Introduction

Autism spectrum disorder (ASD) is a complex neurodevelopmental disorder characterized by social, communication, and behavioral disturbances. That is common to the disorders within the spectrum are difficulties within three areas of development, known as "the triad of impairments"; these are characterized as difficulties in: social and emotional understanding; all aspects of communications; and flexibility in thinking and behavior ***(Walker et al., 2012).***

According to the report released by the United States Center for Disease Control and Prevention, the prevalence of ASD has sharply increased during the recent years and 1 out of 88 children suffers now from ASD symptoms ***(Samsam et al., 2014).***

Neuropathology of Autism is likely due to multiple genetic and environmental factors that alter groups of neurons in different regions of the brain. Both genes and environment can alter the structure of the developing brain in different ways ***(Gadad et al., 2013).***

MRI studies have found regional volumetric differences when comparing Autism subjects to healthy controls. In that, autistic 2-3 years old had more cerebral and cerebellar white matter, and more cerebral cortical grey matter than normal, whereas older autistic children and adolescent did not have such enlarged grey and white matter volumes ***(Courchesne et al., 2001).***

Functional magnetic resonance imaging (fMRI) studies have had a profound impact on the understanding of the neurobiologic basis for autism and autism-spectrum disorders. Initial studies led to the delineation of many neural systems for brain–behavior relationships in ASD; some relationships were previously well established, but others were elucidated in response to distinctive impairments in autism ***(Minshew and Keller, 2010).***

FMRI studies have relied on cognitive tasks to elicit hemodynamic changes in the brain, which represent an indirect measure of neuronal activity; Studies in the last decade have begun examining the activation-driven interregional BOLD (blood oxygen level-dependant) correlations in ASD ***(Muller et al., 2011).***

Aim of the Work

The aim of this work is to emphasize the role of functional magnetic resonance imaging and its benefits in assessment of children with autism spectrum disorder (ASD).

MRI Anatomy of the Brain in Pediatrics

Brain development in the first years of life is extremely dynamic and likely plays an important role in neurodevelopmental disorders. Magnetic resonance imaging (MRI) of the brain is a proven and well-established imaging modality in the evaluation and assessment of normal and abnormal conditions of the brain.

The interior of the central nervous system is organized into grey and white matter. Grey matter consists of nerve cells embedded in neuroglia; it has a grey color. White matter consists of nerve fibers embedded neuroglia; it has white color due to the presence of lipid material in the myelin sheaths of many of the nerve fibers ***(Snell, 2010).***

Because T1W images are generally sensitive to the presence to the small amount of myelin, hyperintense T1 signal is seen earlier and more prominently than the corresponding hypointense signal on T2W Images. Later in infancy and early childhood, T2W images are superior for showing further refinement in myelination ***(Matsumoto et al, 2015).***

Total brain volume: (Figures 1 & 2)

Total brain volume (TBV) was calculated by combining total gray matter and total white matter as defined by the automatic tissue segmentation.

TBV continues to increase in volume from birth throughout childhood. At 2-4 weeks of age TBV is about 36% of adult volume; at 1 year the total brain volume is about 72% of adult volume, and at 2 years it is about 83% of adult volume ***(Knickmeyer et al., 2008).***

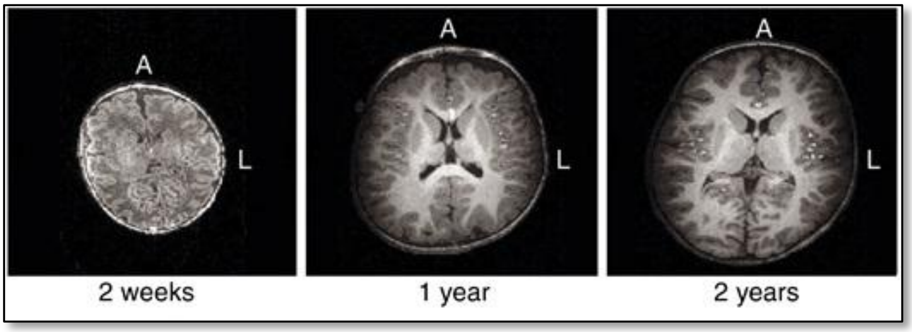

Figure (1): T1 weighted axial MR Images acquired longitudinally from one child at 2 weeks, 1 year and 2 years age; showing age related increase in brain size. A; anterior, L; left ***(Tau and Peterson, 2010).***

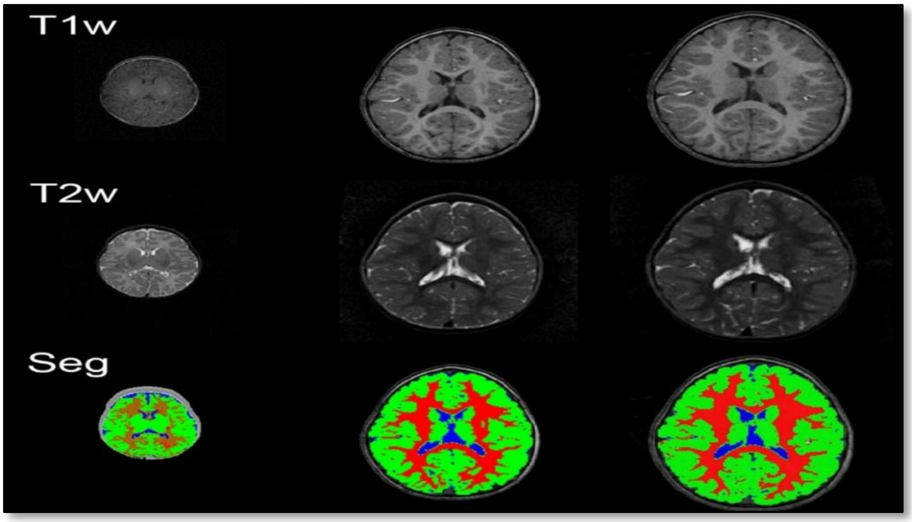

Figure (2): Axial slices from single subject at birth, 1 and 2 years; showing the difference in the TBV. CSF (blue), grey matter (green), white matter (red), unmyelinated white matter (brown) ***(Hess et al., 2011).***

Grey and white matter differentiation:

At birth there is lack of grey and white matter differentiation, they have almost equal signal intensity on T1W images which remains till the age of 6 months (figure 3). During the first year of life differentiation proceeds rapidly; myelination begins first in the occipital region during the second part of the first year ***(Matsumoto et al., 2015).***

Grey matter become distinguishable from white matter after the age of 6 months, the signal intensity of the white matter on T1W images is little higher than cortical grey matter, and myelination extends progressively towards the cortex assuming the appearance of fine arborization ***(Matsumoto et al., 2015).***

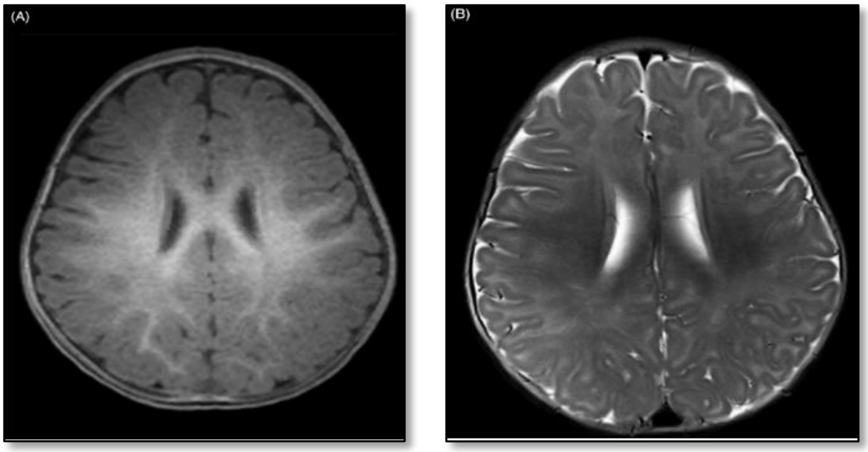

Figure (3): Axial brain MRI of 6 months child (A) T1W image (B) T2W image; showing pseudo thickening of the cortex with lack of grey and white matter differentiation ***(Matsumoto et al., 2015).***

Myelination begins in the occipital region with the last area to myelinate is the frontal cortex and the full adult appearance is not fully established until early adolescence ***(Mastumoto et al., 2015).***

Corpus callosum:

The largest white matter fiber bundle, the corpus callosum is a massive accumulation of fibers connecting the cortices of the two cerebral hemispheres and it is the principle white matter bundle in the brain ***(Moshagian, 2008).***

In the newly born infant it appears as thin slender structure with signal intensity appears close to the intensity of the grey matter on T1 W images and with intermediate intensity on T2 W images ***(Matsumoto et al., 2015).***

Myelination of corpus callosum begins from splenium and progress anteriorly, and become well established by the end of 3 years age taking adult configuration. Signal intensity is high in T1W images (figure 4), and low in T2W images ***(Matsumoto et al., 2015).***

By the age of 1 year the subcortical white matter signal intensity is more than signal intensity of corpus callosum, they become the same signal intensity as in adults by the age of 3 years ***(Hess et al., 2011).***

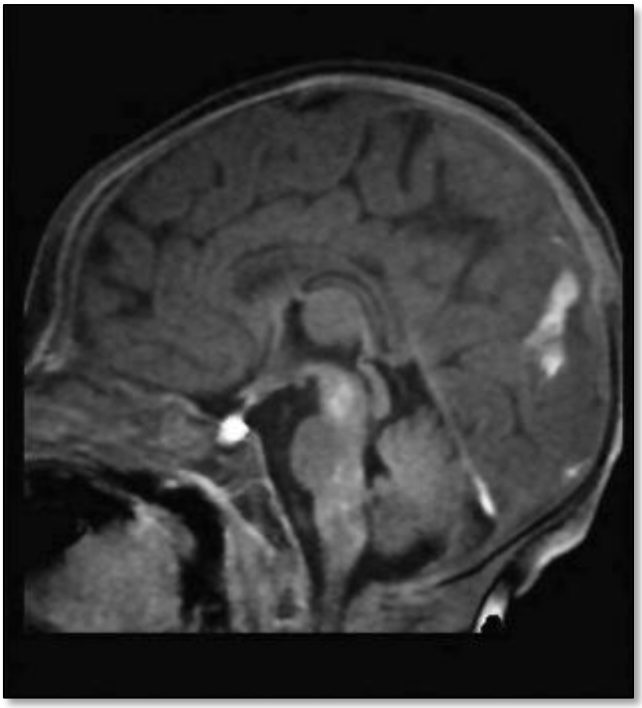

Figure (4): 3D T1Wwighted image; corpus callosum in a normal term infant; it has uniformly thin tubular shape. NB presence of subdural hematomas is common in new borns, in the posterior interhemispheric fissure and tentorium ***(Matsumoto et al., 2015).***

Basal ganglia and thalami: (figure 5)

In newly born infant they are hyperintense on T1W images and slightly hypointense on T2W images, after age of 6 months it's volume appears to decrease relative to cerebral white matter due to rapid growth of white matter.

Between the age of 4 and 8 months, and up to 12 months, the globus pallidus is mildly hyper intense on T2w image in comparison to the rest of basal ganglia (figure 5) ***(Matsumoto et al., 2015).***

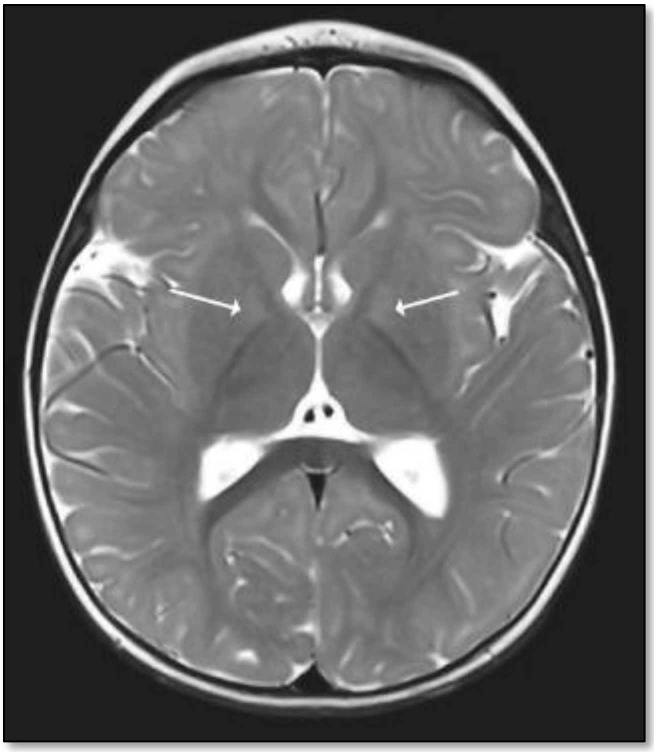

Figure (5): T2 weighted image of normal 11 months old; the globi pallidi (arrows) are slightly hyperintense to the rest of the basal ganglia ***(Matsumoto et al., 2015).***

Hippocampus: (figures 6 &7)

Hippocampus is a curved elevation of the grey matter that extends throughout the entire length of the floor of the inferior horn of lateral ventricle. It is named hippocampus because it resembles a seahorse in coronal section, it is importantly involved in memory mechanisms ***(Snell, 2010).***

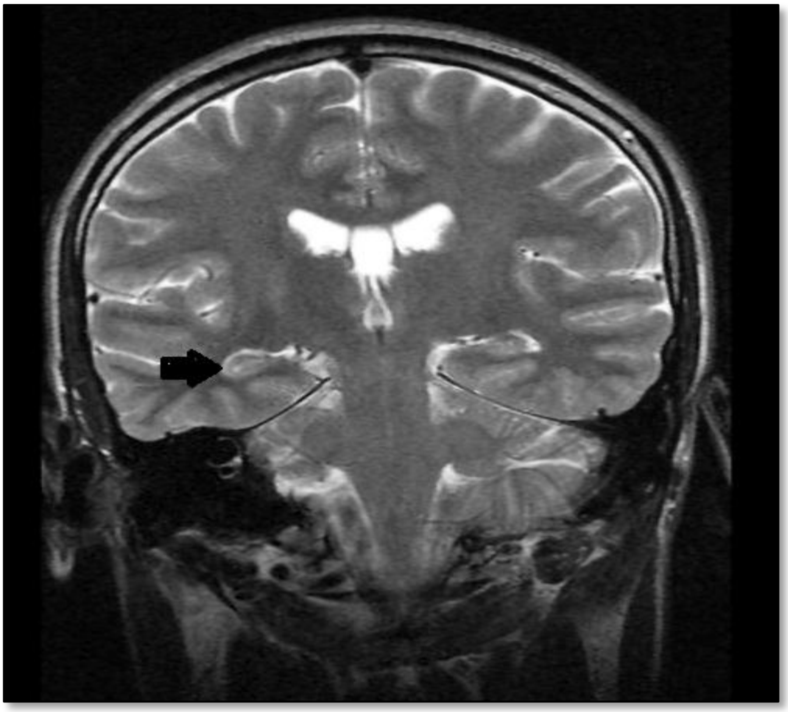

Figure (6): Coronal T2 weighted MR image of the brain, showing hippocampus (arrow) with characteristic seahorse appearance ***(Bican et al., 2013).***

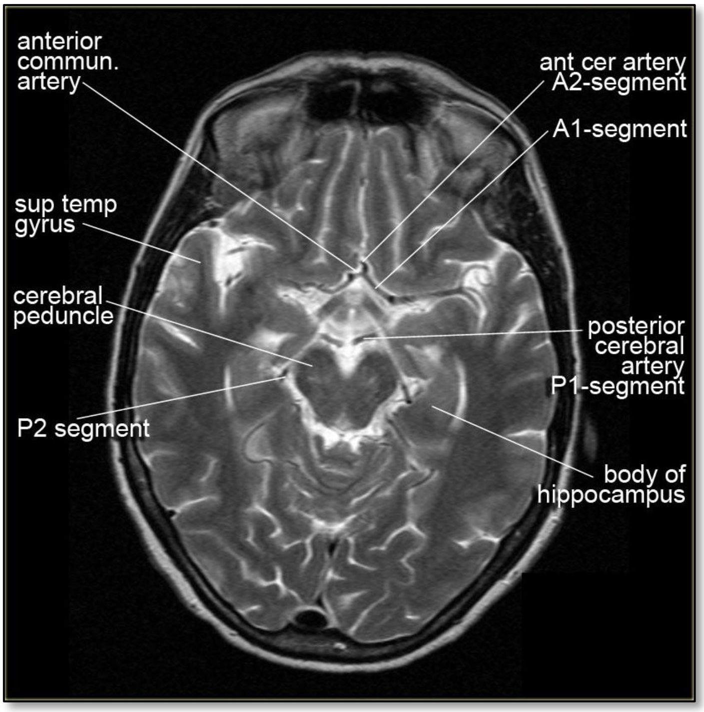

Figure (7): T2W image showing the body of hippocampus ***(Cochard et al., 2011).***

Functional areas of the brain: (Figure 8)

1. Language areas:

Wernick's area of the temporal lobe of one hemisphere (usually left) which has a major role in language interpretation.

a) Broca's area is involved in directing motor speech ***(Friederici, 2011) (Crossman and Neary, 2014).***

2. Auditory areas:

b) Primary auditory cortex (Heschel's gyrus) and auditory association area (superior temporal gyrus) are found in the temporal lobes, which are responsible for receiving sound impulses from inner ear and interpretation of the sound respectively ***(Friederici, 2011) (Crossman and Neary, 2014).***

3. Visual areas:

c) Primary visual cortex and visual association area are found in the occipital lobes, which are responsible for receiving impulses from retina and interpretation of visual information respectively ***(Friederici, 2011) (Crossman and Neary, 2014).***

4. Face processing:

d) Area responsible for face processing is the fusiform face area ***(Friederici, 2011) (Crossman and Neary, 2014).***

5. Motor areas:

e) Primary motor cortex (precentral gyrus in the frontal lobe); allow control of movement of the skeletal muscles.

f) Premotor cortex (anterior to the precentral gyrus in the frontal lobe); allow control of learned repetitive motor skills in addition to coordination of skeletal muscles movements ***(Friederici, 2011) (Crossman and Neary, 2014).***

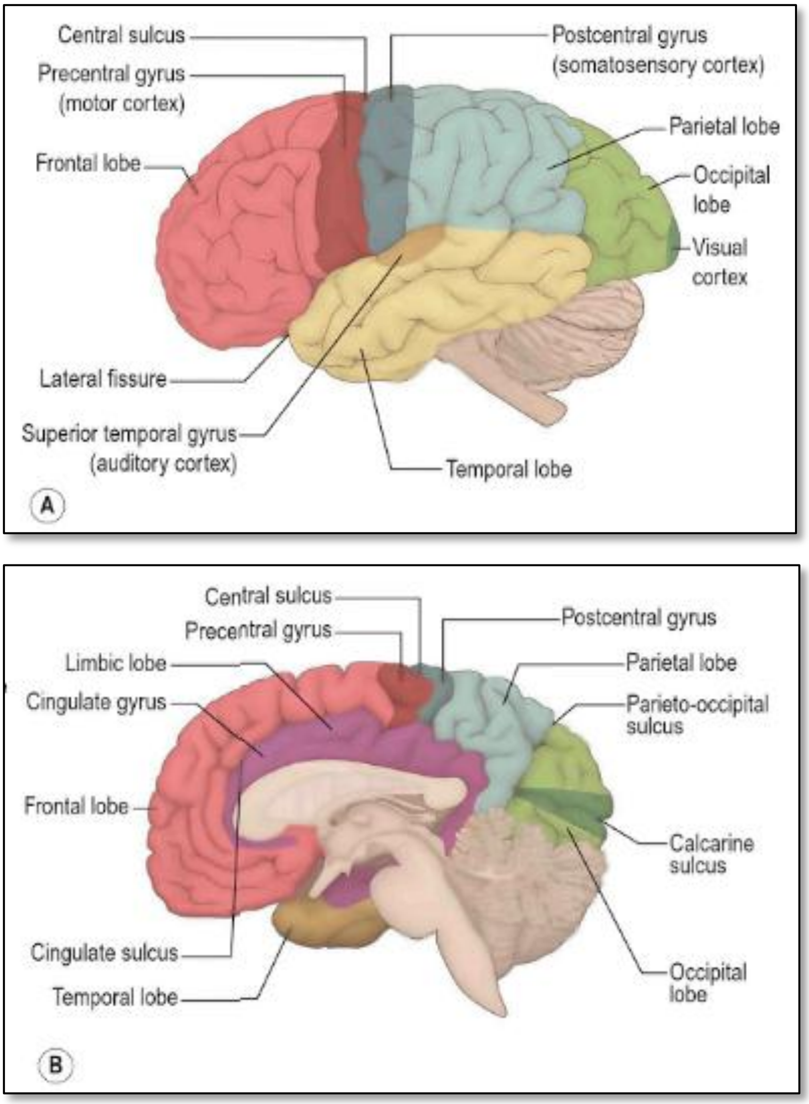

Figure (8): Principle gyri, sulci and functional areas of the cerebral cortex ***(Crossman and Neary, 2014).***

Brain neuronal tracts:

Nerve tract is a bundle of nerve fibers connecting nuclei of the central nervous system; the nerve fibers in the central nervous are of 3 types: association fibers, commissural fibers and projection fibers ***(Blumenfeld, 2010).***

- **Association fibers:** The tracts that connect cortical areas within the same hemisphere, long association fibers connect different lobes of a hemisphere to each other whereas short association fibers connect different gyri within a single lobe. Among their roles, association tracts link perceptual and memory centers of the brain ***(Schmahmann and Pandaya, 2009).***

- **Commissural fibers:** the tracts that connect corresponding cortical areas in the two hemispheres. They cross from one cerebral hemisphere to the other through bridges called commissures. The great majority of commissural tracts pass through the corpus callosum. A few tracts pass through the much smaller anterior and posterior commissures. Commissural tracts enable the left and right sides of the cerebrum to communicate with each other ***(Schmahmann and Pandaya, 2009).***

- **Projection fibers:** the tracts that connect the cerebral cortex with the corpus striatum, diencephalon, brainstem and the spinal cord. The corticospinal tract for example, carries motor signals from the cerebrum to the spinal cord. Other projection tracts carry signals upward to the