Impact of Meningitis on Cognitive Skills and Development in Children

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Abstract

The present systematic review aims to investigate the impact of meningitis on the cognitive skills and development of children. In this systematic review, relevant studies were identified via searches through medical information databases of MEDLINE, PubMed, ISI, EMBASE, Cochrane with the keywords of Meningitis, Meningitis and Complications, Meningitis and Children, Meningitis and Intelligence Quotient (IQ), Meningitis and Development, and their derivatives. In this study, amongst 198 articles reviewed, 11 articles met the inclusion criteria. All studies, except one case, reported a decrease in growth and IQ in children who experienced meningitis. Based on the results of the present study, children who have experienced meningitis at a younger age are more prone to disability, growth retardation, and lower IQ than other children throughout the later years of their life.

Keywords: *Meningitis, intelligence quotient (IQ), development, Children, Systematic Review*

Introduction

Meningitis is the inflammation of the meninges or protective membranes that surround the brain and spinal cord [1, 2]. The disease is usually caused by a bacterial or viral infection or, rarely, a fungal infection [1, 3]. In the bacterial type, the three main pathogens are Streptococcus pneumoniae, Haemophilus influenzae and Neisseria meningitidis [4] and in the viral type, enteroviruses, human parechoviruses and Chikungunya viruses are the causative agents of the disease [5]. Mortality rate in viral meningitis is very low and most patients recover, but in bacterial meningitis, depending on the type of bacterium, it could kill 10% to 25% if left without appropriate treatment. Also, depending on the patient's age, underlying disease, and surgery on the nervous system, different bacteria cause different symptoms in the patient. Bacterial meningitis is contagious and is caused by a specific bacterial infection that could be fatal if left untreated the number of leukocytes, cognitive impairment and infection with Streptococcus pneumonia were collected as prognostic factors in adults with bacterial meningitis. Meningitis, if left untreated, can lead to serious complications and even death. Therefore, early and accurate diagnosis is one of the research priorities of this disease. There are many methods available, such as examining the patient's clinical symptoms, performing MRI and CT scans, biochemical blood tests, and examining the cerebrospinal fluid [6]. Meningitis is a serious and dangerous disease that usually occurs quickly and unexpectedly. Although the disease affects different ages, the highest risk is for infants and young children [1]. In children, the peak age of meningitis is 6 to 12 months, and 90% of cases occur in children under 5 years [7]. The mortality rate of this disease is 2% in children and 20 to 30% in infants [8, 9]. Symptoms of meningitis include fever, headache, refusal to eat or vomit, skin blemishes, drowsiness, photosensitivity, and neck spasms [10, 11]. Pediatric imaging is one of the most indication of procedural sedation and analgesia. In the

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pediatric patient, performing CT scan is stressful and leads to increased mental stress, absence of cooperation with the staff, restlessness, and anxiety in the patient [12]. However, any child with suspected meningitis and seizures should have an LP. All suspected children with meningitis must be closely monitored, whether LP or experimental treatment [6]. Many pharmacologic and non-pharmacologic strategies to manage pain exist for pediatric pain treatment. Pharmacological and integrative non-pharmacological therapies has been indicated in acute and chronic pain treatment [13]. The results showed that both pharmacological and non-pharmacological treatment methods in relieving and reducing pain and anxiety in a wide range of pediatric diseases (such as respiratory tract infections, burns, surgery, dental restorations) are effective [14]. Although the clinical symptoms of most children who survive meningitis subside within a few weeks, some can lead to severe disorders such as cranial nerve dysfunction, hemiplegia, ataxia, hydrocephalus, physical disability, mental retardation, seizures, and visual and hearing impairments [15, 16]. Overall intelligence, measured by IQ, is one of the most powerful predictors of a person's future life, material well-being, and mental health. Even small deficiencies in intelligence affected by meningitis could impair a person's chances of survival and academic achievement [17]. Christie et al., In a systematic review of the effect of meningitis on children's IQ and growth, reported that survival from bacterial meningitis had an adverse effect on children's IQ and growth, while viral meningitis had no significant cognitive effects [17]. The present systematic review also tries to investigate the effect of meningitis on IQ and development of children.

Materials and Methods

In this systematic review, relevant studies were identified via searches through medical information databases of MEDLINE, PubMed, ISI, EMBASE, Cochrane with the keywords of Meningitis, Meningitis and Complications, Meningitis and Children, Meningitis and Intelligence Quotient (IQ), Meningitis and Development, and their derivatives. The references in all articles found during the search process were evaluated, in order to include other possible sources in the study. Then, by studying the abstracts, the studies that were completely unrelated to the objective of this research were removed and the studies that were completely relevant or possibly related were recorded; also, by examining the full text of the articles, the articles that were completely relevant to the purpose of this research were selected. In the last stage, among the selected articles and based on the criteria of critical evaluation, the articles that had the inclusion criteria of the study were selected. It should be noted that all stages of evaluating the quality of articles were performed by two independent researchers.

Inclusion criteria: Laboratory meningitis proven to be caused by any infection (bacterial, viral or fungal), studies in which the results and consequences or complications of meningitis other than death or acute complications were evaluated, Time scale: Results or follow-ups reported 1 month after meningitis, Type of studies used: Prospective, retrospective, and case-control studies or cross-sectional studies on the consequences of meningitis, which were written in English, were used. Also, the articles in which the IQ or growth age or stage of development of the infant were evaluated using valid tools, were included in the present study; In this regard, Intelligence was considered as the average of full-scale IQ, Performance IQ (PIQ) or Verbal IQ (VIQ) as standard scores (mean = 100, SD = 15) or Ratios with low IQ (less than 70, i.e. 2 standard deviations (SD) below average), and Infant development was also considered as the desired result in growth performance in movements, language, or cognitive domains compared to standard data and DD measurements. Exclusion criteria: Studies in which acute complications were evaluated only 1 month after the onset of disease, were excluded. Articles published before 1955; Articles published in languages other than English; Articles about meningitis in people with the suppressed or weakened immune system. Screening and Data Extraction: Two trained authors performed search strategies. In the first stage, the titles and abstracts were reviewed for the selection of articles; in the next stage, the two authors independently reviewed the full text of the articles. Differences in findings were resolved through the criterion method of general conclusion of articles and were organized in this study.

Findings

In this study, 198 articles were reviewed. After removing 41 duplicates, 157 titles and abstracts were reviewed for content validity. After excluding 84 articles

due to content mismatch and differences in variables, 73 articles were registered (Figure 1).

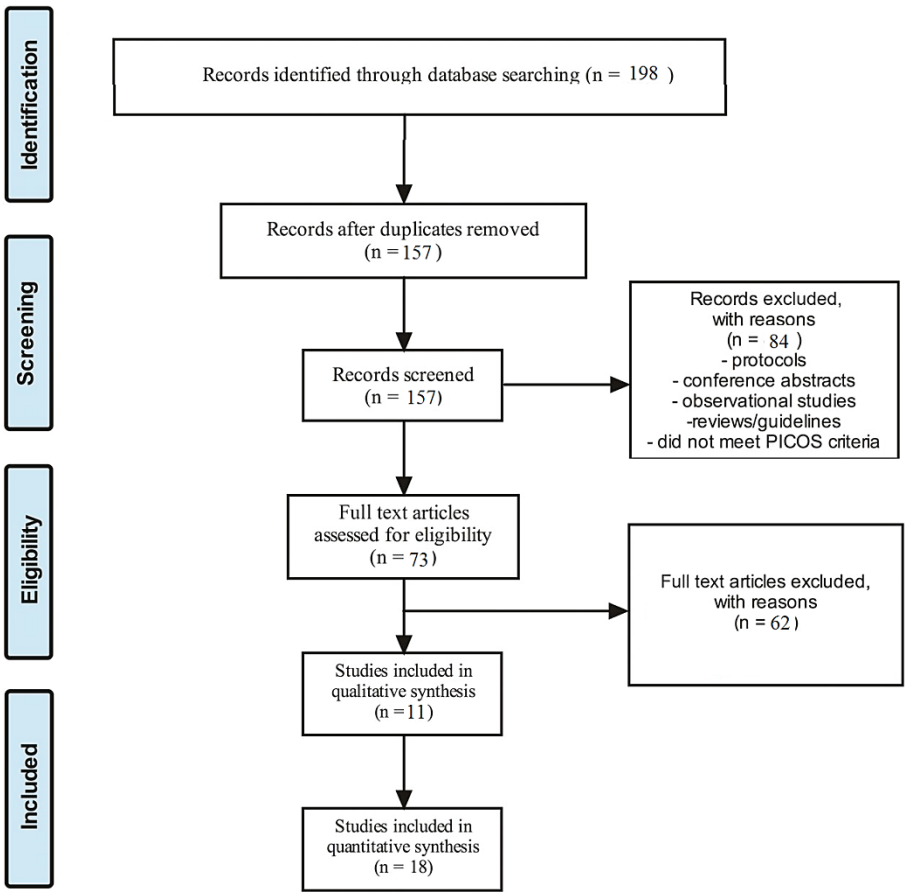

Figure 1: Diagram of the process of review and selection of articles

Finally, 11 articles that met the inclusion criteria were selected, of which 4 articles were prospective cohort, 1 article was prospective, 1 article was a cohort study, 2 articles were retrospective cohort study, and in 3 articles the type of experiment was not specified.

All studies, except one case, reported a decrease in growth and IQ in children who experienced meningitis. Also, hearing loss or impairment in 36%, visual problems and blindness in 18% of cases, reduced ability to read and write in 18%, speech and language problems in 18%, neurological complications in 36%, seizures in 27%, Hydrocephalus in 9%, decreased mobility in 18%, cranial nerve palsy in 27%, and disability in 36% of these articles was reported.

Discussion

Meningitis affects different aspects of children's development. Taylor et al. have reported that these children have poorer reading skills and need special supportive training; They also stated that the outcome of the disease is affected by the age and sex of the child and the socio-economic status of the family [18]. In general, children with meningitis are at higher risk for disability, and these disabilities could include mild to moderate hearing loss and neurological or central auditory impairment, which adversely affects a child's learning, academic performance, and behavior [19]. Compared to control groups, these children showed significantly poorer results in the evaluations of intelligence and high-level neuropsychological skills and had more behavioral differences at home and at school. In addition, the risk of complications is higher in people who have experienced acute neurological complications during their illness [4]. Grimwood et al. Reported that some low-level skills, such as attention, processing speed, and instant memory capacity, improve in 7- and 12-year assessments. However, high-level

cognitive skills such as organizational skills, problem-solving, verbal fluency, and mental flexibility are still impaired in 12-year assessment. This may reflect a delay in the process of developing executive functions [4] . According to Anderson et al., even 12 years after the illness, children with a history of meningitis experience neurobehavioral consequences [15]. Although the risk of side effects is higher for children with acute neurological complications in bacterial meningitis, people with uncomplicated disease are also at risk, and they also have fewer functions than control children in a number of tasks and show a greater degree of disability. The data also show that the apparently normal survivors of meningitis are at a lower level of skill than their peers for a number of their intellectual, educational, and cognitive tasks [19].

Children with meningitis had a significant decrease compared to control children in terms of verbal intelligence, functional intelligence, and full-scale IQ. These children could not perform better than control children in tests of educational ability, visual skills, memory, learning, and executive skills. These differences between the children with meningitis and control children were approximately one-third of SD for each score. Although the mean IQ scores were close to the test standard, the results indicated a slight overall defect in meningitis survivors compared with control children [19]. Infants with viral meningitis under 1 year, 1 to 6 years after the infection have smaller head circumference, lower IQ, and delayed language skills compared to control children [20]. In a study by Christie et al., the results showed that survival from bacterial meningitis had a detrimental effect on IQ and growth, but there was no evidence that reports the efficacy of viral meningitis on IQ. The decrease in IQ in survivors of bacterial meningitis was approximately 5 degrees compared to the healthy control group and was equivalent to a 0.33% decrease in SD in IQ. Survivors of bacterial meningitis are five times more likely to develop mental disorders (IQ <70) than controls [17].

Briand et al. argued that a standard follow-up protocol could help create better rehabilitation protocols for children and parents. Neurological and neurophysiological follow-ups on a larger scale could be useful for the initial follow-up of children with learning disabilities. These follow-up tips may also be helpful for parents since they could help them understand the consequences of long-term complications [27].

Conclusion

According to the results of the present study, children who have experienced meningitis at a younger age are more prone to disability, growth retardation, and lower IQ in later life than other children. Even the children who are apparently healthy survivors of the disease have shown developmental delays and problems in cognitive functions compared to healthy people. Families, school teachers, and health professionals play an important role in identifying or assisting people with learning and behavioral problems. Because the children without identifiable risk factors may have significant functional disabilities after meningitis, families and school teachers should be aware of possible language deficiencies and problems in understanding language-based content.

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