Neurodegenerative Diseases Symptoms and Treatment

Chapter 2

The Reasoning of Dysarthria in Parkinson's Disease

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Abstract

Parkinson's Disease (PD) is one of serious neurodegenerative disorders of central nervous system. Vocalization change is a significant manifestation in early stage of PD development, which including sound quality declined, poor articulation, trembling or hoarseness frequency changed, tone down, rhythm declined, lack of emotional and tonal change. All of these may caused by hypertension of muscle, which reduced the controllability on the vibration of vocal cord and adequate air flow from lung to make the vocalization smoothly. Here we provide one in-depth perspective of vocalization gradually changed accompanied with progression of PD.

Key words: Parkinson's Disease; Vocalization.

1. Background

1.1. Parkinson's Disease

Parkinson's Disease (PD) is a neurodegenerative disorder of the central nervous system [1], which characterized by motor and non-motor symptoms [2]. The motor symptoms of PD patients are dominantly present shaking, rigidity, slowness of movement, postural instability, and difficulty with walking and unsteady gait. They often experiences difficulties with hand functions, gait and are prone to falls when symptoms gradually worsen [1]. Non-motor symptoms (NMS), such as mood disorders, cognitive dysfunction, pain, sensory dysfunction, and dysautonomia [3], may impair quality of life in the vastest degree.

1.2. High Dysarthria Prevalence Rate

PD affects 1.5% of the world's population, and the prevalence rate of people over 80 years of age can reach 2.9% [4]. Close to 80–90% PD patients experienced voice changes [5], this may reduce the quality of communication.

2. Key Manifestations of Dysarthria in PD

2.1. Sound quality change and poor articulation

Firstly, PD patients are clinically characterized by a resting tremor, rigidity, bradykinesia and changes in voice and speech [6,7]. Early In 1989, Lowit A et al. suggested that syllables produced by PD patients have reduced clarity, especially during syllable acceleration, where the interval between syllables is not as clear as it should be [8].

The most salient features of PD are related to phonatory impairment, with the articulation being the second most affected speech subsystem [9]. The prevalence of Parkinson's dysarthria is high close to 90% [10]including poor breath support, resulting in a reduction in utterance length, short rushes of speech and inappropriate pausing behaviour, low speech volume, impaired articulation and monotonous intonation [8].

Poor articulation may dominantly lead to some negative effects. Muscle stiffness may work as a significant factor to reduced maximum pronunciation in vowel and pronunciation [11]. At the vocal level, vocal cord elongation is reduced, sound quality and range contours are affected as well [10].

2.2. Trembling or hoarseness, frequency and number of jitters increased

Sound tremor is one of the symptoms of PD, which may be caused by instability during nerve processes during breathing or vocalization [12]. This caused by gradual loss of dopamine. PD patients are presenting bradykinesia and stiffness [13]. In 2008, Midi I et al figured out that

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both the male and female PD patients have higher jitters and shim values than healthy people [14]; while In 2011, Rusz J et al mentioned the patients with PD show hoarseness and cannot speak fluently [9].

Meanwhile, in 2012, Silva LF et al revealed that the fundamental frequency (F0) and jitter showed a statistical difference between groups with higher values in the PD Group[15] .

2.3. Volume down

Sound volume reduction is another significant characteristics of PD dysarthria[4]. The reduction in acoustic sound is partly attributed to low dyskinesia and stiffness [16]. Dysarthria may be affected by any combination of speech subsystems, respiration, phonation, articulation, and velopharyngeal control [8].

Frequency voice symptoms of PD are mono loudness, mono pitch, breathiness, harshness and reduction of loudness [17]. Reduced sound intensity is a known complication of PD [9]. It is associated with two different but non-coincident mechanisms in clinical manifestations: respiratory support and vocal cord adduction limits [18]. In 2015,Mahler LA et al reported that the reduction in the amplitude of motion and the vocal cord adduction do not occur completely but can reduce vocal loudness during the vocalization process of patients with PD [19].

Moreover, PD patients maybe lack of adequate respiratory support to produce normal phrases and loudness changes. Other factors, such as reduced vocal cord elongation and limited adduction, can affect the sound quality at the vocal level [10].

In addition, a respiratory pressure could be leading deficits in phonation and articulation, such as decreased loudness and decreased ability to alter loudness. In 2011, Rusz J et al found an overall lower intensity level, deficits in intensity range and intensity variations during speech production of PD patients vocalization process [9].

2.4. Tone down or rhythm decline

Speech rate and rhythm in patients with PD are changed during disease progresses [20]. Difficult in secondary control of the laryngeal muscles leading to limited pitch adjustment in PD patients, and the pitch range is significantly lower than health subjects [11]. Many studies confirmed that the throat and pharyngeal stiffness and dynamism have an adverse effect on speech rate [21].

In the clinical setting, we found out that the speech rate of PD patients increased during the speech, which significantly reduced the total number of pauses, indicating that the rhythm of the speech and the timing of tissue function were impaired . In 2008, Skodda S and Schlegel U et al. founded PD reproduces the decline of perceptual speech rhythm ability and the pronunciation ability of accent, the imitative and perceptual ability reduction of emotional

intonation [22]. In 2009, Skodda S et al. suggested that the pitch and tone parameters of female patients were significantly reduced [23]. In 2011,Weismer proposed that PD patients produced speech at a faster rate because of articulation difficulties [24].

2.5. Lack of emotional and tonal changes

In 2011, Rusz et.al revealed that PD patients have lower melody in all FOSD tests, possibly due to changes in laryngeal tone, decreased respiratory support, and reduced range of motion [9]. In 2011, Skodda S et al. found that PD patients pronunciation shown a tendency to accelerate the pronunciation, and it was difficult to maintain a stable rhythm of repeated syllables [25]. In 2004, Kawada et al suggested that patients with PD have a slow pronunciation. When reading a short sentence, the pitch of each syllable is flat, and the speech of a single syllable lacks clarity [26]. The 98 of PD patients have changes in rhythm and speech rate due to stiff muscles, inaccurate pronunciation, small changes in height and intensity, causing flat melody and lack of tone [27]. In 2017, Jin Y et al. proposed that even in the early stages of PD, there are speech features such as reduced voice expression, low volume and non-emotional intonation, and abnormal speech rate [28].

3. Reasoning Analysis

3.1. Making-Sound related muscle coordination poorly

Dopaminergic neuronal degeneration in the striatum is recognized as the major neuropathologically related factor in motor injury in PD [29]. In PD, basal ganglia dopamine is gradually depleted, which is also a dominant part of causing the muscle stiffness and changing the controllability of muscle of larynx [14, 30] (see **Figure 1**). The muscles associated with vocal cord are supplied by the superior laryngeal nerve and the recurrent laryngeal nerve [31,32], including the cricothyroid cartilage, lateral and posterior cricothyroid arytenoid muscles[33]. The mode of vibration of the vocal cords and the generation of sound depend on the geometric shape and stiffness conditions of the adductive vocal cords [34] (see **Figure 2**). PD patients had a higher incidence of incomplete glottic closure and laryngeal tremor [14]. Usually due to the stiffness of the laryngeal muscle tissue, resulting in an increase of the hardness of the vocal cords, affects the closure of the vocal cords and increases the muscle tone [14]. (see **Figure 2**)

Both rhythm intensity and fundament frequency declined are key manifestation of vocalization changes in PD patients. The reason may refer to the principle of how sound generate, the frequency of sound depends on the vibration frequency of object. The more part of object involved in vibrate, the tone present more lowly. Consequently, we infer the controllability of motor neuron on the vocal cord may gradually loss from site a to c (see **Figure 3**), from blue to purple (see **Figure 4**).

The airflow pass through vocal cord, this induced the vibration the vocal cord (see Figure 4). Different colour present the part of vocal cord involved in vibration (see Figure 4). More motor neuron loss the controllability, more part of vocal cord involved in vibration, namely lower sound intensity and frequency. If the control of motor neuron on vocal cord gradually inactive from site a to c (see **Figure 3** and **4**), more part of vocal cord involved in vibration. Therefore, the sound intensity, fundamental frequency presented lower.

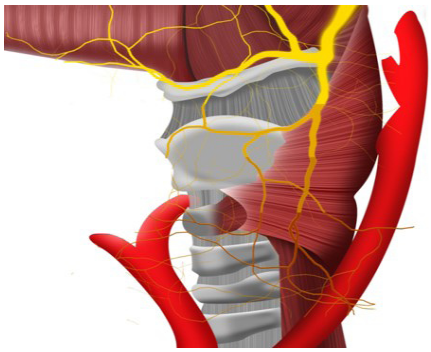

Figure 1: Sagittal View of Voca cord and its surrounding nerves and muscles

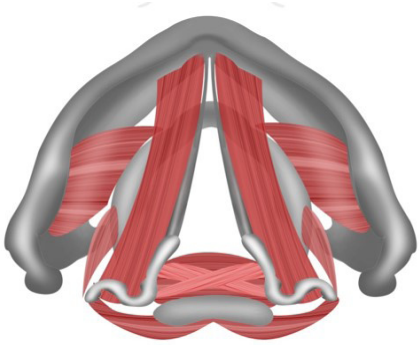

Figure 2: Cross-Section View of Vocal Cord

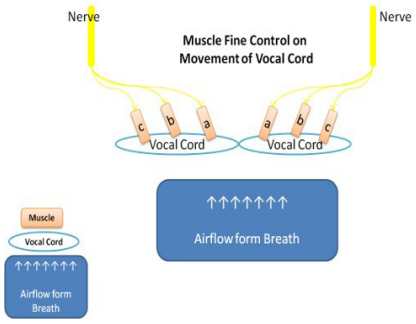

Figure 3: Mechanism of Mucle Fine Control on Vocal Cord gradually lossed

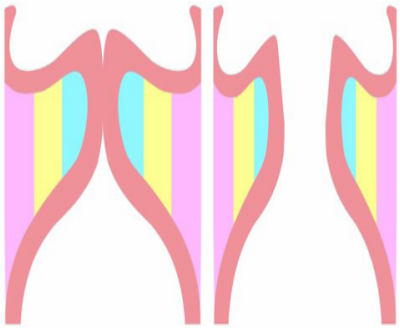

Figure 4: Vibration of Vocal Cord in airflow

3.2. The amount of Airflow reduced

Due to declined muscle controllability on the diaphragm, aerodynamic input of the lungs to the larynx and the vital capacity are significantly decreased [35]. In PD patients, their respiratory muscle endurance and strength are decreased, therefore their respiratory volume and lung volume are significantly decreased as well [36,37]. Less lung capacity per syllable and greater airflow attenuation affect articulation disorders [35,38]. The disturbance of respiratory rhythm in PD patients is accompanied by the reduced respiratory airflow [37]. Therefore, the vocal resistance increased, however the sound quality decreased [38,39].

Furthermore, the degree of closure the laryngeal glottis decreased. According to the aerodynamic data, the glottis adduction and laryngeal resistance decreased in PD patients, it disclosed that a low-function vocal behavior [39]. The generation of sound is affected by the reactionary vibration of vocal cords and the vocal threshold pressure is affected by the shape of vocal cords [35]. Abnormal rigidity of laryngeal muscle tissue and abnormal rigidity of vocal cords in PD patients lead to incomplete glottis closure and increased vocalization pressure,

thus affecting sound quality [40].

4. Perspective

Taken together, declined quality of vocalization in early stage of PD patients may help us to early diagnosis and screening this disease. Poor articulation, decreased tone rhythm and volume and increased jitters, these significant vocalization behaviours provide alert information. These behaviour biomarkers may help us to fast distinguish and screening the disease process.

5. Declarations

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7. Authors' Contribution: X.F drafted the general idea and drafted the manuscript with CWZ; HM, PTT, LXY, JYX collect and sort the references, WYX, ZXW and LXL proofreading the academic accuracy of general idea; GM proofreading the general manuscript, LFF draft the figures.

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