

Eyebrow Movement Aid for Amyotrophic Lateral Sclerosis (ALS)



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Abstract: - In this paper, we depict an application that helps to an Amyotrophic Lateral Sclerosis (ALS) patient. The muscle movement of such patients deteriorates continuously which affect the entire body. Hence, gradually the patient loses the ability to talk and move. The last preserved movement in these cases is the eyebrow movement. Such patient requires lot of assistance throughout the day, but due to their incapability to speak and to move they cannot express their necessities. Patient was diagnosed with this disease five years ago. It began from the fourth finger of patient left hand and eventually started spreading to other parts. It affected her vocal chords and upper and lower limbs. Patient has difficulty in speaking and raising his arms. In this paper proposal is made to assist the patient to communicate. The software is loaded on the netbook with which the patient can express their needs and call at the time of help.

Key words: ALS, Degenerative Disease, Motor Neurons Disorders, Augmentative an Alternative, Communication.

INTRODUCTION

Amyotrophic lateral sclerosis (abbreviated ALS, also referred as Lou Gehrig's disease) is a form of motor neuron disease. The word "amyotrophic" means "without muscle nourishment". It refers to the loss of signals the nerves normally send to the muscles. "Lateral" means "to the side", and refers to the location of the damage in the spinal cord. "Sclerosis" means "hardened" and refers to the hardened nature of the spinal cord in advanced ALS. The ALS is a progressive, fatal, neurodegenerative disease caused by the degeneration of motor neurons, the nerve cells in the central nervous system that control voluntary muscle movement. The condition is often called Lou Gehrig's disease in North America, after the New York Yankees baseball icon that was diagnosed with the disease in 1939 and died from it in 1941, at the age of thirty-seven. Today, renowned physicist Stephen Hawking, British historian Tony Judt, guitar virtuoso Jason Becker and bass virtuoso Mike Porcaro are among the best-known living ALS patients. The disorder causes muscle weakness and atrophy throughout the body as both the upper and lower motor neurons degenerate, ceasing to send signal to muscles. Unable to function, the muscles gradually weaken, develop fasciculations (twitches) because of denervation, and eventually atrophy because of that denervation. The patient may ultimately lose the ability to initiate and control all voluntary movement; bladder and bowel sphincters and the muscles responsible for eye movement are usually (but not always) spared [1]. As shown in the Fig. 1 of Stephen Hawking he has suffered from the ALS disease.

Cognitive function is generally spared except in certain situations such as when ALS is associated with front temporal dementia. However, there are reports of more subtle cognitive changes of the front temporal type in many patients when detailed neuropsychological testing is employed. Sensory nerves and the autonomic nervous system, which controls functions like sweating, generally remain functional. As shown in the Fig 2.



Fig. 1: Stephen Hawking, an ALS Patient.

CHEMICAL CAUSES

There are three types of ALS: sporadic, familial, and Guamanian. The most common form is sporadic. A small number of cases are inherited genetic disorders (familial). A large number of cases, however, occur in Guam and other Pacific territories. The familial type of ALS is caused by a genetic defect in superoxide dismutase, an antioxidant enzyme that continuously removes the highly toxic free radical, superoxide [2, 3]. The causes of sporadic and Guamanian ALS are unknown. Several hypotheses have been proposed including:

- ❖ Glutamate toxicity
- ❖ Oxidative stress
- ❖ Mitochondrial dysfunction
- ❖ Autoimmune disease
- ❖ Infectious disease
- ❖ Toxic chemical exposure
- ❖ Heavy metals such as lead, mercury,
- ❖ Aluminum and manganese
- ❖ Calcium and magnesium deficiency
- ❖ Growth factor deficiency
- ❖ Carbohydrate metabolism

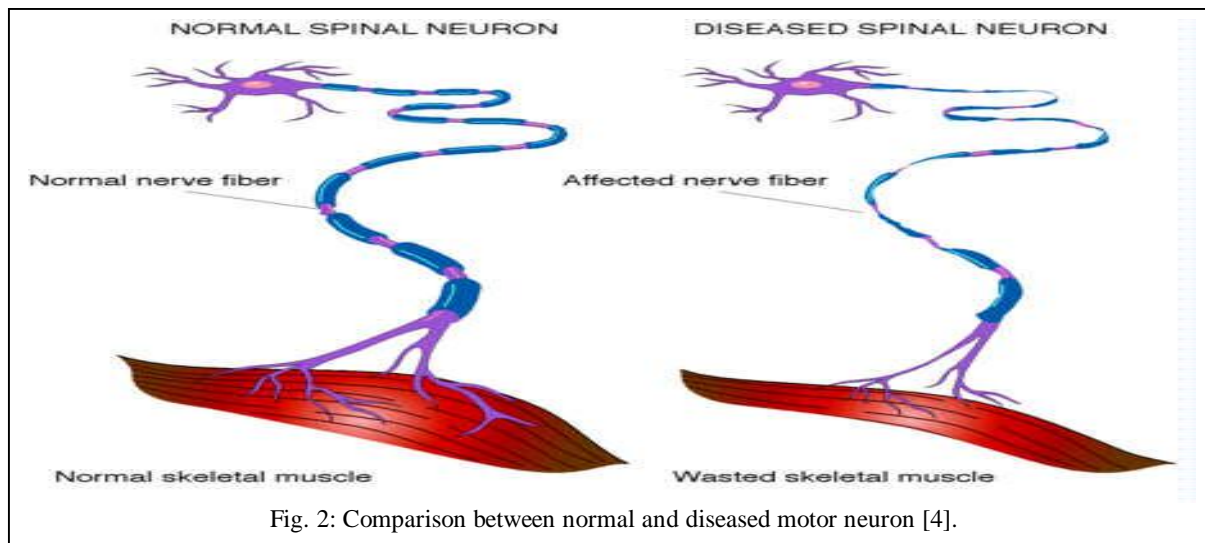


Fig. 2: Comparison between normal and diseased motor neuron [4].

A. researchers have proposed that ALS may have an autoimmune basis. The following are the basis for their hypothesis:

Analyses of ALS patient sera have identified circulating antibodies secreted by denervated muscle. These antibodies inhibit the stimulation of the sprouting of axons, the long arms of neurons which conduct nervous impulses to other neurons throughout the body. (Onion 1998): Researchers have found an immunoglobulin that affects the conductance of neuronal voltage-activated calcium channels which may induce an excessive release of glutamate from nerve endings. (Onion 1998):

Several studies of ALS patients found the presence of antibodies that interact with motor neurons. (Niebroj-Dobosz, Jamrozik et al. 1999) (Pestronk, Adams et al. 1988; Pestronk, Cornblath et al. 1988; Pestronk, Adams et al. 1989): Immune complexes have been found in spinal cords of patients with ALS: It has been proposed that T cells, activated microglia, and immunoglobulin G (IgG) within the spinal cord lesions may be the primary event that leads to tissue destruction in ALS: The increased prevalence in Guam is associated with a decreased delayed hypersensitivity. The secondary response, which occurs with the second

Exposure to the antigen, is normally quicker and usually produces more antibodies than the primary response. The major reason for the enhanced secondary response is the formation of B memory cells during the primary response. (Onion 1998):

In a recent study, a family history of thyroid disease was present in 19% of ALS patients, and an additional 21% of patients described family members with other possible autoimmune disorders. In 19% of the patients with ALS, either past or present thyroid disease was documented. Eleven of 47 additional patients with ALS had significant elevations of microsomal and/or thyroglobulin antibody levels. (Appel, Stockton-Appel et al. 1986):

PHYSICAL CAUSES

Compression of the cervical spinal cord A MRI of the head and cervical spine is usually ordered for patients

with lower neurological disease to rule out compression of the spinal cord and impingement along the spinal nerves.

A. Lyme disease:

The second and third stages of Lyme disease are associated with neurological changes that may cause an axonal, lower motor neuropathy. Lyme disease is caused by the bacterial spirochete (*Borrelia burgdorferi*) spread by a deer tick (*Ixodes dammini*). The first stage of Lyme disease presents with fever, enlarged lymph glands and a characteristic bulls-eye pattern around the bite. (Hansel, Ackerl et al. 1995)

B. Post poliomyelitis:

Polio is an enterovirus, a genus that preferentially inhabits the intestinal tract. Reactivation of a central nervous system polio infection (post-poliomyelitis) may cause a delayed deterioration of motor neurons and muscular atrophy including difficulty in swallowing (dysphagia) from bulbar involvement. Bulbar involvement indicates there is a malfunction in the medulla oblongata, an structure important for collections of nerve cells lying anterior to the cerebellum (Onion 1998) (Roos, Viola et al. 1980).

C. HIV Infection:

HIV infection is associated with extreme immune system dysfunction. HIV-1 proteins Tat and gp120 have been implicated in the pathogenesis of dementia associated with HIV infection. (Jain, Parsons et al. 2000).

D. Neurosyphilis:

Tertiary syphilis is seen 3-4 years after the primary infection with the spirochete *Treponema pallidum*. It is often seen in AIDS patients. Tertiary syphilis usually present with hypersensitivity reactions since few organisms are present. Tabes dorsalis is associated motor and sensory losses in the lower extremities which causes difficulties in coordination.

SYMPTOMS:

The onset of ALS may be so subtle that the symptoms are frequently overlooked. The earliest symptoms are obvious weakness and/or muscle atrophy. This is followed by twitching, cramping, or stiffness of affected muscles; muscle weakness affecting an arm or a leg; and/or slurred and nasal speech. The twitching, cramping, etc. associated with ALS is a result of the dying motor neurons, therefore these symptoms without clinical weakness or atrophy of affected muscle is likely not ALS.

The parts of the body affected by early symptoms of ALS depend on which motor neurons in the body are damaged first. About 75% of people experience "limb onset" ALS [5, 6]. In some of these cases, symptoms initially affect one of the legs, and patients experience awkwardness when walking or running or they notice that they are tripping or stumbling more often. Other limb onset patients first see the effects of the disease on a hand or arm as they experience difficulty with simple tasks requiring manual dexterity such as buttoning a shirt, writing, or turning a key in a lock. Occasionally the symptoms remain confined to one limb; this is known as monomelic amyotrophy. As shown in the fig. 3 the parts of the body affected of ALS.

About 25% of cases are "bulbar onset" ALS. These patients first notice difficulty speaking clearly. Speech becomes garbled and slurred. Nasality and loss of volume are frequently the first symptoms. Difficulty swallowing and loss of tongue mobility follow. Eventually total loss of speech and the inability to protect the airway when swallowing are experienced.

Fig. 3 shows the part of the body first affected by the disease, muscle weakness and atrophy spread to other parts of the body as the disease progresses. Patients experience increasing difficulty moving, swallowing (dysphagia), and speaking or forming words (dysarthria). Symptoms of upper motor neuron involvement include tight and stiff muscles (spasticity) and exaggerated reflexes (hyperreflexia) including an overactive gag reflex. An abnormal reflex commonly called Babinski's sign (the big toe extends upward and other toes spread out) also indicates upper motor neuron damage. Symptoms of lower motor neuron degeneration include muscle weakness and atrophy, muscle cramps, and fleeting twitches of muscles that can be seen under the skin (fasciculations). Around 15–45% of patients experience pseudobulbar affect, also known as "emotional lability", which consists of uncontrollable laughter, crying or smiling, attributable to degeneration of bulbar upper motor neurons resulting in exaggeration of motor expressions of emotion.

ROLE OF ASSISTIVE TECHNOLOGY IN ALS

Other treatments for ALS are designed to relieve symptoms and improve the quality of life for patients. This supportive care is best provided by multidisciplinary teams of health care professionals such as physicians; pharmacists; physical, occupational, and speech therapists; acupuncturists; nutritionists; social workers; and home care and hospice nurses. Working with patients and caregivers, these teams can design an individualized plan of medical and physical therapy and provide special equipment aimed at keeping patients as mobile and comfortable as possible.

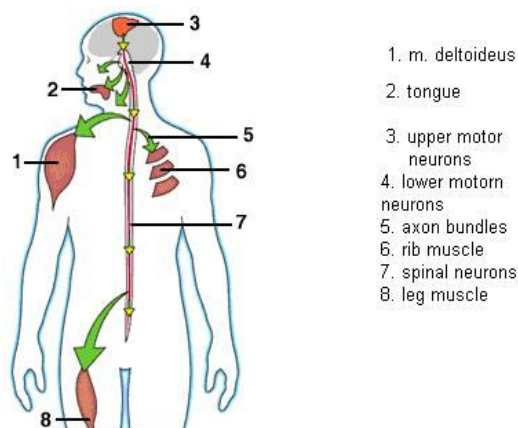


Fig. 3: Parts affected in ALS [7].

Physical therapy and special equipment such as assistive technology can enhance patients' independence and safety throughout the course of ALS. Gentle, low-impact aerobic exercise such as walking, swimming, and stationary bicycling can strengthen unaffected muscles, improve cardiovascular health, and help patients fight fatigue and depression. Range of motion and stretching exercises can help prevent painful spasticity and shortening (contracture) of muscles. Physical therapists can recommend exercises that provide these benefits without overworking muscles. Physiotherapists can suggest devices such as ramps, braces, walkers, and wheelchairs that help patients remain mobile. Occupational therapists can provide or recommend equipment and adaptations to enable people to retain as much independence in activities of daily living as possible. As shown in the fig. 4 Stephen Hawking is unable speak walk or unable do the independence in activities of daily living.



Fig.4: Stephen Hawking and his multipurpose wheelchair.

ALS patients who have difficulty in speaking may benefit from working with a speech-language pathologist. These health professionals can teach patients adaptive strategies such as techniques to help them speak louder and more clearly. As ALS progresses, speech-language pathologists can recommend the use of augmentative and alternative communication such as voice amplifiers, speech-generating devices (or voice output communication devices) and/or low tech communication techniques such as

alphabet boards or yes/no signals [8, 9]. These methods and devices helps patient to communicate.

controlled by small physical movements of, for example, the head finger or eyes and eyebrows.

IMPLEMENTATION

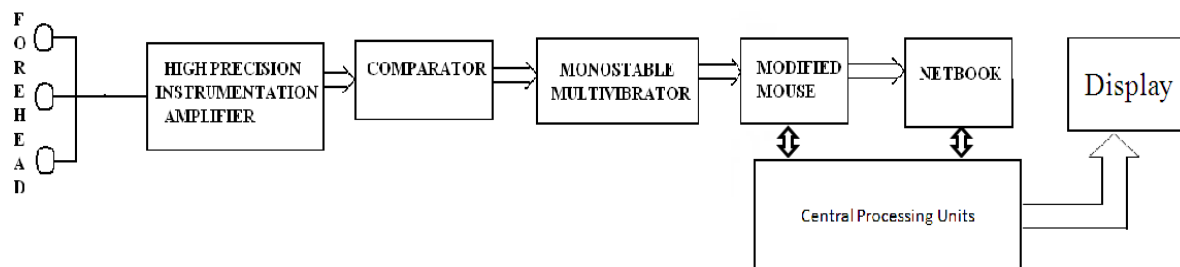


Fig. 5: Functional Block Diagram of Smart Netbook.

The EMG surface electrodes are placed on a Velcro band which is tied around the forehead. Two electrodes that act as positive and negative are placed transversely and at a distance of about 5 cm from each other so that they are placed firmly over the eyebrows. There exists no inter-polarity between them i.e., the same electrode can act as positive or negative. The reference electrode is placed either in between the two electrodes or on the left arm of the person. The interconnection between the electrodes and to the device is done with the help of Coaxial cables. This is because it helps in a three-way connection; it reduces interference and noise and can transfer the signal at a faster rate than normal wires. The copper wire of the cable is connected to the button on the electrode. This wire captures the signal and transfers it along the cable's length into the device for further processing. The copper mesh of the negative electrode is connected to the copper mesh of the positive and the reference electrode. This allows for a two-way connection between the electrodes.

Firstly, the capturing of Electromyograph (EMG) signal from the eyebrow is done. This signal is processed and converted into a binary format that resembles the clicking mechanism of the normal mouse [9, 10]. The modified mouse is then connected to a Netbook that has the click-to-sound converting software. The sound output has various options like "water", "help", "pain", "food", "sleep" and other daily needs. It has a total of 15 icons. The cursor moves automatically from one icon to the other and the speed can be set depending upon the comfort of the patient from 1 sec to 20 sec.

The surface EMG electrodes are placed on the eyebrow muscles. The movement of the muscles is captured by the electrodes and transmitted to the circuit. The signal is has minute amplitude (in μV) and is not in it is amplified with 10,000 gains in first level and 20 in second levels. The pre-processed signal is converted into a binary format using a comparator and monostable multivibrator. This binary signal is sent as input to the modified mouse using a universal port. It runs parallel with the click mechanism of normal mouse. Thus, whenever the patient raises the eyebrow, the icon on which the cursor currently points is clicked. Sound items specific to a particular icon is there so depending upon the icon selected, the sound output comes out [11, 12]. As shown in the fig.6 occupational therapists, speech generating devices can be activated by switches or mouse emulation techniques

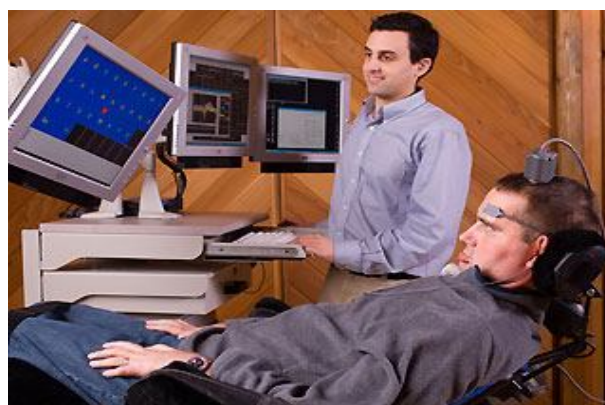


Fig. 6: ALS patient controlling system with eyebrow movement

CONCLUSION

There is no cure for Amyotrophic Lateral Sclerosis because the nerve tissue cannot be replaced or repaired. Treatment for the disorder may include surgery, medication and physiotherapy. However, these treatments do not offer complete cure and the patients need to be dependent on others for their every work. Most discouraging factor of this disorder is that makes the patient captives as they are not able to express their needs due to the non-functioning of vocal cords and arms. The facial movements are preserved in ALS. The Smart Mouse aids such patients to be able to communicate. Not only that, it can also help such patients in mobility, appliances control, past times etc

. It uses surface EMG electrodes that capture the Eyebrow movements and the circuit that conditions that analog signal into an amplified square wave signal that can drive a mouse. The mouse performs 'click' operation on the screen of the netbook where the Handi-talk software is installed. The cursor moves automatically on the icons that represent pictures related to daily activities and alphabets. The 'click' of the mouse selects the highlighted icon and the corresponding sound comes out which alerts the other people of the patient's needs.

FUTUTRE SCOPE:

- This device can be used by any patient that suffers from a Neuro-degenerative disorder where they lose their ability to move, speak.
- The device can be made wireless by placing an RF generator at the electrodes and a receiver at the circuit, which will make the design more compact.
- The patients will be able to play games on the computer that requires only click mechanism, which can be a good past time for them.
- The patients can send emails; write books etc. using this device.

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