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CORRELATIONS BETWEEN LATERAL VENTRICLE TEMPORAL HORN DIAMETERS, HIPPOCAMPAL VOLUME AND MINI MENTAL STATE EXAMINATION: A REVIEW OF 200 HIPPOCAMPAL STUDIES

Valenzuela Sosa, S.
Instituto de Investigación en Salud, Universidad Autónoma de Santo Domingo, Dominican Republic
Dominican Gamma Knife Center, CEDIMAT, Santo Domingo, Dominican Republic

Mármol, F.
Instituto de Investigación en Salud, Universidad Autónoma de Santo Domingo, Dominican Republic

Coats, C.
Instituto de Investigación en Salud, Universidad Autónoma de Santo Domingo, Dominican Republic

Jiménez, O.
Instituto de Investigación en Salud, Universidad Autónoma de Santo Domingo, Dominican Republic

Peralta, I.
Dominican Gamma Knife Center, CEDIMAT, Santo Domingo, Dominican Republic

Valdez, J.
Instituto de Investigación en Salud,
Universidad Autónoma de Santo Domingo,
Dominican Republic

Abstract: **Objectives:** to determine whether the transverse diameter of the anteroposterior portion of the temporal horns of the lateral ventricles has any relationship with the real volume of the hippocampus and the degree of cognitive impairment presented by the patients. **Method**: prospective study, which took place between January 2020 and July 2022, of 100 Dominican adults, divided into a **control group** of 60 patients with normal cognition divided into 3 age subgroups (20-40, 41 to 60 and 61 to 80 years old) and a **case group** of 40 patients complaining of cognitive problems (20 from 41 to 60 and 20 from 61 to 80 years old). They were administered the Folstein Mini Mental State Examination (MMSE) adapted to Latino patients[5]. All of them benefited from a 1.5 Tesla MRI with 1-1.5 mm slices for three-dimensional reconstruction including T1 sequences without contrast, FLAIR, T2 and TOF. To determine the transverse diameter of the temporal horns, the anteroposterior portion of the horns was always chosen and not the one perpendicular to the midline due to the close relationship of the former with the Ammon's Horn, the most voluminous portion of the hippocampus[8,9,10,11,12]. A point was always taken from that portion of the temporal horn that was placed in the same position in the contralateral temporal horn. The hippocampi were examined morphologically to determine if there was any asymmetry in each slice when compared to each other by simple inspection by the Principal Investigator (PI). Real volumetry was performed using voxels and theoretical volumetry using the XYZ Geo method[1,2]. The time taken for each type of hippocampal volumetry was timed. The diameter of the temporal horns was correlated with the volume of the hippocampi studied and the MMSE result of each patient. The data collected was processed using measures of central tendency and dispersion in the Microsoft Excel 2016 platform. **Results:** the data

obtained showed that the diameter of the temporal horns varies according to sex both on the left and on the right, being larger in men than in women on both sides. The diameter of the temporal horns increases with age and cognitive impairment, being more noticeable this correlation on the left side. The volume of the hippocampus has an inversely proportional correlation with respect to the diameter of the temporal horn: the greater the volume of the hippocampus the smaller the transverse diameter of the anteroposterior portion of the temporal horn and vice versa. When comparing temporal horn diameter with MMSE results, we found that the greater the transverse diameter of the anteroposterior portion of the temporal horn, the lower the MMSE score, especially in the left hemisphere. **Conclusion:** There is a close and inversely proportional correlation between the transverse diameter of the anteroposterior portion of the temporal horns of the lateral ventricles, the volume of the hippocampus and the MMSE score, which is more noticeable in the left hemisphere.
Keywords: Diameter of Temporal Horns of the Lateral Ventricles, Hippocampal Volume, Mini Mental State Examination, Magnetic Resonance Imaging,

INTRODUCTION

The close correlation that may exist between the amplitude of the temporal horns of the lateral ventricles, the volume of the hippocampus and cognition has been widely recognized in the international literature[12,13,14,15,16,17,18]. There is an important variability in the conformation of the temporal horn of the lateral ventricle, but in most cases it has an anteroposterior portion that borders the lateral face of the Asta of Ammon (AA)/ Ammon's horn or head of the hippocampus, its widest portion. This portion continues with a more anterior segment arranged transversely, which delimits in front the anterior end of the hippocampus (Image 1 and 2). Because of this close relationship between these two important structures, it is logical to assume that the measurement of the diameter of the temporal horn at any point will be inversely proportional to the real volume of the hippocampus[(12,13,14,15,16,17,18)].

Given that the hippocampus is an extremely important element in the recent memory circuitry, it is easy to infer that patients with increased temporal horn diameter may have decreased hippocampal volume and perhaps a decreased Mini Mental State Examination (MMSE) score[12,13,14,15,16,17,18]. In order to know exactly how this correlation is in Dominican patients, we took advantage of the study of real versus theoretical volumetry that we performed in 100 patients of that nationality trying to confirm the usefulness of the XYZ Geo rapid volumetry method[(1, 2)] applied to the hippocampus. During that investigation we were concerned with measuring the maximum transverse diameter of the anteroposterior portion of the temporal horn in a high-definition MRI slice in which the temporal horns on both sides coincided (Image 2). This option seemed to us easier to practice and reproduce in future investigations because of the constancy of its presentation. After reviewing the literature on the subject, we supported the criterion that measuring the anterior transverse portion of the temporal horn in any of its parts, subject to many anatomical variations, or the angle that joins it to the anteroposterior portion, complicates the process and makes it restrictive for superspecialists (see Image 1 and 2)[12,13,14,15,16,17,18].

It has been amply demonstrated in the international literature on the subject the close correlation that exists between the progressive expansion of the ventricular diameter and the decrease in the cognitive performance of patients[12,13,14,15,16,17,18]. If this variable is determined in the portion of the ventricular system

in the vicinity of the hippocampus, which is one of the centers most involved in the management and storage of episodic and spatial memory, it could become an indispensable tool for the evolutionary follow-up of patients suspected of cognitive problems. ,

It has been published in recent literature that in patients affected by Alzheimer's disease the ventricular volume can grow an average of 14.6% annually while in normal controls the average growth is 11.8% ($p<0.001$)[15]. It is not difficult to infer, therefore, the transcendental interest that the size of the temporal horn of the lateral ventricle could have in the assessment of the cognitive situation of a patient, especially if correlated with the volume of the structure that is in its intimate contact: the hippocampus.

That is why we considered of extreme interest, when undertaking a study of 200 hippocampi in 100 Dominican patients, 60 healthy and 40 with some degree of cognitive compromise, to measure the diameter of the anteroposterior portion of the temporal horn of the lateral ventricle, to determine if any tangible correlation was derived by relating it to the real volume of the hippocampus and the Mini Mental State Examination (MMSE).

MATERIAL AND METHODS

This prospective study was conducted between January 2020 and July 2022 at the Centro Gamma Knife Dominicano (CGKD) belonging to the Centro de Diagnostico, Medicina Avanzada y Telemedicina (CEDIMAT), located at the Plaza de la Salud in the city of Santo Domingo, Dominican Republic. A total of 100 participants were recruited, distributed in 3 age groups (20 to 40, 41 to 60, 61 to 80 years old), composed of cognitively normal individuals. They attended neurology or neurosurgery outpatients for any reason except cognitive dysfunction. All groups were composed of 20 individuals each, with an equal proportion between both sexes. They were compared with another group of 40 patients who consulted for cognitive problems, aged between 41-60 and 61-80 years, periods of life in which dementia is usually detected. Before being included in the research, each patient was asked to read, understand, accept and sign an informed consent form, which was signed by a responsible family member or caregiver in case the patient had severe cognitive impairment. All patients included in the study underwent a 1.5 tesla MRI of 1 to 1.5 mm slice thickness, processed in the Elekta Gamma Plan 11 Work Station of the CGKD, with capacity for three-dimensional reconstruction; the following sequences were used in all cases: T1 without contrast, T2, FLAIR and Time of Flight (TOF). After measuring the degree of deviation from the midline of the T1 images without contrast, applying the Angulus Software[3,4] in the axial slice that revealed the septum pellucidum, the classic hippocampal slice was immediately exposed, in which the Asta of Ammon (AA)/ Ammon's horn, the body of the hippocampus and the temporal horn of the lateral ventricle appear (Images 1 and 2). At that moment the Principal Investigator (PI) determined the degree of asymmetry between the mentioned structures in each hemisphere and proceeded to determine the transverse diameter of the anteroposterior portion of the temporal horn of the lateral ventricle, preferably choosing a slice in which this structure appeared on both sides (Images 1 and 2). After this, the real volumetry was performed by means of voxels (planimetry) and the indirect volumetry by applying the XYZ Geo method[(1,2)] of both hippocampi, timing the time taken for each process. Simultaneously the cognitive level of each patient was determined using the Mini Mental State Examination (MMSE)[5]. The temporal horn diameter, hippocampal volume and MMSE score of the 100 patients studied were correlated. The data

collected were processed using measures of central tendency and Pearson's correlation/ scatter coefficient using the Microsoft Excel 2016 platform.

RESULTS

As already specified, this research work is based on the analysis of 100 high definition MRI scans performed during the process of direct and indirect volumetry of 200 hippocampi of 100 Dominican patients[1,2]. It can be seen in Figure 1 that there are 60 patients without (Control Group) and 40 with cognitive problems (Case Group), 51 women and 49 men, 80% of them over 40 years old. Using the Elekta Gamma Plan 11 Work Station stereotactic platform for MRI image management of thin slices of 1 to 1.5 mm thickness, from the Dominican Gamma Knife Center (CGKD), we determined the transverse diameter of the anteroposterior portion of the temporal horn of the lateral ventricle of each cerebral hemisphere in each of them (Images 1 and 2). All patients were administered the Mini Mental State Examination (MMSE)[5]. By relating these three variables: real hippocampal volume, transverse diameter of the temporal horn of the lateral ventricle and MMSE score, an interesting data emerged and is presented below. The entire measurement process was performed using measures of central tendency and dispersion, with the help of the Microsoft Excel 2016 platform.

As can be seen in Graph 2 the average diameter of the temporal horns as a whole was significantly larger on the left (2.68mms) than on the right (2.11mms) for a difference of 21.26%. This tendency was verified in both sexes.

It is noteworthy that in females the diameter of the temporal horns was smaller than in males, both on the right and on the left (Figure 2).

If we carefully analyze Table 1 we will immediately notice that the hippocampi (Ammon's horn) of the patients without cognitive problems (Control Group) have on average a significantly larger volume both on the left and on the right (2.95cc, 3.11cc) than those of the patients belonging to the Case Group (2.68cc, 2.89cc). This is consistent with what has been found in the international literature: the presence of cognitive problems is related to decreased hippocampal volume[12,13,14,15,16,17,18].

It also appears in Table 1 that the average transverse diameter of the temporal horns, both left and right, is significantly higher in the Case Group (with cognitive problems: 3.55 mm, 2.36 mm) than in the Control Group (without cognitive problems: 2.105 mm, 1.94 mm). This result is in line with the evidence found in many investigations: the transverse diameter of the temporal horn is inversely proportional to the volume of the hippocampus[15,16,17].

Figure 3 shows a clustering of most of the patients' hippocampal volumes between 2 and 4 cc. At the same time, the most prevalent diameters of the anteroposterior portion of the temporal horns range between 1 and 4 mm on both right and left sides. Dispersion towards hippocampal volumes above 5cc and temporal horn diameters greater than 4 mm are rare. This gives us an overall idea of the most frequent values to be found in these structures in Dominican patients of these ages. It is easy to perceive the tendency to have small hippocampal volumes (between 1 and 2 cc) when the diameters of the temporal horns are larger (between 4 and 7 mm). This can be observed both on the right and on the left.

In Figure 4, the tendency for the transverse diameter of the temporal horn of the lateral ventricle to increase with age is very noticeable, going from an average of 2.06 mm on the right or 2.24 mm on the left between 20 and 40 years of age, to 2.11 and 2.10 mm betwe-

en 61 and 80 years of age, in patients without cognitive problems. In cognitively impaired patients these values rise to 3.11 mms left between 41 and 60 years, culminating with an impressive 3.99mms, also on the left, between 61 and 80 years. Therefore, it is easy to infer that age and cognitive impairment play a role in the increase of the transverse diameter of the anteroposterior segment of the temporal horn of the lateral ventricle [15,16,17].

Analyzing Figure 5 we realize that from a diameter of the anteroposterior portion of the temporal horn above 2.5 mm on the right and 3 mm on the left the MMSE score consistently decreases. This shows that cognition is inversely related to the diameter of the anteroposterior portion of the temporal horns: the larger the diameter, the lower the cognitive performance[15,16,17]. This trend is more noticeable in our cases in the left hemisphere, where we observed an increased frequency of cases with more than 3mm transverse diameter of the anteroposterior portion of the temporal horn and MMSE below 25 points.

DISCUSSION

The diameter of the temporal horns of the lateral ventricles has been an obligatory point of reference in the imaging analysis of patients suffering from various pathologies that are a daily challenge for the neuroscientist: ventriculomegaly secondary to intra or extraventricular block in patients affected by hemorrhagic stroke; mesial temporal sclerosis in epileptic patients; hippocampal degeneration in patients with severe cognitive problems, etc. The 2mm diameter as average of normality has been retained in many of the writings on the subject that appear in the specialized literature[(12,13,14,15,16,17,18)].

After a thorough review of the literature, we found that this is the first time that an investigation has been carried out to establish the exact value of the transverse diameter of the anteroposterior portion of the temporal horn of the lateral ventricles of Dominican adult patients with and without cognitive problems:

-Patients without cognitive problems: 2.105 mms on the left, 1.94 mms on the right.

-Patients with cognitive problems: 3.55 mm on the left, 2.36 on the right (Table 1).

It was established that the average transverse diameter of the anteroposterior portion of the temporal horn is usually larger on the left than on the right in both sexes (Table 1). Since the left hemisphere is the dominant hemisphere (possessing the language function) in most human beings, this is relevant when making diagnostic or therapeutic decisions.

It should be noted in this regard that the mean transverse diameters of the temporal horns were larger in males than in females (Table 1, Graphic 2). This is important to keep in mind in order to assess each particular case, personalizing the context before reaching any clinical conclusions.

Given that lower hippocampal volumes are related to increased transverse diameters of the anteroposterior portion of the temporal horns, since these rise above 3.55 mm on the left or 2.36 mm on the right in a patient suspected of cognitive impairment, with an MMSE of 25 points or less (Table 1), we should assess the complete aspect of the hippocampus, taking into account its thickest part (Asta of Ammon, AA/Ammon's horn) and extend the evaluation to its body and tail. If we can apply the method of rapid indirect volumetry XYZ Geo[1,2] published by us recently, and the result is a hippocampal volume below the average expected for age, we approach an objective diagnosis of degenerative dementia with Alzheimer's disease component.

If we analyze well a 1.5 Tesla MRI with thin slices of 1 to 1.5mms, in any platform capable of tracing diameters, locating the anteroposterior segment of the temporal horn and spe-

cifying its transverse dimension, we have at hand a valuable tool to make judgments about the state of the hippocampus and cognitive health. Combining this data with the volumetric assessment of the head, body and tail of the hippocampus, or its indirect volumetry by means of the XYZ Geo method[1,2], and the MMSE result, we will have a solid criterion on the cognitive situation of that patient.

CONCLUSIONS

The transverse diameter of the anteroposterior portion of the temporal horn of the lateral ventricle, due to its close relationship with the thickest part of the hippocampus (Ammón's horn) is of relevant interest in the process of assessing the cognitive status of patients. When associated with hippocampal volumetry and MMSE, it proves to be a robust tool in the clinical-imaging diagnosis of cognitive impairment.

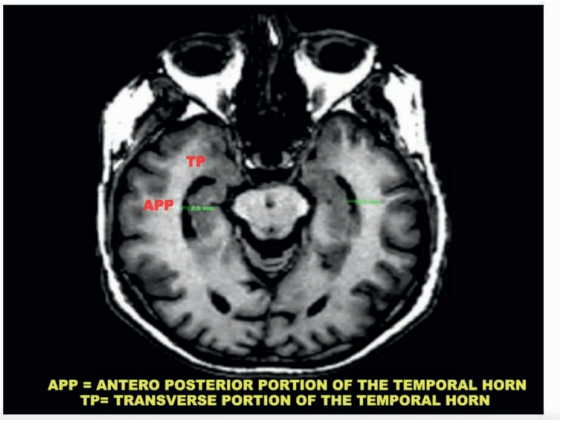


Image 1

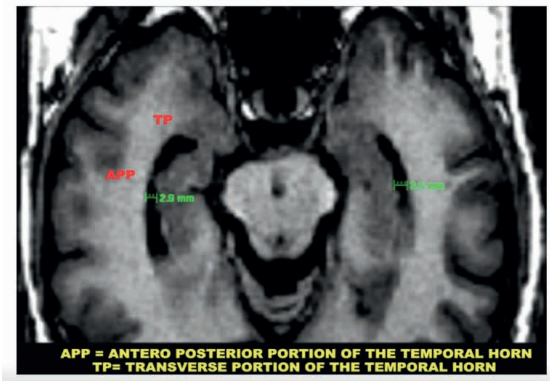
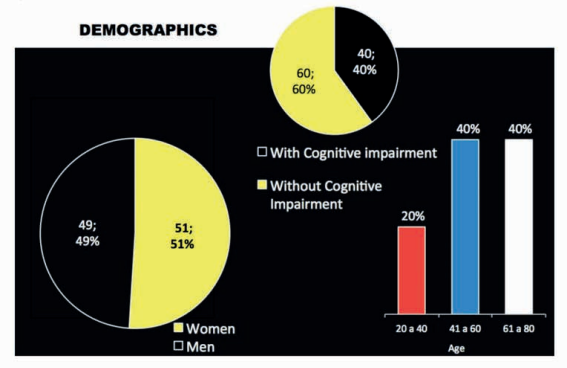
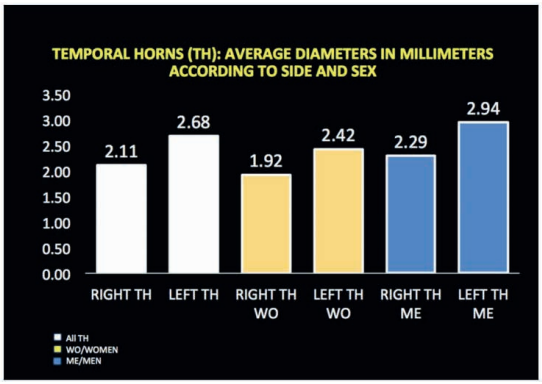


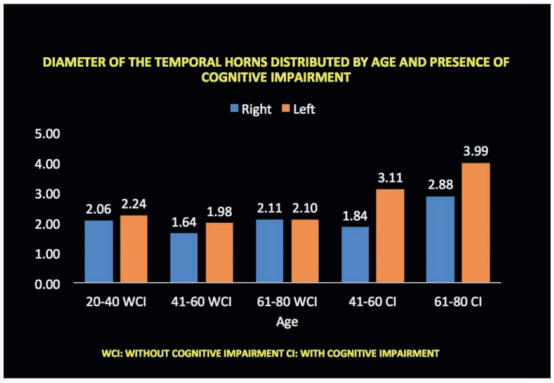
Image 2



GRAPHIC 1



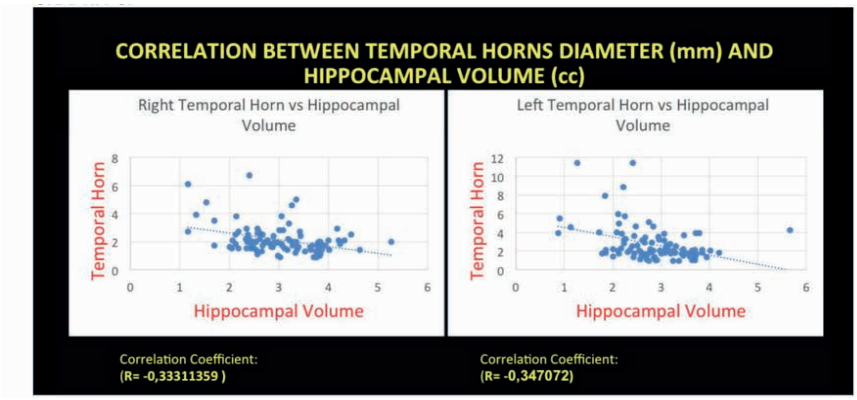
GRAPHIC 2



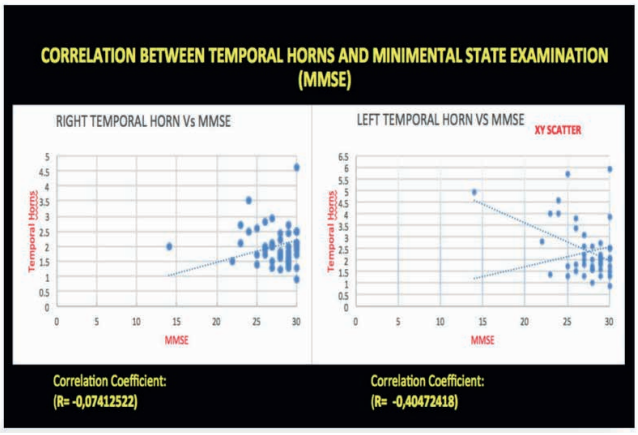
GRAPHIC 4

	Left Temporal Horn (mm)	Right Temporal Horn (mm)	Volume of Left Ammon Horn (cc)	Volume of Right Ammon Horn (cc)	MMSE Average
Control Group					
20 to 40 years					
Women	2.34	2.15	3.01	3.27	29.5
Men	2.14	1.96	3.06	3.17	29.1
41 to 60 years					
Women	1.77	1.42	2.74	3.07	28.3
Men	2.18	1.86	3.35	3.28	28.3
61 to 80 years					
Women	1.71	2.05	2.61	2.71	26.1
Men	2.49	2.2	2.95	3.16	27.9
Control Group Average	2.105	1.94	2.95	3.11	28.3
Cases					
41 to 60 years					
Women	2.97	1.76	2.9	3.19	26.1
Men	3.25	1.91	3.02	3.28	25.56
61 to 80 years					
Women	3.31	2.21	2.41	2.46	21.2
Men	4.66	3.54	2.39	2.61	20.2
Cases Average	3.55	2.36	2.68	2.89	23.28
General Average	2.828	2.15	2.815	3	26.23

TABLE 1



GRAPHIC 3



GRAPHIC 5

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