Brainstem Stroke Injury Rehab from Speech Therapy Perspective and Case Study

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Objectives

1. To understand the anatomy and physiology of the brainstem for human voice, speech, swallow and cognitive communication and the disorders.
2. To understand the goals and scope of speech therapy service in brainstem stroke rehab.
3. To review the recent research literature on brainstem stroke rehab from speech therapy perspectives.
4. To review the patient profile, progress and functional outcome of the structured speech therapy in inpatient rehab setting through the case studies.
5. To discuss key factors for the most improvement and the barriers for the progress in brainstem stroke rehab and speech therapy.
6. To discuss the implications for future clinical practice and research directions for speech pathologists working with brain stem injury population.
Statistics

“Stroke affects roughly 700,000 Americans a year — 150,000 of whom die; total annual costs are estimated at $51.2 billion. Stroke often occurs in individuals over 65 years of age, yet a third are younger.” (Society for Neuroscience, 2008)

“Ischemic vertebrobasilar stroke accounts for 23% of all first episodes of ischemic brain stroke, 48% of these affect the brainstem; 27% involves pons, 14% medullar, 7% midbrain.” (Querol-Pascal, 2010)

“25% of all strokes, basilar or vertebral arteries, significant % are hemorrhagic….Little research published on the rehab of patients with brainstem stroke…despite the significant numbers of patients admitted to stroke rehab unit.” (Kruger et al., 2007)
The Brain Stem

Blood Supply to Brainstem

Anatomy & Physiology of the Brain Stem

- 3 transverse structures:
  - Midbrain (Mesencephalon), Pons, Medullar oblongata
- Located in the posterior cranial fossa between the Spinal Cord and the cerebral hemispheres (Diencephalon)
- 3 longitudinal regions: basis, tegmentum, tectum
- Housing 10 of 12 cranial nerves
- 4th ventricular cavity between tegmentum and tectum
- Covered by Cerebellum, connected by cerebellar peduncles
Anatomy & Physiology of the Brain Stem

Roles:
• Provide transit and procession nuclei for ascending and descending pathways to and from the cerebrum, cerebellum, & spinal cord

• Play a part in integrative functions: level of consciousness, sleep-wake cycle, muscle tone, posture, respiratory, cardiovascular control.

• House actions of the cranial nerves: sensory fibers terminating & motor fibers originating in the brainstem nuclei—Essential Role in controlling balance, coordination, hearing speech, eye movements, swallowing.
CNS & Neural Pathways

Neurology for the Speech-Language Pathology (2008)
Lesions:
- single lesion leading severe mixed deficits of cerebellar, somatosensory, motor symptoms & cranial nerve symptoms

Levels of lesions by injured cranial nerves & clinical symptoms (ipsilateral lesions and contralateral signs of long tract involvement: hemiparesis or hemisensory or bilateral deficits)
- Midbrain: III or IV
- Pons: V, VI, VII or VIII
- Medullar: IX, X, XI, XII

Other symptoms: vertigo, unsteadiness of gait or ataxia, dysarthria-clumsy Hand disease, blepharospasm, hiccup, palatal myoclonus, respiratory dysfunction, peduncular hallucinosis, conjugate eye deviation toward hemiparesis
### Cranial Nerve Names and Main Functions

<table>
<thead>
<tr>
<th>Brainstem</th>
<th>Cranial Nerve</th>
<th>Main Function</th>
<th>Medial Structures and Deficits</th>
<th>Lateral Structures and Deficits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midbrain</td>
<td>I, olfactory nerve</td>
<td>Olfaction</td>
<td>Motor pathway</td>
<td>Spinocephallic pathways</td>
</tr>
<tr>
<td></td>
<td>II, optic nerve</td>
<td>Vision</td>
<td>Contralateral weakness (arm and leg)</td>
<td>ipsilateral ataxia of the arm and leg.</td>
</tr>
<tr>
<td></td>
<td>III, oculomotor nerve</td>
<td>Eye movements, pupil constriction</td>
<td>Medial lemniscus</td>
<td>Spinothalamic pathways</td>
</tr>
<tr>
<td></td>
<td>IV, trochlear nerve</td>
<td>Eye movements</td>
<td>Contralateral loss of vibration and proprioception (arm and leg)</td>
<td>contralateral alteration of pain and temperature (arm, leg, and rarely trunk)</td>
</tr>
<tr>
<td>Pons</td>
<td>V, trigeminal nerve</td>
<td>Facial sensation, muscles of mastication</td>
<td>Medial longitudinal fasciculus</td>
<td>Sensory nucleus of the Vth</td>
</tr>
<tr>
<td></td>
<td>VI, abducens nerve</td>
<td>Eye movements</td>
<td>Ipsilateral internuclear ophthalmoplegia</td>
<td>Ipsilateral alteration of pain and temperature on the face.</td>
</tr>
<tr>
<td></td>
<td>VII, facial nerve</td>
<td>muscles, facial expression, taste, lacrimation, salivation</td>
<td>Motor nucleus and nerve</td>
<td>Sympathetic pathway; ipsilateral Horner’s syndrome</td>
</tr>
<tr>
<td></td>
<td>VIII, vestibulocochlear nerve</td>
<td>Hearing, equilibrum</td>
<td>Ipsilateral loss of the cranial nerve; IIIrd, IVth, Vth, XIth</td>
<td>Cranial nerves; V, VII, IX, and XI</td>
</tr>
<tr>
<td>Medulla</td>
<td>IX, glossopharyngeal nerve</td>
<td>Pharyngeal muscles, salivation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>X, vagus nerve</td>
<td>Parasympathetics org;</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>XI, spinal accessory nerve</td>
<td>laryngeal/pharyngeal muscles</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>XII, hypoglossal nerve</td>
<td>Head turning</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tongue movement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Ascending somatosensory tracts decussate in middle medullar
- Spinothalamic tracts (temp, pain) occupy more lateral position in medulla & pons than medial lemniscus (stereognosis, position)
- Most ascending spinocerebellar tracts are ipsilateral
- Effects of the cranial nerves & their nuclei are ipsilateral except for CN IV

Adapted from Burger et al.\textsuperscript{12}
# Functions of the Crania Nerves

<table>
<thead>
<tr>
<th>Cranial nerve</th>
<th>Type of nerve</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olfactory (I)</td>
<td>Sensory</td>
<td>Smell</td>
</tr>
<tr>
<td>Optic (II)</td>
<td>Sensory</td>
<td>Sight</td>
</tr>
<tr>
<td>Oculomotor (III)</td>
<td>Motor</td>
<td>Eye movements: innervates all extraocular muscles except the superior oblique and lateral rectus muscles (see N. IV and VI); innervates the striated muscle of the eyelid; mediates pupillary constriction and accommodation of the lens for near vision</td>
</tr>
<tr>
<td>Trochlear (IV)</td>
<td>Motor</td>
<td>Eye movements: innervates superior oblique muscle</td>
</tr>
<tr>
<td>Trigeminal (V)</td>
<td>Mixed</td>
<td>Sensory: mediates cutaneous and proprioceptive sensations from skin, muscles, and joints in the face and mouth, and sensory innervation of the teeth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motor: innervates muscles of mastication</td>
</tr>
<tr>
<td>Abducens (VI)</td>
<td>Motor</td>
<td>Eye movements: innervates lateral rectus muscle</td>
</tr>
<tr>
<td>Facial and intermediate (VII)</td>
<td>Mixed</td>
<td>Motor: innervates muscles of facial expression, lacrimal glands, salivary glands</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensory: mediates taste sensation from the anterior two-thirds of the tongue, and sensation from skin of external ear</td>
</tr>
<tr>
<td>Vestibulocochlear (VIII)</td>
<td>Sensory</td>
<td>Hearing, balance, postural reflexes, and orientation of the head in space</td>
</tr>
<tr>
<td>Glossopharyngeal (IX)</td>
<td>Mixed</td>
<td>Autonomic fibers innervate the parotid gland</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Swallowing: mediates visceral sensations from the palate and posterior one-third of the tongue</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Innervates the carotid body</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Innervates taste buds in posterior third of the tongue</td>
</tr>
<tr>
<td>Vagus (X)</td>
<td>Mixed</td>
<td>Autonomic fibers innervate smooth muscle in the heart, blood vessels, trachea, bronchi, esophagus, stomach, and intestine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Innervates striated muscles in the larynx and pharynx and controls speech</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mediates visceral sensation from the pharynx, larynx, thorax, and abdomen</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Innervates taste buds in the epiglottis</td>
</tr>
<tr>
<td>Spinal accessory (XI)</td>
<td>Motor</td>
<td>Motor innervation of the trapezius and sternocleidomastoid muscles</td>
</tr>
<tr>
<td>Hypoglossal (XII)</td>
<td>Motor</td>
<td>Motor innervation of the intrinsic muscles of the tongue</td>
</tr>
</tbody>
</table>

*Principles of Neural Science (1991)*
Brainstem & Cranial Nuclei

B

Motor

Afferent

Special somatic

General somatic

General and special visceral

General somatic

Special somatic

III

IV

V

VI

VII

VIII

IX

X

XI

Midbrain

Pons

Medulla

Spinal cord

C

Afferent: Somatic Visceral

Motor: Visceral Somatic

Special somatic afferent (VIII)

General somatic afferent (V, VII, IX, X)

General and special visceral afferent (VII, IX, X)

General visceral motor (III, VII, IX, X)

Special visceral motor (V, VII, IX, X, XI)

General somatic motor (III, IV, VI, XII)

Principles of Neural Science (1991)
Cranial Nuclei in Brainstem Imaging

(Querol-Pascual, 2010)
## Midbrain Syndromes

<table>
<thead>
<tr>
<th>Midbrain Syndromes</th>
<th>Structures Affected</th>
<th>Signs and Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anteromedial</td>
<td>Corticospinal tract</td>
<td>Contralateral</td>
</tr>
<tr>
<td></td>
<td>Corticobulbar tract</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Red nucleus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decussation of superior cerebellar peduncle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cranial nerve 3 fascicle</td>
<td></td>
</tr>
<tr>
<td>Anterolateral</td>
<td>Corticospinal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medial spinothalamic tract</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Portions of superior cerebellar peduncle</td>
<td></td>
</tr>
<tr>
<td>Lateral</td>
<td>Descending sympathetic fibers</td>
<td>Horner's syndrome contralateral</td>
</tr>
<tr>
<td></td>
<td>Lateral spinothalamic tract</td>
<td></td>
</tr>
<tr>
<td>Dorsal</td>
<td>Superior/inferior colliculi</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Posterior commissure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cranial nerve 3 nucleus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cranial nerve 4 nucleus</td>
<td></td>
</tr>
<tr>
<td>Bilateral</td>
<td>Midbrain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thalamus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medial temporal lobes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Occipital lobes</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Burger et al. ¹²

Querol-Pascal (2010)
# Pontine Syndromes

Table 3: Pontine Syndromes

<table>
<thead>
<tr>
<th>Pontine Syndromes</th>
<th>Structures Affected</th>
<th>Signs and Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anteromedial</td>
<td>Corticospinal tract</td>
<td>Contralateral</td>
</tr>
<tr>
<td></td>
<td>Corticopontine tract</td>
<td>● hemiparesis/hemiplegia</td>
</tr>
<tr>
<td></td>
<td>Corticobulbar tract</td>
<td>● ataxia or pathologic laughter</td>
</tr>
<tr>
<td></td>
<td>Cranial facial nerve fascicle</td>
<td>● dysarthria, dysphagia</td>
</tr>
<tr>
<td></td>
<td>Cranial abducens nerve fascicle</td>
<td>Ipsilateral</td>
</tr>
<tr>
<td></td>
<td>Paramedian pontine reticular formation</td>
<td>● facial weakness</td>
</tr>
<tr>
<td></td>
<td>Medial longitudinal fasciculus</td>
<td>● lateral rectus palsy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● horizontal gaze palsy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Others symptoms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● internuclear ophthalmoplegia</td>
</tr>
<tr>
<td>Anterolateral</td>
<td>Corticospinal tract</td>
<td>Contralateral</td>
</tr>
<tr>
<td></td>
<td>Spinothalamic tract</td>
<td>● hemiparesis/hemiplegia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● ataxia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● contralateral numbness</td>
</tr>
<tr>
<td>Lateral/dorsolateral</td>
<td>Lateral corticospinal tract</td>
<td>Contralateral</td>
</tr>
<tr>
<td></td>
<td>Spinothalamic tract</td>
<td>● hemiparesis leg &gt; arm</td>
</tr>
<tr>
<td></td>
<td>Spinal nucleus/tract of cranial nerve 5</td>
<td>● contralateral numbness</td>
</tr>
<tr>
<td></td>
<td>Cranial nerve 7 fasciculus/nucleus</td>
<td>Ipsilateral</td>
</tr>
<tr>
<td></td>
<td>Cranial nerve 8</td>
<td>● facial numbness</td>
</tr>
<tr>
<td></td>
<td>Cerebellum</td>
<td>● facial weakness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● hearing loss</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● ataxia</td>
</tr>
<tr>
<td>Bilateral</td>
<td>Corticobulbar tract</td>
<td>● aphonia/dysphagia</td>
</tr>
<tr>
<td></td>
<td>Corticospinal tract</td>
<td>● quadriplegia</td>
</tr>
<tr>
<td></td>
<td>Paramedian pontine reticular formation</td>
<td>● bilateral horizontal gaze paresis</td>
</tr>
<tr>
<td></td>
<td>Cranial facial nerve fascicle/nucleus</td>
<td>● bilateral facial weakness</td>
</tr>
<tr>
<td></td>
<td>Reticular formation</td>
<td>● transient disturbances of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>consciousness</td>
</tr>
</tbody>
</table>

Adapted from Burger et al.\textsuperscript{12}
# Medullary Syndromes

<table>
<thead>
<tr>
<th>Medullary Syndromes</th>
<th>Structures Affected</th>
<th>Signs and Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medial medullary</td>
<td>Corticospinal tract</td>
<td>Contralateral</td>
</tr>
<tr>
<td></td>
<td>Medial lemniscus</td>
<td>• Arm and leg hemiparesis</td>
</tr>
<tr>
<td></td>
<td>Cranial nerve XII Nucleus/fascicle</td>
<td>• Sensory loss (vibratory and positional)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Extremities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ipsilateral</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Tongue paresis</td>
</tr>
<tr>
<td>Lateral medullary</td>
<td>Lateral spinothalamic tract</td>
<td>Contralateral</td>
</tr>
<tr>
<td></td>
<td>Spinal trigeminal nucleus/tract</td>
<td>• Arm/trunk/leg numbness</td>
</tr>
<tr>
<td></td>
<td>Inferior cerebellar peduncle</td>
<td>Ipsilateral</td>
</tr>
<tr>
<td></td>
<td>Sympathetic fibers</td>
<td>• Absent corneal reflex/</td>
</tr>
<tr>
<td></td>
<td>Nucleus ambiguous</td>
<td>• facial numbness</td>
</tr>
<tr>
<td></td>
<td>Vestibular nuclei</td>
<td>• Ataxia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Horner syndrome</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Other symptoms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Dysphagia, dysarthria, hoarse voice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Vertigo, nausea, and vomiting</td>
</tr>
<tr>
<td>Hemimedullary syndrome</td>
<td>Both structures (medial and lateral)</td>
<td>Contralateral</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Arm and leg hemiparesis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sensory loss (vibratory and positional)</td>
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<tr>
<td></td>
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<td>• Extremities</td>
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<td></td>
<td>• Arm/trunk/leg numbness</td>
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<td></td>
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<td>Ipsilateral</td>
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<tr>
<td></td>
<td></td>
<td>• Absent corneal reflex/facial numbness</td>
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<tr>
<td></td>
<td></td>
<td>• Ataxia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Horner’s syndrome</td>
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<tr>
<td></td>
<td></td>
<td>• Tongue paresis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Other symptoms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Dysphagia, dysarthria, hoarse voice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Vertigo, nausea, and vomiting</td>
</tr>
</tbody>
</table>

Adapted from Burger et al.\textsuperscript{12}
Brainstem Stroke and Speech Therapy

- Respiratory failure (Tracheostomy & Ventilator)
- Communication disorders (Vocal & non-vocal)
- Swallowing disorders (Dysphagia)
- Motor speech disorders (Dysarthria)
- Cognitive disorders (Attention, Memory, Executive Function)
Respiratory Failure & Tracheostomy/Ventilator

The Human Respiratory System
- Nasal passage
- Oral cavity
- Pharynx
- Larynx
- Trachea
- Bronchi
- Lung
- Heart
- Ribs

Stoma

( Purves et al. emc.maricopa.edu)
Mechanical Ventilator

- Ventilator setting:
  - FIO2
  - Tidal Volume
  - Respiratory Rate
  - Flow Rate
  - Vital Capacity
  - Rate/Frequency
  - Sensitivity
  - PEEP
  - Alarms
- Disadvantages:
- Benefits of Weaning:
Tracheostomy

- Artificial airway by surgical opening in the trachea for extended period of intubation (>14 to 21 days) (Dikeman KJ & Kaszandjian MS, 2003)
- Components: inner cannula, outer cannula, phalange, obturator, pilot balloon, cuffs (high volume-low pressure, low volume-high pressure)
- Types of trach tube:
  - cuffed, cuffless,
  - fenestrated, non-fenestrated,
  - communication tubes (talking trach),
  - tracheal buttons (one way speech valve)
- Sizes, lengths varies
Disruption in typical speaking mechanics: No airway through larynx and upper airway for speech.

One way speaking valve (Passy Muir Valve-PMV)
- placed on the end of trach tube or in-line with a ventilator
- approximate closed airway system & continued use of upper airway: inspiration through tube but remain closed for expiration through larynx
- improved air pressure, oxygenation, voicing & speech (resonance, pressure, articulation of 16 (p/b, t/d, k/g, f/v, s/z, sh/ch, dz/z, th/th) out of 25 consonants in English)
- patient’s dignity and psychosocial needs: communication, comfort-sense of security, satisfaction

Contraindications
Non-Vocal Communication

- All patients have the "right" to communicate in the least restrictive, most natural manner.
- Alternative methods of communication: mouthing words, writing, alphabet board, electrolarynx, computerized devices, etc.)
Impact of OpenTrach on Swallowing & Intervention

- Neuroanatomical (CPG) overlaps for Respiration & Swallowing: bilateral integration of Nucleus tractus solitarius (sensory tract) & Nucleus ambiguus (motor tract)
- Subglottic airway pressure & subglottic air pressure receptors: stimulated before and during swallow, generation of + pressure compressed receptors signals to brain, latency of bolus transit time & pharyngeal activity (Gross RD, 2011)
- Change in threshold for protective cough reflex: by suctioning airway
- Mechanical disruptions: overinflated cuff, large outer diameter, laryngeal tethering in hyoid/laryngeal motion, reduced cricopharyngeal opening, atrophy, etc. (Chest & Romero et al, 2010-Gross RD, 2011)
- Benefits of PMV/Plugging: airflow to upper airway, increased subglottic air pressure & sensation (clear throat, cough, sense secretions, restored PEEP, etc.)
- Decannulation in orderly sequence: secretions, cuff deflation, plugging
Evaluations of Dysphagia

- **Clinical Swallow Evaluation**: medical history, respiratory/postural/behavioral challenges, dysphagia symptoms, oral anatomy & sensation/motor control, feeding trials, screen appropriateness of VFSS. *Required for all patients prior to FEES or VFSS.*

- **Fiberoptic Endoscopic Evaluation of Swallowing (FEES)**: direct visualization of the mucosa of laryngopharynx/esophagus but not evaluate motility.

- **Videofluoroscopic Swallow Study (VFSS)/Modified Barium Swallow Study (MBSS)**: evaluate structure and function (motility) of dynamic swallow.
  - View structures involved in swallowing & inter-relations
  - Obtain dynamic recording and frame-by-frame analysis
  - Include upright lateral and frontal positions
  - Specify dysphagia: what & why & how
  - Institute therapeutic modifications for intervention strategies/plans
Brainstem Stroke and Dysphagia

**Normal Swallow:**
- Anticipatory Phase
- Oral Preparatory Phase
- Oral Phase
- Pharyngeal Phase
- Esophageal Phase
Neurology of Swallowing

FIGURE 7-7
Brainstem Stroke and Dysphagia

- Brainstem Stroke: direct effect on the swallowing center and lower motor neurons: compact clustering of cranial nuclei, sensory fibers & nerve tracts, reticular interneurons for swallowing

- Higher incidence, greater severity, resistance to spontaneous recovery: 40-70% among pts with brainstem stroke vs 16.5-50% in mixed stroke pts (Meng et al, 2000); 47% of inpts with brainstem stroke had dysphagia, 39.5% demo aspiration on VFSS (Teasell et al, 2002); 40% initially required TF (Chua & Kong et al-Kruger et al, 2007); 65% aspirated on VFSS (Horner et al, 1993); 39-78% silent aspiration (Ramsey et al, 2005-Gross RD, 2011)

- Rehab Outcome: 81% of pts with dysphagia post 10-75 days, 65% on TF initially, 78% resumed full oral nutrition after 7-34 months (Meng et al, 2000); 80% to full oral nutrition (Horner et al, 1993); 19.3% of pts with PGJ TF before discharge vs 3.2% of pts with hemispheric stroke (Teasell et al, 2002)

- Poor outcome: Medullary stroke, presence of wet voice, delay or absence of swallowing reflex at initial evaluation (Meng et al, 2000) cranial nerve IX abnormality, vocal fold weakness & severe dysphagia (Horner et al, 1993)
Medullary Stroke and Dysphagia

- Medullar: Swallowing Center, housing dorsal nuclue of solitary tract, middle to ventral reticular formation surrounding nucleus ambiguus; nucleus of Crainal Nerve IX (glossopharyngeal), X (vagal), XI (hypoglossal)
- Lateral medullary lesion (Wallenberg syndrome): 51-100% of pts with dysphagia (Kim et al, 2000)-dysphonia, soft palate dysfunction, facial hypesthesia
- Lower or middle medullar lesion: hypoglossal nerve damage-oral/pharyngeal dysphagia (Kim et al, 2000)
- Extensive unilateral or bilateral medullar lesions: aspirator (Kim et al, 2000)
- Aspiration Pneumonia, sepsis, longer hospital stay, death (Teasell et al, 2002; Kim et al, 2000)
Interventions for Brainstem Stroke Dysphagia

- Sensory Stimulation: thermal tactile stimulation
- Oral motor exercises
- Compensatory Strategies: postural changes, swallowing maneuver, heightened sensory awareness, diet modifications, non-oral feeding
- Behavioral Maneuvers for airway protection (supraglottic swallow), bolus transfer (chin tuck), UES opening (Mendelsohn, Shaker)
- Surgical Interventions (laryngeal suspension, dilation, myotomy)
- Direct therapy programs (Thermal tactile stimulation, surface electromyographic biofeedback, visual biofeedback by FEES): strengthen pharyngeal response with sustained oral/pharyngeal posture for bolus transit (Crary, 1995; Huckabee et al, 1999)
- Barriers for Progress: oral apraxia, esophagogastric deficits, bilateral pharyngeal weakness (Crary, 1995); other medical complications (Huckabee et al, 1999)
Dysphagia & Neural Recovery


- Increased cortical pharyngeal representation in unaffected hemisphere as a function of swallowing recovery using magnetic cortical stimulation and topographic mapping (Hamdy et al, 1996; 1997)

- Cortical Swallowing Processing in early subacute stroke (1-6 months): “bulbar CPGs coordinate the pharyngeal swallowing phase. Right hemispheric lateralization in brainstem stroke..as subacute cortical compensation of subcortically caused dysphagia.” (Teismann et al, 2011)

- Understanding physiology and pathophysiology of human swallowing: future research and swallowing therapies
Brainstem Stroke and Motor Speech Disorders

Dysarthria:

- Respiration: loudness, efficient airflow
- Phonation (laryngeal function)
- Resonance (velopharyngeal function): nasal emission, hypernasality
- Articulation
- Prosody: rate, pitch, stress

- Flaccid: lower motor neuron damage
- Spastic: bilateral upper motor neuron damage
- Ataxic: cerebellar control circuit damage
Brainstem Stroke and Cognitive Disorders

- Afferent and efferent fibers connecting brainstem and cerebral areas via nuclei pontis and central cerebellar peduncle to cerebellum.
- Anosognosia and reduced frontoparietal cortex after pons infarct (Evyapan D & Kumral E, 1999)
- Disturbance in executive function, attention and intelligence due to pons lesions (Garrad et al, 2002)
- Significantly impaired performance on neuropsychological tasks with a small brainstem infarct (Zandvoort et al, 2003)
- Various cognitive functions supported via fronto-parietal-thalamic-brainstem network in the R hemisphere (Strum et al, 1999)
- Hypothesized a significant role of pedunculopontine tegmental nucleus in frontal syndrome (Winn, P, 1998)
- Disturbance in attention and anterograde amnesia impacting executive function and memory due to hematoma across bilateral pons and decreased perfusion in bilateral frontal/temporal lobes (Maeshima S et al, 2010)
Case Study #1
(19 yr male s/p Bilateral Pontine+R mid brain infarct)

History & Physical Exam

- “Hard working rancher” RH w/ no previous medical history, admitted to ER for progressive diffuse weakness & seizure
- MRI Brain: abnormal mild edema with marked diffusion weighted hyperintensity within pons; CT Head: bilateral basal ganglia calcifications, lacunar infarct in Left thalamus/posterior limb of Left internal capsule; CT Angio Head: absent flow in the distal basilar artery. MRI Brain 13 days post onset: infarct in anterior bilateral pons and Right anterior mid brain cerebral peduncle. No change in lacunar infarct in the Left thalamus.
- Admitted to inpatient rehab 19 days post onset
- Weaned off ventilator but w/ Trach (Shiley#8) & PEG
- Impaired mobility, cognition, self care, bladder & bowel incontinence, dysphagia, hx of seizure
- Neurological Exam: Motor strength and control-bilateral weakness, ”0” on R and L side of body. Grossly intact sensation in all 4 limbs. 2+spasticity bilaterally in digits of UE. (“locked-in syndrome”)
- CN II-PERRLA, III, IV,VI-EOMI,V-equal sensation on buccal areas bilaterally, VII-no facial droop, occasional swallow, slightly open mouth, VIII-hearing grossly intact, IX-not tested, X-unable to access uvula position, XI-unable to shrug shoulders, XII-unable to protrude tongue.
Case Study #1
(19 yr male s/p Bilateral Pontine+R mid brain infarct)

Initial Speech-Language-Cognition and Swallow Evaluation

- **Comprehension:** MaxA (2) 50-70% simple 2-3 unit Y/N?s via upward and limited lateral eye gaze, some head nod/shake w/ max cueing. Followed 2-3 unit commands using eye gaze.
- **Expression:** MaxA (2) Non-vocal. Y/N responses by eye gaze+head nod/shake. Excessive laughs. TBD spelling board
- **Memory:** TotalA (1) Ox self, type of place via Y/N responses
- **Problem Solving:** TotalA (1) Alert, aware of deficits, maintain attention to simple ?s and commands. Easily distracted with eye gaze away from target stimulus/tasks. TBD call light use w/ Quad light using R thumb or head turn.
- **Swallow:** Symmetrical face, overall flaccid weakness, able to open/close mouth to a degree. No lingual motor. Secretions & ice chip oral trials-markedly impaired AP oral bolus transit, no mastication, oral pooling. No laryngeal movement. Spontaneous markedly delayed swallow attempts noted x 2 over 60 min.
- **Respiratory Status:** Trach, cuff inflated at all times+ trach collar-mist, frequent suctioning of thick yellow tan secretions/shift.
- **Total FIM Score:** 6/ST vs 16/multidisciplinary
Case Study #1
(19 yr male s/p Bilateral Pontine+R mid brain infarct)

Progresses in Speech Therapy over the rehab course

- Week 1: spelled simple words via Plaxy glass eye gaze alphabet board. Cuff deflation x 30 min x 2. Digital occlusion x 5-15 secs for swallowing, no cough but weak throat clearing. Lingual pumping and inconsistent swallow initiation on oral stim.

- Week 2: emerging head turn to L and used call light by head turn. Loose white secretions. PMV x 60 min w/ sustained phonation /a/ x 2-4 secs with emerging pitch change. Consistent dry swallow initiation w/ lingual pumping on commands+lip seal. Oral ice chips, wet vocal quality.

- Week 3: Verbal routine problem solving. Decreased attention/working memory for lengthy auditory info benefited from visual feedback by writing. Emerging initiation/communicative intent by looking at letter board. Cough after swallow ice chips trials. Trach change to Jackson, plugging in ST. Oral trials of ice chips, trace amount NTL puree. VFSS-prolonged oral transit w/ lingual pumping, piece meal swallows, decreased pharyngeal constriction (BOT, VP, nasal regurgitation, penetration on NTL, thin)
Case Study #1
(19 yr s/p Bilateral Pontine+R mid brain infarct)

- Week 4: Call light use by R thumb or eye gaze, audible phonation 50% of time, /mama/, plugging >60 min. Lingual protrusion pass front teeth. Lip closure/press/suck. Ice chips w/ parents.

- Week 5: Vmax (eye scan-voice activating AAC) w/ min-modA. Plugging 1-3 hs w/ therapists. Hyperadductive voicing w/ VP incompetency, sustained phonation x 1-4 secs. Dysphagia puree/NTL meals via 1/3-1/2 tsp.

- Week 6: phonation x 1-5 secs, /mamama/, /nana/, /no/. Y/N via head nod/shake, thumb up/down. Word/phrase/sentence lists using R thumb pointing. >50% initiated communication. 50-90% puree/NTL meal. Carb Thin via ½ tsp w/ maxA for labial seal.

- Week 7: directed caregivers attention for problem solving via eye gaze, pointing using ataxic R hand/index finger. ModA typing onscreen or regular key board for open communication, using R hand/dinger w/ elbow support on table. 20% lingual protrusion 40% lingual tip elevation, 20% labial rounding/puckering. Episodes of aspiration via trach w/ UTI+increased tone meds x 2 days.
Case Study #1
(19 yr male s/p Bilateral Pontine+R mid brain infarct)

- Week 10: Dysphagia ground/Thin via cup sips w/ R elbow support.

Discharge Status (week 11)
- **Memory**: Mod Independence (6)
- **Problem Solving**: Mod Dependence (6)
- **Comprehension**: Mod Independence (6)
- **Expression**: SBA (5)-SBA set up DynaVox Maestro (touch screen voice activating AAC). SBA for spell check.
- **Eating**: Dysphagia Ground/Thin w/ trials of soft solids.
- **Trach Decannulation**
- **Motor strength/control Return in R > L**
- **Total FIM Score**: 23/ST vs 49/multidisciplinary
Case Study#2
(43 yr male s/p Bilateral Pontine infarct)

History & Physical Exam

- Civilian working for US Navy, RH, w/ no previous medical history, morbid obesity
- Basilar artery thrombosis
- Hospital course complicated by respiratory failure, sepsis, pleural effusion, PNA
- Admitted to inpatient rehab 72 days post onset: weaned off trach & ventilator a week before admission.
- Non-dominant hemiparesis, impaired mobility, impaired self care, bladder/bowel incontinence, dysphagia s/p PEG, dysarthria, DVT RLE, DM, morbid obesity, hx of recurrent respiratory failure, hypertension.
- Neurological Exam: Motor strength/control: R hemiplegia & L distal weakness- R (0-3) vs L (0-4), intact light touch, proprioception, pinprick, in all limbs.
  
  CN II-PERRL, CN III, IV, VI-EOMI, CN V-equal sensation bilateral face, CN VII-symmetrical face and smile, bilateral weakness, VIII-normal hearing to finger rubbing bilaterally, C IX-gag not tested, C X-uvula at midline, C XI-equal shoulder shrug, C XII-minimal tongue protrusion, deviates to R
Case Study#2
(43 yr male s/p Bilateral Pontine infarct)

Initial Speech-Language-Cognition and Swallow Evaluation

• Comprehension: Mod Independence (6)
• Expression: ModA (3)-Severely dysarthric w/ decreased loudness, breathy to aphonic voice, limited lingual motor, nasal emission. Used alphabet board using somewhat ataxic L hand+spell errors. Emotional lability (tearful+laughter).
• Memory: Mod Independence (6)
• Problem Solving: MinA (4)-Aware of deficits. Demo call light use. SBA functional math. Limited mobility
• Swallow: s/p GT feeds. Mod-severely limited lingual ROM/strength, severely prolonged AP oral bolus transit, Left pocketing, delayed but consistent swallow initiation on oral trials of puree & ice chips.
• Total FIM Score: 19/ST vs 29/multidisciplinary
Case Study #2
(43 yr male s/p Bilateral Pontine infarct)

Progresses in Speech Therapy over the rehab course

- **Week 1:** spelling simple words/phrases using alphabet board using L (non-dominant) hand, intelligible yes/no, labial CV utterances, dysarthric, 2-3 syllable per breath w/ max cue, emerging /k/ w/ nasal occlusion. MaxA typing on PC keyboard due to ataxia. Ice chips, puree trials.

- **Week 2:** fluent, accurate spelling on letter board, approximating explosives /p/, /t/, /k/, emerging /s/. VFSS: Puree/NTL meal trials.

- **Week 3:** sustained phonation /a/ x 3-6 secs/breath. 3-4 syllable utterances w/ max cue for loudness, breath support/diaphragmatic breathing, strained vocal quality. 70% intelligible 1-3 word expressions. Dysphagia puree/NTL diet.

- **Week 4:** Mechanical Soft/Thin liquid diet

- **Week 5:** increased labial closure, lingual elevation & lateral ROM, improving loudness, intelligible 2-3 syllable/breath. Emerging writing simple words/phrases using R hand.
Case Study #2
(43 yr male s/p Bilateral Pontine infarct)

- Week 6: sustained phonation /a/ x 10 secs, independently carried over learned oral motor ex’s and tasks. 50% intelligible 2-4 syllable sentences in known context. Regular/Thin diet.
- Week 7: improving chest wall/diaphragmatic breathing & loudness. 30-80% intelligible oral communication of basic wants/needs 70% of the time.

Discharge Status

- Comprehension: Independent (7)
- Expression: SBA (5)- 30-80% intelligible speech communication 70% of time. Typing on PC keyboard simple phrase/sentences using L hand w/ extra time.
- Memory: Mod Independence (6)
- Problem Solving: Mod Independence (6)
- Regular/Thin diet
- Continent in bowel and bladder.
- Total FIM Score: 24/ST vs 33+OTs/multidisciplinary
Case Study#2
(43 yr male s/p Bilateral Pontine infarct)

Voice, Speech, Communication Video Links
Case Study#2
(43 yr male s/p Bilateral Pontine infarct)

- From: [From]
  Sent: Friday, November 11, 2011 11:41 AM
  To: Park, So
  Subject: RE: Hi from Soyoung

“Hi, Soyoung,

Hard for me to lose perspectives at 43 years of age, they took a lifetime to create. I am thankful for all the kind people (like you) I met on my rehabilitation journey. That what is what it is I'm convinced, a rehabilitation journey. Can't wait to get back to a life of independence. My family works so hard with me. At times it is like they are raising two children, except I know what they are doing for me. Can't wait till do for myself and my family. Keep up the good work. You are blessed with a job, that can make a positive impact on people's lives!!

Respectfully, BH”
Case Study#3
(67 yr male s/p L Medullary infarct)

- Professor, LH, w/ history of Crohn’s disease
- Left vertebral artery occlusion w/ paroxysmal atrial fibulation
- MRI Brain: Left Medullary infarct, chronic small vessel disease.
- Neurological Exam: Motor strength/control- R hemiplegia R(0-1) vs L (5)
  CN II-PERRLA, C III, IV,VI-EOMI, L eye ptosis, diplopia, CV-decreased sensation on R, CVII-symmetric smile, elevation of eye brow, CNVIII-gross intact bilateral hearing, CN IX-no gag reflex, CN X-Uvula at midline, C XI-decreased shoulder shrug on R, C XII-tongue deviation to L. Decreased sensation on RUE/RLE and proprioception on R but present on R hand/foot. Normal tone on R.
- Incontinent in bowel/bladder, trach (shiley #6 → Bivona#7) /ventilator dependent, PEG for feeding.
- Admitted to RTC, acute rehab, 20 day post onset
- Hospital course complicated by hypoxic episodes, GI reflux, aspiration PNA
Case Study#3
(67 yr male s/p L Medullary infarct)
Initial Speech-Language-Cognition and Swallow Evaluation

- **Respiratory Status**: Bivona TTS#7, cuff inflated at all times. On ventilator at night. Copious secretions requiring frequent oral/tracheal suctioning x 30/day.
- **Swallow**: Left facial droop, L eye ptosis, lingual deviation to L, mod decreased lingual lateralization, decreased sensation on L face.
- **Communication**: able to mouth or write simple words (decreased legibility).
- **Cognition**: “I feel my cognition is not a 100%.” “Something does not feel right.” Mild impulsivity in reading tasks and writing. Difficulty with multiple definition of words. Mild difficulty recalled newly learned information.
Case Study#3
(67 yr male s/p Medullary infarct)

Course of Rehab

- Trach change to Bivona TTS#6+plugging during day, 50 days post onset + ventilator at night, frequent but decreased oral suctioning w/ laryngeal excursion and swallow initiations on secretions followed by strong cough.

- Mod dysarthric speech w/ decreased length of audible utterance per breath, loudness, nasal emission, imprecise consonant contact in running speech. Benefited from pacing speech by pausing every 2-4 syllable utterance for breath support and articulation.

- RBANS (Repeatable Battery for the Assessment of Neuropsychological Status), 53 days post onset: total score at Average for age group (73%) w/ lower scores in attention, language, and immediate memory skills

- Videofluoroscopic Swallow Study, ~70 days post onset: prolonged AP oral bolus transit, decreased anterior forward hyoid/laryngeal excursion & compression, decreased pharyngeal constriction (VP, base of tongue, pharyngeal wall), decreased UES opening & backflow--> penetration & aspiration with inconsistent cough response on thin/thick. L pharyngeal weakness. Benefited from effortful swallows, head rotation to L+chin tuck.
Case Study #3
(67 yr male s/p Medullary infarct)

Voice, Speech, Communication Video Links
Case Study#3
(67 yr male s/p Medullary infarct)
Further Discussion & Future Direction

1. Identify specific lesion site & differential diagnosis & prognostic indicators
2. Identify probable brainstem injury
3. Collaborated research: scientists and rehab specialists
4. Controlled studies for treatment efficacy and evidence based practice
5. Development of rehab protocols to measure progress and outcomes.
6. Role of Speech Language Pathologist in brainstem injury
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