tinggal RS	:
No. MR	:	Diagnosa	:
Jenis Kelamin	: L/P	Stroke ulang	: Ya/Tidak
Tanggal lahir	:	Sisi Lesi Otak	:
Usia	:	Sisi Stroke	:
Pendidikan	:	Tangan dominan	:
Faktor Risiko	:		

Skrining Kriteria Eksklusi

Gangguan kognitif (MOCA-INA) :
Gangguan kesadaran (GCS) :
Kondisi medis tidak stabil :
Memakai alat pacu jantung :
Cedera atau keterbatasan gerak dan kelemahan otot sebelum stroke :
Perawatan ruang isolasi :
Hipersensitivitas terhadap elektroda gel :

Pemeriksaan Fisik

Tekanan Darah	:	RR	:
Nadi	:	Suhu	:
SpO2	:	BMI	:
VAS	:	NIHSS score	:

Penilaian dan Pemeriksaan MMT, FMA-UE dan sEMG

No	MMT Score	FMA-UE Score	sEMG				
			Deltoid	Biceps	Triceps	Wrist flexors	Wrist extensors
Pemeriksaan 1			K : LK : A :	K : LK : A :	K : LK : A :	K : LK : A :	K : LK : A :
Pemeriksaan 2			K : LK : A :	K : LK : A :	K : LK : A :	K : LK : A :	K : LK : A :
Follow Up 1			K : LK : A :	K : LK : A :	K : LK : A :	K : LK : A :	K : LK : A :
Follow Up 2			K : LK : A :	K : LK : A :	K : LK : A :	K : LK : A :	K : LK : A :
Follow Up 3			K : LK : A :	K : LK : A :	K : LK : A :	K : LK : A :	K : LK : A :

*MMT: manual muscle testing, FMA - UE: Fugl Meyer Assessment – Upper Extremity, sEMG : surface electromyography,
K: kontraksi, LK: lama kontraksi, A: amplitudo

Lampiran 2. Informasi/Penjelasan Subjek Penelitian

"Penggunaan Permukaan Elektromiografi sebagai Alat Prediksi Pemulihan Fungsi Ekstremitas Atas Setelah Stroke"

Saya adalah mahasiswa yang berasal dari Universitas Padjadjaran yang sedang melakukan penelitian untuk disertasi, mengundang Anda untuk berpartisipasi dalam penelitian ini, keikutsertaan Anda dalam penelitian ini bersifat sukarela, jadi Anda dapat memutuskan untuk berpartisipasi atau sebaliknya.

Tujuan Penelitian:

Untuk mengetahui parameter alat sEMG dapat memprediksi pemulihan fungsi motorik anggota gerak atas pada pasien stroke

Mengapa Subjek terpilih:

Kriteria Inklusi:

1. Pasien yang dirawat di rumah sakit dengan kelemahan anggota gerak atas akibat stroke fase akut pada sisi yang sama yang dikonfirmasi dengan computerized tomography (CT) scan atau magnetic resonance imaging (MRI)

2. Pria dan wanita berusia diatas 18 tahun

3. Bersedia berpartisipasi

Tata Cara/Prosedur:

Penelitian ini bekerjasama dengan tim teknik ITB dan prosedur penelitian yang dilakukan sebagai berikut:

1. Pemilihan subjek sesuai kriteria inklusi dan eksklusi.

2. Subyek penelitian diberikan penjelasan mengenai prosedur penelitian serta menandatangani informed consent untuk berpartisipasi dalam penelitian.

3. Subyek penelitian yang bersedia mengikuti penelitian menandatangani informed consent

4. Data registrasi formulir pemeriksaan di rekam medis

5. Pemeriksaan tanda vital untuk melihat kontraindikasi pemeriksaan lebih lanjut.

6. Penilaian fungsi anggota gerak atas dilakukan dengan menggunakan pemeriksaan MMT dan FMA UE.

7. Perekaman aktivitas listrik otot utama yaitu deltoid, bisep, trisep, fleksor pergelangan tangan, dan ekstensor pergelangan tangan dilakukan dengan menggunakan sEMG dengan cara sebagai berikut:

A. Subyek diposisikan duduk dengan sudut 60-90 derajat selama perekaman. Letakkan bantal lengan di bawah tangan yang mengalami gangguan.

B. Persiapan mesin sEMG (Biograph Infinity) untuk observasi kontraksi otot.

C. Bersihkan kulit terlebih dahulu menggunakan kapas alkohol

D. Elektroda ground dipasang pada struktur tulang di siku pada sisi yang mengalami gangguan

E. Elektroda dengan diameter 50 mm ditempatkan pada kelima otot di sisi yang terganggu

F. Setiap otot diperiksa dengan menempatkan dua elektroda di atasnya, dipisahkan dengan jarak satu atau dua sentimeter

G. Elektroda dipasang ketika aktivitas listrik terlihat jelas di monitor

H. Data sinyal otot dikumpulkan selama 30 menit. Selama 30 menit, subjek melakukan aktivitas protokol seperti yang dijelaskan, untuk subjek dengan MMT 0, peneliti kemudian melakukan rentang gerak pasif:

- 00:01:00 (fleksi bahu)
- 00:02:00 (istirahat)
- 00:03:00 (fleksi bahu)
- 00:04:00 (istirahat)
- 00:05:00 (fleksi bahu)
- 00:06:00 (istirahat)
- 00:07:00 (fleksi siku)
- 00:08:00 (istirahat)
- 00:09:00 (fleksi siku)
- 00:10:00 (istirahat)
- 00:11:00 (fleksi siku)
- 00:12:00 (istirahat)
- 00:13:00 (ekstensi siku)
- 00:14:00 (istirahat)
- 00:15:00 (ekstensi siku)
- 00:16:00 (istirahat)
- 00:17:00 (ekstensi siku)

- 00:18:00 (istirahat)
- 00:19:00 (fleksi pergelangan tangan)
- 00:20:00 (istirahat)
- 00:21:00 (fleksi pergelangan tangan)
- 00:22:00 (istirahat)
- 00:23:00 (fleksi pergelangan tangan)
- 00:24:00 (istirahat)
- 00:25:00 (ekstensi pergelangan tangan)
- 00:26:00 (istirahat)
- 00:27:00 (ekstensi pergelangan tangan)
- 00:28:00 istirahat
- 00:29:00 (ekstensi pergelangan tangan)
- 00:30:00 (istirahat)

J. Elektroda dilepaskan dan area goresan diperiksa untuk melihat apakah ada tanda-tanda iritasi

K. Subyek diberitahu bahwa pengumpulan data telah selesai, mesin sEMG dibersihkan.

8. Hasil rekaman sinyal sEMG dalam bentuk digital diserahkan kepada tim Teknik ITB untuk diproses sinyalnya. Hasil gambaran aktivitas listrik otot berupa kontraksi, panjang kontraksi dan amplitudo akan dianalisis.

9. Seluruh penilaian (MMT, FMA UE dan sEMG) dilakukan pada 3 hari setelah timbulnya stroke, hari keluar dari rumah sakit, 1 bulan, 2 bulan dan 3 bulan setelah timbulnya stroke.

Risiko dan ketidaknyamanan:

Tidak ada

Manfaat (langsung untuk subjek dan umum):

Manfaat langsung ke subjek dapat memberikan prediksi untuk pemulihan motorik anggota gerak atas

Manfaat untuk masyarakat dapat memberikan pemahaman pada masalah yang kompleks terkait stroke, mengembangkan teknik baru, menentukan rencana kepulangan pasien, meningkatkan hasil keluaran program rehabilitasi dan sebagai informasi kebijakan publik. Hasil penelitian juga diharapkan dapat meningkatkan pengetahuan dan menjadi dasar penelitian selanjutnya.

Prosedur alternatif:

Tidak ada

Kerahasiaan data:

Dokumen/berkas penelitian akan disimpan pada lokasi yang aman dan hanya dapat diakses oleh petugas yang terlibat dalam penelitian

Perkiraan jumlah subjek yang akan diikut sertakan:
30 subjek penelitian

Kesukarelaan:

Subjek penelitian dijelaskan terkait prosedur dan kesediaan untuk terlibat dalam penelitian. Jika subjek bersedia, subjek wajib menandatangani surat persetujuaan kesediaan ikut penelitian

Periode Keikutsertaan Subjek:

Februari – Agustus 2024

Subjek dapat dikeluarkan/mengundurkan diri dari penelitian:

Subjek akan dikeluarkan jika tidak datang follow up 2x atau lebih.

Subjek dapat mengundurkan diri dari penelitian sewaktu-waktu (kapanpun) tanpa konsekuensi apapun

Kemungkinan timbulnya pembiayaan dari perusahaan asuransi kesehatan atau peneliti:
Tidak ada

Insentif dan kompensasi:

Adanya kompensasi dan insentif akan diberikan kepada subjek penelitian pada akhir penelitian berupa uang transport senilai Rp 200.000,- dan bingkisan senilai Rp 150.000,-

Pertanyaan:
Contact person : Berthy : 082257297452

Lampiran 3. Surat Pernyataan Persetujuan

RUMAH SAKIT UMUM PUSAT Dr. HASAN SADIKIN BANDUNG
Dr. HASAN SADIKIN GENERAL HOSPITAL BANDUNG
KOMITE ETIK PENELITIAN KESEHATAN
HEALTH RESEARCH ETHICS COMMITTEE
Jl. Pasteur No. 38 Bandung 40161

PERSETUJUAN SETELAH PENJELASAN (PSP)
UNTUK IKUT SERTA DALAM PENELITIAN
(*INFORMED CONSENT*)

Saya telah membaca atau memperoleh penjelasan, sepenuhnya menyadari, mengerti, dan memahami tentang tujuan, manfaat, dan risiko yang mungkin timbul dalam penelitian, serta telah diberi kesempatan untuk bertanya dan telah dijawab dengan memuaskan, juga sewaktu-waktu dapat mengundurkan diri dari keikut sertaannya, maka saya **setuju/tidak setuju**[*)] ikut dalam penelitian ini, yang berjudul:

Saya dengan sukarela memilih untuk ikut serta dalam penelitian ini tanpa tekanan/paksaan siapapun. Saya akan diberikan salinan lembar penjelasan dan formulir persetujuan yang telah saya tandatangani untuk arsip saya.
Saya setuju:
Ya/Tidak[*)]

	Tgl.:	Tanda tangan (bila tidak bisa dapat digunakan cap jempol)
Nama Peserta: Usia: Alamat:		
Nama Peneliti:		
Nama Saksi:		

***) coret yang tidak perlu**

Lampiran 4. Fugl Meyer Assessment Upper Extremity

FUGL-MEYER ASSESSMENT **ID:**
UPPER EXTREMITY (FMA-UE) **Date:**
Assessment of sensorimotor function **Examiner:**

Fugl-Meyer AR, Jaasko L, Leyman I, Olsson S, Steglind S: The post-stroke hemiplegic patient. A method for evaluation of physical performance. Scand J Rehabil Med 1975, 7:13-31.

A. UPPER EXTREMITY, sitting position				
I. Reflex activity			**none**	**can be elicited**
Flexors: biceps and finger flexors (at least one)			0	2
Extensors: triceps			0	2
		Subtotal I (max 4)		
II. Volitional movement within synergies, without gravitational help			**none**	**partial** / **full**
Flexor synergy: Hand from contralateral knee to ipsilateral ear. From extensor synergy (shoulder adduction/ internal rotation, elbow extension, forearm pronation) to flexor synergy (shoulder abduction/ external rotation, elbow flexion, forearm supination). **Extensor synergy:** Hand from ipsilateral ear to the contralateral knee	Shoulder	retraction	0	1 / 2
		elevation	0	1 / 2
		abduction (90°)	0	1 / 2
		external rotation	0	1 / 2
	Elbow	flexion	0	1 / 2
	Forearm	supination	0	1 / 2
	Shoulder	adduction/internal rotation	0	1 / 2
	Elbow	extension	0	1 / 2
	Forearm	pronation	0	1 / 2
		Subtotal II (max 18)		
III. Volitional movement mixing synergies, without compensation			**none**	**partial** / **full**
Hand to lumbar spine hand on lap	cannot perform or hand in front of ant-sup iliac spine		0	
	hand behind ant-sup iliac spine (without compensation)			1
	hand to lumbar spine (without compensation)			2
Shoulder flexion 0°- 90° elbow at 0° pronation-supination 0°	immediate abduction or elbow flexion		0	
	abduction or elbow flexion during movement			1
	flexion 90°, no shoulder abduction or elbow flexion			2
Pronation-supination elbow at 90° shoulder at 0°	no pronation/supination, starting position impossible		0	
	limited pronation/supination, maintains starting position			1
	full pronation/supination, maintains starting position			2
		Subtotal III (max 6)		
IV. Volitional movement with little or no synergy			**none**	**partial** / **full**
Shoulder abduction 0 - 90° elbow at 0° forearm neutral	immediate supination or elbow flexion		0	
	supination or elbow flexion during movement			1
	abduction 90°, maintains extension and pronation			2
Shoulder flexion 90° - 180° elbow at 0° pronation-supination 0°	immediate abduction or elbow flexion		0	
	abduction or elbow flexion during movement			1
	flexion 180°, no shoulder abduction or elbow flexion			2
Pronation/supination elbow at 0° shoulder at 30°- 90° flexion	no pronation/supination, starting position impossible		0	
	limited pronation/supination, maintains start position			1
	full pronation/supination, maintains starting position			2
		Subtotal IV (max 6)		
V. Normal reflex activity assessed only if full score of 6 points is achieved in part IV; compare with the unaffected side			**hyper**	**lively** / **normal**
Biceps, triceps, finger flexors	2 of 3 reflexes markedly hyperactive		0	
	1 reflex markedly hyperactive or at least 2 reflexes lively			1
	maximum of 1 reflex lively, none hyperactive			2
		Subtotal V (max 2)		
		Total A (max 36)		

B. WRIST support may be provided at the elbow to take or hold the starting position, no support at wrist, check the passive range of motion prior testing		none	partial	full
Stability at 15° dorsiflexion elbow at 90°, forearm pronated shoulder at 0°	less than 15° active dorsiflexion dorsiflexion 15°, no resistance tolerated maintains dorsiflexion against resistance	0	1	2
Repeated dorsifexion / volar flexion elbow at 90°, forearm pronated shoulder at 0°, slight finger flexion	cannot perform volitionally limited active range of motion full active range of motion, smoothly	0	1	2
Stability at 15° dorsiflexion elbow at 0°, forearm pronated slight shoulder flexion/abduction	less than 15° active dorsiflexion dorsiflexion 15°, no resistance tolerated maintains dorsiflexion against resistance	0	1	2
Repeated dorsifexion / volar flexion elbow at 0°, forearm pronated slight shoulder flexion/abduction	cannot perform volitionally limited active range of motion full active range of motion, smoothly	0	1	2
Circumduction elbow at 90°, forearm pronated shoulder at 0°	cannot perform volitionally jerky movement or incomplete complete and smooth circumduction	0	1	2
	Total B (max 10)			

C. HAND support may be provided at the elbow to keep 90° flexion, no support at the wrist, compare with unaffected hand, the objects are interposed, active grasp		none	partial	full
Mass flexion from full active or passive extension		0	1	2
Mass extension from full active or passive flexion		0	1	2
GRASP				
a. Hook grasp flexion in PIP and DIP (digits II-V), extension in MCP II-V	cannot be performed can hold position but weak maintains position against resistance	0	1	2
b. Thumb adduction 1-st CMC, MCP, IP at 0°, scrap of paper between thumb and 2-nd MCP joint	cannot be performed can hold paper but not against tug can hold paper against a tug	0	1	2
c. Pincer grasp, opposition pulpa of the thumb against the pulpa of 2-nd finger, pencil, tug upward	cannot be performed can hold pencil but not against tug can hold pencil against a tug	0	1	2
d. Cylinder grasp cylinder shaped object (small can) tug upward, opposition of thumb and fingers	cannot be performed can hold cylinder but not against tug can hold cylinder against a tug	0	1	2
e. Spherical grasp fingers in abduction/flexion, thumb opposed, tennis ball, tug away	cannot be performed can hold ball but not against tug can hold ball against a tug	0	1	2
	Total C (max 14)			

D. COORDINATION/SPEED, sitting, after one trial with both arms, eyes closed, tip of the index finger from knee to nose, 5 times as fast as possible		marked	slight	none
Tremor		0	1	2
Dysmetria	pronounced or unsystematic slight and systematic no dysmetria	0	1	2
		≥ 6s	2 - 5s	< 2s
Time start and end with the hand on the knee	6 or more seconds slower than unaffected side 2-5 seconds slower than unaffected side less than 2 seconds difference	0	1	2
	Total D (max 6)			

TOTAL A-D (max 66)	

H. SENSATION, upper extremity eyes closed, compared with the unaffected side		anesthesia	hypoesthesia or dysesthesia	normal
Light touch	upper arm, forearm	0	1	2
	palmary surface of the hand	0	1	2
		less than 3/4 correct or absence	3/4 correct or considerable difference	correct 100%, little or no difference
Position small alterations in the position	shoulder	0	1	2
	elbow	0	1	2
	wrist	0	1	2
	thumb (IP-joint)	0	1	2
			Total H (max12)	

I. PASSIVE JOINT MOTION, upper extremity, sitting position, compare with the unaffected side				**J. JOINT PAIN** during passive motion, upper extremity		
	only few degrees (less than 10° in shoulder)	decreased	normal	pronounced pain during movement or very marked pain at the end of the movement	some pain	no pain
Shoulder						
Flexion (0° - 180°)	0	1	2	0	1	2
Abduction (0°-90°)	0	1	2	0	1	2
External rotation	0	1	2	0	1	2
Internal rotation	0	1	2	0	1	2
Elbow						
Flexion	0	1	2	0	1	2
Extension	0	1	2	0	1	2
Forearm						
Pronation	0	1	2	0	1	2
Supination	0	1	2	0	1	2
Wrist						
Flexion	0	1	2	0	1	2
Extension	0	1	2	0	1	2
Fingers						
Flexion	0	1	2	0	1	2
Extension	0	1	2	0	1	2
Total (max 24)				**Total** (max 24)		

A. UPPER EXTREMITY	/36
B. WRIST	/10
C. HAND	/14
D. COORDINATION / SPEED	/ 6
TOTAL A-D (motor function)	/66

H. SENSATION	/12
I. PASSIVE JOINT MOTION	/24
J. JOINT PAIN	/24

Lampiran 5. National Institutes of Health Stroke Scale (NIHSS)

2706

Providence | Health System

NIH STROKE SCALE

PSVMC - Providence St. Vincent Medical Center
PMH - Providence Milwaukie Hospital
PPMC - Providence Portland Medical Center

PATIENT IMPRINT

Category	Score/Description		Date/Time Initials	Date/Time Initials	Date/Time Initials	Date/Time Initials	Date/Time Initials
1a. Level of Consciousness (Alert, drowsy, etc.)	0 = Alert 1 = Drowsy 2 = Stuporous 3 = Coma						
1b. LOC Questions (Month, age)	0 = Answers both correctly 1 = Answers one correctly 2 = Incorrect						
1c. LOC Commands (Open/close eyes, make fist/let go)	0 = Obeys both correctly 1 = Obeys one correctly 2 = Incorrect						
2. Best Gaze (Eyes open - patient follows examiner's finger or face)	0 = Normal 1 = Partial gaze palsy 2 = Forced deviation						
3. Visual Fields (Introduce visual stimulus/threat to pt's visual field quadrants)	0 = No visual loss 1 = Partial Hemianopia 2 = Complete Hemianopia 3 = Bilateral Hemianopia (Blind)						
4. Facial Paresis (Show teeth, raise eyebrows and squeeze eyes shut)	0 = Normal 1 = Minor 2 = Partial 3 = Complete						
5a. Motor Arm - Left **5b. Motor Arm - Right** (Elevate arm to 90° if patient is sitting, 45° if supine)	0 = No drift 1 = Drift 2 = Can't resist gravity 3 = No effort against gravity 4 = No movement X = Untestable (Joint fusion or limb amp)	Left					
		Right					
6a. Motor Leg - Left **6b. Motor Leg - Right** (Elevate leg 30° with patient supine)	0 = No drift 1 = Drift 2 = Can't resist gravity 3 = No effort against gravity 4 = No movement X = Untestable (Joint fusion or limb amp)	Left					
		Right					
7. Limb Ataxia (Finger-nose, heel down shin)	0 = No ataxia 1 = Present in one limb 2 = Present in two limbs						
8. Sensory (Pin prick to face, arm, trunk, and leg - compare side to side)	0 = Normal 1 = Partial loss 2 = Severe loss						
9. Best Language (Name item, describe a picture and read sentences)	0 = No aphasia 1 = Mild to moderate aphasia 2 = Severe aphasia 3 = Mute						
10. Dysarthria (Evaluate speech clarity by patient repeating listed words)	0 = Normal articulation 1 = Mild to moderate slurring of words 2 = Near to unintelligable or worse X = Intubated or other physical barrier						
11. Extinction and Inattention (Use information from prior testing to identify neglect or double simultaneous stimuli testing)	0 = No neglect 1 = Partial neglect 2 = Complete neglect						
	TOTAL SCORE						

INITIAL	SIGNATURE	INITIAL	SIGNATURE	INITIAL	SIGNATURE

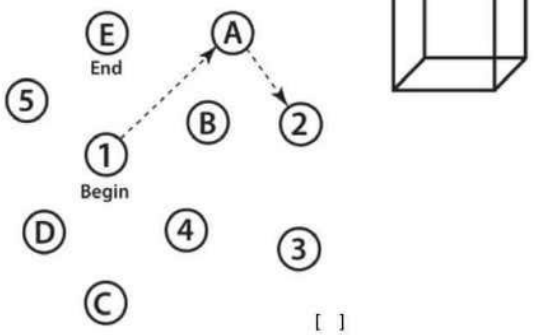
19833 10/04

Lampiran 6. Montreal Cognitive Assessment (MoCA-Ina)

MONTREAL COGNITIVE ASSESMENT-Versi Indonesia (MoCA-Ina)

NAMA:
Pendidikan: Tgl Lahir:
Jen. Kelamin: Tgl Pemeriksaan:

VISUOSPASIAL/EKSEKUTIF — POIN

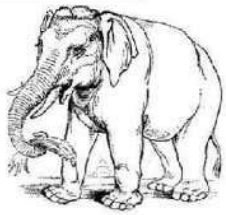


[ ] salin gambar [ ]

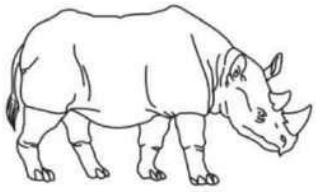
Gambar jam (11 lebih 10 menit) (3 poin)

[ ] bentuk [ ] angka [ ] jarum jam ..../5

PENAMAAN



[ ]



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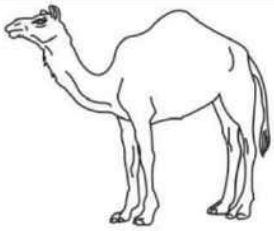

[ ] ..../3

MEMORI Baca kata berikut dan minta subjek mengulanginya. lakukan 2 kali, meski berhasil pada percobaan ke-1. lakukan recall setelah 5 menit

	wajah	Sutera	Masjid	anggrek	merah
ke-1					
ke-2					

ATENSI Baca daftar angka (1 angka/detik) Subjek harus mengulangi dari awal [ ] 2 1 8 5 4
Subjek harus mengulangi dari belakang [ ] 7 4 2 ..../2

Baca daftar huruf. subjek harus mengetuk dengan tangannya setiap kali huruf A muncul. poin nol jika ≥ 2 kesalahan
[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B ..../1

Pengurangan berurutan dengan angka 7. Mulai dari 100 [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65
4,5 hasil benar: 3 poin, 2 atau 3 benar: 2 poin; 1 benar: 1 poin, 0 benar: 0 poin ..../3

BAHASA Ulangi: Wati membantu saya menyapu lantai hari ini. [ ]
Tikus bersembunyi di bawah dipan ketika kucing datang. [ ] ..../2

Sebutkan sebanyak mungkin kata yang dimulai dengan huruf S [ ] ..... (N ≥ 11 kata) ..../1

ABSTRAKSI Kemiripan antara, contoh pisang - jeruk = buah [ ] kereta - sepeda [ ] jam tangan - penggaris ..../2

DELAYED RECALL

	wajah	Sutera	Masjid	anggrek	merah	
Harus mengingat kata TANPA PETUNJUK	[ ]	[ ]	[ ]	[ ]	[ ]	poin untuk recall tanpa petunjuk
Opsional petunjuk kategori						
petunjuk pilihan ganda						..../5

ORIENTASI [ ] Tanggal [ ] Bulan [ ] Tahun [ ] Hari [ ] Tempat [ ] Kota ..../6

Normal ≥ 26 / 30 Total ...../30

Dilakukan oleh..... Tambahkan 1 poin jika pend. ≤12 tahun

Lampiran 7. Glasgow Coma Scale

Glasgow Coma Scale

BEHAVIOR	RESPONSE	SCORE
Eye opening response	Spontaneously	4
	To speech	3
	To pain	2
	No response	1
Best verbal response	Oriented to time, place, and person	5
	Confused	4
	Inappropriate words	3
	Incomprehensible sounds	2
	No response	1
Best motor response	Obeys commands	6
	Moves to localized pain	5
	Flexion withdrawal from pain	4
	Abnormal flexion (decorticate)	3
	Abnormal extension (decerebrate)	2
	No response	1
Total score:	*Best response*	15
	Comatose client	8 or less
	Totally unresponsive	3