Hearing loss after bacterial meningitis, a retrospective study

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Key points

- Meningitis is a life-threatening infection which may develop as a complication to acute otitis media
- The most common sequela after meningitis is hearing loss, but risk factors for hearing loss have not been studied to any great extent.
- When all cases of meningitis (n=187) occurring in a Swedish county during 18 years (2000-2017) were investigated, 71 cases of hearing loss were identified, however 68 of the patients had not done a hearing test after recovery.
- Hearing loss was significantly more common in adults, occurring in 45% in patients aged 21-65 years and in 48% in patients over the age of 65 when assuming that those who had not done a hearing test had normal hearing. This corresponded to ORs of 8.0 and 9.8 compared to children.
- Concurrent acute otitis media and pneumococcal infection increased the odds of hearing loss by 2.1 and 3.6, respectively.

Introduction

Meningitis is a life-threatening infection which sometimes occurs as a complication to acute otitis media (AOM). It is not entirely known what percentage of bacterial meningitis is of otogenic origin. A Dutch study found that the most common agents causing community-acquired meningitis was *Streptococcus pneumoniae* (53%), and *Neisseria meningitidis* (37%), and that concurrent AOM was a risk factor for negative outcome, indicating the importance of prompt ear examination (1). A French study of children with bacterial meningitis also identified *S. pneumoniae* (39%) and *N. meningitidis* (39%) as the most important pathogens(2).

The most common sequela after bacterial meningitis is hearing loss(3). This is particularly common after pneumococcal meningitis, where as many as 30% of patients suffer from hearing loss(3). Some studies have found lower incidences (7-12%) of post-meningitis hearing loss in children compared to adults(4, 5), whereas others have reported similar incidences(6). Animal research has shown a correlation between pneumococcal concentration in the middle ear and the development of hearing loss(7), indicating that early diagnosis of concurrent AOM and subsequent myringotomy could be beneficial. Swedish meningitis guidelines include a recommendation to perform otoscopy in all patients with meningitis, and to follow up patients with audiometry.

The aim of this study was to investigate the incidence of hearing loss in patients treated for bacterial meningitis in the Swedish county of Skåne (1.4 million inhabitants), between 2000 and 2017 and to investigate risk factors for hearing loss.

Materials and methods

In this retrospective, observational study, medical records from all patients admitted to hospitals in Skåne county with the ICD-code G00 (bacterial meningitis) between 2000 and 2017 were retrieved. Exclusion criteria were neonatal, viral, fungal or non-infectious meningitis, borrelia, nosocomial, postoperative, or ventricular shunt-related infections.

Information about gender, age, otoscopy results, CT/MRI signs of middle ear infection, microbiological results, subjective hearing loss and hearing tests were extracted from medical charts. Where pure tone audiograms were available, pure tone averages (PTA4; defined as the average of hearing thresholds at 500, 1000, 2000 and 4000 Hz) were extracted, as was presence of conductive hearing loss (defined as an air-bone gap of [?]10 dB on at least two adjacent frequencies). Hearing loss was defined as PTA4 [?] 25 on either ear, and further subdivided into mild (25-40 dB HL), moderate (41-70 dB HL) and severe (>70 dB HL). High frequency hearing was evaluated by calculating the average hearing thresholds at 6000 and 8000 Hz.

By including data over 18 years in one of the most populous counties in Sweden, we hoped to be able to estimate the incidence of bacterial meningitis in Sweden over a long period of time. The proportion of otogenic meningitis cases, time trends, microbiology and outcomes other than hearing loss will be reported separately.

The study was approved by the Ethics Review Authority. The STROBE guideline was used for the preparation of the manuscript.

Statistical analyses

Data was analysed using Stata 16.1 (College Station, Tx, USA). The association between sensorineural hearing loss and possible risk factors were investigated using uni- and multivariate logistic regression. Variables showing a substantial association with the outcome in the univariate analysis were kept in the multivariate analysis. To evaluate the effect of age, patients were divided into four age groups; children (0-11 years), teenagers (12-21 years), adults of working age (22-65 years), and elderly (over 65 years).

In a substantial number of patients (n=68), hearing tests were not performed. In order not to overestimate the prevalence of hearing loss by only including patients with hearing tests, data for all patients were used, making the conservative assumption that patients lacking hearing tests had normal hearing.

Results

Initially, 556 patients were identified. After applying exclusion criteria, 187 patients remained (Figure 1), 106 of whom were men. The age distribution is shown in Table 1. Hearing tests were available in 119 cases, 107 of which were pure tone audiometries. Hearing loss was diagnosed in 81 patients, in 13 cases unilaterally, and was more common in adults and elderly (Table 1). Three patients had bilateral severe hearing loss, and an additional 13 had unilateral severe hearing loss. Of the 105 patients where data for 6 and 8 kHz were available, hearing thresholds >40 dB on these frequencies occurred frequently in adult patients, however, never in children or teenagers (Table1). The most commonly identified bacteria were *S. pneumoniae* (58%) and*N. meningitidis* (12%) (Table 2).

In the univariate analysis, there was no evidence of a correlation between gender and hearing loss, however, there was strong evidence of adult and elderly patients having greatly increased odds of hearing loss (OR=7.3, p=0.01 and OR=8.4, p=0.007).

There was also evidence that patients with pneumococcal infection had increased odds of hearing loss (OR=4.1, p<0.001). On the other hand, patients with meningococcal infections had decreased odds of hearing loss (OR=0.2, p=0.009). There was also evidence for an association between hearing loss and concurrent AOM (OR=3.3, p<0.001).

Age, concurrent AOM and presence of *S. pneumoniae* /*N. meningitidis* was kept in the multivariate analysis (Table 3). There was still strong evidence that age was a risk factor for hearing loss. Patients with concurrent

AOM had twice the odds of hearing loss, and for those with pneumococcal infection, the odds increased 3.6-fold. In the multivariate analysis, no association was seen between meningococcal infection and hearing loss.

Discussion

In this retrospective study, which comprised data from an entire Swedish county during 18 years, post-meningitis hearing loss was associated with age, pneumococcal infection and concurrent AOM. Despite recommendations in the national guidelines, more

than a third of patients had not done a hearing test after recovery.

The main outcome in this study was post-meningitis hearing loss. Even when we assumed that patients lacking audiometry had normal hearing, as many as 43% had hearing loss. This is a higher prevalence than the 30% wich has been described previously(3). This might, in part, be explained by different definitions of hearing loss, and by some patients in the present study having had previously undiagnosed hearing loss. The conservative assumption that patients lacking audiometries had normal hearing should at least not lead to an over-estimation of the prevalence of hearing loss, and it seems reasonable to suppose that patients who complained about hearing loss in the recovery period should have been tested.

An obvious finding in this study was the increased risk for adults and elderly of developing hearing loss. Age >70 years has previously been associated with an "unfavourable outcome"(8), Since most patients in this study had not tested their hearing prior to their meningitis, the finding might, at least partly, be explained by the fact that the prevalence of hearing loss increases with age. Some patients might therefore have had previously undiagnosed presbyacusis. This risk should partly be alleviated by our assumption that all patients in whom hearing tests were missing had normal hearing. Missing audiometries were not less common among the older age group (data not shown).

The correlation between AOM and hearing loss seems to have been partly confounded by pneumococcal infection, since it decreased in the multivariate analysis, however, the odds of hearing loss was still twice as high among patients with AOM in the multivariate analysis. A Dutch study also found that the odds of hearing loss increased by 2.6 in patients with concurrent AOM (9).

S. pneumoniae – a common otopathogen - increased the odds of hearing loss almost four-fold after controlling for other risk factors. That patients with pneumococcal meningitis are more likely to develop long-term hearing loss has been noticed in a previous meta-analysis as well as in a retrospective review on children(3, 10). The negative association between meningococcal infection and hearing loss in the univariate analysis was not present in the multivariate analysis, indicating the former results were confounded by age, meningococcal infections being almost exclusively found among children and teenagers (data not shown).

This study has several limitations, one of which is the retrospective design, meaning that many patients did not undergo hearing tests. In addition, most patients had not done hearing tests before their meningitis, so there was no way of knowing for certain that the hearing loss was caused by the meningitis. The design also means that microbiological PCR tests and serotyping were not performed.

A strength of the study is that it encompasses a whole county of Sweden during a period of 18 years, implying that the results should be generalisable.

Better knowledge of risk factors for post-meningitis hearing loss can hopefully result in better compliance with existing guidelines, leading to more patients undergoing otoscopy when admitted to hospital with bacterial meningitis, and more patients being followed up audiologically after recovery. As discussed above, early diagnosis of concurrent AOM, and subsequent myringotomy might decrease the risk of developing hearing loss.

Conclusion

This study showed that the incidence of hearing loss after bacterial meningitis was strongly associated with age, but also with concurrent acute otitis media and *S. pneumoniae* infection. In an on-going prospective study on the same population, we hope to be able to confirm the findings more robustly.

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Tables and figures

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`image1.emf` available at https://authorea.com/users/737566/articles/712443-hearing-loss-after-bacterial-meningitis-a-retrospective-study

Bacterium	Patients (%)
S. pneumoniae	108 (58)
N. meningitidis	23 (12)
S. pyogenes	6 (3)
S. aureus	7 (4)

Bacterium	**Patients (%)**
Listeria monocytogenes	5 (3)
H. influenzae type B	8 (4)
Group B streptococci	3 (2)
Other	8 (4)
No growth	19 (10)

Table 2. Bacteriological findings

	Odds Ratio	95%CI	p
0-11 years	ref	-	-
12-21 years	0.7	0.05-9.9	0.8
22-65 years	8.0	1.7-38.4	0.009
65+ years	9.8	2.0-47.9	0.005
AOM	2.1	1.04-4.4	0.040
S. pneumoniae	3.6	1.7-7.8	0.001
N. meningitidis	1.8	0.4-8.9	0.5

Table 3. Correlation between risk factors and the development of sensorineural hearing loss after bacterial meningitis, multivariate logistic regression with adjustments for agegroup, AOM and pneumococcal/meningococcal infection.

Figure 1. Patient flow chart

Age (years)	**No of patients (%)**	**No of patients with hearing loss (% of age group total)**	No of patients with mild hearing loss, right ear		No of patients with moderate hearing loss, right ear		No of patients with severe hearing loss, right ear		No of patients with mild hearing loss, left ear		No of patients with moderate hearing loss, left ear		No of patients with severe hearing loss, left ear	
			PTA4[1]	HF average[2]	PTA4[1]	HF average[2]	PTA4[1]	HF average[2]	PTA4[1]	HF average[2]	PTA4[1]	HF average[2]	PTA4[1]	HF average[2]
0-11	20 (11)	2 (10)	0	0	0	0	0	0	0	0	0	0	1	0
12-21	19 (10)	1 (5)	0	0	0	0	0	0	0	0	0	0	0	0
22-65	89 (48)	47 (53)	15	12	12	20	4	12	14	17	11	13	5	17
>65	58 (31)	31 (53)	11	3	12	10	4	18	8	3	14	12	5	17
Total	**187**	**81 (43)**	**26**	**15**	**24**	**30**	**8**	**30**	**22**	**20**	**25**	**25**	**11**	**34**

Table 1. Age distribution and occurrence of hearing loss in the respective age groups [1.] PTA4=Pure tone average on 500, 1000, 2000 and 4000 Hz. [2.] HF average=High frequency average=average hearing thresholds on 6000 and 8000 Hz

Bacterium	Patients (%)
S. pneumoniae	108 (58)
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S. pneumoniae	3.6	1.7-7.8	0.001
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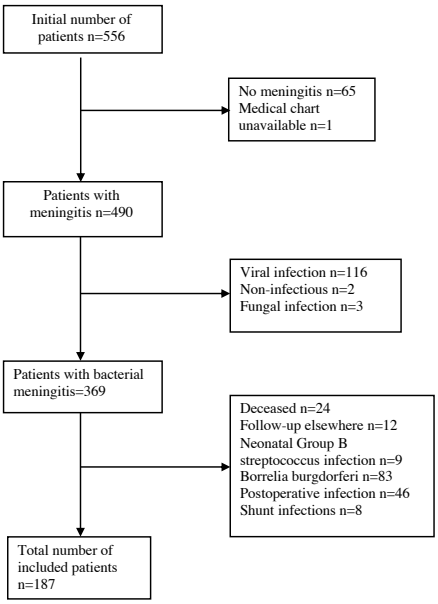

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