Cranial Imaging in the Preterm and Term Infant (Ultrasound and MRI)

University Hospitals of Leicester NHS
NHS Trust

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Contents

1. Introduction and Who Guideline applies to

This guideline is aimed at all Health care professionals involved in the care of infants within the Neonatal Service.

Prematurity

- Formal routine cranial USS are performed by the radiologists on most mornings at LRI but this depends on Consultant availability. At LGH these are performed on **Friday mornings depending on Consultant availability, with less scope for cross-cover due to staff leave.** Consultant neonatologists and SpRs with the appropriate competency may perform scans at other times

- Urgent cranial USS should be discussed with a consultant radiologist

- All infants < 30 weeks (up to 29+6 weeks) should have a screening cranial USS within 3 – 5 days

- All infants <33 weeks (up to 32+6 weeks) should have a cranial USS at around 36 weeks corrected gestation age

Infants 33 weeks and above (including Term)

- Cranial imaging should be performed in all infants with abnormal neurology
- Infants with grade II or III Hypoxic Ischaemic Encephalopathy (HIE) should have a cranial USS within 48 hours of birth and at 1 week.
- In cases of hypoxic-ischaemic encephalopathy, the MRI scan should ideally be done on day 4-5 (but can be up to the second week of life).

Aim/indications

- To screen for evidence of intracranial pathology associated with extreme prematurity
- Detection of cerebral damage following significant hypoxic or hypotensive episode
- Detection of intracranial haemorrhages
- Detection of cerebral anomalies associated with congenital disorder/malformations

The guideline includes

- Cranial Ultrasound Screening Protocol for Asymptomatic Preterm Infants
- Standard ultrasound views (Appendix 1)
- Ventricular index chart (Appendix 2)

Related documents

Diagnostic Testing Procedures UHL Policy

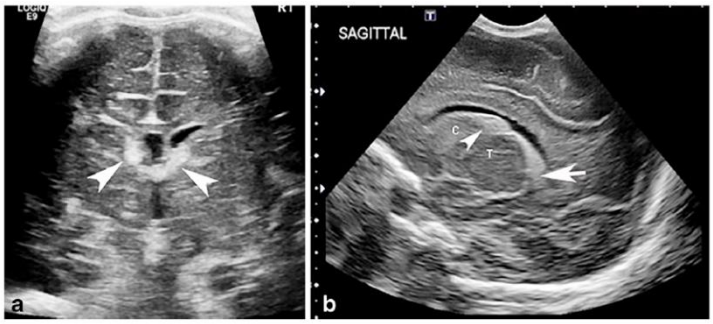
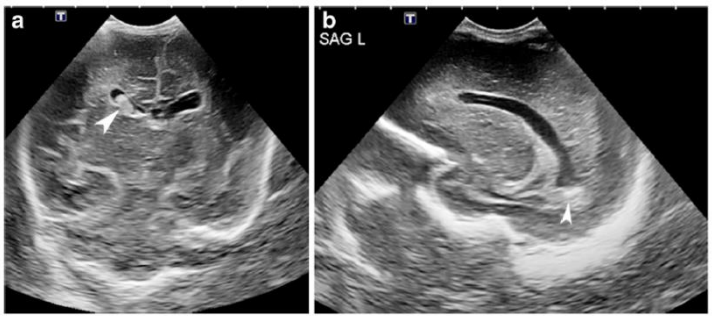
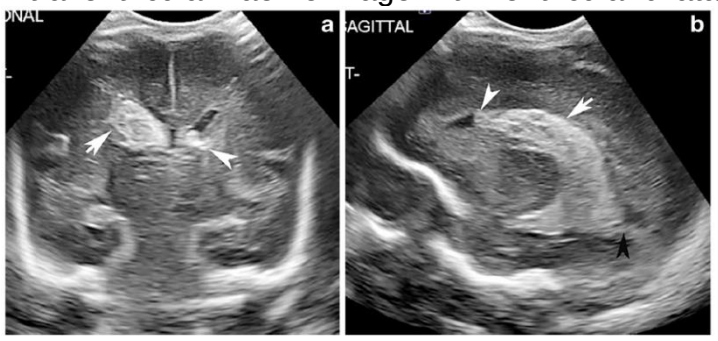
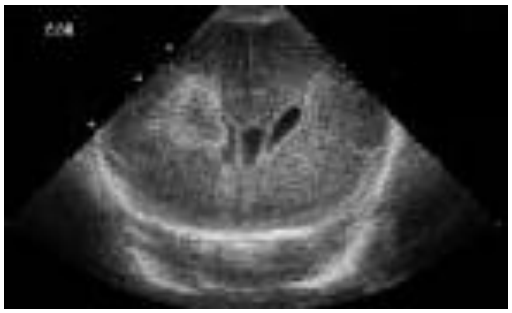
2. Guideline Standards and Procedures

Preterm Infants

Intraventricular haemorrhage (IVH)

There is an inverse relationship between gestational age and intraventricular haemorrhage with the majority occurring in infants <29 weeks within 72 hours of birth [1]. Intraventricular haemorrhage is now classified as in the table below [2,3].

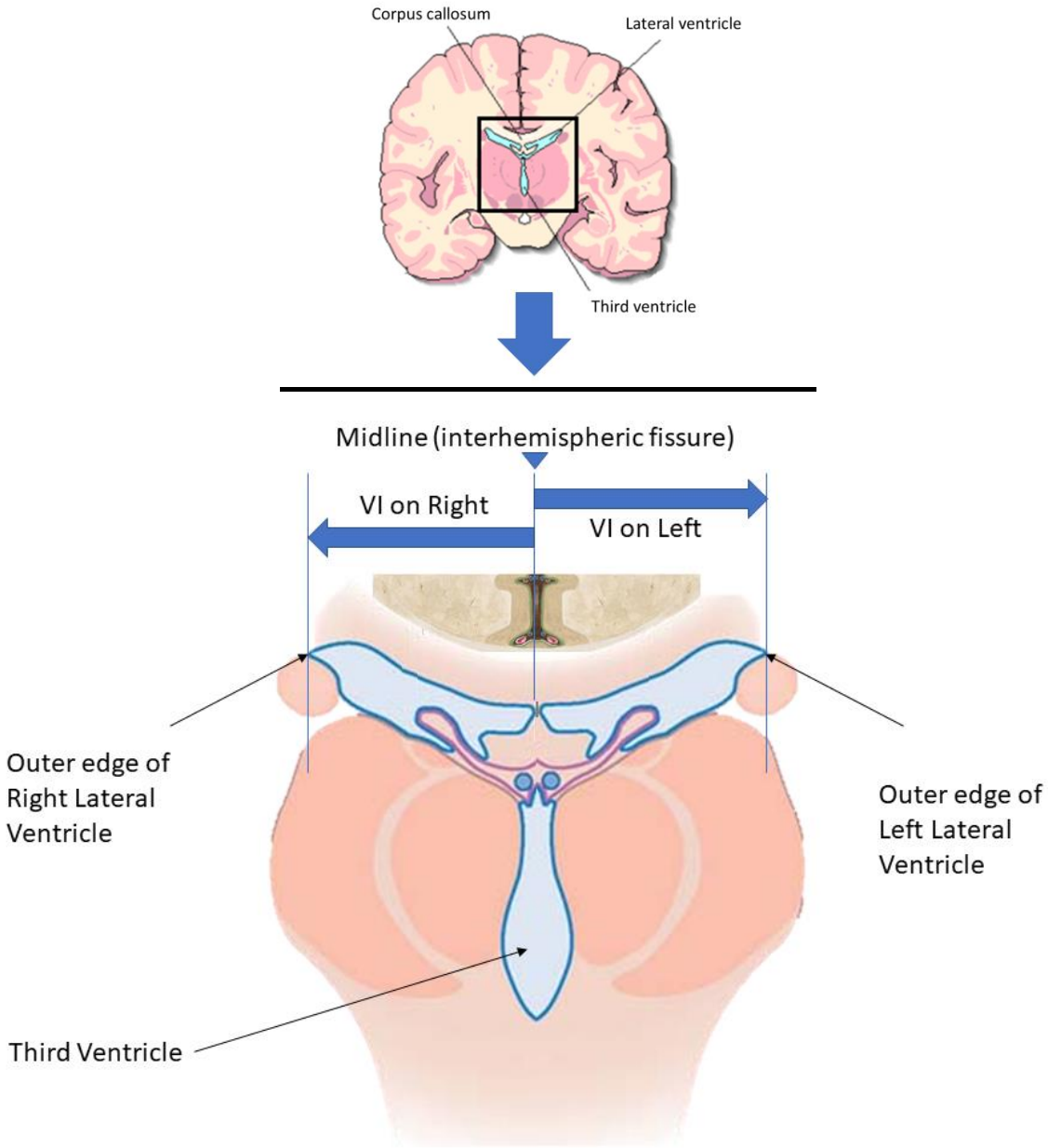
Table 1: Intraventricular haemorrhage

Small (Grade 1) Haemorrhage limited to the germinal matrix (subependymal) or choroid plexus. (May develop into a pseudocyst).	
Small (Grade 2)	Intraventricular haemorrhage but no ventricular dilatation 
Large (Grade 3): blood filling >50% of the area of the lateral ventricle on parasagittal view	Intraventricular haemorrhage with ventricular dilatation 
Haemorrhagic parenchymal infarct (Grade 4) IVH with increased parenchymal echodensity. Develops into a porencephalic cyst	

Ventricular dilatation

Mild ventricular dilatation or asymmetry is common. Significant ventricular dilatation is more likely to follow a grade 3 IVH but may also follow a grade 2 haemorrhage. Ventricular dilatation or hydrocephalus may also follow meningitis.

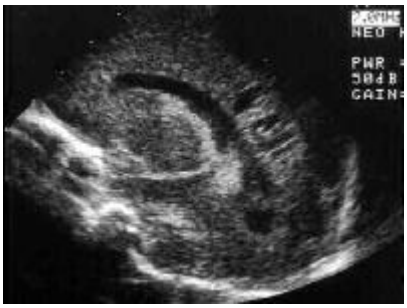
The ventricular index of Levene is a well validated method for documenting ventricular dilatation [4,5,6]. This is a measurement taken in the coronal view through the plane showing the 3rd ventricle and measures the distance from the falx (midline) to the lateral border of the lateral ventricle (shown below). This should be plotted regularly in infants at risk of hydrocephalus (Appendix 2).



Periventricular leukomalacia (PVL)

A periventricular "blush" is common but a true periventricular flare is as bright as the choroid and is seen in both coronal and sagittal planes. These areas should be carefully reassessed as they may develop into cystic areas. Infants < 32 weeks are at risk regardless of birthweight [7]

PVL may be rarely present at birth following an antenatal insult or may not appear until 6 weeks postnatal age [7-10]. Risk factors include chorioamnionitis and postnatal hypotensive episodes [11]. It is important to classify it as unilateral or bilateral and to assess the extent of parenchymal involvement as these facts guide prognosis. A small localised area of infarction has a better prognosis [12].



TORCH Infections

Congenital cytomegalovirus (CMV), toxoplasmosis and rubella infections, of which CMV is currently the most common, may result in intracranial calcification. A CT scan is the imaging technique of choice for calcification but this is rarely indicated and significant calcification can be detected with cerebral ultrasound.

Term Infants

Cerebral sinus and venous thrombosis
This may occur in association with dehydration, sepsis, trauma and leads to raised intracranial pressure, seizures, hypertonia and unexplained lethargy.
CT or MRI are required for diagnosis.

Arterial infarction
Infarction of a cerebral artery (commonly middle cerebral) is increasingly recognised. Initial USS may be normal but focal changes are apparent from 5 days [13]. An MRI will confirm the diagnosis.

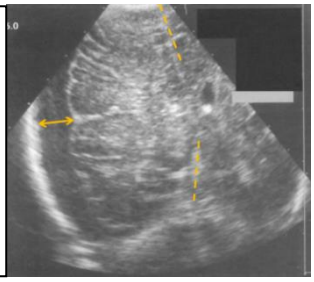
HIE
In HIE there may be acute cerebral oedema visible on USS and this may be followed by evidence of cerebral damage including basal ganglia infarction. An MRI performed at the correct time can give valuable information about the prognosis in an individual case [14-17].

Haemorrhage
Intracranial (and extracranial) haemorrhage occurs less commonly in the term infant and the pattern of haemorrhage is more heterogeneous than in the preterm infant [18]. This is summarised in the table below:

Table 2: Haemorrhage

Haemorrhage type	Risk factors	Symptoms	Imaging techniques
Subdural (SDH) • Supratentorial • Posterior fossa	Instrumental delivery, trauma, thrombocytopenia, coagulopathy	Seizures, fever, tense fontanelle, hypotonia, lethargy, facial palsy. Others depending on site.	USS poor CT (MRI)
Subarachnoid (SAH) • Primary • Secondary to intraventricular haemorrhage	Thrombocytopenia, coagulopathy	Seizures, fever	
Convexity Haemorrhage (Large SAH)	Exchange transfusion and coagulopathy		USS – resembles space-occupying lesion
Intraventricular haemorrhage	Maternal or fetal coagulopathy	Seizures, fever, raised intracranial pressure	USS
Intraparenchymal	Coagulopathy, trauma, hypoxia, ischemia, Arteriovenous malformation, dural venous sinus thrombosis, aneurysm, tumour.	Sudden onset of symptoms in previously well infant	USS
Cerebellar haemorrhage	Breech delivery, trauma	Lethargy, apnoea, bradycardia, poor suck, raised ICP	USS
Thalamic haemorrhage (unilateral)	HIE	Severe abnormality at 2-14 days. Ocular signs	USS
Subaponeurotic	Afro Caribbean infant, vacuum extraction, vit K def.	Severe hypovolemia, swelling of cranium across suture lines	USS CT/MRI

Subdural haematoma with midline shift and bowing of the interhemispheric fissure [19].



Recommendations

Personnel performing scans

Ultrasound is a good bedside imaging technique that can detect IVH and PVL with a high degree of accuracy [20]. The cranial USS are performed and reported by the Consultant Radiologist where possible and when appropriate.
Additional scans may be performed (or supervised) by the neonatal consultant or SpR that has the appropriate competency.
NB: It is easy to misinterpret ultrasound appearances [21].

The following should be documented on badgernet:

- Date and time of the scan
- Name and position of person performing scan (and supervising consultant)
- Findings
    - Always perform a *full* sweep from anterior to posterior and left to right
    - The views to be recorded are shown in Appendix 1
    - Document anatomy (normal/abnormal) and any evidence of haemorrhage or ischaemia

- All ***abnormal*** USS should be discussed with the attending neonatal Consultant and Consultant Radiologist to allow parents to be counselled appropriately.
    - If post-haemorrhagic ventricular dilatation is suspected the ventricular index should be plotted (Appendix 2).

Preterm infants

Asymptomatic

A chart of recommendations is shown on the following page.

- If possible a scan should be performed within 24 hours in infants < 1000g.
- Infants in whom IVH is identified will be rescanned the following week.
- Infants with additional concerns will be dealt with on an individual basis

Infants > 32+6 weeks are not routinely screened but may be scanned if there is an indication.

Symptomatic

An urgent cranial ultrasound scan is indicated in the following circumstances:

- Blood pressure instability
- Significant fall in haemoglobin
- Seizures
- Cardiopulmonary arrest
- Metabolic acidosis (pH < 7.2, Base deficit > 10, increased lactate)
- Persistent apnoeas

Cranial Ultrasound Baseline Screening Protocol for Asymptomatic Preterm Infants

Less than or equal to 29+6 weeks (or less than 1000g)

Radiology Scan request	Neonatal Team Scan
	First 48 hours
Day 3 to 5 ***(up to day 7)***	
	Day 10 to 14 ***(up to day 21)***
Day 28 ***(up to day 35)***	
36 weeks corrected*	

(Radiology requests: First week, first month and 36 weeks corrected)
Symptomatic infants may need more frequent scanning (see previous pages)

From 30+0 to 32+6 weeks gestation

Radiology Scan request	Neonatal Team Scan
	Day 3 to 5 ***(up to day 7)***
36 weeks corrected*	

*The 36 week ultrasound scan correlates with outcome and can pick up pathology not seen on earlier scans. If discharge is planned before 36 weeks corrected please request a pre-discharge ultrasound scan, particularly if the infant is already more than 34 weeks gestation.

If the radiologists are unable to perform the scan on routine scanning days then the scan should be booked to be performed as an outpatient.

In the early stage of **ventricular dilatation**, twice weekly scanning should be performed until it is clear that the situation has stabilised. Measurement of the ventricular index can be readily performed by the neonatal team so that there should be no need for *radiology* scans to be requested more than once a week.

33 weeks and above (includes Term Infants)

Cranial imaging (type to be discussed with Consultant Radiologist) should be **urgently** performed in all term infants with skull fractures or abnormal neurology e.g.

- Seizures
- Extreme lethargy
- Meningitis
- Evidence of raised intracranial pressure

To look for evidence of:

- Haemorrhage
- Cerebral sinus and venous thrombosis
- Arterial infarction

Hypoxic-Ischaemic Encephalopathy (HIE)

Infants with grade II or III HIE should have a cranial USS within 48 hours of birth. A repeat cranial USS at a week can be considered, as ultrasound scan findings may be negative for 24-48 hours after a hypoxic-ischaemic insult.

The recommended timing for a cranial MRI is between 5 and 14 days. Changes in T1 and T2-weighted imaging (‘conventional’ imaging) may not be apparent before this time. Diffusion-weighted scans in the second week of life may be affected by ‘pseudo-normalisation’ (i.e. may give falsely negative results).

So, unless there are clinical reasons for an earlier scan, the aim will be to perform a scan on day 5 after the 72-hour period of cooling has been completed. This will allow useful information to be gathered from both conventional and diffusion-weighted imaging.

The important views on MRI are

- T1 and T2 weighted transverse images
- T1 sagittal image
- Diffusion imaging
- Susceptibility imaging (SWI) to identify blood products
- Spectroscopy may add information [15]

The table below shows the timing of hypoxic-ischaemic changes seen on the various MRI sequences (and comparison with ultrasound and CT). This is the main information taken into consideration when assessing the pros and cons of scanning at different times [22]:

Modality	Findings	Timing
Ultrasound	Increased echogenicity	2 to 10 days
CT	Low attenuation	1 to 7 days
MR imaging		
DW imaging	Restricted diffusion	1 to 5 days
T1-weighted sequences	T1 shortening	2 days to months
T2-weighted sequences	T2 prolongation*, T2 shortening†	24 hours, evolves over 6 to 7 days to months

*T2 prolongation is indicative of oedema †T2 shortening is indicative of mineral deposition

For conventional MR imaging, diffusion-weighted (DW) imaging is best on days 1 to 5 of life. T1- and T2-weighted sequences are sensitive after 2 to 3 days but best after 7 days. https://pubs.rsna.org/doi/10.1148/rg.344130080

Prognosis
Please do not discuss with parents without clarifying the USS findings with the attending consultant.

Recommended Information when requesting scans

- Include gestational age at birth, days post-delivery & corrected gestational age
- Current medical issues (e.g. intensive care, ventilated, inotropic support)

- Previous treatments and significant issues (e.g. steroids for CLD, surgery for NEC)
- Any significant findings on previous scans.

- The reason for requesting the scan (e.g. seizures, fall in haemoglobin)
- What is being looked for (e.g. white matter damage two or more weeks after a serious deterioration, possible haemorrhage or ischaemia)

3. Education and Training

- The cranial USS are performed and reported by the Consultant Radiologist where possible and when appropriate.
- Additional scans may be performed (or supervised) by the neonatal consultant or an SpR that has the appropriate competency.

4. Audit Criteria

1. All infants < 30 weeks (up to 29+6 weeks) should have a screening cranial ultrasound scan within 3 – 5 days (100%)
2. All infants <33 weeks (up to 32+6) should have a ’36 week’ cranial ultrasound.

5. Supporting References

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BAPM Framework for Practice: Neonatal Brain Magentic Resonance Imaging: Clinical Indications, Acquisition and Reporting (November 2023)
https://www.bapm.org/resources/neonatal-brain-magnetic-resonance-imaging

6. Key Words

Arterial infarction, Cerebral sinus thrombosis, Hypoxic-ischaemic encephalopathy, Intraventricular haemorrhage, Periventricular leukomalacia, TORCH, Ventricular dilatation,

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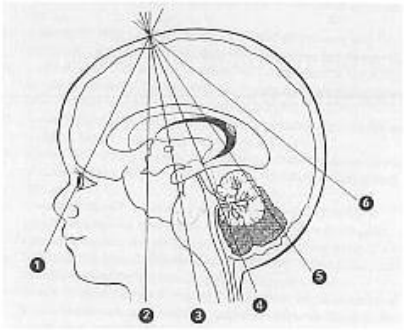
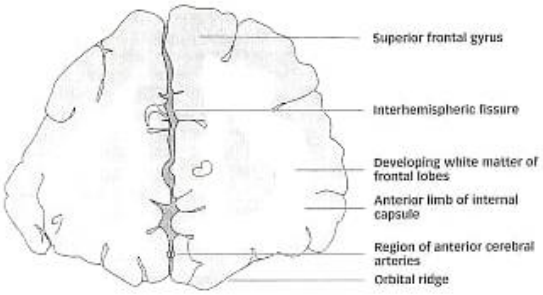
The Trust recognises the diversity of the local community it serves. Our aim therefore is to provide a safe environment free from discrimination and treat all individuals fairly with dignity and appropriately according to their needs.
As part of its development, this policy and its impact on equality have been reviewed and no detriment was identified.

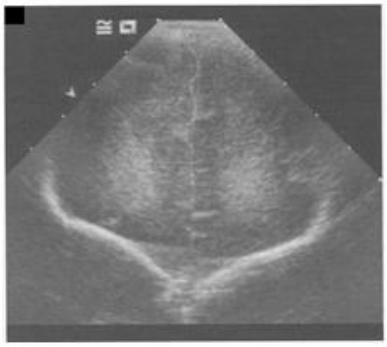
CONTACT AND REVIEW DETAILS			
Original Author: Robin Miralles Reviewed by: Kaseem Ajilogba **Guideline Lead (Name and Title)** Sumit Mittal – Neonatal Consultant			**Executive Lead** **Chief Medical Officer**
Details of Changes made during review:			
Date	**Issue Number**	**Reviewed By**	**Description Of Changes (If Any)**
September 2021	**2**	**Neonatal guidelines Neonatal Governance**	Updated Radiologist routine availability Timing of MRI in HIE infants ≥33 wks changed from between 5-14 days to day 4-5 or in second week (takes into account EDEN trial) unless there are clinical indications for doing it earlier Added the timing of hypoxic ischaemic changes seen on MRI sequences.
January 2025	**3**	Author, KM (neonatology) KA (radiology)	Removal of information on EDEN trial Addition of SWI to sequences performed Addition of BAPM framework for practice to the reference list Documentation of cranial ultrasounds section amended

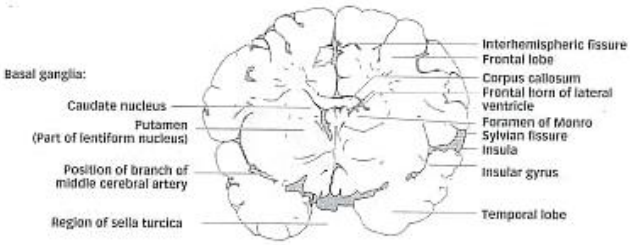
Appendix 1: Standard Ultrasound Views



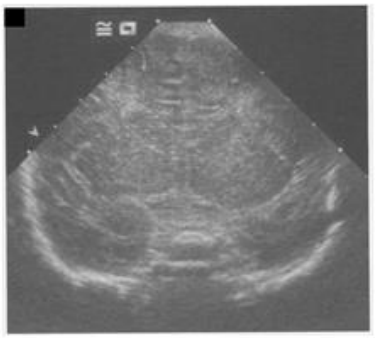


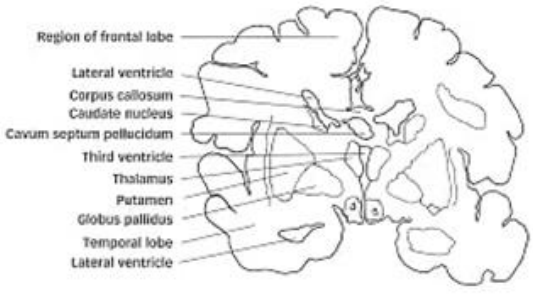
Frontal lobes



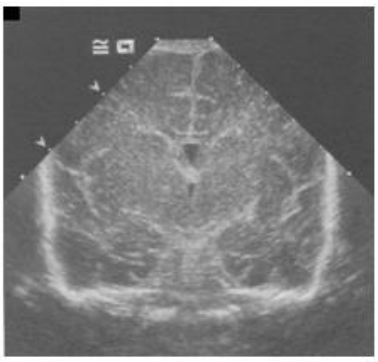


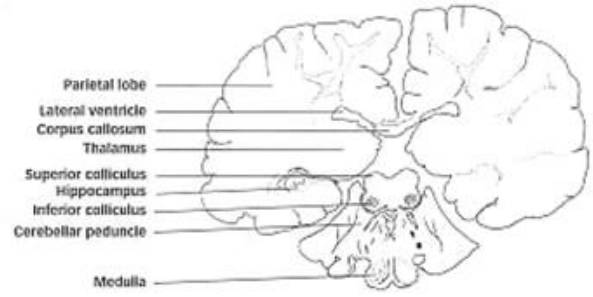
Anterior horns of the lateral ventricles



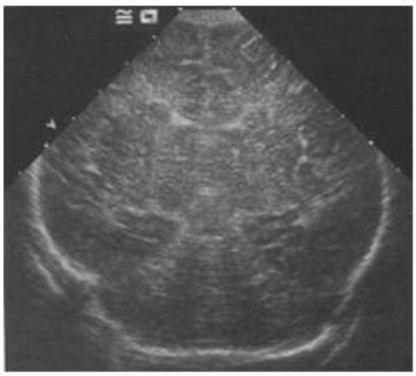


Third ventricle

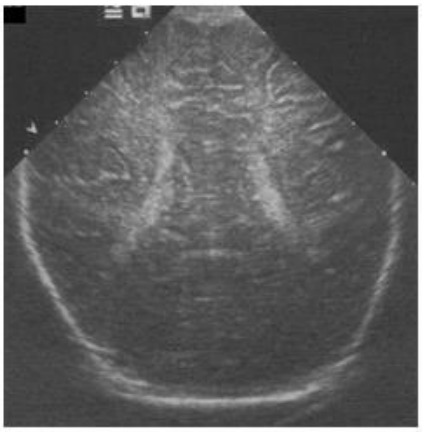


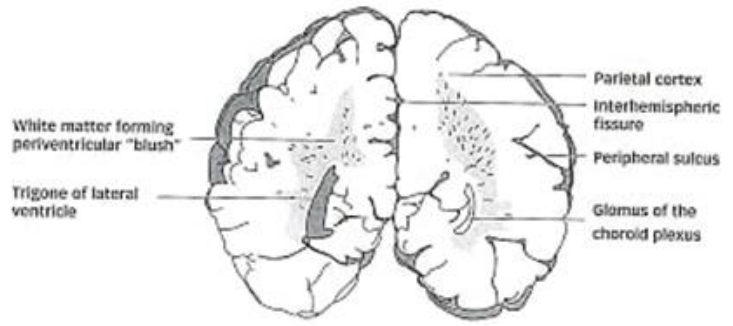


Posterior thalamus - hippocampus

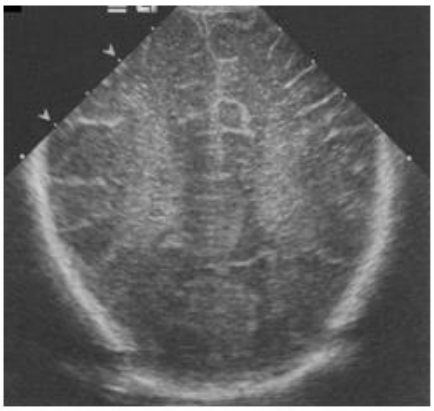


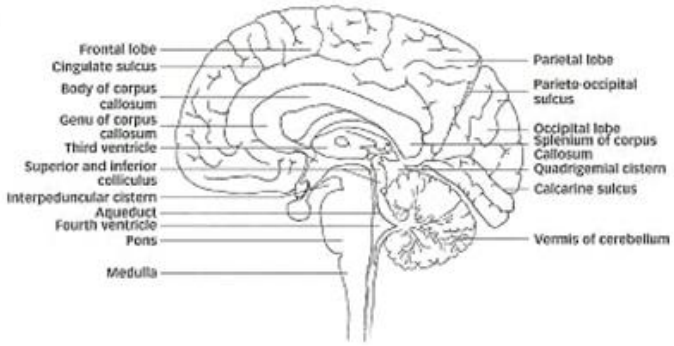
Trigone



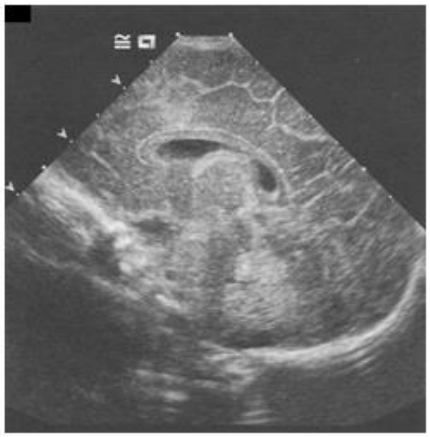


Occipital lobes

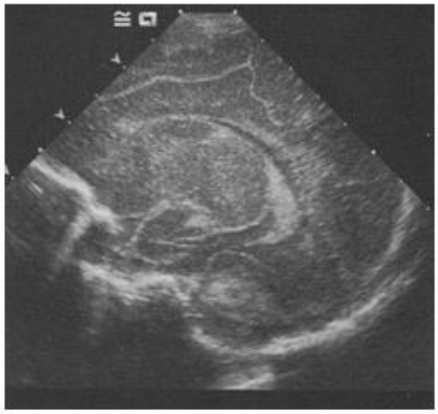


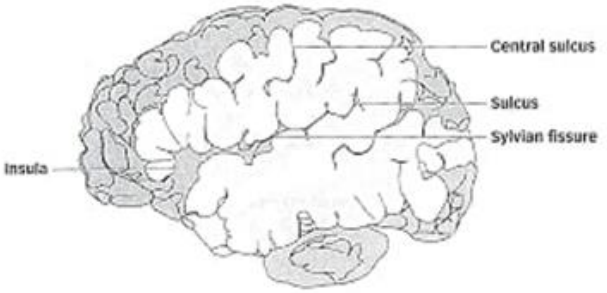


Midline

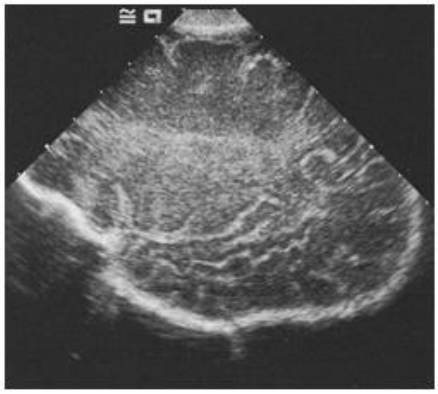


Parasagittal





Tangential parasagittal



Appendix 2: Ventricular Index Chart