NORMAL PARAMETERS OF VENTRICULAR SYSTEM IN HEALTHY INFANTS

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ABSTRACT

Six hundred healthy inborn newborns and infants up to the age of 18 months were studied. Cranial sonography was performed by real time 2D scanner with 5 MHz transducer and images were obtained through anterior fontanelle and temporo—sauanal suture. Various parameters related to ventricular system were measured for different ages till the fontanelle remained open. These values will prove useful for diagnosing hydrocephalus at an early stage of the disease and also to find out the blocks' at various levels in ventricular system.

Keywords: Cranial ultrasound, Hydrocephalus, Ventricular system.

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Enlargement of ventricular system in hydrocephalus results from an imbalance between production and absorption of cerebrospinal fluid(1). It is obvious that for early and precise diagnosis of type of hydrocephalus, knowledge of ventricular size including width of lateral ventricle (LVW) and distance between falx to inner table of skull (FH) in coronal plane, ventricular index (VI) and distance between falx to inner table of skull (FC) in temporal plane, width of lateral ventricle (C) in parasagittal plane, diameter of 3rd ventricle in coronal plane, width of foramen of monro (FM), length (ADL) and width (AD) of aqueduct, distance between foramen of monro and aqueduct (FMAD) and aqueduct to foramen of magnum (ADFM) is mandatory. Leksell was the first to use ultrasound for Echo-Encephalography(2). Since then due to inherent advantages of ultrasonography over other diagnostic modalities (angiography, ventriculography, pneumoencephalography, CT scan and MRI scan), it is emerging as a first investigation of choice in all infants with abnormal head size wherever the fontanelle is open(3,4).

Little work has been done on measurement of cerebral ventricular system in our country. A prospective study was, therefore, undertaken.

Material and Methods

This study was carried out in the Department of Pediatrics of Regional Institute of Maternal and Child Health, Dr. SN Medical College, Jodhpur, between July 1992 to April 1994. Six hundred healthy inborn newborns and infants up to the age of eighteen months were studied and divided into 15 groups. The
gestational age of the newborns was calculated by modified Parkin's criteria(5) and the age of infants was calculated from their date of birth.

Cranial sonography (CR-USG) was performed by real time 2D scanner SIM 3000 OTC Biomedier with a 5 MHz transducer. Images were obtained using anterior fontanelle (all cases) as window in coronal (Fig. 1), both right and left parasagittal, and mid sagittal (Fig. 2) plains(6) as well as through temporosquamoal suture(7). Two measurements were made at each examination and averaged.

The various ventricular parameters—LVW, FH, VI, FC, diameter of 3rd, AD, ADL, FMAD and ADFM were recorded on specially designed performa for this study. Their age, gestational age (newborn), weight (wt), head circumference and sex were also recorded. The development of infants was assessed by Denver Development Screening test (DDST)(8). Only those infants who were developing normally were included in the study.

The mean and standard deviation was calculated with the help of computer using Mark State Programme.

Results

Six hundred infants were included in this study. The male to female ratio was 1.4 : 1. The range of head circumference and weight varied from 28.64 ± 1.9 to 44.79 ± 1.93 cm and 1.44 ± 0.31 to 8.47 ± 1.23 kg, respectively.

![Fig. 1. Mid coronal scan showing falx, both lateral ventricle and the third ventricle.](image)
The size of lateral ventricle LVW gradually increased as age advanced, \( i.e., \) from \( 12.19 \pm 1.42 \) mm at 32 weeks of gestation to \( 18.54 \pm 1.51 \) mm at 13-18 months of age (Table I). The hemispheric width, FH increased from \( 37.09 \pm 3.23 \) to \( 57.58 \pm 3.17 \) mm as age advanced from 32 week of gestation to 13-18 months in the coronal plane (Table I). The ventricular index (VI) gradually increased as age advanced, \( i.e., \) from \( 9.67 \pm 1.17 \) mm at 32 weeks of gestation to \( 10.98 \pm 1.17 \) mm at 3 months of age (Table II). The FC increased from \( 33.89 \pm 4.26 \) to \( 44.90 \pm 2.72 \) mm with age from 32 weeks of gestation to 3 months of age (Table II) in temporal plane.

The ventriculo-hemispheric ratio, LVW/FH ranged between \( 0.26 \pm 0.04 \) to \( 0.33 \pm 0.05 \) (Table I) whereas VI/FC decreased from \( 0.285 \pm 0.03 \) at 32 weeks of gestational age to \( 0.245 \pm 0.02 \) at 3 months of age (Table II). The width of lateral ventricle "C" in parasagittal plane ranged between \( 2.44 \pm 0.77 \) to \( 3.8 \pm 0.96 \) mm (Table I).

The size of foramen of monro ranged between \( 2.81 \pm 0.6 \) to \( 4.4 \pm 0.62 \) mm (Table III). The width (AD) and length (ADL) of aqueduct ranged between \( 1.77 \pm 0.45 \) to \( 2 \pm 0.5 \) mm and \( 2.80 \pm 0.66 \) to \( 4.00 \pm 1.05 \) mm, respectively (Table III). The diameter of third ventricle and distance between FM to AD and
AD to foramen magnum increased as age advanced, i.e., from 3.52 ± 1.2, 15.43 ± 1.78 and 33.16 ± 2.8 mm at age of 32 weeks of gestation to 5.59 ± 1.9, 20.63 ± 2.7 and 57.08 ± 2.7 mm at 13-18 months of age (Table III).

**Discussion**

The development of high resolution 2D real time scanner coupled with increasing expertise has established the role of cranial sonography in the evalua-
tion of neuroanatomy of the brain parenchyma and ventricular system with high precision. The measurement of ventricular area in different planes seems to be the ideal method for early detection of ventriculomegaly, though it is cumbersome and a time consuming procedure. Various ventricular parameters were, therefore, measured by different authors in different planes (2,4).

In coronal scan, lateral ventricle, third and fourth ventricles are clearly visualized in infants till the anterior fontanelle remains open. Both lateral ventricles appear as sickle, with concavity pointing outwards. The size of lateral ventricle LVW gradually increased as age advanced, i.e., from 12.19 ± 1.42 mm at 32 weeks of gestational age to 18.54 ± 1.51 mm at 13 to 18 months of age. Lombroso et al. (2) reported the LVW ranged between 15 to 18 mm in newborns and infants up to 12 months of age. Chowdhary et al. (3) reported the LVW to vary between 10 ± 0.11 to 8.4 ± 2.5 mm in preterm of 28 to 30 and 35 to 38 weeks of gestational age, respectively.

The hemispheric width, FH increased from 37.09 ± 3.23 to 57.58 ± 3.17
mm as age advanced from 32 weeks of gestation to 13 to 18 months of age. Chowdhary et al. reported that FH increased from 36.8 ± 3.3 to 39.5 ± 2 mm in preterm neonates of 28-30 to 35-36 weeks of gestational age, respectively(3). The ventriculohemispheric ratio, LVW/FH ranged between 0.26 ± 0.04 to 0.33 ± 0.05 in newborns of 32 weeks of gestation to 13 to 18 months of age, respectively. Chowdhary et al. reported that LVW/FH decreased from 0.26 ± 0.02 to 0.12 ± 0.06 as age advanced from 28 to 30 to 35 to 36 weeks of gestational age(3), respectively.

The 3rd ventricle appears as a circle and its diameter ranged between 3.52 ± 1.2 to 5.59 ± 1.9 mm at 32 weeks of gestational age to 13-18 months of age. Lombroso et al. reported that the diameter of third ventricle ranged between 4 to 7 mm(2). The size of fourth ventricle is difficult to measure because of its unique anatomy.

The temporo squamal sutures remain open up to the age of 3 months; so sonography through this acoustic window is possible up to the age of 3 months. The size of lateral ventricle, VI gradually increased from 9.67 ± 1.17 to 10.98 ±1.17 mm as age advanced from 32 weeks of gestation to 3 months of age. Johnson et al. reported that VI ranged between 5 to 13 mm in preterm and 9 to 13 mm in term neonates(7). Levene reported that it ranged from 8.5 to 12.5 mm in preterm neonates (26 weeks) to term neonates(9). Soni et al. observed that it increased from 9.0 ± 1.4 to 10.7 ± 0.7 mm as age advanced from <32 to ≥38 weeks of gestational age(10).

The ventriculo-hemispheric width, FC increased from 33.89 ± 4.26 to 44.0 ± 2.72 mm as age advanced, from >32 weeks of gestation to 3 months of age. Jhonson et al. reported the mean value of FC to be 24 to 43 mm in preterm and 31 to 49 mm in term neonates(7). Soni et al. reported the mean value of FC ranged between 31.2 ± 2.9 to 36.2 ± 3.5 mm in newborns of <32 to >38 weeks of gestational age(10).

The ventriculo-hemispheric ratio, VI/FC (Evan's ratio) decreased from 0.285 ± 0.3 at 32 weeks of gestational age to 0.245 ± 0.02 at 3 months of age. Johnson et al. from their study observed that the mean value of Evan's ratio ranged between 0.24 to 0.34 in preterm and 0.24 to 0.30 in term neonates(7). Soni et al. reported this ratio to be 0.32 ± 0.3 in preterm and 0.3 ± 0.3 in term neonates(10).

The para-sagittal scan shows body, frontal occipital and temporal horn of lateral ventricle. The width of lateral ventricle "C" is measured above the thalamus and the values ranged between 2.44 ± 0.77 to 3.8 ± 0.96 mm.

The mid sagittal scan shows—septum pellucidum, foramen of Monro, third ventricle, aqueduct, fourth ventricle and cystema magna. The size of foramen of Monro ranged between 2.81 ± 0.6 to 4.4 ± 0.62 mm (Table III).

The width (AD) and length (ADL) of aqueduct ranged between 1.7 ± 0.75 to 2 ± 0.5 mm and 2.8 ± 0.66 to 4 ± 1.05 mm, respectively. Haslam et al. reported the approximate width and length of aqueduct to be 2 and 3 mm, respectively(1).

The distance between foramen of Monro and aqueduct (FMAD) increases when there is dilatation of third ventricle due to blockage of aqueduct. The
distance between aqueduct and fora-
men of magnum (ADFM) increases in
Arnold-Chiari malformation. Therefore, there distance were also measured,
probably, for the first time.

In conclusion, the diagnosis of
hydrocephalus is difficult clinically and
by measuring head circumference in the
early stage of disease. By measuring all
parameters by real time sonography,
one can diagnose it at an early stage of
diseases. The ventricular size can be
monitored after shunt surgery and
shunt failure can be detected at an early
stage.

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