Comparison of Impedance Parameters and Occupational Therapy Evaluation in the Paretic and Non-paretic Upper Extremity of Hemiplegic Stroke Patients

Chan-Uk Yoo*, Jaehyung Kim**, Youngjun Hwang***, Gunho Kim****, Yong-II Shin******, Gyerok Jeon******

ABSTRACT

Many stroke patients undergoing rehabilitation therapy require a quantitative indicator for the evaluation of body function in paretic and non-paretic regions. In this study, the impedance parameters were acquired to assess the physical status in the upper extremity of thirty six stroke patients with hemiplegia caused by cerebral hemorrhage (10 patients) and cerebral infarction (26 patients), using bioelectrical impedance. Prediction marker (PM), phase angle (PA), PM/PA, and resistance (R) versus reactance (Xc) were utilized to evaluate the functional status of the paretic and non-paretic regions. In addition, the hand grip strength (HGS) and the pinch strength (lateral, palmer, tip) were measured on the upper extremity of hemiplegic stroke patients. PM was distributed in inversely proportional to HGS, but PA was distributed in proportional to HGS. However, there were a number of patients with HGS of 0, regardless of the impedance parameters (PM, PA, R vs. Xc). Paretic and non-paretic status in upper extremity of these patients could not be analyzed using impedance parameters. At the rehabilitation therapist’s instructions, they were unable to move the hand and fingers of the paretic upper extremity by cranial nerve damage, motor nerve damage, and severe cognitive decline.

Key words: Hemiplegic Stroke Patient, Cerebral Hemorrhage, Cerebral Infarction, Impedance parameters, Occupational Therapy Evaluation

1. INTRODUCTION

Stroke is a neurologic disturbance caused by damage to the cerebral blood vessels and one of the most common diseases of adulthood [1]. Most strokes are ischemic strokes that result from insufficient blood flow to the brain when blood vessels become clogged by blood clots or become too narrow for blood to pass through. Brain cells in this area die from lack of oxygen. In other types of strokes, called hemorrhagic strokes, the blood vessels are not blocked and rupture, causing blood to penetrate the brain, resulting in serious brain damage. Many stroke patients have a number of serious disorders such as hemiplegia, motor disturbance, sensory disability, language impairment, communication disorder, emotional disorder, and cognitive impairment [2]. Hemiplegia is paralysis

* Corresponding Author: Gyerok Jeon, Address: 50612 Beomeo-ni, Mulgeum-eup, Yangsan-si, Gyeongsangnam-do, Korea, TEL: +82-55-940-5548, FAX: +82-55-940-5083, E-mail: gjeon@pusan.ac.kr
Receipt date: Sep. 29, 2017, Revision date: Nov. 8, 2017, Approval date: Nov. 10, 2017
** Department of Occupational Therapy, Hanyo University (E-mail: urjdjhaja@hanmail.net)
*** Dept. of Computer Simulation, Inje University (E-mail: jtkim@inje.ac.kr)

**** Medical Science, School of Medicine, Pusan National University (E-mail: daxwms7190@naver.com, kgb0383@naver.com)
***** Dept. of Rehabilitation Medicine & Institute of Medical Science, School of Medicine, Pusan National University (rmshin01@gmail.com)
****** Dept. of Biomedical Engineering, School of Medicine, Pusan National University

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on one side of the body, whereas hemiparesis weakens one side of the body [3]. Hemiplegia is more severe in the symptoms of the disease than hemiparesis. Both are common side effects of stroke or cerebrovascular accidents. Unilateral paralysis or weakness occurs when a stroke affects the corticospinal tract on the contralateral side of the brain. The right side of the brain controls the motor (movement) function on the left side of the body, while the left side of the brain controls the motor function on the right side of the body. Thus, when one side of the brain is damaged, it affects only one side of the body. One of the most common problems after stroke is limb dysfunction. Dysfunction in the extremities seriously degrades the quality of life because it challenges physical function and daily life [4]. Due to these post-stroke disabilities, stroke patients require long-term rehabilitation treatment such as physical therapy and occupational therapy [5].

Bioelectrical impedance analysis (BIA) has been increasingly used to estimate the body composition because it is easy to use, non-invasive, inexpensive and can be performed on a wide range of individuals [6-9]. The bioelectrical impedance (consisting of resistance and reactance) is measured by passing a low alternating current through the tissues in the body [10]. In recent years, BIA has been applied to assess the human body’s hydration and nutritional status and to diagnose diseases [11]. In this study, paralysis and non-paralysis in the upper extremity of 36 stroke patients caused by cerebral hemorrhage and cerebral infarction were evaluated using impedance parameters and occupational therapy assessment. Prediction marker (PM), phase angle (PA), PM/PA, R versus Xc on the parietal and non-parietal regions of the upper extremity of stroke patients with cerebral hemorrhage and cerebral infarction were investigated. These values did not show any significant difference between hemorrhage and cerebral infarction. However, there was a significant difference between paralysis and non-paralysis of upper extremity. In addition, the relationship between impedance parameters and occupational therapy evaluation tools (hand grip strength, pinch strength) did not show significant difference in some hemiplegic stroke patients. This is because the physical movement in the upper extremity is related to the imbalance of the nervous systems or cognitive ability after stroke as well as the function of the muscular systems. As a rehabilitation assessment tool, BIA could be used as an effective adjunct to quantitatively evaluate paralysis and paralysis in upper extremity of hemiplegic stroke patients.

2. THEORY

2.1 Bioelectrical Impedance (Z)

Impedance (Z) is the obstruction to the flow of an alternating current and is dependent on the frequency of the applied current. Z is defined in impedance magnitude (|Z|) and phase angle (θ) as shown in Equation (1) - (3) and Fig. 1. Bioimpedance is a complex quantity composed of resistance (R) caused by total body water and reactance (Xc) caused by the capacitance of the cell membrane [12].

\[ Z = R + jX_c \]  

\[
\omega = \frac{1}{\sqrt{LC}} 
\]

\[ X_c = \frac{1}{\sqrt{LC}} \]

\[ |Z| = \sqrt{R^2 + X_c^2} \]

\[ \theta = \tan^{-1}\left(\frac{X_c}{R}\right) \]

Fig. 1. Diagram showing the concept of a complex impedance, Z is impedance, |Z| is the magnitude of the impedance, R is the resistance, Xc is the reactance, and θ is the phase angle.
Resistance \( (R) \) is the real part of impedance; a device with purely resistive impedance does not exhibit a phase shift between voltage and current. Resistance reflects the hydration status in the body.

\[
R = |Z| \cos \theta
\]  

(2)

Reactance \( (X) \) is the imaginary part of the impedance; a component with a finite reactance induces a phase shift \( (\theta) \) between the voltage across it and the current passing through it. Reactance reflects the body cell mass (muscle mass) in the body.

\[
X = |Z| \sin \theta
\]  

(3)

The physical significance of complex impedance is that the steady-state current is not in phase with the applied voltage [13].

Resistance and reactance together determine the magnitude and phase angle of the impedance through the following relationship:

\[
|Z| = \sqrt{Z^2} = \sqrt{R^2 + X^2}
\]  

(4)

In a phasor diagram as shown in Fig. 1, the angle between the resistance and the reactance is the phase angle of the source voltage \( V \) with respect to the current \( I \); that is the angle by which the source voltage leads the current.

From the diagram,

\[
\tan \theta = \frac{X}{R}
\]  

(5)

\[
\theta = \tan^{-1} \left( \frac{X}{R} \right)
\]  

(6)

The resistance of an object depends on the shape and the material of the object. For a given shape, the resistance depends on the material the object is made of. Different materials provide different resistance to charge flow. The resistivity \( \rho \) of a material can be defined so that the resistance \( R \) of an object is directly proportional to \( \rho \). The resistivity \( \rho \) is an intrinsic property of a material, regardless of its shape or size. The resistance of an object of length \( L \), made of a material having a cross-sectional area \( A \) and a resistivity \( \rho \), is as follows [14].

\[
R = \frac{L}{\rho A}
\]  

(7)

The capacitor affects the current, so it has the ability to stop the current in a fully charged state. Since an AC voltage is applied, the rms current is limited by the capacitor. Since this is regarded as the effective resistance \( R_{eff} \) of the capacitor for AC, the rms current \( I \) in a circuit containing only capacitor \( C \) is given by another version of the Ohm's law as follows.

\[
I = \frac{V}{X_C}
\]  

(8)

where \( V \) is the rms voltage and \( X_C \) is defined to be

\[
X_C = \frac{1}{2\pi fC}
\]  

(9)

where \( X_C \) is called the capacitive reactance, because the capacitor reacts to impede the current. \( X_C \) has units of ohm and is inversely proportional to the capacitance \( C \); the larger the capacitance, the greater the charge it can store and the greater the current that can flow. \( X_C \) is also inversely proportional to the frequency \( f \); the greater the frequency, the less time there is to fully charge the capacitor, and so it impedes current less [14].

3. METHOD

3.1 Subject

Thirty-six stroke patients caused by cerebral hemorrhage (6 females and 4 males) and cerebral infarction (21 females and 5 males) were included in the measurement. Table 1 shows anthropometric data (age, height, mass, and body mass index) of 36 hemiplegic stroke patients participating in this study. The mean age (73.6 years) of hemiplegic stroke patients caused by cerebral infarction was 6.8 years higher than that (66.8 years) of hemiplegic stroke patients caused by cerebral hemor-
Table 1. Subject’s anthropometric data (n=36) and illness duration

<table>
<thead>
<tr>
<th>Variables</th>
<th>Status</th>
<th>Cerebral hemorrhage</th>
<th>Cerebral infarction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age [years]</td>
<td>66.8 ± 9.2</td>
<td>73.6 ± 8.9</td>
<td></td>
</tr>
<tr>
<td>Height [cm]</td>
<td>164.0 ± 5.6</td>
<td>162.3 ± 2.6</td>
<td></td>
</tr>
<tr>
<td>Mass [kg]</td>
<td>63.8 ± 8.8</td>
<td>55.2 ± 6.4</td>
<td></td>
</tr>
<tr>
<td>BMI [kg/m²]</td>
<td>23.4 ± 2.4</td>
<td>21.9 ± 2.0</td>
<td></td>
</tr>
<tr>
<td>Duration [years]</td>
<td>2.4 ± 0.5</td>
<td>2.0 ± 0.7</td>
<td></td>
</tr>
</tbody>
</table>

BMI: body mass index. BMI was calculated by dividing body mass [kg] by height squared [m²].

...rhage. Illness duration represents the period from the diagnosis of the disease to the time of the measurement.

3.2 Segmental Bioelectrical Impedance

Bioelectrical bioimpedance for 20 hemiplegic stroke patients was measured at Medifarm Hospital in Korea between October and November, 2015, and then for 16 hemiplegic stroke patients was measured at Gurye Nursing Hospital on September 1, 2017, using bioelectrical impedance spectroscopy (MultiScan 5000, Bodystat Ltd., Isle of Man, UK) according to the recommendations of the National Institutes of Health (NIH) Technology Assessment Statement. Before the measurement, the subjects were instructed to fast for at least 4 hours and not to consume alcohol for 24 hours. The subjects were also instructed to drink at least eight glasses of water and empty their bladders before the measurement was taken. Eight cutaneous electrodes (Bodystat-0525, Bodystat Ltd, Isle of Man, UK) were attached to the wrists (left, right) and the ankles (left, right) of the hemiplegic stroke patient while they were in a supine position on a nonconductive surface in Fig. 2. The distance between the electrode used to apply current and the electrode used to collect voltage was maintained at least 5 cm to prevent an interactional effect between them. To provide more accurate measurements, the anthropometric measurement was combined with body composition determined using BIA, which provides accurate measurements of body composition. Prior to participation in this study, each patient received an explanation of the study purpose and method and provided written informed consent. The study was approved by the Ethics Committee of Inje University Institutional Review Board for Clinical Studies (document number: 2014-250) and also approved by the IRB committee of Pusan National University Yangsan Hospital (IRB No. 03-2016-017).

3.3 Occupational Therapy Evaluation

3.3.1. Hand grip and pinch strength

Hand grip strength test is to measure the maximum isometric strength of the hand and forearm muscles. Hand grip strength in the paretic and non-paretic upper extremity of hemiplegic stroke patients was measured using a Jamar Hand Hydraulic Dynamometer (50330J1, Jamar Ltd., USA). Hand grip strength is in the range of 0 ~ 200lbs (90 kg). The subject holds the dynamometer in the hand to be tested, with the arms at right angle (90°) and the elbow by the side of the body. The handle of the dynamometer is adjusted if...
required. The base should rest on first metacarpal (heel of palm), while the handle should rest on middle of four fingers. When ready to measure hand grip strength, the subject should hold the dynamometer for about 5 seconds with the maximum isometric effect. Other body movements are not allowed at this time. The subject should be strongly encouraged to give a maximum effort. The hand grip strength was measured three times, and the subject was given a one-minute break between measurements. According to the occupational therapy assessment guide [15], there are 3 methods to measure the pinching strength of fingers. Lateral (or Key) pinch is to measure the strength between thumb pad and lateral aspect of index finger. Palmar (or 3-Jaw Chuck) pinch is to measure the strength among thumb, index, and middle finger. Tip-pinch is to measure the strength between thumb finger and index finger. Pinches (lateral, palmar, tip) were measured using a Jamar hydraulic pinch gauge (7498-05, Jamar Ltd., USA). Maximum pinch strength of a Jamar hydraulic pinch gauge was up to 45 lbs (20 kg).

4. RESULTS AND DISCUSSION

4.1 Bioelectrical Impedance

4.1.1 Prediction Marker (or Impedance ratio)

Prediction marker (PM) is defined as the ratio of the impedance \( Z \) measured at 200 kHz to the impedance \( Z \) measured at 5 kHz. When an alternating current (AC) having a frequency of 5 kHz is applied to the body, the current can not pass through the cell membrane but flows mainly into the extracellular fluid (ECF). Since the ECF is narrow and the external wall of cell is composed mainly of adipose (fatty) tissues, the impedance \( Z \) is measured high. However, current having a frequency of 200 kHz has enough energy to pass through the cell membrane and can flow to both ECF and the intracellular fluid (ICF). The larger the difference between \( Z \) at 5 kHz and \( Z \) at 200 kHz, the healthier the cells in the body. The PM close to 1.00 indicates a poor cellular health or excessive amount of fluid [16]. Fig. 3 shows the PM values for paretic and non-paretic upper extremity of hemiplegic stroke patients caused by cerebral hemorrhage and cerebral infarction. In both stroke patients caused by cerebral hemorrhage and stroke patients caused by cerebral infarction, mean values of PM (0.875, 0.885) in paretic regions were higher than those (0.861, 0.856) in non-paretic regions. The standard deviation (SD) of paralysis and non-paralysis in the upper extremities of 26 stroke patients caused by cerebral infarction was measured to be larger. This is due to the fact that there were many elderly subjects in 26 patients with cerebral infarction (21 females and 5 males), age distribution ranged from 32 to 90 years, and cerebral infarction had progressed for a long time.

4.1.2 Phase Angle (\( \delta \))

The phase angle (\( \delta \)) has long been associated with nutritional status and body cell mass and is a direct measurement of the functionality of cell membrane. It is also recognized as a global health indicator in body health assessment [17]. A higher phase angle means an increase in BCM (body cell mass) or a decrease in fluid, either recovery from infection or injury or a decrease in fluid from
dehydration. A loss of fat could also increase phase angle. On the other hand, a lower phase angle means a loss of BCM, or an increase of fluid (rehydrating, or sign of inflammation or infection [18]. Fig. 4 shows the phase angle (θ) for paretic and non-paretic upper extremity of hemiplegic stroke patients caused by cerebral hemorrhage and cerebral infarction. In both stroke patients caused by cerebral hemorrhage and stroke patients caused by cerebral infarction, mean values (3.58°, 3.59°) of PM in paretic regions were significantly lower than those (3.90°, 4.35°) in non-paretic regions. These results revealed that the loss of muscular mass in the paretic regions of stroke patient’s upper extremity had progressed considerably and that the integrity of the cell membranes in the lean mass had also deteriorated.

4.1.3 Relationship between PM and PA (θ)

PM is related to the function of the cell membrane and PA (θ) is proportional to the lean mass (LM) in the body. Fig. 5 shows the relationship between PM and PA for paretic and non-paretic upper extremity of hemiplegic stroke patients caused by cerebral hemorrhage and cerebral infarction. PM was found to be inversely related to PA in the paretic/non-paretic upper extremity of stroke patients. On the other hand, patients #26, #28, #29, #30, and #33 showed higher PM and lower PA in paretic regions (black circles, black squares) compared to non-paretic regions (white circles, white squares). Patient #29 is an 80-year-old male suffering from trauma and a traffic accident. The function of the cell membrane in the paretic region is deteriorated (PM=0.967) and the lean mass (muscles) is considerably reduced (PA=1.4°). Patient #33 is a 32-year-old male with brain injury who is classified as stroke hemiplegia caused by cerebral infarction. The onset of the disease was 25 years, but he was youngest (32 years) among 36 subjects. PM was 0.770 in the paretic upper extremity and 0.768 in the non-paretic upper extremity. PA was 6.3° in the paretic upper extremity and 6.6° in the non-paretic upper extremity.

4.1.4 Reactance (Xc) versus Resistance (R)

Resistance (R) reflects the total body water consisting of ECF and ICF in the body, and gives the information about the function of the cell membrane. Therefore, the relationship between R and Xc for hemiplegic stroke patients with upper extremity can be assessed to determine the status of physical functioning of paralysis and non-paralysis. Fig. 6 shows the relationship between resistance
(R) and reactance (X) for paretic and non-paretic upper extremity of 36 hemiplegic stroke patients caused by cerebral hemorrhage and cerebral infarction. The low resistances on the left reflect a lot of lean mass, while the high resistances on the right reflect a low lean mass and a high fat content. When the function of the cell membrane is significantly reduced, the paralysis/non-paralysis states of stroke patients are distributed below. However, when the cell membrane is healthy, the paralysis/non-paralysis states of stroke patients are distributed on the above. Therefore, the left upper regions indicate an healthy function of the body, and the right below regions reflect a state of stroke patients in which the bodily function is remarkably deteriorated. Overall, the status of the paralytic regions are distributed below, and the status of the paretic parts are distributed in the upper part. The mean value of R and X in the paretic upper extremity of 10 stroke patients caused by cerebral hemorrhage was (338.49Ω, 20.19Ω) and that in the non-paretic upper extremity of 10 stroke patients caused by cerebral hemorrhage was (337.21Ω, 22.39Ω). On the other hand, the mean value of R and X in the paretic upper extremity of 10 stroke patients caused by cerebral infarction was (324.57Ω, 19.53Ω) and that in the non-paretic upper extremity of 10 stroke patients caused by cerebral infarction was (311.96Ω, 23.03Ω).

4.2 Occupational Therapy Evaluation

4.2.1 Hand grip strength and pinch strength

Table 2 shows hand grip strength (HGS) and pinches (lateral, palma, tip) for paretic and non-paretic upper extremity of 36 hemiplegic stroke patients caused by cerebral hemorrhage and cerebral infarction. Hand grip strength and pinches in paretic region were significantly lower than those in non-paretic region for hemiplegic stroke patients. In the clinical setting, tools used to assess rehabilitation treatment of hemiplegic stroke patients include hand grip strength and pinch strength. The rehabilitation assessment of hemiplegic stroke patients caused by cerebral hemorrhage and cerebral infarction was as follows. For stroke hemorrhage patients, a mean value of HGS was 7.2 lb in the paretic hand and 13.4 lb in the non-paretic hand. A mean value of lateral pinch was 2.1 lb in the paretic fingers and 4.5 lb in the non-paretic fingers. A mean value of palm (three point) pinch was 1.8 lb in the paretic fingers and 3.5 lb in the non-

| Table 2, Hand grip strength (HGS) and pinch strength (lateral, palma, tip) for paretic and non-paretic upper extremity of 36 hemiplegic stroke patients caused by cerebral hemorrhage (N=10) and cerebral infarction (N=26) |
|-----------------------------------|-----------------|-----------------|-----------------|-----------------|
|                                   | P.CH            | NP.CH           | P.CI            | NP.CI           |
| HGS [lb]                          | 7.2±2.9         | 13.4±8.5*       | 7.2±2.6*        | 14.2±6.3*       |
| Pinch [lb]                        |                 |                 |                 |                 |
| Lateral                           | 2.1±2.1         | 4.5±19*         | 2.0±1.9         | 4.2±1.8*        |
| Palmer                            | 1.8±1.8         | 3.5±17*         | 1.7±1.4         | 3.4±17*         |
| Tip                               | 1.3±1.3         | 2.5±10*         | 1.1±1.1         | 2.3±11*         |

* Significant difference p<0.05.
parietic fingers. A mean value of tip pinch was 1.3 lb in the parietic fingers and 2.5 lb in the non-parietic fingers. Thus, there were significant differences between the parietic upper extremity and the non-parietic upper extremity (p < 0.05). For stroke infarction patients, a mean value of HGS was 7.2 lb in the parietic hand and 14.2 lb in the non-parietic hand. A mean value of lateral pinch was 2.0 lb in the parietic fingers and 4.2 lb in the non-parietic fingers. A mean value of palmer pinch was 1.7 lb in the parietic fingers and 3.4 lb in the non-parietic fingers. A mean value of tip pinch was 1.1 lb in the parietic fingers and 2.3 lb in the non-parietic fingers. Thus, there were also significant differences between the parietic upper extremity and the non-parietic upper extremity (p < 0.05).

In particular, hand grip strength (HGS) was nil in the parietic regions of eleven hemiplegic stroke patients (#10, #11, #20, #28, #29, #30, #32, #34, #35, and #36), illustrating a significant difference in neurophysiological function between parietic upper extremity and non-parietic upper extremity. Seven stroke patients had significantly lower phase angles (2.0° for #10, 2.7° for #11, and 2.1° for #20, 2.1° for #26, 1.4° for #29, 2.0° for #32, 2.5° for #34) in the parietic regions, suggesting a decrease in muscle mass and deterioration in cell membrane function. Four stroke patients had relatively higher phase angles (3.5° for #28, 3.0° for #30, 4.0° for #35, and 5.0° for #36) in the parietic regions, but their HGS score was rated as 0, indicating that brain nerve damage, motor nerve damage, or decreased cognitive ability affected the measurement results.

4.2.2 Relationship between impedance parameters and hand grip strength

Fig. 7 shows the relationship between prediction marker (PM) and hand grip strength (HGS) for parietic and non-parietic upper extremity of 36 hemiplegic stroke patients caused by cerebral hemorrhage and cerebral infarction. In general, PM is supposed to be inversely proportional to HGS. However, as shown in the left-hand side of Fig. 7, PM values are distributed in a variety of ways in vertical line but all HGS have zero. #29 was a hemiplegic stroke patient caused by cerebral infarction mentioned in Fig. 5. The patient #29 had a very high PM (0.967 in parietic region and 0.918 in non-parietic region) and a very low phase angle (1.4° in parietic region and 2.6° in non-parietic region). Patient #29 shows that the reactance is very low (7.27Ω in parietic region and 12.33Ω in non-parietic region) in Fig. 6, indicating a significant decrease in lean mass and a deterioration in muscular function in the paralysis and non-paralysis regions. Patient #34 is a 56-year-old female patient with low PM values (0.848 in parietic region and 0.812 in non-parietic region) and a significantly high value for PA (4.5° in parietic region and 5.9° in non-parietic region). The cause of paralysis for #34 could not be analyzed by impedance parameters (PM, PA, and PM/PA). However, in Fig. 7, HGS was 0 in parietic and non-parietic upper extremity. This seems to be due to loss of function in the brain nervous system or the motor nerves, which makes it impossible for the hand to move at all in the paralysis/paralysis area.
Fig. 8 shows the relationship between phase angle [°] and hand grip strength [lb] for paretic and non-paretic upper limbs of 36 hemiplegic stroke patients caused by cerebral hemorrhage and cerebral infarction. Generally, the phase angles are exposed to be proportional to HGS. The non-paretic regions are mainly distributed in the upper right and the paretic regions are mainly distributed in the lower left. However, as shown in the left-hand side of Fig. 8, PM values have various values as a vertical distribution, but all HGS values were zero. Patient #29 has low phase angles (1.4° in paretic region and 2.6° in non-paretic region). Patient #34 had low PM (0.812 in paretic region and 0.848 in non-paretic region) and high PA (6.3° in paretic region and 6.6° in non-paretic region), but HGS was 0 in paretic and non-paretic upper extremity. As described in Fig. 7, Patient #29 and #34 are supposed to have HGS measured as 0 for the same pathological cause.

4.3 DISCUSSION

Long-term muscle changes such as a loss in muscle mass, a reduction of fiber cross-sectional area, and an increase in intramuscular fat deposition are reported to occur between 3 weeks and 6 months after stroke in both paretic and non-paretic upper extremity [19, 20]. Therefore, appropriate stroke rehabilitation is needed in a timely manner (within 3–6 months) for stroke patients. Non-invasive measurements are essential to evaluate paralysis and non-paralysis in stroke patients according to rehabilitation therapy. Measurement of recovery after stroke is becoming increasingly important with the advent of new treatment options in stroke rehabilitation research [21, 22]. The effects of inpatient rehabilitation on functional recovery of chronic stroke patients with cognitive dysfunction were investigated [5].

For example, the Fugl-Meyer scale was also developed as the first quantitative assessment tool to measure stroke recovery in stroke patients [21]. In addition, among patients who had a stroke within 3–9 months, constraint-induced movement therapy resulted in statistically significant and clinically relevant improvements in arm motor function lasting at least one year [22]. However, these methods are subjective in assessing body function in the paralysis caused by stroke, and it takes a lot of time and labor to test. On the other hand, evaluating paralysis and non-paralysis sites in stroke patients using BIA is a simple, non-invasive approach and provides an easy way to obtain the physiological/pathological functions of muscles [23] as well as body hydration and composition.

5. CONCLUSION

Many researchers have long used biological impedance parameters to investigate the physical composition and physiological characteristics of tissues. However, there has been little research on the relationship between bioimpedance parameters and occupational therapy assessment tools for upper extremity paralysis in stroke patients. In this study, we used biological impedance parameters to quantitatively evaluate paraplegic and paralytic upper limb in stroke hemiplegia patients caused by cerebral hemorrhage and cerebral infarction. The
impedance parameters (PM, PA, PM/PA, R vs. X) were compared with occupational therapy evaluation (hand grip and pinch strength) to determine whether the impedance parameters are related to the paretic/non–paretic status of hemiplegic stroke patients and the outcome of the rehabilitation assessment.

The results using biimpedance and occupational therapy evaluation can be summarized as follows. First, in both stroke patients caused by cerebral hemorrhage and stroke patients caused by cerebral infarction, mean values of PM (0.875, 0.885) in paretic regions were higher than those (0.861, 0.856) in non–paretic regions. Mean values (3.58°, 3.59°) of PA in paretic regions were significantly lower than those (3.90°, 4.35°) in non–paretic regions. PM was found to be inversely related to PA. Second, in R–X graph, the status of the paralytic regions are distributed below and the status of the paralytic parts are distributed in the upper part. The mean value of R and X, in the paretic upper extremity of 10 stroke patients caused by cerebral hemorrhage was (338.49°, 20.19°) and that in the non–paretic upper extremity of 10 stroke patients caused by cerebral hemorrhage was (337.21°, 22.39°). Third, PM is inversely proportional to hand grip strength. But, PM values are distributed in a variety of ways in vertical line and all have zero HGS. Fourth, the phase angles are proportional to HGS. The non–paretic regions are mainly distributed in the upper right, and the parietic regions are mostly distributed in the lower left. Some patients had zero HGS, regardless of the value of the impedance parameters (PM, PA, PM/PA, R vs. X). They were unable to move their hands and fingers in the paretic upper extremity because of brain nerve damage, motor nerve damage, and cognitive impairment.

The limitations of this study are as follows. The number of hemiplegic stroke patients with paretic upper extremity caused by cerebral hemorrhage was limited to 10. When the subjects are categorized by gender, age, and disease states, and the impedance measurement are performed for a long time intervals in the rehabilitation therapy, impedance characteristics could be quantitatively distinguished as a more confident manner.

REFERENCE


Yoo Chan-Uk
He received B.S. from Inje University, Korea, in 2006, and M.S. degree from Yonsei University, 2008, respectively, and Ph. D degree from Inje University, Korea, 2016. He is currently professor of occupational therapy at Hanlyo University and has deep interest in Bioelectrical impedance analysis and Cognitive rehabilitation, etc. He has been serving as a lecturer at the Korea Safety Promotion Association from 2012, and also as a lecturer in dementia education at National Insurance Corporation from 2013.

Kim Jaehyung
He received B.S. and M. S. degree from Pusan National University, Korea, in 1979 and 1981, respectively, and Ph. D degree from Kyungnam University, Korea, in 1992. He was visiting scientist at Liquid Crystal Institute of Kent State University, USA in 1993, and visiting professor at Physics Department of Portland State University, USA, in 2003. He is currently researcher at Research Institute of Nursing Science, Pusan National University and has deep interest in bioelectrical impedance, electro-dermal activity, and electrical stimulator, etc.

Hwang Youngjung
He received a bachelor’s degree from Pusan National University, Korea, 2017. He is in the master’s degree in dept. of medical science, Pusan National University, Yangsan, Korea.

Kim Gunho
He received a bachelor’s degree from Pusan National University, Korea, 2017. He is in the master’s degree in dept. of medical science, Pusan National University, Yangsan, Korea.

Shin Yong-II

Jeon Gyerok
He received B.S. and M.S. degree from Pusan National University, Korea, 1978 and 1982, respectively. And doctor degree from Donga University Korea, 1993. He is currently professor at department of biomedical engineering, school of medicine, Busan National University, and working at Busan national university Yangsan hospital. His major is biomedical signal processing and biomedical measurement system.