Neurological Emergencies

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INTRODUCTION

The human nervous system can operate and regulate bodily functions in a voluntary and involuntary manner. It can also sense, perceive, think and feel. Information from throughout the body is constantly being received, processed, and acted upon by the brain and nervous system.

The brain and nervous system are responsible for memory, feelings, senses, intuition, intellect, movement, and organ function. Visual, tactile, olfactory, auditory, and gustatory senses all go to the brain. Personality, memory, intellect and the essence of one's being all stem from the inner-workings of this mass of neural tissue.

The human nervous system is made up of a network of sensory input and muscle output pathways which communicate via miles of nerves interconnected to not only each other, but also to the spinal cord and, ultimately, to the brain. These pathways send messages through nerves using chemical neurotransmitters. The nervous system's input is typically sensory and its output is typically neuromuscular (movement). It is the brain's job to handle and interpret all of these sensory inputs and to coordinate outputs through the nervous system – telling your legs to move away from danger, tasting and enjoying a sugary dessert, or seeing something sad and eliciting an emotional response.

Many bodily functions are regulated by the brain. The body's hormones are produced, regulated, and monitored by the brain. Vital cardiac, circulatory, and respiratory functions are also monitored and regulated by the brain.

With such a complex system there are many things that can go wrong. Incredibly sophisticated and not fully understood, the human brain and nervous system will be examined in this course, with a focus on some of the more common anomalies that can occur with this system.

ANATOMY & PHYSIOLOGY OF THE NERVOUS SYSTEM

Anatomically, the nervous system is broken down into two main sections:

- The central nervous system (CNS) comprised of the brain and spinal cord.
- The peripheral nervous system (PNS) comprised of the ends of nerves that reach from the CNS into the organs of the body.

Central Nervous System

Brain

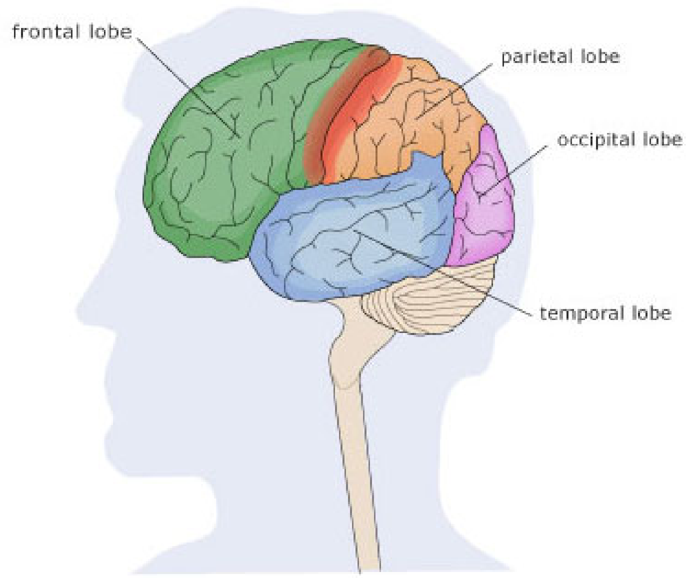
The brain is a highly specialized organ in the body. It is richly supplied with blood and demands a constant supply of both oxygen and glucose. When a patient is deprived of oxygenated blood or glucose altered mental status or loss of consciousness rapidly ensues.

The brain is typically divided into three regions:

- cerebrum
- cerebellum
- brain stem

Cerebrum

The cerebrum is the largest region of the brain. It is here that most of the brain's higher intellectual functions reside. This region of the brain creates and controls conscious thought, memory, personality, speech, motor function, visual perception and tactile impulses.



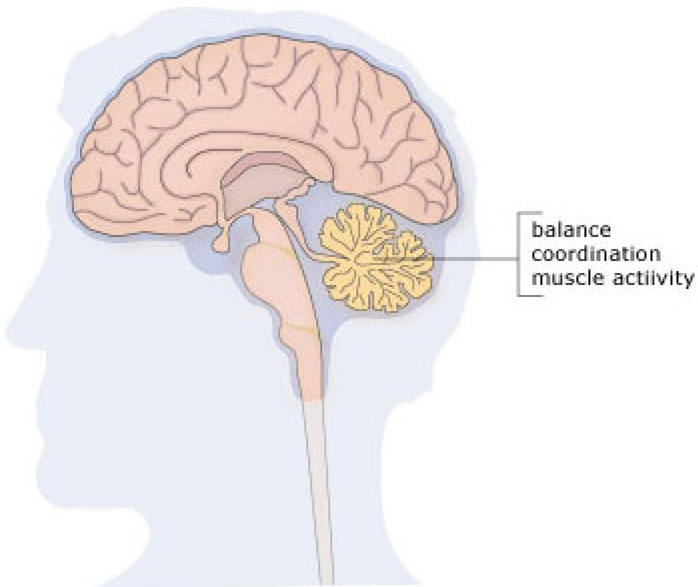
The cerebrum is split into two hemispheres. The left hemisphere was historically thought to contain the language centers of the brain. However, research has shown that language has assets in both hemispheres – some parts of speech and other nuances of language are thought to occur in the right hemisphere.

When a person has a stroke or brain injury, the area of injury can often be determined by the patient's presentation, for example whether one side is affected more than the other or whether speech is affected.

The brain is a remarkably resilient organ. Over time, a person with a stroke or brain injury can learn to use undamaged parts of the brain to take over some tasks of the part of the brain that is no longer functioning.

Cerebellum

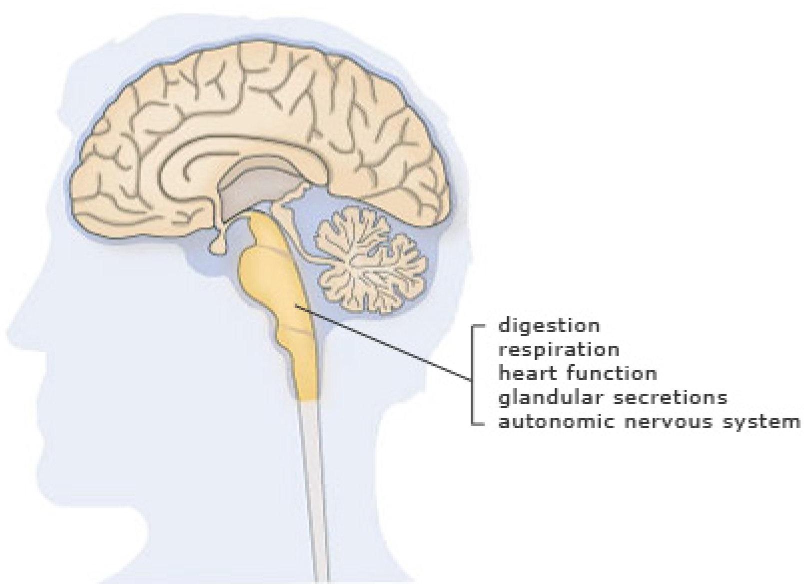
Coordination of body movement is controlled by the cerebellum (Latin: Little Brain). The cerebellum is located below and behind the cerebrum in the base of the skull. Its primary function is to coordinate muscle activity and balance through impulses it receives from the eyes, ears and balance input from the body.



A person with a stroke in this part of the brain may become uncoordinated and have vertigo, while having no deficits in other functions.

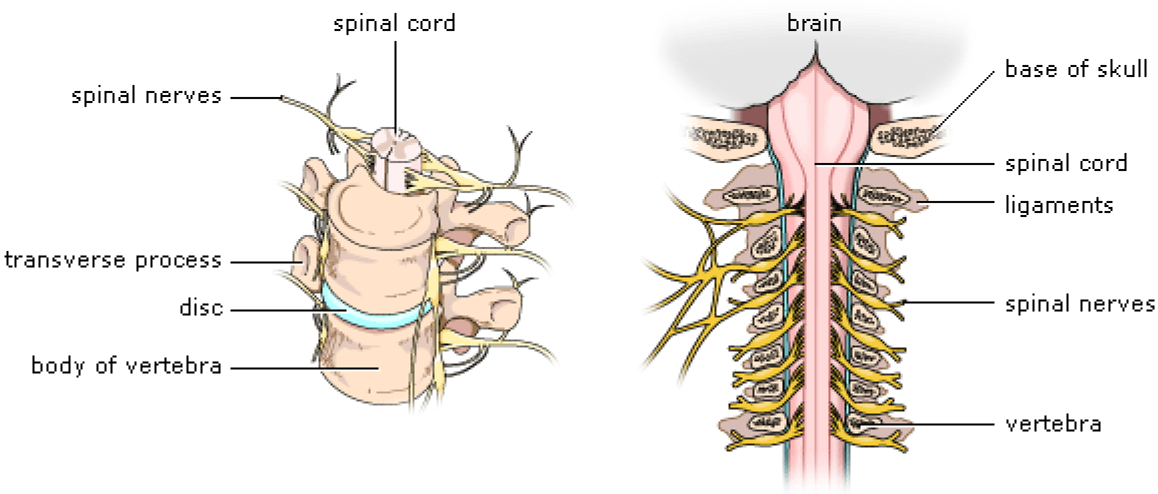
Brain Stem

Moving lower down toward the bottom of the brain, the brainstem controls the most primitive functions vital to survival. These include respiratory and cardiac functions, digestion, glandular secretions and the autonomic nervous system. It connects the brain to the spinal cord, passing through a hole in the base of the skull called the foramen magnum.



When a person has suffered trauma to the brain, bleeding can cause swelling of the brain inside the closed box of the skull. Increased intracranial pressure can force the lower brain structures through the foramen magnum. This is called herniation and is usually neurologically devastating. A patient who is herniating typically presents deeply unconscious with high blood pressure, often a low heart rate, and irregular breathing patterns.

Spinal Cord



The spinal cord extends downward as a continuation of the brain stem. It is encased in and protected by the bony vertebral column. The spinal cord itself is made up of thousands of nerve fibers, some of the longest cells in the body, extending downward from the brain.

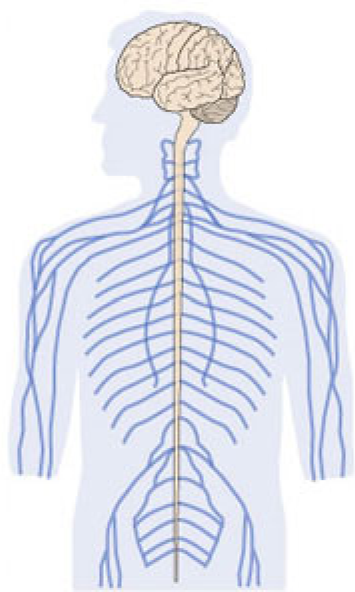
Sensory nerves carry messages from sensory receptors back to the brain. An example would be petting a kitten; the sensation that you feel travels from your hand back to your brain to allow you to interpret that signal as “soft.”

Motor nerves carry messages from the brain to your muscles. In this case, a motor neuron allows you to pet the kitten.

Messages that travel from the sensory neurons to the brain, the motor neurons, and then to your muscles, as in the example above, may take too long to allow you to react to some types of danger. The body also has a system to allow a much faster reaction time, called a spinal reflex arc. When you touch something hot, you have probably experienced the sensation of yanking your hand away without thinking about it. This rapid response occurs because you have sensory neurons that terminate in the spinal cord, not in the brain. These sensory neurons transmit their impulses to motor neurons, also in the spinal cord. In this way, the brain is “bypassed” allowing for a much faster response to something potentially dangerous. When the doctor taps on your knee, he is testing your reflex arc.

PERIPHERAL NERVOUS SYSTEM

The peripheral nervous system consists of the long fibers of nerve cells that extend outward from the spinal column. The peripheral nervous system connects the muscles and organs to the central nervous system.



The peripheral nervous system is broken down into two parts

- Somatic (voluntary), responsible for responding to the environment by relaying sensation to the brain and then responding, usually by stimulating muscle contraction.
- Autonomic (involuntary) system, responsible for the functioning of organs in response to environmental stimuli

Somatic (voluntary) Nervous System

The somatic (voluntary) nervous system includes a variety of different nerves:

- Spinal nerves, which carry sensory information into, and motor commands out of, the spinal cord
- Cranial nerves are responsible for the specialized functions of;
    - sight,
    - smell,
    - taste,
    - movements of the tongue
    - Other nerves (sometimes called “association nerves”) that help integrate sensory input and motor response

Autonomic (involuntary) Nervous System

The autonomic (involuntary) nervous system includes those aspects of our body's responses that are mostly outside our conscious control. These include heart rate, respiratory rate, digestion, pupillary responses, and others.

There are two main branches of the autonomic nervous system:

- the sympathetic nervous system
- the parasympathetic nervous system

Sympathetic Nervous System

The sympathetic nervous system is also known as the "fight or flight" response – your body's reaction to a threat. If you find yourself in a dangerous or stimulating situation, your body must engage or prepare to flee. When this portion of the nervous system is activated, the heart rate increases, pupils dilate to let in more light, blood flow gets diverted to muscles, stored glucose is released for quick energy, and many other responses occur. You may have noticed this system being activated when you are engaged in strenuous exercise or when you are frightened. These responses are mediated through nerves that release specific chemicals – neurotransmitters – that bind to receptors on each organ, causing the desired response.

Parasympathetic Nervous System

The parasympathetic nervous system acts through a similar mechanism – neurotransmitters released by nerves – but when this system is activated, the opposite response occurs. The parasympathetic nervous system slows down the heart and respiratory rate, and diverts blood from muscles to the GI tract for digestion.

PATIENT ASSESSMENT FOR NEUROLOGIC EMERGENCIES

Patient History

A key part of the BLS assessment is a thorough medical history. A good medical history is often a primary component in the determination of the patient's diagnosis.

During the questioning process, inquire if the patient has previously experienced any history of neurological problems or conditions. Also ask if there have been any significant events that had previously taken place that may have led up to this event.

In a patient exhibiting an altered mental status, certain medical conditions like atrial fibrillation or chronic pain might give you a hint as to the cause of the patient's altered state. For example, atrial fibrillation can cause small clots to form in the heart and travel to the brain causing an ischemic stroke.

A patient with chronic pain may have accidentally overdosed on his or her pain medicines causing altered mental status. Hydrocodone, Hydromorphone (Dilaudid), Methadone, Demerol, Oxycodone and OxyContin are common pain medicines which, in high doses, could lead to somnolence or even unconsciousness.

The patient's medicines may also provide hints. For example, patients who take anti-clotting medications, such as Plavix, Xarelto, Coumadin (warfarin), and Pradaxa put the patient at risk of bleeding everywhere, but particularly in and around the brain.

Your patient assessment ends with a repeat set of vital signs and reevaluating the patient's ABC's, Level of Consciousness, GCS score, and your Sick / Not Sick impression. At this point, you can reconsider whether ALS is necessary.

Secondary Assessment

Performing a basic physical exam is critical in all patient management, but especially so in patients with neurologic symptoms, as these symptoms can sometimes change and worsen over time.

A good physical exam for a neuro patient can start with a determination of the patient's level of consciousness and comparison of this to the patient's baseline. It is also important to obtain a set of vital signs to establish a baseline. If the patient's level of consciousness is altered, look for clues such as slurred speech or stroke signs, trauma, medic alert tags, signs of hypoxia, drug use or diabetes. Blood glucometry and pulse oximetry are tools to help assess the cause of altered mental status.

Neurological Assessment Scales

A patient exhibiting altered mental status can have a wide variety of presentations. The patient's ability to articulate may be altered – from confused or garbled speech to unintelligible words or no speech whatsoever. The patient's level of consciousness could range from alert to unconscious. Their gaze might be normal, favoring a particular direction, or their eyes may not open spontaneously whatsoever.

Because there are so many different presentations of altered mental status, it is important to consistently document the way that the patient is presenting. This is done through a variety of different neurological assessment scales.

AVPU

AVPU Evaluation	
A:	Awake and alert
V:	Responsive to verbal stimuli
P:	Responsive only to pain
U:	Unresponsive

If the patient is (A) awake and alert, the health care provider can evaluate level of orientation by asking a patient four questions:

Person: "What is your name?"

Place: "Do you know where you are?"

Time: “Do you know what month and year it is? [and approximate date]”

Event: “Do you know what happened to you?”

These questions test long-term memory (name), intermediate memory (place, time), and short-term memory (event). A patient may be described as being completely alert and oriented, or partially oriented, perhaps to person and place but not time and event.

Glasgow Coma Scale

The Glasgow coma scale (GCS) provides additional and more detailed information about a patient’s mental status. The GCS is a neurologic scale that aims to give an objective measure of level of consciousness. The GCS assesses three components of a patient’s level of consciousness: eye opening, best verbal response, and best motor response. A chart scores each level of response.

Glasgow Coma Scale for Adults

Eye opening	Scale	Best Verbal	Scale	Best Motor	Scale
Spontaneous	4	Oriented conversation	5	Obeys commands	6
Response to speech	3	Confused conversation	4	Localizes pain	5
Response to pain	2	Inappropriate words	3	Withdraws from pain	4
None	1	Incomprehensible sounds	2	Abnormal flexion	3
		None	1	Abnormal extension	2
				None	1

Mostly the GCS will be presented as the sum of the individual scores. However sometimes it is helpful to write each component separately. For example, a person with no neurologic deficits would be scored E4, V5, M6 for a total score of 15.

Infants and young children may not understand your requests and may be unable to respond verbally. The GCS must be modified for infants and children.

Glasgow Coma Scale for Infants

Eye opening	Scale	Best Verbal	Scale	Best Motor	Scale
Spontaneous	4	Coos, babbles	5	Normal spontaneous movement	6
Response to speech	3	Irritable cry	4	Localizes pain	5
Response to pain	2	Cries to pain	3	Withdraws from pain	4
None	1	Moans to pain	2	Abnormal flexion	3
		None	1	Abnormal extension	2
				None	1

Glasgow Coma Scale for Children

Eye opening	Scale	Best Verbal	Scale	Best Motor	Scale
Spontaneous	4	Oriented conversation	5	Obeys commands	6
Response to speech	3	Confused conversation	4	Localizes pain	5
Response to pain	2	Cries, inappropriate words	3	Withdraws from pain	4
None	1	Incomprehensible words/ sounds	2	Abnormal flexion	3
		None	1	Abnormal extension	2
				None	1

FAST Exam

An important part of the physical exam for a stroke patient is testing neurological function with the FAST Exam. FAST is based on the Cincinnati Prehospital Stroke Scale and focuses on three symptoms with the addition of time: facial droop (F), arm drift (A), speech problems (S) and (T) time when the patient was last known well (LKW). It is accurate in identifying patients with stroke. The results of this test will be used in further diagnosis and treatment at a hospital. An abnormal finding in any of the three tests strongly suggests a stroke.

FAST Exam

F (Face drooping) – Does one side of the face droop or is it numb? Ask the person to smile. Is the person's smile uneven?

A (Arm weakness) - Is one arm weak or numb? Ask the person to raise both arms. Does one arm drift downward?

S (Speech difficulty) – Is speech slurred? Is the person unable to speak or hard to understand? Ask the person to repeat a simple sentence, like "The sky is blue." Is the sentence repeated correctly?

T (Time last known well) – Document the time that the patient was last known to be normal.

Additionally, you may check both hands for equal grip strength and check if the individual can push with both feet equally.

Identify a contact person (family member, spouse, care giver, etc.) who has the best information about the onset of the stroke, as well as knowledge of the medical history or any medications the patient may be taking. If possible have this person accompany the patient to the hospital. If this person does not accompany the patient you must write their name and phone number on the incident report so hospital staff can contact this person. Key information the hospital will need, in addition to the last known well, includes medications (particularly anticoagulants) and a history of recent surgery, trauma, brain cancer, or bleeding disorder.

The Los Angeles Motor Scale (LAMS)

Like the FAST exam, the LAMS scale evaluates patients with a possible stroke using a simple screening exam that only takes 20-30 seconds to perform. The LAMS scale is unique among stroke evaluation tools in that it not only permits prehospital healthcare providers to accurately identify stroke patients in the prehospital setting, it also affords the ability to judge stroke severity. This permits prehospital responders to identify patients with more severe (large vessel) strokes so that they can direct them to a stroke center that has emergency capability to restore blood flow to the brain using either thrombolytic drugs (tPA) or by using a catheter intervention, similar to the treatment of STEMI.

Using the LAMS, each side of the body is scored independently based on the presence of facial strength (normal or droop), arm strength (normal, drifts down slowly, or falls rapidly after being raised to chest level), and grip strength (normal, weak, no grip).

This scale yields a total score from 0 (least affected) to 5 (most affected) in patients in whom stroke affects only one side of the body, and from 0 (least affected) to 10 (most affected) when a stroke affects both sides of the body.

Los Angeles Motor Scale (LAMS)

Facial droop	Scale	Arm drift	Scale	Grip Strength	Scale
Absent	0	Absent	0	Normal	0
Present	1	Drifts down	1	Weak grip	1
		Falls rapidly	2	No grip	2

Pupils

Patient assessment should also include a check of a patient’s pupils. Size and reactivity of pupils can reflect neurologic status or individual variation. For example, patients with a hemorrhagic stroke or head injury who are experiencing increased intracranial pressure may exhibit unequal pupil sizes (anisocoria). This is often a late and dire sign of a head bleed, so do not confuse it with the surprisingly large number of people in the world (as many as 20%) who have normal variations in pupil size with no associated pathology. Occasionally, local trauma to the eye can also cause a dilated pupil on one side. The patient with a head bleed or catastrophic head injury with unequal pupils will generally be obtunded and/or have other SICK presentations (e.g., irregular breathing, abnormal vital signs). If your patient is conscious, ask them if they have ever been told that they have unequal pupils – this may help you avoid going down a misleading treatment path.

Pupils			**Potential Conditions**
Size	**Symmetry**	**Reactivity**	
Dilated	Equal	Reactive	▪ Hypoxia ▪ Alcohol ▪ Stimulants (cocaine, meth)
Dilated	Equal	Unreactive	▪ Anoxia ▪ Profound alcohol intoxication ▪ Seizures ▪ Drugs (psychedelics, LSD)
Dilated	Unequal	Unreactive	▪ Stroke ▪ Head injury
Constricted	Equal	Unreactive	▪ Opiates ▪ Barbiturates ▪ Brainstem injury

Vital Signs

A patient with a neurologic emergency can deteriorate quickly. Often a change in vital signs will be the first clue. For example, a patient with rapidly increasing intracranial pressure due to head trauma or a hemorrhagic stroke will often show Cushing's Response (also known as “Cushing's Triad”). As pressure in the brain increases, the body increases blood pressure to try to perfuse the brain; this results in a decreased heart rate, and there is also often irregular breathing. These patients have a very high morbidity and mortality rate.

In addition to documenting the vital sign number, note any other qualities. For example, a respiratory rate of 16 could be normal, but if the respiratory pattern is agonal or irregular, it is also important to note that.

TREATMENT FOR NEUROLOGIC EMERGENCIES

ABCs

In general, the best treatment for the neurologically impaired patient is assessing and managing the ABCs, assessing and treating hypoperfusion or signs of shock, determining whether the patient requires an ALS or BLS level of care, and (if ALS is not needed) providing rapid transport.

The treatment of a neurologically impaired patient is very much patient-centered. A patient's altered mental status may result from a variety of causes ranging from low blood sugar to stroke. Your treatment approach will depend somewhat on the cause of the patient's signs and symptoms; a confused patient with low blood sugar is given sugar, whereas a confused patient with a possible stroke should be transported as soon as possible.

Oxygen

Hypoxic patients and patients who show signs of hypo-perfusion may need high flow oxygen. But gone are the days of giving all patients high flow oxygen. In fact, studies show that patients experiencing ischemic strokes who have a pulse oximetry reading of >95% not only do not benefit from high-flow oxygen, but they may actually suffer from it. Refer to your agencies guidelines or protocols on the use of oxygen

EMTs evaluating patients whose altered mental status is due to drugs or alcohol should make sure to closely monitor the patient's ABC's. The brainstems of these patients have impaired ability to sense and react to states of hypoventilation. These patients are also prone to vomiting and aspiration.

Transport and Destination

Not all emergency rooms are appropriate destinations for patients with neurologic emergencies. For example, stroke patients (hemorrhagic as well as ischemic) will generally require a CT scan or MRI, and if a bleed is found, neurosurgical intervention may be required. Even the administration of anti-coagulant cannot be done at all hospitals.

Most neurologic emergencies associated with trauma, unless they are minor, should be transported to a designated trauma center.

Become familiar with the capabilities of your local hospitals for managing patients with neurologic emergencies, whether it is trauma, neurosurgery, or stroke care.

SPECIAL CONSIDERATIONS

Pediatric Patients

Altered mental status in children can result from the same causes as adults. However some conditions are more common in children than adults, and vice versa. Strokes are uncommon in pediatric patients, whereas infection is a common cause of altered mental status, particularly in babies.

Understanding a child's baseline mental status is critical for evaluating any mental status changes. This is important for children, and especially so for children with medical complexity who may be developmentally delayed. A parent or caregiver can relay information on baseline mental status so you can better determine if there are any significant changes.

A modified Glasgow Coma Scale is used for infants and small children.

Among the more common neurologic emergencies in pediatric patients are seizures. Be aware that infants and young children may have a more subtle presentation of seizures than an adult with a grand mal seizure. An infant may make sucking motions, have roving eye movements, or have repeated "bicycling" motions of the arms or legs. In a child with a history of seizures, ask the parents what the child's normal seizure is like.

A common cause of seizures in a child between the ages of 6 months and 6 years is fever. Febrile seizures are usually tonic-clonic seizures that are short-lived and have a short post-ictal phase. They usually do not predispose the child to seizures as an adult, though the child may have more febrile seizures. Treatment is to cool with tepid (not cold) water.

An uncommon but very serious cause of altered mental status in a child is meningitis. This infection of the meninges may be caused by a virus, bacteria, fungus, or other pathogen. An infant may present with fever and increased irritability. A child may complain of headache, photophobia, and a sore or stiff neck. Rarely, in addition to these symptoms, you may see a child (or a teenager or an adult) with an unusual rash consisting of tiny, pinpoint-sized red dots, sometimes merging into splotches of purple or black. This may be an infection caused by the bacteria Neisseria meningitides; this is a life-threatening infection. Often by the time the patient is seen by EMS, he or she may have altered mental status, hypotension, and shock. ABCs and ALS care are important, but definitive care (antibiotics and supportive care) happens in the hospital; early recognition and transport provide the best chance for survival. Be aware, if you suspect meningitis, that some types of meningitis can be transmitted through droplets to other care providers. Wear your PPE including a mask, and follow-up with the hospital.

When evaluating a child with altered mental status with an unknown cause, consider the possibility of abuse. While a rare event, as an EMT on scene in the patient's home or other environment, you are in a unique position of observing things that cannot be seen by the hospital staff. In some cases, there may be no physical evidence of trauma. As an example, abusive head trauma (previously known as shaken baby syndrome) occurs when a baby is shaken violently. A baby's neck muscles are not strong enough to support the baby's head and as the baby is shaken back and forth, blood vessels can be torn and brain damage can occur. If you suspect abuse or neglect, notify the appropriate authorities and document your findings carefully.

Head trauma in pediatric patients is common, because children have proportionately bigger heads than adults. In terms of presentation, most of the signs and symptoms are similar, except that children are more prone to nausea and vomiting than adults.

Treatment of a child with a neurologic emergency is similar to an adult, but has special challenges. In the case of an accident with a possible head or spine injury, for example, a child may not understand the need for a c-collar and backboard. Explain everything you are doing, and engage the parents to keep the child as relaxed as possible if this restraint is needed.

Children are often transported to specialty pediatric hospitals. Again, be familiar with the capabilities of the hospitals in your area. In some cases of pediatric trauma, for example, a trauma center is the destination of choice rather than a pediatric hospital.

Geriatric Patients

Altered mental status in geriatric patients can be complicated by not knowing the patient's baseline functioning and level of awareness. Family or friends can often provide this information; if the patient is in a nursing home or care facility, ask the staff or caregivers. This is critical information to pass on to the hospital, so that they can evaluate any new symptoms in the context of the patient's baseline functioning.

Two similar concepts are worth contrasting. Dementia is a slow onset of progressive neurologic decline that occurs over a period of years. Patients with dementia range from being forgetful to being in a vegetative state. Delirium is a change in mental status that occurs relatively quickly, over a period of hours to days or weeks. Delirium often has a very treatable cause, such as a fever, medication reaction, or an electrolyte imbalance, making it imperative to determine the cause. Do not discount a confused or agitated patient as someone with "dementia," but take the time to find out the onset of this behavioral change, and convey this information clearly and accurately to the hospital. Many patients with delirium, once the cause is identified, go on to make complete recoveries.

Older patients are at higher risk of neurologic emergencies for many reasons. Increasing age increases the risk of stroke, as do certain medications such as anti-coagulants. While traumatic injuries decline with increasing age, when accidents do happen, they are often more serious for older adults. This is due to other medical problems as well as physiologic changes that happen with aging. For example, the mass of the brain shrinks slightly with increasing age. When this happens, blood vessels can be stretched and are more prone to tearing with mild trauma.

When restraint is needed as in the case of a possible neck or back injury, use as much padding as possible to reduce the risk of pressure spots. Many older adults have very thin skin and often suffer significantly if forced to lie on a backboard for a long period of time.

While elder abuse is not as well-known as child abuse, it definitely happens and most frequently occurs among older adults with mental status that is already impaired by conditions such as dementia or stroke. Be alert to signs of trauma or other problems, and consider yourself an advocate for both children and geriatric patients who may not be able to protect themselves.