Midline shift (MLS)

Brain shift past its center line.

For several decades, clinicians have predicted intraparenchymal brain pressure or brain tissue compression indirectly based on the degree of distortion of the midline structures (midline shift) and ventricle wall (ventriculomegaly). However, this method has several limitations.

Kernohan notch phenomenon is an imaging finding resulting from extensive midline shift due to mass effect, resulting in indentation in the contralateral cerebral crus by the tentorium cerebelli. This has also been referred to as Kernohan-Woltman notch phenomenon and false localising sign.

Etiology

The sign can be caused by conditions including traumatic brain injury, ischemic stroke, intracranial hematoma, or birth deformity that leads to a raised intracranial pressure.

Acute subdural hematoma is a serious complication following traumatic brain injury. Large volume hematomas or those with underlying brain injury can cause mass effect, midline shift, and eventually brain herniation.

Serial CT scans have shown that midline shift increases after ischemic stroke and reaches a maximum 2-4 days after.

Diagnosis

Computed tomography

The most prominent measurement is done by a head computed tomography (CT) scan and the CT Gold Standard is the standardized operating procedure for detecting MLS.
It is defined at the level of the foramen of Monro\(^1\).

**Measurement**

Dividing the diameter from the inner table to inner table at the level of the foramen of Monro by 2 and subtracting the distance from the inner table to the septum pellucidum on the side of the shift.

**Magnetic Resonance Imaging**

Since the midline shift is often easily visible with a CT scan, the high precision of Magnetic Resonance Imaging (MRI) is not necessary, but can be used with equally adequate results.

**Sonography**

Newer methods such as bedside sonography can be used with neurocritical patients who cannot undergo some scans due to their dependence on ventilators or other care apparatuses.

Sonography has proven satisfactory in the measurement of MLS, but is not expected to replace CT or MRI.

Automated measurement algorithms are used for exact recognition and precision in measurements from an initial CT scan.

A major benefit to using the automated recognition tools includes being able to measure even the most deformed brains because the method doesn’t depend on normal brain symmetry.

Also, it lessens the chance of human error by detecting MLS from an entire image set compared to selecting the single most important slice, which allows the computer to do the work that was once manually done.

The incidence of chronic subdural hematoma (cSDH) is increasing and its rate of recurrence varies from 5 to 33%. A postoperative brain midline shift (MLS) on computed tomography (CT) equal or larger than 5mm is a risk factor for chronic subdural hematoma recurrence. Transcranial color coded duplex sonography (TCCDS) is a noninvasive bedside reproducible technique useful to detect MLS.

The aim of our study was to compare in patients affected by cSDH, the values of MLS obtained pre- and post-operatively by TCCDS and brain CT.

32 patients affected by cSDH entered the study between July 2016 and January 2017. MLS values obtained by TCCDS and brain CT were compared using Bland-Altman plot and linear regression analysis. Using the same techniques we also explored if the agreement between the two imaging modes was comparable in pre- and post-operative data pairs.

64 data pairs of MLS values obtained by TCCDS and CT were analysed. Bland-Altman diagrams did not show any systematic bias of the data and linear regression indicated a significant correlation between the two measures both before and after hematoma evacuation.
In patients affected by cSDH, MLS values obtained before and after surgery by TCCDS are comparable to those obtained by CT; TCCDS might be considered an alternative to CT scan in the management of patients after cSDH evacuation. We suggest that close clinical bedside examination and TCCDS might be appropriate for the post-operative management of cSDH, reserving CT scan only to patients with overt clinical deterioration and/or increasing MLS \(^2\).

**Structures of the Midline**

Three main structures are commonly investigated when measuring midline shift. The most important of these is the **septum pellucidum**.

It is easily found on CT or MRI images due to its unique hypo density.

The other two important structures of the midline include the **third ventricle** and the **pineal gland** which are both centrally located and caudal to the septum pellucid.

Identifying the location of these structures on a damaged brain compared to an unaffected brain is another way of categorizing the severity of the midline shift. The terms mild, moderate, and severe are associated with the extent of increasing damage.

**Midline Shift in Diagnoses**

Midline shift measurements and imaging has multiple applications. The severity of brain damage is determined by the magnitude of the change in symmetry. Another use is secondary screening to determine deviations in brain trauma at different times after a traumatic injury as well as initial shifts immediately after.

The severity of shift is directly proportional to the likeliness of surgery having to be performed. MLS also has the aptitude to diagnoses the very pathology that caused it. The MLS measurement can be used to successfully distinguish between a variety of intracranial conditions including acute subdural hematoma, malignant middle cerebral artery infarction, epidural hematoma, subarachnoid hemorrhage, chronic subdermal hematoma, infarction, intraventricular hemorrhage, a combination of these symptoms, or the absence of pertinent damage altogether.

**Outcome**

The sign is considered ominous because it is commonly associated with a distortion of the **brainstem** that can cause serious dysfunction evidenced by abnormal posturing and failure of the **pupils** to constrict in response to light.

Midline shift is often associated with high intracranial pressure (ICP), which can be deadly.

**Treatment**

In fact, midline shift is a measure of ICP; presence of the former is an indication of the latter.

Presence of midline shift is an indication for neurosurgeons to take measures to monitor and control
ICP.

Immediate surgery may be indicated when there is a midline shift of over 5 mm.

**Case series**

**2016**

Kazdal et al performed a prospective, blinded observational study in an intensive care unit. Forty-five patients were divided into groups. Of those, 19 patients had a midline shift, whereas 26 had no intracranial pathology or shift and served as control individuals.

Spearman rank correlation coefficient of difference of ONSD and midline shift was 0.761 (P < 0.0005), demonstrating a significant positive correlation between patients with midline shift and control group.

Despite small numbers and selection bias, this study suggests that bedside ultrasound may be useful in the diagnosis of midline intracranial shift by measurement of ONSD.\(^3\)

**1989**

Ropper reported that horizontal brain shift caused by acute unilateral mass lesions correlated closely with consciousness, and suggested that recovery of consciousness was unlikely to occur after surgical evacuation if the shift was insufficient to explain the observed diminution of consciousness. The authors have sought to confirm the correlation of pineal shift with level of consciousness and to assess the prognostic value of brain shift measurements in a prospective study. Forty-six patients (19 with subdural hematoma, 14 with intracerebral hematoma, and 13 with epidural hematoma) were accrued to the study group consecutively. A correlation was found between a decrease in the level of consciousness and a significant increase in the mean lateral brain displacement at the pineal gland (from 3.8 to 7.0 mm) and septum (5.4 to 12.2 mm). When outcome was examined in patients who were stuporous or comatose on admission, a significant increase in septal shift was found among patients with a poor outcome, but there was no significant relationship between outcome and degree of pineal or aqueductal shift. A poor outcome was more likely with effacement of both perimesencephalic cisterns or the ipsilateral cistern, but not the contralateral cistern, although this difference did not reach statistical significance. These results do not substantiate the value of brain shift as an independent prognostic factor after evacuation of an acute unilateral mass lesion. The decision to operate and the determination of prognosis should be based rather on established criteria such as the clinical examination, age of the patient, and the mechanism of injury.\(^4\)

**1986**

Brain-tissue shifts associated with drowsiness, stupor, and coma were studied by clinical examination and CT scanning in 24 patients with acute unilateral cerebral masses. Studies were performed soon after the appearance of the mass to detect the earliest CT changes associated with depression or loss of consciousness. Contrary to traditional concepts, early depression of the level of alertness corresponded to distortion of the brain by horizontal displacement rather than transtentorial herniation with brain-stem compression. Horizontal displacement of the pineal body of 0 to 3 mm from the midline was associated with alertness, 3 to 4 mm with drowsiness, 6 to 8.5 mm with stupor,
and 8 to 13 mm with coma. Moreover, drowsy or stuporous patients and some comatose patients had widened cisterns between the tentorial edge and the midbrain on the side of the mass, suggesting that the space was not filled by herniated medial temporal lobe. Downward displacement of the pineal body, indicating central transtentorial herniation, did not occur. Compression of one hemisphere by the other anteriorly (transfalcial herniation) was inconsistently related to alertness, though very large anterior displacements may have caused stupor in some patients. Current concepts of the pathoanatomical nature of depressed consciousness, based on pathological material obtained well after clinical examinations, may require revision, because they do not reflect early brain-tissue distortions

0-3 mm alert

3-4 mm drowsy

6-8.5 mm stuporous

8-13 mm comatose

1) Bullock MR, Chesnut R, Ghajar J Appendix II Evaluation of relevant computed tomographic scan findings. Neurosurgery 2006;58


