كلية الدراسات العليا

Sudan University of Sciences and Technology

College of Graduate Studies

Study of the Brain Structures Development During Childhood Using Magnetic Resonance Imaging

دراسة تطورتركيب الدماغ في مرحلة الطفولة باستخدام التصوير بالرنين المغناطيسي

A Thesis submitted for Fulfillment of the Requirement of Master Degree (M. Sc) in Diagnostic Radiological Technology

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الآية

بسم الله الرحمن الرحيم

اقْرَأْباسْمِ رَبّكَ الّذِي خَلَقَ * خَلَقَ الإِنْسَانَ مِنْ عَلَقٍ * اقْرَأْوَرَبُّكَ الأَكْرَمُ * الّذِي عَلّمَ بِالْقَلَمِ * عَلّمَ الإِنْسَانَ مَالَمْ يَعْلَمْ (سورةالعلق: 1-5.)

صدق الله العظيم

Dedication

To my parents

To my family

To all my friends

To colleagues for their love and support**.**

Acknowledgment

First of all, I thank Allah the Almighty for helping me complete this study. I thank Professor Caroline Edward Ayad Khilla, my supervisor, for her help and guidance. Thanks a lot, and all grateful for her.

I would like to express my gratitude to Doctor Heba Tolab a medical radiologist at the Saudi Germen hospital. She lent a hand to getting samples Attention to the importance of research and what they aspire to, and all research samples were diagnosed as normal by her. I would like to thank Doctor Khalid Abdlhafith head of the of Radiology Technicians Department at the International Medical Center hospital by extending a helping hand to provide me samples for research.

Finally I would like to thank everybody who helped me prepare and finish this study.

Abstract

This is a descriptive analytical study, the study population composed of normal brain patients presenting to the Magnetic resonance unit. The study was applied in International Medical Center and Saudi Germen hospitals. Superconducting system Siemens Avanto 1.5 Tesla was used. The cases were confirmed to be normal with the presence of the radiologist during the selection of cases for study. And began during the period extended from July 2016 to July 2018. The reason for the study was noticed that there is no presence of normal measures in children from the age of less than one year up to 15 years old. The objectives of the study were to study the normal dimensions of the cerebellum, cerebrum, pons and tentorium angle as well as to evaluate the gender differences and the age-related changes. Axial, and midsagittal of normal brain MRI scans of 200 subjects (104 were males and 96 were females) were evaluated. The measurements were performed using spin echo sequences the images are T_1 weighted sagittal plane (TR 400) (TE 12). And T_2 weighted axial plane TR =4500, TE =117. Slice thicknesses =2mm, gap= 5 mm, field of view =20 cm and display matrix= 314 x 448. Measurements were performed to properly measure the children posterior fossa. The study evaluated: (1) The dimensions of the cerebellum for the right and left anteroposterior and transverse at axial plane (2) the cerebrum right and left anteroposterior dimension and transverse diameter at axial plane and (3) the Pons anteroposterior and craniocaudal dimensions as well as the tentorium angle at sagittal plane. The collected data were statistically analyzed by using SPSS program version 16. Student's t -test was applied for gender comparisons. To determine the associations between age and anatomical structures, Pearson correlation coefficients were calculated, Post Hoc test for

multiple comparisons was also used. The mean of right and left cerebellum anteroposterior and transverse dimension were found to be 4.67±0.87, 4.60±0.92 and8.68±1.48 cm in respectively. Mean right and left cerebrum anteroposterior and transverse dimension were found to be 13.88±1.91, 13.88±1.91 and 11.61±1.53cm in respectively. The mean of Pons anteroposterior and cranio caudal dimension were found to be 1.47±0.38and3.68±18.74inrespectivelyTheMeantentorialanglewas40.93º±8.68 .The study showed that the cerebellum and cerebrum right and left anteroposterior dimensions and transverse diameter were significantly increased with increasing age during the developing period from ages less than 1 year to 15 years old at p=0.027,0.021,0.000 and 0.000,0.000,0.000 In respectively, as well; the Pons anteroposterior diameter was significantly affected with age at p=.033. On the other hand; no significant relationship was found between the Pons craniocaudal diameter/age and the Tentorialangle/age. No significant gender related differences were detected in all the selected variables except the Tentorialangle. New predictive equations for the cerebrum, cerebellum, and pons dimensions were established as standard reference values for subjects with known age □ 1year≤15 years old. The study recommended applying these equations in medical radiology departments as reference for the age of study in clinical and for further studies on anatomical structures like ventricals, medallaoblingata, and other.

المستخلص

هذه دراسه تحليليه وصفيه يتكون مجتمع الدراسة من مرضى الدماغ العاديين من فئة الاطفال الذين قدموا الى وحدة الرنين المغناطيسي تم تطبيق الدراسة في مستشفى السعودي الالماني ومستشفى الطب الدولي في الفترة مابين عام 2016 الى 2018 باستخدام جهاز سيمنز افانتو قوة مغناطيسيته 1.5 تسلا. سبب الدراسة ملاحظة عدم وجود مقاسات طبيعيه لدماغ الاطفال من عمر الاقل من عام حتى عمر الخامسة عشر . هدف الدراسة هو دراسة الابعاد الطبيعية للمخيخ والمخ والجسر المخيخي وزاوية المخيخ الخيمية في الأعمار الأقل من عام الى عمر الخامسة عشرة, وكذلك لتقييم الفروق بين الجنسين والتغيرات المرتبطة بالعمر , قياس الخط النصفي والأفقي للدماغ الطبيعية ثم عمل رنين مغناطيسي لمئتي حالة . مئه وأربعة ذكور وتسع وتسعون اناث قامت الدراسة بتقييم أبعاد المخيخ الأيمن والأيسر من الأمامي الخلفي والمستعرض للمقطع الأفقي . والمخ الأيمن والأيسر من الأمامي الخلفي والمستعرض للمقطع الأفقي . والجسر المخيخي الأمامي الخلفي والمحور الرأسي الجانبي وقياس زاوية المخيخ الخيمية في المقطع الرأسي الطولي . تم تحليل البيانات التي تم جمعها احصائيا بواسطة برنامج تحليل احصائي . تم تطبيق اختبار الباحث للمقارنة بين الجنسين لتحديد الصلة بين العمر والهياكل التشريحية . تم حساب العديد من المعاملات تم توضيحها بجداول لتختصر في جدول واحد يوضح الاحتمالية لمقارنات متعددة استخدمت أيضا المخيخ الأيمن والأيسر, قياس الجزء الأمامي الخلفي والمستعرض

الذي وجد على التوالي :4.67±0.87, 4.60±0.92 and8.68±1.48 cm

وقياس الجزء الأيمن والأيسر للمخ وقياس الأمامي الخلفي والمستعرض الذي وجد على التوالي

13.88±1.91, 13.88±1.91 and 11.61±1.53cm :

وقياس الجزء الأمامي الخلفي والرأسي الجانبي لجسر المخيخي الذي وجد على التوالى :

1.47±0.38and3.68±18.74 cm

كانت زاوية المخيخ 40.93º±8.68

أظهرت الدراسة أن المخيخ والمخ الايمن والايسر بأخذ المقطع الامامي الخلفي والمستعرض يزيد بشكل ملحوظ مع زيادة العمر خلال فتره النمو من اقل من عام الى عمر الخامسة عشرة. والقيمه الاحتمالية p=0.027,0.021,0.000 and 0.000,0.000,0.000

على التوالي والجسر المخيخي الامامي الخلفي أظهر تأثرا بالعمر وكانت القيمة الاحتمالية p=.033

من جهة أخرى لم توجد علاقة لمقطع الرأسي الجانبي للجسر المخيخي لم يظهر تأثرا بالعمر وكذلك زاوية المخيخ. تم الكشف عن عدم وجود فروق ذات صلة بين الجنسين في جميع المتغيرات المحددة ماعدا زاوية المخيخ .تم التوصل الى معادلات تنبئيه جديدة توضح أبعاد المخ والمخيخ والجسر المخيخي انشئت كمرجع قياسي لقيم موضوعة مع عمر معروف من أقل من عام الى عمر الخامسة عشرة . توصية الدراسه هي تطبيق هذه المعادلات في اقسام الاشعه الطبيه كمرجع في الفحوصات السريرية وللمزيد من الدراسات حول الهياكل التشريحيه.

Tables of Contents

List of Tables

List of figures

List of abbreviations

abbreviations	Full name
a	angle of the cerebellar tentorium to Twinning's line
AP	Antero Posterior diameter
APDP	Anterior-Posterior Diameter of the Pons
C	length of cerebellar hemisphere
C plane	Coronal plane
C.T	Clivus-Tentorium angle
CC	Cranio Caudal diameter
CMI	Chiari I Malformation
2D	Two dimensional
3D	Three- dimensional
GM	Gray Matter
GW	Gestational Weeks
ICARS	International Cooperative Ataxia Rating Scale
ISCC	Inferior part of the Splenium of Corpus Callosum
MRI	Magnetic Resonance Imaging
n	angle tentorial
SC	Superior colliculi
SCC	Splenium of Corbuscollosum
TCD	Transverse Cerebellar Diameter
T.W	Twining's Line
VAIS	Volumetric Asymmetry I ndices
VER	Vermis
VH	Vermis Height

Chapter One

1.1 Introduction :

The human brain grows and increases in structural complexity at a more rapid rate than in any other period of developments which begin around 13 gestational weeks (GW) and continue until early in the second year after birth. The development of the skull was dependent on the increasing volume of the cranial contents, of which normal development and growth of the brain is one important factor. (Stiles J and Jernigan T. L 2010)

In this study attempts to test that measurement of three parts of brain using MRI this technology is important to illustrate more clearly than ever before, the difference between healthy and diseased tissue, and can provide important information about the brain, spine, joints and internal organs it can lead to early detection and treatment of disease and has no known side effect. The human brain is not only one of the most important organs in the human body; it is also the most complex. In the following tour, about the basic structures that make up the brain as well as how the brain works. (Carmona R.R et al. 2019) the size of the brain may not always indicate a measure of intelligence. The human brain is an amazing organ, capable of surprising feats of memory susceptible to damage, and yet remarkably adaptable to change. (Cardy M and Getty 2013). The place examination was cerebellum, cerebrum, and pons and compared it to gathers. (Malinger et al. 2009) Some normative brain volumes assessed with magnetic resonance imaging (MRI) can be used to distinguish between pathological changes and normal age-related changes (Matsumae et al. 1996). The cerebellum is potentially akey modulator that impacts and is impacted by addition. Specific structures in the posterior cerebellar hemispheres, such as hemispheric lobule are particularly salient as contributing factors. (Moulton et al. 2015) However, the cerebellum is located at the bottom of the brain with the portion of the brainstem called the Pons separated from the overlying cerebrum. (Griffiths et al. 2016) cerebellum appears at the end of fifth week.(Goel P et al.2010) Findings for the right and left sides of male and female cerebra and cerebella are summarized.(Henery and Mayhew 1989) and Tentorial Angle has great importance position The present study investigates changes in the trajectory of the tentorium as measured by the occipital and tentorial angles at different stages of development Methods the tentorial and occipital angles steadily increase reflecting the dynamic growth of the posterior fossa structures, Postnatal, the tentorial angle decreases and the tentorium slopes downward and plateaus, possibly due to stabilization of posterior fossa development and ongoing growth of the cerebrum. Together, these findings suggest that the tentorial angle can serve as an imaging biomarker of posterior fossa development during the second half of fetal life. (Moulton EA et al. 2015)The cases were collected from the German and Saudi Medical hospital, and were diagnosed by radiologist and ended up normal. There are many researches in the literature where anatomical structures in brain are measured quantitatively in terms of dimensions.(Yucel K et al. 2002) Investigations of aging effects on the brain stem and cerebellum are significant, not only to understand normal aging, but also for comparative study of the path physiology of degenerative brain disorders. Since the development of magnetic resonance imaging (MRI), many neuroanatomical studies of normal brain growth and atrophy have been reported (Coffey C.E et al. 1992; Pfefferbaum A et al. 1994; Blatter D.D et al. 1995; Matsumae M et al. 1996).The cerebellum is known to undergo volumetric declines with advanced age. Individual differences in regional cerebella volume may therefore provide insight into performance variability across the lifespan, as has been shown with other brain structures. (Jessica A et al. 2013)The Tentorial Angle has great importance in the clinical setting as it has an implication on surgeries of the pineal region (Hasan R. S and Walter C. J 2018) there is a growing interest in MRI-based measures and associated standard measurements as imaging methods allowing for the optimal calculation of future clinical changes. (Leow A.D et al. 2009) MRI is widely used as a noninvasive method to evaluate structural measurements, with good results. (Leos A.D et al. 2006)

Many neuroanatomical studies of brain development have been reported as well as investigations of aging and gender impact. (Griffith's P. D et al. 2004) There is a lack of studies examining together the entire tentorial angle, Pons, cerebellum and cerebellum in young adults and its development between □I year and≤15 years old. Increasing the knowledge of normal brain development strengthen understanding brain abnormalities when it happened. In this study, we analyzed the dimensions of some normal cranial structures. We hypothesized that the dimensions would be proportionally reduced at different ages. We also investigated whether the changes are related to gender.

1.2 Problem of the study:

The detection of brain measurement and development is an important issue because the knowledge of the normal values will reffelect any abnormality to be detected so early detection regarding changing in size manly help in early treatment or organizing the method and plan of management . There for: the question to be answered

1- Can MRI is able to measure the cerebellum, cerebrum, pons tentorium angle effectively.
2- What are the normal measured for cerebellum, cerebrum, and pons tentorium angle during the childhood?

3- Are there any difference between males and females regarding the brain measurement?

1.3 Objectives of the study:

1.3.1General objective:

- To Study the Brain Structures Development during Childhoods using MRI

1.3.2Specific objective:

- To measure the cerebellum and cerebrum anteroposterior diameter (Right and Left) and transverse diameter in axial section
- To measure the tentorium angle and the craniocaudal diameter and anteroposterior of pons in sagittal section.
- To Correlate between the RT and LT Cerebrum and Cerebellum Anteroposterior measurements
- To Correlate between (cerebellum & cerebrum transverse and Anteroposterior diameter with age & gender)
- Correlation between (Pons Anteroposterior diameter with age & gender)

1.4 Thesis Overview:

This study consisted of five chapters. Chapter one; general introduction which includes problem and objective of the study. Chapter two; a literature review which includes theoretical background**;** Anatomy, Physiology, and previous studies. Chapter three; detailed the materials and methods. Then Chapter four; presents the results and Chapter five; includes discussion, conclusion and recommendations also there are the references and the appendix at the end of the study.

Chapter Two

2.1 Theoretical Background

2.1.1 Anatomy:

The brain has 3 main parts: cerebrum, cerebellum and brain stem.

2.1.1.1 Anatomy of cerebellum:

The cerebellum is located at the bottom of the brain, with the large mass of the cerebral cortex above it and the portion of the brainstem called the Pons in front of it.

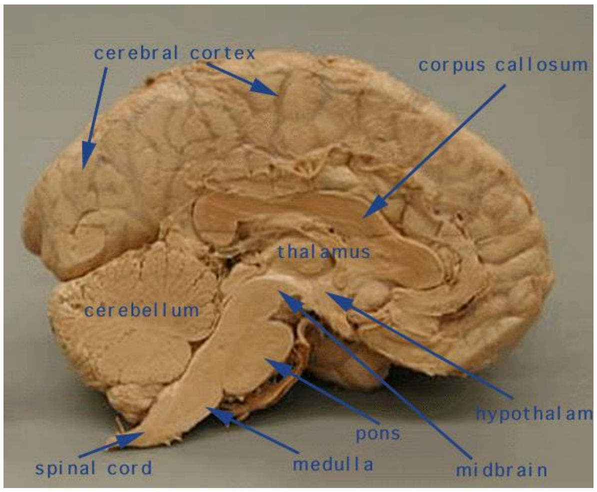

Fig 2.1.1.1 Show Brain Structures (Serendip, 2018)

It is separated from the overlying cerebrum by a layer of leathery all of its dura mater; connections with other parts of the brain travel through the Pons. The cerebellum can be separated into three lobes: the flocculonodular lobe, anterior lobe, and posterior lobe. The medial zone of the anterior and posterior lobes constitutes the spinocerebellum, or paleocerebellum.There is about 3.6 times as many neurons in the cerebellum as in the neocortex. (Serendip, 2018)

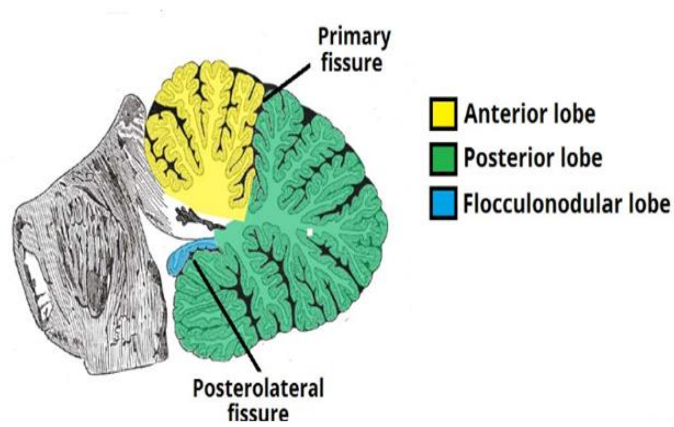

Fig 2.1.1.1 Show Anatomical lobes of the cerebellum. (Venturini, 2018)

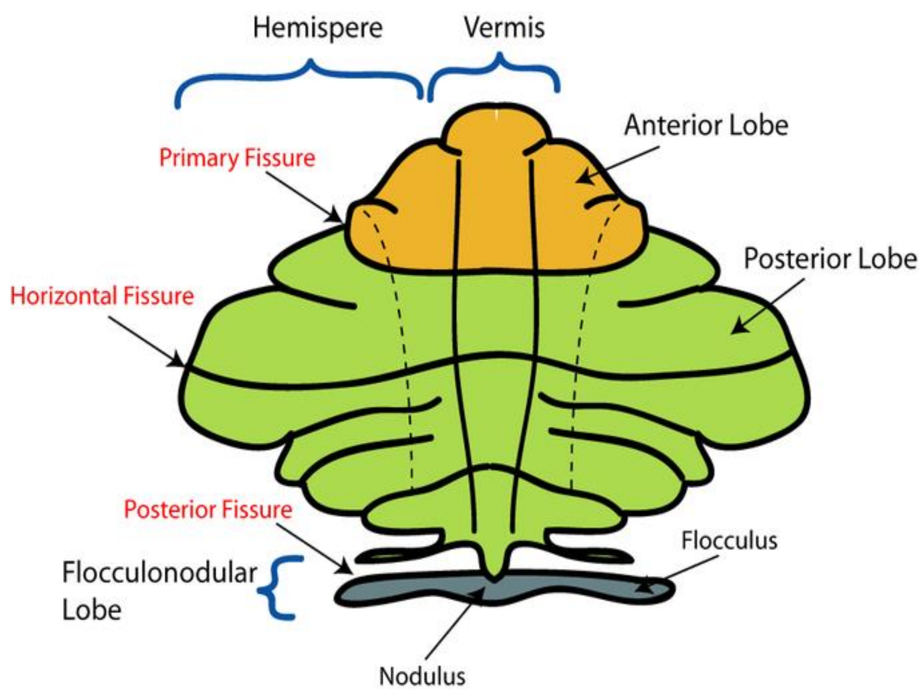

Fig.2.1.1.1 shows Divisions of the cerebellum: Schematic representation of the major anatomical subdivisions of the cerebellum. Superior view of an "unrolled" cerebellum, placing the vermis in one plane. (Boundless, 2013)

The cerebellum is divided into two hemispheres; it also contains a Narrow midline zone called the vermis. A set of large folds are conventionally used to divide the overall structure into ten smaller lobules. Because of its large number of tiny granule cells the cerebellum contains more neurons than the rest of the brain put together, but it only takes up 10% of total brain volume. The cerebellum receives nearly 200 million input fibers; in contrast, the optic nerve is composed of amere one million fibers. The unusual surface appearance of the cerebellum conceals the fact that the bulk of the structure is made up of Avery tightly folded layer of gray matter, the surface of the Cerebellum is covered with finely spaced parallel grooves, in striking Contrast to the broad irregular convolutions of the cerebral cortex. These Parallel grooves conceal the fact that the cerebellum is actually continuous thin layer of tissue (the cerebella Cortex), tightly folded in the style of an accordion. (Venturini, 2018)

2.1.1.2 Anatomy of cerebrum:

The cerebrum described is the largest part of the brain. It is divided into 2 halves called the left and right cerebral hemispheres. The 2 hemispheres are connected by bridge of Nerve fibres called the corpus callosum. The right half of the cerebrum (right hemisphere) controls the left side of the body. The left half of the cerebrum (left hemisphere) controls the right side of the body.

Fig. 2.1.1.2 Show the hemispheres of the cerebral cortex: The human brain is divided into two hemispheres–left and right. (Gromisch, 2010).

The inner part of the cerebrum is called the white matter. It is mostly made up of the long fibers of a nerve cell (called axons) that send signals to and from the brain to the rest of the body. The fatty coating that surrounds axons (called myelin) gives this part of the brain a whitish appearance. Each hemisphere is divided into 4 sections called lobes. These include the frontal, Parietal, temporal and occipital lobes. Distinguished by clear tentorium cerebella (Gromisch, 2010)

2.1.1.3 Anatomy of tentorium Cerebelli:

The cerebellar tentorium or tentorium cerebelli is an extension of the dura mater that separates the cerebellum from the inferior portion of the occipital lobes ,The cerebellar tentorium is an arched lamina, elevated It .in the middle, and inclining downward toward the circumference covers the top of the cerebellum, and supports the occipital lobes of the brain Its anterior border is free and concave, and bounds a large oval opening, the tentorial incisure, for the transmission of the cerebral peduncles It is attached, behind, by its convex border, to the transverse ridges upon the inner surface of the occipital bone, and there encloses the transverse sinuses; in front, to the superior angle of the petrous part of the temporal bone on either side, enclosing the superior petrosal sinuses At the apex of the petrous part of the temporal bone the free and attached borders meet, and, crossing one another, are continued forward to be fixed to the anterior and posterior clinoid processes (respectively) To the middle line of its upper surface the .of the sphenoid bone posterior border of the falx cerebri is attached, the straight sinus being placed at their line of junction. (Stiles and Jernigan 2010)

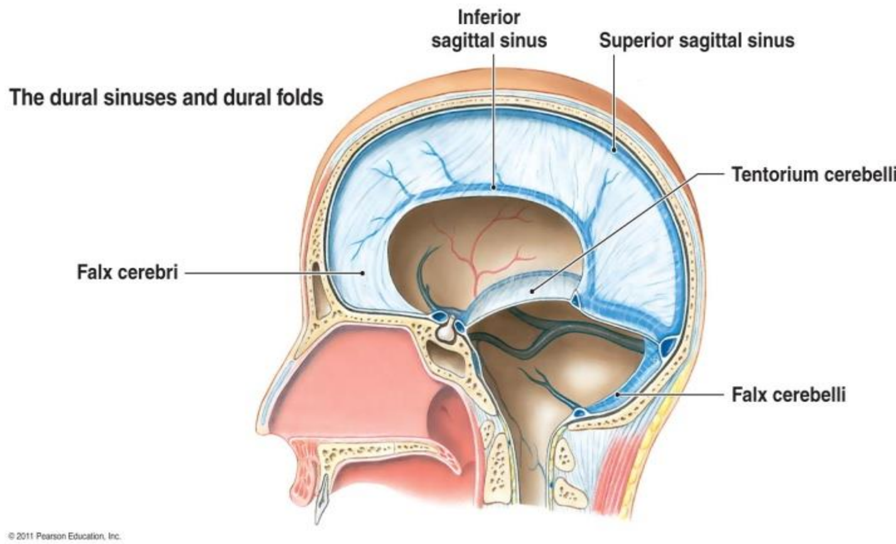

Fig 2.1.1.3 Show Tentorium cerebelli (Stiles and Jernigan 2010)

2.1. 1.4 Anatomy of Pons:

The Pons is the largest part of the brain stem, located above the medulla and below the midbrain. Although it is small, at approximately 2.5 centimeters long, it serves several important functions. It is a bridge between various parts the Nervous system, including the cerebellum and cerebrum, which are both Parts of the brain. (Patel H and Sugano Y 2018)

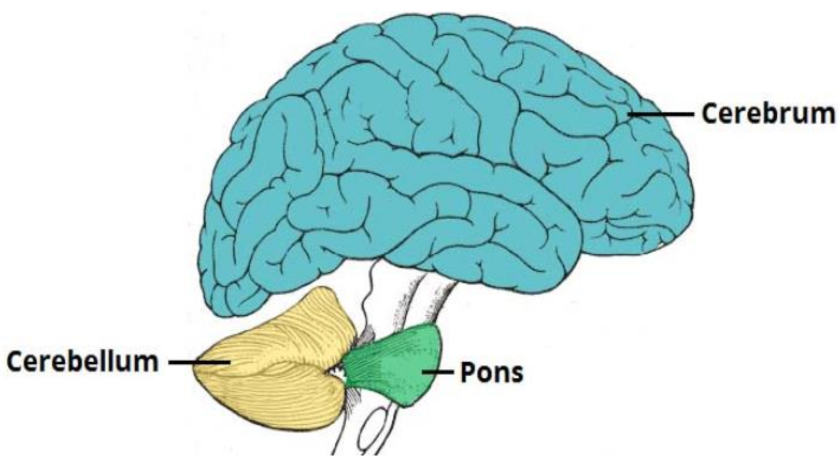

Fig 2.1.1.3 Show Anatomical position of the cerebellum. It is inferior to the cerebrum and posterior to the pons (Venturini, 2018)

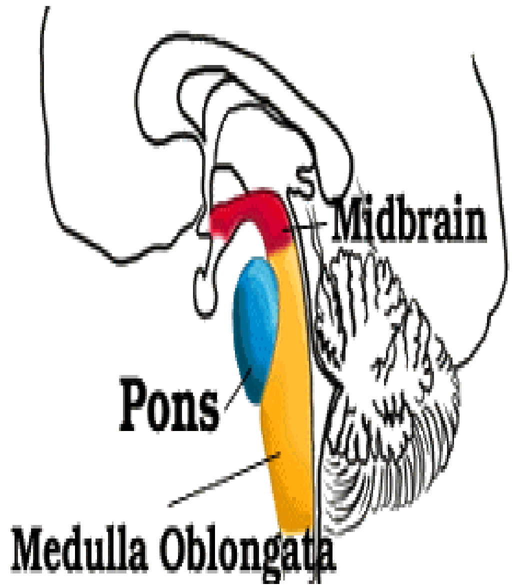

Fig 2.1.1.3 Show the brain stem is made up of the Midbrain, the Pons and the Medulla Oblongata (Gordon's et al. 2015)

2.2 Physiology

2. 1.2 Physiology of Cerebellum:

The brain is the body's control centre. It constantly receives and interprets nerve signals from the body and sends new signals based on this information. Different parts of the brain control movement, speech, emotions, consciousness and internal body functions, such as heart rate, breathe in anybody temperature.

The cerebellum is a region of the brain that plays an important role in Motor control and motor learning, contributing to coordination, Precision and accurate timing.Itis also involved in some cognitive Functions, such as attention and language, and probably in some Emotional functions,suchas there gulation of fear and pleasureres ponses (Liu F. Z. Z et al. 2014)

Cerebella disorder was frequently reported to have relation with structural brain volume alteration and or morphology change. In dealing with such clinical situations, the cerebellum is located under the cerebrum at the back of the brain. It is divided into 2 parts or hemispheres and also has grey and white matter. The cerebellum is responsible for: movement posture balan cereflexes complex actions (walking, talking) collecting sensory information from the body the medial zone of the anterior and posterior lobes constitutes the spinocerebellum, also known as the paleocerebellum. It receives proprioception input from the dorsal columns of the spinal cord (including the spino cerebella tract) and from the trigeminal nerve, as well as from visual and auditory systems. It sends fibers to deepcerebellar nuclei that in turn project to both the cerebral cortex and the brain stem, thus providing modulation of descending motor systems. (Winter L, 2014).

2.1 .2.1 Physiology of Cerebrum:

Each hemisphere is divided into 4 sections called lobes. These I include the frontal, parietal, temporal and occipital lobes.

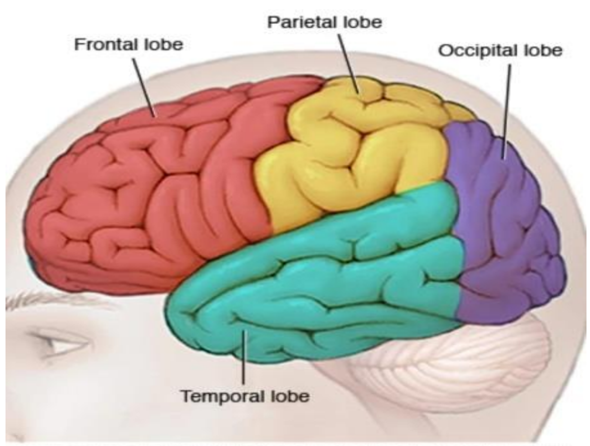

Fig 2.1.2.1 Show Lobes of brain Foundation M, 2019)

Each lobe has different functions: The frontal lobe controls movement, speech, behavior, memory, emotions and intellectual functions, such as thought processes, reasoning, problem solving, decision-making and planning. The parietal lobe controls sensations, such as touch, pressure, pain and temperature. It also controls the understanding of size, shape and direction (called spatial orientation).associated with movement, orientation, recognition, perception of stimuli the temporal lobe controls hearing, memory and emotions. And also controls speech. The inner part of the cerebrum is called the white matter. It is mostly made up of the long fibres of a nerve cell (called axons) that send signals to and from the brain to the rest of the body. The fatty coating the Surrounds axon called (myelin) gives this part of the brain a whitish appearance. The occipital lobe associated with visual processing controls vision. (Serendip, 2018)

2.1.2 .3 Physiology of Pons:

There are many important nerves that originate in the pons. The trigeminal nerve is responsible or feels in the face. It also controls the muscles that are responsible for biting, chewing, and swallowing. The abducens nerve allows the eyes to look from side to side. The facial nerve controls facial expressions, and the vestibule cochlear nerve allows sound to move from the ear to the brain. All of these nerves start within the Pons. Apart of the brainstem, the pons also impacts several automatic functions necessary for life. A section of the lower pons stimulates and controls the intensity of breathing, and a section of the upper pons decreases the depth and frequency of breaths. The pons has also been associated with the control of sleep. (Boundless, 2013)

2.2 Previous studies:

In the Edward C et al. 1998 study the effect of sex and age related changes in brain structure, for some structures probably the most obvious effect of aging on all remaining brain areas examined, the effects of aging are likely to be more pronounced in men than in women. Main effects of age were observed for all the remaining brain regions examined (cerebral hemisphere volume, frontal region area, temporo-parietal region area, lateral ventricular volume, and third ventricle volume), but these effects were similar in men and women. Asymmetries in brain structures were not affected by aging in either sex .results. In the unique research of relationship between atrophy of cerebellum and brainstem with age and repeats, by Teixeira S. C et al. 2011 their study, were found no correlation has been found with disease duration and clinical manifestations. They were testing the hypothesis that atrophy of cerebellum and brainstem related to clinical severity, disease duration and repeat length as well as to other variables such as age and ICARS (International Cooperative Ataxia Rating Scale). Whole brain high resolution MRI and volumetric measurement with cranial volume normalization were obtained from normal patients, age and sex-matched controls. Applied ICARS and compared the score with volumes and, disease duration and age. They found great correlation between brain stem and cerebella atrophy length, duration of, illness, age and degree of disability. In the Gur R C et al. 1991 study Chose perspective sample of healthy adults, age range18-80 years was studied with magnetic resonance imaging scans of the entire cranium. Volumes were obtained by a segmentation algorithm that uses proton density and pixel values to correct field in homogeneities brain volume, excluding cerebellum, and cerebrospinal fluid (CSF) volume Brain was higher in the right hemisphere, The slope of the regression line with age for CSF was steeper for men than women, this difference in slopes was significant for sulcal, but not ventricular, CSF. The greatest amount of atrophy in elderly men was in the left hemisphere, whereas in women age effects were symmetric. The findings may point to neuroanatomic substrates of hemispheric specialization and gender differences in age-related changes in brain function. They suggest that women are less vulnerable to age-related changes in mental abilities, whereas men are particularly susceptible to aging effects on left hemispheric functions. In the pioneering study which was achieved by Viñals F, et al. 2005 applied analogy to use of ultrasound that was the ultrasound examination was in the foreground to follow measurements of brain structure to describe the normal appearance fetal cerebellar vermis by three- dimensional (3D) volume contrast imaging in the coronal (C) plane used measure of the anteroposterior (AP) diameter, craniocaudal (CC) diameter and surface area of the cerebella vermis. TCD were expressed by regression equations. From mid-sagittal sections of a stored 3D multilane examination. The excellent resolution in the sagittal planes made possible by magnetic resonance imaging (MRI) led to demonstration of vermian dysgenesis as one of the anomalies included in the, fetal MRI not readily in most countries, requires radiological expertise, and more expensive and time-consuming compared with sonography. Quoting the study written by Malinger et al.2009 Ultrasound limitations have several compared with magnetic resonance imaging (MRI), such as the relatively poor contrast resolution. For some brain structures, it can only delineate their gross anatomy. Otherwise in another study authored by Pier D. B et al. 2017 To verify current diagnosis of fetal posterior fossa anomalies by sonography and conventional MRI it was limited by fetal position, motion, and by 2D, rather than 3D, representation., designed to validate the use of a novel MRI technique, 3D Super-Resolution Motion-Corrected from a database of pregnant women who received fetal MRIs images of normal fetal brains. Six measurements of the cerebellum, vermis, and pons were obtained for all cases on 2D conventional and 3D reconstructed MRI, and the agreement between the two methods was determined using concordance correlation coefficients. Concordance of axial and coronal measurements of the transcerebellar diameter (TCD) and the anterior-posterior diameter of the pons (APDP). Achieved at the sagittal plane at the level of the corpus callosum.. In the initial research which authored by Nemir J et al. 2018 they have reached Tentorial alignment and assessment relationship to the sensory dimensions of the pineal region, anatomical study of MRI with surgical repercussions using the new clivotentorial method that the can reduce the diversity of surgical freedom if not taken into account when choosing the approach to the pineal region, to provide quantitative anatomical information regarding these dimensions, and to discuss their relevance in two most used approaches to this region. The occipital transtentorial and supracerebellar-infratentorial approach. Retrospective study of midsagittal T1-weighted MRI images of randomly selected healthy subjects was performed. The clivus-tentorium (C-T) angle was measured to assess tentorial alignment. The following distances were used as craniocaudal cisternal measurements: quadrigeminal cistern = superior colliculi - inferior part of the splenium of corpus callosum (SC-ISCC), and superior cerebellar cistern = vermis - inferior part of the splenium of corpus callosum (VER-ISCC). Median C-T angle value was the quadrigeminal cistern height, and the superior cerebellar cistern height. The C-T angle was negatively correlated with the SC-ISCC distance and the VER-ISCC distance. The SC-ISCC distance was positively correlated with the VER-ISCC distance. The new method of measuring tentorial alignment provides a simple and effective assistance in preoperative planning. The first time, data are provided on the craniocaudal dimensions of posterior fossa cisterns, their relationship with tentorial alignment. In the study authored by Syed HR and Jean W. C 2018 they described that there is no standard way to define the angle of the tentorium. The current trend to use the Twining line to define this angle has significant pitfalls. The goal of the current study was to provide a new and accurate way to measure the tentorial angle and demonstrate its impact on surgeries of the pineal region. A new technique (n-angle) to measure the tentorial angle was introduced using the floor of the fourth ventricle and the torcula. Comparisons with older techniques were made to illustrate reliability. Midline sagittal MR images were used to measure the tentorial angle in 240 individuals to obtain population-based data. A cohort of 8 patients who underwent either the infratentorial or the transtentorial approach to the pineal or upper vermian region were examined in search of correlations between tentorial angle and surgical approach. The data showed that the Twining line technique understates the tentorial angle in people with lowlying torcula. The n-angle is more reliable in reflecting the true steepness of the tentorium regardless of torcula position. On average, men have slightly steeper tentoriums. In the clinical cohort, all patients who underwent infratentorial surgery had tentorial angles <55°, whereas the majority of patients who underwent transtentorial surgeries had angles >67°.The n-angle provides a reliable and accurate way to describe the slope of the tentorium. The population-based average of 60° may be a useful measurement to influence the choice of surgical approach, either under or through the tentorium, to the pineal region in another study helped them foster the concept performed by Sik H.H et al. 2013 had studied of posterior cranial fossa in retrospective patients has studied clinical and radiological data; the structures of the brain and skull base were investigated using magnetic resonance imaging. The length of the clivus angle between the tentorium and a line connecting the internal occipital protuberance to the opisthion The mean vertical length of the cerebellar hemisphere and the mean length of the coronal and sagittal superoinferior aspects of the cerebellum, while the mean length of the axial anteroposterior aspect of the cerebellum elucidate the transformation of the posterior cranial fossa into the narrow funnel shape. In standard study which verify by authors Sekula RF.Jr, et al. 2005 designed to study the dimensions of the posterior cranial fossa in patients with significant tonsillar descent but with symptoms comparable to CMI. Preliminary morphologic data suggests that subgroup of patients exists with tonsillar descent less than 3 mm below the foramen magnum but with congenitally hypo plastic posterior fossa causing symptomatology consistent with CMI. In the prospective and analytical study of the Iwata S et al. 2016 which about the verify that brain sizes of premature infants at term-equivalent age differ from those of term-born peers, which have been linked with later cognitive impairments. However, dependence of regional brain volume loss on gestational age has not been studied in detail. To investigate the spatial pattern of brain growth in neonates without destructive brain lesions, head MRI of 189 neonates with a wide range of gestational age (24–42 weeks gestation) was assessed using simple metrics measurements. Dependence of MRI findings on gestational age at birth (Age_{birth}) and the corrected age at MRI scan (Age_{MRI}) were assessed. The head circumference was positively correlated with Age_{MRI}, but not Age_{birth}. The bi-parietal width, deep grey matter area and the transcerebellar diameter were positively correlated with both Age $_{birth}$ and Age$_{MRI}$. The colossal thickness (positive), atrial width of lateral ventricle (negative) and the inter-hemispheric distance (negative) were exclusively correlated with Age $_{birth}$. The callosal thickness and cerebral/cerebellar transverse diameters showed predominant dependence on Age $_{birth}$ over Age$_{MRI}$, suggesting that brain growth after preterm-birth was considerably restricted or even became negligible compared with that in utero. Such growth restriction after preterm birth may extensively affect relatively more matured infants, considering the linear relationships observed between brain sizes and Age $_{birth}$.In the Massey LA , et al. 2013 study had developed a simple and reliable measurement in pathologically confirmed disease based on the topography of atrophy in PSP with high sensitivity and specificity that may be a useful tool in the clinic. Were selected in which conventional 1.5-tesla, midsagittal, T1-weighted images were electronically available the measurements were taken as described the midbrain to pons ratio was derived by dividing the midbrain by the pons measurements. Midsagittal T1 image on conventional MRI. Elliptical regions of interest were placed over the pons and the midbrain in the midsagittal slice. Two lines were drawn to define the major axes of the ellipses, corresponding to oblique superior-inferior axes; the maximal measurement perpendicular to the major axis was taken In all cases, the posterior border of the pons was clearly identifiable and did not include the pontine tegmentum; the midbrain measurement did not include the collicular plate and was chosen to maximize the chance of detecting atrophy of this region in progressive supranuclear palsy as exhibited by the concave appearance in the midsagittal plane. In the research which authored by Ali H.B and Emine C 2019 determine the normal reference values for cerebellar volume and sagittal pons dimensions in pediatric population with routine magnetic resonance imaging (MRI) and compare relationships with gender and age. Material and Methods: This retrospective study evaluated 120 cases (61 male, 59 female) with normal brain MRI (age range: 0-18 years). The cases were divided into four subgroups based on age as 0-2 years (infants; n=21), 3-6 years (young children; n=35), 7-12 years (children; n=35) and 13-18 years (adolescents; n=29). Demographic data like sex and age were recorded. Cerebellar volumes were calculated with semi-automatic volumetric software. Pons CC and AP dimensions were measured manually. Cerebellar volumes and pons dimensions comparisons were made for gender and age groups. Statistical analysis used the Mann Whitney U test, Pearson's correlation analysis and Tamhane test. The median cerebellar volumes, pons CC and pons AP dimensions were 103.3 cm3, 20.9 mm, 13.3 mm for infants; 134.4 cm3, 24.6 mm, 15.3 mm for young children; 148.8 cm3, 25.5 mm, 15.6 mm for children; 153 cm3, 26.2 mm, 16 mm for adolescents, respectively. There was no significant difference identified for cerebellar volumes, pons CC and pons AP dimensions between the genders in all age groups. There was a positive significant correlation between age and cerebellar volumes, pons CC and pons AP dimensions. As age group increased, there were significant increases in normal cerebellar volume, pons CC and AP dimensions. Quantitative reference values for normal cerebellar volume, pons CC and AP dimensions were revealed for pediatric population using MRI. These results could be promising for clinical practice in pediatric neurology or Neuroradiology. In the Carmona. R et al. 2016 study anatomical (cerebral hemisphere) and demographic (age and gender) variables on the gray matter (GM) volumes and volumetric asymmetry indices (VAIs) of selected structures involved in episodic memory.A cross-sectional study was performed in 47 healthy volunteers. The main effects of gender and cerebral hemispheres on GM volumes were significant ($p < .001$), while there was no significant interaction effect between gender and cerebral hemisphere. VAI measurements showed a non-significant effect of gender, but a significant influence of age ($p = .015$). The linear model of interactions and main effects explained 33% of the variance influencing the GM volume quantification. While cerebral hemisphere and gender were found to affect the volumes of brain structures involved in episodic memory, the calculation of VAIs was affected only by age.

Chapter Three

Materials and Methods

3.1 Materials

3.1.1 Subjects

This descriptive analytical study, the study population composed of normal brain patients presenting to the Magnetic resonance unit of International Medical Center (IMC) and Saudi Germen hospitals. Superconducting system Siemens Avanto 1.5 Tesla was used .The sample size consisted of 200 participants. The cases were confirmed to be normal with the presence of the radiologist during the selection of cases for study. The participant's ages were between □I year and≤15 years. The fetus and

Elderly and over fifteen and have brain disease were excluded. The study took place during the period from July 2016 to July 2018.

3.1.2 Equipment: superconducting system Siemens avanto 1.5 Tesla

Fig 3.1.1.1 Show Magnetic Resonance device Siemens avanto 1.5 Tesla New when installed in 2013 SaudiGermem hospital

Fig. 3 .1.1.2 Show Magnetic Resonance device Siemens avanto 1.5 Tesla New when installed in 2007 International Medical Center.

3.2 Methods

3.2.1 Technique

The measurements were performed using spin echo sequences the images are T_1 weighted sagittal plane (TR 400) (TE 12). And T_2 weighted axial plane TR =4500, TE =117. Slice thicknesses =2mm, gap= 5 mm, field of view =20 cm and display matrix= 314 x 448. Measurement were performed to properly measure the children posterior fossa, important parts were measured: cerebellum, cerebrum, tentorium angle and pones. Using a high-resolution fast spin echo technique providing the area of the posterior fossa and tentorial angle. Similar methods to measure tentorial angle done by (Syed HR and Jean W. C 2018**)** and (Houston J R, al. 2018)

3.2.2 Measurements

In sagittalsection**:** the structure under study is best visualized in this plane was the pons

3.2.2.1The Pons: Two lines were drawn to define the major axes, corresponding to determine the maximum vertical measurement on horizontal axis. In all cases, the posterior border of the Pons was clearly identifiable and did not include the pontine tegmentum .AP diameter was measured in midline at the level of the opening of the sella turcica. The craniocaudal diameter was measured as the distance between two points perpendicular to the midline along the tangent lateral to the Pons; this was similar to the methods done by (Massey LA, et al. 2013). (Pier D. B, et al. 2017**)** and Sik H.H, et al. 2013

In axial section**:** the structure under study is best visualized in this plane was the

3.2.2.2 The Cerebellum:

Axial transversecerebellar diameter (TCD) measurements were taken at the point of maximal length. Allows examination of mid brain at cisterna magna and cerebellar vermis the routine examination includes atransverse scan at the level of the cavum septum demonstrates the lateral borders of the anteriorportion.TCD was defined as the maximum distance from the right to left hemispheres in the transverse plane. Right and left hemispheric the medial aspect of each cerebral hemisphere was taken as a convenient' horizontal' and all vertical sections were cut normal to this reference plane. Anteroposterior (AP) diameter is defined as the maximum distance between the most anterior portion and the most posterior portion of the cerebellum**.** This was similar to the methods done by (Sik H.H, et al. 2013) and (Iwata S, et al. 2016) and (Viñals F, et al. 2005)

3.2.2.3 The cerebrum:

transverse diameter which is the longest measurement of the long axis of the cerebral hemispheres as done by (Bruno LA, et al. 2017) the level of the cavum septi pellucidi, which demonstrates the lateral borders of the anterior, medial and posterior horns of the lateral ventricles measures were done on the axial image in T2-weighted including deep nuclei gray matter and Monro's foramens. The right and left sides were measured. (Iwata S, et al. 2016, Sekula RF.Jr, et al. 2005).

3.2.2. 4 Data Aquisesion:

The data were collecting by using images of patients in the computer. After the examination is completed, it included different age of the patients beginning □I year and≤15 years old The differences between the boys and girls were study and taking the difference in age into account for healthey brain different structures of brain were measured cerebellum, Pons, cerebrum and tentorium cerebelli angle determine their value.

3.2.2.5 Data analysis

Data were analyzed by using SPSS program and the results were presented in form of tables

3.2.2.6 Ethical consideration

No identification or individual details were published.

No information or patient details were disclosed or used for reasons other than the study.

Chapter Four

Results and Analysis

The following tables represented the study results

Table (4.1) shows the participant age classes, frequency and percentage, mean maximum and minimum values

Age	Frequency	Percentage (%)
< One years	38	19.0
1-5 years	74	37.0
6-10 years	63	31.5
11-15 years	25	12.5
Total	200	100.0
Mean	5.39±3.98min=0.11- max=15.00	

Table (4.2) Descriptive Statistics of cerebellum measurements/cm (axial)

Cerebellum	N	Minimum	Maximum	Mean	Std. Deviation
Anteroposterior (RT) in axial plane	200	1.83	6.50	4.67	0.87
Anteroposterior (LT)in axial plane	200	1.96	9.90	4.60	0.92
Transverse Diameter	200	4.01	11.80	8.68	1.48

Table (4.3) Descriptive Statistics of Tentorialangle/º measurement

	N	Minimum	Maximum	Mean	Std. Deviation
Tentorium Angle	200	21.70º	64.26º	40.93º	8.68

Table (4.4) Descriptive Statistics of cerebrum/cm measurements

Cerebrum	N	Minimum	Maximum	Mean	Std. Deviation
Anteroposterior (RT)	200	5.60	18.79	13.88	1.91
Anteroposterior (LT)	200	5.40	18.85	13.83	1.91
Transverse Diameter	200	4.40	14.44	11.61	1.53

Table (4.5) Descriptive Statistics of Pons/cm measurements

Pons	N	Minimum	Maximum	Mean	Std. Deviation
Anteroposterior dimension in sagittal plane	200	0.72	2.97	1.47	0.38
Craniocaudal Diameter	200	0.54	2.18	3.68	18.74

Table (4.6) Group Statistics of cerebellum measurements classified according to gender

Cerebellum	Gender	N	Mean	STDV	P-value
Anteroposterior (RT)/cm	Male	104	4.68	0.86	0.785
	Female	96	4.65	0.88	
Anteroposterior (LT)/cm	Male	104	4.56	0.81	0.521
	Female	96	4.64	1.03	
Transverse Diameter/cm	Male	104	8.75	1.53	0.447
	Female	96	8.59	1.42	

Table (4.7) Group Statistics of Tentorialangle measurements classified according to gender

	Gender	N	Mean	Std. Deviation	P-Value
Tentorium Angle	Male	104	39.81º	8.21	.059
	Female	96	42.13º	9.04	

Table (4.8) Gender differences of Cerebrum measurements and p- value

Cerebrum	Gender	N	Mean	Std. Deviation	P-value
Anteroposterior (RT)/cm	Male	104	13.83	2.06	0.668
	Female	96	13.94	1.76	
Anteroposterior (LT)/cm	Male	104	13.78	2.07	0.724
	Female	96	13.88	1.74	
Transverse Diameter/cm	Male	104	11.61	1.67	0.983
	Female	96	11.62	1.36	

Table (4.9) Gender differences of Pons measurements and p- value

Pons	Gender	N	Mean	Std. Deviation	P-value
Anteroposterior dimension/ cm	Male	104	1.43	0.36	0.112
	Female	96	1.52	0.40	
Craniocaudal Diameter/cm	Male	104	1.80	0.45	0.138
	Female	96	5.75	27.04	

Table (4.10) Cerebellum measurements classified according to age and p- value

Descriptive Statistics							
Cerebellum		**N**	**Mean**	**STDV**	**Minimum**	**Maximum**	**P- value**
Anteroposterior (RT)/cm	< One years	38	4.59	0.86	2.20	6.15	0.027
	1-5 years	74	4.59	0.91	2.70	6.50	
	6-10 years	63	4.60	0.87	1.83	6.10	
	11-15 years	25	5.16	0.59	4.04	6.25	
	Total	200	4.67	0.87	1.83	6.50	
Anteroposterior (LT)/cm	< One years	38	4.48	0.81	2.20	6.38	0.021
	1-5 years	74	4.48	0.84	3.00	6.40	
	6-10 years	63	4.67	1.11	1.96	9.90	
	11-15 years	25	4.95	0.66	3.80	6.39	
	Total	200	4.60	0.92	1.96	9.90	
Transverse Diameter/cm	< One years	38	8.04	0.00	4.20	10.01	0.000
	1-5 years	74	8.60	1.47	4.20	11.20	
	6-10 years	63	8.62	1.55	4.01	10.70	
	11-15 years	25	9.98	0.59	9.09	11.80	
	Total	200	8.68	1.48	4.01	11.80	

Table (4.11) Tentorium angle measurements classified according to age and p- value

Descriptive Statistics							
		N	**Mean**	**STDV**	**Minimum**	**Maximum**	**P-value**
Tentorium Angle	< One years	38	41.17º	7.95	23.98º	54.00º	0.603
	1-5 years	74	41.11º	9.64	26.00º	64.26º	
	6-10 years	63	41.43º	9.05	21.70º	64.24º	
	11-15 years	25	38.74º	5.17	29.10º	49.10º	
	Total	200	40.93º	8.68	21.70º	64.26º	

Table (4.12) Cerebrum measurements classified according to age and p-value

Descriptive Statistics							
Cerebrum		**N**	**Mean**	**STDV**	**Minimum**	**Maximum**	**P-value**
Anteroposterior (RT)/cm	< One years	38	12.74	0.00	5.60	16.88	0.000
	1-5 years	74	13.79	1.76	9.43	18.79	
	6-10 years	63	13.99	1.84	7.76	16.81	
	11-15 years	25	15.63	.79	14.41	17.39	
	Total	200	13.88	1.91	5.60	18.79	
Anteroposterior (LT)/cm	< One years	38	12.69	2.04	5.40	16.86	0.000
	1-5 years	74	13.73	1.78	9.29	18.85	
	6-10 years	63	13.94	1.83	7.71	16.92	
	11-15 years	25	15.56	.73	14.36	17.04	
	Total	200	13.83	1.91	5.40	18.85	
Transverse Diameter/cm	< One years	38	10.88	0.00	7.23	13.44	0.000
	1-5 years	74	11.64	1.65	4.40	14.44	
	6-10 years	63	11.56	1.43	6.27	13.64	
	11-15 years	25	12.79	.56	11.97	14.22	
	Total	200	11.61	1.53	4.40	14.44	

Table (4.13) Pons measurements classified according to age and p- value

Descriptive Statistics							
Pons		**N**	**Mean**	**Std. Deviation**	**Minimum**	**Maximum**	**P-value**
Anteroposterior dimensions/cm	< One years	38	1.61	0.31	1.11	2.20	.033
	1-5 years	74	1.49	0.39	0.79	2.60	
	6-10 years	63	1.39	0.43	0.72	2.97	
	11-15 years	25	1.42	0.21	0.97	1.80	
	Total	200	1.47	0.38	0.72	2.97	
Craniocaudal Diameter	< One years	38	1.63	0.36	0.54	2.45	0.815
	1-5 years	74	4.68	2.51	0.87	2.18	
	6-10 years	63	4.41	1.94	1.00	1.55	
	11-15 years	25	2.04	0.31	1.40	2.54	
	Total	200	3.68	1.87	0.54	2.18	

Table (4.14) Post Hoc Test for testing the impact of age and cerebellum measurements

Multiple Comparisons

Cerebellum	(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.
Anteroposterior (RT)	< One years	1-5 years	-.00813*	.17	.962
		6-10 years	-.01540*	.17	.931
		11-15 years	-.57281*	.22	.011
	1-5 years	< One years	.00813*	.17	.962
		6-10 years	-.00727*	.14	.961
		11-15 years	-.56468*	.19	.005
	6-10 years	< One years	.01540*	.17	.931
		1-5 years	.00727*	.14	.961
		11-15 years	-.55741*	.20	.007
	11-15 years	< One years	.57281*	.22	.011
		1-5 years	.56468*	.19	.005
		6-10 years	.55741*	.20	.007
Anteroposterior (LT)	< One years	1-5 years	.00669*	.18	.971
		6-10 years	-.18565	.18	.325
		11-15 years	-.46263*	.23	.051
	1-5 years	< One years	-.00669*	.18	.971
		6-10 years	-.19234	.15	.222
		11-15 years	-.46932*	.21	.028
	6-10 years	< One years	.18565*	.18	.325
		1-5 years	.19234*	.15	.222
		11-15 years	-.27698*	.21	.202
	11-15 years	< One years	.46263	.23	.051
		1-5 years	.46932	.21	.028
		6-10 years	.27698	.21	.202
Transverse Diameter	< One years	1-5 years	-.56394*	.27	.044
		6-10 years	-.58119*	.28	.043
		11-15 years	-1.94181*	.35	.000
	1-5 years	< One years	.56394*	.27	.044
		6-10 years	-.01725	.23	.942
		11-15 years	-1.37787*	.32	.000
	6-10 years	< One years	.58119*	.28	.043
		1-5 years	.01725	.23	.942
		11-15 years	-1.36062*	.32	.000
	11-15 years	< One years	1.94181*	.35	.000
		1-5 years	1.37787*	.32	.000
		6-10 years	1.36062*	.32	.000
		11-15 years	-.43339	.22	.059
	6-10 years	< One years	-.17766	.20	.382
		1-5 years	-.13137	.16	.438
		11-15 years	-.56476*	.23	.016

Table (4.15) Post Hoc Test for testing the impact of age and Tentoria angle measurements

Multiple Comparisons					
Dependent Variable	**(I) Age**	**(J) Age**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**
Tentoria angle	< One years	1-5 years	.05198	1.73	0.976
		6-10 years	-.26546	1.78	0.882
		11-15 years	2.43184	2.24	0.280
	1-5 years	< One years	-.05198	1.73	0.976
		6-10 years	-.31744	1.49	0.832
		11-15 years	2.37986	2.01	0.239
	6-10 years	< One years	.26546	1.78	0.882
		1-5 years	.31744	1.49	0.832
		11-15 years	2.69730	2.05	0.192
	11-15 years	< One years	-2.43184*	2.24	0.280
		1-5 years	-2.37986*	2.01	0.239
		6-10 years	-2.69730*	2.05	0.192

Table (4.16) Post Hoc Test for testing the impact of age and Cerebrum measurements

Multiple Comparisons					
Cerebrum	**(I) Age**	**(J) Age**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**
Anteroposterior (RT)	< One years	1-5 years	-1.05502*	.35077	.003
		6-10 years	-1.25080*	.36101	.001
		11-15 years	-2.89601*	.45262	.000
	1-5 years	< One years	1.05502*	.35077	.003
		6-10 years	-.19578	.30130	.517
		11-15 years	-1.84099*	.40659	.000
	6-10 years	< One years	1.25080*	.36101	.001
		1-5 years	.19578	.30130	.517
		11-15 years	-1.64521*	.41545	.000
	11-15 years	< One years	2.89601*	.45262	.000
		1-5 years	1.84099*	.40659	.000
		6-10 years	1.64521*	.41545	.000
Anteroposterior (LT)	< One years	1-5 years	-1.03868*	.35123	.003
		6-10 years	-1.25347*	.36148	.001
		11-15 years	-2.86395*	.45321	.000
	1-5 years	< One years	1.03868*	.35123	.003
		6-10 years	-.21479	.30169	.477
		11-15 years	-1.82527*	.40712	.000
	6-10 years	< One years	1.25347*	.36148	.001
		1-5 years	.21479	.30169	.477
		11-15 years	-1.61048*	.41599	.000
	11-15 years	< One years	2.86395*	.45321	.000
		1-5 years	1.82527*	.40712	.000
		6-10 years	1.61048*	.41599	.000
Transverse Diameter	< One years	1-5 years	-.75804*	.28924	.009
		6-10 years	-.67459*	.29768	.025
		11-15 years	-1.90677*	.37322	.000
	1-5 years	< One years	.75804*	.28924	.009
		6-10 years	.08345	.24844	.737
		11-15 years	-1.14872*	.33526	.001
	6-10 years	< One years	.67459*	.29768	.025
		1-5 years	-.08345	.24844	.737
		11-15 years	-1.23218*	.34257	.000
	11-15 years	< One years	1.90677*	.37322	.000
		1-5 years	1.14872*	.33526	.001
		6-10 years	1.23218*	.34257	.000

Table (4.17) Post Hoc Test for testing the impact of age and Pons measurements

Multiple Comparisons					
Pons	**(I) Age**	**(J) Age**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**
Anteroposterior dimension/cm	< One years	1-5 years	.12214	.07	.108
		6-10 years	.22418*	.07	.004
		11-15 years	.19259*	.09	.050
	1-5 years	< One years	-.12214	.07	.108
		6-10 years	.10204	.06	.119
		11-15 years	.07045	.08	.422
	6-10 years	< One years	-.22418*	.07	.004
		1-5 years	-.10204	.06	.119
		11-15 years	-.03159	.08	.725
	11-15 years	< One years	-.19259*	.09	.050
		1-5 years	-.07045	.08	.422
		6-10 years	.03159	.08	.725
Craniocaudal Diameter/cm	< One years	1-5 years	-3.05260	3.75	.418
		6-10 years	-2.78185	3.88	.474
		11-15 years	-.40835	4.85	.933
	1-5 years	< One years	3.05260	3.75	.418
		6-10 years	.27075	3.24	.934
		11-15 years	2.64425	4.35	.545
	6-10 years	< One years	2.78185	3.88	.474
		1-5 years	-.27075	3.24	.934
		11-15 years	2.37350	4.46	.595
	11-15 years	< One years	.40835	4.85	.933
		1-5 years	-2.64425	4.35	.545
		6-10 years	-2.37350	4.46	.595

Table (4.18) Correlation between the RT and LT Cerebrum and Cerebellum Anteroposterior measurements

Cerebellum		**Anteroposterior dimension(RT)/cm**
Anteroposterior dimensions (LT)/cm	Pearson Correlation	.821(**)
	Sig. (2-tailed)	.000
	N	200
Cerebrum		**Anteroposterior dimension(RT)/cm**
Anteroposterior dimension(LT)/cm	Pearson Correlation	.992(**)
	Sig. (2-tailed)	.000
	N	200
**** Correlation is significant at the 0.01 level (2-tailed).**		

Table (4.19) Coefficient of variable (cerebellum transverse diameter and age)

Coefficients							
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R Square
		B	Std. Error	Beta			
1	(Constant)	8.018	.167		47.877	.000	.108
	Age	.123	.025	.329	4.907	.000	
a. region = Cerebellum b. Dependent Variable: transverse diameter							
Cerebellum transverse diameter = 8.013 + 0.123 * Age							

Table (4.20) Coefficient of variable (cerebellum Anteroposterior diameter and age)

Coefficients							
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R Square
		B	Std. Error	Beta			
1	(Constant)	4.491	.103		43.436	.000	.023
	Age	.033	.015	.151	2.147	.033	
a. region = Cerebellum. Dependent Variable: anteroposterior (RT)							
Cerebellum Anteroposterior (RT) = 4.491 + .033 * Age							

Table (4.21) Coefficient of variable (cerebrum Anteroposterior diameter and age)

Coefficients[a,b]							
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R Square
		B	Std. Error	Beta			.169
1	(Constant)	12.818	.209		61.251	.000	
	Age	.198	.031	.411	6.341	.000	
a. region = Cerebrum b. Dependent Variable: anteroposterior (RT)							
Cerebrum anteroposterior (RT) = 12.818 + 0.198 * Age							

Table (4.22) Coefficient of variable (cerebrum transverse diameter and age)

Coefficients[a,b]							
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R Square
		B	Std. Error	Beta			
1	(Constant)	10.961	.174		63.102	.000	.101
	Age	.122	.026	.317	4.704	.000	
a. region = Cerebrum b. Dependent Variable: transverse diameter							
Cerebrum transverse diameter = 10.961 + 0.122*Age							

Table (4.23) Coefficient of variable (Pons Anteroposterior diameter and age)

Coefficients							
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	R Square
		B	Std. Error	Beta			0.023
	(Constant)	1.555	.045		34.231	.000	
	Age	-.015	.007	-.151	-2.143	.033	
a. region = Pons b. Dependent Variable: anteroposterior							
Pons Anteroposterior Diameter = 1.555-0.015*Age							

Chapter Five

Discussion, Conclusions and Recommendations

5.1 Discussion:

Knowledge of normal brain development is a gate for understanding brain malformations, while the introduction of magnetic resonance imaging (MRI) into clinical practice has improved the detection and classification of brain anatomy and pathology.

We determined the dimensions of cerebellum, cerebrum, and Pons and tentorium angle on normal MRIbrain scans. Our study evaluated the following (1) The dimensions of the cerebellum for the right and left anteroposterior and transverse at axial plane (2) the cerebrum right and left anteroposterior dimension and transverse diameter at axial plane and(3) the Pons anteroposterior and craniocaudal dimensions as well as the Tentorialangle at sagittal plane.

A sample of 200 participant was involved in the current study with mean age of 5.39±3.98 years old .The higher frequency was found in the ages between 1-5 years old(74) constituting (37.0%),this was presented in table (4.1) .Descriptive statistics of cerebellum (RT) and (LT) anteroposterior dimensions and transverse diameter ,tentorium angle , cerebrum(RT) and (LT) anteroposterior dimensions and transverse diameter and Pons anteroposterior and craniocaudal were presented as mean and standard deviation ,maximum and minimum values in tables (4.2)-(4.5).

The current study showed no significant gender related differences for all the measured variables: tables (4.6), (4. 8),(4. 9)except the tentorium angle, there is significant difference between the two genders at p=0.059 as presented in table (4.7).This was not consigned with what was mentioned in other previous studies who mentioned that there are sex differences in gross cerebellar neuroanatomy (Escalona P.R,et al 1991,Shah S.A et al 1991,Raz N., et al 1998,Luft A.R., et al 1999).The justification may be due to the small sample size.

The cerebellum and cerebrum selected dimensions were significantly increased by increasing age from 6 months up to 15 years old tables (4.10),(4.12) however the increasing of age have no impact neither on the tentorial angle measurements nor the Pons craniocaudal diameter at p=0.603 table (4.11) and p=0.815 table (4.13) in respectively.

The study showed that the ages where the most changes/development happened in the cerebellum right and left anteroposterior dimensions and transverse diameter were found between 11-15 years table (4.14).For the Cerebrum the right and left anteroposterior dimensions and transverse diameter maximum, development were happened at the ages between11-15years table (4.16) it developed by nearly about 1 cm every five classes of ages (6-10 years and 11-15 years old)

Early MR morphometry studies comparing the cerebrum morphology in children and adults showed that changes were considerably larger in school-aged children than in young adults (Jernigan and Tallal 1990; Jernigan et al. 1991; Pfefferbaum et al. 1994), another studies showed that the changes in gross brain structure that continue past the ages over the first 2-3 years of life are subtle (Joan Stiles and Terry L. Jernigan2010), this was similar to our results. As wellour results showed the progress of growth was found to be increased at the age of 6-10 years old and increasing more at the young adults at 11-15 years for the right and left anteroposterior dimensions and transverse diameter of cerebrum, cerebellum however the Pons was found to be at maximum measurements at the ages less than one year for the anteroposterior measurements, and reduced at the age from 6-10 years and then increased again at the age of 11-15 years significantly at p=0.033 with no significant changes were found in all age groups for the cranio caudal diameter .This might be justified as suggested by (Joan Stiles and Terry L. Jernigan2010)that tissue alterations related to brain maturation might be much more extended during childhood than was generally supposed, and that some of these alterations might be regressive; that is, they might involve tissue loss. These findings were also confirmed and extended by the study done by (Toga et al. 2006) but the changes remain a matter of assumption as mention by (Joan Stiles and Terry L. Jernigan2010). Other studies have provided more anatomical details for studying age-related change (Giedd, et al. 1996; Sowell et al. 1999a; Sowell et al. 1999b; Sowell et al.2002).

The tentorial angle measurement does not affected by increasing age as presented in table (4.15).The maximum development for Pons Anteroposterior dimensions was found at the age between 6-10 years old, it was developed significantly at p = 0.004 table (4.17).No significant difference between the right and left side of cerebrum and cerebellum anteroposterior measurements at ***p***= 0.000 and 0.000 respectively table (4.18).

Understanding the normal development of the cerebellum and cerebrum might help to distinguish pathological changes from healthy growth during development in the age's than 1 and≤15 years old, which can help in the early diagnosis of any presence of abnormalities. There is a lack of studies examining the cerebellum, cerebrum, pons and tentorium angle. Therefore in this study, we analyzed the dimensions of the selected variable in normal brain scans in order to establish values to be as reference at this period of ages. As well we study the development progression at different age groups in order to ease the diagnosis if any pathology might occur.

the results could supply reference material for the identification of abnormalities in the anteroposterior dimensions of pons ,cerebrum and cerebellum as well as the transverse diameter of cerebrum and cerebellum and thus could be used in the detection of any abnormalities that may took place. Tables (4.19)-(4.23) presented the new equations that might predict the normal dimensions for the known subjects’age.

5.2 Conclusion

The study concluded that the cerebellum and cerebrum right and left anteroposterior dimensions and transverse diameter were significantly increased as the age increased during the developing period from ages less than 1 year to 15 years old, as well the Pons anteroposterior diameter was significantly affected with age. On the other hand; no significant relationship was found between the Pons craniocaudal diameter/age and the tentorium angle/age. No significant gender related difference was detected in all the selected variables except the tentorium angle. New predictive equation for the variables were establishes as reference values.

Cerebellum transverse diameter = 8.013 + 0.123 * Age

Cerebrum transverse diameter = 10.961 + 0.122*Age

Cerebellum Anteroposterior (RT) = 4.491 + 0.033 * Age

Cerebrum anteroposterior (RT) = 12.818 + 0.198 * Age

Pons Anteroposterior Diameter = 1.555-0.015*Age

5.3 Recommendations:

1/ to apply this equations in medical radiology departments as reference for the age of study in clinical.

2/ for further studies on anatomical structures Ventricals, medallaoblingata, and others.

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Appendix
(A)

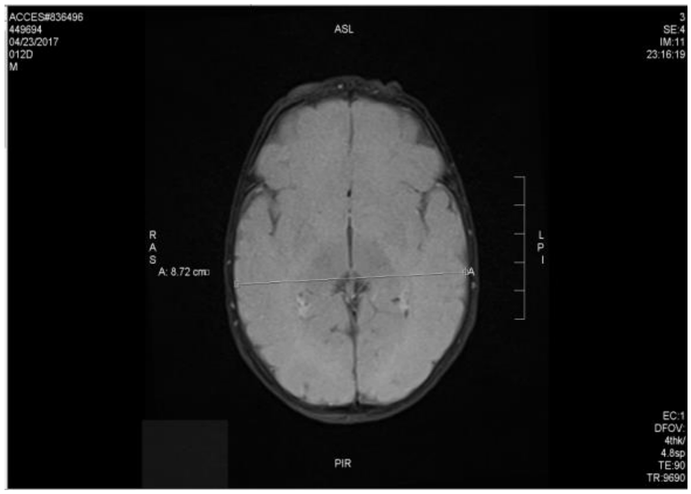
Sudan University of Sciences and Technology

College of Graduate Studies

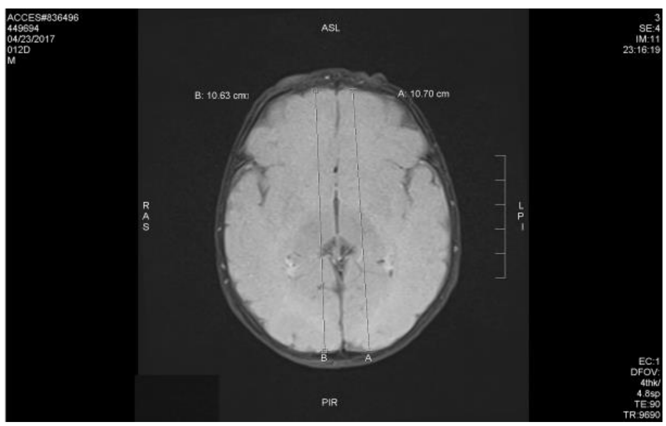
Images Magnetic Resonance

A. on MRI, sagittal T1 sequence shows the pons measurements (B) CC dimension, (A) AP dimension in a 1-year old male

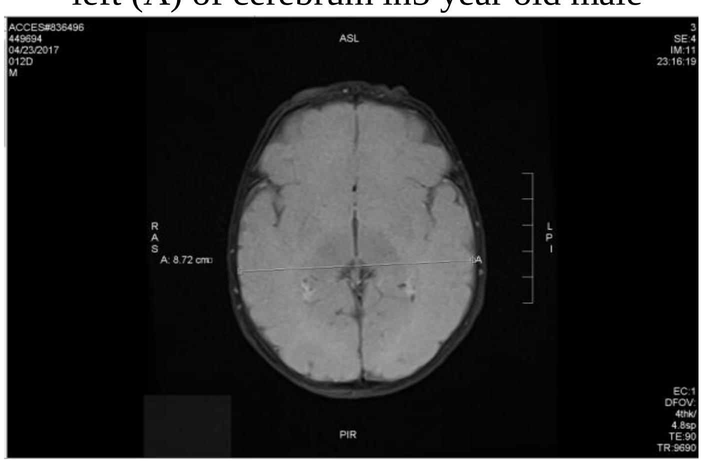
B.On MRI, sagittal T1 sequence shows tentorium angle of cerebellum in 5 year old male



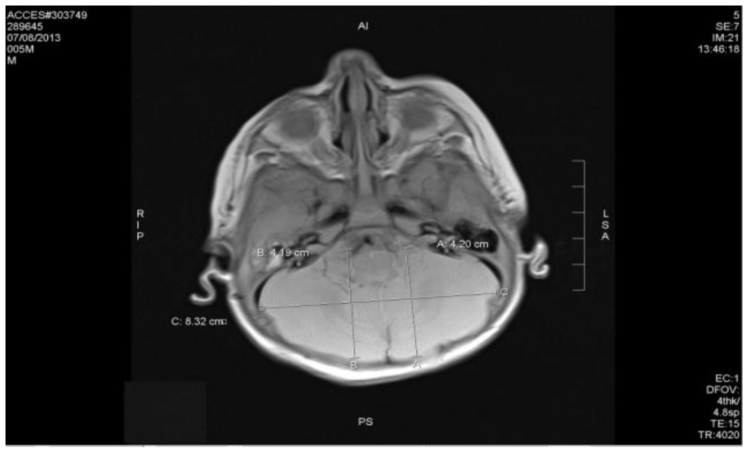
C. On MRI, axial T2 sequence shows transverse dimension of cerebrum in 5 year old male



D.On MRI, axial T2 sequence shows Anteroposterior dimension right (B) and left (A) of cerebrum in5 year old male



C. On MRI, axial T2 sequence shows transverse dimension of cerebrum in 5 year old male



E.On MRI, axial T2 sequence shows Anteroposterior right (B) & left (A) & transverse dimension (C) of cerebellum in one year old male

Appendix
(B)
Datasheet

Tentorium angle	Sagittal		Axial			Body weight	Gender	Age	PIN	Region
	AP	CC	AP		TV					
			RT	LT						
										Cerebellum
										Cerebrum
										Pons
										Cerebellum
										Cerebrum
										Pons
										Cerebellum
										Cerebrum
										Pons
										Cerebellum
										Cerebrum
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										Pons
										Cerebellum
										Cerebrum
										Pons
										Cerebellum
										Cerebrum
										Pons

Appendix

(C)

Publishing paper

بسم الله الرحمن الرحيم

جامعة السودان للعلوم والتكنولوجيا
عمادة البحث العلمي
SUDAN UNIVERSITY OF SCIENCE & TECHNOLOGY
DEANSHIP OF SCIENTIFIC RESEARCH

Date: 23/07/2020

Authors:

1. **Suhair Talha Shaheen**
2. **Maha Esmeal Ahmed**
3. **Caroline Edward Ayad**

Title of the paper:

Evaluation of Normal Dimensions of Cerebellum, Cerebrum, Pons and Tentorial Angle Using MRI

Dear Author:

It gives me pleasure to inform you that the above mentioned paper has been accepted for publication in the (**Journal of Natural and Medical Science**).

The paper will be published according to priority of flow.

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