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Mini Review

White Matter, Psychomotor Development, Cognitive and Behavior Disorders in Patient with Congenital Heart Defects

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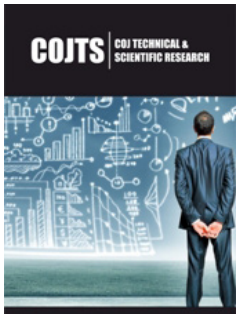

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Submission: October 04, 2019

Published: October 15, 2019

Volume 2 - Issue 4

How to cite this article: Emmanuel Suluba, Liu Shuwei, Ally Mwanga, Balowa Musa. White Matter, Psychomotor Development, Cognitive and Behavior Disorders in Patient with Congenital Heart Defects. COJ Technical & Scientific Research.2(4). COJTS.000541.2019.

Abstract

A hemodynamic disturbance in children with congenital heart defects (CHD) impairs cerebral perfusion resulting into brain neural injury. Neural injury in CHDs patients can occur prenatally, postnatal or during surgical repair of the defects (reperfusion injury) often following hypoxia induced oxidative stress. The brain subventicular zone (SVZ) contain postnatal niche of neural stem cells. SVZ cells are very sensitive to hypoxia and may be damaged in children with CHDs. Oligodendriocytes and myelinated fibers are documented to be most vulnerable in conditions of diminished oxygen supply to the brain thus frequently damaged in patient with CHDs. The evaluation of brain associated consequences is frequently overlooked in many cases of CHDs. Therefore, this mini review put forward the impact of CHDs on brain white matter, cognitive and behavior. In addition, it highlights the important infant cognitive evaluation tools and novel techniques used to study the brain white matter.

Keywords: Congenital heart diseases CHDs; White matter injury; Brain volume; Cortical thickness; Psychomotor development; Cognitive; Behavior

Abbreviations: CHD: Congenital Heart Defects; SVS: Sub Ventricular Zone; HLHS: Hypoplastic Left Heart Syndrome; TOF: Tetralogy of Fallot; TGV: Transposition of Greater Vessels

Introduction

The brain is the part of central nervous system which is responsible for coordination and control of all body activities. It consists of grey matter, white matter and neuronal supporting cells. The white matter contains neuronal conducting fibers which transmit information and connect different part of grey matter in the brain. These fibers are classified as; projection fibers, communicating fibers and association fibers [1]. The brain is very sensitive to hypoxia, thus hypoxemic spells can result into permanent neural injury. The damage of brain white matter may affect children psychomotor development, with long term consequences in their cognitive and behavior [2]. The intrauterine and extra uterine hemodynamic disturbance resulting into decrease in cerebral perfusion in fetuses and neonates with CHDs and subsequently affects brain development. Neonates with congenital heart defects have reduced brain oxygen delivery to the brain [3], cause brain maturation delays [4,5] and reduce white matter and grey matter volume [6].

White matter changes cognitive and behavior

The brain subventricular zone (SVZ) contains postnatal niche of neuronal stem cells. Proliferation and neurogenesis of the cells in (SVZ) is impaired by hypoxia [7]. Impairment of regional and global cerebral perfusion therefore affect both structural and function of the brain [8-12] and has detrimental effect on central nervous system [13-17] consequently increase risk of both neurodevelopmental and psychiatric disorders including cognitive, speech, motor and behavioral [18-20]. Children with CHDs have increased risk of hyperactivity and attention deficit [21]. The prenatal brain growth is also impaired in CHDs [22] particularly with CHDs phenotypes namely; hypo plastic left heart syndrome (HLHS), Tetralogy of Fallot (TOF) and transposition of greater vessels (TGV) [23].

White matter injury is particularly common in patient with various forms of CHDs [24-26] with oligodendrocytes and myelinated neurons most affected [27], this strongly correlate with reduced cognitive development [28]. Patient with CHDs have low volume of corpus callosum [29], diffuse microstructure abnormalities in splenium, a part which is involved in visual spatial function [30], uncinate fasciculus and right middle cerebellar peduncle abnormalities which affect memory and auditory attention [31] as well as decreasing thalamocortical development [32]. Diffusion tensor imaging has become the gold standard for diagnosis of brain neurological disorders apart from neurite orientation dispersion and density imaging model which are regarded as more advanced models [33].

DTI provide microstructure assessment of white matter injury within the brain. DTI use the rate of diffusion of water in a tissue to produce images. Using DTI, we can quantitatively measure Fractional Anisotropy, mean diffusivity (MD), axial diffusivity (AD), and radial diffusivity (RD) [34]. Standard infant development evaluation tools such as; Bayley scale of infant development (BSID-II), Denver development screening test (DDST),Mental developmental index (MDI) and psychomotor developmental index (PDI) [35-39] are used to study the impact of white matter injury on psychomotor, cognitive and behavior development in patient with CHDs.

Conclusion

Congenital heart diseases affect both the heart and brain. Indeed, disturbance in fetal hemodynamics which do occur either intra or extra-uterine in CHDs patients have severe brain consequences. We advocate the routine evaluation of white matter using contemporary imaging techniques in order to detect the extent of white matter injury. In addition; we should also pay attention in assessing the psychomotor, cognitive and behavior in CHDs using standard infant development evaluation tools. Therefore, we should not only take care of the heart in management of CHD patients but also the brain. This will ensure proper management for patient with CHDs..

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