

Measurement of Cranial and Brain Ventricle Volumes Relative to Pathologies

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Abstract: A volumetric study has been carried out using CT imaging to measure the cranial volume and correlate with the common pathologies that influencing their dimension such as brain ventricle volume and cranial volume. The study taking a sample of 150 patients referred to hospital for CT imaging version (GE - bright speed 16 slice - 2002). And according to basic protocol, spiral scanning with equal slice thickness and interval space, patient without contrast media, supine position, head first, orbito-metal line as anatomical reference, radiographic base line (RBL) perpendicular to couch, and the reconstruction of images have been carried out according to organ of interest for diagnosis. The results showed that: the incidence of pathologies that influencing the brain ventricle volumes and cranial volume was higher among male with 62% relative to 38% among female and the common pathology that influences the cranial and brain volume was the hydrocephalus taking a percent of 40.5%, mixed (hydrocephalus and tumor) represents 23%, tumors 21.5% and schizophrenia 15%. In relation to age groups, these pathologies have been peaking on age groups 1-10 years old which representing (40%) and among age groups of 55-65 years old 25%. The age was correlated with ventricle and cranial volumes in a form of linear proportional equation: ($y = 0.71x + 12.12$) and ($y = 18.35x + 2776$), where x refers to age in years and y refers volume of ventricle and cranial in cm^3 . In relation between cranial volumes with age among both gender: The cranial volume increases by aging among male and female up to 21-30 years old, then became semi-constant after, and the male cranial volume was $3191.7 \pm STD114 cm^3$ which is greater than in female which was $3133 \pm STD124 cm^3$ in average. While the relation between the ventricle volumes and age groups for both genders, revealed that: the brain ventricles volume increase with aging among both genders, in a relation that could be fitted in the following form: ($y = 5.97x + 2075$) among male and ($y = 5.61x + 13.48$) among female, where x refers to age in years and y refers to ventricle volume in cm^3 . The correlation so significant at $R^2 = 0.8$, and the ventricles volumes of male appear greater than in female i.e. $50.6 \pm STD17.9$ for male and $41.5 \pm STD17.3$ for female. The ratio of ventricle/cranial volumes have been influenced by cranial pathologies, leading to increment of ventricular/cranial ration as follows: for mixed i.e. (tumor/hydrocephalus) representing 0.06, hydrocephalus 0.1, tumor 0.02 and schizophrenia was 0.03 relative to normal case which was 0.01.

Keywords: Cranial, Ventricles, Volumetric, CT, Radiology

1. Introduction

Volumetric studies of human organs or systems have been under focus by many scholars recently due to its relation with pathologies evidences such as hydrocephalus, schizophrenia, tumors, Trauma ... etc [1, 2] as well as gender and aging which could lead to dementia and or brain geriatric. Hence the aim of this study is to measure the brain ventricle volumes and the cranial volumes in relation to pathologies. For instance, the precise detection of hydrocephalus, many parameters are needed such as 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. In this realm some authors have studied the parameters of cranial volume and brain ventricles using CT [3], MRI [4, 5] and ultrasound [6, 7]. One of the results related to brain ventricle volume, cranial volume and inter-cranial volume or dimension of maximum lateral ventricle and maximum of inter-cranial

distance at same level have been highlighted by Akdogan et al, [3], in which they found that: the mean volume fraction of total ventricle volume to total brain volume was found to be 1.21% in the first and 3.37% in the last decades and the mean volume fraction was found to increase significantly with age ($p < 0.01$, $r = 0.630$, Pearson). While David et al, [8] introduced study on measurements of the lateral ventricles in normal Sudanese, which showed that the measurement of the different part of the lateral ventricles in Sudanese were: 26 mm for anterior horn and 44 mm in body in both (CT and MRI), the posterior horn was 44 in (CT) imaging, while it was 25 mm in (MRI) imaging. Inferior horn it was 31 mm in (MRI), also she found that the different part of the lateral ventricles were found to be large in males than females, the size of anterior horn and bodies of the lateral ventricles significant correlation with age, body weight and length. The size of posterior and inferior horns of the lateral ventricles has no significant variation in relation to age, body weight and length.

2. Methodology

250 patients referred to hospital for CT imaging (version GE - bright speed 16 slice - 2002). And according to basic protocol, spiral scanning with equal slice thickness and

interval space, patient without contrast media, supine position, head first, orbito-metal line as anatomical reference, radiographic base line (RBL) perpendicular to couch, and the reconstruction of images have been carried out according to organ of interest for diagnosis or for research requirement (spiral CT) to avoid the overlapping of organ of interest between slices or missing area. Then the images have to be sending to Picture Archiving and Communication Systems PACS. The volumes of brain ventricles for the patients have been obtained from multiplication of slice thickness by the area of each ventricle then a summation done to obtain the total brain ventricle volume, the areas for each ventricle per slice has been traced and outlined by the system caliper then the system software used to calculate the area. While for the cranial volume, the measurement taken from maximum bi-parietal distance (width), from internal acoustic meatus to the highest point of vertex (Pregma) [9] (height) and from glabella to inion (longitudinal) have been used to determine the cranial volume. And the other variables (age, gender, diagnosis) have been collected from Picture Archiving Computerized System PACS of each patient.

3. Results:

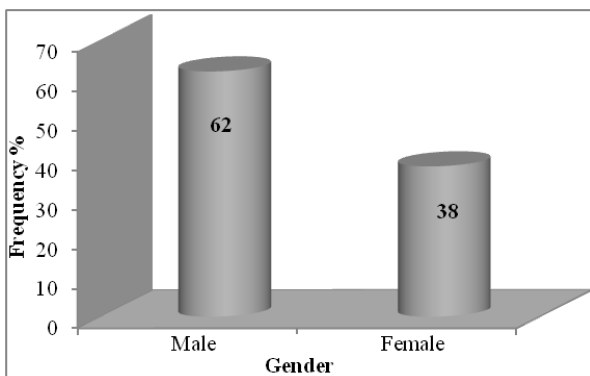


Figure 1: Distribution of cranial pathologies based on gender

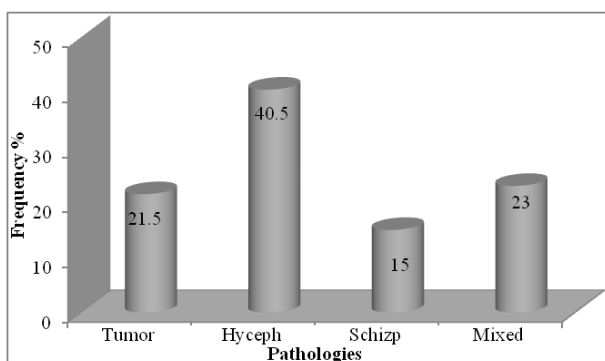


Figure 2: Frequency percent of pathologies influencing the cranial and brain volume.

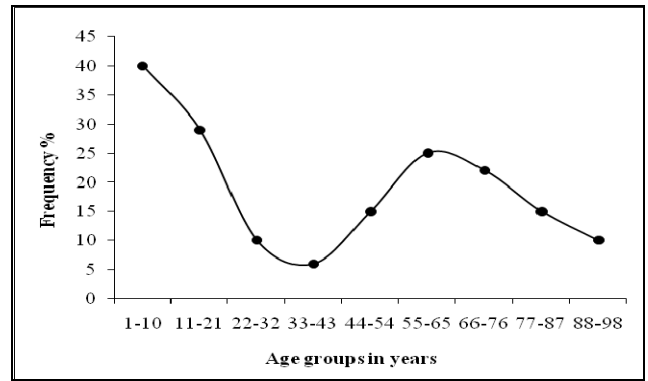


Figure 3: Frequency of pathologies influencing brain and ventricles volume based on age in years.

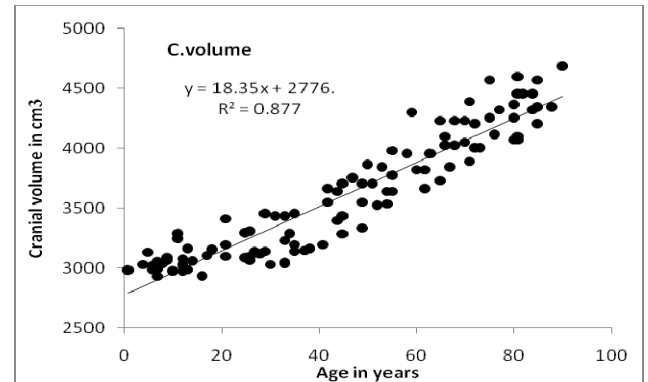


Figure 4: Correlation between the patient's age and the cranial volume in mm.

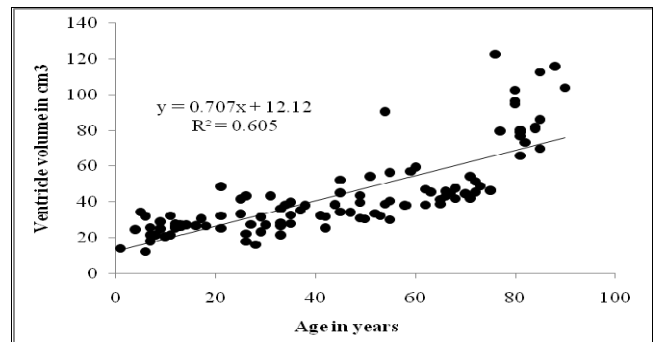


Figure 5: Correlation between patient age and the ventricles volume in mm.

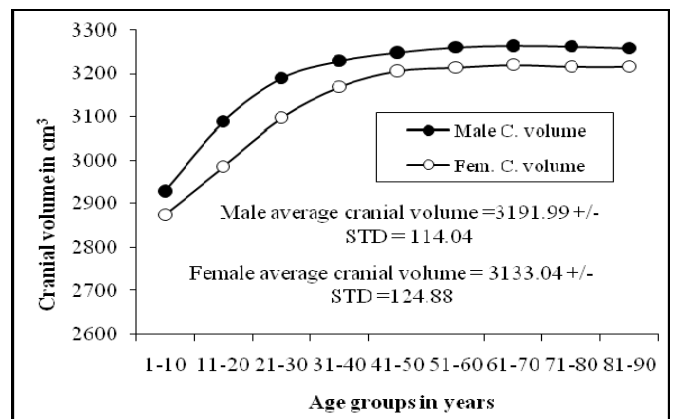


Figure 6: Correlation between age groups in years and cranial volume in mm³ for male and female.

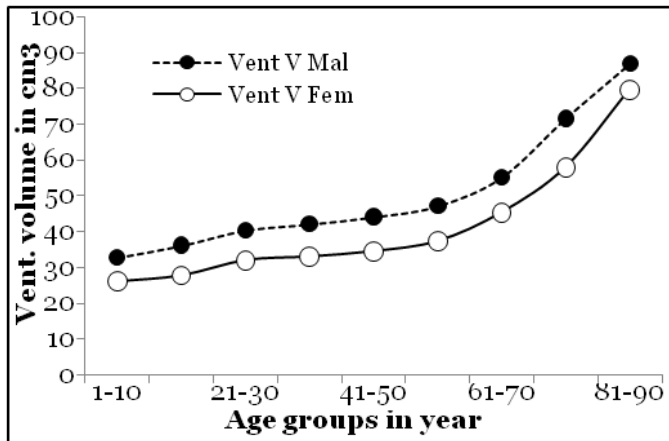


Figure 7: Correlation between age groups in years and brain ventricle volumes in mm³ for male and female.

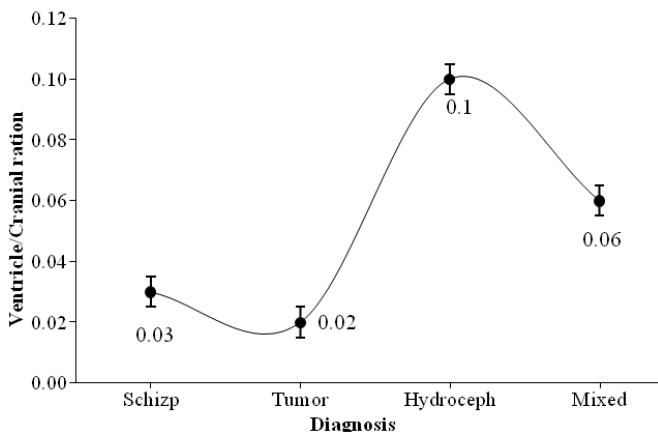


Figure 8: Ratio of brain ventricle/cranial volumes for common cranial pathologies.

4. Discussion and analysis:

Figure 1 shows the distribution of cranial pathologies based on gender. It reveals that: the incidence of pathologies that influence the cranial and brain ventricle volumes predominated among the male with a percent of 62 relative to female that account for 38%, such high incidence could be ascribed to high incidence of some diseases like (epilepsy, Schizophrenia, tumors and hydrocephalus among male [10]. As men have a greater brain (mainly white matter, the amygdala, hypothalamus and fronto-medial cortex) and cerebrospinal fluid volume, with a greater age-related loss in brain volume (specifically in the frontal and temporal lobes) [11-15].

Figure 2 shows the frequency percent of pathologies that influence the cranial and brain volume. Generally the common diseases induced brain ventricle and cranial volumes variability are hydrocephalus [16], schizophrenia [5], Alzheimers [17], and a group of neurodegenerative disorders [18], however the results showed that the common induction factor for cranial and brain volume were the hydrocephalus which representing 40.5% relative to mixed 23% and tumors taking 21.5%. The high incidence in hydrocephalus could be ascribed to predominant cases among children and the cases of cancer among adult.

Figure 3 shows the distribution of cranial pathologies based on age. It reveals that: the pathologies that increase the cranial and brain volume have been peaking (40%) on age groups 1-10 years old then decreasing following aging and reaching 6% among age groups of 33-43 years old then again peaking among age groups of 55-65 years old. Such high incidence among childhood ascribes to susceptibility of children to tissue dysplasia i.e. benign and malignant tumors, while the high incidence among adult age of 55-65 could be ascribed to high incidence of metastatic tumors.

Figure 4 shows the correlation between the patient's age and the cranial volume in cm. it shows that: there is proportional linear relation between age in years and the cranial volume in mm³ based on the following equation: $y = 18352x + 356$, which is so significant at $R^2 = 0.9$, and where x refers to age in years and y refers to cranial volume in mm³. Such increment in cranial volume has been shown by Dekaban, [19], in which he stated that: at 1 year of age, the cranial volume has increased by a factor of 2.3 and the head circumference, cranial breadth, length, and height by a factor of 1.4 over that at birth. And by 20 years of age the cranial volume is about 3.8 times that at birth, and the head circumference and the three principal cranial dimensions (breadth, length, and height) have increased by a total factor of about 1.6. Hence it confirms that the cranial volume increases by aging.

Figure 5 shows the correlation between patient age and the ventricles volume in mm. it shows that: the brain ventricle volume increases following the age increment in years, and the correlation could be fitted to the following equation: $y = 707.7x + 12127$, which is so significant at $R^2 = 0.61$, where x refers to age in years and y refers to brain ventricle volume in cm. such result could be ascertained by the study done by Brij et al, [20], in which he found that: a gradually progressive increase in ventricular size from the first through sixth decades followed by dramatic increase in the eighth and ninth decades.

Figure 6 shows the correlation between age groups in years and cranial volume in mm³ for male and female. It reveals that: the cranial volume increases by aging among male and female up to 21-30 years old then became steady and semi constant after, which could be ascribed to ossification of cranial switchers. However the general cranial volume of male was greater than that of female as $3191.7 \pm \text{STD}114 \text{ cm}^3$ among male and $3133 \pm \text{STD}124 \text{ cm}^3$ among female in average. Such greater cranial volume among male ascribed to increasing volume of white matter during the age of 4-20 years old [4].

Figure 7 shows the correlation between age groups in years and brain ventricle volumes in cm³ for male and female. It reveals that: the brain ventricles volume increase with aging among both genders, in a relation that could be fitted in the following form: $y = 5.97x + 20.75$ among male and as: $y = 5.61x + 13.48$ among female, where x refers to age in years and y refers to ventricle volume in cm³. The correlation so significant at $R^2 = 0.8$. However the ventricles volumes of male appear greater than in female i.e. $50.6 \pm \text{STD}17.9$ for male and $41.5 \pm \text{STD}17.3$ for female. Such

greater ventricle volume among male could be ascribed to atrophy of white matter, the amygdala, hypothalamus and fronto-medial cortex [11, 14] and same study has been highlighted by Gyldensted, [21] and Sabancioğulları et al, [22].

Figure 8 shows the ratio of ventricle/cranial volumes for common cranial pathologies. It shows that: the ventricular/cranial dimension was increases in case of mixed i.e. (tumor/hydrocephalus) representing 0.04, 0.03 for hydrocephalus, 0.02 for tumor relative to normal case which was 0.01 [1, 2]. In this realm, however some authors studied the brain volume which was correlated with major disease such as schizophrenia (SZ), bipolar disorder (PD) and schizoaffective disorder) depending on intercerebral volume (ICV), total brain volume (TBV), ventricular volume (VV), ventricular/brain ratio (VBR) and TBV/ ICV ratio, and they obtained that: the (TBV)/(ICV) were significantly decrease, and (VBR) increase in the (SZ) and (PD) groups compare to Control group i.e. the ratio between brain ventricle volumes to cranial volume increases among all cases of pathologies (tumor, hydrocephalus and mixed).

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