"THE PATTERN OF INTRACRANIAL LESIONS DETECTED BY CRANIAL SONOGRAPHY IN INFANTS AT THE KENYATTA NATIONAL HOSPITAL, NAIROBI."

By

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DECLARATION

Candidate

This dissertation is my original work and has not been presented for a degree in any other University.

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CONTENTS

SUMMARY

A one year prospective study was carried out at the Kenyatta National Hospital (KNH) to establish the pattern of intracranial lesions detectable by cranial sonography in 100 infants. Patients were recruited from the paediatric wards and clinics with varied neurological signs and symptoms.

A real time, B mode scanner with 3MHZ and 5MHZ sector scanning transducers was used to obtain coronal and sagital images of the infants brains. The number of female infants practically equalled their male counterparts. 77% of the infants presented for scanning at or below 6 months of age. Thus 23% of the patients were aged between 7 months and 12 months.

The three commonest symptoms were convulsions, fever and enlargement of the head. The combined accounted for 88% of the presenting symptoms. A few patients had two or more presenting symptoms. Enlargement of the head especially when confirmed by measurement of the head circumference was found to be an important symptom and sign. Its presence is a strong indicator that a structural abnormality of the brain detectable by ultrasound is present.

Meningitis was the commonest clinical indication for requesting ultrasound evaluation and was diagnosed in 35 infants. Out of these, 30 infants (86%) had normal sonographic findings. 3 had previously unsuspected hydrocephalus and 2 had abscesses. This confirms the limited role of cranial ultrasound in acute meningitis.

Hydrocephalus was suspected clinically in 31 patients and confirmed by ultrasound in 27 of these patients, demonstrating good correlation between clinical suspicion and sonographic results. 10 unsuspected cases sent for other reasons were found to have hydrocephalus. Curiously, however, 22 female infants had hydrocephalus while only 15 male patients had sonographically demonstrated hydrocephalus. Also notable was the fact that all the abscesses and neoplasm were diagnosed in only male infants.

Intracranial hemorrhage was suspected in 11 patients but only confirmed in 4 cases (36%). The other 2 infants diagnosed by sonography to have hemorrhage in fact were sent with a different indication. Other findings at sonography included, abscesses, intracranial neoplasms, hydranencephaly and encephaloceles.

INTRODUCTION AND HISTORICAL PERSPECTIVES

The use of ultrasonic waves to create visual images of body structures began in the 1950s. Imaging techniques were then poorly understood, images difficult to interpret and results ambigous.

The human brain was one of the first organs to be systematically examined using A mode echoencephalography (Leksell). Initial attempts at two-dimensional brain scanning with a B-mode transducer met with variable success as a result of poor resolution and failure to penetrate the thick adult calcarium (Brinker). Detailed cross-sectional images of the infant brain were published by Kossof in 1974. The use of cranial sonography however did not gain much prominence until 1979. That year Pape first reported demonstration of hemorrhage sonographically in the preterm infant. A linear array transducer was applied to the side of the infant's head. This produced horizontal (transverse) slices of the brain similar in orientation to those produced by computerised tomography (CT) thereby allowing comparison.

In 1980, Dewsburry and Aluwihare and almost at the same time, Babcock and Han first reported using the anterior fontanelle as a large bone free window through which to image the brain. They used a B-mode static transducer.
In the short time since these early descriptions, transfontanellar ultrasound evaluation of the infants brain has become a widely used technique now regarded as the primary imaging modality for the infant brain.

MOTIVATION

In Kenya today, cranial sonography has not yet become established as an imaging modality. Bashir (1990) studied the incidence of intracranial hemorrhage in preterm infants at the Kenyatta Newborn Unit. To date, no other study has appeared in our literature concerning this very important field of paediatric neuroradiology.

The purpose of this study, is to create awareness among clinicians about the availability of this revolutionary imaging modality. The study aims to demonstrate the scope of intracranial lesions that can be diagnosed and followed up using a locally available ultrasound scanner operated by indigenous staff.

Computerised tomography is a parallel imaging modality which is much more expensive, less accessible for the patients and less portable for the radiologist and employs ionising radiation. By showing that most intracranial disease processes usually evaluated by CT can effectively and cheaply demonstrated by cranial sonography, the number of requests for paediatric CT scans should decline. This will considerably reduce the cost of health care at the paediatric unit.

LIMITATIONS OF THE STUDY

The available clinical information in the request forms was usually very scanty and tailored to justify ultrasonic examination. Because of this, many infants would be sent for sonographic examination with irreproducible neurological signs.

The availability of only one good quality scanner was a major setback in this study. Many infants would have to wait for long hours away from good resuscitation facilities. Thus many very sick neonates with possible intracranial hemorrhages had to be managed without radiological evaluation.

It was difficult to obtain computerised tomographic (CT) correlation where ultrasound diagnosis was not definite. While surgical confirmation was obtained for all intracranial abscesses detected sonographically, only 2 out of 4 (50%) of intracranial mass lesions were histologically confirmed.

There were problems in obtaining good follow up in many cases. Many infants with hydrocephalus would be sent home to buy shunt equipment and a good number would not come back again.

ETHICAL CONSIDERATIONS

Ultrasound is an effective and relatively cheap imaging modality for the evaluation of intracranial disease processes. It is also much more readily accessible to the patient and a portable tool for the radiologist (or technologist) compared with CT or MRI.

No untoward effects have been proven with the use of ultrasound in the diagnostic range. Heating and cavitation occur at energy levels way above those used in diagnosis. Its non usage of ionising radiation makes it ideal for infant imaging without the attendant risk of future carcinogenesis.

With portable equipment, now available in this hospital, one can examine critically ill and severely premature infants under intensive care in their incubators. This way, assisted ventilation and monitoring need not be interrupted during examination and temperature loss does not present a problem. Further, no special preparation or premedication is necessary.

OBJECTIVES OF THE STUDY

Broad Objectives

1. To show the pattern of intracranial lesions detected by cranial sonography in infants at Kenyatta National Hospital.

2. To demonstrate the use of ultrasound in the follow up of these patients.

3. To establish the appropriate technical factors for producing the most informative images of the various age groups. These include transducer shape, frequency and ultrasonic planes which give the most information.

Specific Objectives

1. To show the age and sex distribution of patients sent for cranial sonography.

2. To determine the age at which various intracranial disease processes present or are identified.

3. To establish the most common presenting symptoms and relate this to their accuracy in predicting structural abnormalities of the brain detected by ultrasound.

4. To determine the most appropriate transducer type and frequency as well as essential imaging plane for providing ultrasound information.

LITERATURE REVIEW

Cranial sonography has been studied by various workers regarding its role in the detection of intracranial disease. Anisa Bashir studying preterm infants born at a gestation of less than 32 weeks or a birth weight less than 1500g found a high incidence of intracranial hemorrhage. Even then, the reported incidence of 37% is low when compared with 50% reported by Burnstein and Papile. Diane Babcock working at the Childrens Hospital Centre in Cincinnati,Ohio found an incidence of 55% among preterm infants.

90% of hemorrhages occur in the first 7 days of life but only 30% are found in the first 24 hours (Bacock). This suggests that screening should be performed at the end of the first week of life. Of course patients presenting earlier would be scanned at presentation. Roy found hemorrhage occurring after the first post partum week in 17 infants. He however did not report the total population under evaluation. This goes on to disapprove older beliefs that intracranial hemorrhages occur primarily in the first 4 days of life (Han). It is notable that the later hemorrhages are usually confined to the germinal matrix and may only have minimal neorological consequences.

Hemorrhages are classified into germinal matrix hemorrhage, intraventricular as well as intraparenchymal hemorrhage (Rumarck). Intraparenchymal hemarrhage is the least common accounting for 11-26% of hemorrhages in preterm infants (Burstein) but carries the worst prognosis (Banker, Sinnar). Bleeding into

the ventricles and brain parenchyma is presumed to develop by direct physical extension of germinal matrix hemorrhage. It carries a mortality rate anywhere between 25% and 69% (Banker). Once demonstrated an adverse neurodevelopmental outcome is predictable in 54% (Stewart).

Respiratory distress with presumed cerebral hypoxia plays a central role in the aetiology of white matter hemorrhage (Stewart). In some patients periventricular leukomalacia could have preceded hemorrhages and the latter always erupted in territories previously affected by periventricular leukomalacia. Flodmark working with others have shown computerised tomographic/autopsy correlation that parenchymal hemorrhages in the premature neonate represent secondary hemorrhage within periventricular infarcts or periventricular leukomalacia with secondary hemorrhage into it. The same was shown in another autopsy based study by Donat. Pope and Wigglesworth identified primary white matter hemorrhages that were thought to represent secondary hemorrhage into infarcted brains.

Recent literature highlights the unique capabilities of magnetic resonance imaging to pick myelin defects within the infant brain (Dubowitz) and can assess later progress of myelinization. In his study, Don imaged 24 infants diagnosed sonographically to have periventricular leukomalacia using magnetic resonance imaging (MRI).

Abnormalities were accurately picked and characterised into poor outcome and good outcome groups. He however concludes that ultrasound should remain the primary modality for evaluation of these patients. There is consensus about this. This point is further emphasised by a comparative study between sonography and magnetic resonance imaging (Dubowitz) which showed that the presence of periventricular leukomalacia detected by ultrasound had a better predictive value of the neunodevelopmental outcome than did MRI.

Ultrasound is also effective in the detection of parenchymal abnormalities in patients with hypoxic ischaemic encephalopathy (Babcock). Cortical grey matter and basal ganglia are more often involved by ischaemic damage and hypoxia. This can result in cerebral oedema and necrosis of both white and grey matter. Some ultrasound findings in cerebral oedema include obilteration of the ventricles, sulci and inter hemipheric fissure with mild diffuse increase in brain parenchymal echogenicity. A decrease in intracranial vascular pulsations may be noted with real time sonography. The brain parenchymal echo may be abnormal with areas of dystrophic calcification. Some patients experience diffuse cystic encephalomalacia with destruction of brain parenchyma (Babcock). Babcock in a retrospective study found an accuracy of ultrasound in diagnosing brain injury in full term infants with birth asphyxia to be 71% (sensitivity) during the acute phase and 89% on delayed studies. An

abnormal result showing cerebral atrophy or cystic encephalomalacia is accurate for predicting an abnormal neurological outcome and ultrasound can be used to screen these infants (Han).

Confusing ultrasound images may sometimes be seen. While we know that low level echoes are a feature of various body fluids including ascites, abscesses and flowing venous blood, this has not been mentioned as a picture of progressing hemorrhage (Edward). This has now been seen in upto 50% of patients with significant post hemorrhagic hydrocephalus especially with high frequency transducers. The cause of this as well as its relationship to the original hematoma however is less clear. Probably this low level echogenicity merely represents a normal phase of thrombolysis when it occurs in cerebrospinal fluid (Verness). No relationship has been established between the presence of low level echogenicity and severity of post hemorrhagic hydrocephalus (Edward). Occassionally it signifies ventriclitis a consideration of utmost importance knowing its important consequences (Verness).

Previous data on longitudinal follow up of low birth weight babies is scanty and incomplete. Clinical studies of low birth weight infants who have suffered intracranial hemorrhage suggest that at 2 years of age, only 40% are neurologically normal (Krishina). Wilbur found on overall incidence of abnormality to be 37%. This is quite low when

compared with the results of Burstein and much lower than the incidence reported by Babcock. However when he corrected for lower gestational age, the result of 46% was closer to internationally reported in the 0-5 - 1.5 Kg weight range. Wilbur found persistent ventriculomegally in an unselected infant population to be 12%. This becomes larger (17%) when one follows only infants with documented intracranial hemorrhage. Follow up of infants who survived grades III and IV intracrnial hemorrhages gave frightful results. The incidence of persistent ventriculomegally in these is 72% at 12 months of age (Chuang). The conclusion to be arrived at here is that ultrasound is of value in predicting whether an anatomical abnormality will persist especially if the ventricular dilatation worsens or if there is no definite improvement within the first two months after birth.

Infants with idiopathic ventricular dilatation present a diagnostic problem (Chuang). They may have mild ventricular dilatation without sonographic evidence of intracranial hemorrhage for the whole duration of follow up. Their examination at 6 months did not reveal gross neurological defects. These infants could have had subarachnoid hemorrhage or mild intraventricular hemorrhages undetected by ultrasound. However lack of progress make this unlikely (Chuang). Alternatively the findings could represent secondary atrophy to an in utero insult but again, this would be expected to progress.

Wilbur postulates that this represents a normal variant confirming the wide range of normal ventricular sizes.

Congenital infections may have serious consequences on the fetus and newborn including gross congenital malformations. The commonest encountered infections include toxoplasmosis, rubella, cytomegalovirus, herpes type II and syphillis (Volpe). Sonographic findings in cytomegalovirus vary with the stage of the disease (Frank). Early infection begins with a necrotizing periventricular inflammation with a predilection for subependymal germinal matrix. Sonography shows this as an area of increased periventricular echogenicity and parenchymal architectural distortion. Typical findings of periventricular calcification are commoner after birth (Frank). Subependymal cysts can be a sequelar of cytomegalovirus infection but is also seen in toxoplasmosis. Microcephaly is common.

Toxoplasmosis is the second most common congenital infection (Frank), worse outcomes are to be expected when the infection is acquired earlier in pregnancy. Classical sonographic findings include scattered calcification in the brain (Rumarck) with predilection for basal ganglia (Diebler). Some may be periventricular (Collins). Destructive lesions resulting in multicystic encephalomalacia and poroencephaly may occur in the most severe early gestational infections. Hydrocephalus from aqueductal stenosis or resorption of necrotic material is common with

ventricular dilatation of the posterior horns of the lateral ventricles predominating (Rumack).

Herpes type II infection is commoner in the neonate, type I causing disease in older children and adults (Florman). Most infected infants suffer major destructive lesions of periventricular white matter. cystic encephalomalacia of the periventricular while matter and hemorrhage infection with scattered calcifications is seen (Benator). Relative sparing of the lower neural tissue including the basal ganglia, thalamus and cerebellum and brain stem is typical. Infections acquired in utero may lead to microcephaly intracranial calcifications and retinal dysplasia (South).

The frequency of rubella has declined in the west due to widespread use of rubella vaccine since 1961 but remains a common problem elsewhere (Rumack). Rubella is not known to cause cerebral malformation (Levene). A case described by Levene showed echogenic calcifications in the basal ganglia confirmed at autopsy. Subependymal cysts (Shaw), microcephaly vasculopathy (Frank) and massive calcification are reported.

Edward also found intracranial calcification in young infants to be abnormal. It was associated with intrauterine infections mentioned above but also with tuberous sclerosis, tuberculosis and tumour. In the above study intracranial calcification was better picked by computed tomography than ultrasound.

Ventriculomegally was reported by Bonido and Storving to be the most common complication of meningitis. However Han found ventriculomegally in only 14% of 78 patients with proven bacteriological meningitis. It is usually reversible (Babcock). Occassionally it may progress to obstruction or loss of brain tissue. Therefore if ventriculomegally is discovered at an early stage, follow up sonography is recommended. If ventricles are of normal size then follow up head circumference as well as neurological evaluation will suffice (Han).

Echogenic sulei and increased extraaxial fluid appear to be the more commoner sonographic findings in meningitis than ventriculomegally (Han). They are also transient and probably represent pial and arachnoidal inflammation. Significant subdural effusions are common and so are subdural empyemas. Reeder recorded ventriculitis in 65-90% of confirmed cases of meningitis concluding like Han did that this is the commonest complication of meningitis. He however found ventriculitis to cause considerably increased morbidity and mortality. This state is though to represent a reservoir and protected site for infecting organisms making it difficult to treat (Reeder). Many of these patients with ventriculitis go on to develop parenchymal brain damage possibly mediated by versculitis and subsequent thrombosis and brain necrosis. Rosenberg recommends screening in all patients with proven bacterial meningitis having picked a complication rate of 75%. Han and Babcock give an exactly opposite recommendation because none of the patients they evaluated who had sonography without

clinical evidence of complications showed clinically significant findings at ultrasound. They therefore recommend that ultrasound should be performed only when there is clinical evidence of a complication.

Harwood lists some sonographic features of ventriculitis. They include:-

. Hydrocephalus.

. Echogenic debris in the ventricle.

. Increased echogenicity of ependyma.

. Shaggy ependymal lining and fibrous septa.

The intraventricular septa should be recorded because they can be problematic for shunting of hydrocephalus. Sequestered compartments within the ventricles can cause shunt failure or allow bacteria to escape antibiotic attack. Abscess formation and infarction are common complications of meningitis (Frank). Later one may get ponoencephaly or cystic encephalomalacia in bacterial meningitis.

Most brain tumours presenting before 2 years are congenital (Chuang). Sonography does play an important role in screening the infant brain and can accurately delineate the tumour site size and anatomical relationship as well as evaluate, cystic solid and vascular components. Chuang reports that only 11% of children with brain neoplasm present below 2 years of age. Although that uncommon, they are the second most common malignant neoplasm found in infants after neuroblastoma (Farwell). Brain tumours present with signs and symptoms of hydrocephalus and increased intracranial pressure such

as an enlarging head, vomitting, behavioural alteration and abnormal eye movements (Jooma).

Tumour location under one year differs from that in older children supratentorial neoplasms outnumber intratentorial neoplasm by a ratio of 2.5:1 (Jooma/Han). Neoplasms may present initially as hemorrhage and may be extremely difficult to differentiate from a simple hematoma. Rumack and Johnson recommend a search for an occult neoplasm any time hemorrhage occurs in unusual circumstances or in an unusual location. Follow up imaging may be of value as clotting from hemorrhage will resolve allowing the tumour to be more easily visualised.

Cystic lesions of the brain are quite common and ultrasound of the brain is the best method for evaluating such masses. Most are benign (Maravilla). Arachnoid cysts are the commonest true cysts of the brain but they only make up 1% of space occupying lesions of the brain in children (Chuang). They are cerebrospinal fluid containing spaces between two layers of arachnoid. Primary cysts are believed to result from abnormal splitting of the arachnoid and from cerebrospinal fluid collecting between the two layers. Secondary cysts develop when cerebrospinal fluid becomes trapped between arachnoid adhesions (Chuang). Those in the midline may grow and cause obstruction of the ventricular system (Armstrong). They also tend to be associated with other congenital anomalies (Youssefzadeh) and frequently the corpus callosum is absent.

Ponoencephalic cysts occur as a result of brain necrosis and cavitation which is continous with the ventricular system.

They are usually the result of parenchymal hemorrhage, infection or surgery (Chuang). Chorad plexus cysts are common but are usually asymptomatic. They occur at all age groups and are found in 34% of fetuses and infants at autopsy. They should not be confused with subependymal cysts. It appears as a cystic mass within the chroid plexus with well defined walls (Fahry). Rare cases of symptomatic choroid cysts causing obstructive hydrocephalus have been described (Giongi) but are related to some specific cause rather than a normal variant.

Subependymal cysts present as a disarete cyst in the lining of the ventricles. They are as a result of a variety of causes including hemorrhage, infection and ischaemia. Shaw and Aluord have coined the term subependymal germinolysis to describe the cause of subependymal cysts in full term infants. This is because the cysts in full term infants at autopsy do not contain hemosiderin and therefore are not secondary to hemorrhage. They proved a viral cuase in 23% (Horbar) although Escherichia coli has been implicated.

The evaluation of increased head size in infants is a common problem to many pediatricians. Measurement of head circumference is a standardized and a central part of the clinical examination and the reading can be compared with published charts according to sex and age (Hamil). Babcock examined 255 infants referred because they had enlarged heads and found an incidence of intracranial disease was

only 5.6%. This is much less than 75% quoted by Kingsley in a computerised tomography based study. The increased cost and ionising radiation involved probably influenced patient selection in the later case. In her study Diane went on to show good correlation between ultrasound and computed tomography thus proving that lower percentages reported by sonography were not due to underdiagnosis. These studies conclude that an infant with an enlarged head should have a neurological examination and a head circumference measurement taken. If this is greater than the 95th percentile and particularly if there are positive neurological findings, ultrasound will be used as the first imaging modality. Computed tomography is indicated if there is significant abnormality requiring further clarification or when the child becomes too old for transfontanellar sonography (Babcock).

Hydrocephalus may result from obstruction of the cerebrospinal fluid pathways by clot or organising ependymitis or basilar arachnoiditis (Harwood). Hydrocephalus may also be seen in association with neural tube defects and as a complication of meningitis. As the lateral ventricles dilate in progressive hydrocephalus, it is frequently the posterior horns which show the most severe dilatation. The foramina of Monroe are readily identified in these infants. Serial measurements will identify those who may require ventricular shunting and those only needing medical treatment (Harwood). The incidence of hydrocephalus was

noted to increase with increased severity of neural tube defects.

A variety of congenital malformations of the brain can be diagnosed by ultrasonography (Babcock). Congenital hydrocephalus is most commonly due to aqueductal stenosis (Babcock). Communicating hydrocephalus may also be seen in the newborn secondary to infection or hemorrhage or due to an in utero event not apparent at the time of birth (Han). Chiari malformations have been classified into 4 types by Rumack. Chiari I malformation is simply the downward displacement of the cerebellar tonsils without displacement of the fourth ventricle or medulla oblangata. Chiari II malformation is the most common and of greatest clinical importance because of its almost universal association with meningomyelocele (Harwood). It involves downward herniation of the cerebellar tonsils along with caudal displacement of the pons and medulla, through an enlarged Foramen magnism into the upper cervical spinal canal. The fourth ventricle is also elongated into the upper spinal canal and the posterior fossa is small (Byrd). Chiari III malformation is a high encephalomeningocele in which the medulla, 4th ventricle and virtually all the cerebellum reside. Chiari IV malformation refers to a severe hypoplasia of the cerebellum without displacement although many authors do not consider this to be part of the Chiari malformation (Harwood).

Dandy Walker malformation is classically thought to be secondary to agenesis of the foramina of Luschka and Magendie in the first trimester of pregnancy. The current theory is that the Dandy Walker cyst develops as a result of malformations of the roof of the fourth ventricle rather than obstruction (Babcock). The posterior fossa is enlarged or distorted with elevation of the tentorium cerebelli (Tay). Hypoplastic cerebellar hemispheres are usually symetric but can be asymetric. The inferior cerebellar vermis is rudimentary or absent. The Dandy Walker variant is more common. Sonographically it looks similar with a smaller posterior fossa cyst and less severe hydrocephalus (Fitz). The Dandy Walker syndrome is associated with other anomalies in 68% of cases (Hart). These include agenesis of the corpus callosum, microcephaly encephalocele unfundibular hamartoma, aqueductal stenosis, posterior fossa lipoma, heterotopia, syringomyelia and gyral malformation (Hart). Arachnoid cysts can cause confusion but these can be distinguished because of lack of communication with the fourth ventricle (Harwood, Naidich).

Hydranencephaly is a term derived from a combination of hydrocephalus and anencephaly. Since the cranial vault and meninges are present however, the term is inaccurate (Wolper, Strotter). Hydrencephaly is probably more accurate but the former has more established usage. The most quoted aetrological mechanism is intrauterine infarction of cerebral structures due to supradinoid obstruction of the internal carotid artery (Yu Kovlev). Massive cerebral

destruction has similarly been produced in association with specific entities such as congenital herpes, toxoplasmosis and equina virus infections (Aerzen). A specific clinical non-radiographic diagnosis is impossible since other entities may present with macrocephaly and transillumination (Crome). While sonography may show most features, computed tomography and occasionally angiography may be necessary before a diagnosis can be made (Dublin). Even at computed tomography appearances of hydranencephaly can be simulated by massive subdural effusions, massive hydrocephalus and alobar holoprosencephaly or severe post infective entities (Dublin).

Lisencephaly (agyria) is a rare syndrome due to interruption of normal neuronal migration from a peri-ventricular matrix to a cortical surface and takes place in the first trimester of fetal life (Babcock). Total or partial, agyria, brain atrophy with ventricular dilatation, increase of cerebrospinal fluid space and cisterns, wide sylvian fissure and incomplete or absent epercularisation of the insula can be seen (Harwood). Prognosis is poor and death occurs within 18-24 months after birth due to recurrent infections (De Meyer).

A 10MHZ ultrasound probe increases the diagnostic capability. The pseudoliver homogeneous and smooth echo pattern of the brain cortex is pathognomonic of lisencephaly (Babcock). Holoprosencephaly results from incomplete clearage of the prosencephalon. Facial anomalies

are associated (Harwood) as well as maternal diabetes, trisomies 13, 15 and 18 as well as congenital rubella.

Absence of the corpus callosum may be partial or complete owing to agenesis before the twelfth week. Absence of the corpus callosum may be associated with polymicrogyria, cortical heterotopias, intracerebral lipomas, encephaloceles, Dandy Walker syndrome, cyclopia, arachnoid cyst and psychamotor anomalies (Babcock). Davidoff and Dyke described the classic signs of this syndrome and pneumo-encephalography. Their findings are applicable to ultrasound and include:-

1. Marked separation of the frontal horns and bodies of the lateral ventricles.
2. Narrow frontal horns.
3. Sharply angled lateral peaks of the lateral horns.
4. Relative dilatation of the occipital horns.
5. Concave medial border of the lateral ventricles due to protrusion of bundles of the cingulate gyrus.
6. Elongation of the foramen of Monro.

MATERIALS AND METHODS

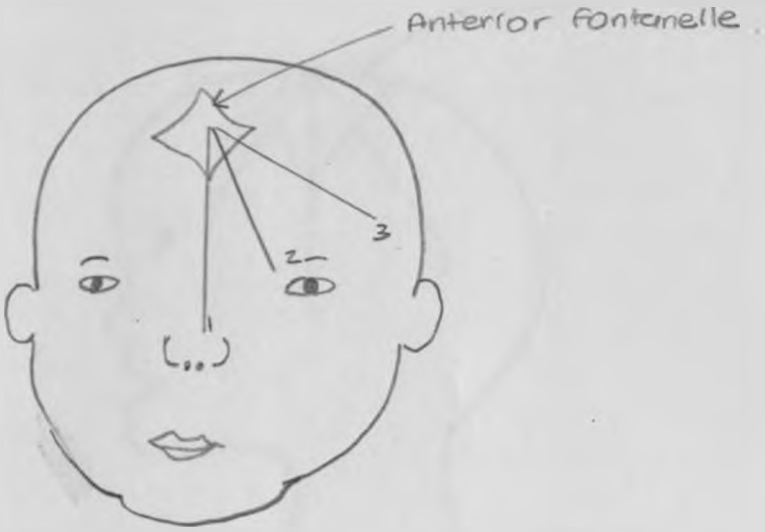
The study was carried out at the Kenyatta National Hospital's Radiology Department. 100 infants were referred for cranial sonography from various pediatric wards and clinics. A Phillips real time ultrasound (Orion model) was used. It has a 3MHZ, 5MHZ and 7.5MHZ sector scanning transducers. In addition it has a long 4MHZ linear array transducer which was not used for cranial sonography. Ultrasonic gel made by Aquasonics Limited was used as coupling medium. No sedation or premedication was necessary. Informed consent was obtained from the infant's mother.

Infants were scanned lying supine, on the side or on the mothers' lap or even when breastfeeding. Care was taken to keep the infants warm at all times to prevent hypothermia. All these ensured maximal cooperation from the babies. Images were obtained in cornonal sagittal and axial scan planes and the results recorded in a questionnaire, a copy of which is attached at the end of this write up. The anterior fontanelle was identified by palpation.

Coronal Scans

These were obtained through the anterior fontanelle, advantage being taken of the brain symetry in this plane.

3 images were taken as shown below.



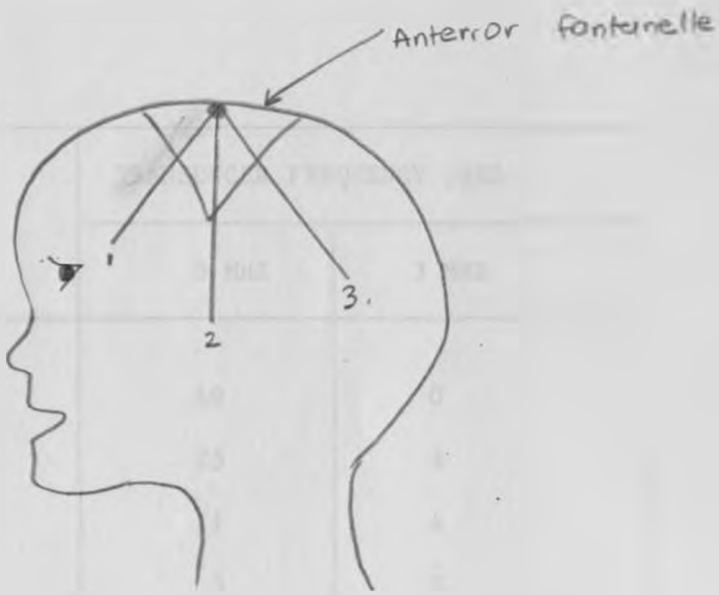
Sagittal Scanning

Sagittal images were obtained through the anterior fontanelle with the point of the transducer towards the babies nose. The first is a midline scan showing the midline structures including the falx cerebri, third ventricle and fourth ventricle, septum pellucidum and cerebellar vermis.

A 15^{o} lateral angulation shows the full sweep of the lateral ventricles, the thalami and caudate nucleus.

A 30^{o} lateral angulation passes through the sylvian

fissure and contained branches of the middle cerebral arteries.



Axial Scanning

Axial or horizontal images of the brain are obtained by placing the transducer on the thin part of the temporal bone (squamous temporal).

The point of the transducer takes the same plane as the orbitomeatal line thus producing images comparable to computed tomography. The first image is obtained at the level of the cerebral peduncles, a second image is taken at the level of the thalami.

The axial imaging plane is also called the plane of three lines. Passes through the lateral ventricles on either side and the midline.

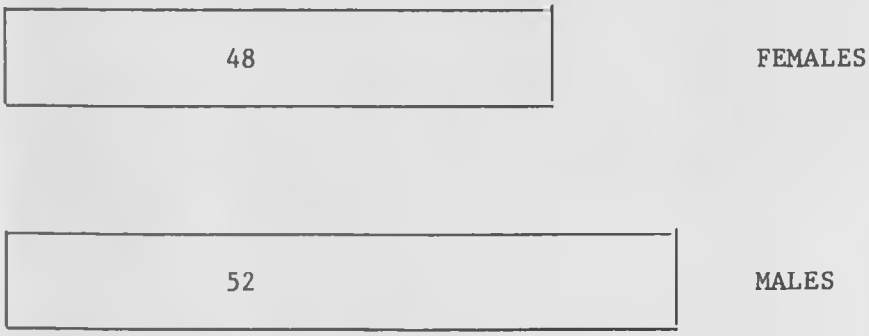
RESULTS

TABLE 1

AGE	TRANSDUCER FREQUENCY USED	
	5 MHZ	3 MHZ
0-3 Months	49	0
4-6 Months	25	3
7-9 Months	11	4
10-12 Months	3	5

TYPE AND FREQUENCY OF TRANSDUCER USED IN 100 PATIENTS

TABLE 2



SEX DISTRIBUTION

TABLE 3

AGE	NUMBER	PERCENTAGE
0 - 3 Months	49	49%
4 - 6 Months	28	28%
7 - 9 Months	15	15%
10 - 12 Months	8	8%
TOTALS	100	100%

AGE DISTRIBUTION

TABLE 4

SYMPTOM	FREQUENCY
Convulsions	38
Enlarged Head	36
Fever	31
Failure to Thrive	9
Nasal Swelling	2
Occipital Swelling	1
Asphyxia	5
Delayed Milestone	1
Coma	1

FREQUENCY OF PRESENTING SYMPTOMS

TABLE 5

SIGN	FREQUENCY
Increased Head Circumference	41
Bulging Fontanelle	24
Sunset Eyes	12
Dull	5
Floppy	5
Ethmoidal Swelling	2
Occipital Swelling	1
Normal Findings	16

FINDINGS AT PHYSICAL EXAMINATION

TABLE 6

WORKING DIAGNOSIS	FREQUENCY	PERCENTAGE
Meningitis	35	35%
Hydrocephalus	31	31%
Intracranial Bleed	11	11%
SOL	8	8%
Abscess	8	8%
Failure to Thrive	2	2%
Birth Asphyxia	2	2%
Ethmoidal Encephalocele	2	2%
Occipital Encephalocele	1	1%

WORKING DIAGNOSIS

TABLE 7

DIAGNOSIS BY ULTRASOUND	FREQUENCY	PERCENTAGE
Normal Scan	44	44%
Hydrocephalus	37	37%
Intracranial Bleed	6	6%
Cerebral Abscess	4	4%
Cerebral Neoplasm	3	3%
Hydranencephaly	2	2%
Ethmoidal Encephalocele	2	2%
Occipital Encephalocele	1	1%
TOTAL	100	100%

ULTRASOUND DIAGNOSIS

TABLE 8

FINDINGS	0-3/12	4-6/12	7-9/12	10-12/12	TOTAL
Normal Scan	22	14	5	3	44
Hydrocephalus	17	10	6	4	37
Intracranial Bleed	6	0	0	0	6
Cerebral Abscess	0	2	2	0	4
Cerebral Neoplasm	1	0	2	1	4
Hydranencephaly	1	1	0	0	2
Ethmoidal Encepalocele	1	1	0	0	2
Occipital Encephalocele	1	0	0	0	1
TOTALS	49	28	15	8	100

ULTRASOUND DIAGNOSIS TABULATED AGAINST AGE OF THE PATIENT.

TABLE 9

FINDINGS	MALE	FEMALE	TOTAL
Normal Scan	21	23	44
Hydrocephalus	15	23	37
Intracranial Bleed	3	3	6
Cerebral Abscess	4	0	4
Cerebral Neoplasm	4	0	4
Hydranencephaly	1	1	2
Ethmoidal Encephalocele	0	2	2
Occipital Encephalocele	0	1	1
TOTAL	48	52	100

SONOGRAPHIC FINDINGS TABULATED AGAINST SEX OF THE PATIENT

TABLE 10

COMMUNICATING	History of Meningitis	26
	No history of Meningitis	7
NON-COMMUNICATING	History of Meningitis	2
	No history of Meningitis	2
TOTAL		37

TABLE 11

		CONVULSION		
		Yes	No	Row Total
ULTRASOUND	NORMAL	28	16	44
	ABNORMAL	10	46	56
	COLUMN TOTAL	38	62	100

Convulsions as a Predictor of an Abnormal Ultrasound.

P<0.05 (By Chi squared statistics)

TABLE 12

		FEVER		
		Yes	No	Row Total
ULTRASOUND	NORMAL	19	25	44
	ABNORMAL	12	44	56
	COLUMN TOTAL	31	69	100

Fever as a Predictor of an Abnormal Ultrasound.

P<0.05 (By Chi square statistics)

TABLE 13

		ENLARGED HEAD		
		Yes	No	Row Total
ULTRASOUND RESULT	NORMAL	3	41	44
	ABNORMAL	33	23	56
	COLUMN TOTAL	36	64	100

Enlarged Head as a Predictor of an Abnormal Ultrasound.

P<0.05 (using Chi squared statistics)

TABLE 14

		INCREASED HEAD CIRCUMFERENCE		
		Yes	No	Row Total
ULTRASOUND	NORMAL	2	42	44
	ABNORMAL	39	17	56
	COLUMN TOTAL	41	59	100

Increased Head Circumference as a Predictor of an Abnormal Ultrasound.

$P<0.05$ (using Chi squared statistics)

TABLE 15

		BULGING FONTANELLE		
		Yes	No	Row Total
ULTRASOUND RESULT	NORMAL	6	38	44
	ABNORMAL	18	38	56
	COLUMN TOTAL	24	76	100

Bulging Fontanelle as a Predictor of an Abnormal Ultrasound.

$P<0.05$ (by Chi squared statistics)

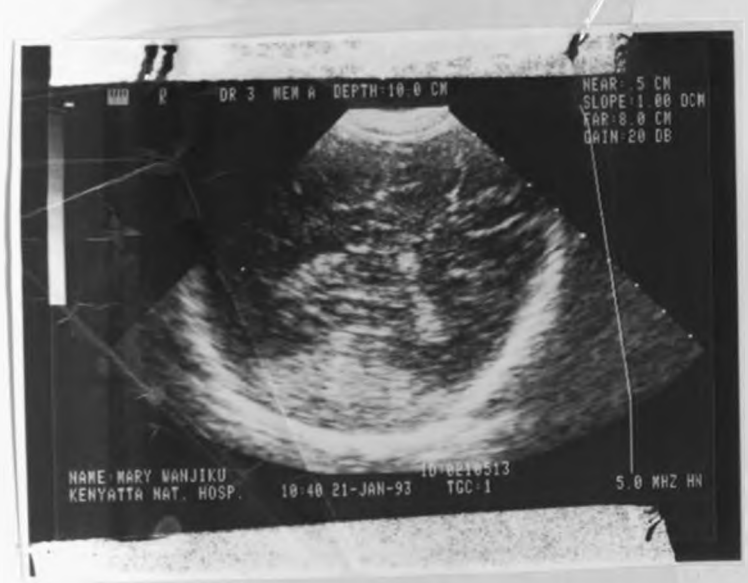
TABLE 16

		SUNSET EYES		
		Yes	No	Row Total
ULTRASOUND RESULT	NORMAL	0	44	44
	ABNORMAL	12	44	56
	COLUMN TOTAL	12	88	100

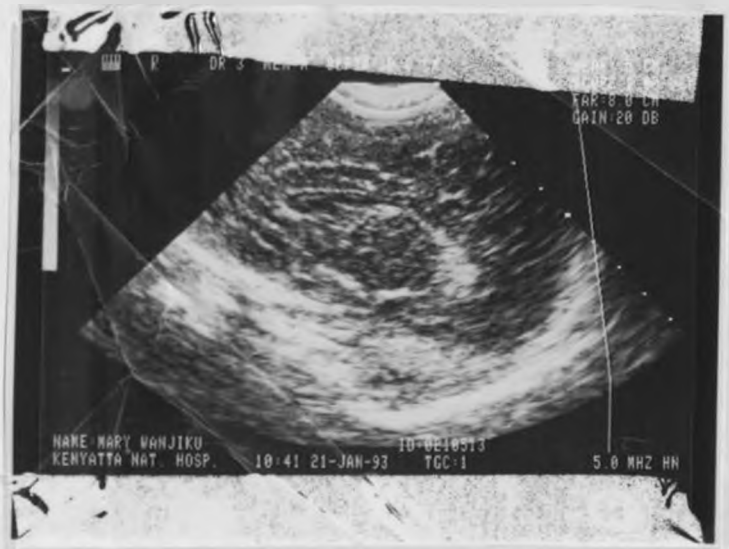
Sunset Eyes as a Predictor of an Abnormal Ultrasound.

$P<0.05$ (by Chi squared statistics).

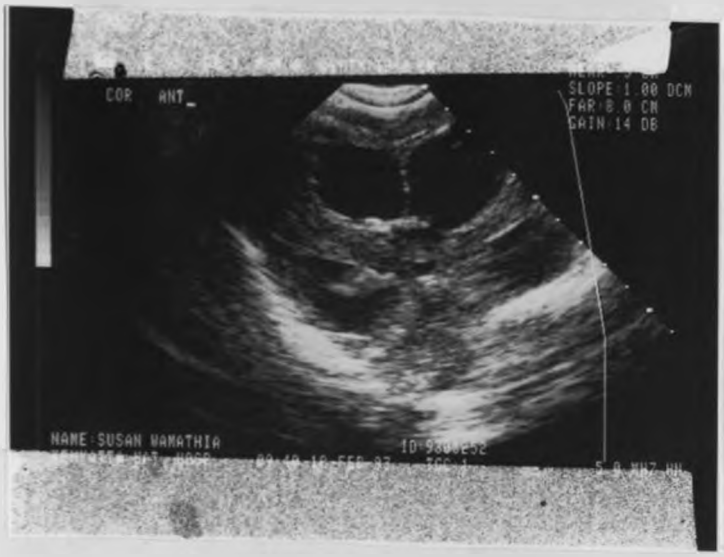
Normal Coronal Scan



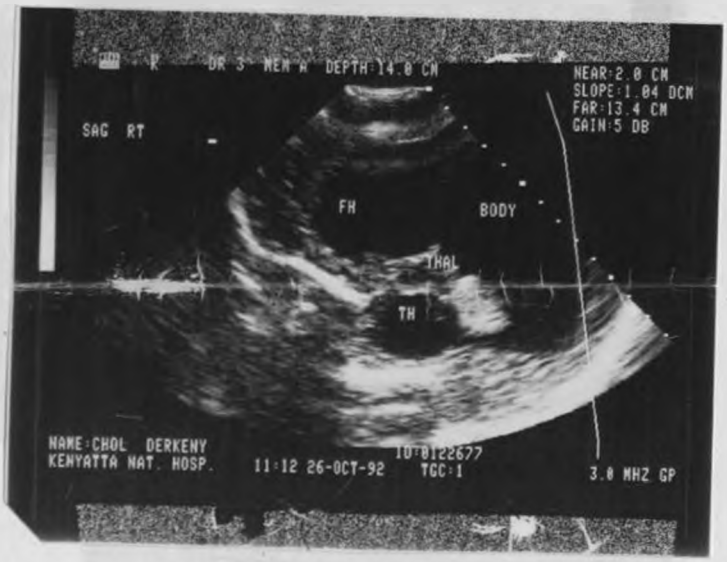
Normal Saggital Scan



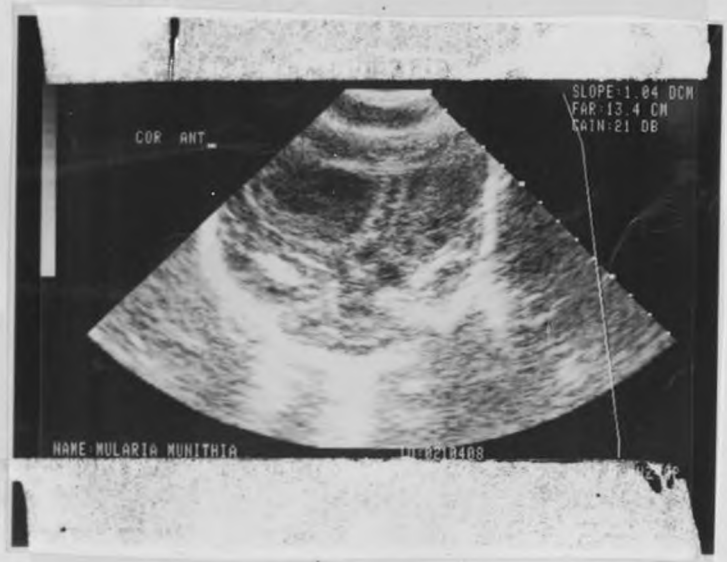
Hydrocephalus on Mid-Coronal Scan



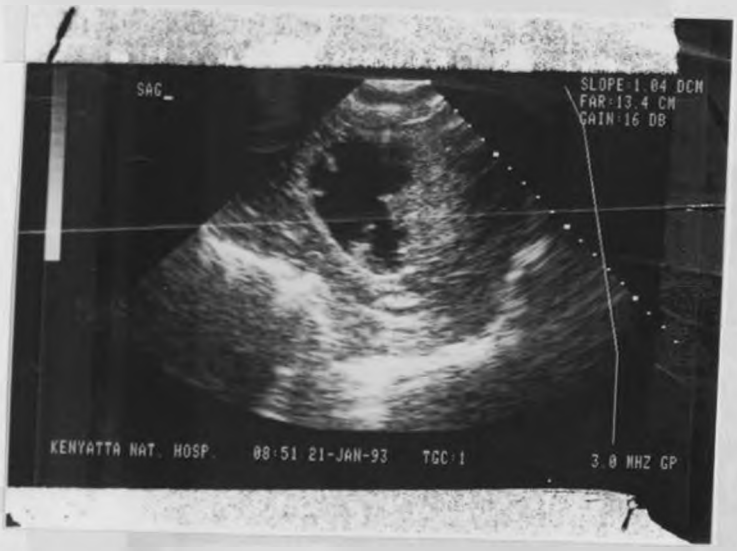
Hydrocephalus on Left Saggital Imaging



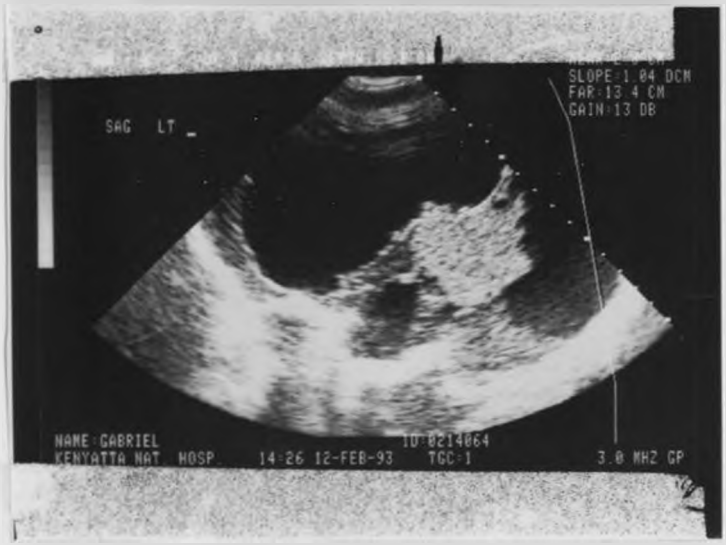
Multiple Cerebral Abscesses



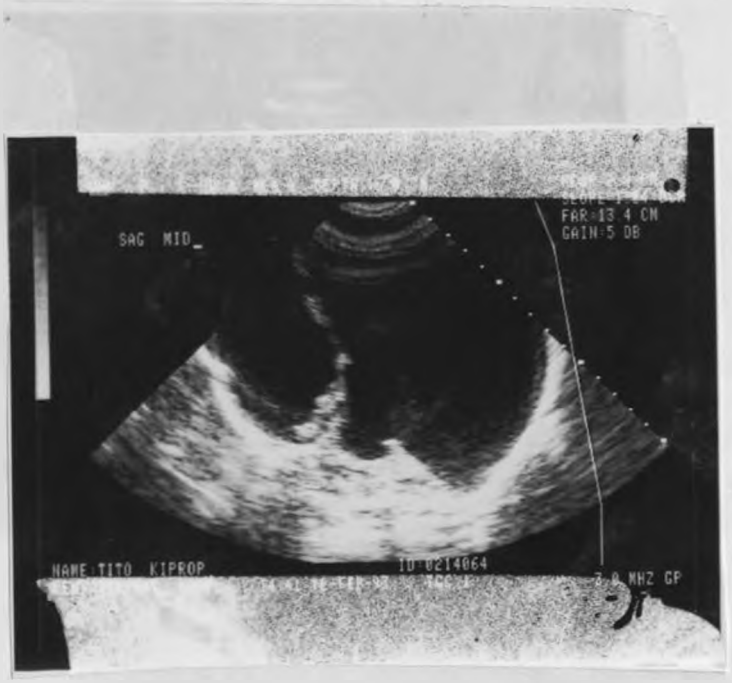
Huge Supratentorial Astrocytoma



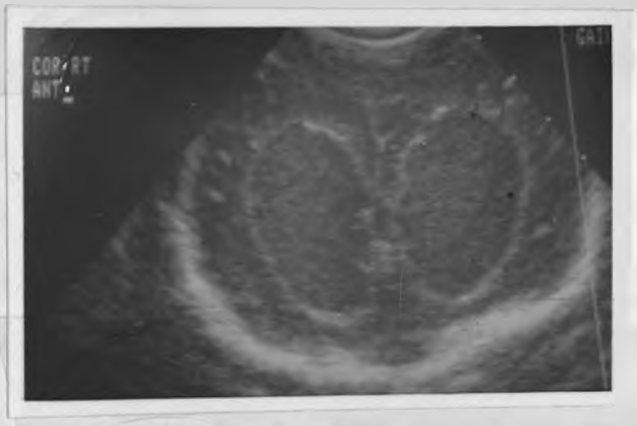
Left sided Choroid Plexus Papilloma + Hydrocephalus



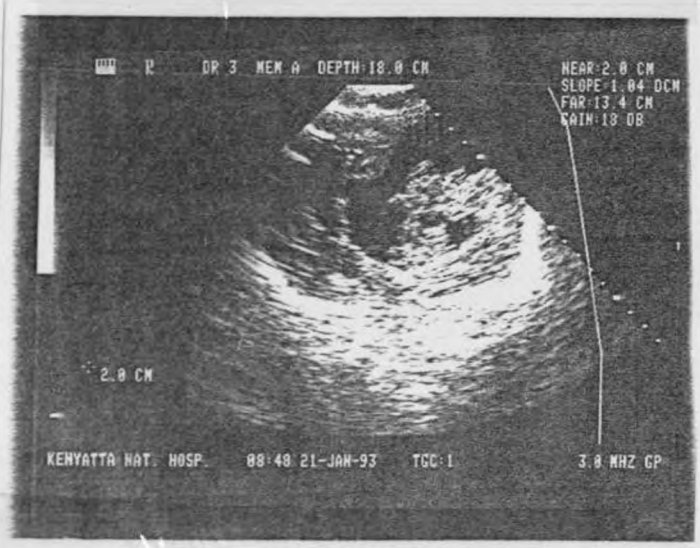
Hydranencephaly at 3 months of age



Huge bilateral intraventricular hemorrhage



Occipital Encephalocele



DISCUSSION OF RESULTS

Ultrasound equipment has been available at the Kenyatta National Hospital for the last 10 years. While its role in the investigation of obstetrical, gynaecological and gastroenterological diseases is now established, the same is not true of neurosonography. This delay has occurred because of the lack of a high frequency ultrasonic transducer, an essential tool for neurosonography.

With the addition of a 5MHZ transducer to the already available Phillips ultrasound machine in 1992, this study was initiated to give an overview of diseases seen in the first year of life. This pioneer study also tried to show the best technical factors which are appropriate according to the infants age. This was seen to be necessary because authors in world literature differed in the recommendations. This study therefore aimed to establish the most appropriate technical factors which are applicable in this set up with the available equipment.

Clinical data is then presented and discussed with a view to establishing which among the presenting symptoms and signs predict an abnormal ultrasound result. Subsequently, correlation is made between the diagnosis made on clinical grounds comparing it with sonographic findings to show the impact ultrasonography of the head has on making the right diagnosis. The results are discussed under the following headings; technical factors, symptoms, signs, working diagnosis and ultrasound diagnosis.

Technical Factors

Sonography was carried out in all patients using the real time sector scanner with a 3MHZ and 5MHZ transducers. These were found to be adequate for standard imaging. Acceptable axial images could only be obtained in the 0-3 month age group using the 5MHZ transducer and abundant coupling medium. At older age groups however skull penetration was inadequate for good imaging.

Curtis recommends the use of high frequency transducers including 7.5MHZ or even 10MHZ frequency. In our experience, the 5MHZ transducer gave the best balance between good penetration and good resolution. The ability of our scanner to magnify and zoom images rendered our 7.5MHZ transducer redundant and in no patient did it add clinically significant information. May be this is a reflection of the fairly gross pathology evaluated in this study. As sonography gains wider usage, more infants will be sent for study with subtle pathology requiring use of the higher frequency transducers.

The 5MHZ transducer was adequate for scanning all infants in the 0-3 month age group (Table 1). However in the 4-6 month age group, 3 infants had such gross macrocrania that visualization of the posterior fossa was only possible with a 3MHZ transducer. 4 out of 15 patients (27%) in the 7-9 month age group were similarly evaluated using a lower frequency, 3MHZ transducer, in order to achieve adequate penetration of course trading this off with resolution.

Above 10 months, 60% of infants had better images on the 3MHZ transducer than that of higher frequency.

Most diagnostic information could be obtained from a minimum 3 coronal scans and 3 saggital and parasaggital images. Cremin describes 6 coronal scan planes for routine scanning. This did not give extra information to justify the extra time it took. Rumack recommends axial scanning in order to measure ventricular sizes and diagnose hydrocephalus. Coronal scans at the level of the Foramen of Munroe gave more reproducible results and it was easier to anatomically classify ventricles as normally shaped or dilated (Brant).

There were 48 female patients who practically equalled their male counterparts who were 52 (Table 2). Out of 44 infants who had sonographically normal scans, 21 were male and 23 female. 77% of all patients presented in the first 6 months of life leaving only 23% who were 7 months or older. The most varied sonographic findings were seen in the 0-3 month age group. This variation became less marked as patients grew older so that after 9 months,50% had hydrocephalus, one had a cerebral neoplasm and the rest were normal. (Table 8).

Convulsions

Convulsions are among the most common acute and potentially life threatening events encountered in infants and children.

About 5% of children have had one or more Convulsions by the time they reach maturity (Nelson).
38% of the infants investigated present with convulsions.
Out of these 38 infants, 28 had normal sonographic findings and 10 were normal. Out of 62 infants without convulsions, 46 had an abnormal ultrasound results and 16 had normal findings. The presence of convulsions in infants is an insensitive and non-specific sign of a structural abnormality of the brain detectable by ultrasound. Statistically, however, it was found to be significant in predicting an abnormal ultrasound result. ($P<0.05$ see statistical table 1).

Fever

Fever was a presenting symptom in 31 out of 100 infants. Of these, 19 had normal ultrasound scans and 12 were abnormal. Out of 69 patients who did not have fever at presentation, 44 were abnormal and 25 were normal. Thus fever or its absence is of little value in predicting an abnormal sonographic outcome. This was statistically shown to be so.
($P>0.05$ see statistical table 2).

Enlargement of the Head

This may be a subjective or an objective sign. In the former, a mother may look at a baby's head and think that it is rather large. This requires confirmation by measurement of the head circumference and comparison with standard charts. Babcock found this to be a sign of utmost importance.

36 infants were referred for sonography because the mothers thought these infants had enlarged heads. 33 out of these had an abnormal ultrasound finding and only 3 had normal findings. while these results agree with the findings by Babcock about the great significance of macrocrania, it was found in this study that macrocrania is a late sign occurring after considerable neurologic damage had occurred.

As a separate category, patients with increased head circumference were also recorded and analysed. 39 out of 41 infants with head circumference above the 95th percentile had abnormal sonographic findings. Statistical analysis of both objective and subjective increases in head size were found to be important predictors of intracranial disease. (see statistical table 4).

Bulging Fontanelle

During the first one year of life, intracranial pressure can be assessed clinically by palpation of the anterior fontanelle. Normally the fontanelle of the sitting infant is soft and slightly depressed (Nelson). The fontanelle is tense and bulging in the infant with increased intracranial pressure. It is sunken with dehydration and destructive lesions which lead to low intracranial pressure. In this study, a bulging fontanelle was recorded in 24 infants. Out of these, 18(75%) had an

abnormal ultrasound result. Thus the presence of a bulging fontanelle justifies further radiological evaluation to exclude a structural abnormality of the central nervous system. However, when a bulging fontanelle is not present, the possibility of an abnormal ultrasound equals that of a normal ultrasound. As a pointer of intracranial disease, it did achieve statistical significance. ($P<0.05$ see statistical table 5).

Sunset Eyes

Sunset eye are regarded as a traditional sign of established hydrocephalus. As expected, its presence meant that an abnormal ultrasound result was to be expected. In fact all 12 patients with sunset eyes did have hydrocephalus. Inspite of the foregoing, it is an unfortunate late sign signifying neglected hydrocephalus with significant neuronal damage (Nelson).

Its absence, however, is not as important: 44 out of 88 without sunset eyes had an abnormal ultrasound result and a similar number had normal scans. Its value as a predictor of an intracranial disease detectable by ultrasound was statistically significant. ($P<0.05$ statistical table 6).

Meningitis

Acute a septic meningitis, an inflammatory process of the meninges is a relatively common illness caused by different factors. In most the illnesses are self-limited (Nelson) but in some the resulting diseases are severe and

progressive and lead to disability and death. Septic meningitis however commonly has a bacterial cause. Bell and Comick found Escherichia Coli and group B streptococci to be the most common at birth and during the neonatal period. Streptococci were more important at 4-12 weeks and Hemophilus influenza was more frequent at 3 months to 3 years.

Meningitis was the commonest indication for which sonography was requested. This accounted for 35% of the study population. Microbiological confirmation was only available in a small number because of compromised laboratory facilities. 30 out of 35(86%) infants had normal scans, 3 had mild hydrocephalus and 2 had cerebral abscesses. This agrees with work done by Han and Babcock that the primary role of sonography in meningitis is to search for complications. This is because uncomplicated meningitis is sonographically normal.

Han in a later study reported increased echogenicity in a few of his 78 patients accompanied by widening of sulci. There was however no correlation between echogenicity and prognosis. Edwards, Reeder and later Rosenberg reported ventriculitis to accompany meningitis in 65-90%. They went on to suggest sonographic features of ventriculitis including;

- hydrocephalus
- increased echogenicity of the ependymal lining
- echogenic debris within ventricles
- shaggy ependymal lining.

This was not the experience of this study. It would be nice

to see the sample size they studied and even the images from which these conclusions were drawn. One patient in this study was found to have echogenic debris within the ventricles. This case was reported as pyocephalus. He was comatose at presentation, went rapidly downhill and died. Postmortem did show dilated ventricles with pus in them.

Hydrocephalus

The lateral ventricles in the normal neonate may be small and difficult to define accurately. The mean width of the lateral ventricle in the full term infant is 12 mm. Hydrocephalus refers to enlargement of the ventricular system due to an imbalance between production and absorption of cerebrospinal fluid (CSF). CSF pressure is usually elevated but occasionally it may be normal.

Obstructive hydrocephalus is due most commonly to congenital aqueductal stenosis. In a small number aqueductal stenosis is inherited as an X linked recessive trait (Drachman). Others are due to viral causes and congenital lesions like a Dandy Walker malformation.
Communicating hydrocephalus may be seen in Arnold Chiari malformation meningitis and subarachnoid hemorrhage. Choroid plexus papilloma and vit. A intoxication are less common causes.

In this study, hydrocephalus was clinically suspected in 31 infants and in 27(87%) sonographic findings were in

agreement. One infant had communicating hydrocephalus due to overproduction of cerebrospinal fluid by a left sided choroid plexus papilloma. An infant thought clinically to have hydrocephalus turned out to have hydranencephaly. Another infant also sent for sonography as a case of hydrocephalus was found to have multiple intracerebral abscesses. Conversely 3 patients diagnosed to have intracerebral abscesses had hydrocephalus and another thought to have an intracerebral bleed also had hydrocephalus.

Overall 37 cases of hydrocephalus were diagnosed sonographically. 33(89%) of these were communicating. Of these 26(79%) had a positive record of meningitis clinically or microbiologically. Rumack and Johnson found the cause of hydrocephalus to be obscure in most cases. The commonest cause of an intraventricular obstruction included infection and hemorrhage. The cause for extra-ventricular obstruction was fibrosis at basal cisterns, incissura and parasaggital region. In this study 4 cases presented with features of an aqueductal stenosis. All were referred at 0-3 months of age suggesting a possible congenital aetiology.

Intracranial Hemorrhage

The germinal matrix is a neural vascular tissue in the fetus which has normally involved by term. It is situated

subependymally in the ventricles and is prominent in the groove between the caudate and the nucleus (Sutton). This is a frequent site for hemorrhage in premature infants. The vascular choroid is also an important site for cranial hemorrhage in infants. The symetry of the 2 sides of the brain is of value in detecting an abnormality.

Sudden shock and collapse during the first few days of life are often due to massive intraventricular hemorrhage. Less severe degrees of hemorrhage may be associated with lethargy convulsions and poor feeding.

Intracranial hemorrhage was suspected in 11 infants but only 4(36%) had sonographic confirmation. The other 7(64%) were normal. This apparent overdiagnosos by clinicians is fully justified. First, signs and symptoms of hemorrhage may be vague, minimal or totally absent in this very common problem. Incidence of hemorrhage varies from 30-55% (Babcock) in preterms weighing 1500g or less. Bashir quoted local figures at 34%. Ultrasound is the most effective method for detection and follow up of these hemorrhages in the newborn period (Babcock).

90% of hemorrhages occur in the first 7 days of use but only 30% occur in the first 24 hours (Rumack). In view of the foregoing, cranial sonography should be requested in all those suspected within the first week of life. One patient sent for study as a case of meningitis turned out to have intracerebral hemorrhage. Another

thought to have a congenital hydrocephalus turned out also to have a large bleed and moderate hydrocephalus most likely a secondary phenomenon.

Brain Neoplasms

After leukemias, brain tumours are the most common neoplasms in children. The incidence is highest in the second half of the first decade but may occur at any age (Nelson). Tumours of the cerebellum are commonest and are reported in 40% of cases (Nelson) in 80% of neoplasms, the basic cell is glial. The remainder are craniapharyngiomas, teratomas, hemangiomas, sarcomas and meninglomas. Metastatic tumors of the brain are rare in childhood.
Most occur sporadically and the cause is unknown. Teratomas and craniopharyngiomas possibly result from congenital malformations. An increased incidence is seen with neurocutaneous syndromes as well as following radiation therapy (Nelson).

Babcock, Jooma and Han in recent studies showed supra-tentorial neoplasms to be commoner than intratentorial by a ratio of upto 2.5:1. This has possibly resulted from an increased accuracy of diagnosis by sonography and computed tomography (Babcock).

Clinical manifestations in childhood neoplasms are largely those of increased intracranial pressure because many are in the posterior fossa and midline where a mass lesion will obstruct cerebrospinal fluid flow (Nelson).

Brain stem gliomas however despite their midline location rately lead to increased intracranial pressure. Jooma also found signs of raised intracranial pressure including macrocrania to be useful.
Chuang suggests a congenital aetiology for most intracranial neoplasms occurring below 2 years of age.

This study found clinical signs and symptoms to be insensitive and not specific in the diagnosis of brain neoplasms. Sonography only confirmed one intracranial space occupying lesion among 8 suspected (12.5%). 4 patients (50%) were normal and 3(37.5%) turned out to have communicating hydrocephalus possibly secondary to meningitis.
Conversely, one infant suspected of an intracerebral abscess because of features of raised intracranial pressure and fever at 10 months had a supratentorial tumour confirmed at computer tomography.

Overall, brain neoplasms accounted for 4% of the study population. This very high frequency is most probably due to patient selection in this referral hospital. It is notable that all 4 neoplasms were supratentorial thus conforming with more recent research work. While histological work up was not always possible, current literature reports astrocytomas to be the most frequent in the first year of life (Han, Jooma). This is followed by choroid plexus papilloma and ependymoma. Unfortunately neoplasms are usually large at initial diagnosis (Babcock). Almost

50% of the infants confirmed to have cerebral neoplasms in this study died before surgery could be performed. The patient with a choroid plexus papilloma stood the best chance but was lost to follow up because the mother absconded from the ward. Nash reports that most childhood tumours are echogenic and that cystic elements are uncommon. This study found large cystic components in 2 out of 4 cases (50%) detected sonographically. However the numbers are too small to be used to bring out any argument.

Brain Abscesses

Enterobacterial neonatal meningitis especially when due to proteus or klebsiella predisposes not only to ventriculitis but also to the formation of intraparenchymal abscesses (Pourplard). Mass effect is due to the abscess and edema around. While the latter is not seen at sonography, it will be seen clearly at computed tomography as a peri-lesional hypodensity.

In the newborn and particularly if the infection is due to proteus,there may be multiple abscesses somtimes associated with an intraventricular suppuration in the case of pyocephalus. Thus sonographic follow up should allow earlier detection and thus earlier intervention in these important disease conditions.

5 infants suspected to have intracranial abscesses had normal scans and the remaining 3 had hydrocephalus.

As already mentioned, 2 infants suspected to have meningitis, had abscesses at sonographic evaluation. This goes on to show how difficult it is to make a positive diagnosis of an intracranial lesion clinically and helps emphasise the important role of sonography in telling them apart.

Midline Defects in the Face or Calvarium

These malformations are very variable. Some are obvious such as ethmocephalus, or midline slit with hypotelorism (Manelfe), while others are more subtle. Even if they evoke an underlying cerebral malformation no definitive clinical argument exists (Robain). A complete neuroradiological survey is recommended in all infants with midline defects before plastic surgery (Khalisa). In this study 2 ethmoidal and 1 occipital encephaloceles were suspected from history and physical examination.
Sonography was of value in confirming the diagnosis and excluding associated anomalies such as arachnoid cysts or poroencephalic cysts (Babcock).
On infant had reconstructive surgery for an ethmoidal encephalocele based on sonographic findings alone.

Midline Cerebral Malformations

Ultrasonic examination should be sufficient for exploration of all cerebral malformations: cyclops holopnosencephaly, agenesis of the septum pellucidum, total or partial agenesis of the corpus callosum. A lobar or semilobar form of

holopnosencephaly which is usually a severe form of malformation usually incompatible with life can be diagnosed by ultrasound (Manelfe). This diagnosis is even made more important by existence of fomilial cases thus necessitating genetic counselling (Deveze). Early echographic exploration is necessary as cerebral modifications especially progressive hydrocephalus which laminates the cerebral parenchyma may render the diagnosis more difficult.

Agenesis of the septum pellucidum is a well defined entity. (Manelfe) on sonographic examination, one see a single frontal cavity of the ventricular system. The differential diagnosis from holopnosencephaly is based on presence and normality of the third ventricle, the existence of an interhemispheric fissure and absence of fusion of the basal ganglia. The pormitive agenesis is rare whereas the secondary agenesis is more common (Khalifa). In this later case, the essential cause is hydrocephalus which results in excessive pressure within the ventricular system and a progressive destruction of the septum due to multiple areas of necrosis.

In this study, 2 cases of hydranencephaly were detected. Both were sent for sonography as cases of hydrocephalus in the first 3 months of life with failure to thrive and macrocrania. Transielumination was not performed. While this not specific, it would help narrow

differential diagnostic possibilities. Further neuroradiologic evaluation include cerebral angiography and computed tomographic examination of the brain. These later examinations were not performed because of cost considerations.

CONCLUSIONS

1. Meningitis was the commonest indication for requesting cranial sonography. In these who numbered 35(35%), sonography was normal in 31(88%). 2 had previously unsuspected moderate hydrocephalus and another 2 had abscesses. This agrees with the work done by Babcock indicating that the primary role of sonography is to identify complications. Uncomplicated meningitis is usually normal sonographically.

2. Clinical evaluation was quite accurate in picking cases of hydrocephalus. Out of 31 cases suspected, 27(86%) had sonographic confirmation. In 26 cases out of 37 diagnosed sonographically to have hydrocephalus, (70%) a positive history of meningitis was forthcoming. Most were at an advanced level some cerebral cortices having been reduced to a shell con thick.

3. Macrocranial detected by increased head circumference was seen in 41 patients (41%). An abnormal ultrasound was found in 39(95%) of these cases making this the most sensitive indication of intracranial disease. This agrees with Diane in showing that the tape measure is the cheapest, simplest and reliable predictor of structural abnormalities of the brain.

4. While our reported incidence of intracranial neoplasms of

4% was greatly influenced by patient selection, it is notable that all 4 were supratentorial. This contrasts with old literature that brain neoplasms in children are predominantly intratentorial. But is in agreement with current thinking that below 1 year, supratentorial neoplasms outnumber intratentorial lesions by a ratio of 2.5:1.0.

5. Except in cases of hydrocephalus, clinical non-radiologic evaluation is non-specific in diagnosis of neoplasms, intracranial hemorrhage, cerebral abscesses and sonography is indicated in all cases of macrocrania to tell these apart.

6. A real time sector scanner with a 3MHZ and a 5MHZ transducer is adequate for evaluation of intracranial disease in most infants. Little additional information is to be gained by using a 7.5MHZ transducer.

7. 3 coronal and 3 saggital and parasaggital scan planes are adequate in reaching an ultrasound diagnosis in most infants. Axial projections are difficult to obtain with sector transducers especially in the older infant. Additional coronal images described by Cremin do not yield new information to justify the extra time spent.

RECOMMENDATIONS

1. All infants diagnosed and treated for meningitis should have a neurological examination at the time of discharge including head circumference measurement. This should be repeated at clinic follow up in a week's time. If there is any suspicion of a complication of meningitis, sonography should be the imaging modality of first choice. Tertiary studies like computed tomography, angiongraphy or magnetic resonance imaging may only be requested based on sonographic findings.

2. Cases of enlarged heads should be confirmed objectively by measurement of head circumference. If this is increased again sonography is indicated to cheaply tell the underlying cause for macrocrania.

3. This is really a pioneer study as far as the Radiology Unit is concerned. The stage is now set for studying various disease processes such as intracranial hemorrhages in preterms, term infants, at later dates.

We recommend follow up studies on patients sonographically found to be abnormal and those found to be normal. We would like to propose a study correlating sonographic findings in infancy with findings at computed tomography of the brain.

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