Speech Disorders Resulting From Bulbar Poliomyelitis

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The virus of poliomyelitis belongs to a group of infectious agents which has a particular affinity for cells of the central nervous system, especially those of the anterior horn of the spinal cord and its bulbar extensions (*5*). Bower (*8*) says, 'The pathological changes produced in the central nervous system by the poliomyelitis virus consists primarily of damage to motor cells.' In cases where there is bulbar involvement, including medulla, pons, and midbrain, with resultant damage to one or more of the cranial nerve nuclei subserving the speech function, motor speech production may become defective. Speech symptoms in such cases are classified as dysarthria.

It is estimated that there are 30,000 new cases of poliomyelitis each year (*1*). Thousands of persons in this country are undergoing treatment for residual disabilities. Brown and others (*9*) have reported that the incidence of bulbar involvement among unselected cases of poliomyelitis during the 1946 epidemic in Minnesota was 23 per cent in children under 16 years of age, and even higher in patients beyond this age. Although not all post bulbar poliomyelitis patients suffer sufficient permanent neural damage to produce dysfunction at the clinical level, the speech therapist can expect to see a sizable number each year. Hence, it is useful to review the clinical signs of bulbar poliomyelitis where nuclei of cranial nerves are involved, indicating potential effects on speech production, and to consider speech examination procedures, recovery factors, and speech therapy.

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Clinical Signs

Brown (*9*) divides bulbar poliomyelitis cases in which the nuclei of cranial nerves are involved into upper and lower cranial nerve groups. The upper group includes involvement of V, VI, VII, and VIII, as well as ocular nerves. This classification is based on observations of symptomatology in special functional disturbances during life and pathologic changes found post mortem in fatal cases. Manifestations of damage consist of disturbances of mastication (motor portion of V) which may be either unilateral or bilateral, occasional ocular neural palsies (VI), paralysis of facial nerve (VII), and infrequent bilateral deafness and vestibular disturbances (VIII). The lower group includes involvement of IX, X, XI and XII with the following manifestations: difficulty in swallowing, impaired innervation of the vocal cords, nasal speech, and weakness of tongue muscles. Frank (*14*) says,

> This (bulbar poliomyelitis) is recognized by involvement of the cranial nerves

arising from the brain stem with or without dysfunction of the vital centers of circulation or respiration. The cranial nerves most frequently attacked are V, IX, X, and XI. (Other cranial nerves are rarely involved, and then usually VII.) The resultant signs and symptoms are one or more of the following: difficulty in swallowing with regurgitation through the nose; nasal voice or hoarseness; tongue, mastication, and occasionally facial paralysis (usually unilateral). Complete paralysis of both vocal cords is not common. With bulbar involvement respiratory embarrassment commonly occurs because of obstruction to the airway.

Effects Upon Speech

The speech disorders which result are usually of two sorts: articulation and voice. Voice defects result from damage to the cranial nuclei most responsible for innervation of the larynx, of the striated musculatures of the soft palate, and of the pharynx (principally X with additional fibers from IX and XI). Dysphonia and hyperrhinolalia are heard. The articulation disturbances result from impairment of the cranial nuclei affecting motor performances in mastication and movements of lips and tongue (principally the motor division of V, and VII, IX, and XII). The degree of musclar involvement affecting speech production ranges from mildly paralytic to severe loss of motor function, even including definite loss of reflex movement. Obviously, then, the degree of motor speech impairment can be expected to be contingent in large measure upon the degree of neuro-muscular complication.

Speech Examination

In most cases where the speech therapist is called upon to examine and to treat post bulbar poliomyelitis cases with speech impairment, the individual will have begun his program of general rehabilitation. He will have regained health sufficient to enable him to undertake physical therapy, occupational therapy, and other appropriate rehabilitation procedures. Occasionally the speech therapist may be consulted before this time to provide suggestions regarding the achieving of improved swallowing function by the patient. Several references concerning the swallowing mechanism and its function have been included in the bibliography. (*2*, *3*, *12*, *19*, *25*)

The speech therapist relies upon the neuropathologist for information concerning neurological complications. The therapist needs to be able to interpret these findings in terms of involvement of musculatures used for speech production, and he should be able to recognize reflex, involuntary clues to motor function as well as gross, voluntary performance.

The speech examination consists of two parts: observations of motor function and an analysis of speech characteristics. The observation of motor function involves an inspection of oral, facial, and laryngeal parts used in speech production as they are at rest and as they are moved. It is an efficient practice to conduct these observations methodically. After making a gross examination of appearance and mobility of the patient's face, mouth, and larynx, attention is directed to specific areas in sequence, usually following the numerical designation order of cranial nerves. The following procedures have been found useful in observing motor function. The examiner will do well to devise a check sheet on which to record results so that subsequent test results can be compared with the earlier ones. Patients will vary in oral motor

performance proficiency at the time of the examination. Some will experience continuing difficulty with drinking and swallowing; others will recover markedly in this respect but will have persistent speech difficulty. Patients vary from week to week as recovery or training becomes effective Others will maintain a relatively static status of performance.

Jaw Muscles. The examiner determines whether there is weakness or loss of power in raising, lowering, protruding, retracting, and deviating the mandible. The patient is asked to clench his jaw, open his mouth, and move his jaw from side to side. The speed, strength, and accuracy of these movements are observed. The movements are studied during chewing activities and during speaking.

Facial Muscles. The patient's ability to draw back the angles of his mouth voluntarily, to show his teeth, and purse his lips is tested. Any abnormal or asymmetrical movements are noted. Facial muscle movements during spontaneous smiling and while attempting to drink fluid through a straw are observed. The patient's kinaesthesia for movement, tension, and relaxation of these parts is checked by having him describe whether the movements he makes are rapid or slow, tense or easy.

Tongue Muscles. Observe the position of the tongue at rest and on protrusion. Strength, speed of movement, and accuracy in all directions, on command, are noted. Evidences of weakness, paralysis, or abnormal movements are checked. The patient is asked to protrude, lift the tip, and raise the back of his tongue. He is asked to perform a series of repetitive movements. As with the facial muscles, he is asked to describe kinaesthetic impressions of movement, tension, and relaxation of his tongue. Observe the swallowing skill of the patient. Is it done easily or with considerable awkwardness?

Observation of the swallowing act will be appropriate also when considering the efficiency of function of lips, velum, and pharynx. Absence, weakness, or sluggishness of movement of one or more of these parts may be detected. The patient may not be adept at moving his tongue in a way which will send the bolus or fluid toward the back of his mouth; there may be leakage of fluid into the nasal cavity, or an annoying sticking of the bolus in the pharynx. Muscular paresis may prevent the lowering of the pharynx and larynx with sufficient energy to send the bolus into the esophagus.

Velar and Pharyngeal Muscles. Observe the velum at rest and during the utterance of the vowel 'ah.' Determine whether velar movement is present and symmetrical. Test the gag reflex by using a tongue depressor to touch or to stroke the posterior pharyngeal wall or faucial pillars. If possible, observe the soft palate during yawning to determine whether movement is discernible. Ascertain whether the patient can drink fluid through a straw without nasal regurgitation.

A spirometer can be useful in making an estimate of the efficiency of the patient's velopharyngeal closure. Spirometric readings are taken after the patient has blown into the apparatus, first with the nares open, then while the nares are occluded. If the two readings are approximately the same, it is judged that with the nares open sufficient velopharyngeal closure is being accomplished to pre-

vent any appreciable amount of air leakage.

A small polished steel mirror with concentric arcs on one edge traced at centimeter intervals provides another device with which to make a roughly calibrated measure of nasal leakage of air. The patient is asked to utter an 'ah,' whistle, and so forth while the mirror is held just below the nares, with the arc traced nearest to the edge of the mirror adjacent to the midline of the upper lip. Air escaping from the nostrils will fog the mirror. Some measure of the severity of the leakage can be judged by observing how far the fogging extends across the concentric arcs. Such readings are of value for comparative purposes rather than for calibrated results.

At this point, Bloomer's (*6*) observations of palatal movement in two patients with operated facial defects should be mentioned. He studied their palatal movements during swallowing, drinking through a straw, speech, pitch and stress movements, snoring, and yawning. He noted that movements of the palatopharyngeal mechanism appear to differ according to the physiological activity being performed. From his observations he judged there was a striking contrast between the configurations of the valve during speech (including the various forms of pneumatic control) and those exhibited during the various phases of swallowing. He believes there is a distinct difference between the simple valve action and the peristaltic waves observed during swallowing. Admitting that the patterns of palatopharyngeal movement may be different during various activities, the presence of movement is critical, not the pattern of the movement. The examiner is looking for any signs of movement at this stage. It is to be expected that in some patients where movement is found it will not be transferred into speech and a distinct hyperrhinolalia will persist.

Larynx. The evaluation of laryngeal function may require the assistance of a laryngologist who is skilled in making such examinations. The appearance of the vocal cords at rest should be noted. Their movements should be observed during phonation and inspiration, and during coughing. Determine whether any involvement present is unilateral or bilateral. The cough reflex can be set off by stimulating the mucous membrane of the pharynx. This reflex consists of a deep inspiration followed by forced expiration with the glottis closed briefly by the adduction of the vocal cords.

General Information. In addition to these observations of motor function, it will be helpful to obtain information concerning the onset, duration, and recovery from the illness. The patient's present physical status and limitations should be known, and some indication of the medical prognosis should be ascertained.

Speech Characteristics. Having observed the motor function of the various musculatures, attention is turned to the second part of the speech examination, the analysis of speech characteristics. First, impressions of the general intelligibility, pitch, quality, and steadiness of the speech are obtained by engaging the patient in casual conversation. This preliminary appraisal will give clues as to the aspects of the patient's speech which need additional examination and those which are to be judged as satisfactory. In addition, during this time much can be learned concerning the patient's awareness of his

speech and his feelings about it. In some cases where dysfunction is minimal or where the patient is quite young, there will be little awareness or concern. In other cases, impatience, frustration, despondency, or chagrin will be observed. Obviously, the attitude of the patient toward his speech condition can play an important part in the speech therapy program, and the therapist will do well to note it. Further indications of his cooperation, initiative, aggressiveness, and persistence can be obtained by keeping close touch with his work and progress in physical therapy, occupational therapy, or whatever other services are being provided.

A detailed phonetic analysis is made. Sounds are tested in the context of words and phrases as well as in osolation to determine whether the character of production is consistent. The rate, agility, precision, and quality of the sounds produced are checked. In these cases there is apt to be difficulty with the velar sounds, and those formed by the occlusion of lips and tongue also are apt to be weakened, for much of the air required for their production escapes through the nose. In this respect the speech is similar to that found in cleft palate persons.

Notes are made concerning the voice of the patient with reference to the presence or absence of phonation, hypernasality, monotony, breathiness, and intensity. Air escaping through the nose during speech is checked. In some cases the hypernasality is more marked when the head is tipped forward and is less evident when the patient is lying with his head back, for the paralyzed soft palate is carried forward or backward by the pull of gravity.

Recovery Factors

On the basis of an extensive histopathologic survey of 24 fatal human cases of poliomyelitis, Bodian (7) has said that in poliomyelitis some parts of the brain seldom if ever are affected, namely: the entire cerebral cortex except for the motor area, the corpus striatum except the globus pallidus, and the cerebellar cortex except the vermis. Of these lesions he says, 'it is doubtful that they are sufficiently intense to produce clinical signs, except in rare instances.' According to Bodian, there is every reason to suppose that the patient can rapidly begin to relearn patterns of motor activity which were smoothly and subconsciously regulated by now severely damaged brain stem mechanisms. Motor re-education is of the greatest importance in assisting recovery, and in this respect the cerebral cortex must play a dominant role.

Apparently severe destructive lesions usually are necessary to produce dysfunction at a clinical level. Bodian points out that recovery of motor function 'should result from at least two processes: first, the recovery of neurons not damaged sufficiently to be destroyed, and second, the rerouting of neuron-chain discharge pathways from interrupted primary paths to secondary alternate paths. The second process is of longer duration, since it is a part of the relearning process.'

Jelliffe and White (*18*) say that 'as a rule the functional involvement by reason of edema, hyperemia, and infiltration is far in excess of the permanent anatomical loss, hence the widespread character of the paralysis in the early stages and the marked degree of recovery possible.'

Recognizing the possibility of re-

covery features in these cases, the therapist may be able to look forward to some natural help from this direction. On the other hand, where several weeks or months have elapsed since the onset of the disease, it is likely that the therapist will be faced with the problem of assisting the patient to make the best use of neuromuscular function which remains.

Speech Therapy

When the patient has become medically stabilized and adequate movements have not returned, attention is turned to seeking to restore function where needed. In cases where there is speech involvement, the therapist provides a sort of speech apparatus physical therapy program. As needed, exercises for lips, tongue, velum, pharynx, and jaw muscles are instituted to re-establish motor control and to achieve the best speed, accuracy, and duration of function of which the patient is capable. The patient then attempts to incorporate the restored or improved functions of involved parts into speech production.

A number of the principles of muscle re-education which are followed by physical and occupational therapists can be applied to working with oral musculatures. Bennett (*4*) has outlined such principles and has stated certain objectives for muscle re-education. He enumerates four objectives:

1. To obtain or regain the ability to contract voluntarily individual muscles or muscle groups.
2. To obtain or regain coordinate and effective patterns of motion.
3. To regain or increase strength in individual muscles or groups of muscles.
4. To regain or increase endurance in individual muscles or groups of muscles.

Each of these objectives is appropriate for the post bulbar poliomyelitis patient who seeks to improve function of oral musculatures. Several of the principles of muscle re-education in Bennett's outline will be useful to the speech therapist. They are:

1. The patient must thoroughly understand what is being done and what is expected of him.
2. All motion must follow as nearly as possible a normal pattern.
3. The segment controlled by the muscle group should be carried through as complete a range of motion as possible.
4. Coordination must be established before any attempt is made to increase strength and endurance of a bodily segment.
5. Exercise must be carefully graded.
6. Fatigue is not dangerous unless when fatigued, incoordination or substitution results.
7. Patient must be thoroughly instructed in his activity between periods of daily treatment.

Additional information concerning principles, concepts, and objectives in muscle re-education can be obtained from DeLorme and Watkins (*13*), Fries (*15*), Kabat (*20, 21*), and Levine (*22*).

Those who have tried to restore or to improve muscle function in speech handicapped persons know that working with the speech apparatus presents some unique problems. For example, the inaccessibility of the velum and vocal folds to all-out manipulation necessitates some indirect maneuvering. Further, where previously muscle movements have for the most part occurred on an involuntary level, it is often quite difficult for a patient to achieve skill in voluntary movement. Similarly, he is often extremely slow in achieving a kinaesthesia for muscle movement where such move-

ment previously was automatic. Hence, supplementary visualization and auditory stimulation must accompany and re-enforce whatever muscle training is provided.

Several writers in the field of speech correction have developed or adapted training materials, techniques, and devices by which to implement the principles of muscle re-education. Cable (*10*), Cass (*11*), Hansen and Longerich (*16*), Hawk (*17*), and Westlake (*23, 24*) are among those who have done this. Their material was prepared to meet the needs of patients with speech deficiencies other than those encountered in post bulbar poliomyelitis cases, but much of it is suitable for use by them. Much of it was intended for use by children, but the basic techniques are valuable and can be adapted to older persons.

Other factors affecting the speech training program must be considered. First is the fact that although a patient may show useful improvement of oral motor function and is able to transfer some of it to speech production when supervised, he does not show consistently improved speech. Second, where one or more cranial nerve nuclei important in motor speech production have been severely and irreversibly damaged, success in the rehabilitation of muscle function, and consequently in speech, is unlikely.

The problem of carry-over suggested by the first factor is a vexing one to speech therapists in work with brain-injured patients. In gait training, the patient may be able to make use of leg muscles in unassisted and resistance exercises. He is able to step correctly and to follow through. Gait seems much improved, yet as he leaves the therapy room he uses the same gait he has been trying to overcome. In speech work, a patient may be brought along from velopharyngeal movement induced by seting of the gag reflex, to recognizing the movement as he watches himself in a mirror. He is able to get the 'feeling' of the movement and to perform it voluntarily. The patient maintains velopharyngeal closure while speaking in therapy sessions. However, in most conversational speech, the hypernasality persists. There has been little tangible, consistent carry-over of improved velopharyngeal control into speech.

Clinical experience has shown that because a patient has improved in motor control of speech musculatures, it does not follow that he is guaranteed more acceptable speech. The rehabilitation of motor control is apt to be slow and difficult, and it requires persistence, perspective, and patience to achieve it. In some cases, so much time and effort are involved that there is a tendency to give up or to make less and less effort to transfer the improvement to consistent use in speech. Where the most return of function of which the patient seems capable provides only minimal useable control, it is not unusual to find him deciding that the demands of therapy do not give sufficient speech dividends to warrant the effort required to do it consistently. Even where there is good potential for restoration of movement, and with tangible control being established, the daily speech may be essentially unchanged. Here, it would seem, the personality of the patient is an essential factor. If he has not been a fairly aggressive, well-motivated, persistent individual before the onset of the disease, he will have difficulty becoming that sort of person following the debilitating effects of

poliomyelitis. If inconsistent results are obtained with a patient who makes every attempt to improve himself, the speech therapist should examine his training method to be sure that he has been explicit, methodical, and understandable in his teaching, and has provided sufficient practice at each level of the restoration process to effect sequential, automatic movement patterns by the patient.

Some bulbar poliomyelitis patients will have sustained such extensive, irreversible cranial nerve nuclei damage that return of function is unlikely. Even reflex movement may be lost. If this is the case, the outlook for speech improvement is limited even though some compensatory movements may be developed. To establish velopharyngeal closure, some prosthetic support for the velum in the form of a modified obturator may be employed; or even a surgical fixing of part of the velum against the posterior wall of the pharynx may be conceived. These measures are apt to be poor substitutes for natural occluding mechanisms and are considered as a last resort.

Summary

Persons who have had the bulbar type of poliomyelitis may have sustained damage to cranial nerve nuclei involved in speech production. Disturbances of mastication and of swallowing and paralysis of face, tongue, and laryngeal muscles may be found, resulting in varying degrees of articulation defects, hypernasality, and dysphonia. The speech therapist examines the patient's motor function of speech musculatures and analyzes the speech characteristics to ascertain the speech rehabilitation needs. In some cases, lesions are not sufficient to creat significant clinical signs. In others, the loss of motor function is confined principally to the acute phase of the disease, followed by a degree of recovery. However, where residual loss of oral motor function is found and concomitant defective speech is noted, the speech therapist can provide a training program consisting of activities to improve or to restore oral motor skills which can then be utilized in the elimination of the defective speech. Just how much improvement can be achieved is dependent upon (1) the extent of damage to neural mechanisms, (2) whether there is any natural recovery of function, (3) how much the patient can use returned function for speech improvement, (4) the initiative and persistence of the patient, and (5) the effectiveness of the therapist's program for the patient.

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