Acoustic Analysis of Speech Disorder Associated with Motor Aphasia - A Case Report -

Myung-Hwan Ko.* · Hyun-Ki Kim · Yun-Hee Kim***

ABSTRACT

Motor aphasia is an affection frequently caused by insult of the left middle cerebral artery and usually accompanied by a large lesion involving the Broca's area and the adjacent motor and premotor areas. Therefore, a patient with motor aphasia commonly shows articulatory disturbances due to failure of the motor programing of speech sound. Objective assessment and treatment of phonologic programing is one of the important aspects of speech therapy in aphasic patients. We analyzed the speech disorders acompanied with motor aphasia in a 45-year-old man using a computerized sound spectrograph, Visi-Pitch®, and Multi-Dimensional Voice Program®. We concluded that a computerized speech analysis system is a useful tool to visualize and quantitatively analyse the severity and progression of dysarthria, and the effect of speech therapy.

Keywords: Motor aphasia, Dysarthria, Computerized speech analysis system

1. INTRODUCTION

Motor aphasia is a syndrome of language disorder characterized by difficult speech production, impairments in melodic line and articulation, semantic and phonemic paraphasias, telegraphic or shortened phrase lengths, and reduced and abnormal grammatical form[1]. A patient with motor aphasia usually has dyarthria, regarded as a disturbance of the motor programing of speech sound when the lesion involves the Broca's area and adjacent motor and premotor area[3]. Therefore, a patient with motor aphasia usually has articulation disorder, i.e., dysarthria in an acute stage.

Traditionally, dysarthria has been evaluated based on auditory perceptual judgment, which is subjective and not quantifiable. For successful rehabilitation of speech

* Dept. of Rehabilitation, Chonbuk National University School of Medicine
* Faculty of European Language and Literature, Chonbuk National University

disturbance, an objective and quantitative analysis of speech disorder is required. In this study, we report a 45-year-old man with motor aphasia combined with dysarthria to delineate the usefulness of acoustic analysis in assessing the articulatory disturbance quantitatively and qualitatively as well as the progress after speech therapy.

2. A CASE REPORT

A 45-year-old right-handed man was transferred to our rehabilitation department after sudden left hemiplegia and aphasia. Upon neurological examination he was alert, but had global aphasia. The cranial nerve examination showed a right supranuclear facial paralysis. There was a right hemiplegia, which was worse in the upper limb. His reflexes were increased on the right side, with an extensor plantar response. The initai CT scan showed a wedge shaped low density area in the left middle cerebral artery distribution area involving the Broca's area and a adjacent premotor and motor areas (Fig. 1-A). The left common carotid artery angiogram showed a severe proximal internal carotid artery stenosis (Fig. 1-B). There was extensive collateral circulations from the left external carotid artery, but the left middle cerebral artery was not visualized (Fig. 1-C). The patient was treated with a comprehensive rehabilitation program including speech therapy for seventeen months (from October 1997 to March 1999). We assessed the severity of aphasia and dysarthria three times during his treatment period using the Chonbuk Aphasia Assessment Battery (Appendix) and the computerized speech analysis system.

2.1 Aphasia Assessment

We assessed the patient using the Chonbuk Aphasia Assessment Battery. The Chonbuk Aphasia Assessment Battery consisted of five categories; auditory comprehension, oral expression, reading comprehension, oral reading, and writing. The initial assessment was performed on October 1997, one month after onset of stroke. The total language performance rate was 18.2 %. Oral expression performance rate was the worst, however auditory comprehension, reading comprehension, oral reading, and writing performance were also severed. These results led us to diagnose him with global aphasia. On the second assesment in June 1998, the total performance rate tripled to 56.8 %. The oral expression performance rate increased to 39.4 %. On the third assessment in May 1999, the total performance rate showed another great increase to 71.2 %. The oral expression performance rate was 60 % (Fig. 2). On the final assessment, his aphasia pattern was converted to motor aphasia.

2.2 Acoustic Assessment of Articulation Disturbance

2.2.1 Assessment of Vowels

We assessed the abnormality of voice quality by Multi-Dimensional Voice Program Model 403® (Kay Electrics Co. USA) and Visi-Pitch®. On the initial assessment, the degree of sub-harmonics (DSH), values of harmonic structure of the spectrum (Soft Phonation Index, SPI), peak amplitude variation (vAM), and fundamental frequency variation (vFo) showed a high increment. On the second assesment, SPI value was decreased. On the third assessment, all of these abnormalities became normalized (Fig. 3). The jitter score of sound /a/ was 1.198 % on the initial, 0.317 % on the second, and 0.265 % on the third assessment. The diadochokinetic rates of alveolar consonant were gradually improved from 4 on the initial assessment to 8 on the second and the third assessments (Table 1).

On the initial assessment, the first forment (Fl) frequency of /i/, /e/, /u/, and /o/ was higher. However, that of /a/ was lower than normal person. These values indicated abnormal articulation movement, i.e. aperture, etc., On the second and the third assessment, these abnormalities became normalized (Fig. 4).

2.2.2 Assessment of Consonants

The three different types of stop consonants were assessed by sound spectrography. The stimulation word was a meaningless triple-syllable word. The first syllable was assessed. On the initial assessment, slightly and heavily aspirated sounds were substituted by glottalized sound except heavily aspirated sound of velar consonant. On the second and the third assessments, the sounds of /p/ and /k/ became normalized, but slightly aspirated sound and heavily aspirated sound /k/ were changed to glottalized sound (Fig. 5). The voice onset time (VOT) was within normal value in all the assessed consonants at last assessment (Table 2).

2.2.3 Assessment of Intonation

We assessed the prosody patterns of question phrase by Visi-Pitch®. On the initial assessment, the patient was not able to complete speaking the task phrase. On the second and the third assessment, the patient spoke monotonously, and total speaking time was increased (Fig. 6).

3. DISCUSSION

Aphasia has been defined as an "acquired impairment of language processes understanding receptive and expressive modalities; caused by damage to areas of the brain that are primarily responsible for the language function."[4] Traditional bedside testing for aphasia emphasizes six areas of assessment: fluency, comprehension, naming, repetition, reading, and writing. Observation of literal or verbal paraphasia, neologisms, and paragramatism in spoken or written responses of a patient are regarded as clues for further characterizing the nature of the aphasia. Objective aphasia assesment is performed by many standardized aphasia batteries, such as the Minnesota Test for Differential Diagnosis of Aphasia, the Boston Diagnostic Aphasia Examination (BDAE), the Western Aphasia Battery, the Porch Index of Communicative Ability, the Token Test, and the Reading Comprehension Battery[6,8,10,11,13,15].

We assessed the patient by the Chonbuk Aphasia Assessment Battery. It consisted of five categories; auditory comprehension, oral expression, reading comprehension, oral reading, and writing. Auditory comprehension, oral expression, and reading comprehension categories have six subtests. The reading category has three subtests, and the writing category has seven subtests. Therefore, this battery is considered to have an ability for differential diagnosis of aphasia by comparing the performance of many aspect of language areas. The standardization of this battery in Korean normal and aphasic persons remained to be elucidated in future.

The eight major types of aphasia in the Boston system are accepted as classification of aphasic syndrome, such as Global, Broca, Wernike, conduction, tanscortical motor, transcortical sensory and mixed transcortical aphasia and anomia[5]. Major motor aphasia is frequently caused by the infarction which affect the dominant middle cerebral artery, encompassing not only Broca's inferior frontal region, but also the insula and the adjacent opeculum in the frontal to temporal lobe. In the acute stage, these patients frequently have the complete inability to speak and their degree of comprehension are difficult to discern. This result is in an apparent global aphasia. As time passes, the ability to understand language can improve, but these patients are left with deficit in many aspect of language skills. Usually, the patient with motor aphasia has articulation disturbance for speech, regarded as a disturbance of the motor programing of speech sound when the lesion involves the Broca's area and adjacent motor and premotor area. Therefore, the patient with motor aphasia usually has problems with articulation, i.e. dysarthria in acute stage[3]. Alexander[2] described variable clinical manifestations of Broca's aphasia according to the associated brain lesions. He reported that the lesions in the lower motor cortex produced a restricted dysarthric disorder, and the lesions extending more deeply to involve subcortical white matter and periventricular white matter may result in a much more complex syndrome with phonemic substitution and writing impairment, in addition to dysarthria.

As reported above, our patient's CT scan showed ischemic damage in the Broca's area and adjacent posteroinferior frontal, temporal, and parietal lobes. Initially he had global aphasia with articulatory disturbance in an acute stage. However, during rehabilitation speech therapy, the ability of language comprehension progressively improved and articulatory disturbance had also markedly decreased. These findings suggest that the damage of white matter in the temporal and premotor white matter may be incomplete in this patient. He showed improvement in oral expressive language by the end of therapy.

Dysarthria is a group of motor speech disorders characterized by slow, weak, imprecise, or uncoordinated movements of speech musculature. During the assessment of this impairment, the focus is placed on the speech production process. Traditional approaches to the assessment of dysarthria have been based on auditory perceptual judgments. More recent studies have used acoustic as well as perceptual methods, in order to quantify and objectify the assessment of dysarthria[7,9,12,16]. Since Potter et. al.[14] first developed the voice spectrography in the 1940's, many useful instruments to quantify and objectify the articulation disturbance have been developed: Sound spectrography, Nasometer®, Visi-Pitch®, etc.

In our experience, the use of the computer-implemented speech analysis system was very useful to determine the pattern of articulation disturbance for each phonemes in the patient with motor aphasia. We also think that these equipments can be applied for the biofeedback therapy of articulatory disorder in many patients with articulatory problem to obtain successful results with long-term treatment.

4. CONCLUSION

We reported a patient who showed ischemic damage to the Broca's area and adjacent fronto-parieto-temporal lobes. He had a articulatory disturbance in addition to motor aphasia. During rehabilitation speech therapy, articulatory disturbance was improved and this progress could be assessed objectively and quantitatively by computerized speech analyzing systems.

REFERENCES

[1] Albert ML, Goodglass H, Helm-Estabrooks N, Rubens AR, Alexander MP. 1981. Clinical aspects of dysphasia. Vienna: Springer-Verlag.
[2] Alexander MP, Naeser MA, Palumbo C. 1990. Broca's area aphasia: Aphasia after lesions including the frontal operculum. Neurology. 40: 353-362.
[3] Bogousslavsky J, Caplan L. 1995. Stroke syndrome, 1st ed, New York: Cambridge University Press, 118-133.

[4] Braddom RL. 1996. Physical Medicine and Rehabilitation, 1st ed, Philadelphia: W.B. Saunders Company, 49-pp65.

[5] DeLisa JA. 1998. Rehabilitation Medicine, 3rd ed, Philadelphia: Lippincott-Raven.

[6] DeRenzi E, Vignolo LA. 1962. The token test: a sensitive test to detect receptive disturbances in aphasia. Brain ; 85: 665-678.

[7] Gentil M. 1990. Acoustic characteristics of speech in Friedrich's disease. Folia Phoniat, 42: 125-134.

[8] Goodglass H, Kaplan E. 1983. The assessment of aphasia and related disorders. Philadelphia: Lea & Febiger.

[9] Kent R, Netsell R, Abbs JH. 1979. Acoustic characteristics of dysarthria associated with cerebellar disease. J Speech Hear Res, 22: 627-648.

[10] Kertesz A. 1982. The Western aphasia battery. New York: Grune & Stratton.

[11] LaPoint LL, Horner J. 1979. The reading comprehension battery. Tigard, OR: CC Publication.

[12] Miller M. 1995. Pronunciation error in acquired speech disorders: the errors of our ways. Eur J Disord Commun 30(3): 346-61.

[13] Porch BE. 1967. The Porch index of communicative ability. Palo Alto CA: Consulting Psychology Press.

[14] Potter R, Kopp G, Green H. 1947. Visible Speech, New York: D. Van Nostrand Company.

[15] Schuell H. 1965. The Minnesota test for differential diagnosis of aphasia. Minneapolis: University of Minnesota Press.

[16] Seaver EJ, Dalston RM, Leeper HA, Adams LE. 1991. A study of Nasometric values for normal nasal resonance. J Speech Hear Res, 34: 715-721.

Table 1. The Diadochokinetic Rate of Bilabial, Alvelor, and Velar Consonants.

Type of Consonats	1st Assessment	2nd Assessment	3rd Assessment
Bilabial	N.A.	8	8
Alveolar	4	8	8
Velar	N.A.	5	6

N.A.: not applicable

Table 2. The Voice Onst Time of Three Different Types of Consonats (value: msec)

Type of Consonant		1st Assessment	2nd Assessment	3rd Assessment
Bilabial	/pe/	27	34	36
	/p^{h}e/	14	36	48
	/p'e/	18	32	11
Alveloar	/te/	19	30	38
	/t^{h}e/	21	34	45
	/t'e/	21	22	14
Velar	/ke/	12	33	38
	/k^{h}e/	29	58	49
	/k'e/	36	50	46

(A) (B) (C)

Figure 1. (A) Axial contrast-enhanced CT scan shows a left-sided wedge-shaped low density area in the middle cerebral artery distribution. (B) In the left common carotid artery angiogram, anterior-posterior view shows a severe proximal internal carotid artery stenosis (arrow). (C) In the left common carotid artery angiogram, lateral view shows extensive collateral circulations through left external carotid artery, but middle cerebral artery is not visualizd.

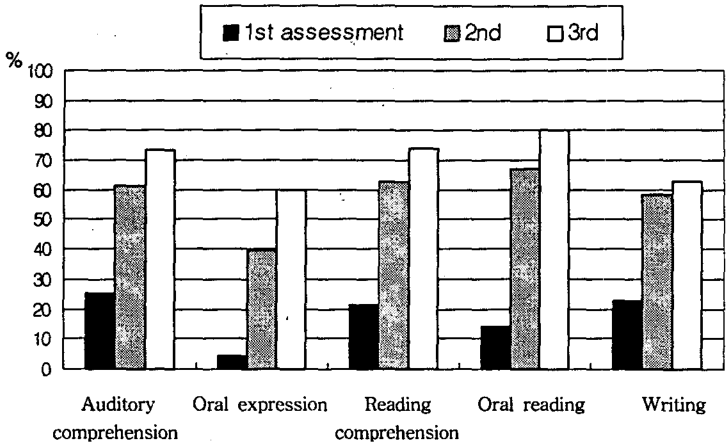
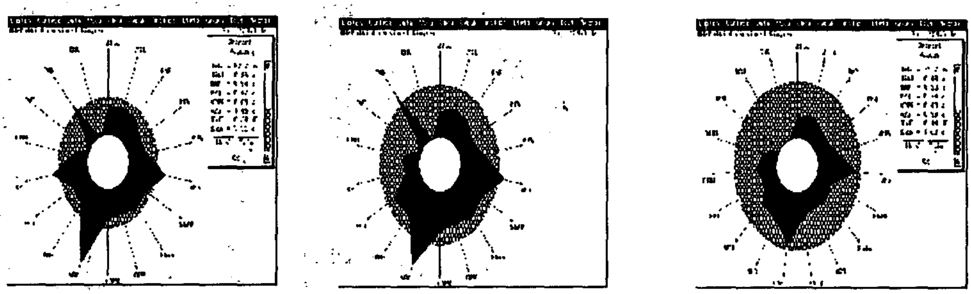


Figure 2. Aphasia profile assessment by the Chonbuk Aphasia Assessment Battery. On the initial assessment, the total performance rate was 18.2 %. Oral expression performance rate was the worst, 4.3 %. The performance rates of auditory comprehension, reading comprehension, oral reading, and writing were 25, 21.4, 14, and 22.9 % respectively. On the second and the third assessment, the performance rates were markedly improved in all language areas.



1st Assessment | 2nd Assessment | 3rd Assessment

Figure 3. Assessment of vowel by Multi-Dimensional Voice Program: On the initial assessment, the degree of sub-harmonics (DSH), values of harmonic structure of the spectrum (Soft Phonation Index, SPI), peak amplitude variation (vAM), and fundamental frequency variation (vFo) were highly increased. On the second assesment, degree of sub-harmonics (DSH), peak amplitude variation (vAM), and fundamental frequency variation (vFo) were still increased, but SPI value was decreased. On the third assessment, all parameters showed normal values.

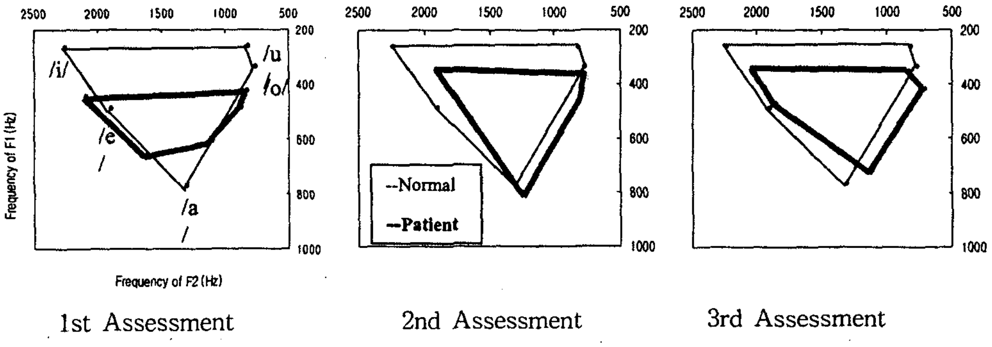


Figure 4. Vowel chart of /a/, /e/, /i/, /o/, and /u/ in patient and normal person: On the initial assessment, the first foment (F1) frequency of /i/, /e/, /u/, and /o/ was higher, however, that of /a/ was lower in the patient. On the second and the third assessment, these abnormality became normalized.

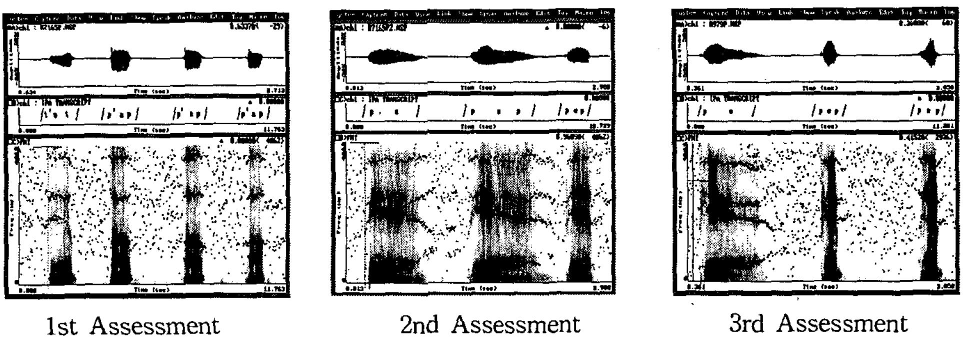
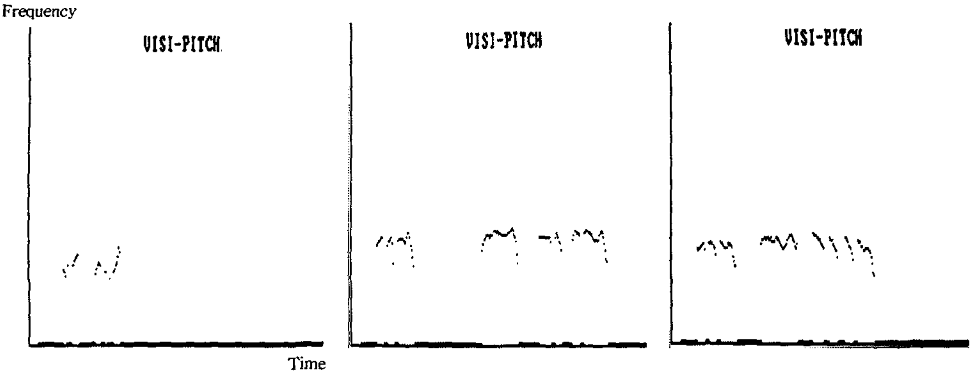


Figure 5. Assessment of consonants by spectrography: The Stimulation was /pe/, /pep/, /pep/. On the initial assessment, addition and substitution were observed; patients respones was [t'et], [p'ap], [p'ap], [p'ap]. The second and the third assessments showed more distinguishable formants without addition.



Stimulation phrase: " jɔposejo ɔmɔni tsipekyesjɔjo ? "

Figure 6. Assessment of prosody patterns by Visi-Pitch. (A) Normal person; total speaking time was 3.5 seconds, and the average and the standard deviation of frequency were 118.5 Hz and 42.5 Hz. (B) First assessment of patient; total speaking time was 8.3 seconds, and average and the standard deviation of frequency were 153.4 Hz and 14.3 Hz. (C) Second assessment of patient; total speaking time was 6.7 seconds, and the average and the standard deviation of frequency were 140.9 Hz and 11.2 Hz.

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▲ Myung-Hwan Ko
Dept. of Rehabilitation
School of Medicine, Chonbuk National University
634-18, Keum-dong, Dukjin-Ku,
Chonju, 561-721 KOREA
Tel: +82-652-250-1780 (O)
Fax: +82-652-254-4145
e-mail: rehab@moak.chonbuk.ac.kr

▲ Hyun-Ki Kim
Faculty of European Language and Literature
Chonbuk National University
664-14, Dukjin-dong, Dukjin-Ku,
Chonju, 561-721 KOREA
Tel: +82-2-652-270-3196 (O)
e-mail: hyungk@moak.chonbuk.ac.kr

▲ Yun-Hee Kim
Dept. of Rehabilitation
School of Medicine, Chonbuk National University
634-18, Keum-dong, Dukjin-Ku,
Chonju, 561-721 KOREA
Tel: +82-652-250-1780 (O)
Fax: +82-062-254-4145
e-mail: yunkim@moak.chonbuk.ac.kr