The Association between Meningitis and Myopia in the Pediatric Population: A Systematic Review

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Abstract. Meningitis in the pediatric population is highly associated with complications due to its non-specific nature and early use of antibiotics. A common complication noted to occur in the setting of meningitis is visual impairment. However, a lesser exposed aspect is the connection of meningitis with myopia. The objective of this systematic review is to analyze the potential association between meningitis with myopia and any underlying factors contributing to it. The literature was gathered from PubMed for this article review using conventional keywords and medical subject heading (Mesh) subheadings. Regular keywords were: Bacterial Meningitis and myopia. Mesh subheadings used were: meningitis, bacterial/complications, meningitis, bacterial/epidemiology, and myopia/etiology. Following the application of inclusion/exclusion criteria, a total of 6,483 publications were obtained. A lack of relevancy to the outcomes of interest led to the removal of 6,382 of these publications. Following this, a refined manual search was done with the remaining 101 articles. Finally, 22 publications were selected for review after the removal of duplicates. Myopia was linked to meningitis in a variety of these studies. On further review, the studies revealed that myopia occurred in the presence of meningitis sequelae such as vasculitis, vasospasm, and elevated intracranial pressure.

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Keywords: Meningitis, Myopia, Visual Complications.

1. Introduction and Background:

Meningitis is due to an infection of the meninges, which are the membranes surrounding the brain and spinal cord (Albuquerque, Moreno, dos Santos, Ragazzi & Martinez, 2019). A variety of organisms can cause it, including bacteria, viruses, and fungus. In regards to bacteria, there have been numerous types known to cause meningitis in children, with the cause depending on the child's age (Albuquerque, Moreno, dos Santos, Ragazzi & Martinez, 2019; Oliveira et al., 2014; Hoffman & Weber, 2009). Nevertheless, meningitis remains a leading source of illness and mortality among children and is linked to a variety of short and long-term complications.

Meningitis is associated with a variety of complications, one of which is vision impairment. Visual defects can range from refractive errors to cortical blindness (Takeuchi et al., 2018; Mankhambo et al., 2006). The mechanism by which this occurs is by the invasion of the bacteria through the vasculature and neuronal damage.

Table 1. Most common organism(s) causing meningitis in the pediatric population based on age group:

Age Group	Most common organisms	Reference
<2 months	Group B Streptococcus, E. coli	(Albuquerque, Moreno, dos Santos, Ragazzi & Martinez, 2019; Oliveira et al., 2014)
2-6 months	Streptococcus pneumonia	(Oliveira et al., 2014)
>6 months	Streptococcus pneumonia	(Oliveira et al., 2014)
1 yr. – 18 yr.	Neisseria meningitidis, Streptococcus pneumonia, Hemophilus Influenza,	(Albuquerque, Moreno, dos Santos, Ragazzi & Martinez, 2019; Hoffman & Weber, 2009)

Bacterial invasion of the vasculature can result in inflammation and vasospasm. This can eventually progress to cerebral infarction (Oliveira et al., 2014).

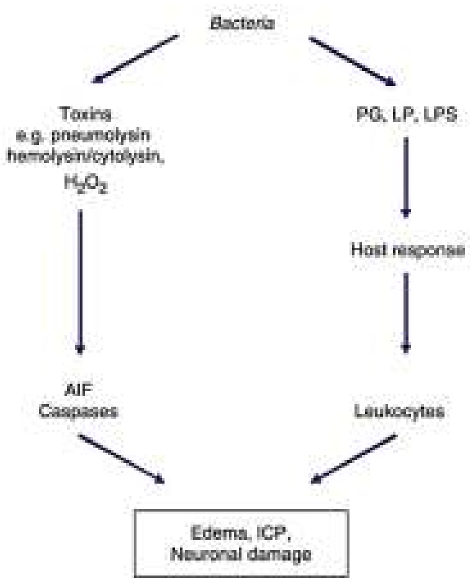

Figure 1. The Pathogenesis of Meningitis

Neuronal damage due to bacteria can be multifactorial. (A) Bacteria, through the release of toxins (pneumolysin, H202), can lead to damage and death of neurons via damage of its internal mitochondria. (B) Bacteria can also cause damage by the activation of the inflammatory response causing a release in a wide release of mediators, like prostaglandins, lipoproteins, and lipopolysaccharides (Hoffman & Weber, 2009)

Myopia affects 1.45 billion individuals worldwide, or 27% of the world's population, and is constantly rising in prevalence and severity (Holden et al., 2016). Diet, inadequate sun exposure, and increased near-work activities are all significant causes (Holden et al., 2016). In cases of severe myopia, there is an increased risk of complications such as retinal detachment, early macular degeneration, early cataracts, and glaucoma (Holden et al., 2016).

Meningitis and myopia do not have a causal relationship yet despite several studies reporting myopia in the setting of meningitis (Takeuchi et al., 2018; Parajuli, Adhikari & Shrestha, 2020; Bosch, Boonstra, Willemsen, Cremers & de Vries, 2014; Pehere, Chougule & Dutton, 2018). By conducting this systematic review, we can acquire a better understanding of the typical pathophysiological mechanisms at work and determine if they play a role in the hypothesized link.

Uncovering this association can provide significant benefits. We can increase awareness among doctors and the patient's family. The child's relatives can be more observant, assisting in the early detection of visual issues. Regarding doctors, they can begin early screening for refractive problems in children who have a past medical history of meningitis. It can also improve the child's quality of life in terms of school and social life. By not undergoing this research, people will still be unaware of the potential association between meningitis and myopia. As a result, this can significantly impact the scholastic side of a child's life and other elements such as social and psychological development.

Although many studies have been done regarding visual impairment associated with meningitis, very few have explored the association between meningitis and myopia. Therefore, by doing this study, our objective was to analyze the association between meningitis and myopia and any underlying factors contributing to it.

2. Review

2.1 Protocol

According to Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Group Guidelines, a systematic literature review was performed using PubMed.

2.2 Eligibility Criteria

Only original human studies in English within the past 20 years were considered in the search. These papers also contained abstracts, free full text, and full text, which were available for viewing. The type of journal incorporated was Medline. We included all records with the following article type: case reports, classical article, clinical conference, clinical study, clinical trial, clinical trial protocol, controlled clinical trial, journal article, meta-analysis, newspaper article, observational study, randomized controlled trial, review, and systematic review. Papers relevant to the association of meningitis with myopia in the pediatric population were incorporated using the 'related articles' feature from PubMed. Papers containing non-human species in languages other than English and were more than 20 years old were not included in our review.

2.3 Data Source and Strategy

The data for this article review was gathered from PubMed using both standard keywords and medical subject heading (MeSH) subheadings. Medical Subject Heading Terms and Keywords include: Meningitis, Myopia, Meningitis, bacterial/complications; meningitis, bacterial/epidemiology, myopia/etiology.

2.4 Study Selection and Design

Screening for the relevant articles was done independently by three authors (D.K., S.B., and J.C) by reading the titles first, followed by the abstract. This was followed by reading full - text articles. Only articles that were pertinent to the systematic review were included. These included articles relevant to meningitis, myopia, or visual impairment and the potential association between the two. Articles containing significant information regarding the pathophysiological process involved were also included in the paper.

2.5. Risk Bias Assessment

Once the final articles were selected, a quality assessment of the final articles was performed using the Newcastle Ottawa scale.

3. Results

3.1 Search Outcome

Table 1. Total records acquired after applying inclusion/exclusion criteria:

	Regular keyword - Bacterial Meningitis
Total records	155,675
Inclusion/exclusion:	
Published within 20 years	81,986
Language - English	75,315
Text Availability[1]	30,852
Article type[2]	20,242
MEDLINE	22,425
Humans	19,344
Male, Female	13,135
Age	4,478
	Regular Keyword - Myopia
Total records	33247
Inclusion/exclusion:	
Published within 20 years	22683
Language - English	20,723
Text Availability[1]	7570
Article type[2]	7,422
MEDLINE	4,911
Humans	4,388
Male, Female	3269
Age	1413
	MeSH keyword: Meningitis, bacterial/complications
Total records	3,955
Inclusion/exclusion	
Published within 10 years	795
Language - English	694
Text Availability[1]	294
Article type[2]	290
MEDLINE	290
Humans	282
Male, Female	248
Age	101
	MeSH keyword: Meningitis, bacterial/epidemiology
Total records	4815
Inclusion/exclusion	
Published within 10 years	1349
Language - English	1266
Text Availability[1]	660
Article type[2]	646
MEDLINE	646
Humans	633
Male, Female	415

Age	302
	MeSH keyword: Myopia/etiology
Total records	5853
Inclusion/exclusion	
Published within 10 years	1789
Language - English	1648
Text Availability[1]	662
Article Type[2]	648
MEDLINE	648
Humans	574
Male, Female	466
Age	189

[1]Text availability: abstract, free full texts, full text.
[2]Article types included: Case reports, classical article, clinical conference, clinical study, clinical trial protocol, controlled clinical trial, journal article, multicenter study, newspaper article, observational study.

After the input of the regular keywords, MeSH keywords, and inclusion/exclusion criteria in PubMed, 6,483 records were obtained. A lack of relevancy to the outcomes of interest led to the removal of 6,382 of these publications. Following this, a refined manual search was performed using the remaining 101 articles. Finally, 22 articles were chosen for evaluation since they were relevant to the research. All the articles reviewed are available for reference. Table-2 shows the process of collection of records for the current literature review. The steps of the article screening process are depicted in the PRISMA flow diagram. Following the selection of the final 22 articles, important aspects pertaining to the articles were presented in Table-3.

4. Discussion

4.1 Severe Meningitis and its Evaluation

Studies showed that myopia was observed in the context of severe disease along with complications of meningitis (Takeuchi et al., 2018; Parajuli, Adhikari & Shrestha, 2020; Bosch, Boonstra, Willemsen, Cremers & de Vries, 2014; Pehere, Chougule & Dutton, 2018).

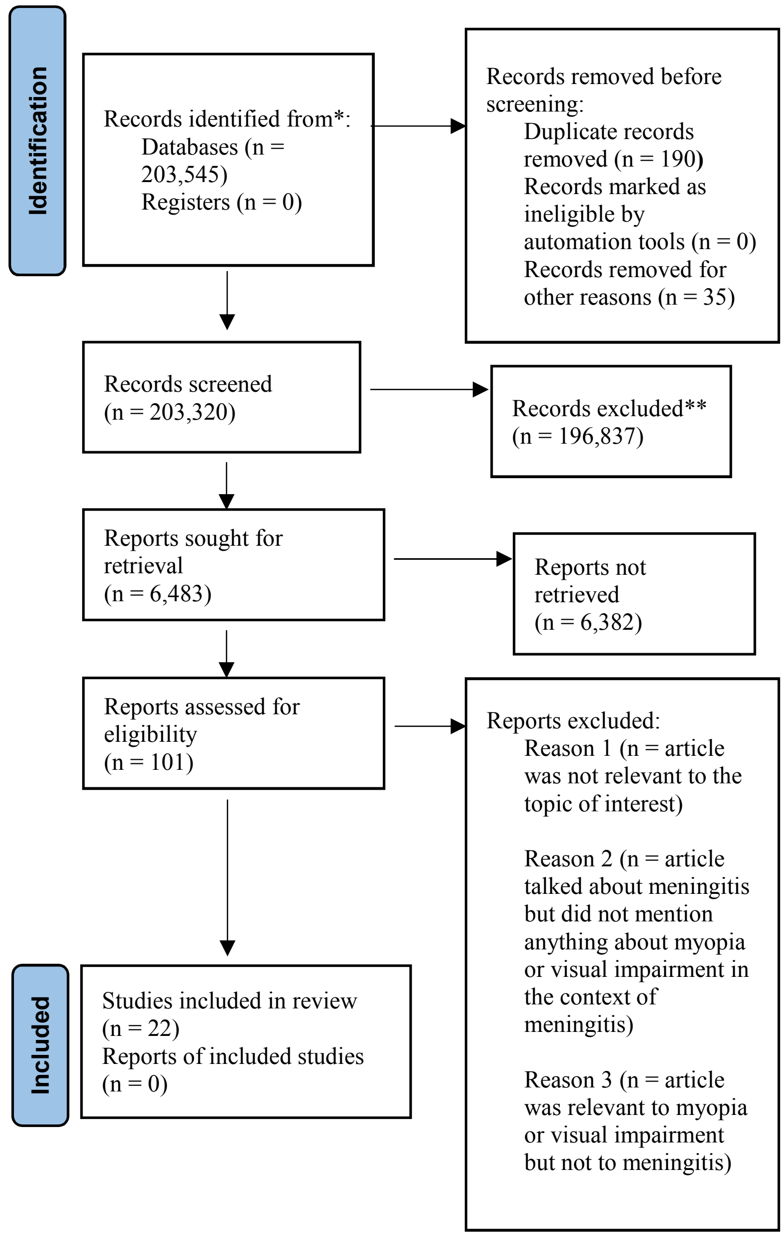

Figure 2. Prisma Flow Diagram 2020

Bacterial meningitis, inflammation of the meninges, has a high morbidity and mortality rate despite the use of antibiotics and vaccinations. In the current period, mortality is over 5-10%, with survivors facing a 5-40% risk of developing neurological complications (Ye et al., 2016).

These complications are more common in children with meningitis, owing to the lack of distinct signs and symptoms and the early administration of treatment (Ye et al., 2016; Srinivasan, Kilpatrick, Shah, Abbasi & Harris, 2018).

Table 3. Table of Study Characteristics

Author, Year	Study design	Location	Sample Size	Age Range	Conclusion
Albuquerque, Moreno, dos Santos, Ragazzi & Martinez, 2019	Nonrandomized clinical trial	Brazil	447	N/A	Multiplex-PCR is a quick and accurate method for analyzing CSF samples. It can also be used to diagnose meningitis with negative CSF culture and differentiate between bacterial and viral meningitis.
Oliveira et al., 2014	Retrospective study	Dallas, Texas	440	<12 months	Brain MRIs were abnormal in infants with meningitis. This abnormal imaging influenced the clinical management of infants.
Hoffman & Weber, 2009	Narrative review	N/A	N/A	N/A	Studies have shown that toxins and inflammatory responses are involved in the pathophysiology of meningitis. Therefore, immediate treatment with antibiotics are required for improvement and should be tailored according to the causative organism.
Takeuchi et al., 2018	Cohort study	Japan	1,319	18-27 years old	Myopia is associated with a greater Total Intracranial Volume and CSF Volume. Psychomotor intelligence is associated with a greater Gray Matter and White Matter volume but not refractive error.
Markham et al., 2006	Case report	Malawi	1	3 years	Cerebral infarction is a rare complication of meningococcal meningitis, leading to the development of eventual vision loss.
Holden et al., 2016	Systematic review and meta-analysis	Multiple countries	2.1 million people	Birth – 100 years	Myopia has become more prevalent recently, according to studies. Severe myopia is known to associate with complications like vision loss.
Parabular, Adhikari & Shrestha, 2020	Retrospective Analysis	Nepal	40	4 months – 8 years old	Birth asphyxia and postnatal infections can lead to cortical visual impairment.
Bosch, Bootstrap, Willemsen, Cremer's & de Vries, 2014	Cohort study	Netherlands	309	4 months – 45 years	Genetic disorders are associated with cerebral visual impairment.
Peered, Choogle & Dutton, 2018	retrospective study	Andhra Pradesh, India	124	Mean age: 5 years	Many things can cause cerebral visual impairment. The most common cause is hypoxic-ischemic encephalopathy.

Table 3. Table of Study Characteristics

Author, Year	Study design	Location	Sample Size	Age Range	Conclusion
Ye et al., 2016	Prospective Observational Study	China	140	1 month - 10 years	The combination of CSF IL-6 and CSF/blood IL-6 ratio is more efficient in diagnosing meningitis than CSF IL-6 alone.
Srinivasan, Kilpatrick, Shah, Abbasi & Harris, 2018	Prospective cohort	Philadelphia, Pennsylvania	189	<6 months	An increase in the IL-18, IL-23, and sRAGE levels are helpful in diagnosing bacterial meningitis and can also be helpful in making decisions regarding antibiotic usage.
Taskin, Turgut, Kilis, About & Ayun, 2004	Prospective analysis	Turkey	44	4 – 160 months	Serum procalcitonin and cytokine levels are useful in the diagnosis of meningitis, along with differentiating bacterial from viral meningitis.
Pinto Junior et al., 2011	Case-control Study	Brazil	60	5 months - 46 years	IL-6 and IL-8 are both elevated in bacterial meningitis. IL-8 has been more elevated in acute bacterial than aseptic meningitis, aiding in its differentiation.
Suzuki, Ishiguro & Shembo, 2003	Case-control study	Tokyo	58	2 - 6 years	IL-16 has shown elevation in levels in meningitis's initial stages, indicating its involvement in the early inflammatory response.
Peered, Narasimha & Dutton, 2019	retrospective study	Andhra Pradesh, India	428	3 years and younger	Cerebral visual impairment is a significant cause of impaired vision in the region, and developmental delay associates with many of the cases.
(Lowery, Lambert & Atkinson, 2006	case study	Atlanta, Georgia	7	2 – 10 years	Cerebral visual impairment can be hard to diagnose in those with mild visual impairment. Neuroimaging needs to be done to confirm the condition and differentiate it from similar appearing causes.
Nicolette, N 2014	Retrospective study	South Africa	40	6 weeks - 12 years	Tuberculous meningitis is associated with complications, like neurological sequelae, in those with a higher stage of the disease.
Rohlwink et al., 2016	Prospective cohort study	South Africa	44	3 months - 13 years	Radiological imaging can help diagnose tuberculous meningitis. MRI shows a more detailed image in comparison to a CT scan.

Table 3. Table of Study Characteristics

Author, Year	Study design	Location	Sample Size	Age Range	Conclusion
Verhoeven et al., 2013	meta-analysis	Multiple countries	37,382	N/A	A large-scale multi-country meta-analysis was performed, following which 24 new loci were discovered associating with refractive error development.
Zadnik et al., 2015	observational cohort study	United States	4512	6 - 13 years	A single measure of refractive error in children is a good predictor of the possibility of myopia developing in those children.
Jinn et al., 2019	longitudinal study	Shanghai, China	118 children	7- 12 years	Choroidal thinning and retinal thinning are both associated with the progression of myopia. Choroidal thinning has been observed to occur before retinal thinning.
Saw et al., 2005	Cohort	Singapore	543	7-9 years	Rapid progression of myopia relates to an increase in axial length. An increase in the severity of myopia is also associated with a change in the vitreous chamber depth.

Table 4. Newcastle Ottawa Scale

	Selection				Comparison	Outcome			
Included Studies	Representative-ness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of the exposure	Incident disease (did they have the disease at the start of study)	Matching/ adjusting of confounders	Assessment of outcome	Length of follow-up	Adequacy of follow-up	Total number of stars
Albuquerque, Moreno, dos Santos, Ragazzi & Martinez, 2019	*	*	*	*		*			5
Oliveira et al., 2014	*	*	*	*		*			5
Hoffman & Weber, 2009	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Takeuchi et al., 2018	*		*		**	*			5

Table 4. Newcastle Ottawa Scale

	Selection				Comparison	Outcome			
Included Studies	Representative-ness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of the exposure	Incident disease (did they have the disease at the start of study)	Matching/ adjusting of confounders	Assessment of outcome	Length of follow-up	Adequacy of follow-up	Total number of stars
Markham et al., 2006	*		*	*		*		*	5
Holden et al., 2016	*	*	*	*	**	*			7
Parabular, Adhikari & Shrestha, 2020	*		*	*		*		*	5
Bosch, Bootstrap, Willemsen, Cremer's & de Vries, 2014	*	*	*	*	**	*			7
Peered, Choogle & Dutton, 2018	*		*	*		*			4
Ye et al., 2016	*	*	*	*		*			5
Srinivasan, Kilpatrick, Shah, Abbasi & Harris, 2018	*	*		*	**	*		*	7
Taskin, Turgut, Kilis, About & Ayun, 2004	*	*	*	*		*			5
Pinto Junior et al., 2011	*	*	*	*		*			5
Suzuki, Ishiguro & Shimbo, 2003	*	*	*	*	**	*			7

Table 4. Newcastle Ottawa Scale

	Selection				Comparison	Outcome			
Included Studies	Representative-ness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of the exposure	Incident disease (did they have the disease at the start of study)	Matching/ adjusting of confounders	Assessment of outcome	Length of follow-up	Adequacy of follow-up	Total number of stars
Pehere, Narasaiah & Dutton, 2019									
Lowery, Lambert & Atkinson, 2006	*		*	*		*			4
(Nicolette, Wilmshurst, Multiway & James, 2014	*		*	*		*			4
Rohlwink et al., 2016	*	*	*	*		*		*	6
Verhoeven et al., 2013	*		*	*		*			4
Zadnik et al., 2015	*	*	*			*			4
Jin et al., 2019	*	*	*			*		*	5
Saw et al., 2005	*	*	*			*		*	5

Hence, early detection is vital for the identification and prevention of such complications. Due to the early initiation of antibiotics, CSF cultures showed a low yield when performed (Ye et al., 2016; Srinivasan, Kilpatrick, Shah, Abbasi & Harris, 2018).

4.2 Cytokines and its Significance in the Evaluation of Meningitis

Cytokines are hormone-like proteins that elicit an inflammatory response when attaching to their specialized receptors (Taskın, Turgut, Kılıc, Akbulut & Aygun, 2004). Studies have revealed numerous types involved in the establishment of meningitis. Hence, assessing cytokines can be helpful in understanding more about the diagnosis and pathophysiology of meningitis. Interleukin-6 (IL-6) promotes the development of differentiated B lymphocytes into antibody- generating cells (Pinto Junior et al., 2011). Whereas interleukin-eight (IL-8) attracts neutrophils to the site of inflammation by acting as a chemoattractant (Pinto Junior et al., 2011). The concentrations of IL-6 were significantly increased in both aseptic and acute bacterial meningitis, indicating that this molecule works as a mediator of meningeal inflammation but is non-specific (Ye et al., 2016). However, the study of IL-6 combined with CSF/blood IL-6 ratio increases diagnostic accuracy (Ye et al., 2016). This is in contrast to IL-8. Patients with bacterial meningitis had significantly higher levels of this chemokine in their CSF than patients with aseptic meningitis, indicating its specificity (Pinto Junior et al., 2011). IL-10, an anti-inflammatory cytokine, also shows significant elevation in levels during bacterial meningitis (Ye et al., 2016). IL-16, a pro-inflammatory cytokine, was highly diagnostic during the beginning stages of meningitis (SUZUKI, ISHIGURO & SHIMBO, 2003). Cytokine levels peaked during the first five days of sickness and, after that, decreased in correlation with an improvement of meningeal signs or symptoms (SUZUKI, ISHIGURO & SHIMBO, 2003). Although multiple studies show a synchronous increase in specific cytokines during meningitis, there are still discrepancies regarding the cut-off values and sensitivity/specificity (Ye et al., 2016; Pinto Junior et al., 2011). This difference occurs because of variations in the study population, instrumentation, approach, and reagent (Ye et al., 2016; Pinto Junior et al., 2011).

4.3 Pathophysiology of Visual Impairment

Visual impairment is a common complication associated with meningitis. The mechanism by which this occurs is by extension of inflammation and neuronal injury (Oliveira et al., 2014; Mankhambo et al., 2006). Meningitis is defined as the inflammation of the meninges. This infection and inflammation can extend to the brain's arteries, causing vasculitis and vasospasm, and finally cerebral infarction (Oliveira et al., 2014). Neuronal damage has also been shown to be a cause of visual impairment (Mankhambo et al., 2006). Multiple processes are at work throughout the pathophysiology of bacterial meningitis-induced neuronal damage:1) increased intracranial pressure caused by cytotoxic edema and increased vascular permeability with secondary ischemia, 2) efflux of leukocytes into the subarachnoid space, 3) cerebral ischemia caused by decreased cerebral perfusion pressure or vasculitis, 4) reactive oxygen intermediates, caspases, and proteases which contribute to direct toxic action on neurons (Oliveira et al., 2014).

4.4 Cerebral Visual Impairment

Among the various etiologies that can lead to visual impairment in children with meningitis, cerebral visual impairment is a common cause. Cerebral visual impairment is defined as visual dysfunction caused by injury to the retrochiasmatic pathways in the absence of severe ocular disease (Bosch, Boonstra, Willemsen, Cremers & de Vries, 2014). This degeneration in the pathway can lead to optic atrophy, accounting for the refractive errors found in the children affected. Studies show that it is a common cause of impaired vision in children in developed nations (Bosch, Boonstra, Willemsen, Cremers & de Vries, 2014; Pehere, Narasaiah & Dutton, 2019). Cerebral visual impairment can arise from genetic or acquired causes. Acquired causes range from perinatal acquired infections to postnatal insults such as ischemic brain injury or infections like meningitis [Bosch, Boonstra, Willemsen, Cremers & de Vries, 2014;Pehere, Chougule & Dutton, 2018). Neuroimaging helps in confirming the exact cause. CT and MRI are known to be the best modalities for detection, with CT being a better diagnostic tool in those with severe presentations and MRI as a confirmatory tool when imaging findings are non-specific (Lowery, Lambert & Atkinson, 2006).

4.5. Pathophysiology of Visual Complications in Tuberculous Meningitis

Tuberculous meningitis is associated with a high prevalence of visual complications. It primarily affects young children, ranging in age from 23 to 49 months and is known to have a severe presentation in this age group (Nicolette, Wilmshurst, Muloiwa & James, 2014). This is due to a delay in diagnosis because of falsely normal imaging in the early stages and inadequate resources (Nicolette, Wilmshurst, Muloiwa & James, 2014). Vasculitis and blockage of basal vessels are common complications of tuberculous meningitis, putting the brain at risk of ischemia and infarction (Rohlwink et al., 2016). This can lead to further visual impairment (Rohlwink et al., 2016). Additionally, it is associated with the formation of exudates in the setting of inflammation (Rohlwink et al., 2016). As the exudate builds, it can obstruct the normal flow of CSF, leading to the development of hydrocephalus (Rohlwink et al., 2016). The increase in intraocular pressure in hydrocephalus is associated with a low spherical equivalent, characteristic of myopia (Takeuchi et al., 2018).

4.6. Myopia

Myopia is characterized by the blurriness of vision observed with viewing things at a distance. It is associated with genetic as well as environmental causes. Regarding the genetic component, there have been around 24 loci that associates with refractive error development (Verhoeven et al., 2013). Factors associated with near work (reading, studying, computer use) contribute to most of the environmental causes of myopia (Zadnik et al., 2015). The progression of myopia is also associated with characteristic anatomic changes, which contribute to its pathogenesis (Jin et al., 2019; Saw et al., 2005). Studies show that myopia is positively associated with an increase in axial length (Saw et al., 2005). This increase in axial length is greater in children whose parents have myopia (Saw et al., 2005). The axial length is known to increase in a developing eye until it becomes emmetropic (Jin et al., 2019). However, in those with myopia, the axial length continues to increase past the emmetropic point (Jin et al., 2019). This accounts for the increase in axial length in myopics. Vitreous chamber depth is also known to be analogous to the severity of myopia. This is on account of physiological changes that occur in the eye. Changes in the choroidal and retinal thickness can also be observed analogous to myopic progression (Jin et al., 2019). Severe myopia also relates to a decrease in choroid thickness. The thinning of the choroid is reported to start in the periphery, accounting for its sensitivity in predicting myopia (Jin et al., 2019). This is in contrast to retinal thickness, which presented with unequal changes in thickness of the retina (Jin et al., 2019). The central foveal layer was shown to decrease in the thickness, whereas other parts of the retina reported no change or an increase in thickness (Jin et al., 2019). Inconsistent results were seen during the measurement of the values. These can be due to factors like diverse range of the refractive error, hereditary factors like myopic parents, young age group which can pose difficulties during the measurement of the values and instrumentation.

4.7. Low Spherical Equivalent Correlates with Increase in Intracranial Volume

Assessing spherical equivalent can be helpful in analyzing myopia. Spherical equivalent is the required quantitative power of a spectacle lens needed to focus images on the eye's retina (Takeuchi et al., 2018). Myopia is known to be associated with a lower spherical equivalent (Takeuchi et al., 2018). Studies have shown that an increase in total intracranial volume correlates with a lower spherical equivalent (Takeuchi et al., 2018). This increase in the intracranial volume results from an increase in the cerebrospinal fluid (Takeuchi et al., 2018). A parallel study has shown that the intraocular volume of a myopic eye is greater than usual and is associated with an increase in aqueous and vitreous volume, further supporting the hypothesis that there is an association of spherical equivalent with intracranial volume and CSF volume (Takeuchi et al., 2018). There have also been other hypotheses suggesting that there is a correlation between myopia and brain anatomy. Given that the common origin of the cranium and scleral coat of the eye is from the mesenchyme surrounding the neural tissue, studies suggest that myopia may be associated with greater brain size (Takeuchi et al., 2018).

5. Limitations

Whereas the above studies show a correlation between meningitis and its sequelae and visual impairment, which can further lead to myopia, there are limitations. The sample sizes in the study were significantly less and not representative of the general population. The methodology also varied between each study, influencing the results. With respect to the instrumentation, they can act as a source of bias. We also have to note that genetic and environmental factors influence the study results, acting as a potential source of bias. Given the young age group, lack of cooperation can pose difficulties in acquiring accurate measurements. Overall, only a few studies have been conducted regarding assessing the association between these two variables. Hence, more studies would need to be done in the future with a larger sample size to establish a causative relationship between myopia and meningitis.

6. Conclusion

In conclusion, myopia has been observed in the setting of meningitis. Studies show that it manifests itself in the context of severe presentations of meningitis and sequelae. The pathophysiological mechanism by which this occurs is spread of the inflammation to the vessels causing vascular anomalies such as vasospasm and vasculitis as well as neuronal damage. This can result in infarction which eventually progresses to refractive error in the form of myopia. Cerebral visual impairment also plays a significant role in the development of myopia in the context of meningitis. It presents itself as visual abnormalities due to damage of the retrochiasmatic pathway in the setting of normal ophthalmology findings. Although our systematic review has demonstrated myopia in the context of meningitis and its associated pathophysiology, more studies with a larger sample size will need to be conducted in the future to establish a causal relationship between these two factors.

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8. Statement of interest:

The authors of this article state that they have no conflicting interests on the subject matter of this paper.

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