

The Rehabilitation of Patients Recovering from Brainstem Strokes: Case Studies and Clinical Considerations

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An estimated 15% of all patients admitted to stroke rehabilitation units experience a brainstem stroke. Two case studies are presented to illustrate some of the difficulties encountered in the rehabilitation of these individuals. Unlike hemispheric stroke, the characteristic consequences of brainstem stroke include ataxia, dysarthria, and diplopia. Additionally, individuals with brainstem stroke may suffer from severe dysphagia and may require enteral feedings. Unlike the rehabilitation of patients with hemispheric stroke, where there is an impressive and relatively comprehensive research literature, there has been surprisingly little research published on the rehabilitation of patients with brainstem stroke despite the fact they represent a significant number of patients admitted to stroke rehabilitation units. **Key words:** *ataxia, brainstem stroke, diplopia, dysarthria, dysphagia, paresis, rehabilitation*

Lesions affecting the brainstem region account for up to 25% of all strokes.¹ Typically brainstem strokes are a consequence of an infarction occurring in the territories of the basilar or vertebral arteries,² although a significant percentage are hemorrhagic in etiology. The brainstem plays an essential role in controlling balance, coordination, hearing, speech, eye movements, and swallowing; hence, patients who have sustained brainstem strokes often suffer from ataxia and dysphagia, while a lesser number may experience hemiparesis, diplopia, and dysarthria.³ Signs of cortical involvement such as neglect, visual-perceptual disorders, aphasia, and apraxias are generally absent as hemispheric cortical and subcortical areas are spared.

Chua and Kong² reported that the prognosis for functional recovery and long-term survival in individuals with brainstem stroke was better than that of individuals with hemispheric stroke. Similarly, Turney et al.⁴ reported 35% of brainstem infarction survivors returned to living independently within the first year after stroke onset, whereas only 22% of hemispheric stroke survivors achieved independent living within the first year poststroke. Given that blood supply to the

brainstem region is provided via the multiple tiny blood vessels arising directly from the vertebrobasilar arteries, brainstem strokes are often small.⁵ Generally, there is no involvement of

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cortical or subcortical structures, thereby improving rehabilitation prognosis for the individual with brainstem stroke.

Teasell et al.³ reported that among a cohort of 565 stroke patients admitted to a stroke rehabilitation unit, a substantial percentage (15%) suffered from a brainstem stroke. Despite the relative frequency with which brainstem strokes occur, and their considerable representation on rehabilitation units, there is surprisingly little written about the rehabilitation of these patients. In this report, we present two cases of individuals who suffered from a brainstem stroke and then discuss rehabilitation issues specific to brainstem stroke patients.

Case Study 1

A 35-year-old man experienced a left-sided cerebellar and pontine infarct. Two days following the incident, he underwent a left occipital craniotomy after developing a cerebellar hemorrhage. Clinical presentation included right hemisensory loss, severe left-sided ataxia, dysarthria, diplopia, urinary retention, extreme paresis, fatigue, and some memory loss. Initially, he was treated at an acute care hospital and, after 3 weeks, was transferred to a rehabilitation facility. He remained a patient in the rehabilitation facility for a little over 3 months and returned home following discharge. The etiology of his initial stroke was never established. Prior to the initial stroke event, the patient lived at home with his wife and children in a rural community. His medical history appeared to be noncontributory to the stroke event. He was normotensive with normal serum cholesterol levels, and no history of diabetic or cardiac disease.

During inpatient rehabilitation, he made slow but steady improvements. His mobility was hindered by severe left-sided ataxia and right hemisensory loss. Initially, he was unable to sit on the side of the bed without immediately falling to the left. He underwent standard physiotherapy exercises designed to improve sensation, range of motion, postural control, mobility, balance, transfers, stair climbing, and locomotion. Occupational therapists provided functional mobility training, self-care retraining, and assessments of his upper

extremity function, cognition and perception, community living skills, and ability to drive and return to work. The speech language pathologist initially placed him on a soft solids and thin fluids diet after assessing his swallowing and ataxic dysarthria. He received oral motor exercises as well as dysarthria therapy beginning at a single-word level and progressing to the level of reading out loud.

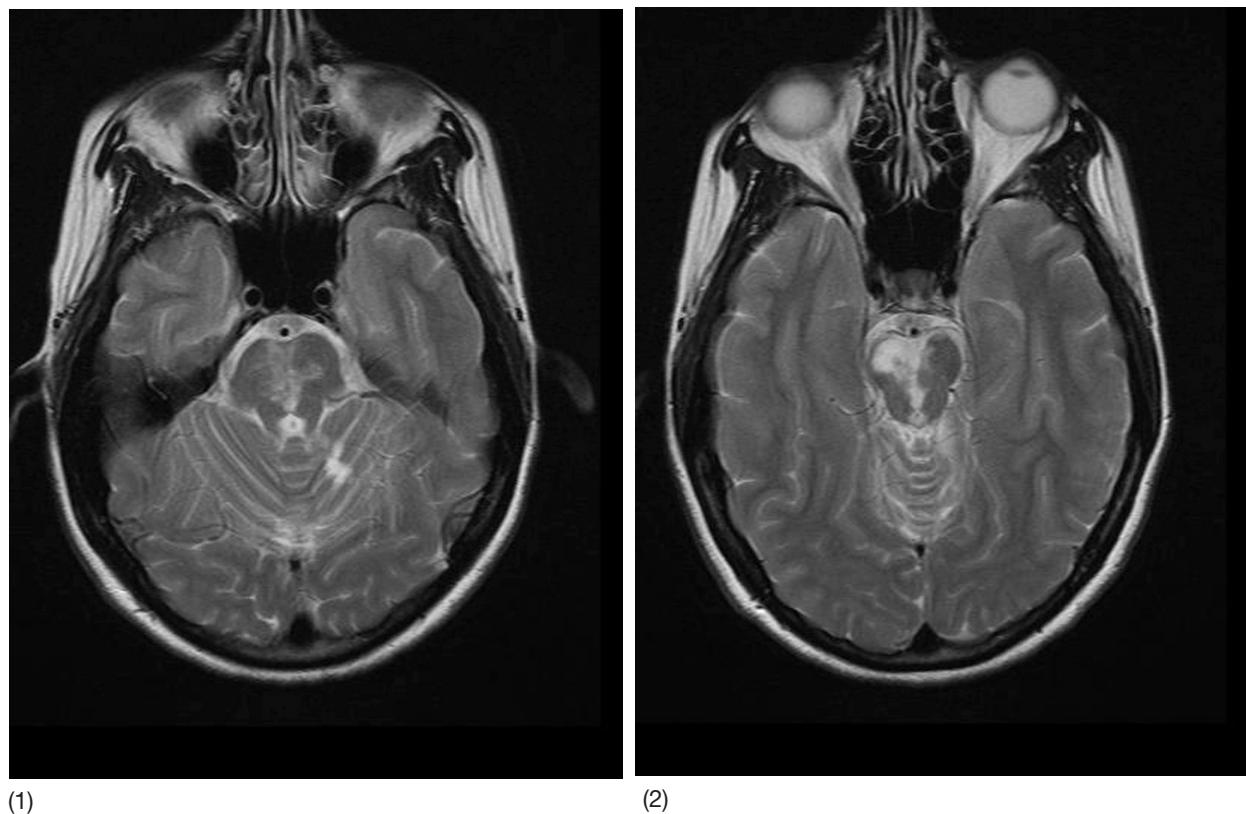
By discharge, the patient was able to ambulate slowly with a cane and was independent in activities of daily living (ADLs). His urinary retention resolved. Dysarthria improved in both vocal quality and pitch through therapy. He experienced some mood swings due to frustration with his disability; however, his mood improved as his functional abilities improved. He continued to experience diminished balance, decreased coordination on the left side, right-sided sensory deficits and numbness, fatigue, and weight gain.

Approximately 1.5 years poststroke, he was able to return to his place of work with return to full-time hours, following a graduated return-to-work schedule. Significant ergonomic adjustments to his office were required. A vocational therapist monitored his progress throughout the work trial. On review at 1 year, he remained, successfully, at work.

Case Study 2

The second case was a 32-year-old married woman working full-time. She was admitted to hospital with sudden onset of right vertebral artery and basilar artery occlusion. MRI demonstrated right thalamic, right pontine, and left cerebellar infarcts (**Figures 1 and 2**). She required intubation with subsequent tracheostomy, an ICU stay, and a feeding tube for demonstrated aspiration on modified barium swallow examination (**Figure 3**). Initial problems included a spastic left hemiparesis, left-sided ataxia, dysarthria, dysphagia, diplopia, and emotional lability. She was in acute care for 6 weeks and on the rehabilitation unit for 18 weeks.

Significant gains were made during the 18 weeks she was on the inpatient rehabilitation unit (**Table 1**). Her physiotherapy incorporated activities such as postural correction, trunk and pelvis



Figures 1 and 2. MRI demonstrates infarcts involving the left cerebellum, right thalamus, and right hemipons (case 2).



Figure 3. Videofluoroscopic modified barium swallowing tests study of 31-year-old female demonstrating laryngeal penetration and aspiration of thin fluids.

Table 1. Test results for case study 2

	Admission	Discharge
Timed Up and Go	Nonambulatory	Not tested
2-Minute Walk Test	Nonambulatory	46 meters
Greatest distances walked before requiring a rest	Nonambulatory	81 meters
Time to walk greatest distance	Nonambulatory	3 minutes, 38 seconds
Berg Balance Score	2/56	32/56
COVS	22/91	63/91
Stages of motor recovery (Chedoke-McMaster Stroke Assessment Score)^a		
Arm	2	4
Hand	2	5
Leg	3	5
Foot	3	5
Postural control	2	5

Note: COVS = Clinical Outcome Variables Scale.

^aThe Chedoke-McMaster Stroke Assessment provides a means by which to classify patients according to stage of motor recovery. Each dimension is rated on a 7-point scale that corresponds to Brunnstrom's seven stages of motor recovery.³⁹

activation, sitting and standing balance activities, shoulder mobilization and elongation into external rotation-reaching, scapular mobility, stability exercises, ambulation, and stair climbing. She received standard occupational therapy exercises and assessments. Her speech therapy was focused on improving her breath support, working at the word level at the reduced rate of speech, and contractive stress at the two-word level. Attempts to improve her conversational speech were made using tasks requiring her to either increase or lower her pitch and develop greater inflection in her voice.

At the time of discharge, the patient was able to ambulate with a rollator walker and one-person assist. She was independent for ADLs. The combination of ataxia and hemiparesis presented some special challenges. At time of follow-up 6 months later, she was regularly exercising, walking with a cane, and optimistic she would eventually be able to return to work.

Discussion

It is well known that patients with brainstem stroke are a heterogeneous group in terms of pathophysiology, symptomatology, and prognosis.² Common problems following a brainstem

stroke include dysphagia/aspiration, ataxia, dysarthria, paresis, and diplopia in a number of combinations (**Table 2**). Our first patient suffered from ataxia, dysarthria, and diplopia but was spared dysphagia and paresis. Our second patient experienced more of the spectrum of sequelae common to brainstem stroke.

Dysphagia

Dysphagia, a common consequence of brainstem stroke, is typically associated with a greater likelihood of occurrence when compared

Table 2. Clinical impairments in brainstem patients

Impairment	Number of brainstem patients (N = 85)
Dysphagia	40 (47%)
Ataxia	73 (86%)
Dysarthria	42 (49%)
Paresis	41 (48%)
Diplopia	32 (38%)

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Table 3. Incidence of aspiration confirmed by VMBS among hemispheric and brainstem stroke patients admitted to stroke rehabilitation unit

Lesion location	All hemispheres	Brainstem
Total pts	192	38
Pts with VMBS	28	18
Pts with aspiration on VMBS	21	15
Pts with aspiration on VMBS (%)	75	83
Aspiration of total stroke (%)	10.9	39.5

Note: Patients were evaluated by videofluoroscopic modified barium-swallowing (VMBS) if they were suspected of experiencing sufficient swallowing difficulties to place them at risk for aspiration. Swallowing difficulties were suspected in individuals with the following: choking with oral feeds, dysarthria, or wet-hoarse vocal quality. Pts = patients.

Adapted from Teasell RW, Bach D, McRae M. Prevalence and recovery of aspiration poststroke: a retrospective analysis. *Dysphagia*. 1994;9:35–39. Copyright © 1994 by Springer.

with hemispheric strokes.⁶ However, there are few studies reporting the incidence of dysphagia in brainstem stroke patients. Teasell et al.³ reported that 40/85 (47%) of the patients with brainstem stroke admitted to a rehabilitation unit suffered from dysphagia and, in an earlier publication, demonstrated that 39.5% (15/38) of brainstem patients demonstrated aspiration on videofluoroscopic modified barium-swallowing (VMBS).⁴ Chua and Kong² reported a dysphagia incidence of 40% (21/53) in patients with brainstem stroke, all of whom initially required tube feeding due to a high risk of aspiration. Similarly, Horner et al.⁷ found that 15 of the 23 brainstem patients included in their study showed aspiration on VMBS. Current clinical guidelines recommend all patients with high risk for aspiration and/or dysphagia, including those with brainstem stroke, be tested by VMBS.⁸

A brainstem stroke is believed to have a direct effect on the swallowing centers and, hence, the lower motor neurons.⁹ In addition, Miller et al.¹⁰ noted that the structure of the brainstem contains dense packaging of cranial nuclei, sensory fibers, neurons, and reticular interneurons that are vital to swallowing. As a consequence, dysphagia following a brainstem stroke is often more severe and the chances for spontaneous recovery are less likely compared with dysphagia following a hemi-

spheric stroke.¹¹ The higher incidence and greater severity of dysphagia highlights the importance of timely screening and appropriate management.

In a small sample ($n = 6$) of brainstem stroke patients, Crary¹² reported that a direct therapy program, incorporating swallowing instruction and biofeedback techniques over a period of at least 3 weeks, proved beneficial and efficient for brainstem stroke patients suffering from chronic neurogenic dysphagia 5 months following stroke onset. The program was designed to safely and successfully institute oral feeding in high-risk patients. Following therapy, Crary¹² reported patients established improved pharyngeal coordination and an increase in duration and effort (mean and peak myoelectric motion) of swallowing musculature. Maintaining “oral and pharyngeal postures” during therapy helped to better swallowing coordination posttreatment.

Patients with severe dysphagia may require enteral tube feeding. It is accepted that for patients in whom it is anticipated that enteral feeds will be required for less than a month, feeding can be accomplished via nasogastric (NG) tube; whereas gastrostomy and jejunostomy feeding tubes may be utilized for patients who require enteral feeding for a longer period.¹³ Teasell et al.¹³ reported 19.3% of patients with brainstem stroke admitted to an inpatient rehabilitation unit required a percutaneous gastrojejunostomy (PGJ) feeding tube before being discharged (Table 4) compared with only 3.2% of patients with hemispheric stroke. Enteral feeding tubes are frequently used in the rehabilitation of dysphagia for brainstem stroke

Table 4. Use of PGJ tubes in patients with brainstem stroke

Total pts	88
Pts with initial VMBS	33
Pts with aspiration on initial VMBS	29
% aspirators requiring PGJ tube	51.7
% pts requiring PGJ tube	19.3

Note: Pts = patients; VMBS = videofluoroscopic modified barium-swallowing; PGJ = percutaneous gastrojejunostomy.

Adapted from Teasell RW, Foley N, McRae M, Finestone H. Use of percutaneous gastrojejunostomy feeding tubes in the rehabilitation of stroke patients. *Arch Phys Med Rehabil*. 2001;82:1412–1415. Copyright © 2001 by Elsevier.

patients, particularly in those patients who show evidence of aspiration.

Although the occurrence of dysphagia appears fairly high among patients with brainstem stroke, the long-term result is favorable. Meng et al.¹⁴ found dysphagia present in 81% of patients with brainstem stroke and, of these, 79% relied on tube feeding at the time of initial evaluation. Four months following stroke onset, 27 of the brainstem stroke patients were contacted. Eighty-eight percent of those contacted had resumed complete oral intake.¹⁴ Similarly, Chua and Kong² investigated 53 brainstem stroke patients admitted to an inpatient rehabilitation institution, over the course of 6 years. All patients relied on tube feeding on admission; however, after a very intense rehabilitation program, only six patients required tube feeding on discharge.

In general, treatment for dysphagia may include compensatory strategies (including posture change, swallowing manoeuvres, and heightened sensory awareness), active exercise programs, or diet modifications as well as nonoral feeding.⁸ Treatment recommendations provided in current clinical guidelines include considering enteral feeding for individuals unable to maintain adequate intake orally, possible use of a feeding tube, and receipt of direct swallowing treatment and/or management by a speech language pathologist where available.⁸

Ataxia

Ataxia is defined as the loss or decreased ability to coordinate muscle movement during voluntary activity.¹ Teasell et al.³ reported that 73/85 (86%) of patients with brainstem stroke admitted to a rehabilitation unit were ataxic upon admission, while Chua and Kong² reported a somewhat lower incidence (68.9%) (**Table 2**). Patients with ataxia suffer from movement inaccuracies including timing errors, irregular trajectories, delayed movements, imprecision during reaching activities, and joint decomposition as a result of an inability to produce muscle torques that predict and compensate for interaction torques generated during multijointed movement.¹⁵

Studies examining treatment strategies for ataxia

are limited and diverse.¹ Exercises specific for ataxic patients include balance training, postural awareness training, motor learning, motor control, and strengthening exercises.¹⁶ Postural control impacts the function of upper extremity, which influences the precision and rate of movement.¹ Shifting weight in any plane causes the trunk to compensate for the alteration in the body's center of gravity with a compensatory movement.¹⁷ The Bobath treatment approach (also known as neurodevelopmental treatment [NDT]), currently popular among therapists, focuses on retraining a patient's postural control and reactions,^{1,18} because posture is critical to movement control. Postural training aims to stabilize movement for the upper limb and integrate "postural control into activities of daily living."¹

Stoykov et al.¹ reported improvements in movements of the upper extremity in an ataxic patient following a brainstem stroke utilizing neuromuscular postural control exercises performed during a 4-week course of rehabilitation. Exercises included maintaining sitting posture without support, strengthening truncal musculature via forward and backward rolling on the less affected side, pelvis forward elevation and postural depression, trunk flexion, and reaching while weight shifting. The patient demonstrated improved isolated control of distal and proximal movements in the upper extremity along with quantifiable increases in function subsequent to the neuromuscular postural control intervention.¹ However, few studies have examined the treatment of apraxic patients. Empirically, it has been shown that compensatory techniques (such as the use of external support and distal weighting of limbs)¹ improves performance of ADLs. However, upper extremity strengthening itself is reportedly not effective in resolving coordination deficits.¹

Dysarthria

Dysarthria has been defined as a "neurological motor speech impairment that is characterized by slow, weak, imprecise, and/or uncoordinated movements of the speech musculature and may involve respiration, phonation, resonance, and/or oral articulations."¹⁹ Dysarthria occurs when the areas of the brainstem responsible for controlling speech are

affected, thereby reducing coordination of respiratory and laryngeal muscles during speech. A common component of dysarthria is phonatory dysfunction.²⁰ Robertson²¹ stated that poststroke patients often experience a variety of "motor speech parameters," particularly intelligibility of speech that results from inaccurate articulation caused by poorly functional oro-facial muscle action. Dysarthria has been reported in 49% to 89% of patients with brainstem stroke^{2,3} (**Table 2**), whereas studies of all stroke types have reported lower frequencies of only 20% to 30%.²²⁻²⁴

Treatment of dysarthria focuses on patients regaining normal muscle tone and increasing strength in their facial and buccal muscles to improve movement accuracy and coordination.²⁵ Treatment strategies generally involve reducing ones' rate of speech, pausing more frequently throughout dialogue, taking deep breaths before important words, and overarticulating certain syllables.²⁶ In addition, specialized devices to improve intelligibility can be used. Sellars et al.²⁷ found that devices vary from low-tech aids including alphabet boards to more advanced aids such as computerized systems. Pacing boards assist patients in reducing their rate of speech,^{26,28} and sign language can be used as an alternative if the patient's speech remains unintelligible.²⁷ In addition, changing environments, training the listeners, or encouraging communicating more frequently with dysarthric patients can all decrease the negative impact of dysarthria.²⁹

The combination of a palatal lift and palatal augmentation prosthesis can be effective when used together with treatment by a speech language pathologist. Palatal lifts help to improve velopharyngeal closure and articulation and compensate for hypernasality during speech and articulation.³⁰ Unfortunately, large-scale clinically controlled trials examining the effectiveness of dysarthria treatment are lacking.²⁷

Paresis

Paresis is a result of damage at any point along the corticospinal motor pathway³¹ and is common in patients with brainstem stroke. Teasell et al.³ reported that 48% of patients recovering from brainstem stroke suffered from some form of pare-

sis (**Table 2**). Chua and Kong² found that paresis was the most common neurological disorder, occurring in 94% of individuals with brainstem stroke. Management of hemiparesis has been well described in the stroke rehabilitation literature.

Dean and Shepherd³² demonstrated that task-related motor training was effective in improving patients' capability to maintain balance while sitting and performing reaching activities, as well as using the lower extremity as support. This study emphasized the importance of designing rehabilitation programs specific to the needs of patients experiencing paralysis.

Alternatively, the restorative approach is used more often for patients with mild-to-moderate paresis and focuses on improvement of motor function via strengthening, treadmill training with partial body weight support, constraint-induced movement therapy, and use of functional electrical stimulation (FES).⁸ However, much of the literature derives from the study of hemispheric strokes with cortical and subcortical involvement where adjacent areas of cortex can take over lost function and facilitate neurological recovery. Brainstem stroke paresis does not involve the cerebral cortex but rather the corticospinal tract and, theoretically, reorganization within the cerebral cortex itself plays a reduced role in recovery when hemiparesis occurs in conjunction. Recovery is likely more focused on reestablishing pathways from existing cortical centers.

Diplopia

When the normal axis of vision is not aligned because one eye has turned away due to cranial nerve abnormality, diplopia is experienced. The incidence of diplopia following brainstem stroke has not been frequently reported. Teasell et al.³ reported that diplopia occurred in 38% of patients with brainstem stroke (**Table 2**). The rehabilitation of diplopia focuses on the realignment of the eyes. Pambakian et al.³³ described the rehabilitation strategies for patients with "homonymous visual field defects" and noted that some of these strategies can be used in the rehabilitation of patients suffering from diplopia including optical aides such as "mirrors attached to spectacle frames, partially reflecting mirrors (beam splitters) and diachronic mirrors

(which reflect a red image and transmit a green one), reversed telescopes, prisms, wide-angle lenses, and closed circuit television monitors.”³⁷ These aids help relocate images to an area of the vision field outside of the scotoma or increase the visual field.³³ Diplopia can also be improved through simple techniques such as fogging, occlusion, suppressing vision in one eye, and pharmacologic measures, although these techniques do not always provide the best result.³⁴⁻³⁷ Surgical procedures may be of benefit in the restoration of vision, but they are only considered when rehabilitation has failed, usually at least 6 months poststroke.^{36,38}

Summary

Dysphagia/aspiration, ataxia, dysarthria, paresis, and diplopia are all common impairments associated with patients with brainstem stroke. Rehabilitation of these patients often requires strategies that are less commonly utilized in stroke rehabilitation. Further research is needed that focuses on rehabilitation strategies specific to patients suffering from brainstem stroke, especially in the areas of dysphagia and diplopia. In addition large-scale clinically controlled trials examining the effectiveness of dysarthria treatment are lacking.

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