Success of Cochlear Implantation in patients after bacterial meningitis

Original Article

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Abstract

Aim: To present the results of cochlear implantation after bacterial meningitis, regarding auditory gain, time of use and improvement in quality of life.
Material and Methods: Retrospective, transversal study, based on the analysis of data from patients with severe and profound sensorineural hearing loss due to bacterial meningitis, who underwent uni or bilateral cochlear implant surgery at CHLO between 2014 and 2022.
Results: The sample included 13 patients. Four had cochlear ossification. The insertion of electrodes in the cochlea was total, except for 1 case. Six ears achieve 100% intelligibility. No relationship was found between cochlear ossification and intelligibility.
Conclusion: Auditory rehabilitation with cochlear implants in this group of patients is effective, improving levels of intelligibility and quality of life, even in cases of late referral and in the presence of fibrosis/partial ossification of the cochlea.

Keywords: Bacterial meningitis, sensorineural deafness, cochlear implant.

Introduction

Bacterial meningitis (BM) is one of the chief acquired causes of sensorineural hearing loss (SNHS)[1]. Deafness can occur within 48 hours after the onset of BM[2]. Definitive deep SNHS develops in approximately 10% of patients after BM , mostly due to direct injury to the cells of the organ of Corti, through the dissemination of the infection from the subarachnoid space to the cochlear aqueduct, with resulting fibrosis and ossification of the cochlea[2,3].
The introduction of vaccination has drastically reduced the number of cases of meningitis caused by *Haemophilus influenza* type B, and currently the most frequent etiological agents are *Streptococcus pneumoniae* and *Neisseria meningitidis* [1-4]. Cochlear implantation (CI) surgery in these patients, whether unilateral

or bilateral, is a priority, and a referral should be made urgently. However, some factors make this procedure challenging in these patients when compared to patients with no history of BM. Labyrinthitis ossificans, resulting from the spread of meningeal infection to the cochlear spaces, mainly affects the basal turn of the scala tympani, and when present, may be an obstacle to the insertion of the cochlear electrodes[5]. Thus, labyrinthitis ossificans, described in 30–57% of patients after BM, is one of the main contributors to the low functional outcome of CI rehabilitation, even in the presence of minimal ossification and complete introduction of electrodes into the cochlea[1]. Accordingly, this study aimed to analyze the outcomes of CI after BM, namely the hearing gain, time of use, and improvement in the quality of life of patients.

Materials and Methods

This retrospective, cross-sectional study analyzed the data of patients with severe and profound SNHS due to BM. The collected data were entered into a database, and statistical analysis was carried out using Excel for iOS. All patients underwent unilateral or bilateral CI surgery. The same surgeon performed all surgeries in the central operating room of the Egas Moniz Hospital, Western Lisbon Hospital Centre between 2014 and 2022. Inclusion criteria were severe and deep SNHS, normal otoscopy, and absence of middle ear disease. All patients with an uncertain diagnosis of BM as the cause of SNHS were excluded. The study sample included 13 patients. The native language of all patients was Portuguese. This study included patients with Portuguese nationality, as well as individuals from Portuguese-speaking countries (PALOPs). Data on patient demographics, time interval between BM and CI, CI laterality, presence of cochlear ossification, electrode insertion, and perioperative neuronal response telemetry (NRT) were collected. All patients underwent formal hearing assessment by means of tonal and vocal audiogram before and after CI. The minimum follow-up time was one year. The presence of cochlear ossification was assessed by preoperative computed tomography (CT) of the ear. The degree of patient satisfaction was evaluated by using the Nijmegen Cochlear Implant Questionnaire (NCIQ), validated for European Portuguese. Information on the mean daily use of the implant was also recorded.

Results

A total of 13 patients with severe to profound acquired SNHS after BM underwent CI. The sample included seven women and six men. Seven had Portuguese nationality and were residents of Portugal, while six patients were referred from PALOPs. Four patients were diagnosed with BM during childhood, three during adolescence, and six in adulthood. Only three patients were referred early. The mean time interval between BM and CI was 24 years, with a minimum of 1 month and maximum of 59 years (Table 1). In the preoperative period, only four patients exhibited partial ossification of the cochlea on CT scan of the ear. A total of 17 ears underwent CI. The procedure was unilateral in nine patients, and bilateral in four patients. Bilateral implantation was performed in the same surgical time in two cases and sequentially in the remaining two cases, with an interval of 4 and 11 months between the surgeries, respectively. The electrodes were completely inserted into the cochlea in all ears except one. Perioperative NRT was unresponsive in the basal electrodes of five ears, two of which showed partial ossification of the cochlea (Table 2). Of the initially enrolled 13 patients, six were lost to follow-up. Of the remaining seven patients, six ears achieved 100% intelligibility following the implant (two of which had ossification of the cochlea on preoperative CT), while three had 0% intelligibility. We found no relationship between cochlear ossification and intelligibility. The average duration of daily use was 12.4 hours. The mean overall satisfaction score in the NCIQ was 49.38, and the mean scores of the subdomains of basic sound perception and advanced sound perception were 50.36 and 34.29, respectively. Table 3 summarizes the results of the NCIQ questionnaire.

Table 1
Data on the age at infection, year of infection, year of cochlear implantation surgery, and time interval between meningeal infection and cochlear implantation surgery in years (n=13)

Patient	Age at infection (years)	Year of infection	Year of CI surgery	Duration between infection and CI (years)
1	16	2010	2018	8
2	63	2013	2018	5
3	54	2018	2018	0,33
4	42	2016	2018	2
5	39	2019	2019	0,08
6	14	2001	2021	20
7	56	2021	2022	1,25
8	4	1958	2017	59
9	0,60	1963	2014	51
10	0,20	1996	2018	22
11	13	1961	2019	58
12	42	2021	2022	0,58
13	1	1960	2014	54

Table 2
Data on the presence of cochlear ossification on preoperative ear CT scans, laterality of surgery, insertion of electrodes in the cochlea, and neuronal response telemetry in the perioperative period (n=13)

Doente	Signs of ossification	Laterality of surgery	Insertion of the electrodes into the cochlea	Neuronal response telemetry
1	Absent	Unilateral	Total	Present in all electrodes
2	Absent	Unilateral	Total	Present in all electrodes
3	Absent	Unilateral	Total	Present in all electrodes
4	Present	Bilateral	Total	Absent in basal electrodes
5	Absent	Bilateral	Total	Absent in basal electrodes
6	Present	Unilateral	Total	Present in all electrodes
7	Present	Unilateral	Total	Present in all electrodes
8	Absent	Unilateral	Total	Absent in basal electrodes
9	Absent	Unilateral	Total	Present in all electrodes
10	Present	Unilateral	Total	Absent in basal electrodes
11	Absent	Unilateral	Total	Present in all electrodes
12	Absent	Bilateral	Total	Present in all electrodes of the right ear Absent in the basal electrodes of the left ear
13	Absent	Unilateral	Partial	Present in all electrodes

Table 3
Responses to the NCIQ questionnaire (n=7)

Sick	BSP	ASP	SP	SE	LA	SI	Total Score
2	37,5	47,5	80	32,5	35	55	60,42
5	30	20	87,5	42,5	42,5	65	46,25
7	37,25	47,5	80	32,5	35	55	37,25
8	60	30	55	47,5	47,5	50	53,33
9	27,5	20	35	27,5	40	47,5	46,25
11	67,5	40	70	60	57,5	56,25	47,5
12	62,5	40	50	47,5	37,5	45	58,75
Mean	50,36	34,29	61,07	43,93	50,00	56,61	**49,38**

BSP – Basic sound perception; ASP – advanced sound perception; SP – speech production; SE – self-esteem; LA – limitation to activities; SI – social interactions

Discussion

Ossification of the cochlea

Cochlear ossification is an adverse factor for CI in patients with BM, since its presence interferes with the correct and total insertion of the cochlear electrodes in the scala tympani. The presence of cochlear ossification, even when mild and associated with total electrode insertion, is the main risk factor for a poor postoperative audiometric outcome.[1]

However, in this study, complete introduction of the electrodes into the cochlea was achieved in all four patients who had cochlear ossification on preoperative ear CT scan. Among these four patients, two had absent NRT in the basal electrodes, but audiometric evaluation showed an intelligibility of 100% at 40 dB in one patient and at 60 dB in the other patient.

These results are consistent with those of *Carvalho et al.,* who showed that partial insertion of the electrodes can be performed with favorable audiometric outcomes in the presence of cochlear ossification without obliteration. However, due to the lower stability of the partially inserted electrodes, there is a greater risk of extrusion in the long term[6].

Time between infection and cochlear implantation surgery

Since osteoneogenesis of the cochlea occurs in the first few weeks after the onset of meningitis, all patients should undergo audiometric evaluation 4 to 8 weeks after hospital discharge. One study showed that the success of CI was higher in children implanted within 6 months after BM, compared to children implanted more than 6 months after infection[7]. In the present study, the minimum time between BM and CI surgery was 4 weeks, while the maximum was 59 years.

A 39-year-old postpartum woman developed iatrogenic BM after epidural injection, with isolation of *Streptococcus agalactea* in the cerebrospinal fluid culture. She underwent simultaneous bilateral CI 1 month after the onset of BM. The preoperative CT scan did not show signs of cochlear ossification, but granulation tissue was observed intraoperatively in the round window bilaterally. One year after CI, she had a maximum intelligibility of 70% at 50 dB, with a decrease in intelligibility with increasing intensity in both ears.

In contrast, a patient with a history of BM at 2 years of age, whose preoperative CT scan showed bilateral cochlear ossification, underwent CI of the right ear at the age of 22 years. Insertion of the electrodes into the cochlea was incomplete and intraoperative NRT was absent in the basal electrodes. One year after CI, the implanted ear had an intelligibility of 100% at 60 dB.

These results lead us to believe that the time between meningeal infection and CI surgery is not, by itself, a determining factor of postoperative audiometric success.

Laterality

In the case of post-meningitis SNHS in children and adults, early and bilateral CI is recommended due to the risk of cochlear ossification. In addition, several studies have shown the benefit of bilateral CI in terms of speech intelligibility in silence and noise[1].

In this study, only four patients underwent bilateral CI. One of the patients implanted bilaterally was the woman with postpartum BM mentioned above, who underwent simultaneous bilateral CI 1 month after BM. The other patient with simultaneous CI had BM at the age of 42 years and underwent surgery 7 months after the infection. Preoperative CT scan of the ear showed no signs of labyrinthine ossification, and the electrodes were completely inserted in both ears; however, NRT was absent in the basal electrodes of the left cochlear implant. Currently, the patient has an intelligibility of 0% in the right ear, reaching 100% at 50 dB in the left ear.

Finally, a 24-year-old patient with BM at the age of 16 years was implanted bilaterally 8 years after the onset of deafness. Implantation was sequential, with a 7-month interval between the surgeries. Currently, the patient has an intelligibility of 100% at 50 dB in both ears. Another case of sequential implantation, with an interval of 11 months between the surgeries, developed BM at 14 years of age, and underwent the first surgery at 35 years of age (infection-implantation time 21 years).

This study has some limitations, namely the retrospective design of the study, small sample size, sample heterogeneity (differences in ages, timing of deafness, and implantation), and loss to follow-up. Consequently, we could not draw a conclusion regarding the relationship between cochlear ossification and speech intelligibility after CI. The strength of the study is that the same surgeon performed all surgeries.

Conclusion

Our results suggest that auditory rehabilitation with cochlear implants in patients with BM-induced deafness is effective, and improves the intelligibility levels and quality of life of patients, even in cases of late referral and presence of fibrosis/partial ossification of the cochlea. Therefore, these two factors should not in themselves be a contraindication to CI.

Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

Data Confidentiality

The authors declare having followed the protocols in use at their working center regarding patients' data publication.

Protection of humans and animals

The authors declare that the procedures were followed according to the regulations established by the Clinical Research and Ethics Committee and to the 2013 Helsinki Declaration of the World Medical Association.

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Availability of scientific data

There are no datasets available, publicly related to this work.

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