Brain herniation

* **Supratentorial herniation**
1. Uncal (transtentorial)
2. Central
3. Cingulate (subfalcine)
4. Transcalvarial
5. Tectal (posterior)
* **Infratentorial herniation**
1. Upward (upward cerebellar or upward transtentorial)
2. Tonsillar (downward cerebellar)

The uncus can squeeze the oculomotor nerve, which may affect the parasympathetic input to the eye on the side of the affected nerve, causing the pupil of the affected eye to dilate and fail to constrict in response to light as it should. Pupillary dilation often precedes the somatic motor effects of cranial nerve III compression, which present as deviation of the eye to a "down and out" position due to loss of innervation to all ocular motility muscles except for the lateral rectus (innervated by cranial nerve VI) and the superior oblique (innervated by cranial nerve IV). The symptoms occur in this order because the parasympathetic fibers surround the motor fibers of CNIII and are hence compressed first.[citation needed]

Another important finding is a false localizing sign, the so-called Kernohan's notch, which results from compression of the contralateral[7] cerebral crus containing descending corticospinal and some corticobulbar tract fibers. This leads to ipsilateral hemiparesis (as these tracts are above their decussation where they are compressed). S

The disrupted brainstem can lead to decorticate posture, respiratory center depression and death. Other possibilities resulting from brain stem distortion include lethargy, slow heart rate, and pupil dilation.[6] Uncal herniation may advance to central herniation.[4] The sliding uncus syndrome represents uncal herniation without alteration in the level of consciousness and other sequelae mentioned above.

A complication of an uncal herniation is a Duret hemorrhage. This results in the midbrain and pons being compressed, possibly causing damage to the reticular formation. If untreated, death will ensue.

Central herniation[edit]

In central herniation, the diencephalon and parts of the temporal lobes of both of the cerebral hemispheres are squeezed through a notch in the tentorium cerebelli.[5][8] Transtentorial herniation can occur when the brain moves either up or down acros

] Other symptoms of this type of herniation include small, dilated, fixed pupils with[9] paralysis of upward eye movement giving the characteristic appearance of "sunset eyes". Also found in these patients, often as a terminal complication is the development of Diabetes Inspidus due to the compression of the pituitary stalk.

Radiographically, downward herniation is characterized by obliteration of the suprasellar cistern from temporal lobe herniation into the tentorial hiatus with associated compression on the cerebral peduncles.

Upwards herniation, on the other hand, can be radiographically characterized by obliteration of the quadrigeminal cistern.

Intracranial hypotension syndrome has been known to mimic downwards transtentorial herniation.

Cingulate herniation[edit]

 Subfalcine herniation on CT

In cingulate or subfalcine herniation, the most common type, the innermost part of the frontal lobe is scraped under part of the falx cerebri, the dura mater at the top of the head between the two hemispheres of the brain.[5][10] Cingulate herniation can be caused when one hemisphere swells and pushes the cingulate gyrus by the falx cerebri.[4] This does not put as much pressure on the brainstem as the other types of herniation, but it may interfere with blood vessels in the frontal lobes that are close to the site of injury (anterior cerebral artery), or it may progress to central herniation.[5] Interference with the blood supply can cause dangerous increases in ICP that can lead to more dangerous forms of herniation.[11] Symptoms for cingulate herniation are not well defined.[11] Usually occurring in addition to uncal herniation, cingulate herniation may present with abnormal posturing and coma.[4] Cingulate herniation is frequently believed to be a precursor to other types of herniation.[11]

Transcalvarial herniation[edit]

In transcalvarial herniation, the brain squeezes through a fracture or a surgical site in the skull.[4] Also called "external herniation", this type of herniation may occur during craniectomy, surgery in which a flap of skull is removed, preventing the piece of skull from being replaced.[1]

Upward herniation[edit]

Increased pressure in the posterior fossa can cause the cerebellum to move up through the tentorial opening in upward, or cerebellar herniation.[5] The midbrain is pushed through the tentorial notch. This also pushes the midbrain down. This is also known as a transtentorial herniation since it occurs across the tentorium cerebelli.

Tonsillar herniation[edit]

In tonsillar herniation, also called downward cerebellar herniation,[4] transforaminal herniation, or "coning", the cerebellar tonsils move downward through the foramen magnum possibly causing compression of the lower brainstem and upper cervical spinal cord as they pass through the foramen magnum.[5] Increased pressure on the brainstem can result in dysfunction of the centers in the brain responsible for controlling respiratory and cardiac function. The most common signs are intractable headache, head tilt, and neck stiffness due to tonsillar impaction. The level of consciousness may decrease and also give rise to flaccid paralysis. Blood pressure instability is also evident in these patients.[9]

Tonsillar herniation of the cerebellum is also known as a Chiari malformation (CM), or previously an Arnold-Chiari malformation (ACM). There are four types of Chiari malformation, and they represent very different disease processes with different symptoms and prognosis. These conditions can be found in asymptomatic patients as an incidental finding, or can be so severe as to be life-threatening. This condition is now being diagnosed more frequently by radiologists, as more patients undergo MRI scans of their heads, especially upright MRI, which is more than twice as sensitive for detecting this condition.[12] Cerebellar tonsillar ectopia (CTE) is a term used by radiologists to describe cerebellar tonsils that are "low lying" but that do not meet the radiographic criteria for definition as a Chiari malformation. The currently accepted radiographic definition for a Chiari malformation is that cerebellar tonsils lie at least 5mm below the level of the foramen magnum. Some clinicians have reported that some patients appear to experience symptoms consistent with a Chiari malformation without radiographic evidence of tonsillar herniation. Sometimes these patients are described as having a 'Chiari [type] 0'.

There are many suspected causes of tonsillar herniation including: decreased or malformed posterior fossa (the lower, back part of the skull) not providing enough room for the cerebellum; hydrocephalus or abnormal CSF volume pushing the tonsils out; or dural tension pulling the brain caudally. Connective tissue disorders, such as Ehlers Danlos Syndrome, can be associated.

For further evaluation of tonsillar herniation, CINE flow studies are used. This type of MRI examines flow of CSF at the cranio-cervical joint. For persons experiencing symptoms but without clear MRI evidence, especially if the symptoms are better in the supine position and worse upon standing/upright, an upright MRI may be useful.[2]

Signs and symptoms[edit]

Decorticate posturing, with elbows, wrists and fingers flexed, and legs extended and rotated inward

Brain herniation frequently presents with abnormal posturing[2] a characteristic positioning of the limbs indicative of severe brain damage. These patients have a lowered level of consciousness, with Glasgow Coma Scores of three to five.[2] One or both pupils may be dilated and fail to constrict in response to light.[2] Vomiting can also occur due to compression of the vomiting center in the medulla oblongata.

**Physical Examination**

The emergency medicine clinician must quickly assess the adequacy of the ABC’s and the patient’s neurological status, while simultaneously evaluating for life-threatening signs and symptoms of intracranial hypertension or impending herniation, such as altered level of consciousness, pupillary dysfunction, lateralizing extremity weakness, Cushing’s triad (hypertension, bradycardia, and irregular respirations), or other herniation syndromes (**Table 2**).

