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Developmental and behavioral disorders. Magnetic Resonance Image study

RESUMEN

Introducción: Las cifras de trastornos del comportamiento y desarrollo en población infantil se han incrementado en los últimos años. Definidas como un grupo de impedimentos (físicos, cognitivos, psicológicos, del lenguaje) que pueden aparecer en cualquier momento durante la infancia y la adolescencia, los trastornos del comportamiento y desarrollo incluyen la hiperactividad, trastorno bipolar, síndrome de Down, entre muchos otros.

Objetivo: Presentar nuestra experiencia con pacientes con trastornos de comportamiento y desarrollo.

Material y métodos: Estudio retrospectivo longitudinal de Resonancia Magnética de cráneo efectuada en un grupo de pacientes (72) con el diagnóstico de enfermedades del comportamiento y desarrollo. Los diagnósticos fueron hechos con base en el cuadro clínico y los criterios de DSM IV. Los estudios fueron efectuados en un equipo de RM de 1.5 tesla Philips con las secuencias habituales.

Resultados: 36 pacientes eran masculinos y 36 femeninos. 12 pacientes presentaron alteraciones relacionadas con el autismo. Ocho alteraciones del comportamiento y doce alteraciones del lenguaje. Cuarenta presentaron alteraciones mixtas que incluyen: hiperactividad y déficit de atención.

Conclusión: Los trastornos de oposición presentan una amplia variedad de manifestaciones anatómicas y fisiológicas algunas de las cuales se pueden visualizar con Resonancia Magnética. El conocimiento de las vías neurofisiológicas y su manifestación con Resonancia Magnética nos ayudan a comprender y analizar estas enfermedades con los métodos de imagen.

Palabras clave: Trastornos del comportamiento y desarrollo, Resonancia Magnética.

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Introduction

Developmental and behavioral issues in children are being reported in epidemic numbers and those numbers are growing. According to the centers for disease control (CDC) estimates, approximately 17% of children in the United States have some form of a developmental disability.[1] The CDC defines developmental disabilities as “a diverse group of physical, cognitive, psychological, sensory, and speech impairments that begin anytime during development up to 18 years of age”; as this definition indicates, there is a wide range of what is included under the umbrella of “developmental disabilities”: from mild developmental delays and disorders to more serious developmental disorders such as mental retardation, cerebral palsy, and autism spectrum disorders. Within each type of developmental disorder, or diagnostic category, there are numerous sub-types, varying intensity of symptoms, and most importantly, considerable individual variation.

The most common behavioral and developmental disorders are: attention deficit hyperactivity disorder (ADHD), pervasive developmental disorders (PDD), Language related disorders (LRD), Oppositional disorders (OP), Angleman syndrome, bipolar disorders (BD), central auditory processing disorder (CAPD), cerebral palsy, Down syndrome, fragile x syndrome, Landau

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ABSTRACT

Introduction: Numbers for development and behavioral disorders in children have increased in recent years. Defined as a group of impairments (physical, cognitive, psychological, language) that can occur at any time during childhood and adolescence, behavior and development disorders including hyperactivity, bipolar disorder, Down syndrome, among many others.

Objective: To present our experience in patients with developmental and behavioral disorders.

Material and methods: A retrospective longitudinal analysis of brain Magnetic Resonance studies was performed on a group of patients (72) with developmental and behavioral disorder diagnosis with 60 patients with normal MRI studies was used as control group. Diagnosis was made based on clinical criteria and DSM IV studies. Examination was performed on a 1.5 Philips MRI with standard imaging sequences. Analysis was performed on a PACS system.

Results: Seventy two patients were studied. Age range between four and 17 yeas of age. 36 male and 36 female. 12 patients had autism related disorder. Eight had behavioral abnormalities and 12 patients presented language related disorder. 40 patients had mixed behavioral disorders that included: ADHD and ODD twelve patients, PDD and ALD eight patients, OCD, SD and DDD eleven patients. ADD, DD and SD nine patients.

Conclusion: Behavioral and developmental disorders have a wide range of anatomical and physiological alterations some o which we can visualize in neuroimaging studies. The knowledge of neurophysiological pathways and their manifestations on magnetic resonance exams can help us comprehend these illnesses.

Key words: Behavioral and developmental disorders, MRI.

Kleffner syndrome, learning disabilities, mental retardation, Prader-Willy syndrome, Tourette syndrome, brain truma and Williams syndrome. We present our experience in patients with developmental and behavioral disorders.

Material and methods

The study was a retrospective longitudinal analysis of brain Magnetic Resonance studies performed on a group of patients with developmental and behavioral disorder diagnosis. 60 patients with normal MR studies as a control group. 72 patients were studied between September 2006 and March 2008. At outpatient clinic, Child Neurology of South Texas, at Valley Baptist Medical Center, University of Texas System. Harlingen Texas. The patients were included on the basis of their clinical findings and DSM IV criteria for behavioral and developmental disorders. A 1.5 tesla system was employed (INTERA) Philips Medical Systems, Eindhoven. Standard imaging sequences where performed. T1: TR 596 MS and T3 15 MS, T2: 4,896 MS and TE 110 MS. Flair TR 6,000/2,000 and TE 120 MS. Dual TR 2,200 MS with TE 20/120 MS. Diffusion weighted TR: 3,070 MS with TE 74 MS. The results were analyzed through a PACS System Accessnet. Aspyria, Calabasa, California. At Clinical Radiology Center, San Luis Potosi, Mexico by a Neuroradiologist.

Results

Seventy two patients were studied. Age range between four and 10 yeas of age. 36 male and 36 female. All patients had a clinical history of developmental and/or behavioral disorder with according DSM IV criteria. 12 patients had autism related disorder. Eight had behavioral abnormalities and 12 patients presented language related disorder. 40 patients had mixed behavioral disorders that included: ADHD and ODD twelve patients, PDD and ALD eight patients, OCD, SD and DDD eleven patients. ADD, DD and SD nine patients *(Table I)*. 21 patients showed decreased right temporal hippocampal volume. Five diminished left hippocampal volume and four bilateral decreased volume. Two patients had high signal nonspecific lesions at the parietal white matter. Four patients had cystic lesions at the basal cysterns. Two medial to the left hippocampus and two with rostral temporal cysts, one on the right and one on the left temporal fossa. 16 patients presented ethmoidal and or maxillary sinus inflammatory changes with normal MRI scans. 18 patients had normal MRI studies *(Table II)*.

Discussion

Developmental and behavioral disorders is a term used to describe a group of entities which have in common a life long disability attributable to mental o physi-

Table I. Developmental and behavioral disorders.

Diagnosis	Patients
ADHD, ODD	12
ADHD	08
OCD, SD, DDD	11
ADD, DD, SD	09
Behavioral AB	08
Language related DIS	12
PDD	12

ADHD: Attention deficit hyperactivity disorder. ODD: Oppositional defiant disorder. PDD: Pervasive deficit disorder. ADD: Attention deficit disorder. DD: Developmental disorder. SD: Social disorder.

Table II. Behavioral and developmental disorders.

Right temporal asymmetry	21 P
Left temporal asymmetry	05 P
Bilateral temporal volume loss	04 P
Demylinizating lesions	02 P
Sinusitis	16 P
Normal	18 P
NCC	04 P
Low intensity basal ganglia	02 P
Total	72 P

NCC: Neurocysticercosis.

cal impairment or both. All of which affect daily interaction in one or several of the following areas:

- Capacity of independent living.
- Economic self sufficiency.
- Learning.
- Mobility.
- Receptive and expressive language.
- Self care.
- Self direction.

The prevalence of these entities has had small variations in the past decades mainly related to the population sample studied. We can consider a prevalence of 3.5 to 5% of some type of developmental and/or behavioral problem in population studies in the United States.[1,2]

Autism spectrum disorder is characterized by developmental abnormalities in social and emotional behavior, associated with stereotyped and obsessional behaviors (World Health Organization 1993). The neuropathological basis of pervasive developmental disorders have not been determined. However a number of anatomical substrates have been suggested. Like dysfunction in mesolimbic (dopaminergic) brain areas (ventromedial prefrontal cortex, medial temporal lobe (hippocampal regions CA1 and CA4), striatum and limbic thalamus) cerebellar vermis and hemisphere (with a reduction in the number of Purkinje cells), inferior olive (with smaller cells that tend to cluster in the periphery of the nuclear comlex) and decreased number of glial cells in the primary auditory cortex.[3-6] Neuroimaging studies have found structural abnormalities in the amygdalar configuration in autism. The neurobiological basis remains elusive. Although these findings are inconsistent, several groups have reported no abnormal amigdalar size difference between autistic patients and normal controls[7] while other have found increased size or reduced amygdalar size.[8-13] Nine of the twelve patients in our series with autism related disorders had amigdalar size reduction. Consistent with previous reports. No other anatomical alteration was noted.[14,15] *(Figure 1)*.

Attention deficit hyperactivity disorder (ADHD) is characterized behaviorally by impulsiveness, poor attention and hyperactivity. The cognitive deficit in these patients includes functions of inhibitory, attentional and motivational control and timing. Anatomical findings in Magnetic Resonance Imaging studies include reduced cerebral volumes mainly in the prefrontal cortex, basal ganglia and the hippocampus.[16-18] Circuits connecting the amygdala and orbitofrontal cortex support decision making and reward reinforcement. Disturbances along these circuits can cause behavioral disinhibition and impulsivity.[19,20] In healthy patients successful inhibition is associated with brain regions that include the inferior frontal gyrus (Brodmann area 9) and the right superior temporal gyrus (Brodmann 22). In patients with ADHD and unsuccessful inhibition we can also see a similar network that includes; bilateral insular and ventrolateral prefrontal cortex (Brodmann 13; 37, 13 and 12; and 34, 17 and 1) anterior cingulated cortex (Brodmann 32) the left inferior occipital gyrus (Brodmann 19) and the right superior parietal lobule (Brodmann 7).[21]

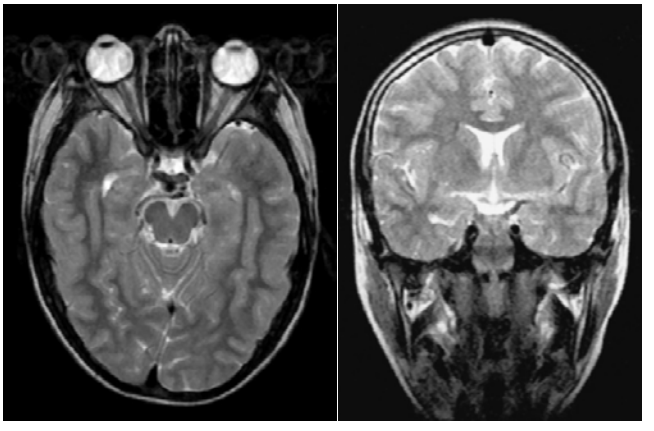

Figure 1. Nine year old male patient with pervasive related disorder with atrophy to the right hippocampus.

Cognitive processes are intrinsically connected thus deficit in one system can affect another. While other investigations report hippocampus hypertrophy on our group of patients we saw atrophy of the hippocampus. These findings could be associated with the other behavioral and developmental disorders associated with our group of ADHD patients. The hypertrophy reported in other series could represent a compensatory mechanism in response to neural processes to the presence of neural disturbances. And the atrophy we saw on our series could represent and advance stage of the neural disturbances. More extended studies should be performed on these patients. The basal ganglia represent a special area in the neurobiology of patients with ADHD. It is basically a group of large subcortical structures that are divided into two sets:

- The striatum with consist of the caudate, putamen and ventral striatum.
- The palliudm with the external segment, internal segment and ventral pallidum.

The striatum receives input from the entire cerebral cortex, thalamus, *substantia nigra* and amygdala. It also sends projections to the *pallidum* and *substantia nigra*. The *pallidum* sends input to the thalamic nuclei and subcortical nuclei, where information will be sent back to de frontal and prefrontal cortex. The striatum is important in the execution of motor planning, sequencing and coordination.[22,23]

The primary neurotransmitter involved in modulation of the basal ganglia activity is dopamine. The disruption of this system is found in patients with ADHD. There are higher levels of dopamine metabolite and homovanillic acid in cerebral spinal fluid in ADHD patients.[24] Also there are decreased blood flow in the putamen in patients with ADHD compared to normal children *(Figure 2)*.

Human language is a complex and multifaceted cognitive capacity. Although the neural basis is not fully understood, language functions are classically thought to be mediated by two areas in the left hemisphere: Broca (for speech production) and Wernike for speech comprehension. The arcuate fasiculus, a fiber track that originates in the temporal lobe curves around the sylvian fissure to project itself to the frontal, lobe contects these two areas. The production of language has several components. Phonemes for example have two mayor aspects; receptive processing of phonemes in the Wernike area (posterior Brodmann 22 and 40) and expressive production of phonemes (Broca posterior 44 and 6). While the lexical-semantic system is believed to originate in the middle and inferior temporal lobe.[25,26] Developmental language disorder (sometimes called language delay) is a condition wherein a child

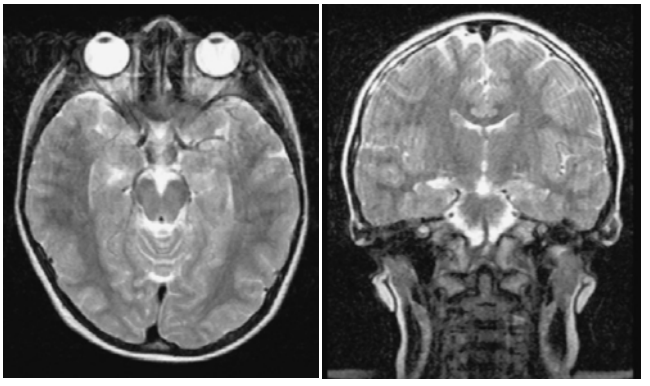

Figure 2. Eight year old patients with attention deficit hyperactivity disorder and developmental disorder with right hippocampus atrophy. T2 weighted images in axial and coronal planes.

does not learn language as quickly as his/her peers. Children with developmental language disorders learn language in the same sequence as their normally developing peers, but the pace is delayed. These children may recover with or without treatment to "catch up" with their peers; however, depending on the severity, speech/language therapy is usually advisable. Temporal asymmetry has been previously described in patients with language disorders.[27,28] Their findings correlate with our group of patients. A bigger sample of patients with language related disorders should be studied.

All children are oppositional from time to time, particularly when tired, hungry, stressed or upset. They may argue, talk back, disobey, and defy parents, teachers, and other adults. Oppositional behavior is often a normal part of development for two to three year olds and early adolescents. However, openly uncooperative and hostile behavior becomes a serious concern when it is so frequent and consistent that it stands out when compared with other children of the same age and developmental level and when it affects the child's social, family, and academic life.

In children with oppositional defiant disorder (odd), there is an ongoing pattern of uncooperative, defiant, and hostile behavior toward authority figures that seriously interferes with the youngster's day to day functioning. Symptoms of ODD may include:

- Frequent temper tantrums.
- Excessive arguing with adults.
- Active defiance and refusal to comply with adult requests and rules.
- Deliberate attempts to annoy or upset people.
- Blaming others for his or her mistakes or misbehavior.
- Often being touchy or easily annoyed by others.

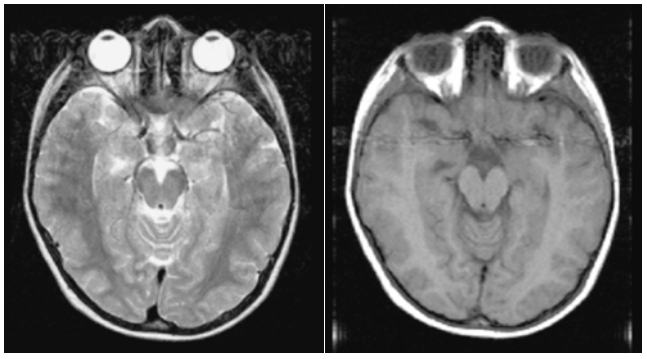

Figure 3. Eleven year old patients with history of ADHD and ODD. T1 and T2 weighted images. Right hippocampal atrophy.

- Frequent anger and resentment.
- Mean and hateful talking when upset.
- Seeking revenge.

The symptoms are usually seen in multiple settings, but may be more noticeable at home or at school. Five to fifteen percent of all school-age children have odd. The causes of odd are unknown, but many parents report that their child with odd was more rigid and demanding than the child's siblings from an early age. Biological and environmental factors, gray matter reduction in the anterior insular cortex and left amygdala has been described in these patients.[29,30] Our cases showed hippocampal atrophy. Although none presented odd as a single diagnosis, all associated either with ADHD o LRD *(Figure 3)*.

Behavioral and developmental disorders have a wide range of anatomical and physiological alterations some o which we can visualize in neuroimaging studies. The knowledge of neurophysiological pathways and their manifestations on magnetic resonance exams can help us comprehend these illnesses and diagnose alterations on imaging examinations.

Referencias

1. Chan E, Zhan C, Homer CJ. Health care use and costs for children with attention-deficit/hyperactivity disorder: national estimates from the Medical Expenditure Panel Survey. Arch Pediatr Adolesc Med 2002; 156: 504-11.
2. Blancard LT, Gurka MJ, Blackman JR. Emotional, Developmental and Behavioral Health of American Children and their Families: A Report from the 2003 National Survey of Children's Health. Pediatrics 2006; 117: el1202-el1212.
3. Damasio AR, Maurer RG. A neurological model for childhood autism. Arch Neurol 1978; 35: 777-86.
4. Palmen SJ, Van Engeland H, Hof PR, Schmitz C. Neuropathological findings in autism. Brain 2004; 127: 2572-583.
5. Munson J, Dawson G, Abbott R, et al. Amygdalar volume and behavioral development in autism. Arch Gen Psychiatry 2006; 63: 686-93.
6. Courhesne E, Yeung-Courchesene R, Press GA, Hesselink JR, Jernigan TL. Hypoplasia of cerebellar vermal lobules VI and VII in autism. N Engl J Med 1988; 160: 387-93.
7. Haznedar MM, Buchsbaum MS, Wei TC, Hof PR, Cartwright C, Bienstock CA, Hollander E. Limbic circuitry in patients with autism spectrum disorders studied with positron emission tomography and magnetic resonance imaging. Am J Psychiatry 2000; 157: 1994-2001.
8. Schumann CM, Hamstra J, Goodlin-Jones Bl, Lotspeich LJ, Kwon H, Buonocore MH, et al. The amygdala is enlarged in children but not adolescents with autism: the hippocampus in enlarged at all ages. J Neurosci 2004; 24: 6392-401.
9. Abell F, Krams M, Ashburner J, Passingham R, Friston K, Frackowiak R, et al. The neuroanatomy of autism: a voxel-based whole brain analysis of structural scans. Neuroreport 1999; 10: 1647-51.
10. Sparks BF, Friedman SD, Shaw DW, Aylward EH, Echelard D, Artru AA, et al. Brain structural abnormalities in young children with autism spectrum disorder. Neurology 2002; 59: 184-92.
11. Kates WR, Mostofky SH, Zimmerman AW, Mazzocco MMM, Landa R, Warsofsky IS, et al. Neuroanatomical and neurocognitive differences in a pair of monozygous twins discordant of strictly defined autism. Ann Neurol 1998; 43: 782-91.
12. Aylward EH, Minshew NJU, Goldstein F, Honeycutt NA, Augustine AM, Yates KO, et al. MRI volumes of amygdala and hippocampus in non-mentally retarded autistic adolescents and adults. Neurology 1999; 53: 2145-50.
13. Pierce K, Muller RA, Ambrose J, Allen G, Courchesne E. Face processing occurs outside de fusiform "face area" in autism: evidence from functional MRI. Brain 2001; 124: 2059-73.
14. McAlonan GM, Cheung V, Cheung C, Suckling J, Lam GY, Tai KS, Yip L, et al. Mapping the brain in autism. A voxel-based MRI study of volumetric differences and intercorrelation in autism. Brain 2005; 128: 268-76.
15. Hollander E, Anagnostou E, Chaplin W, Esposito K, Haznedar MM, Licalzi E, et al. Striatal volume on Magnetic Resonance Imaging and repetitive behaviors in autism. Biol Psychiatry 2005; 58: 226-32.
16. Rapaport JL, Castellanos FX, Gogate N, Janson K, Kohler S, Nelson P. Imaging normal and abnormal brain development: new perspectives for child psychiatry. Aust N Z J Psychiatry 2001; 35: 272-81.
17. Castellanos FX, Guiedd JN, Berquin PC, Walter JM, Sharp W, Tran TM, et al. Quantitative brain magnetic resonance imaging in girls with attention-deficit/hyperactivity disorder. Arch Gen Psychiatry 2001; 58: 289-95.
18. Plessen KJ, Bansal R, Zhu H, Whitman R, Amat J, Quackenbush GA, et al. Hippocampus and amygdala morphology in attention-deficit/hyperactivity disorder. Arch Gen Psychiatry 2006; 26: 795-807.
19. Schoenbaum G, Setlow B, Ramus SJ. A systems approach to orbitofrontal cortex function: recordings in rat orbitofrontal cortex reveal interactions with different learning systems. Behav Brain Res 2003; 146: 19-29.
20. Behcara A, Damasio H, Damasio AR. Emotion, decision making and the orbitofrontal cortex. Cereb Cortex 2000; 10: 295-307.
21. Pliszka SR, Glahn DC, Semrud-Clikeman M, Fanklin C, Perez R III, Xiong J, Liotti M. Neuroimaging of inhibitory control areas in children with attention deficit hyperactivity disorder who were treatment naïve or in long-term treatment. Am J Psychiatry 2006; 163: 1052-60.
22. Parent A. Basal ganglia. In: Cryell P (ed.). Carpenter's human neuroanatomy. 9th Ed. Baltimore: Williams & Williams; 1996, p. 795-863.
23. Teicher MH, Anderson CM, Glod CA, Maas LC, Renshaw PF. Functional deficits in basal ganglia of children with attention-deficit/hyperactivity disorder show with functional magnetic resonance imaging relaxometry. Nature Medicine 2000; 6: 470-4.
24. Castellanos FX, Giedd JN, Hamburger SD, Vaituzis AC, Dickstein OP, Serfatti SE. Quantitative brain magnetic resonance imaging in attention-deficit/hyperactivity disorder. Arch of Gen Psychiatry 1996; 53: 607-16.
25. Binder JR, Frost JA, Hammeke TA, Cox RW, Rao SM, Prieto T. Human brain language areas identified by functional magnetic resonance imaging. J Neurosci 1997; 17: 353-62.
26. Price CJ. The anatomy of language: contributions from functional neuroimaging. J Anat 2000; 197: 335-59.
27. Glasser MF, Rilling JK. DTI Tractography of the human brain's language pathways. Cereb Cortex 2008; 18(11): 2471-82.
28. Geschwind N, Lewitsky W. Human brain: left-right asymmetries in temporal speech region. Science 1968; 53: 974-81.
29. Leonard CM, Voeller KS, Lombardino LJ, Morris MK, Alexander AW, Andersen HG. Anomalous cerebral structure in dyslexia revealed with magnetic resonance imaging. Arch Neurol 1993; 50: 461-9.
30. Spetzer P, Stadler C, Pustka F, Kleinschmidt A. A structural neural deficit in adolescents with conduct disorder and its association with lack of empathy. Neuroimage 2007; 37: 335-42.