TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS

OPEN ACCESS JOURNAL

# Investigation of Infants with Hydrocephalus at Muhimbili National Hospital Using Anterior Transfontanelle Ultrasound Scan

Mboka Jacob[1], Byela Emmanuel Kasilima[2], Ramadhan Kazema[1]

[1]Department of Radiology and Imaging, Muhimbili University of Health and Allied Sciences
[2]Department of Radiology and Imaging, Lugalo General Military Hospital

**Correspondence to**
Dr. Mboka Jacob
Department of Radiology and Imaging
Muhimbili University of Health and Allied Sciences,
P.O. Box 65001,
Dar Es Salaam-Tanzania
mbokajacob@gmail.com

**ABSTRACT**

**Background:** Hydrocephalus is accumulation of cerebrospinal fluid in the cranium due to an imbalance between its production and absorption. There is an estimated 750,000 children and adults living with hydrocephalus. It is one of the most common developmental disabilities as it affects one in every 500 live births. There is a significant burden of hydrocephalus in East Africa, with more than 6000 new cases estimated per year and in the majority the cause is neonatal infection. Though there a number of studies on this study area, less is reported on the sonographic pattern of infantile hydrocephalus at our set-up.

**Objective:** We aimed at determining the sonographic pattern of infantile hydrocephalus and the associated factors.

**Methods**: Eighty (80) infants with hydrocephalus were consecutively included into the study. To every infant a cranial ultrasound was performed using an Ultrasound machine (Phillips, HP5000, Eindhoven, Best, Netherlands) with 2-5MHZ frequency curve-linear transducer. Questionnaires were used to collect demographic data and clinical information.

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



Data analysis was done using the Statistical Package for Social Sciences (SPSS) version 17. Chi-square ($X^2$) and Fisher's exact tests were used to compare between clinical and sonographic variables. The p-value of < 0.05 indicated statistically significance difference

**Results:** Among the 80 studied infants 42 (52.5%) were males, the youngest was 1 month and the oldest was to 10 months old with mean age of 3.4 months. Hydrocephalus was most common (46.2%) in much younger infants aged 2 months and below (P-value=0.012). Non-communicating hydrocephalus was the most common type 62 (77.5%). Higher proportions of hydrocephalus were seen in infants with >2500grams of birth weight (76.2%), normal (spontaneous vertex) delivery 61 (76.2%) and those who were born at term (75%).

**Conclusion:** Cranial Ultrasonography is an important tool in evaluation of infants with hydrocephalus. This information is helpful in making accurate management decision. Hydrocephalus was most common in much younger infants aged 2 months and below and the most common type was non-communicating hydrocephalus which accounted for 77.5%. Hydrocephalus is common in males and is associated with >2500grams of birth weight, term delivery and normal spontaneous vertex delivery though the observations were not statistically significant.

**Key words:** Hydrocephalus, Infant, Cranial Ultrasonography.

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



## Introduction

Hydrocephalus can be defined broadly as a disturbance of formation, flow, or absorption of cerebrospinal fluid (CSF) that leads to an increase in volume in spaces occupied by this fluid in the CNS[1]. Cerebrospinal fluid is produced mainly by the choroid plexus within the lateral ventricles, circulation starts from the lateral ventricles, third ventricle, fourth ventricle then to cisterns or subarachnoid space. It is absorbed by arachnoid villi or granulations to enter into sinuses mainly superior saggital sinus[2]. Many studies have been done on infantile hydrocephalus but less is known on the sonographic pattern of this study area at our set-up.

There is an estimated 750,000 children and adults living with hydrocephalus and 160,000 ventriculo-peritoneal shunts are implanted each year worldwide[3]. Pediatric hydrocephalus affects one in every 500 live births, making it one of the most common developmental disabilities. It is the leading cause of brain surgery for children in United States[4]. The burden of infant hydrocephalus in East Africa is significant, with more than 6000 new cases estimated per year and in the majority the cause is neonatal infection[5].

Hydrocephalus is classified as communicating or a non communicating and majority (65.6%) of hydrocephalus is obstructive (non-communicating) while non obstructive type (communicating) is about 16.2%. In non-communicating or obstructive hydrocephalus, the flow of CSF from the ventricles to subarachnoid space is obstructed thus there is no communication between the ventricular system and the subarachnoid space[2,6].

There are over 180 different causes of the condition but the most common cause is aqueductal stenosis[7].

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



Acquired hydrocephalus can be a complication of premature birth, intraventricular haemorrhage (IVH), subarachnoid haemorrhage, meningitis, brain tumour or lesion, a spinal cord tumour or lesion, a traumatic head injury[4]. Large head size, episodic vomiting, sleepiness, reduced activity, poor feeding, failure to thrive, irritability, sun setting and seizure disorders are considered as symptoms in infants[8].

In developing countries the commonest cause is meningitis, both bacterial and tuberculous, followed by congenital anomalies and brain tumors[9]. In the United States and other industrialized countries, infant hydrocephalus is usually due to either a congenital anomaly or, in low birth weight premature infants who have intracerebral hemorrhages from immature blood vessels[10]. Approximately 55% of all hydrocephalus are congenital[11].

Hydrocephalus is more common (57.97– 62%) in preterm infants[8,12]. This is due to the fact that they are more prone to get germinal matrix hemorrhage which causes obstruction of the foramina and hence hydrocephalus[13]. Though some studies have shown that hydrocephalus is more common in term compared to preterm infants[13]. Males are affected more than females with a male to female ration of 3:1 though other studies show no sex predilection. Low birth weight is also associated with hydrocephalus as most infants with hydrocephalus have low birth weights less than 2,500g (69%) [12].

Mode of delivery has also been reported to be associated with hydrocephalus; mode of delivery is caesarian section (55.3%) followed by vaginal in 44%, vacuum extraction in 8.5% and 2.12% by forceps. Though some studies report vaginal delivery to be the most frequent(58%) mode in infants with hydrocephalus [12].

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



Clinical features of hydrocephalus in children depend, on the age of the child. In children before the age of 2 years where in most fontanels are not yet closed presents with increase in size of the head, wide anterior fontanels, prominent scalp veins, sun setting eyes, optic nerve atrophy, nystagmus and increase muscle tone, vomiting, drowsiness, headaches and others are asymptomatic(7,8). Children above 2years presents with normal head circumference, obliterated anterior fontanel, atrophy of optic nerves, papilloedema of optic disc, spastic lower limbs and deranged hypothalamic functions (short stature or gigantism, delayed puberty, primary amenorrhea or menstrual irregularity and diabetes inspidus). Performance IQ is worse than verbal IQ and learning problems are common(7,8).

Imaging has important role in evaluating infants with hydrocephalus. Ultrasound have some advantage over the other modalities like Computed tomography (CT) and Magnetic Resonance Imaging (MRI) as it is affordable, available and no radiation, non invasive and portable· It has been shown by other studies that no significant abnormality is missed by sonography and CT does not contribute any additional information over Ultrasonography(14). Other imaging modalities such as CT and MRI are needed if there is significant abnormality detected by CUS and further clarification is needed

Ultrasonography CT findings in term infants and preterm infants with macro crania reveals that preterm infants presents more with abnormal sonograms and increased intra and/ or extra axial fluid spaces or germinal matrix hemorrhages. Cranial Ultrasonography (CUS) is the initial imaging modality in infants suspected of having hydrocephalus since it accurately evaluates cerebral ventricular size, extra axial fluid and cranial congenital malformation.

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



Identifying the type of hydrocephalus is essential for the initial management decision which is going to take place· There is limitation of the available data in developing countries such as Tanzania as to the estimated prevalence of both communicating and non communicating hydrocephalus

Less is reported at our set-up on sonographic pattern of infantile hydrocephalus and associated factors; hence we aimed at studying the sonographic features of infantile hydrocephalus and associated factors. We used Ultrasound as it delivers similar results to MRI in terms of sensitivity and ability to direct initial management.

**METHODS**

This was a cross sectional study conducted at the Ultrasonography unit, department of Radiology, Muhimbili National Hospital Dar Es Salaam. The duration of the study was 6 months from July to December, 2013. Ethical clearance to conduct this study was obtained from Muhimbili University of Health and Allied Sciences Ethics Committee.

A total of 80 infants with clinical diagnosis of hydrocephalus were consecutively included in this study after obtaining written consent. Once the subject was entered in the study, cranial ultrasound was done through the standard anterior fontanel using sequential coronal and saggital/parasaggital projections. Ultrasound machine (Phillips, HP5000, Eindhoven, Best, Netherlands) with 2-5MHZ frequency curve-linear transducer was used for every patient. Cerebral ventricular size was measured through lateral ventricle, third ventricle is usually not seen unless dilated · In diagnosing hydrocephalus, the size of the lateral ventricle was measured at the level of foramen of Monro.

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



The mean diameter of anterior horns of right and left lateral ventricle of more than 2.5mm +/- 0.7mm was considered to be hydrocephalus.

Infants were divided into two groups, those with communicating and non communicating hydrocephalus. Communicating hydrocephalus was seen as tetra ventricular dilatation which is enlargement of third, both lateral ventricles and fourth ventricle with or without extra axial fluid collection and obstructive hydrocephalus as triventricular dilatation. The measurements were taken from mid coronal image which display the diameter of anterior horn of lateral ventricle at the level of foramen of Monro.

The images obtained were reviewed by the Principle Investigator and a Senior Radiologist. Same observer was performing examination every time and in order to avoid inter-observer variations, 10 percent of the patients were rescanned. The final diagnosis was reached by consensus.

The variables evaluated on Sonography were:

I. Size of the ventricles
II. Size of the extra axial cerebral spinal fluid spaces
III. Masses /lesions
IV. Congenital brain abnormalities

Sex, age, Mode of delivery, age and weight at delivery were all recorded into a questionnaire.

Data analysis was done using the Statistical Package for Social Sciences (SPSS) version 17. Chi-square ($X^2$) and Fisher's exact tests were used to compare between clinical and sonographic variables. The p-value of $< 0.05$ indicated statistically significance difference.

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



**RESULTS**

A total of 80 infants were included into this study. The age range was from 1 to 10 months with mean age of 3.4 months of which 42 (52.5%) were males (P-value = 0.012 [**Table 1**].

Non communicating hydrocephalus was the most common type 62 (77.5%). When compared to sex non communicating hydrocephalus was the most frequent type in both groups,34 (81%) and 28 (73.7%) in males and females respectively (P-value =0.437) [**Table 2**].

Hydrocephalus was generally most common in infants aged 1-2 months old, 37 (46.2%). Generally the frequency of hydrocephalus was decreasing with an increase in age. We also observed that non communicating hydrocephalus was increasing with an increase in age which was contrary to communicating type , though the observed differences were statistically not significant (P-value =0.766) [**Table 3**].

Most (75%) of infants were born at term. More of the communicating hydrocephalus were seen in preterm infants 5(25%) as compared to term infants 13(21.7%). Non-communicating hydrocephalus was almost equally common on both preterm and term infants (15(75%) and 47(78.3%) respectively) though these observations were statistically not significant (P-value =0.763%) [**Table 4**].

When we compared the type of hydrocephalus by birth weight, most of the infants had a birth weight of >2500grams. Communicating hydrocephalus was more common in infants who had birth weight below 2500 grams 5(26.3%) as compared to those who had birth weight >2500grams 13(21%). We also observed that non-communicating hydrocephalus was the most frequent type in both groups, though these observations were statistically not significant (P-value = 0.754) [**Table 5**].

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



In this study most of the infants (76.2%) were delivered through a normal (spontaneous vertex) delivery (P-value=1:00)[**Table 6**].

**Table1. Distribution of infants presenting with hydrocephalus by age and sex ( n=80).**

| AGE (Months) | SEX MALE (%) | FEMALE (%) | TOTAL (%) | *P value |
|---|---|---|---|---|
| 1 | 9 (45) | 11 (55) | 20 (25) | 0.012 |
| 2 | 5 (29.4) | 12 (70.6) | 17 (21.2) | |
| 3 | 3 (37.5) | 5 (62.5) | 8 (10) | |
| 4 | 8 (72.7) | 3 (27.3) | 11 (13.8) | |
| 5 | 9 (75) | 3 (25) | 12 (15) | |
| 6 | 3 (75) | 1 (25) | 4 (5) | |
| 7 | 3 (100) | 0 (0) | 3 (3.8) | |
| 8 | 0 (0) | 2 (100) | 2 (2.5) | |
| 9 | 0 (0) | 1 (100) | 1 (1.2) | |
| 10 | 2 (100) | 0 (0) | 2 (2.5) | |
| **Total** | **42 (52.5)** | **38 (47.5)** | **80 (100)** | |

*Fischer's exact test was used.

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



**Table 2: Comparison of types of hydrocephalus by sex(n=80)**

| Sex | Hydrocephalus type | | Total (%) | p- value |
|---|---|---|---|---|
| | Communicating (%) | Non-communicating (%) | | |
| Male | 8 (19) | 34 (81) | 42(52.5) | 0.437 |
| Female | 10 (26.3) | 28 (73.7) | 38(47.5) | |
| **Total(%)** | **18 (22.5)** | **62 (77.5)** | **80(100)** | |

**Table 3: Comparison of types of hydrocephalus by age groups(n=80)**

| | **Hydrocephalus type** | | | |
|---|---|---|---|---|
| **Age groups (months)** | Communicating (%) | Non-communicating (%) | **Total** | ***p- value** |
| 1-2 | 10 (27) | 27 (73) | 3(46.2) | |
| 3-4 | 5 (26.3) | 14 (73.7) | 19(23.8) | |
| 5-6 | 2 (12.5) | 14 (87.5) | 16(20.0) | |
| 7-8 | 1 (20) | 4 (80) | 5 (6.2) | 0.766 |
| 9-10 | 0 (0) | 3 (100) | 3 (3.8) | |
| **Total** | **18 (22.5)** | **62 (77.5)** | **80 (100)** | |

Fisher’s exact test was used.

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



**Table 4: Percentage distribution of types of hydrocephalus by gestation age (n=80)**

| Gestation age at delivery in weeks | Hydrocephalus type | | Total(%) | P-value |
|---|---|---|---|---|
| | Communicating (%) | Non-communicating (%) | | |
| < =37 | 5(25) | 15(75) | 20(25) | 0.763 |
| 38+ | 13(21.7) | 47(78.3) | 60(75) | |
| **Total (%)** | **18 (22.5)** | **62 (77.5)** | **80(100)** | |

**Table 5: Percentage distribution of types of hydrocephalus by birth weight (n=80)**

| Birth weight (grams) | Hydrocephalus type | | | |
|---|---|---|---|---|
| | Communicating (%) | Non-communicating (%) | Total (%) | *p-value |
| 2500 | 5(26.3) | 14(73.7) | 19(23.8) | 0.754 |
| 2501+ | 13(21) | 48(78.7) | 61(76.2) | |
| **Total (%)** | **18 (22.5)** | **62 (77.5)** | **80(100)** | |

*Fisher's exact test was used.

**Table 6: Percentage distribution of types of hydrocephalus by mode of delivery.**

Mode of Hydrocephalus type

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



| delivery | Communicating (%) | Non-communicating (%) | Total | *p-value |
|---|---|---|---|---|
| Normal | 14(23.0) | 47(77.0) | 61(76.2) | 1.00 |
| Abdominal | 4(21.1) | 15(78.9) | 19(23.8) | |
| **Total (%)** | **18(22.5)** | **62(77.5)** | **80 (100)** | |

*Fisher's exact test was used.

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



## DISCUSSION

Many studies have been carried out to determine the incidence of hydrocephalus and other central nervous system abnormalities. In these studies the peak age incidence of hydrocephalus is below 2 years old (39%) which is mostly of congenital type (55%) [11] and the aqueduct stenosis forms the main cause but in developing countries the commonest cause is neonatal infection[5]. The incidence of human hydrocephalus presents a bimodal age curve. One peak occurs in infancy, another peak occurs in adulthood[15]. This can be due to the fact that premature infants have an increased risk of intraventricular hemorrhage in which severe bleeding within the ventricles of the brain can lead to hydrocephalus.

Complications of untreated hydrocephalus can be poor development of cognitive function in infants and children, or loss of cognitive function in adults. Visual loss can complicate untreated hydrocephalus and may persist after treatment. In untreated hydrocephalus, death may occur by tonsillar herniation secondary to raised ICP with compression of the brain stem and subsequent respiratory arrest. Shunt dependence occurs in 75% of all cases of treated hydrocephalus and in 50% of children with communicating hydrocephalus. Imaging has an important role in evaluating infants with hydrocephalus. We used Ultrasound as it delivers similar results to MRI in terms of sensitivity

In our study total of 80 infants with hydrocephalus were studied. The youngest was 1 month old and the oldest was 10 months old with mean age of 3.4 months ,these results differs slightly from a Nigerian study which showed age range of 1 to 8 months with mean age of 1.97 (+/- 2.17 SD)[10]. The prevalence in this age group coincides with the prevalence of the congenital hydrocephalus.

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



The commonest type of hydrocephalus was non-communicating (77.5%). This finding concurs well with other studies elsewhere[11].

Some studies have identified no sex preponderance in hydrocephalus [12,15], but other have found a male preponderance ; there was a mild male domination(52.5% vs. 47.5.%) in our study.

Preterm infants are reported to be more prone to develop hydrocephalus secondary to germinal matrix hemorrhage[13]. Studies done somewhere else revealed predominance of hydrocephalus in preterm infants[12] which is contrary to our findings as in the current study most of the infants with hydrocephalus (75%) were born at term but our findings concurs with some other studies elsewhere[13].

Most infants in this study were of normal birth weight (76.2%). These results are different from the studies done in China, California and Saudi Arabia which reported low birth weight in most of hydrocephalic infants. The results difference are due to different study methodology since the studies reporting prevalence in low birth weight are retrospective epidemiological studies where infants included were recruited from the data registry.

Mode of delivery has also been reported to be associated with hydrocephalus. Abdominal delivery has been reported by some studies to be the commonest mode of delivery in infants with hydrocephalus. Though some studies report vaginal delivery to be the most frequent(58%) mode of delivery[12]. In the current study the most of infants 61(76.2%) were delivered normally (spontaneous vertex delivery), this finding is similar to a study done in Saudi Arabia [12] However it is contrary to other studies which shows that the commonest mode of delivery is abdominal (caesarian section).


TMJ Jacob M, et al. TMJ 2015 v 27. http://dx.doi.org/10.4314/tmj.v27i1.201.117

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



In developing countries the commonest cause of hydrocephalus is neonatal infection[5] this can explain the difference between this study and the studies done in developed world.

Investigating hydrocephalus through anterior horn of lateral ventricle at level of foramen of Monro is simple and easily reproducible· However follow up is needed in cases of early suspicion of hydrocephalus or borderline measurement. Follow up is a big problem in most developing countries due to low socio economic status of most of the patients, ignorance, poor health seeking behavior and due to the fact that most equipped hospitals are located in urban areas being far from rural areas where most patients lives.

Diagnosing and identifying hydrocephalus into either communicating or non communicating types is essential for making initial management decision. Primary hydrocephalus management depends on whether it is communicating or non communicating type. For communicating type the ideal management is extra cranial shunt placement and non communicating is managed by endoscopic procedures· Thus identifying hydrocephalus type is crucial for initial management to take place.

## CONCLUSION

Cranial Ultrasonography is an important tool in evaluation of infants with hydrocephalus. In this study Ultrasound helped to identify types of hydrocephalus. This information is helpful in making accurate decision regarding to management. Hydrocephalus was most common in much younger infants aged 2 months and below and the most common type was non-communicating hydrocephalus, which accounted for 77.5%. Hydrocephalus is common in males and is associated with >2500grmas birth weight, term delivery and normal spontaneous vertex delivery. This study

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



could not identify the causes of hydrocephalus, we recommend future studies to be done by using much advanced imaging methods to study the brain matter and associated causes infantile hydrocephalus.

**ACKNOWLEDGEMENTS AND COMPETING INTERESTS**

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

**AUTHORS' CONTRIBUTIONS**

M.J. (MUHAS) wrote the original manuscript and worked on the literature review and on the final document. B.E.K did data collection, analysis and contributed to manuscript preparation. R.K was involved in manuscript preparation and in the final editing of the document.

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



**REFERENCES**

1. Rekate HL. A contemporary definition and classification of hydrocephalus. Semin Pediatr Neurol. 2009;16:9-15.

2. Oi S. Hydrocephalus research update--controversies in definition and classification of hydrocephalus. Neurol medicochirurgica. 2010;50:859-69.

3. Simon TD, Riva-Cambrin J, Srivastava R, Bratton SL, Dean JM, Kestle JRW. Hospital care for children with hydrocephalus in the United States: utilization, charges, comorbidities, and deaths. J Neurosurg Pediatr. 2008;1:131-7.

4. Chi JH, Fullerton HJ, Gupta N. Time trends and demographics of deaths from congenital hydrocephalus in children in the United States: National Center for Health Statistics data, 1979 to 1998. J Neurosurg. 2005;103:113-8.

5. Warf BC. Pediatric hydrocephalus in East Africa: prevalence, causes, treatments, and strategies for the future. World Neurosurg. 2010;73:296-300.

6. Rekate HL. A consensus on the classification of hydrocephalus: its utility in the assessment of abnormalities of cerebrospinal fluid dynamics. Childs Nerv Syst ChNS Off J Int Soc Pediatr Neurosurg. 2011;27:1535-41.

7. Vaessen S, Mouchamps M, Born J, Lepage P. Hydrocephalus in children. J Pak Med Assoc. 1957;79:87-90.

TMJ Downloaded from http://tmj.or.tz/index.php/tmj/article/view/201 on April 1, 2017 - Published by OJS



8. Kirkpatrick M, Engleman H, Minns RA. Symptoms and signs of progressive hydrocephalus. Arch Dis Child. 1989;64:124–8.

9. Peacock WJ, Currer TH. Hydrocephalus in childhood. A study of 440 cases. South African Med J SuidAfrikaanse Tydskr vir Geneeskd. 1984;66:323–4.

10. Li L, Padhi A, Ranjeva SL, Donaldson SC, Warf BC, Mugamba J, et al. Association of bacteria with hydrocephalus in Ugandan infants. J Neurosurg Pediatr. 2011;7:73–87.

11. Losowska-Kaniewska D, Oleś A. Imaging examinations in children with hydrocephalus. Adv Med Sci. 2007;52 Suppl 1:176–9.

12. Murshid WR, Jarallah JS, Dad MI. Epidemiology of infantile hydrocephalus in Saudi Arabia: birth prevalence and associated factors. Pediatr Neurosurg. 2000;32:119–23.

13. Fernell E, Hagberg G, Hagberg B. Infantile hydrocephalus--the impact of enhanced preterm survival. Acta Paediatr Scand. 1990;79:1080–6.

14. Babcock DS, Han BK, Dine MS. Sonographic Findings in Infants with Macrocrania. AJNR Am J Neuroradiol [Internet]. 1988 Mar 1 [cited 2015 Nov 24];9(2):307–13. Available from: http://www.ajnr.org/content/9/2/307.short

15. J. Alberto. Hydrocephalus. J e Med [Internet]. 2009 [cited 2015 Nov 26];5:1–8. Available from: http://prettyill.com/downloads/3_Hydrocephalus.pdf