Review Article

Neurodevelopmental Disorders Comorbid with Deafness in Children: A Review

Manole Felicia[1], Florica Voiţă-Mekereş[2*], Ioan Bogdan Voiță[3], Gabriel Mihai Mekeres[4]

[1]Department of Surgical, Faculty of Medicine and Pharmacy, University of Oradea, 410087 Oradea, Romania. [2]Department of Morphological Discipline, Faculty of Medicine and Pharmacy, University of Oradea, 410087 Oradea, Romania. [3]Regional Institute of Gastroenterology and Hepatology "Prof. Octavian Fodor", Cluj-Napoca, Romania. [4]Faculty of Medicine and Pharmacy, University of Oradea, 410087 Oradea, Romania.

Abstract

Deaf children are not a homogenous group and differ in terms of type, severity, and causes of damage and coexisting disorders. In 20 to 30% of deaf children, there is at least one co-occurring disorder that may make it difficult for these children to achieve the language, social, emotional, and communication skills expected from rehabilitation services. Therefore, the current study seeks to answer the question, how much has been addressed in past research on the etiology, evaluation, and rehabilitation of neurodevelopmental disorders associated with deafness? In the present study, an attempt was made to provide coherent information regarding the prevalence rate, methods, and barriers of evaluation by reviewing the research conducted in the field of deafness and co-occurring disorders, including attention-deficit/hyperactivity disorder, autism spectrum, learning disability, and mental disability separately and provide rehabilitation and training. By studying the research conducted in this field, it was found that attention-deficit/hyperactivity disorder, autism spectrum disorder, learning disability, and mental retardation play a greater role in co-occurring disorders with deafness compared to other neurodevelopmental disorders.

Keywords: Neurodevelopmental disorders, Deafness, Children, Skills

Introduction

Deaf children are not a homogenous group, and they differ from each other in terms of severity and, causes of damage and coexisting disorders. In 20-40% of deaf children, there is at least one co-occurring disorder that may make it difficult for these children to achieve the language, social-emotional, and communication skills expected from rehabilitation services [1, 2]. Research shows the frequency of coexistence of deafness with neurodevelopmental disorders [3-5], among which the prevalence of attention-deficit/hyperactivity disorder (ADHD), Autism spectrum disorder (ASD), learning disability (LD), and intellectual disability (ID) are reported higher. For example, in the study conducted by Chilosi *et al.* [4] on 100 sensorineural deaf children, 48 of them had neurodevelopmental disorders, and the share of mental and motor disabilities was higher compared to other disorders. Comorbidity disorders may be observed alone or as a set of disorders that vary in severity and clinical manifestations and affect the behavioral-cognitive, social, and emotional skills of deaf children [6, 7]. In other words, in deaf people with concurrent disorders, clinical symptoms are more varied.

Early interventions play an effective role in the development of language, communication, social, and emotional skills of deaf children, and deaf children with concomitant disorders are no exception to this rule. What is important is to pay attention to some differences in the education and rehabilitation of these children, highlighting the importance of paying attention to early diagnosis. In recent years, studies and investigations have increased in the identification of co-occurring disorders with deafness. However, there is still a gap in research on the rate, prevalence, and evaluation of educational and rehabilitation services. On the other hand, even though in the last decade, the number of deaf people with peripheral problems who receive cochlear implants has increased [8, 9], in terms of the development of expressive and receptive language skills after the operation of Cochlear implantation and necessary considerations in the rehabilitation of these children are scattered information available. In the present study, an attempt has been made to provide consistent information regarding the prevalence rate, methods, and the obstacles to assessment rehabilitation and

Address for correspondence: Florica Voiţă-Mekereş, Department of Morphological Discipline, Faculty of Medicine and Pharmacy, University of Oradea, 410087 Oradea, Romania. mekeres_florina@yahoo.com

How to cite this article: Felicia M, Voiță-Mekereș F, Voiță IB, Mekeres GM. Neurodevelopmental Disorders Comorbid with Deafness in Children: A Review. Arch Pharm Pract. 2023;14(1):104-8. https://doi.org/10.51847/lx8I4GJZDl

training should be presented to take an effective step towards effective and early interventions in this field. Therefore, the present study aims to review neurodevelopmental disorders associated with deafness in children.

Results and Discussion

Comorbid Deafness with Autism Spectrum Disorder

Several studies indicate a higher prevalence of autism spectrum disorder in deaf children [10-13]. According to Szymanski *et al*.'s report [14], the prevalence of autism spectrum disorder in deaf children with an average age of 8 years is 1 in 59 children, which is higher than the normal population (1 in 91 children) [15]. Early diagnosis is important in the coexistence of these two disorders because, due to the lack of appropriate diagnostic tools and the overlapping of many symptoms, it is often challenging to determine which results from social and communication problems. Furthermore, One of these two disorders is hidden in the shadow of the other and may not be accurately diagnosed. For example, sometimes fake gestures used in deaf children with autism spectrum disorder prevent the correct recognition of hand gestures as a result of this neurodevelopmental disorder [16, 17].

Another noteworthy point is the success or failure of deaf children with autism spectrum disorder in cochlear implantation. Autism spectrum disorder in deaf children does not negate the necessity of cochlear implantation, but it should be noted that language problems and communication skills in children with autism spectrum disorder have a neurological origin. Therefore, parents' realistic expectations of cochlear implantation and rehabilitation in these children are important. Zaidman-Zait *et al*. [18] research on 23 families with deaf children with co-occurring disorders indicated the unique challenges of these parents in the field of attitude and expectations and providing services.

In the past decades, cochlear implantation in deaf children with autism spectrum disorder was challenging among experts, but today, in numerous studies, the usefulness of cochlear implantation in deaf children with autism spectrum disorder has been confirmed [10, 19, 20]. What highlights the importance of this area is the expectations of parents and experts from cochlear implant surgery. Language and communication problems of children with autism spectrum disorder have a neurological origin. Therefore, it cannot be expected that after cochlear implantation, the development of language skills of these children will be similar to that of purely deaf children. For example, in Mikic *et al*.'s [21] research, auditory perception skills and verbal intelligibility were investigated after cochlear implantation for five years in 14 deaf children, four of whom had been diagnosed with an autism spectrum disorder. The result indicated a significant difference in the field of auditory perception and verbal clarity between two groups of deaf children and deaf children with autism spectrum disorder. The difference in rehabilitation and communication approaches in deaf children with autism spectrum disorder highlights the importance of unique education and rehabilitation for each child.

Deafness with Attention Deficit/Hyperactivity Disorder

Attention deficit/hyperactivity disorder can be considered one of the most common neurodevelopmental disorders of childhood, adolescence, and even adulthood, which has attracted the attention of many researchers and therapists in recent years [22]. The prevalence of attention deficit hyperactivity disorder has been reported to be higher in deaf children compared to hearing people [23]. The research conducted in the field of deaf children with attention-deficit/hyperactivity disorder is limited. In most of the research, the behavioral problems of deaf children have been investigated in the form of investigating the status of the executive functions of this group, and the prevalence of behavioral problems in this group has been reported to be higher [24, 25]. For example, in the study of Hintermair [26] on 214 students studying in normal and deaf schools, executive function was examined with a brief test, and higher executive function problems were reported in the deaf group compared to their peers. Also, in the research of Barker *et al*. [27] on 116 young deaf people, the relationship between language skills, attention, motor control ability, and social-emotional skills was investigated, and the direct effect of language performance on non-verbal problems. Behavior and the indirect effect of language on attention and motor skills were confirmed. In the study of Pisoni *et al*. [28], it was found that cognitive processes such as executive functions affect the language and speech development of cochlear-implanted deaf children with a different pattern than hearing children; language abilities also affect executive function. In this research, which was conducted on 64 deaf children with cochlear implants and 74 hearing peers, it was found that there is a correlation between verbal and mental working memory, speed, and language skills in deaf children, while in hearing children this correlation is The areas of spatial working memory and inhibition are observed. It seems that different parts of the executive function play a role in the language and speech development of deaf children compared to hearing peers.

In the study of Cockcroft and Dhana-Dullabh [29], the score of the norm children was higher in all components of working memory compared to the other two groups. In this study, the profile of working memory in children with attention-deficit/hyperactivity disorder and deafness was similar, which seems that similar patterns are needed in the educational placement and educational planning of the two mentioned groups. In some research, it has been determined that visual-spatial skills in deaf people depend on the preferred communication approach of these people, and deaf children who benefit from the natural sign language approach in communicating have a higher visual-spatial ability

compared to deaf children whose dominant communication approach is verbal [30]. Deaf children use both approaches simultaneously when facing difficult tasks. It has been emphasized, but today, it is clear that the skill of hearing people in visual-spatial abilities and executive function is higher compared to deaf people with cochlear implants or users of sign language. The difference between the performance of hearing and deaf people in visual-spatial tasks is greater since it is related to the hearing condition; it relies on cognitive abilities and different paths of cognitive processing [31].

Deafness with Learning Disability

Learning disability is related to problems in basic cognitive processes, including understanding and using the oral and written form of language, listening, thinking, speaking, reading, writing, spelling, and mathematics [32]. The prevalence rate of learning disability in deaf children is reported to be 7-8%, of which the share of reading disorders is higher and about 10% [33]. Other manifestations of disability, including writing disorder and math disorder, have a lower prevalence in deaf children. Reading skill includes the coordination between the visual and written form and requires skills such as phonological awareness, familiarity with the letters of the alphabet, vocabulary, and motivation [34]. Despite the advancement of technology in cochlear implantation and the existence of advanced hearing aids, deaf children's reading skills are weaker compared to their hearing peers. It seems that reading comprehension in deaf students and students with learning disabilities is more related to perceptual skills than to phonological awareness [35]. Despite the studies conducted in the field of learning disabilities and deafness, the diagnosis and assessment of learning disabilities in young deaf students.

Strengthening reading skills in deaf children requires the design of a regular and individual continuous intervention program. Despite the effectiveness of the bottom-up approach in the reading skills of hearing students, deaf students do not benefit much from this approach. On the other hand, the top-down approach is not effective due to deaf students' lack of familiarity with the context and the limited range of words. The best approach to teaching deaf students to read is the interactive approach. In this approach, attention to the text and the context of the application of language skills is emphasized [36]. It seems that in the interactive approach, in the development of working memory and phonological awareness, the bottom-up approach, and in learning vocabulary and the basic knowledge of reading and writing, the top-down approach is effective [35]. Also, the best way to teach children with learning disabilities is direct and regular teaching so that all steps are explained by the teacher in clear steps. Also, the active participation of parents in reading books with the child, the use of attractive books appropriate to the age, the use of time management images, and the creation of objective and appropriate incentives to increase enthusiasm and motivation. The child plays a significant role in learning. Parents' active participation in learning language skills and academic skills is the best predictor of academic achievement in deaf students with learning disabilities [37].

Few studies have been done in the area of math disorders in deaf students. Research by Bull *et al*. [38] indicates that deaf students have less skill in counting and math skills compared to their hearing peers. It seems that more investigations are necessary for the field of basic math skills evaluations, such as symbolic behaviors and problem-solving strategies in deaf students.

Deafness with Mental Retardation

The prevalence of deafness in children with cognitive disabilities has been reported to be 6-8%, which is higher in people with Down syndrome. About 53-88% of children with Down syndrome have degrees of transitional hearing loss [39]. In the last decade, the number of children with developmental disabilities who benefit from cochlear implants has increased. Potential cognitive problems, the effectiveness of this Children from cochlear implantation reduces hearing. On the other hand, comparing the non-verbal and verbal IQ of deaf children with cognitive problems is effective in deciding on cochlear implantation, so if the verbal IQ is Compared with non-verbal IQ, it is significantly weaker, and cochlear implantation seems suitable [29]. What is important in the intervention of these children is the level of awareness of parents in using hearing aids, whether hearing aids or implants. Cochlear hearing is also the active participation of parents in the rehabilitation of these children [40].

Regarding the educational methods of deaf people with intellectual disabilities, few types of research have been done [41], and it seems necessary to examine the appropriate method of school concepts, especially reading and writing skills. The result of the study by Weis *et al*. indicates that if teachers actively participate in the design and implementation of the program according to the student, and if necessary, they can change the educational method and content according to the cognitive capacity of the students, the level of learning concepts especially reading and writing skills increase. Also, the use of aids such as the FM system in the classroom is effective in improving speech comprehension and production skills, vocabulary, and communication skills of deaf children with intellectual disabilities.

Conclusion

In the present study, an attempt was made to provide coherent information regarding the prevalence, methods, and barriers by examining the research conducted in the field of deafness and co-occurring disorders, including attention-deficit/hyperactivity disorder, autism spectrum, learning disability, and mental disability, separately. Evaluation rehabilitation and training should be provided. By studying the research conducted in this field, it was found that attention-deficit/hyperactivity disorder, autism spectrum disorder, learning disability, and mental retardation play a

greater role in co-occurring disorders with deafness compared to other neurodevelopmental disorders. Since comorbid disorders are often not easily diagnosed, the age of diagnosis and rehabilitation in these children is increased compared to children who are simply deaf. But what is certain is that the prevalence of neurodevelopmental disorders in deaf children is higher compared to the normal population. Various statistics are mentioned in numerous types of research, the reasons for which can be explained by the lack of appropriate and standard tools in the investigation of neurodevelopmental disorders in deaf children. Some characteristics of children with autism spectrum disorder, such as weakness in communicating stereotyped behaviors, may be mistaken for the result of deafness; therefore, knowing the criteria of both disorders is effective in differential diagnosis or identifying these two coexisting disorders. The development of language and speech in deaf children with autism spectrum disorder after receiving hearing aids or cochlear implant prostheses takes place with less progress compared to hearing children, hence managing the level of real expectations of parents and designing individual rehabilitation programs for this group of children is necessary to achieve the desired result. This finding has been confirmed in the research of Beers *et al*. [42]. The research conducted on deaf children with attention deficit hyperactivity disorder is limited. In the majority of research, the behavioral problems of deaf children have been investigated in the form of investigating the status of executive functions of this group, and it seems that different parts of executive function play a role in the development of language and speech of deaf children compared to hearing peers.

On the other hand, weakness in executive functions will lead to academic problems, including weakness in reading, writing, and math skills. Therefore, it is necessary to change the educational strategies and adapt the methods and study materials according to the strengths and weaknesses of these students, which is emphasized in the research of Marschark *et al*. [31]. Deaf people are not a homogenous group in terms of age of damage, degree, and type of hearing loss, type of hearing aid, communication approach, language skills, cognitive abilities and academic experience, and accurate diagnosis and assessment of learning disability in deaf students is new. Accurate and comprehensive evaluations that include developmental history, educational status, and educational system are necessary to diagnose learning disabilities in deaf children [43]. Diagnostic evaluations to investigate cognitive problems in deaf children should examine cognitive and adaptive skills, and the use of tools based on language skills in deaf people is not suitable for differential diagnosis of language problems and basic cognitive skills. On the other hand, deciding on cochlear implantation in deaf children with developmental delays requires detailed and comprehensive investigations; in children with profound deafness, cochlear implantation is an effective solution, but in children with severe deafness with developmental delay, more detailed investigations and evaluations are necessary. Comparison of non-verbal and verbal IQ is effective in deciding on cochlear implantation. In this way, if the verbal IQ is significantly weaker compared to the non-verbal IQ, cochlear implantation seems appropriate, which has been confirmed in the study of Wiley *et al*. [44]. Because coexisting disorders affect the effectiveness of intervention programs, such as hearing aids, cochlear implants, and rehabilitation, the need to pay attention to specialized evaluations and the knowledge of specialists in identifying coexisting disorders as soon as possible deafness is essential. Also, paying attention to comprehensive rehabilitation programs to develop these children's language and communication skills according to their capacity and potential requires the teamwork of experts in the field of speech and hearing language and psychological and cognitive skills.

ACKNOWLEDGMENTS: None
CONFLICT OF INTEREST: None
FINANCIAL SUPPORT: None
ETHICS STATEMENT: None

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