FLEX CEUs

Stroke - Role of Physical Therapy

Introduction

Around 800,000 people in the United States have a cerebrovascular accident (CVA) each year. Also known as “stroke”, CVA is a sudden interruption of circulation to the brain, resulting in damage to brain tissue. This can lead to a wide range of physical, cognitive, and emotional challenges for those affected. Physical therapy is imperative to the rehabilitation journey and should start right after the event and proceed until survivors reach their highest potential. Physical therapy helps stroke survivors to regain their independence, mobility, and overall well-being. This course will explore the types of CVAs, clinical presentation, prevalence, anatomy, important outcome tests, rehabilitation considerations, and case studies. After this course, physical therapists and physical therapist assistants will be well-versed to treat patients rehabilitating from CVA with patient-centered, evidence-based care.

Background on CVA

A cerebrovascular accident (CVA), commonly known as a stroke, is a critical medical condition that occurs when the blood supply to a part of the brain is disrupted or reduced, leading to damage or death of brain cells. This can result in a wide range of neurological deficits, including paralysis, speech and language difficulties, cognitive impairment, and sensory disturbances. Understanding the background and underlying factors of CVA is crucial for both prevention and effective management of this life-altering event. This section will overview types of CVA, clinical presentation, prevalence, and risk factors for CVA.

Types of CVA [1,2]

Understanding the different types of cerebrovascular accidents (CVAs) is crucial for healthcare professionals, as it informs diagnosis, treatment, and prognosis. This section provides a basic overview of the primary types of CVAs which are ischemic and hemorrhagic in nature.

Ischemic CVA

Ischemic strokes account for approximately 87% of all CVAs. They occur when a blood vessel leading to the brain is obstructed, usually by a blood clot or plaque buildup. As a result, the affected area of the brain receives insufficient blood supply, as the term implies thus leading to tissue damage. Ischemic strokes can be further categorized based on the location and cause of the blockage. The prognosis for individuals who have experienced an ischemic stroke varies widely based on a multitude of factors such as the size and location of the affected area, promptness of medical intervention, and the presence of underlying health conditions. Early intervention, including the administration of clot-dissolving medications or mechanical thrombectomy, can significantly improve outcomes.

Thrombotic CVA

As opposed to ischemic insults, a thrombotic stroke occurs when a blood clot (thrombus) forms within an artery supplying blood to the brain, often due to atherosclerosis or narrowing of the arteries. As with ischemic insult, the symptoms of a thrombotic stroke can vary widely depending on the location and size of the clot. Common signs include sudden weakness or numbness on one side of the body, difficulty speaking or understanding speech, and problems with coordination or balance. Immediate treatment typically involves medications to dissolve or prevent blood clots through use of thrombolytics and antiplatelet agents to manage underlying risk factors.

Embolic CVA

An embolic stroke is different from a thrombotic stroke as it occurs when a blood clot or other debris forms elsewhere in the body and travels through the bloodstream to block a blood vessel in the brain. The most common region of the body to develop a clot is the heart. Conditions such as atrial fibrillation, heart valve disorders, and certain congenital heart defects can lead to the formation of emboli. Additionally, other sources of emboli can originate from the aorta or other major arteries. Similar to thrombotic strokes, symptoms of an embolic stroke can include sudden weakness or numbness, difficulty speaking or understanding speech, and coordination problems. As with ischemic and thrombotic CVAs, the specific symptoms depend on the location and size of the blockage. Treatment for embolic strokes is similar to thrombotic CVAs and may involve medications to dissolve or prevent blood clots, as well as addressing the underlying heart or arterial conditions. In some cases, procedures like thrombectomy (surgical removal of the clot) may be necessary.

Cryptogenic CVA

In some cases, the exact cause of an ischemic stroke cannot be determined, even after a thorough evaluation. These cases are termed cryptogenic strokes. Possible causes that are difficult to detect include paroxysmal atrial fibrillation, patent foramen ovale, vasculopathies, coagulation disorders, and other cardiac conditions. Paroxysmal atrial fibrillation causes irregular heart rhythms, such as atrial fibrillation, that are intermittent and not detected during routine monitoring. Patent foramen ovale is a congenital heart condition where a small hole between the heart's upper chambers fails to close after birth. Although it may not cause any symptoms, it can sometimes allow blood clots to pass from the right side of the heart to the left, potentially leading to a stroke. Vasculopathies such as vasculitis or moyamoya disease, may lead to cryptogenic strokes.

Transient Ischemic Attack (TIA)

A TIA is often referred to as a "mini stroke." It is a temporary episode of stroke-like symptoms that usually last for a short period (typically less than 24 hours) and resolve without causing permanent damage. TIAs are warning signs that should not be ignored. While TIAs don't cause permanent damage, they indicate an increased risk of subsequent strokes and should be taken seriously. TIAs have similar risk factors as thrombotic strokes.

Hemorrhagic CVA

Hemorrhagic strokes result from the rupture of a blood vessel within the brain, causing bleeding into the surrounding brain tissue. This can occur due to various factors, including high blood pressure, aneurysms, or arteriovenous malformations (AVMs). Hemorrhagic strokes can be particularly severe and have a higher mortality rate compared to ischemic strokes. However, with prompt medical attention and appropriate treatment, some individuals can make significant recoveries. Rehabilitation, including physical therapy, occupational therapy, and speech therapy, may be necessary to regain lost functions and improve quality of life.

An intracerebral hemorrhage (ICH) is a type of hemorrhagic CVA where bleeding occurs within the brain tissue itself, often due to the rupture of small, weakened blood vessels. Symptoms of ICH may include sudden severe headache, nausea, vomiting, weakness or numbness on one side of the body, difficulty speaking or understanding speech, loss of coordination, and altered consciousness levels. Treatment for ICH focuses on controlling bleeding, reducing pressure within the skull, and stabilizing vital signs. This may involve surgery to remove the blood clot, medication to control blood pressure, and other supportive measures.

A subarachnoid hemorrhage (SAH) occurs from bleeding between the brain and the thin tissues that cover it (subarachnoid space). The layers the bleeding is between is the pia mater and the arachnoid mater. This typically occurs from the rupture of an aneurysm and can also result from other causes like head injury, bleeding disorders, or drug abuse. SAH typically presents with a sudden, severe headache (often described as the "worst headache of my life"). Other symptoms may include nausea, vomiting, sensitivity to light (photophobia), neck stiffness, and altered consciousness levels. Treatment for SAH involves securing the ruptured aneurysm to prevent further bleeding. This can be done through surgical clipping or endovascular coiling, a minimally invasive procedure. Medications may also be used to manage symptoms and prevent complications.

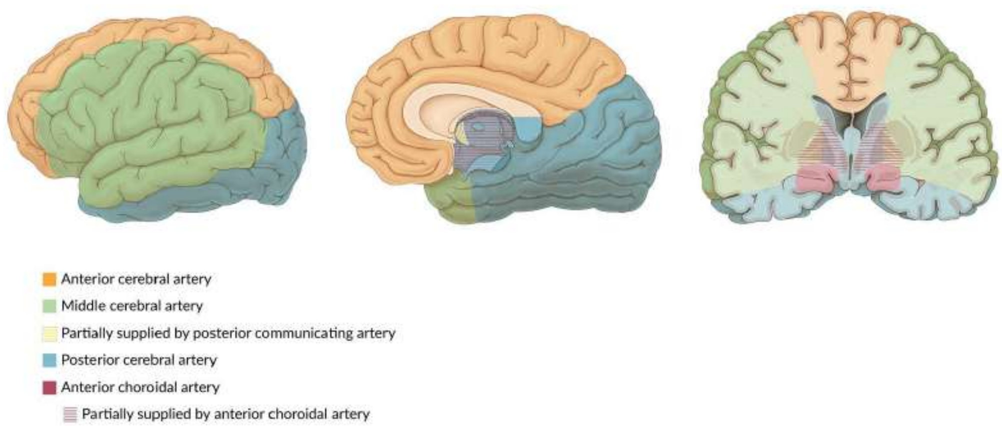
CVA can occur anywhere in the brain and depending on where circulation was restricted, results in a variety of symptoms and clinical presentation.

Ischemic CVA Clinical Presentation

The clinical presentation post CVA depends greatly on the type of stroke, the artery involved, the treatment response time, and many individual patient factors. This section will overview the clinical presentation following specific arteries of ischemic stroke, hemorrhagic stroke and cerebral vs cerebellar infarcts.

An ischemic stroke, as mentioned previously, is an infarct that disrupts circulation in an artery that leads to oxygen deprivation in the tissues that artery supplies. The clinical presentation for middle cerebral artery, anterior cerebral artery, posterior cerebral artery, the vertebrobasilar arterial system, and the basilar artery are distinguishable from each other in a variety of ways.

Circulation of brain regions based on respective artery:



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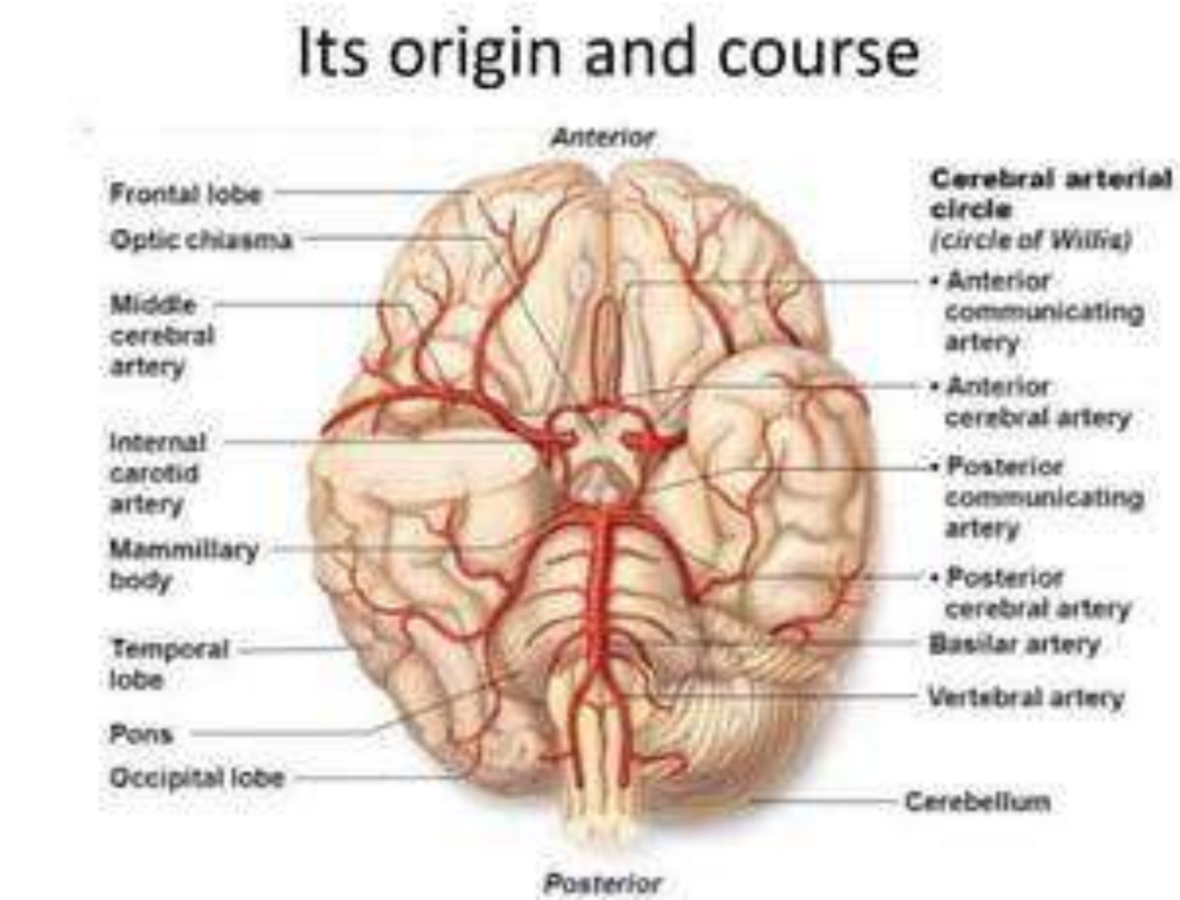

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Middle Cerebral Artery (MCA) [3]

The Middle Cerebral Artery (MCA) is the most common artery occluded during an ischemic stroke. An infarct that affects the MCA follows a specific pattern of deficits. These deficits vary in severity based on how long blood flow was disrupted. The middle cerebral artery arises from the internal carotid artery, which is one of the two main arteries that supply blood to the brain. It is a branch of the common carotid artery, which originates in the neck. After branching off from the internal carotid artery, the MCA takes a course along the lateral (outer) surface of the brain. The MCA supplies circulation to the frontal lobe, the parietal lobe, and the temporal lobe. The frontal lobe portion that the MCA supplies with blood contains the primary motor cortex, the superior, middle, and inferior frontal gyri, the caudate, internal capsule, and thalamus. These areas represent parts of the brain responsible for voluntary movement, reasoning, planning, problem-solving, and aspects of personality. The superior division of the MCA supplies the postcentral gyrus (primary somatosensory cortex) and parts of the parietal lobe. This is responsible for processing sensory information from the body. The MCA supplies the superior and middle temporal gyri, parts of the temporal lobe. These regions are involved in auditory processing and certain aspects of memory and language.

The clinical presentation of an MCA stroke depends on the location of the blockage within the artery and the extent of brain tissue affected. Common clinical signs are the following:

Hemiparesis/Hemiplegia

The most common presentation of CVA is hemiparesis or hemiplegia or contralateral weakness or paralysis on one side of the body, often affecting the face, arm, and leg on the opposite side of the affected artery. Hemiparesis or hemiplegia occur due to tissue death in the primary motor cortex. In an MCA stroke, contralateral facial muscles and muscles of the upper extremity are often weak. The lower extremity can be affected as well if the necrosis is severe.

Sensory Impairments

An MCA stroke can result in reduced or altered sensation on the contralateral side of the body. Patients will have difficulty with the sensation of touch, temperature, or pain in the contralateral lower extremity, upper extremity, and face.

Aphasia

Aphasia, or the difficulty with language and communication, often occurs due to injury to the MCA. This is because of the location of the MCA in regards to the left hemisphere of the cerebrum and its involvement in language and processing. Aphasia is broken down into either expressive, receptive, or global aphasia, which are explained below.

Expressive Aphasia (Broca's Aphasia)

Expressive aphasia occurs when one has difficulty forming sentences and speaking fluently. Speech will be slow and labored, and words may be produced in short, choppy phrases. One's vocabulary and grammar skills are limited as well. Those with Broca's aphasia will have intact comprehension despite not being able to articulate. Broca's area, located in the frontal lobe of the dominant hemisphere (usually the left hemisphere), is often supplied by the MCA. Damage to this area due to an MCA stroke can result in Broca's aphasia.

Receptive Aphasia (Wernicke's Aphasia)

Receptive aphasia occurs when one has difficulty understanding language, resulting in fluent speech that is rapid, verbose, and nonsensical. Individuals with Wernicke's aphasia often have difficulty understanding language, both written and spoken. Wernicke's area, located in the superior temporal gyrus of the dominant hemisphere, is frequently supplied by the MCA. Damage to this area due to an MCA stroke can result in Wernicke's aphasia.

Global Aphasia

Global aphasia is a severe form of aphasia involving both expressive and receptive aphasia. This is due to damage to both Broca's and Wernicke's areas, which can typically be affected by a severe MCA stroke. Individuals affected will present with difficulty in both expressing and understanding language. Such manifests as being limited to a few words or gestures.

Apraxia

Apraxia can occur as a result of an MCA stroke to the dominant hemisphere. With apraxia, one has difficulty planning and executing purposeful movements. This can affect activities such as dressing, grooming, and using tools or utensils.

Neglect Syndrome

In some cases, individuals with an MCA stroke in the non-dominant hemisphere may exhibit neglect for one side of their body or environment. They may not be aware of objects or stimuli on the affected side.

Visual Field Deficits

Homonymous hemianopia is a common visual deficit associated with MCA strokes. It involves the loss of vision on the same side in both eyes.

Behavioral Changes

Depending on the specific brain regions affected within the frontal lobe, behavioral changes, mood disturbances, and emotional lability (rapid mood swings) can occur.

Anterior Cerebral Artery CVA [4]

The Anterior Cerebral Artery (ACA) arises from the internal carotid artery, which is one of the two main arteries that supply blood to the brain. Specifically, it is a branch of the terminal or bifurcation segment of the internal carotid artery. The ACA courses along the midline of the brain, running superiorly and anteriorly between the cerebral hemispheres. The anterior cerebral artery supplies circulation to the medial and superior parts of the brain's frontal and parietal lobes. The parts of the medial frontal lobe the ACA supplies includes the superior frontal gyrus and the medial aspects of the frontal gyrus. These areas are involved in aspects of motor planning, initiation, and certain cognitive functions. The ACA supplies the superior frontal gyrus, which is responsible for higher-level cognitive functions, such as decision-making, attention, and planning. The ACA supplies also supplies the medial parietal lobe, including the superior parietal lobule and adjacent areas. These regions play a role in sensory processing, including proprioception (awareness of body position) and spatial perception. The ACA supplies a portion of the corpus callosum, which is a bundle of nerve fibers that connects the left and right hemispheres of the brain. This structure facilitates communication between the two hemispheres.

Deficits following a CVA in the anterior cerebral artery are listed and explained below.

Motor and Sensory Deficits

Weakness or paralysis may occur, particularly in the legs and feet. This is known as contralateral hemiparesis or hemiplegia, meaning it affects the side of the body opposite to the stroke. Sensory impairments, such as reduced or altered sensation in the legs and feet, may also be present on the contralateral side.

Gait Disturbances

Due to motor deficits in the legs, individuals may experience difficulties with walking and maintaining balance. This can lead to a distinctive gait pattern, often characterized by a "marching" or "high stepping" appearance.

Apraxia

Apraxia is a condition in which the individual has difficulty planning and executing purposeful movements, especially with fine motor skills. In the case of an ACA stroke, this may affect activities such as dressing, grooming, and using utensils.

Cognitive and Behavioral Changes

Depending on the specific areas affected, individuals may experience cognitive impairments. This can include difficulties with memory, attention, concentration, and problem-solving. Behavioral changes may also occur. For example, some individuals might become more cautious or show signs of apathy.

Language and Communication

While the ACA is not primarily responsible for language functions, in some cases, a stroke involving the ACA may lead to mild language difficulties, especially if the stroke affects areas adjacent to language centers.

Urinary Incontinence and Other Bladder Issues

Due to the proximity of the ACA territory to the motor and sensory areas controlling the lower extremities and bladder, individuals may experience problems with urinary function. This can range from urgency and frequency to incontinence.

Personality Changes

Depending on the location of the stroke, there may be alterations in an individual's personality or emotional state. This could manifest as mood swings, emotional lability, or changes in temperament.

Neglect Syndrome

Neglect syndrome, where the individual ignores or fails to notice one side of their body or environment, is more commonly associated with strokes involving the non-dominant hemisphere MCA stroke and may occur less frequently after an ACA stroke.

Posterior Cerebral Artery CVA [5]

The Posterior Cerebral Artery (PCA) is one of the major arteries that supply blood to the brain. It is part of the circle of Willis, a circulatory system at the base of the brain that helps ensure a consistent blood supply to critical areas. The PCA supplies blood to the posterior part of the brain, including portions of the temporal and occipital lobes. The PCA arises from the basilar artery, which is formed by the fusion of the two vertebral arteries. After its origin, the PCA courses upward and posteriorly along the ventral surface of the brainstem, eventually curving around to reach the posterior part of the brain. The PCA supplies blood to the posterior portion of the brain, including the occipital lobes, parts of the temporal lobes, portions of the thalamus, and the midbrain. It is responsible for providing blood to important visual processing centers in the occipital lobes.

Damage or occlusion of the PCA can lead to specific neurological deficits, particularly related to vision. Depending on the location and extent of the damage, individuals may experience visual impairments and other specific deficits, which are outlined below.

Visual Deficits from PCA Stroke

Homonymous Hemianopia

This is the loss of vision on the same side in both eyes, typically on the opposite side from the damaged hemisphere.

Visual Agnosia

This is the difficulty with recognizing familiar objects or stimuli. For instance, one might be unable to identify a common object like a key or a chair, despite having normal vision.

Prosopagnosia

Prosopagnosia is a specific type of visual agnosia where individuals have difficulty recognizing familiar faces, even those of close family members or friends.

Quadrantanopia

In some cases, individuals may experience a loss of vision in one quadrant of the visual field. This can be upper or lower, and on one side or both, depending on the location of the damage.

Cortical Blindness

In severe cases, a PCA stroke can lead to cortical blindness, where a person loses all visual perception. This is different from other types of blindness, as it's not related to eye problems but rather to damage in the visual processing areas of the brain.

Other Deficits

Alexia (Reading Difficulty) and Agraphia (Writing Difficulty)

Depending on the location and extent of the damage, individuals may have difficulty reading (alexia) and writing (agraphia). This can be related to visual processing or language centers supplied by the PCA.

Memory Impairments

Depending on the extent of the stroke, memory functions, particularly those associated with the temporal lobes (supplied by the PCA), may be affected.

Hemianesthesia

In some cases, there may be a loss of sensation on one side of the body, which can include a decrease in tactile perception, temperature sensation, or pain perception.

Other Neurological Deficits

In more extensive strokes, other functions, such as language, motor skills, and higher cognitive functions, may be affected depending on the areas supplied by the PCA.

The deficits after PCA stroke, just like any other CVA, vary based on the amount of time brain tissue was deprived of oxygen. There are little mobility deficits after PCA strokes, making cognition and vision the focus of rehabilitation.

Vertebrobasilar Arterial CVA [6]

A stroke involving the vertebrobasilar artery, which is a critical blood vessel supplying the brainstem, cerebellum, occipital lobes, the midbrain, pons, cranial nerves, and the thalamus, can lead to several deficits. Through supplying the brainstem, the vertebrobasilar arterial system is responsible for essential functions of the medulla oblongata, pons, and midbrain. These functions include breathing, regulation of heart rate, and consciousness. This arterial system supplies collateral circulation to the thalamus, which is responsible for relaying sensory and motor signals, and to the cranial nerves responsible for facial expression and sensation. The vertebrobasilar arterial system also supplies a significant amount of circulation to the cerebellum, which is responsible for coordinating voluntary movements and motor control. The deficits from a vertebrobasilar CVA vary depending on the location and severity. Some of these deficits are outlined below.

Vertigo and Dizziness

Vertigo, a false sensation of spinning or movement, is a common symptom of a vertebrobasilar artery stroke. Severe dizziness and imbalance can also occur. Vertigo can be explained by involvement in disrupting circulation to the vestibular system. The vertebrobasilar artery supplies blood to the vestibular system and several nuclei involved in processing vestibular information. Part of this supplies the vestibulocochlear nerve (cranial nerve VIII), which is responsible for both hearing and balance. In some cases of vertebrobasilar stroke, particularly those involving the inner ear structures, hearing or balance may be affected along with facial symptoms.

Visual Disturbance

Visual disturbances can occur after a vertebrobasilar artery stroke due to the critical role this arterial system plays in supplying blood to various structures involved in vision processing. Homonymous hemianopia, as previously mentioned, involves the loss of half of the visual field in both eyes. For example, if the right side of the visual field is affected, individuals will have difficulty seeing objects on their right side. Quadrantanopia, a loss of vision in one quadrant of the visual field, can also occur. This can be upper or lower, and on one side or both, depending on the location of the damage. Visual field deficits can occur depending on the exact location and extent of the stroke. Examples of these include scotomas (blind spots) and difficulty perceiving objects in specific regions of the visual field. Visual agnosia can occur, which is a difficulty recognizing familiar objects. Blurred vision can also result due to disruption in the processing of visual information. Diplopia, or double vision, is a condition where a person sees two images of a single object. This can be due to impaired coordination of the eye muscles. In addition, after a vertebrobasilar arterial stroke, individuals may have difficulty adjusting the focus of their eyes, leading to problems with clear vision. Nystagmus, a rhythmic, involuntary movement of the eyes, can occur and lead to difficulties with visual fixation and can further contribute to balance issues. Lastly, in severe cases, a vertebrobasilar artery stroke can lead to cortical blindness, where a person loses all visual perception. This is different from other types of blindness, as it's related to damage in the visual processing areas of the brain.

Dysarthria

Dysarthria can occur after a vertebrobasilar artery stroke due to damage in the brainstem and other structures involved in motor control, such as the facial cranial nerve. It results from weakened or impaired control of the muscles used for speech production. Speech may be slurred or difficult to understand due to impaired muscle control, particularly in the mouth and tongue (articulation difficulty). Resonance changes may occur as a result of this CVA, which will manifest in changes in the quality of the voice. Speech may sound nasal or hypernasal. This occurs due to problems with the soft palate's movement. The rate of the speech may be either too fast (due to lack of control) or too slow (due to the effort required to articulate). In addition, difficulty in controlling the loudness of speech can occur, which can create excessively loud or very soft speech. Dysarthria can also create irregularities in the rhythm, stress, and intonation of speech. This can make speech sound monotonous or uneven. Respiratory control changes in the breath support needed for speech can change as well. This results in difficulty maintaining steady airflow for speech production.

Dysphagia

Dysphagia, or difficulty swallowing, can occur after a vertebrobasilar artery stroke due to the critical role this arterial system plays in supplying blood to structures involved in swallowing, including the brainstem. Weakness or coordination problems due to stroke may affect the muscles involved in swallowing.

Facial Weakness or Numbness

Weakness or numbness may occur on one side of the face, often affecting the mouth or eye. This is due to involvement in cranial nerves. The facial nerve (cranial nerve VII) is primarily responsible for controlling the muscles of facial expression. It also carries sensory information from the taste buds on the anterior two-thirds of the tongue. Damage to the facial nerve can lead to weakness or paralysis of the facial muscles, affecting functions like smiling, frowning, closing the eyes, and raising the eyebrows. In a vertebrobasilar artery stroke, the facial nerve can be affected due to its proximity to the brainstem structures that may be damaged. The trigeminal nerve (cranial nerve V) is responsible for sensations in the face and controls the muscles used in chewing. Although facial weakness or numbness is not a direct symptom of trigeminal nerve involvement, damage to this nerve could lead to altered facial sensation or difficulty with tasks like chewing.

Imbalance and Coordination Problem

Imbalance and coordination problems are common neurological deficits that can occur after a vertebrobasilar artery stroke. These symptoms are often related to damage in the brainstem, cerebellum, and adjacent structures that are crucial for maintaining balance and coordinating movements. This can lead to difficulty walking, a lack of coordination, and a tendency to veer or fall to one side. Cerebellar dysfunction resulting from a vertebrobasilar artery CVA can cause significant coordination difficulties. The cerebellum, located at the posterior aspect of the brain, plays a central role in coordinating voluntary movements, maintaining balance, and fine-tuning motor skills. Dysmetria can also occur, which refers to difficulties in judging distances, leading to overreaching or underreaching when attempting to touch or grasp objects. Ataxia is common as well, and is a lack of coordination in voluntary movements, often resulting in unsteady and shaky movements. It can affect tasks like walking, reaching, and handling objects. Dysdiadochokinesia refers to difficulty performing rapid alternating movements, such as rapidly pronating and supinating the hand. After vertebrobasilar CVA, one may have an intention tremor as well. An intention tremor occurs during purposeful movements and is characterized by a trembling or shaking of the limb. It can make tasks like reaching for an object challenging. Gait disturbances including an unsteady gait, difficulty with balance, and a tendency to veer or stumble are common after this type of CVA.

Muscle Weakness or Paralysis

Depending on the location and extent of the stroke, there may be weakness or paralysis in the arms, legs, or both. This will typically occur on the contralateral side to the CVA. Facial weakness can occur due to facial nerve damage. Unilateral extremity muscles may also lose endurance, becoming fatigued much sooner than before the CVA. One may also have fine motor deficits in the hand and fingers, making dexterity difficult.

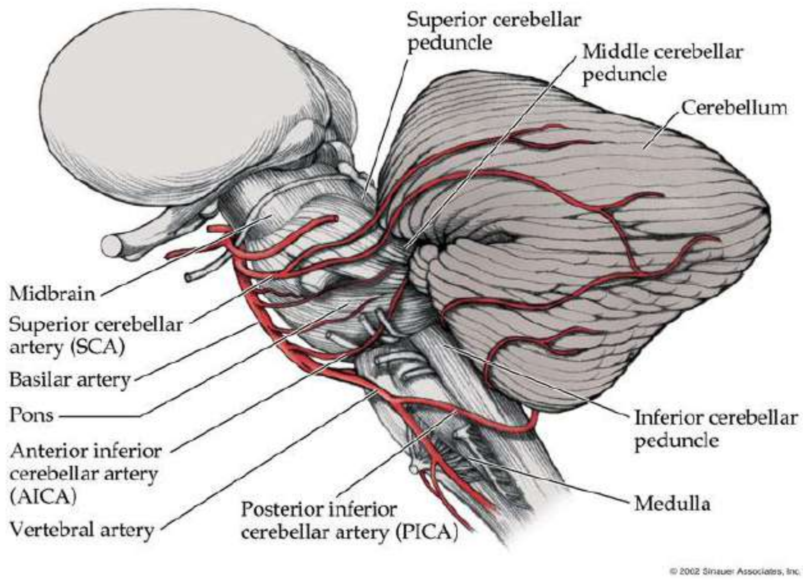
Other Deficits

A CVA in the vertebrobasilar arterial system can also cause sensation loss to various extremities. It can also cause a loss of bladder or bowel control in severe cases. One may enter a coma after a CVA in this area due to its supply to the brainstem.

Ischemic Cerebellar CVA Presentation [7]

A cerebellar cerebrovascular accident (CVA), also known as a cerebellar stroke or cerebellar infarct, occurs when the blood flow to a part of the cerebellum is disrupted, usually due to a blocked or ruptured blood vessel. The cerebellum is a crucial structure at the posterior aspect of the brain responsible for coordinating movements, maintaining balance, and fine-tuning motor skills. The cerebellum is primarily supplied with circulation by three major arteries: the posterior inferior cerebellar artery, the anterior inferior cerebellar artery, and the superior cerebellar artery. The Posterior Inferior Cerebellar Artery (PICA) is one of the three branches of the vertebral artery, which itself is a branch of the subclavian artery. The vertebral arteries ascend through the cervical vertebrae and merge at the base of the skull to form the basilar artery. The PICA branches off from the vertebral artery just before this junction. The PICA supplies the inferior portion of the cerebellum, including the posterior and lateral aspects. The Anterior Inferior Cerebellar Artery (AICA) is another branch of the basilar artery. It arises near the junction of the basilar artery and supplies the anterior and lateral portions of the cerebellum. Additionally, the AICA provides blood flow to parts of the pons of the brainstem and the inner ear. The Superior Cerebellar Artery (SCA) is the final branch of the basilar artery. It ascends along the upper surface of the pons before entering the cerebellum. The SCA supplies the superior part of the cerebellum.

While the cerebellum is primarily supplied by the vertebral and basilar arteries, it can also receive some collateral blood flow from the anterior circulation through the Circle of Willis. This is a circulatory anastomosis that helps distribute blood evenly to the brain. It's important to emphasize that the cerebellum's functions are highly dependent on a consistent and well-regulated blood supply. Disruption of blood flow to the cerebellum, as in the case of a stroke or other vascular events, can lead to significant neurological deficits, including problems with coordination, balance, and motor skills. These deficits are explained in more detail to follow.



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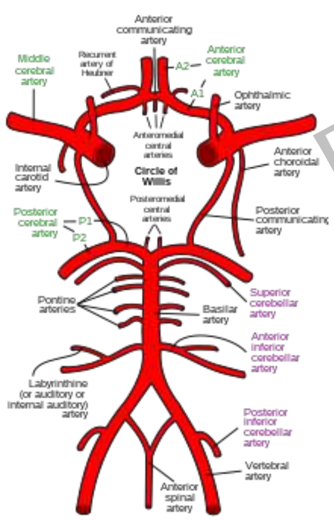

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Ataxia

Ataxia is a prominent and defining symptom of cerebellar stroke. It refers to a lack of coordination and control in voluntary movements. This can affect both fine and gross motor skills, leading to unsteady, shaky movements.

Gait Disturbances

Walking can be severely affected, with individuals experiencing an unsteady gait, wide-based stance, and difficulty maintaining balance while walking. After a cerebellar CVA, one may stagger, have difficulty initiating and stopping walking, lack arm swing, titubation, and inconsistent step timing. Titubation is a rhythmic, back and forth movement of the trunk or head during walking.

Coordination

Dysmetria is the inability to gauge distances accurately. This can result in overreaching or underreaching when attempting to touch or grasp objects. Dysdiadochokinesia refers to difficulty performing rapid alternating movements, such as rapidly pronating and supinating the hand.

Intention Tremor

Intention tremor occurs during purposeful movements and is characterized by a trembling or shaking of the limb. It tends to get worse as the individual approaches their target.

Eye Coordination

Nystagmus is a rhythmic, involuntary movement of the eyes. It can lead to difficulties with visual fixation and can further contribute to balance issues. Nystagmus in cerebellar stroke can manifest in different directions, including horizontal, vertical, or rotational. The direction and amplitude of the eye movements can vary based on the specific location and extent of cerebellar damage. Cerebellar dysfunction can affect both smooth pursuit (tracking) and saccadic (rapid, voluntary) eye movements. This may contribute to the appearance of nystagmus. In some cases, nystagmus can occur concurrently with an intention tremor, which involves a trembling or shaking of the eyes when trying to focus on a specific target.

Vertigo and Dizziness

Vertigo is a specific type of dizziness characterized by a false sensation of movement or spinning. It often feels like the individual or their surroundings are rotating or moving when they are actually still. This sensation can be intense and is typically accompanied by nausea or vomiting. In cerebellar stroke, vertigo can occur due to the disruption of the cerebellum's role in processing vestibular (inner ear) signals and coordinating them with visual and proprioceptive information. Dizziness is a broader term that encompasses various sensations of unsteadiness, lightheadedness, or feeling off-balance. It does not always involve a spinning sensation, as in vertigo. Individuals may feel like they are going to faint or lose their balance. In the context of cerebellar stroke, dizziness can result from the cerebellum's involvement in regulating postural control and coordinating movements.

Headache

Depending on the size and location of the stroke, individuals may experience headaches, which can range from mild to severe. A headache can be a symptom associated with a cerebellar stroke, although it may not always be present. The severity, location, and characteristics of the headache can vary widely based on the individual and the specific circumstances of the stroke. Headaches associated with cerebellar strokes may occur at the back of the head or in the occipital region, as this is the area near the cerebellum. The pain may be focused on one side or can be more generalized. The headache may result from various factors, including increased pressure within the skull due to swelling or bleeding, irritation of the blood vessels, or changes in cerebrospinal fluid circulation.

Nausea and Vomiting

These symptoms can occur due to the disruption in the vestibular system, which is closely connected to the cerebellum. Disruptions in spatial orientation and balance can lead to sensations of motion sickness, nausea, and vomiting. Individuals with cerebellar stroke may become more sensitive to motion, leading to an increased likelihood of experiencing nausea in response to movement.

Dysarthria and Dysphagia

The cerebellum is involved in coordinating the muscles used in speech and swallowing. Damage to this area can lead to dysarthria (speech difficulties) and dysphagia (swallowing difficulties). Impaired coordination of the tongue, vocal cords, and lips can result in inaccurate articulation and variable speech patterns. Dysphagia results due to damage in muscle contractions involved in swallowing, impaired muscular control, and a delayed swallow reflex.

Hypotonia or Reduced Muscle Tone

There may be a decrease in muscle tone, which can lead to a floppy or 'limp' feeling in the affected limbs. The cerebellum helps regulate the tone of muscles, ensuring they maintain an appropriate level of tension for posture and movement. Damage to the cerebellum can lead to a decrease in muscle tone, resulting in a sensation of floppiness or limpness in the affected limbs. Hypotonia can lead to difficulties in maintaining an upright posture. Individuals may appear to slouch or have a tendency to lean when sitting or standing. Individuals with hypotonia may struggle with bearing weight through their limbs, which can affect activities like walking and standing.

Decreased Proprioception

Proprioception refers to the body's ability to sense its position and movements in space. It relies on information from receptors in the muscles, tendons, and joints. The cerebellum plays a crucial role in processing and integrating this proprioceptive information to coordinate smooth and accurate movements. Reduced proprioception can lead to difficulties in coordinating movements, as the brain has less accurate information about the position and motion of body parts. Activities that involve fine motor skills, such as buttoning a shirt or writing, may be affected. Decreased proprioception can lead to inaccuracies in these tasks.

Hemorrhagic CVA Presentation

A hemorrhagic cerebrovascular accident (CVA) occurs when there is bleeding in or around the brain. Hemorrhagic strokes are less common than ischemic strokes but can be more severe. The fatality rate of a hemorrhagic stroke is between 30 and 50 percent. This is compared to a fatality rate of five to fifteen percent after ischemic CVA. The presentation of a hemorrhagic CVA can vary depending on the location and extent of the bleeding. Hemorrhagic CVA can occur in the cerebrum, cerebellum, or surrounding the brain in the subarachnoid and/or subdural space. Hemorrhagic strokes follow a similar pattern of symptoms per brain tissue affected by the loss of blood flow as ischemic strokes, and deficits outlined below.

Headache

During and after a hemorrhagic stroke, a hallmark sign is a sudden and severe headache. It is often described as the "worst headache of my life" and arrives with little to no warning.

Hemiparesis/Hemiplegia

After a hemorrhagic stroke, one may experience weakness or paralysis on one side of the body. This is typically affecting the side opposite to the hemisphere of the brain where the hemorrhage occurred (contralateral).

Numbness and Tingling

Numbness, tingling, or a loss of sensation on one side of the body often accompanies weakness or paralysis. This is typically seen on the side of the body opposite the hemisphere of the brain where the bleeding occurred. Depending on the location of the hemorrhage, there may be numbness or a "pins and needles" sensation on one side of the face. The numbness might be limited to specific areas of the body, such as the arm, leg, or hand, or it could involve a broader region.

Speech Difficulty

Dysarthria and aphasia can occur as a result of a hemorrhagic stroke, just like with an ischemic one.

Visual Changes

Visual disturbances can occur, including blurred vision, loss of vision in one or both eyes, or other visual impairments.

Vital Sign Changes

Vital signs can change as a result of a hemorrhagic stroke, including heightened blood pressure and an elevated heart rate. This can occur before, during, and after the stroke.

Seizure

Seizures can occur at various times after a hemorrhagic stroke. They can happen shortly after the stroke or even weeks to months later. Generalized seizures involve both sides of the brain and typically lead to a loss of consciousness. Partial seizures begin in a specific area of the brain and may or may not lead to loss of consciousness. Some individuals may continue to be at risk for seizures after experiencing one. Long-term medication may be prescribed, depending on the individual's specific circumstances.

Subdural Hemorrhage [8]

A subdural hemorrhage, also known as a subdural hematoma, is a type of bleeding that occurs between the outermost layer of the brain (the dura mater) and the next layer (the arachnoid mater). This bleeding can exert pressure on the brain tissue, potentially leading to serious complications if not promptly addressed. There are two types of subdural hemorrhages: acute and chronic. An acute subdural hemorrhage occurs within 72 hours of the head injury. It is often associated with a rapid onset of symptoms and can be life-threatening. A chronic subdural hemorrhage develops over a period of weeks to months after a minor head injury or spontaneously in older individuals. Symptoms may be subtle at first and progress gradually. Symptoms include a headache, altered level of consciousness, confusion, nausea, vomiting, weakness, numbness, difficulty with speech, seizures, and visual disturbances.

Subarachnoid Hemorrhage [9]

A subarachnoid hemorrhage (SAH) is a type of bleeding that occurs in the subarachnoid space, which is the area between the arachnoid mater (one of the layers covering the brain) and the pia mater (the delicate layer that directly covers the brain). This type of hemorrhage is typically caused by the rupture of a cerebral aneurysm or less commonly, other vascular abnormalities. Symptoms include nausea, vomiting, a sudden and severe headache, stiffness in the neck, light sensitivity, altered mental state, and an altered level of consciousness.

Demographics

To understand the need for rehabilitation for CVA, physical therapists and assistants should have general knowledge of demographics and epidemiology of the disease. This section will outline prevalence, statistics, and presentation of CVA across sexes and races.

Prevalence [10–12]

Stroke is a common condition and cause of mortality worldwide. Globally, stroke is the second leading cause of death and the leading cause of disability. Approximately one quarter of people across the world will have a stroke in their lifetime. This number has increased by 50 percent in the past two decades due to lifestyle factors. The impact of CVA is large in underdeveloped countries. In fact, just under 90 percent of deaths and disabilities occur in low to middle income countries as a result of CVA.

There are approximately 750,000 cases of acute stroke per year and 140,000 deaths per year in the United States alone. This means that just under three percent of US adults have a CVA in their lifetime. The highest state-wide prevalence is in Alabama at just under five percent, and the lowest is in Minnesota, at just under two percent. CVAs are the 7th leading cause of mortality in the United States. In addition, one stroke can increase the risk for multiple strokes without prevention methods. Just under 200,000 people who have had a stroke have had multiple. One in six deaths due to cardiovascular disease in the US is from stroke. Someone in the US has a CVA every 40 seconds. Around 87 percent of strokes are ischemic, and thirteen percent are hemorrhagic. Stroke prevalence varies based on many factors, including age, race and ethnicity, and sex.

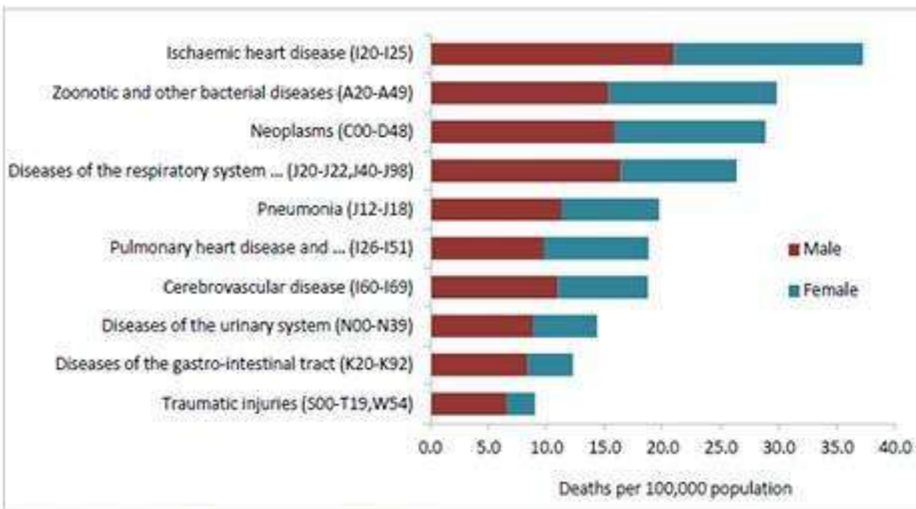


Figure 2.4 : Leading Causes of Hospital Deaths, 2019

Age [12,13]

Although a stroke can occur at any age, the prevalence for CVA increases with age. The risk of stroke approximately doubles for each decade after the age of 55. For young adults under 45 years old, stroke is relatively rare. Approximately ten percent of strokes occur in this age group. Middle aged adults, from 45 to 64 years old account for 25 percent of all strokes. Older adults, those aged 65 or older represent 65 percent of all strokes. Those 85 years and older have the highest overall risk and the most significant portion of cases of CVA out of any other age group.

Sex [14]

Historically, males have had a higher rate of stroke than females. In recent years, however, males and females are experiencing CVA at almost equal rates. Either sex can be at risk for CVA, depending on lifestyle factors and comorbid conditions. Hemorrhagic stroke is more common in men, while ischemic strokes are slightly more common in women.

Race and Ethnicity [15]

Race and ethnicity can play a role in the risk factors, incidence, and outcomes of CVAs. African Americans have the highest risk out of any race or ethnicity to have their first CVA, which is up to two times higher than Caucasians. Hispanic Americans and American Indian/Alaska Natives are at a higher risk than Caucasians for CVA but at lower risk than African Americans. In addition, African Americans and Hispanics are more likely to die than Caucasians after having a stroke. Asian Americans generally have lower stroke prevalence than other ethnic groups. Native Americans and Alaska Natives have similar or slightly higher rates than other ethnic groups. One theory of stroke prevalence being higher in other ethnicities than Caucasians is disparities among cultures to access and afford healthcare. There can be language barriers, socioeconomic considerations, and cultural influence in lifestyle choices that raise the rate of stroke in Hispanic and African American communities.

Geography [16]

The highest death rates post CVA in the country are found among the Southeastern United States. The "Stroke Belt" refers to a region in the southeastern United States, including states like Alabama, Arkansas, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee, where stroke rates have historically been higher than the national average. The "Stroke Buckle" specifically refers to a particularly high-risk area within this region. The reason for this includes socioeconomic factors, education levels, and access to healthcare. In addition, rural areas face higher mortality rates from CVA due to lack of timely access to healthcare and less prevention methods.

Risk Factors and Causes of CVA

There are many factors that may increase one's risk for stroke. These typically fall into categories of comorbidities, lifestyle factors, and genetic factors. This section will detail each factor that increases the risk for CVA.

Comorbidities [17–19]

Comorbid conditions that increase the risk for a future CVA include cardiovascular diseases, diabetes mellitus, chronic kidney disease, chronic obstructive pulmonary disease, and obesity. Comorbidities represent the most causative risk factors for CVA.

Hypertension, or persistent high blood pressure, can damage blood vessels over time, making them more susceptible to blockages or ruptures. It is the single most important modifiable risk factor for stroke. *Atrial fibrillation (A Fib)* is an irregular heart rhythm that can lead to the formation of blood clots. If a clot dislodges and travels to the brain, it can cause an ischemic stroke. *Coronary artery disease (CAD)* is a condition in which the blood vessels that supply the heart muscle become narrowed or blocked. Individuals with CAD are at an increased risk of stroke due to the shared underlying vascular pathology. *Heart failure* is a condition in which the heart is unable to pump blood effectively. It can lead to inadequate blood supply to the brain, increasing the risk of stroke. *Peripheral artery disease (PAD)* is a condition in which the blood vessels outside of the heart and brain become narrowed or blocked. It indicates systemic atherosclerosis and an increased risk of stroke. *Thrombophilias* (blood clotting disorders) are conditions that increase the tendency to form blood clots, whether genetic or acquired. They can elevate the risk of stroke. *Sickle cell disease (SCD)* is a genetic disorder characterized by abnormal hemoglobin, the protein in red blood cells responsible for carrying oxygen. In SCD, the red blood cells become rigid and assume a crescent or "sickle" shape. This can lead to a range of health complications, including an increased risk of stroke. SCD most commonly affects those of African, Mediterranean, Middle Eastern, and South Asian descent and most severe in African Americans. *Diabetes Mellitus* can lead to elevated blood sugar levels, which can cause damage to blood vessels and nerves when it is uncontrolled. It also increases the risk of atherosclerosis, which can lead to stroke. *Hyperlipidemia*, or high cholesterol, can lead to the formation of fatty deposits in the arteries (atherosclerosis). Hyperlipidemia is marked by elevated levels of low-density lipoprotein (LDL) rather than high-density lipoprotein (HDL) cholesterol. This can obstruct blood flow and increase the risk of stroke. *Chronic kidney disease (CKD)* can lead to CVA due to inflammation, calcification of arteries, and hypertension. Autoimmune and inflammatory disorders like lupus, rheumatoid arthritis, and other autoimmune disorders can increase the risk of stroke due to inflammation and immune system dysfunction. *Sleep apnea* is a disorder characterized by interrupted breathing during sleep. It is associated with an increased risk of hypertension and other cardiovascular problems, which can contribute to stroke risk. Migraines with aura are migraines with visual disturbances, and some studies suggest that individuals who experience these may have a slightly higher risk of stroke. *Obesity*, particularly around the abdomen, can contribute to conditions like high blood pressure, high blood sugar, and high cholesterol, all of which increase stroke risk.

Certain medical treatments can increase the risk for CVA as well. Hormone replacement therapy (HRT), particularly estrogen, in postmenopausal women may be associated with a slightly increased risk of stroke. On a related note, contraceptives, particularly those with higher doses of estrogen, may increase the risk of blood clots, which can lead to stroke. Anticoagulant medications, if the dosage is not properly monitored or if there are other risk factors present, can lead to an increased risk of bleeding, which can result in a hemorrhagic stroke. Antiplatelet medications, like anticoagulants, are used to prevent blood clots. If not used as directed or if there are other risk factors present, they can increase the risk of bleeding and hemorrhagic CVA. Some surgeries, particularly those involving blood vessels or the heart, can temporarily increase the risk of stroke due to factors like changes in blood flow or the formation of blood clots during the procedure. Radiation therapy to the head and neck for certain cancers can sometimes lead to changes in blood vessels or an increased risk of blood clots. Some chemotherapy drugs, like cisplatin and methotrexate, may increase the risk of blood clots, which can lead to stroke. Stent placement to open narrowed arteries can carry a small risk of blood clots forming on the stent, which can potentially lead to stroke. Hemodialysis, which is often needed for patients with CKD, may increase one's risk for CVA, particularly if they have other risk factors like high blood pressure or diabetes. Electroconvulsive therapy (ECT), used for treating severe mental illness, slightly increases the possibility of blood clots or changes in blood pressure.

Lifestyle Factors [20–22]

There are several risk factors in one's lifestyle that lead to an increased rate of stroke. These also increase the risk of developing the comorbid conditions explained prior in this section. *Smoking* is a leading modifiable risk factor for stroke. A person who smokes around 20 cigarettes per day is at a six times higher risk of stroke than someone who does not smoke. Smoking damages blood vessels, raises blood pressure, and makes blood more likely to clot. It is a significant independent risk factor for stroke. Quitting smoking can significantly reduce this risk. *Physical inactivity* can contribute to obesity, high blood pressure, and other cardiovascular risk factors. When someone spends four or more hours per day sedentary, there is an increase in the rate of stroke. If this is more than eleven hours per day, each hour beyond that increases stroke risk by 20 percent. Engaging in regular exercise helps maintain overall health and reduces stroke risk. *Unhealthy diets*, high in saturated fats, cholesterol, sodium, and processed sugars can contribute to atherosclerosis. Conversely, a diet rich in fruits, vegetables, whole grains, and lean proteins can help reduce stroke risk. *Excessive alcohol consumption* can lead to high blood pressure, irregular heart rhythms, and other cardiovascular problems, all of which can increase the risk of stroke. It is estimated that alcohol consumption contributes to around eight percent of ischemic and sixteen percent of hemorrhagic strokes. *Drug abuse*, especially cocaine, heroin, and amphetamines, can lead to hypertension, irregular heart rhythms, and other cardiovascular problems that increase stroke risk. Drug abuse is one of the leading contributors to strokes in young people.

Genetic Factors [23,24]

Genetic factors play a role in a person's susceptibility to stroke. While strokes are not directly inherited like some genetic diseases, there are genetic variations that can increase the likelihood of certain risk factors for stroke. Some families have a history of stroke, which can suggest a genetic predisposition. This may be due to a combination of shared genetic traits and common environmental factors. Certain genetic mutations have been associated with an increased risk of stroke. For example, mutations in genes related to blood clotting (MTHFR gene and Factor V Leiden mutation) can elevate the risk of clot formation and ischemic stroke. Conditions like hereditary hemorrhagic telangiectasia (HHT) and cerebral cavernous malformations (CCM) are genetic disorders characterized by abnormalities in blood vessels. These conditions can increase the risk of hemorrhagic stroke. Genetic factors can influence blood pressure regulation. High blood pressure is a significant risk factor for both ischemic and hemorrhagic stroke. In addition, variations in genes associated with cholesterol metabolism can impact an individual's cholesterol levels. Elevated levels of LDL cholesterol are a risk factor for atherosclerosis and ischemic stroke. Certain inherited metabolic disorders, like homocystinuria, can lead to elevated levels of homocysteine, an amino acid associated with an increased risk of blood clots and stroke. Sickle cell disease, a genetic condition mentioned in the comorbidities section, can lead to abnormal hemoglobin production and increase the risk of blood clots and strokes, particularly in children. Variations in genes related to blood clotting factors can affect how easily blood clots form, potentially increasing the risk of both ischemic and hemorrhagic strokes. Genetic factors can also influence the health and elasticity of arterial walls. Conditions that affect arterial health, such as fibromuscular dysplasia, can increase the risk of stroke. Lastly, families often share not only genetics but also lifestyle factors (diet and exercise habits) that can influence stroke risk.

Having a genetic predisposition does not guarantee the development of a stroke. It is important to consider that while genetics can contribute to stroke risk, they interact with environmental factors, comorbidities, and lifestyle choices listed in this section.

Section 1 Key Words

Cryptogenic CVA - A type of stroke where the exact cause cannot be definitively determined, even after a thorough medical evaluation

Apraxia - A neurological condition characterized by the inability to execute or coordinate purposeful and skilled movements, despite having the physical ability and intention to perform them

Dysarthria – A motor speech disorder characterized by difficulties in the coordination and control of the muscles used in speech production

Dysphagia - A motor speech disorder characterized by difficulties in the coordination and control of the muscles used in speech production

Aphasia - A communication disorder that impairs a person's ability to process and use language due to damage within the brain's language centers

Section 1 Summary

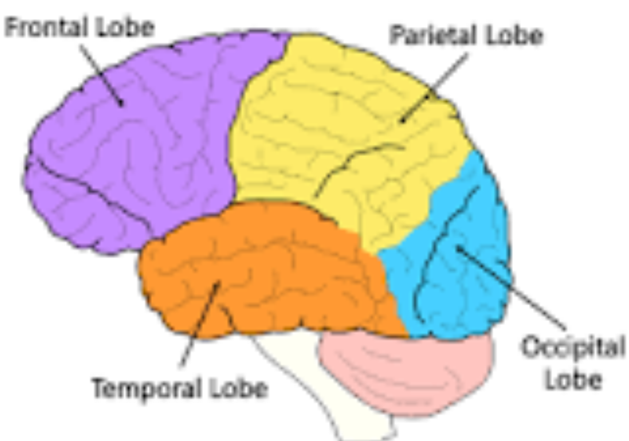
A cerebrovascular accident (CVA), more commonly known as a stroke, is a serious medical event characterized by the interruption or reduction of blood flow to a specific part of the brain. This can lead to the injury or demise of brain cells, causing a diverse array of neurological impairments like paralysis, speech and language challenges, cognitive limitations, and sensory disruptions. Having a comprehensive grasp of the foundational elements, presentation, and root causes of CVAs is pivotal for physical therapists and assistants to understand to develop and carry out effective rehabilitation programs.

Anatomy of Central Nervous System

It is crucial to understand the structure and function of the central nervous system that is affected by the loss of circulation from a CVA. Knowledge of this will help PTs and PTAs understand a patient's deficits and formulate realistic rehabilitation programs to achieve improvements in function.

Cerebrum Structure and Function [25]

The cerebrum contains four lobes and connecting structures to control and regulate several functions and thought processes in the body. This section will explain each as a foundation of understanding the effects of CVA on these structures.



https://www.brainframe-kids.com/brain/facts-lobes.htm

Frontal Lobe

The frontal lobe is located at the anterior aspect of the brain. The primary motor cortex in the frontal lobe controls voluntary movements of specific body parts. The frontal lobe is responsible for higher order thinking and is involved in decision-making, planning, judgment, and problem-solving. The prefrontal cortex, a part of the frontal lobe, plays a role in regulating emotions, social behavior, and personality traits. In the left hemisphere, Broca's area is crucial for speech production and language processing.

Parietal Lobe

The parietal lobe is situated at the superior posterior part of the brain. It processes sensory information from the body, such as touch, pressure, temperature, and pain. It is responsible for spatial awareness and recognition. It is also involved in mathematical calculations and spatial awareness.

Temporal Lobe

The temporal lobe is found on the lateral aspect of the brain, near the temples. It is primarily responsible for processing auditory information, including speech and sound recognition. The hippocampus, located within the temporal lobe, is essential for the formation of new memories.

Occipital Lobe

The occipital lobe is at the posterior aspect of the brain. Its primary function is processing visual information received from the eyes.

Limbic System (Including Parts of Several Lobes)

The limbic system comprises various interconnected regions within the cerebrum. It is crucial for emotions, motivation, and long-term memory formation. It includes structures like the amygdala and hippocampus.

Corpus Callosum

The corpus callosum is a thick bundle of nerve fibers that connects the two hemispheres. It facilitates communication and information transfer between the left and right hemispheres.

Cerebellum Structure and Function [26]

The cerebellum is a complex structure located at the back of the brain, underneath the cerebral hemispheres, in the posterior cranial fossa. It's primarily responsible for coordinating movement, balance, posture, and fine-tuning motor activities. The cerebellum receives information from various sources including the cerebral cortex, spinal cord, and vestibular system. The cerebellum consists of three lobes, with various functions.

Anterior Lobe (Spinocerebellum)

Located at the front of the cerebellum, it is responsible for regulating muscle tone and coordinating voluntary movements.

Posterior Lobe (Cerebrocerebellum)

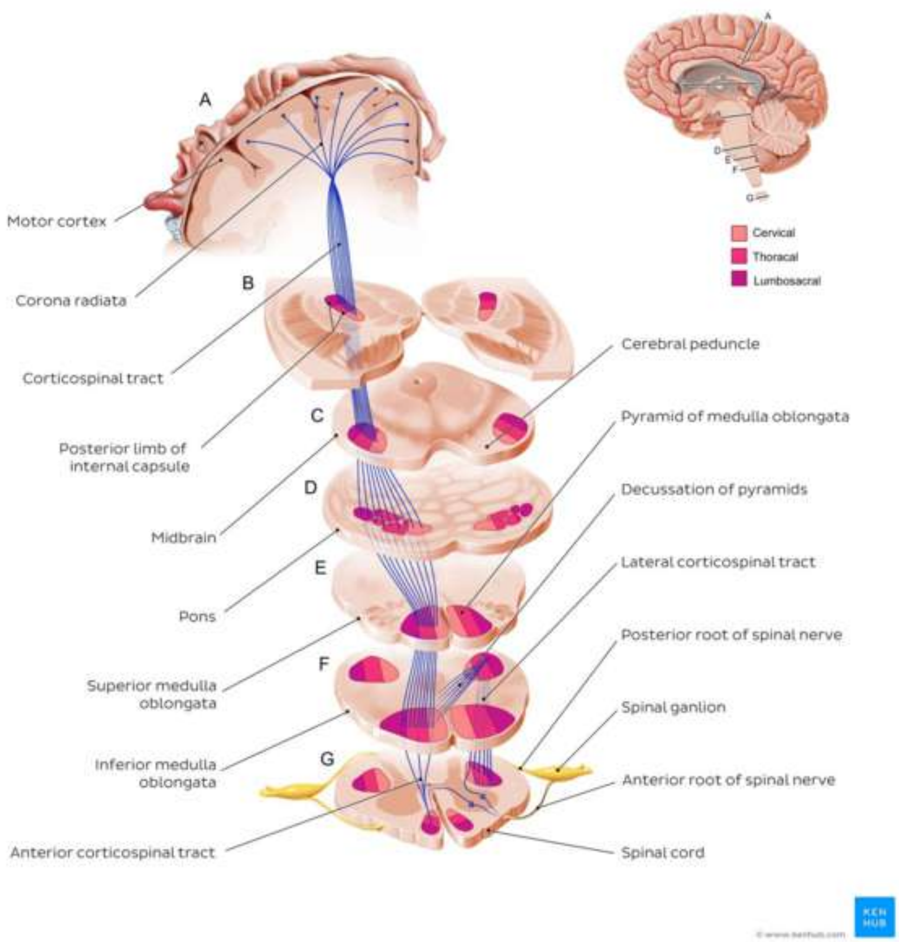
Situated behind the anterior lobe, it's involved in planning and executing fine, coordinated movements.

Flocculonodular Lobe (Vestibulocerebellum)

Positioned at the bottom, it plays a crucial role in balance, eye movements, and spatial orientation.

Spinal Tracts Structure and Function

The effects of a stroke can expand from the brain into the spinal tracts, impacting both motor and sensory functions. The spinal tracts, which are bundles of nerve fibers that transmit signals between the brain and the spinal cord, can be affected, altering sensory and motor function.

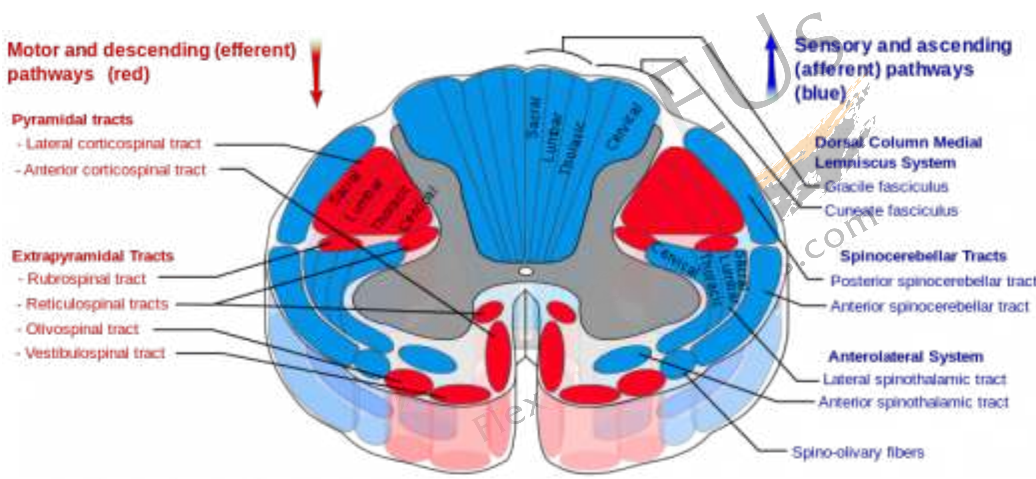


Corticospinal Tract [27]

This is a crucial motor pathway that originates in the motor cortex of the cerebrum, descends through the brainstem, and terminates in the spinal cord. It controls voluntary movements of the limbs and trunk. When a stroke affects the corticospinal tract, it can lead to weakness or paralysis on one side of the body (hemiparesis or hemiplegia) or on the opposite side of the brain injury.

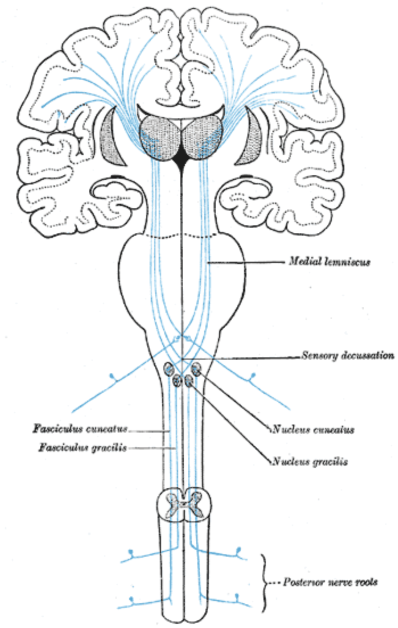
Spinothalamic Tract [28]

This tract is responsible for transmitting sensory information such as pain, temperature, and crude touch from the body to the brain. It transmits information from the stimulus in the body through the anterolateral system of the spinal cord, through the thalamus, and to the primary sensory cortex. Damage to this tract due to a stroke can result in sensory deficits on the opposite side of the body from the brain lesion.



Dorsal Column-Medial Lemniscus Pathway [29]

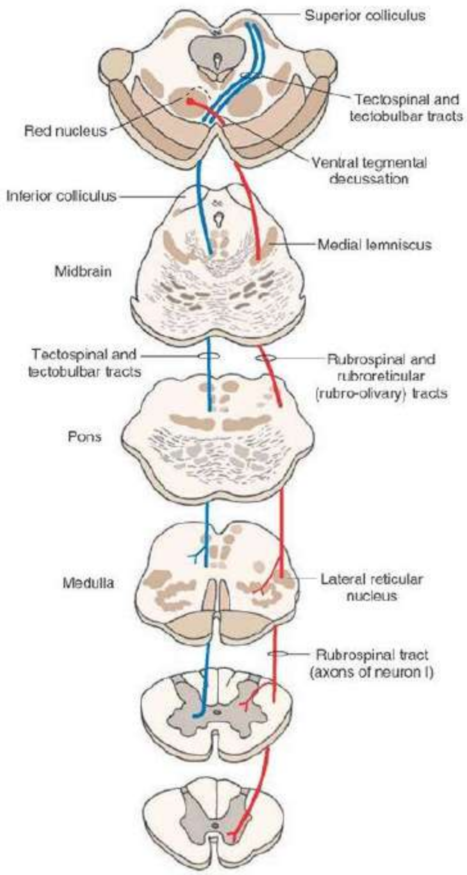
This pathway carries information related to fine touch, proprioception (awareness of body position in space), and vibration sense. If a stroke affects this pathway, it can lead to deficits in these sensory modalities on the opposite side of the brain injury. Information is carried from the peripheral nerves to the cerebral cortex through the medial leminiscus of the spinal cord.



https://www.physio-pedia.com/Dorsal_Column_Medial_Lemniscal_Pathway

Rubrospinal Tract [30]

This motor pathway is involved in motor coordination and posture. Damage to this tract due to a stroke may contribute to impairments in fine motor control and coordination. This tract originates in the red nucleus of the midbrain and courses through the pons and medulla oblongata to the lateral white column of the spinal cord.



Vestibulospinal Tracts [31]

These tracts help control balance and posture. Damage to either the medial or lateral vestibulospinal tracts can result in balance and gait disturbances.

Reticulospinal Tracts [32]

These tracts play a role in various aspects of motor control, including posture and muscle tone. Damage to these tracts can contribute to abnormalities in muscle tone. It originates in the reticular formation (pathway that connects the spinal cord to the brain) and spans to the periphery of the body.

Section 2 Key Words

Flocculonodular Lobe - The most inferior and oldest part of the cerebellum, positioned at the bottom of the cerebellar hemispheres and responsible for coordination of eye movement and vestibulocular reflexes

Corticospinal Tract – A neural pathway responsible for transmitting motor signals from the cerebral cortex, particularly the primary motor cortex, to the spinal cord

Spinothalamic Tract – A neural pathway responsible for transmitting sensory information related to pain, temperature, and crude touch from the body to the brain

Section 2 Summary

PTs and PTAs must know the structure and function of the central nervous system in order to understand the effects of prolonged loss of circulation from a CVA. This provides a basis for rehabilitation timelines and protocols, along with expected deficits during rehabilitation.

Physical Therapy Examination and Evaluation

A thorough physical therapy examination for a patient who has experienced a cerebrovascular accident involves a comprehensive assessment of various aspects to understand the individual's specific impairments, functional limitations, and rehabilitation needs. It is critical to move through a subjective history, detailed examination with tests and outcome measures, to monitor vitals, and gather other pertinent information to create an effective and measurable plan of care. Examination may be different per setting of rehabilitation and depending on the patient's acuity and medical history.

Subjective History [33]

It is crucial to investigate information about the patient's background, medical history, and specific concerns related to the stroke event. This will provide the foundation for the development of an evaluation and plan of care. The subjective history is similar in all settings. Communication barriers from the deficits of a CVA (aphasia) should be addressed by consulting with speech language pathology colleagues if needed. Patients may be able to communicate through writing or gestures rather than articulate speech.

Chief Complaint and Symptoms

Prior to taking a history, therapists should screen the patient for orientation to name, place, time, and situation. Physical therapists should start the history by encouraging the patient to provide a detailed account of their main concerns, including specific symptoms they are experiencing. They should ask about the onset, duration, and progression of these symptoms. This should include how it affects their lives as well in terms of activities of daily living and physical ability. The physical therapist should obtain a precise timeline of the stroke event, including the date, time, and circumstances surrounding it. They should ask about the initial signs and symptoms observed, as well as any changes or developments in the days or weeks following the event. Symptoms may be pain, weakness, lack of coordination, impaired mobility and other things.

Medical History

An initial evaluation for a patient post CVA should include a detailed medical history review. This includes asking the patient and checking available medical records. Physical therapists should inquire about any chronic medical conditions or comorbidities, such as hypertension, diabetes, heart disease, or previous strokes. It is important to know the duration of these conditions, previous treatments received, and how they were managed before the stroke. A medication review should also be conducted to screen for side effects.

A discussion of modifiable risk factors for stroke, including smoking, diet, exercise, alcohol consumption, and stress management, is warranted. PTs may provide education and support for making positive lifestyle changes to reduce the risk of recurrent events.

Stroke Specifics

Physical therapists should determine the type of stroke (ischemic or hemorrhagic) and the affected side of the brain. They should ask about any residual deficits or impairments resulting from the stroke, such as weakness, sensory changes, visual disturbances, or speech difficulties. They should assess the patient's cognitive function, including memory, attention, problem-solving, and comprehension. In addition, they should inquire about any difficulties with communication, such as aphasia, dysarthria, or other speech-related challenges.

Treatment and Hospitalization History

Providers should discuss the immediate care received after the stroke, including hospitalization, medical interventions, and any rehabilitation services provided. Inquire about medications prescribed post-stroke and any modifications made to the treatment plan. Depending on the setting of rehabilitation, this information may be available in medical history.

Functional Status Prior to the Stroke

Providers should gain insight into the patient's level of independence in activities of daily living (ADLs) such as bathing, dressing, grooming, toileting, and eating. It is important to know both their current status and their status prior to the CVA. They should ask about mobility, including walking, transferring, and using assistive devices if applicable.

Specific Concerns and Goals

To build an effective rehabilitation program and patient rapport, the physical therapist should encourage the patient to articulate any specific challenges they are facing in their daily life due to the stroke. They should ask about their short-term and long-term rehabilitation goals, whether related to mobility, communication, self-care, or other areas of function.

Social Support and Environment

Physical therapists should determine the availability of support from family members, caregivers, or friends. They should understand the patient's living situation, including whether they live alone, with family, or in a care facility. In addition, it is important to identify any potential challenges or adaptations needed in their environment.

Psychosocial and Emotional Well-Being

Physical therapists should address the patient's emotional state and any psychological impact of the stroke. They should inquire about feelings of depression, anxiety, frustration, loss, or any adjustment difficulties they may be facing. Providers should take note of their social support system and coping mechanisms.

Patient's Expectations and Preferences

The provider may ask the patient about their expectations for rehabilitation and any specific preferences they have regarding treatment approaches or techniques. It is also important to know the patient's prior experience with rehabilitation services, including physical therapy, occupational therapy, speech therapy, or other interventions. Providers should ask about the patient's perception of their previous experiences and what they found helpful or challenging.

Summarize and Address Questions

At the end of the subjective history, providers should summarize the information discussed, ensuring accuracy and completeness. Invite the patient to ask any additional questions or share any concerns they may have.

Vital Signs [34]

Vital signs are key to recognizing states that put patients at a higher risk of stroke. The two most important vitals to collect before, during, and after activity are blood pressure and heart rate. Physical therapists should measure these vital signs at the initial evaluation and continue to monitor during subsequent sessions to see the response to activity.

Blood Pressure (BP)

Normal: Systolic BP: Less than 120 mm Hg, Diastolic BP: Less than 80 mm Hg

Hypotension: Below 90/60 mmHg

Elevated: Systolic BP: 120-129 mm Hg, Diastolic BP: Less than 80 mm Hg

Hypertension Stage 1: Systolic BP: 130-139 mm Hg, Diastolic BP: 80-89 mm Hg

Hypertension Stage 2: Systolic BP: 140 mm Hg or higher, Diastolic BP: 90 mm Hg or higher

Hypertension Response: A systolic blood pressure (SBP) that exceeds 220 mm Hg or a diastolic blood pressure (DBP) that exceeds 105 mm Hg during or immediately after exercise. This is an emergent situation and patients are in need of immediate medical attention.

Hypotensive Response: A drop in SBP of more than 10-20 mm Hg or DBP of more than 10 mm Hg below baseline levels during or after exercise. This is an abnormal response and may be accompanied by dizziness or loss of consciousness. This should be monitored and if there is significant dizziness or altered consciousness, a patient should be sent to the emergency department.

Heart Rate (HR)

Normal: 60-100 beats per minute (bpm)

Excessive Tachycardia: A heart rate (HR) that exceeds the predicted maximum based on age (220 minus age) after exercise. If this persists, patients should be monitored and sent to cardiology for an examination of the cause.

Respiratory Rate (RR)

Normal: 12-20 breaths per minute (bpm)

Excessive RR: A respiratory rate that exceeds 40 breaths per minute during or after exercise. This could occur from comorbid conditions like asthma, bronchitis, or chronic obstructive cardiopulmonary disease (COPD).

Oxygen Saturation (SpO2)

Normal: 95-100%

Abnormal SpO2: A decrease in SpO2 below 90% during or after exercise. This could occur from pulmonary diseases like COPD. It is crucial to monitor oxygen saturation in patients with any respiratory condition. A consistent rate in the 80s necessitates urgent pulmonary workup and management.

Neurological Assessment [35]

A neurological assessment in physical therapy after a cerebrovascular accident (CVA) is crucial for understanding the extent of neurological deficits and planning appropriate rehabilitation. This should include an examination of cranial nerve function, muscle tone, sensory examination, a coordination examination, and a reflex examination.

Cranial Nerve Tests [36]

Cranial nerve integrity testing after a CVA is a crucial component of neurological assessment. It helps evaluate the function of the twelve cranial nerves, which play vital roles in various sensory and motor functions of the head and neck.

Olfactory Nerve (Cranial Nerve I)

The therapist should provide the patient with familiar scents (for example coffee and vanilla) and ask them to identify each scent with each nostril separately.

Optic Nerve (Cranial Nerve II)

Visual Acuity

The physical therapist should conduct a Snellen eye chart test at a standardized distance (20 feet or 6 meters) and ask the patient to read aloud the smallest line they can see clearly.

Visual Fields

The PT should have the patient cover one eye and look directly at the therapist's nose. Then, the therapist should gradually move their hand or an object from the periphery towards the center, asking the patient to indicate when they first see it.

Oculomotor (Cranial Nerve III), Trochlear (Cranial Nerve IV), and Abducens (Cranial Nerve VI) Nerves

Extraocular Movements (EOMs):

The patient follows the therapist's finger as they move it through the cardinal fields of gaze (up, down, left, right, and diagonally). A test is positive if there are any limitations or abnormalities in eye movement.

Trigeminal Nerve (Cranial Nerve V)

Sensory Function

The therapist should lightly touch the patient's forehead, cheeks, and chin with a cotton swab. They should ask the patient to close their eyes and identify which area is being touched and note inaccuracies.

Motor Function

The therapist should palpate the temporal and masseter muscles while asking the patient to clench their jaw and note aberrant movements or unequal movements.

Facial Nerve (Cranial Nerve VII)

The therapist should observe the face for any signs of asymmetry or drooping at rest. They should also ask the patient to perform specific facial expressions like smiling, frowning, closing eyes tightly, raising eyebrows, and puffing out cheeks. They should note any asymmetry or aberrant movement patterns.

Vestibulocochlear Nerve (Cranial Nerve VIII)

Rinne Test

The Rinne test differentiates between conductive and sensorineural hearing impairment. The therapist should place the base of a vibrating tuning fork on the patient's mastoid process and then in front of the ear. They should ask the patient to indicate when they can no longer hear the sound. A normal test is if the patient hears the sound better through the air. An abnormal test is when the patient hears the sound better when the tuning fork is on the mastoid process. This is suggestive of conductive hearing loss.

Weber Test

The Weber test differentiates conductive versus sensorineural hearing loss. The test should be conducted by placing a vibrating tuning fork on the patient's forehead or crown of the head and asking the patient to indicate if they hear the sound better in one ear or equally in both. A normal Weber test means the sound is heard equally in both ears and at the midline of the head. With conductive hearing loss, the patient would hear the sound more loudly in the ear with conductive hearing loss because the sound is being transmitted through the bone rather than air. With sensorineural hearing loss, the patient would hear the sound loudly in the better ear.

Glossopharyngeal Nerve (Cranial Nerve IX) and Vagus Nerve (Cranial Nerve X)

Gag Reflex

The therapist should use a tongue depressor to gently stimulate the back of the throat on each side and observe for a gag reflex. An absent reflex may suggest glossopharyngeal nerve involvement.

Voice Assessment

The therapist should ask the patient to speak and assess voice quality, pitch, and resonance. Any abnormalities may suggest vagus and glossopharyngeal nerve dysfunction.

Accessory Nerve (Cranial Nerve XI)

Trapezius muscle strength is the standard test for cranial nerve XI. Ask the patient to shrug their shoulders against resistance. The PT may also test sternocleidomastoid muscle strength by asking the patient to turn their head to one side against resistance.

Hypoglossal Nerve (Cranial Nerve XII)

Tongue movement can be assessed by asking the patient to stick out their tongue and move it from side to side. Observe for deviations, weakness, or fasciculations, which would indicate that cranial nerve XII was involved in the CVA.

Muscle Tone Tests [37,38]

After a cerebrovascular accident, individuals may experience changes in muscle tone. This can range from flaccidity (low muscle tone or weakness) to spasticity (increased muscle tone). Several tests may be conducted to determine what a patient's level of muscle tone is. Tone can prevent a joint from moving through its full range of motion. Angles for joint range of motion should be recorded through tone testing for documenting progress.

Modified Ashworth Scale

To conduct the Modified Ashworth Test, the evaluator moves the patient's limb passively through its available range of motion. During this movement, the evaluator should assess the resistance encountered. This is usually done at a moderate speed, neither too slow nor too fast. The score corresponds to the level of resistance felt during the test.

Scoring:

0: No increase in muscle tone (Normal)

1: Slight increase in muscle tone, manifested by a catch and release or minimal resistance at the end of the range of motion (Mild)

1+: Slight increase in muscle tone, manifested by a catch, followed by minimal resistance through the remainder of the range of motion (Mild to Moderate)

2: More marked increase in muscle tone through most of the range of motion, but the limb can still be easily moved (Moderate)

3: Considerable increase in muscle tone; passive movement is difficult (Severe)

4: Affected part(s) rigid in flexion or extension (Very Severe)

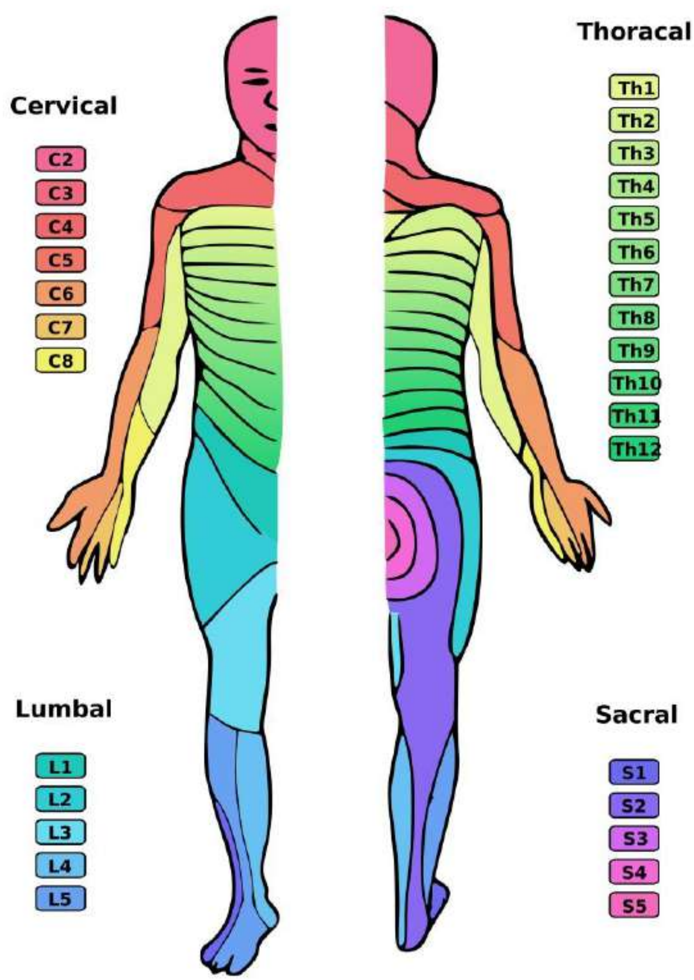
Tardieu Scale

The Tardieu Scale is a clinical assessment tool used to evaluate spasticity in individuals with neurological conditions, particularly those who have experienced stroke, traumatic brain injury, or other conditions affecting muscle tone. It provides a more comprehensive assessment of spasticity by considering both the dynamic and static components of muscle resistance.

It consists of two measurements: R1, the angle of muscle reaction where resistance is first felt during passive movement and R2, the angle at maximum resistance. The evaluator should move the patient's limb passively at a slow, then a fast velocity. They should measure R1 and R2 at both fast paces of movement. The measurement of R1 should be subtracted from R2 and this indicates the level of spasticity. A larger number equates to a higher degree of spasticity.

Sensory Examination [33]

A sensory examination provides valuable information about the integrity and function of the sensory pathways in the nervous system. This helps identify any deficits or abnormalities resulting from the stroke. Practitioners should investigate which dermatomes via the map below are impaired following CVA.



https://www.ncbi.nlm.nih.gov/books/NBK535401/figure/article-29335.image.f1/

Light Touch – Superficial Sensation

Using a cotton ball or soft brush, the physical therapist should assess the patient's ability to perceive light touch bilaterally in various areas of the body. The therapist should compare responses between affected and unaffected sides, while the patient's eyes are closed. Light touch information is carried through the dorsal column-medial lemniscal pathway in the spinal cord.

Pinprick Test – Pain Sensation

A PT should use a sterile safety pin to assess the patient's ability to perceive sharp or dull sensations. Apply gentle pressure in different areas, noting any alterations in sensation. This tests the integrity of the anterolateral spinothalamic tract (or just spinothalamic tract). This tract carries information related to temperature, pain, and pressure.

Temperature Discrimination

Using warm and cool objects, the PT should assess the patient's ability to differentiate between temperature sensations. This is done through the application of objects to the patient's skin and asks for feedback on warmth or coolness. This information is carried in the spinothalamic tract of the spinal cord.

Proprioception – Joint Position Sense

To complete this testing, the PT should passively move a joint (for example a finger or toe) and ask the patient to identify the direction of movement, with the patient's eyes closed. This assesses the patient's awareness of limb position. This information is carried in the dorsal column-medial lemniscal pathway.

Vibration Perception

To test for vibration sense, a PT should use a tuning fork to determine the patient's ability to perceive vibratory sensations. Apply the tuning fork to a bony prominence (for example the distal phalanx of a finger) and ask the patient to indicate when they no longer feel the vibration. This information is carried in the dorsal column-medial lemniscal pathway.

Two-Point Discrimination

Physical therapists should use a caliper or paperclip to assess the patient's ability to discriminate between two separate points of contact on the skin. They should test various areas, particularly in the hand. This information is carried in the dorsal column-medial lemniscal pathway.

Coordination Examination [39]

A coordination examination involves a series of movement challenges to evaluate a patient's ability to perform coordinated movements. Coordination is the harmonious interaction of muscles and joints in executing purposeful movements.

Observation of Gait and Posture

The first coordination element is simply a visual analysis of the patient's gait pattern, noting any abnormalities in stride length, step width, arm swing, and trunk posture. This assessment helps identify potential coordination deficits during ambulation.

Dysmetria Assessment

Finger-to-Nose Test

This test evaluates the patient's ability to perform accurate and coordinated movements. The therapist instructs the patient to touch their nose with the tip of their index finger, alternating between the dominant and non-dominant hands.

Any overshooting or undershooting of the target indicates potential dysmetria. A more refined version of this test is having the patient close their eyes for no visual feedback. Dysmetria is typically caused by cerebellar damage.

Finger-to-Finger Test

In this test, the patient is instructed to touch their nose, then extend their arm to touch the therapist's finger, and return to touch their nose again. The therapist observes for any dysmetria in the movement, which is a sign of impaired cerebellar function.

Rapid Alternating Movements (Dysdiadochokinesia)

Dysdiadochokinesia assesses the patient's rapid alternating movements. The patient is directed to quickly and sequentially pronate and supinate their hands and/or dorsiflex and plantarflex their ankles. The therapist observes for smoothness, speed, and accuracy of these movements. Dysdiadochokinesia is a symptom associated with cerebellar dysfunction. Having the patient close their eyes is a more refined version of this test because it eliminates visual feedback.

Heel-to-Shin Test

This test evaluates the coordination of the lower limbs. The patient is instructed to slide their heel along the shin of the opposite leg, from the knee down to the ankle, while maintaining contact with the shin. Any deviations from a straight path may suggest coordination deficits and cerebellar dysfunction.

Rapid Alternating Movements (RAM)

RAM assesses the patient's ability to perform quick, alternating movements. The patient is asked to rapidly tap their fingers on their thigh or perform rapid dorsiflexion and plantar flexion of the feet. The therapist observes the speed, regularity, and amplitude of these movements.

Observation of Intention Tremor

The therapist assesses for intention tremor, which is a fine tremor that occurs during voluntary, purposeful movements. This is particularly observed in tasks requiring precise endpoint accuracy.

Reflex Examination

A reflex examination after a stroke in physical therapy is crucial for assessing the integrity of reflexes and identifying any abnormalities or changes that may have occurred as a result of the stroke.

Deep Tendon Reflexes (DTR)

DTR tests assess the function of the stretch reflex, which involves the afferent/ sensory and efferent/motor pathways in the spinal cord.

To assess, the therapist uses a reflex hammer to tap specific tendons with cues for the patient to completely relax, eliciting a reflex response.

Biceps Reflex: Assesses the nerve roots of C5 and C6. The PT should tap the biceps tendon, located just above the elbow.

Triceps Reflex: Assesses the integrity of C7-C8 by tapping the triceps tendon, located just proximal to the olecranon process of the ulna.

Brachioradialis Reflex: Assesses the integrity of the C5-C6 nerve roots by tapping the brachioradialis tendon, located at the lateral aspect of the forearm.

Patellar Reflex: Assesses the integrity of the L2-L4 nerve roots by tapping the patellar tendon, just distal to the patella.

Achilles Reflex: Assesses the integrity of the S1-S2 nerve roots by tapping the Achilles tendon, just proximal to the calcaneus.

The therapist should observe the intensity and timing of the reflex responses. Altered reflexes could indicate changes in neural pathways due to the stroke. The scoring scale for DTRs is below.

Absent (0): No response is elicited, even with repeated stimulation.

Hypoactive (1+): A slight response is elicited, but it's diminished or weak compared to normal.

Normal (2+): The reflex response is within the normal range, indicating a healthy neurological function.

Hyperactive (3+): The reflex response is brisker or exaggerated than normal.

Very Hyperactive (4+): The reflex is significantly exaggerated and may cause clonus (repetitive, rhythmic muscle contractions).

Pathological Reflexes and Upper Motor Neuron Signs [40]

Pathological reflexes may indicate neurological dysfunction, including upper motor neuron pathology associated with CVA.

Common pathological reflexes include the Hoffman and Babinski test. **Hoffmann's Reflex** indicates an abnormality in the corticospinal tract, upper motor neuron dysfunction and hyperreflexia. To conduct the test, the physical therapist should flick or snap the terminal phalanx of the middle or index finger. A positive response involves flexion of the thumb and index finger. The **Babinski Sign** indicates an abnormality of the corticospinal tract and upper motor neurons. The test involves stroking the lateral sole of the foot. A positive response involves dorsiflexion and fanning of the toes. This reflex is normally integrated after infancy.

Clonus

A series of rhythmic, involuntary muscle contractions and relaxations. It's often elicited by rapid dorsiflexion of the ankle and wrist. The causes of clonus include dysfunction of upper motor neurons (caused by CVA), hyperreflexia, and spasticity.

Functional Mobility Assessment [41]

Functional mobility assessment is crucial for understanding the impact of the event on a patient's ability to move and perform everyday activities. Physical therapists should replicate every movement that the patient must do on a daily basis. This may include ambulation, transfers, sit to stands, bed mobility, stairs, and more. They should record the level of assistance required for each task.

Independent means that the patient is capable of completing a task physically and safely without supervision.

Supervision means the patient can complete a task physically but should be supervised for safety.

Stand By Assist means the therapist is right next to the patient with no contact, for safety.

Contact Guard Assist means the therapist maintains contact with the patient but does not assist physically.

Minimal Assist means the patient completed around 75 percent of the task and the therapist completed 25 percent.

Moderate Assist means the patient completed 50 to 74 percent of the task and the therapist completed 26 to 50 percent of the task.

Maximum Assist means the patient completed 25 to 49 percent of a task while the therapist completed 51 to 75 percent.

Dependent means the patient performed under 24 percent of the task while the therapist performed 76 to 100 percent of the task.

Gait Assessment [42]

After a stroke, individuals may exhibit various specific gait patterns, depending on the location and extent of the brain damage, as well as the resulting neurological deficits.

Hemiplegic Gait

This gait pattern is characterized by significant weakness or paralysis on one side of the body (hemiplegia). It often results in a circumducted gait, where the affected leg is swung outward in a semi-circular motion to clear the ground. Patients will display limited weight-bearing on the affected side, hip hiking on the unaffected side during swing phase, and foot drag or steppage gait on the affected side due to foot drop.

Spastic Gait

This gait pattern is characterized by increased muscle tone (spasticity), which leads to stiffness and resistance to movement. It can result in a stiff, jerky, and slow walking pattern. Individuals may display scissoring of the legs during walking due to excessive adductor muscle tone, an equinus foot position (toes pointed downward), and a tendency for toe walking.

Ataxic Gait

Ataxia is a lack of coordination, and this gait pattern is characterized by unsteady and jerky movements. It results from damage to the cerebellum or its connections. Features of this gait pattern are a wide-based stance, irregular, exaggerated, and imprecise movements, and difficulty with tandem (heel-to-toe) walking.

Propulsive Gait

This gait pattern is characterized by a forward-flexed posture, where the individual is inclined forward with a stooped position. It can result from increased muscle tone in the trunk and hip flexors. Features are a forward head and trunk posture, short, shuffling steps, and difficulty in initiating walking and stopping abruptly.

Cautious Gait

Individuals with this gait pattern exhibit an exaggerated, careful approach to walking. It may be due to fear of falling or a decreased sense of balance. Features are slow, deliberate steps, a tendency to look down at the ground, and the use of a wide base of support for stability.

Steppage Gait

This gait pattern is characterized by excessive hip and knee flexion during the swing phase. It is often seen in individuals with foot drop, where they may lift their leg higher to clear the ground. Features are a high stepping motion during swing phase and foot slap as the foot returns to the ground.

Range of Motion and Muscle Length Testing [33]

Range of motion testing is an important measure to understand the extent to which a joint can move in various directions. The therapist moves the patient's limb or joint through its natural range of motion while assessing for any restrictions, pain, or discomfort. The PT may feel increased muscle tone with this and should use one of the muscle tone scales in a prior section. Individuals with a history of CVA may experience spasticity (increased muscle tone) or contractures (permanent shortening of muscles or tendons). ROM testing helps identify and manage these issues.

Muscle length testing assesses the flexibility and extensibility of a specific muscle or muscle group. Many individuals develop contractures in muscles of the extremities as a result of CVA, which need physical therapy intervention to manage.

Muscle Strength Assessment [43]

A myotome refers to a group of muscles that are innervated by a specific segment of the spinal cord. Each myotome is associated with a particular spinal nerve, which carries motor signals from the spinal cord to the corresponding muscle group. Myotomes are assessed on a scale of 0 to 5, from weak to strong. Below are the grades and the test results assigned to each grade.

0: No muscle contraction or movement detected

1: Muscle contraction is present, but there is no movement at the joint

2: Movement occurs at the joint, but it is unable to move against gravity

3: The muscle can move against gravity, but not against any resistance applied by the examiner

4: The muscle can move against moderate resistance applied by the examiner

5: Normal muscle strength with the ability to move against strong resistance

The myotome chart below explains each nerve root and muscle action for testing purposes against the provider's manual resistance to each action.

Myotomes	
Nerve root(s)	Action
C1	*Upper cervical flexion*
C2	*Upper cervical extension*
C3	*Cervical lateral flexion*
C4	*Shoulder girdle elevation*
C5	*Shoulder abduction*
C6	*Elbow flexion*
C7	*Elbow extension*
C8	*Thumb extension*
T1	*Finger adduction*
L1 / L2	*Hip flexion*
L3	*Knee extension*
L4 / L5	*Ankle dorsiflexion*
L5	*Great toe extension*
S1	*Ankle plantar flexion*
S4	*Bladder and rectum motor supply*

https://twitter.com/realbrainbook/status/1232400662425735168

Physical Therapy Outcome Tests [44–47]

Outcome measures are crucial to capture a patient's functional status at evaluation, progress, and discharge assessments. Appropriate outcome measures for those recovering from stroke should involve functional status, balance, cardiovascular endurance, and functional strength.

Functional Independence Measure (FIM)

The FIM is a widely used assessment tool that evaluates a person's ability to perform basic activities of daily living (ADLs) and mobility tasks. It covers areas such as self-care (feeding, grooming), sphincter control, mobility (transfers, walking), locomotion, communication, and social cognition. Each task is scored on a scale from 1 (total assistance) to 7 (complete independence), providing an overall picture of the individual's functional status.

Berg Balance Scale (BBS)

The BBS assesses a person's ability to maintain balance during various static and dynamic activities. It includes tasks like sitting to standing, standing unsupported, turning to look behind, standing on one leg, and transferring. Each task is scored on a scale from 0 to 4, with higher scores indicating better balance control.

Timed Up and Go (TUG)

The TUG assesses a person's mobility and functional mobility by measuring the time taken to stand up from a chair, walk a short distance, turn, return, and sit back down. The time taken to complete the task is recorded, with longer times indicating potential mobility issues. A score above 14 seconds in older adults post stroke indicates a high fall risk.

Modified Rankin Scale (mRS)

The mRS is a scale used to assess overall disability and functional dependence after a stroke. Scoring ranges from 0 (no symptoms) to 6 (death), with each level indicating a different level of disability.

Six-Minute Walk Test (6MWT)

This test evaluates a person's walking capacity and endurance over a six-minute period. The patient walks as far as possible in six minutes, with rest breaks allowed if needed. They may use assistive devices if needed. The total distance covered is recorded. A normal score for elderly is around 390 to 575 meters ambulated.

Dynamic Gait Index (DGI)

The DGI assesses a person's ability to perform a variety of walking tasks that challenge balance and mobility. Tasks include walking at different speeds, changing direction, and performing head turns. Each task is scored on a scale from 0 to 3, with higher scores indicating better performance.

Section 3 Key Words

Modified Ashworth Scale – A measure used to quantify the level of spasticity in specific muscle groups after neurological insult

Clonus – A neurological sign characterized by a rhythmic, involuntary, and repetitive muscle contraction and relaxation, often occurring in response to a rapid stretch or movement of a limb

Ataxic Gait - Also known as cerebellar gait, it is a distinctive walking pattern characterized by unsteady, uncoordinated movements

Hemiplegic Gait - A specific walking pattern characterized by significant weakness or paralysis on one side of the body

Section 3 Summary

Conducting a thorough physical therapy assessment for a patient recovering from a cerebrovascular accident (CVA) encompasses an evaluation of multiple facets. This process aims to gain insights into the patient's unique challenges, functional boundaries, and rehabilitation requirements. Proceeding from a subjective history to a detailed examination involving various tests and outcome measures, monitoring vital signs, and gathering relevant information, this approach enables the formulation of an impactful plan of care. It's important to note that the specific examination process may vary based on the rehabilitation setting, as well as the patient's current acuity and medical background.

Physical Therapy Treatment and Plan of Care

Rehabilitation following a stroke is a critical phase in a survivor's journey towards recovery and regaining independence. Physical therapy plays a pivotal role in this process, employing a multidimensional approach to address the unique challenges individuals face post-stroke. A carefully tailored plan of care encompasses a range of therapeutic interventions, each designed to target specific deficits and optimize functional outcomes. By focusing on motor relearning, strength restoration, balance enhancement, and gait retraining, physical therapy aims not only to mitigate impairments but also to empower individuals to reclaim control over their lives.

Rehabilitation Timeline and Protocol [48,49]

The rehabilitation timeline after a cerebrovascular accident (CVA) can vary widely depending on several factors, including the type of stroke, the severity of the neurological deficits, the individual's overall health, and the effectiveness of rehabilitation efforts. This section will give an overview of expected rehabilitation timelines based on specificities of the CVA.

Ischemic Stroke

The most rapid neurological recovery occurs from the time of the CVA up to four months after the event. However, individuals may progress for up to two years before deficits are considered permanent.

Acute Phase (0-72 hours)

This phase focuses on stabilizing the patient, preventing complications like contractures, deep vein thrombosis and pneumonia, and initiating early mobility exercises. Early rehabilitation efforts, including range of motion exercises and bed mobility, can begin within hours of the stroke. If deemed safe by the leading physician due to stable vital signs and other factors, physical therapists should work on bed mobility, sitting at the edge of the bed, standing, and ambulating. This phase is nearly always in the acute care hospital.

Subacute Phase (1-6 weeks)

During this phase, intensive rehabilitation begins. Goals may include regaining motor function, relearning activities of daily living (ADLs), and addressing specific deficits. Depending on the severity, some individuals may transition to an inpatient rehabilitation facility, either a skilled nursing facility (SNF) or an acute inpatient rehabilitation facility. At acute inpatient rehab, the patient will receive three hours of therapy per day between occupational, physical, and speech therapy depending on the patient's needs. This phase occurs in either acute, subacute, home health, or outpatient rehabilitation.

After 72 hours and up to One Week

Therapy should focus on upper and lower extremity exercises to gain strength, balance, and prepare for transfers and ambulation. Therapists should progress the patient toward weight bearing activities as soon as it is safe, such as standing and supported ambulation.

Two Weeks to Six Weeks

Once a patient is able to progress to standing and ambulating with guarding, gait training, balance, and coordination training should be prioritized. This can include static and dynamic balance exercises, ambulation with assistive devices, and progressively challenging strength and coordination exercises.

Chronic Phase (Six Weeks and Beyond)

Rehabilitation continues in subacute, home health, and outpatient settings, focusing on further improvement in motor skills, mobility, and functional independence. Therapy intensity may decrease as the individual progresses. Goals of therapy are reintroduction to home and into the community at early in this stage. This stage may last up to years as the individual works on progressing to their highest level and occurs in outpatient or home therapy settings.

Hemorrhagic Stroke

Hemorrhagic stroke recovery timelines vary greatly on the severity of the bleed, its location, the individual's overall health, and the effectiveness of rehabilitation efforts. Generally, the protocol is similar to ischemic CVA, prioritizing progressing individuals to their highest level of independence.

Acute Phase (0-72 hours)

Similar to ischemic stroke, initial management focuses on stabilizing the patient. Rehabilitation may begin once the patient is medically stable. Early mobility should be the focus in the acute care setting, only at the level deemed safe by the physician and physical therapy team. PTs and PTAs should progressively work on bed mobility, extremity exercise for strength in functional mobility, sitting tolerance, and standing if tolerated. Patients will likely be in the acute hospital at this stage.

Subacute Phase (2-6 weeks)

Physical therapists should begin intensive rehabilitation efforts, targeting specific deficits. Individuals with hemorrhagic strokes may have longer hospital stays and more complex medical needs, potentially leading to a delayed start of rehabilitation. Rehabilitation should focus on highest level activity that is medically safe. This may include bed mobility, edge of bed sitting, standing, and ambulating with guarding from the therapist. Patients may be in the acute care hospital, subacute settings, home health, or outpatient rehabilitation at this point.

Chronic Phase (3+ months)

Continued rehabilitation in outpatient or home settings, with a focus on further functional improvement. This stage may last until the patient has reached their highest potential.

Cerebellar Stroke

Cerebellar stroke presents with coordination and balance deficits that affect one's safety in mobility after. The goal initially should be medical stabilization, followed by progressive rehabilitation to reach the highest functional level possible.

Acute Phase (0-72 hours)

The most crucial first step of rehabilitation is ensuring medical stability. The therapist should focus on ensuring the patient's vital signs are stable and addressing any immediate medical concerns. Then, the therapist should introduce gentle movements to prevent complications associated with immobility, such as bed mobility and seated and supine exercises. They should conduct a comprehensive neurological assessment to evaluate the extent of cerebellar dysfunction. This phase of rehabilitation will be in the acute care hospital.

Subacute Phase (1-8 weeks)

The therapist should introduce exercises to address impaired coordination and balance, gradually progressing in difficulty. They should initiate gait training, starting with basic stance and weight-shifting exercises. In addition, they should implement exercises to improve proprioception and sensory awareness. Over weeks, the therapist should incorporate more advanced coordination tasks, vestibular rehabilitation, strength training, endurance training, balance training, and mobility progressing towards daily tasks. These should be progressed towards the two-month mark to include dynamic balance exercises, advanced ambulation, and gait abnormalities if safe for the patient. This phase could take place in acute rehab, subacute rehab centers, home health, or outpatient.

Chronic Phase (8+ weeks)

In the chronic phase, therapy should continue with exercises and activities that simulate real-world scenarios to help the individual regain confidence in everyday tasks. It should focus on sustaining and enhancing the progress made during earlier phases and help the patient to reach their highest potential. This would likely be in the home health or outpatient settings.

Specific Interventions

Evidence for interventions beyond balance, coordination, strength, gait training, and others is emerging every day in the field of stroke rehabilitation.

Constraint-Induced Movement Therapy [50]

The unaffected limb (usually the arm and hand) is immobilized or constrained using a mitt, splint, or sling. This restriction forces the individual to rely on and actively use the affected limb for daily activities. The individual is encouraged and motivated to use the affected limb for a significant portion of their waking hours. This may involve specific therapeutic tasks and functional activities. CIMT is conducted in an intensive manner, often involving multiple hours of therapy each day for a set period (usually two to three weeks). The therapy includes repetitive practice of specific functional tasks that are gradually progressed in difficulty. This helps improve motor skills and coordination. Techniques and strategies learned during therapy are encouraged to be applied in real-life situations outside of therapy sessions. Evidence suggests improvements in muscle tone and increased functional use of the extremity after 24 sessions.

Virtual Reality [51]

Virtual reality (VR) stroke rehabilitation is an innovative approach to therapy that leverages advanced technology to aid in the recovery of individuals who have experienced a stroke. It uses immersive, computer-generated environments to engage and challenge patients in therapeutic exercises. Patients wear a VR headset that provides an immersive visual and auditory experience. Motion sensors track the movements of the head and sometimes the limbs, allowing for real-time interaction in the virtual environment. Specially designed software creates a virtual world in which patients can interact. The software can be programmed to simulate various activities and environments. Some VR systems come with handheld controllers or gloves that allow patients to manipulate objects or perform specific tasks within the virtual environment. VR allows for task specific training, enhances patient engagement, feedback, and provides a safe environment.

Complications [52]

Stroke rehabilitation can be accompanied by various complications. These complications can arise due to the complexity of the condition and the challenges individuals face during their rehabilitation journey.

Abnormal Vitals

Blood pressure management is a crucial aspect of stroke care, both during the acute phase and throughout the rehabilitation process. Uncontrolled hypertension can increase the risk of recurrent stroke or other cardiovascular complications. It may also worsen cerebral edema (swelling) and increase the risk of hemorrhagic transformation in ischemic stroke. It is crucial throughout every stage of rehabilitation to monitor blood pressure – especially with activity and exercises. Heart rate and respiratory rate should also be monitored. If vital signs are abnormal and accompanied by symptoms like dizziness, headache, or stroke symptoms (slurred speech, unilateral weakness, numbness), patients should be sent to the emergency department.

Spasticity and Contractures

Spasticity and contractures can impede movement and make it more difficult to perform exercises and activities of daily living. These are focuses of rehabilitation but can slow progression in gait training, transfer training, and achieving functional independence.

Pressure Sores (Decubitus Ulcers)

Prolonged immobility, especially in individuals with limited mobility after a CVA, can lead to pressure wounds on areas of the body where pressure is applied. This may occur anywhere with prolonged pressure, and typically on the buttocks, over the sacrum, and other bony prominences. Pressure sores can be painful, lead to infections, and hinder the rehabilitation process. It is crucial for staff and patients to be educated on weight shifting in seated positions and a turning schedule every two hours if patients are only in bed.

Shoulder Subluxation

Weakness and altered muscle tone in the shoulder region can lead to instability and partial dislocation (subluxation) of the shoulder joint. Shoulder subluxation can cause pain and limit the effectiveness of upper limb exercises and activities.

Depression and Emotional Issues

CVA survivors may experience depression, anxiety, and emotional challenges as they navigate the physical and psychological impact of the stroke. Emotional well-being is closely linked to physical recovery, and addressing mental health is an important aspect of rehabilitation. PTs and PTAs should refer to mental health professionals if their patients screen positive for depression or anxiety.

Pain and Discomfort

Pain, whether related to the CVA itself or secondary complications like muscle imbalances, can be a significant issue during rehabilitation. Pain can hinder participation in therapy and limit progress in exercises and functional activities.

Durable Medical Equipment [53]

Durable medical equipment (DME) is crucial to know and prescribe to patients for safety with mobility and activities of daily living. This section will explain the purpose and uses of orthotics, splints, assistive devices, and safety equipment.

Orthotics and Splints [54]

Orthotics and splints used after a stroke are designed to support and stabilize limbs affected by weakness, spasticity, or paralysis. These devices play a crucial role in stroke rehabilitation by promoting proper alignment, preventing contractures, and facilitating functional use of the affected limb.

Ankle-Foot Orthosis (AFO)

AFOs are often used to address foot drop, a common consequence of stroke, where individuals have difficulty with dorsiflexion during the swing phase of gait. They are custom-made or prefabricated braces that provide support to the ankle and foot, helping to control the position and movement of the affected limb. Physical therapists should recommend AFOs to patients who are at a fall risk due to foot drop. Many patients will continue to need the AFO long after the CVA.


https://www.orthomerica.com/products/fuzion/fuzion-afo/

Knee-Ankle-Foot Orthosis (KAFO)

KAFOs provide stability and support for the entire lower limb. They are used when there is weakness or instability in both the knee and ankle joints and muscles. This will be most pronounced in the quadriceps and the anterior tibial muscles. KAFOs are custom-made or prefabricated braces that extend from above the knee to the foot, providing support to the entire leg.

https://www.allardusa.com/products/kneeleg/rigid/combo-hyperextension-kafo-p34960

Hip-Knee-Ankle-Foot Orthosis (HKAFO)

HKAFOs provide even more stability than KAFOs by extending up to the hip. They are used for individuals with significant weakness or instability in the hip, knee, and ankle joints. This would be most common after an involved hemorrhagic or ischemic CVA that affects the motor cortex.

https://www.gulfmedicalequipment.com/orthotics-bracing/hkafo-hip-knee-ankle-foot-orthotic

Functional Electrical Stimulation (FES) Orthosis

FES devices use electrical stimulation to trigger muscle contractions, aiding in walking for individuals with weak or paralyzed muscles. They can be applied to various areas of the lower extremity, most commonly the anterior tibialis to help train the muscles out of foot drop.

Resting Hand Splint

Resting hand splints are designed to maintain the hand and wrist in a neutral position, preventing contractures and reducing spasticity. They are typically made of a lightweight material and may have adjustable straps for a customized fit. Dynamic hand splints assist with hand opening and closing by using a spring-loaded mechanism or elastic bands.

Wrist Cock-Up Splint

Wrist cock-up splints provide support to the wrist, keeping it in a neutral or slightly extended position. They help improve wrist stability and reduce the risk of contractures. These splints typically extend from the palm to just below the wrist joint.

Elbow Extension Splint

Elbow extension splints are used to prevent elbow flexion contractures by maintaining the arm in an extended position. They cover the back of the forearm and extend over the elbow joint. Dynamic elbow extension springs use springs to actively extend the elbow during movement.

Shoulder Abduction Sling

This type of sling supports the shoulder and helps maintain abduction (away from the body) after stroke to prevent shoulder subluxation. It wraps around the shoulder and may have adjustable straps to control the degree of abduction.

Assistive Devices [55]

Physical therapists and assistants need to recommend and train patients on the least restrictive assistive device. This means a goal of rehabilitation should always be working on improving the ease of mobility, for example transitioning from a walker to a cane.

Wheelchair

A wheelchair is a mobility aid with wheels that serves as a substitute for ambulation in cases where it is needed for safety. It can be manual, self-propelled by the user or pushed by a caregiver, or a power wheelchair/scooter. The choice between a manual or powered wheelchair depends on factors such as upper body strength, coordination, and the individual's ability to self-propel. Powered wheelchairs should be recommended only for patients who cannot self-propel, because it is considered the most restrictive AD, requiring no physical effort by the patient.

Patients who need wheelchairs for any extent of time should be fit properly for their chair to prevent skin breakdown and pressure wounds. Seat cushions that improve the fit of the chair and reduce pressure on the buttocks are always recommended. The cushion should fit the width of the person's hips without overhanging, the patient should have a neutral pelvis, and the cushion should have pressure relief technology (foam density, gel inserts, air-cell technology).

Walker

A walker is a stable device with four legs that provides support and stability for individuals with balance or coordination deficits. It helps distribute weight evenly and provides a wider base of support. Therapists should recommend a standard walker for more stability, a two wheeled walker for moderate stability, and a four wheeled walker for ease of mobility if they are able to use the brakes and seat properly. Patients may need a walker in early rehabilitation or for long term use depending on how the CVA affected their lower extremities and balance.

Platform walkers are helpful for those with upper extremity weakness or poor coordination as a result of CVA. This allows increased proximal stability by using pressure through the forearm recruiting muscles of the shoulder rather than the wrist and hand.

https://www.mymedicalhouse.com/products/platform-walker-attachment

Cane or Quad Cane

Canes are single-pointed devices that help with balance and stability during walking. A quad cane has a broader base with four points, offering additional stability. The cane should be held in the opposite upper extremity as the weak or uncoordinated lower extremity. Canes are typically used for mild to moderate balance or weight-bearing issues. Quad canes provide more stability than standard canes but can be difficult to manage with four points.

Hoyer Lift

Hoyer lifts are used for transferring individuals with limited mobility from one surface to another, such as from a bed to a wheelchair or a shower chair. This is only for patients with significant safety concerns for the patient and staff.

Sit to Stand Lift/Stand Assist Lifts

Sit to stand lifts are a progression more difficult than dependent lifts for standing and transferring to a chair or toilet. They should be used for patients with difficulty with lower or upper extremity strength, poor endurance, and high fall risk. They may be used as part of treatment sessions to work on standing tolerance and lower extremity strength and control.

Bathroom Safety Equipment

Occupational therapy colleagues typically recommend equipment for activities of daily living once patients transition home, but PTs should be well versed in initiating that process if there are safety concerns. Shower chairs and benches provide a safe and stable seat in the shower, allowing the individual to sit while bathing. Raised toilet seats or toilet safety frames allow increased independence and safety. Grab bars should be installed on bathroom walls to offer support and stability when standing, sitting, or maneuvering in the bathroom.

Bed Rails

Bed rails are safety devices that can help prevent falls while in bed and provide support when getting in or out of bed. They are adjustable and should be properly fitted to the bed to ensure safety. These should be recommended in acute care, subacute care, and home health settings if they optimize the patient's independence and are needed for safety.

Section 4 Key Words

Acute Stroke Rehabilitation – Rehabilitation efforts within 72 hours or three days after the CVA occurred

Subacute Stroke Rehabilitation – Rehabilitation efforts from three days to six weeks after the CVA occurred

Chronic Stroke Rehabilitation – Rehabilitation efforts from six weeks to years after the CVA occurred

Functional Electrical Stimulation (FES) – The application of electrical stimulation to targeted muscles to facilitate controlled muscle contractions and movement

Section 4 Summary

This section detailed intervention strategies, rehabilitation timelines and protocols, special considerations, complications, possible DME, and setting specific rehabilitation considerations. Physical therapists and assistants should realize that each patient post CVA will present with a unique presentation of deficits and need an individualized rehabilitation program to reach their highest potential.

Case Study 1

John is a 58-year-old male who was admitted to the hospital following sudden onset right-sided weakness and difficulty speaking. Imaging confirmed an ischemic stroke affecting the left MCA. He was stabilized and referred for physical therapy to address his functional deficits. He had the CVA 24 hours prior to the physical therapy evaluation. His vitals upon entering the hospital room are 140/90 mmHG for blood pressure, 80 beats per minute for heart rate, and 96% for oxygen saturation. He is alert and oriented to name and place.

Reflection Questions

1. What examination items should the physical therapist focus on for the initial visit?
2. Based on the location of the CVA, what deficits might the physical therapist find in the examination?
3. What should the focus of the first three days of rehabilitation in the acute care setting be?

Responses

1. The physical therapist should determine whether vitals have been stable, and the patient is safe for mobility. If so, they should test the patient's functional mobility for bed mobility, sitting at the edge of the bed, and standing if safe. They should test myotomal strength of the upper and lower extremities, deep tendon reflexes, sensation, range of motion, and screen for muscle tone. Once safe for ambulation based on vitals and medical treatment, the PT should evaluate gait and balance.

2. The PT may find right hemiparesis, right sided sensory deficits, aphasia, and poor coordination on the right side of the body.
3. The focus should be progressing safe mobility within stable vital ranges. This includes contracture management, pressure wound prevention, functional mobility training, and activity tolerance training.

Case Study 2

Mary is a 68-year-old female who presented to an outpatient physical therapy clinic with the goal of improving her mobility and functional independence following a hemorrhagic stroke she experienced nearly a year ago. The stroke affected the right basal ganglia and Mary has a history of hypertension, hyperlipidemia, and type 2 diabetes mellitus. Mary reports she has continued weakness on the left, imbalance, and difficulty with cooking and cleaning due to poor coordination. Her blood pressure is 135/80, her heart rate is 78, and SpO2 level is 97% when checked at the time of examination.

Reflection Questions

1. Given Mary's deficits, what other examination items might the physical therapist include to optimize patient safety and outcomes?
2. How should the physical therapist respond if Mary develops lightheadedness during testing?
3. If Mary ambulates with a wide base of support, reduced weight bearing on the right, scores 17 seconds on a TUG, and reports no falls at home, what immediate intervention should the PT provide?

Responses

1. The therapist should screen for fall risk using a scale like the Dynamic Gait Index or Timed Up and Go. They should inquire about the use of assistive devices for safe ambulation and recommend one immediately if needed. They should assess functional mobility, gait, reflexes, sensation, and proprioception to understand Mary's baseline. Vitals should be monitored throughout.

2. The PT should immediately screen all vitals and assess for abnormality. Mary also has Type 2 diabetes mellitus, so blood glucose levels should be checked as well. The PT should screen for Mary's ability to manage her blood glucose consistently as well.

3. These factors indicate an elevated risk for a fall, even if it has not happened yet. The PT should assess for stability and safety with assistive devices. A four wheeled walker with brakes or a single point cane could be good choices, but they should be evaluated in the clinic before recommending for household and community ambulation.

Conclusion

Approximately 800,000 individuals in the United States experience a CVA annually. As explored in this course, CVAs can result in a wide array of physical, cognitive, and emotional hurdles for those impacted. Immediate physical therapy is crucial in the recovery process, which should persist until survivors attain their highest functional potential. Physical therapy plays a pivotal role in aiding stroke survivors in reclaiming their autonomy, mobility, and overall quality of life. This course explored CVA types, clinical manifestations, prevalence, anatomical considerations, pertinent assessment tools, rehabilitation strategies, and illustrative case studies. Physical therapists and physical therapist assistants should be well-equipped to provide patient-centered, evidence-based care for individuals undergoing CVA rehabilitation.

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