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Morphometric Assessment of Aging Impact in Cranial/Ventricles' Volumes and CT/MRI Imaging Systems Parameters

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Abstract A retrospective study aims to assess aging impact in cranial/ventricles volumes and the effect in signal intensity of imaging modalities (CT & MRI). The analysis of collected data using Excel and SPSS showed that: aging has less significant (R^2 =0.4) impact on ventricle volume generally and the correlation best fitted to equation: Volume = 1.46 age - 40.742. The impact of aging in ventricles volume was significant (p = 0.05) increment after 69 years with prominent effect among male relative to female; and steady before the age of 69 years old. Aging had less significant decreasing impact (R^2 = 0.3) in signal intensity (T_1, T_2) of white and gray matter and having prominent high signal intensity of white mater relative to gray mater. The age showed high significant (R^2 = 0.8) reducing impact in white matter HU that fitted to equations of the following forms: HU = 0.53 age + 9.6864; while there is an increasing impact in gray matter HU that fitted to: HU = -0.26 age + 40.093.

Keywords: *volumetric, cranium, ventricle, ageing-impact*

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1. Introduction

The brain ventricular system consists of lateral ventricles (LVs), third ventricle (TdV) and the fourth ventricle (FthV) [1]. The ventricles are filled with cerebrospinal fluid, which is produced by the choroid plexuses of the two lateral ventricles, the third ventricle, and the fourth ventricle. The cerebrospinal fluid escapes from the ventricular system through the three foramina in the roof of the fourth ventricle and enters the subarachnoid space [2]. Such system like any others in the human body that could be involved by many factors and parameters. In such context; Brain ventricle volumes denote variability in some diseases such as hydrocephalus [3], schizophrenia [4], Alzheimer's [5], and a group of neurodegenerative disorders [6], but some of these diseases also represent parenchymal atrophy leading to ventricle/brain ratio changes [6,7]. One previous study by Resnick et al, [8] reported variable results concerning the measurements of ventricle volumes in different age groups. In the same realm Coffey et al [9] showed different results related to brain ventricle volume and gender. Also, in the study carried out by Rania et al, [10] in which they carried out a morphometric of hepatic ducts angle has been measured and related to some pathologies for the importance of overcoming some further invasive techniques and deducing valuable diagnostic findings by using Image J\ImageJ.exe software program. Another morphometric study done by Mohammed et al, [11] in which they used CT imaging to measure the cranial volume and correlated with the common pathologies that influencing their dimension such as brain ventricle volume and cranial volume. Their results revealed 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%.

Despite many authors contribute in this domain, the gender and age impact in ventricle and brain changes is still obscure, therefore further studies may be in needful to this scope; as aging studies showed recently has an impact in human behavior, thinking and even responding to surrounding environment based on hypothesis called age differentiation [12].

The trend and focus of this study are to reveal the impact of aging in cranial and ventricular system morphometry as well as the impact on medical imaging

signals such as magnetic resonance imaging (T1 & T2) and computerized tomography CT Hounsfield Unit (HU). Such trend will be based and rely on the fact that: signal intensity would provide independent biomarker for all anatomical structures with relative alteration during man development, aging and pathologies involvement [13,14].

In medical field the imaging modalities basically applied for diagnostic possibilities with different accuracy and relative hazards and moreover for texture analysis [15,16]. However, the morphometry could be derived from the images with the usage of algorithmic equation incorporated to the relevant system (CT, MRI, U/S, NM) in addition to medical software program applied to Digital Imaging and Communications in Medicine (DICOM).

2. Methodology

A total of 150 patients have been randomly who were complained of headache, seizures, eye problem and dizziness and referred to diagnostic radiology clinics in Khartoum. The CT system was (version GE - bright speed 16 slice-2002) and the MRI system was Siemens Avanto 2010, strength 1.5 Tesla closed MRI machine with super conductive coil. And some exclusion criteria have been considered such as brain pathologies related to volumetric effects in addition to MRI contraindications including disallowed implants, pacemakers, recent surgery or any previous brain surgery, current pregnancy, facial- or very recent tattoos, or a history of multiple seizures or fits. The technique was spiral scanning having equal slice thickness and interval space. The general patient position maintained by laser beams in supine position and the anatomical reference was orbito-meatal line. 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) [17] (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. And the ethical approval for the study was obtained from the clinical and university ethical committees.

3. Results

The following results reflecting the main impact of aging and geriatric on brain, with selective focus on correlation between age versus ventricles volume generally, ventricle volume based on gender, ventricle to cranium volume ratio, signal intensity (T_1) for gray and white matter, signal intensity (T_2) for gray and white matter, signal intensity (T_1, T_2) for white matter, signal intensity (T_1, T_2) for gray matter, HU for white and gray matter and HU versus signal intensity of white and gray matter.

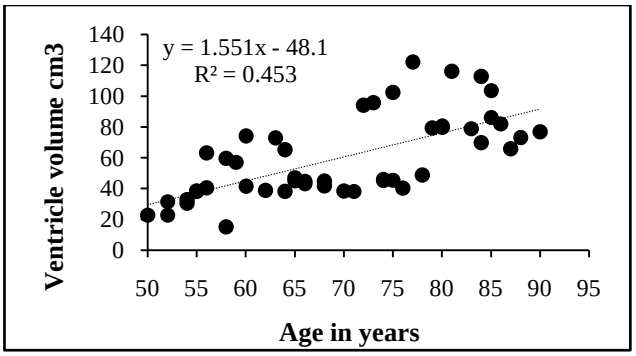

Figure 1. Shows the correlation between age in years and ventricle volume in cm3 in Sudan

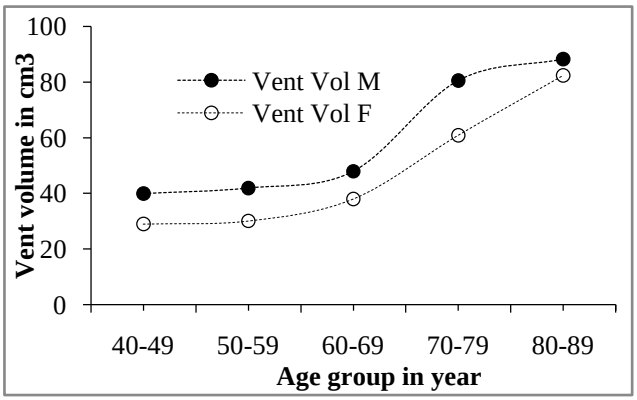

Figure 2. Shows the correlation between age in years and ventricles volume in cm3 for male and female in Sudan

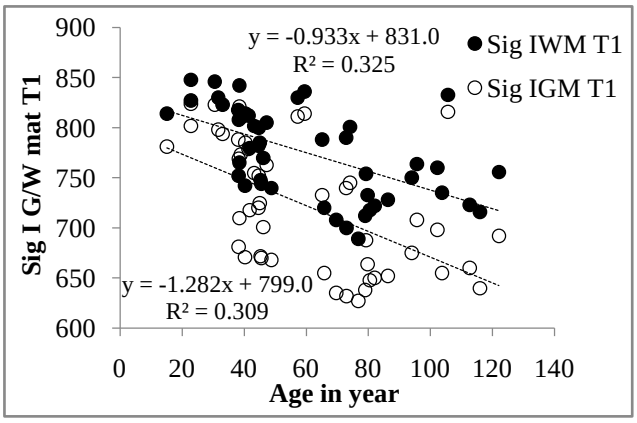

Figure 3. Shows the correlation between age in years and signal intensity (T1) for gray and white matter in Sudan

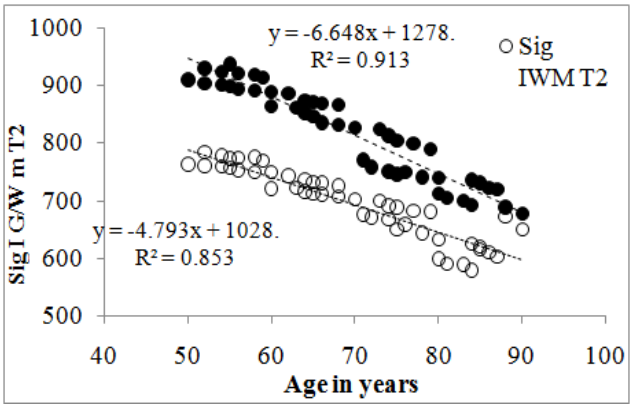

Figure 4. shows the correlation between age in years and signal intensity (T2) for gray and white matter in Sudan

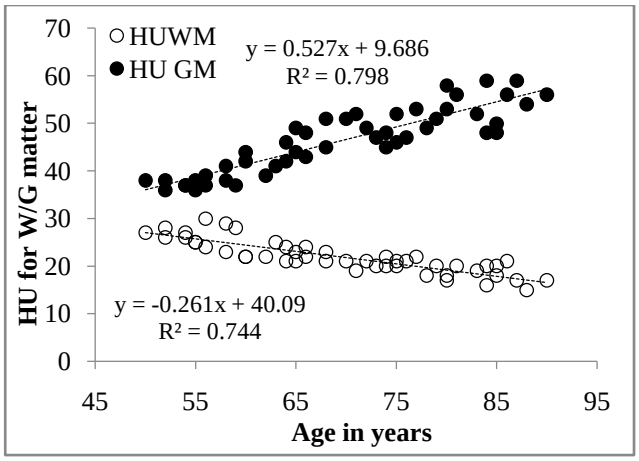

Figure 5. Shows the correlation between age in years and HU for white and gray matter in Sudan

4. Discussion

With reference to Figure 1 that shows the correlation between age in years and ventricle volume in cm^3 in Sudan. In which the aging shows less significant (R^2 =0.4) impact on ventricle volume generally (due to gender factor) and the correlation best fitted to equation: y = 1.4588x - 40.742, where x refers to age in years and y refers to ventricle volume in cm3. However, the impact of aging in ventricles volume for male and female shows significant (p = 0.05) increment in ventricle volume after 69 years with prominent effect among male; while before the age of 69 years old the impact on volume was so steady as shown in Figure 2. The increment of ventricle volume (from the first through sixth decades followed by dramatic increase in the eighth and ninth decades) with aging accompanied by excessive volume of cerebrospinal fluid (CSF) which will be as reductive impact to the brain volume. And due to such impact in brain the relative behavior of man would be deteriorated or influenced as well as cognitive capability [18,19]. Relative to this study an agreement of Bijaylakshmi et al, [20] and Sasank et al, [21] laid out concrete findings such as: Sizes of all three ventricles were more in elderly individuals and increase with ageing. In both higher age-groups, males had more expansion of ventricular system than females. Increase in ventricular size was more evident in the lateral ventricle. Changes in ventricular size did not show any effective change in cranial diameters. Such volumetric study has been prone to medical imaging to deduce the effect in MRI signal; in such context Figure 3 showing the correlation between age in a year and signal intensity of white and gray matter in T_1. The aging showing less significant impact (R^2 = 0.3) in signal intensity (T_1) of white and gray matter which are in decreasing proportionality with aging with prominent high signal intensity of white mater relative to gray mater. The low signal intensity of gray matter could be ascribed to an increased water content in the white matter and the progressive neuronal loss in the grey matter that occurs with age; as same result has been found by Magnaldi et al, [22]. The correlation between ageing and signal intensity for white/gray matter at (T_1) could be best fitted to equation y = 0.9337x + 831.09 (white matter) and y=1.2823x +799.03 (gray matter), where x refers to age in years and y refers to signal intensity of (T_1). Such results have been agreed with the study done by Lars et al, [23], in which he found that: decline of signal intensity of white and gray matter respectively with age and the reducing intensity following the age increment was ascribed to decrease of proton density and water content with aging. Same significant (R^2 = 0.9) phenomena of reduced signal intensity (T_2) following aging for white and gray matter have been noticed in Figure 4 with correlation could be fitted to equations of the form y = -6.6489x + 1278.2 (white matter) and y = -4.7937x + 1028.4 (gray matter) which is ascribed to decrease of water content as Kim et al, [24] found that: effect of age on signal intensity as significant inverse relationship between age and signal intensity of both gray and white matter with prominent high signal intensity for white matter compared to gray mater. The decrement of signal intensity for both white and gray matter following aging reflects important fact that: aging lead to brain deterioration that obviously reflected in man behavior, controlling, interpretation, thinking and even response to surrounding environment that agreed with the findings of Anders and Kristine, [12] in which they found that: reductions in specific cognitive abilities for instance processing speed, executive functions, and episodic memory are seen in healthy aging. whereas aging has less significant (R^2 = 0.3) impact in reducing signal intensity of W & G matter at T_1, however there is high significant (R^2 = 0.9) impact in reducing signal intensity of W & G matter at T_2 and also the signal intensity at T_1 is higher for white matter while at T_2 the gray matter signal is higher.

The aging effect has been studied by CT imaging as in Figure 5 that showing the correlation between age in year and the HU for white and gray matter. In which the age showed high significant (R^2 = 0.8) reducing impact in white matter HU that fitted to equations of the following forms: y = 0.5274x + 9.6864; while there is an increasing impact in gray matter HU that fitted to equation: y = -0.2618x + 40.093, where x refers to age in year and y refers to HU for relative white and gray matter. The age reduction impact in HU for white matter and the increasing impact in HU for gray matter indicates the dense compound of white matter and the presence of many contents factors such iron, blood, myelin content, macromolecular chemical exchange, and fiber orientation relative gray matter [25]. Based on the reduced HU that attribute to low CT number and further less radiation absorption, researchers could judge that: by aging the white matter lose it is density and or undergoes atrophy.

5. Conclusion

Aging has obvious and significant impact in brain and ventricles volumetric as an increase ventricular volume that totally obliterated by cerebrospinal fluid (CSF) and decreased brain volume that influence man behavior, thinking and interpretation. The role of imaging systems has successfully detecting the ageing impact in Hounsfield Units and Signal intensity by CT and MRI respectively.

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