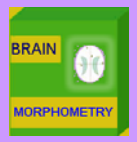

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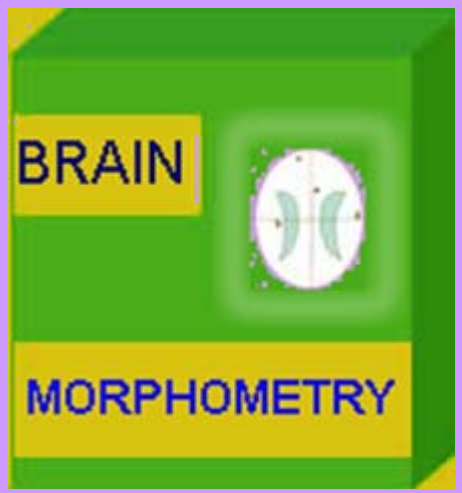


BRAIN MORPHOMETRY

Techniques of evaluation of Brain Morphometry

- Radiography
- Ultrasound
- CT
- MR

Techniques of evaluation of Brain Morphometry

- Linear - distances
- Planimetric - areas
- Volumetric - volumes

Radiography

- Plain Radiography
- Pneumoencephalogram - obsolete

USG

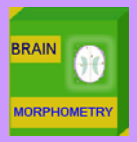
- Fetal
- Neonatal – Through the fontanelles
- Transcranial in adults
  - limited access through squamous temporal bone, orbit, foramen magnum
  - Burr holes, craniectomy defects

CT

- Can be acquired in axial / coronal planes
- Spiral acquisition allows high resolution reconstruction in any desired plane.

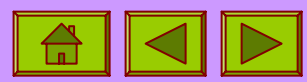
MRI

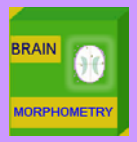
- Highest resolution and soft tissue discrimination
- Multi-plane acquisition
- Allows segmentation of brain into gray matter, white matter and CSF compartments



Subjective or Objective assessment

- Wide inter-observer variability in subjective assessment of brain size
- Objective criteria
  - time consuming
  - indeterminate range between normal & abnormal
  - depend on skull shape and size which has individual & racial variation





Objective assessment

- Linear
- Planimetric
- volumetric

Planimetric method

- Areas of ventricles, brain parenchyma and intracranial volume are measured by manually moving cursors along the outlines of ventricles, cortex and inner table respectively.

Volumetric method

- Volumes are calculated by multiplying the areas obtained by planimetric method by slice thickness

Computerised methods

- Palnimetric & volumetric methods can employ software programmes to do these measurements.
- Automatic segmentation of intracranial contents to gray matter, white matter and csf can be done, and their areas, volumes measured.

Atrophy

- Subjective
- Objective criteria
  - –Structures
  - –Indices

Atrophy

- cortical
  - wide sulci
- sub cortical
  - enlarged ventricles
- diffuse
  - wide sulci & enlarged ventricles

Ventricular measurement

- Evans ratio
- Bi-caudate ratio / bifrontal ratio
- lateral ventricular brain ratio
- third ventricular brain ratio
- Fourth ventricular brain ratio
- Relative Area of lateral ventricles
- Ventricular atrophy index

Sub arachnoid spaces

- Four cortical sulci ratio
- Sylvian fissure ratio
- Third ventricle sylvian fissure ratio
- frontal inter hemispheric fissure ratio
- pre-pontine - pontine ratio
- Cortical Atrophy index

Evans ratio

- 1942
- First used on encephalography
- Ratio of transverse ‘D’ of anterior horns of lat ventricles to inner ‘D’ of skull
- normal- 0.23 +/- 0.04

*Evans WA Jr, Arch. Neurol. Psychiat.(1942) 47,931-937

Bifrontal Ratio

- Measured on axial section best showing caudate nuclei
- Distance between tips of frontal horns / distance between inner tables along same line
- normal - 2.34 +/- 0.37

*Oepen Goj neurol (1981)225;189-96

Bicaudate ratio

- Ratio of minimal distance between caudate indentations of frontal horns and distance between inner tables along same line
- normal-0.120 +/- 0.02

*Oepen Goj neurol (1981)225;189-96

Lateral ventricular brain ratio

- Section showing lateral ventricles above thalami
  - min distance between lateral walls of lateral ventricles (a)
  - AP length of lateral ventricle (b)
  - Transverse inner table ‘D’ at line a, (c)
  - mid saggital inner table ‘D’ (d)
  - LVBR = $\frac{a \times b}{c \times d}$

*Gomori JM neuroradiology (1984)26;21-24

Four cortical sulci ratio

- At highest two cuts
- Ratio of sum of width of four widest sulci to trans pineal transverse inner table distance

*J of neurol neurosurg psychiatry 1984;38:948-53

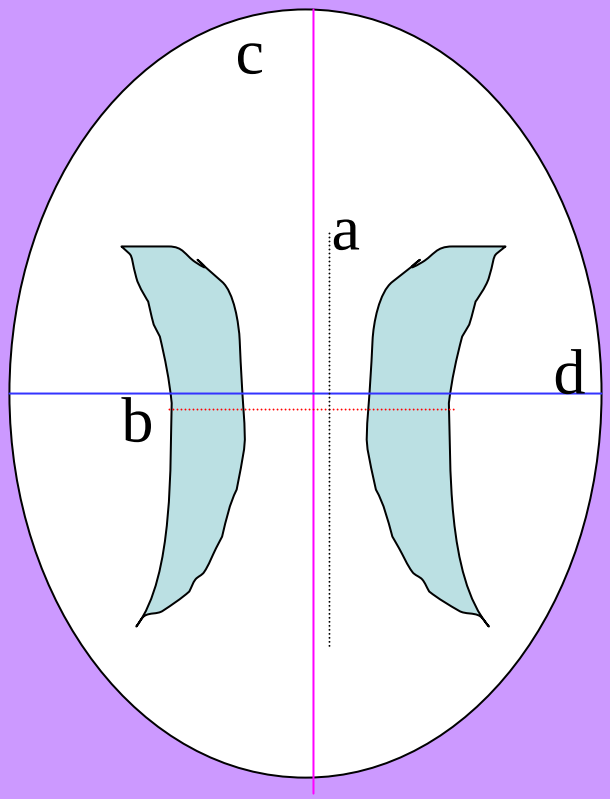
Fourth ventricular brain ratio

- AP D of IV ventricle (a)
- Transverse D of IV ventricle (b)
- AP inner table D along line a. (c)
- Transverse inner table D along line b. (d)

$$= \frac{(a) \times (c)}{(b) \times (d)}$$

*Gomori JM neuroradiology (1984)26;21-24

Fourth ventricular brain ratio



$$\frac{(a) \times (c)}{(b) \times (d)}$$

Third ventricle sylvian fissure ratio

- Sum of distances between lateral wall of 3rd ventricle and sylvian fissures, at the level of thalamus on either side, divided by transverse inner table D along same line

- *Gomori JM neuroradiology (1984)26;21-24

Relative Area of lateral ventricles

- Maximum area of lateral ventricle divided by brain area at the same level

*Acta radiologica(1993)34;296-302

Ventricular atrophy index

- Ventricular volume divided by inner cranial volume

*Acta radiologica(1993)34;296-302

Cortical Atrophy index

- Brain volume divided by inner cranial volume
- an index of volume of sub cortical spaces

*Acta radiologica(1993)34;296-302

Pre pontine – pontine ratio

- On axial slice through lower dorsum sella.
- Mid saggital AP width of pre pontine cistern divided by pontine AP diameter along same line

*Gomori JM neuroradiology (1984)26;21-24

Frontal inter hemispheric fissure ratio

- Maximal width of IHF divided by transverse inner table D through the pineal gland.

- *Meese W Neuroradiology(1980)19:131-6

Sylvian fissure ratio

- Average of maximal sylvian fissure width on either side divided by transverse inner table D through the pineal gland

*Meese W Neuroradiology(1980)19:131-6

Inter-uncal distance

- On axial plane parallel to bicommissural plane
- At level of suprasellar cistern
- the distance between the unci.

*J of neurol neurosurg psychiatry 1996;61:157-65

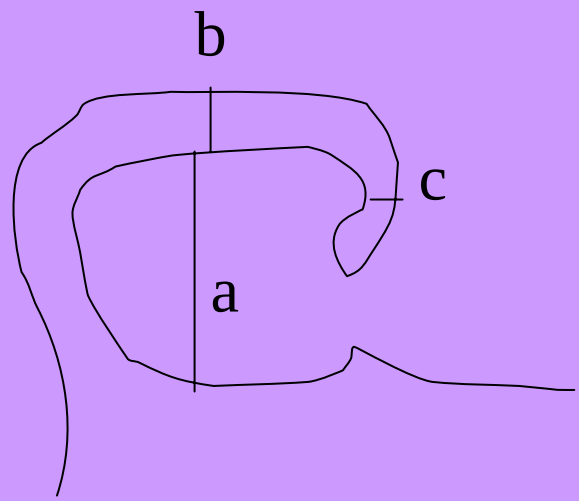
Minimum thickness of temporal lobe

- Thickness of temporal lobe at its thinnest point

- *J of neurol neurosurg psychiatry 1996;61:157-65

Hippocampal height
Width of choroidal fissure
& temporal horn

- Hippocampal height (a)
  - Rt 15.5mm (SD 1.6)
  - Lt 14.7mm (SD 1.3)
- Width of choroidal fissure (b)
  - Rt 2.5mm (SD 1.1)
  - Lt 2.8mm (SD 1.1)
- Width of temporal horn (c)
  - Rt 3.1mm (SD 1.3)
  - Lt 3.3mm (SD 1.1)



J of neurol neurosurg psychiatry 1996;61:157-65

Measurements in hydrocephalus

- Enlargement of **anterior/posterior recesses of third ventricle**
- Enlargement of **temporal horns** commensurate with dilated body of lateral ventricles
- Reducing **mamillo-pontine distance**
- **Ventricular angle**- angle made by frontal horn at foramen of monro, reduces with icreasing hydrocephalus
- **Frontal horn radius** - widest D of frontal horns at 90^0 to long axis of frontal horn
- **Ventricular index** is the ratio of ventricular D at level of frontal horns to brain D at same level, on axial section

Corpus callosum

- Mid saggital area, increases upto adulthood
- It matures from anterior to posterior
- Corpus callosal index- ratio of MSA to cerebral volume.
- MSA is greater in males. However the area correlates with the total cerebral volume, hence the corpus callosal index is the same in both sexes

Corpus callosum area

- In diffuse cerebral atrophy and schizophrenia Mid saggital area is reduced, but the length is normal .
- MSA and length of corpus callosum in controls are 6.31 cm^2 and 6.83 cm while in schizophrenics are 6.06 cm^2 and 6.9 cm respectively.
- J Neurol Neurosurg Psy 1995;58(4):457-61

Normal ageing

- Diffuse cerebral atrophy, causing cortical sulcal prominence and ventricular enlargement.
- Temporal horns are relatively less dilated.
- cerebellum is less severely affected. Predominantly the dorsomedial vermis

Complex Partial Seizures

- Mesial temporal sclerosis is a common cause of CPS
- hippocampal atrophy, causing increase in temporal horn, choroid & hippocampal fissure volumes. Normal adult hippocampal volume is 2-4cc
- Unilateral or predominantly unilateral MTS can benefit from anterior lobectomy
- Hippocampus has increased SI on T2WI and reduced NAA on MRS

Toxic & Metabolic Disorders

- All cause diffuse cerebral atrophy in terminal stages
- Imaging early in the course of disease helps in narrowing D/D, by detecting region of predominant involvement
- Involvement of WM / GM / both
- WM – subcortical / deep
- GM – cortical / deep

Toxic & Metabolic Disorders

- Cortical GM involvement causes widened cortical sulci
- Deep GM involvement – acute / chronic
  - *Acute – swollen deep GM
  - *Chronic – atrophic deep GM
- GM involvement also causes WM atrophy due to wallerian degeneration of axons

Toxic & Metabolic Disorders -involving sub-cortical WM

- Canavan’s disease
- Alexander’s disease
- Van der knaap disease
- Pelizaeus-Merzbacher disease
- Galactosaemia
- Cockayne’s syndrome

Canavan's disease

- Macrocephaly
- Diffuse symmetrical involvement of cerebral & cerebellar sub cortical WM first
- Increased SI of globus pallidus
- Increased NAA
- Diffuse cerebral atrophy later
- Death by 2 years

Alexander’s disease

- Present in first year
- Macrocephaly
- Bilateral symmetrical subcortical WM involved
- Predominantly frontal involvement

Van der knaap disease

- Macrocephaly
- leukoencephalopathy
- mild clinical course
- complete absence of myelination in subcortical WM, sparing occipital lobes.
- Subcortical cysts in frontal and temporal lobes
- donot involve globus pallidus and thalami

Galactosaemia

- Present in first year
- Diffuse sub-cortical WM involvement with out macrocephaly
- However WM appears normal on T1WI
- Cerebral and cerebellar atrophy in older children

Pelizaeus-Merzbacher disease

- Present with nystagmus and slow motor development
- slowly progressive, with death in adolescence
- progressive WM atrophy

Metabolic Disorders -involving central/deep WM

- Metachromatic leucodystrophy
- Krabbe’s disease
- Adrenoleucodystrophy
- Zellweger’s syndrome
- Palizaeus Merzbacher disease
- Phenylketonuria
- Maple syrup urine disease
- Radiation/chemotherapy

Metachromatic leukodystrophy

- Commonest Infantile, juvenile and rare adult forms.
- Deep WM involvement. Earliest is peritrigonal. Spares sub-cortical WM till late stage
- Progressive hemispheric brain atrophy

Krabbe’s disease

- Deficiency of beta-galactosidase, causes destruction of oligodendrocytes
- Deep WM involvement in cerebrum and cerebellum, causing diffuse WM atrophy. Parietal lobes are most affected
- Bilateral symmetrical hyperdense thalami on CT

Adrenoleukodystrophy

- X-linked, seen in males
- Deep WM, splenium and occipital predominantly. Anterior advancing edge enhances
- Thalami are normal
- Cortico spinal tracts in pons & medulla are involved
- skin hyperpigmentation due to adrenal insufficiency

Adrenomyeloneuropathy

- A form of ALD
- affects the cerebellum and brainstem rather than cerebrum
- presents in adults

Metabolic Disorders - involving cortical GM

- Ceroid lipofuscinosis
- Glycogen storage disorders

Metabolic Disorders predominantly involving deep GM

- **Striatal involvement**
  - Mitochondrial disorders
    - Leighs disease, MELAS
  - Wilsons disease
  - Juvenile huntingtons disease
  - Asphyxia, hypoglycemia
- **Globus pallidal involvement**
  - Halloverden Spatz disease (dark on T2)
  - Kernicterus (bright on T2)
  - Carbon monoxide poisoning (bright on T2)

Metabolic Disorders -Involving both GM & WM

- Normal bones
  - With cortical malformations
    - Congenital CMV infection
    - Peroxisomal disorders
  - Without cortical malformations
    - Menkes disease
    - Alpers disease
- Abnormal bones
  - Mucopolysaccharidoses
  - mucolipidoses

Mitochondrial disorders

- Affect multiple systems. Brain and striated muscles are most affected.
- Usually present in childhood.
- Present with seizures, muscle weakness, neurosensory hearing loss
- Deep gray matter is always involved. Also involves WM

Mitochondrial disorders

- Menkes disease
- Glutaric aciduria
- Leigh’s disease
- Alper’s disease
- MELAS disease
- Kearns-sayre syndrome

Menkes disease

- X linked recessive disorder
- Impaired Cu absorption
- Rapidly progressive diffuse cerebral & cerebellar atrophy
- Sudural hematomas
- Osteoporotic and flared metaphyses of long bones
- Ususally die by 2y

Glutaric aciduria

- Marked fronto temporal atrophy
- Prominent sylvian fissures
- Atrophic basal ganglia with T2 hyperintensity, predominantly in putamen, and periventricular WM

Leigh’s disease

- Usually present by one year with hypotonia and psychomotor deterioration
- T2 hyperintensities in caudate, lentiform nuclei, periaqueductal and cerebral peduncles
- less commonly involves cortical GM and WM

Alper’s disease

- A multi system disorder.
- Involves brain and liver
- cortical atrophy, predominantly occipital
- atrophy of basal ganglia, particularly thalami and globus pallidi

MELAS disease

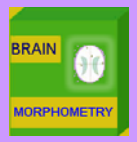
- Mitochondrial encephalomyopathy with lactic acidosis and stroke
- most commonly present in second decade
- Increased lactate in urine/csf and in brain on MRS
- increased T2 SI predominantly in basal ganglia and parieto-occipital WM. Multiple infarcts not corroborating to vascular territories

Kearns-sayre syndrome

- Progressive external ophthalmoplegia, retinitis pigmentosa and may have heart block
- present by 20 years
- cortical and WM atrophy.
- Thalami, globus pallidi and dorsal midbrain are involved
- subcortical and deep WM is involved sparing the periventricular WM

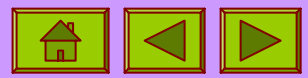
Vascular dementia

- Multi infarct dementia
  - multiple cortical and subcortical infarcts
  - diffuse cerebral atrophy
- large stroke
  - focal atrophy involving the part of brain involved



Normal pressure hydrocephalus

- Ventricular enlargement, with compressed cortical sulci
- Increased flow through the aqueduct causing prominent aqueductal flow void.



Movement disorders

- Parkinson’s disease
- Parkinson’s plus syndrome
- Huntingtons disease
- Halloverden Spatz Disease
- Amyotrophic lateral sclerosis

Parkinson’s disease

- Affects 1% population above 50y
- Reduced width of pars compacta, causing merging of red nucleus and pars reticulata on T2WI.

Parkinson's plus syndrome

- Striato-nigral degeneration
  - putaminal atrophy
- progressive supranuclear palsy syndrome
  - mid brain and tectal atrophy
- olivo ponto cerebellar degeneration
  - atrpohy of inferior olives, medulla oblongata, pons and cerebellum
- Shy- Dager syndrome
  - Putaminal hypointensity on T2 euals that of globus pallidus

Halloverden Spatz Disease

- T2 hypointensity of globus pallidi, with focal hyperintensity in internal segment of globus pallidus giving eye of tiger appearance

Huntingtons disease

- Atrophy of basal ganglia, maximal in caudate and putamen
- Ex vacuo enlargement of frontal horns giving a box car appearance

Amyotrophic lateral sclerosis

- Symmetrical T2 hyperintensities from motor cortex to pons
- Atrophy of spinal cord anterolaterally with preservation of dorsal columns

Schizophrenia

- Thalamic volumes are significantly smaller and may reflect a greater susceptibility for the disorder, but seem unrelated to outcome.
- In contrast, gray matter volume loss of cerebrum, particularly in the frontal lobes, and lateral and third ventricular enlargement appear related to outcome.

*Staal WG, Am J Psychiatry 2001 Jul;158(7):1140-45

Dementia

- Alzeimers disease
- fronto-temporal dementia
- Picks disease
- Multi-infarct dementia
- Normal pressure hydrocephalus
- Creutzfeldt-Jacob disease

Alzeimers disease

- Diffuse cerebral atrophy, predominantly anterior temporal lobes.
- Both the hippocampus and medial temporal lobe are atrophied

Lewi body disease

- Lewi body disease is a variant of Alzeimers disease, with predominant frontal lobe atrophy

Fronto temporal dementia

- Fronto temporal dementia have greater atrophy of anterior brain than in AD hippocampus is atrophied, but medial temporal lobe is spared
- Frontal and hippocampal atrophy in absence of medial temporal atrophy occurs in FTD

Picks disease

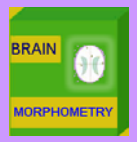
- Cortical atrophy predominantly frontal & temporal

Cerebellum

	Folia	Sulci/fissures	Dev. Of components
Atrophy	Thin	Wide	Complete
Hypoplasia	Small	Normal	Complete
Hypogenesis	Normal	Normal	Incomplete

Cerebellar atrophy

- Age related
  - predominantly dorso-medial vermis
- congenital
  - Friedreich's ataxia, olivo ponto cerebellar atrophy, spino cerebellar atrophy, neuronal ceroid lipofuscinoses, GM_2 gangliosidoses, downs syndrome, infantile autism, rets syndrome, fragile x syndrome
- acquired
  - Chronic alcoholics



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