Changes in programming over time in postmeningitis cochlear implant users

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OBJECTIVE: **Although successful cochlear implantation of patients with deafness following meningitis is expected, long-term stability of electrical current requirements has not been systematically evaluated. This study evaluated changes in programming for patients deafened by bacterial meningitis and stability of auditory performance over time.**
STUDY DESIGN AND SETTING: **In this retrospective descriptive study, cochlear implant (CI) stimulation mode and performance of 14 patients deafened by meningitis were compared with those of an age-matched control group of patients deafened by other causes.**
RESULTS: **There were no significant differences in mean performance between the meningitis group and control group ($P > 0.05$). However, the postmeningitis group required progressively higher stimulation levels and higher programming modes over time as compared to the control group.**
CONCLUSIONS: **Even with deafness accompanied by labyrinthine ossification attributed to meningitis, neural elements were present and could be stimulated. Because increasing levels of stimulation were required over time, postmeningitic children with CIs, and those with cochlear ossification in particular, may need frequent programming adjustments to maintain performance.**
SIGNIFICANCE: **These patients need close follow-up of stimulation levels and programming modes postoperatively in order to perform optimally with CIs.**
EBM rating: B-3. (Otolaryngol Head Neck Surg 2004;131:885-9.)

Bacterial meningitis is a leading cause (up to 90% of cases) of acquired deafness in children.[1] Reported incidence of hearing loss in children following meningitis ranges from 6 to 37%,[2] of which approximately 5% are profound in severity. The cochlear aqueduct was shown to be the likely pathway for extension of infection from the meninges to the labyrinth.[3] Histopathologic studies on human temporal bones in ears deafened by meningitis reveal a marked reduction in spiral ganglion cells and increased labyrinthitis ossificans of the cochlear scalae. Merchant and Gopen reported that 49% of temporal bones showed evidence of suppurative labyrinthitis after meningitis.[3] Keithley et al found that 20 to 30% of temporal bone specimens with meningitis/labyrinthitis contained new bone.[4] Nadol et al reported that new bone formation and perielectrode fibrosis were common after implantation; however, there was no firm evidence that further degeneration of the spiral ganglion cell could predicted as a consequence.[5]

Although successful implantation of patients with meningitis-related deafness is expected, long-term stability of electrical current requirements has not been systematically evaluated. This study evaluated changes in programming of patients deafened by bacterial meningitis and stability of auditory performance over time. Such information could prove helpful in determining the frequency of programming necessary to maintain optimal stimulation levels.

SUBJECTS AND METHODS

Subjects

Twenty-eight pediatric cochlear implant (CI) users implanted at the University of Miami Ear Institute were included in this study. Fourteen patients were included in the postmeningitis group and 14 in a control group. Controls were matched for age at implantation. All patients except one had a Nucleus 22 multichannel CI. Mean length of implant use was 38.4 months for the postmeningitis group and 30.1 months for the control group. Demographic information for each group is summarized in Table 1.

Methods

A retrospective record review was utilized to gather the data for this study. Stimulating current levels, modes of stimulation, and auditory performance were compared at initial, 6-month, and most recent programming sessions.

Mode of stimulation refers to the number of electrode contacts between the active and ground elec-

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Table 1. Demographic data

	Study group: Meningitis	Control group: Other etiologies
Number of patients	14 (6 M, 8 F)	14 (8 M, 6 F)
Age at implantation	72.7 mo (22–144)	61.2 mo (15–120)
Duration of deafness before implantation	45.6 mo (5–144)	48 mo (12–111)
Cochlear ossification	3 Total, 3 Partial	No ossified cochlea
Pathogens or etiologies	1 Pneumococcus, 2 Hemo Influenza, 8 Unknowns	10 Congenital, 2 Ototoxicity, 2 Congenital CMV
Follow-up	38.4 mo	30.1 mo

Table 2. Mean of auditory performances after cochlear implantation

	Meningitis group	Control group
Children's BKB sentences	56%	51%
PBK words	50%	42%
Oral*	82%	71%
Total communication†	10%	26%

*Oral refers to children in an oral rehabilitation program who do not use sign language.
†Total communication refers to children who use some combination of sign language and listening/talking.

Table 3. Changes in stimulation mode of postmeningitis and control groups

	Meningitis group		Control group	
Modes	Initial stimulation (1 month)	Later stimulation (>12 months)	Initial stimulation (1 month)	Later stimulation (>12 months)
BP + 2 or less	11	8	13	13
BP + 3 or higher	3*	6†	1‡	1‡

*2 ossified cochlea and 1 abnormal (Mondini) cochlea.
†5 patients with ossified cochlea and 1 with malformed cochlea (Mondini).
‡Congenital CMV.

trodes. Distance along the cochlea increases as the number of intervening electrodes increases, eg, BP+1 indicates l electrode between active and ground, BP+2 indicates 2 electrodes between active and ground, and so on. Variable mode (VM) encompasses intervening electrodes of 6 or more (BP+6, BP+7, . . .).

Changes in mode of stimulation between programming sessions were analyzed. *t* tests were used to assess the statistical significance of differences between the auditory performance of the 2 groups as well as changes in stimulation mode between the first stimulation and most recent programming.

RESULTS

Postoperative results showed that all patients could be successfully stimulated by the CI. Six of the patients within the bacterial meningitis group had been found to have some degree of cochlear ossification preoperatively. The mean scores of Children's BKB sentences and PBK words are shown in Table 2. There was no significant difference between mean performance of the meningitis and control groups ($P > 0.05$), although there was a large range of performance within each group (Table 2).

Statistical analysis showed a significant difference in the required programming modes between the 2 groups. After at least 12 months of CI use, subjects in the meningitis group required higher modes (BP+3 or higher) than did the control group ($P < 0.05$) (Table 3).

Figure 1 shows the distribution of stimulation modes of the nonmeningitic group. Fewer patients required higher stimulation modes among this group. Figure 2 shows the distribution of stimulation modes of the meningitis group, where there was a tendency to move to higher stimulation modes over time.

Changes in stimulation mode over time in postmeningitis patients without ossification are shown in Figure 3. These patients required higher modes of initial stimulation but showed little change over time. Figure 4 shows changes over time of stimulation mode in postmeningitis patients with ossification. These patients tended to begin with lower modes of stimulation that increased over time.

DISCUSSION

Early research reported that thresholds of electrical stimulation tended to increase in macaque monkeys implanted with various multichannel electrode arrays and followed for periods of up to 8 years.[6] Eddington et al reported on threshold to electrical stimulation in 2 patients implanted with multichannel electrode arrays over a period of 2 years and concluded that there was no change in electrical stimulation levels over the study period.[7] More recently,

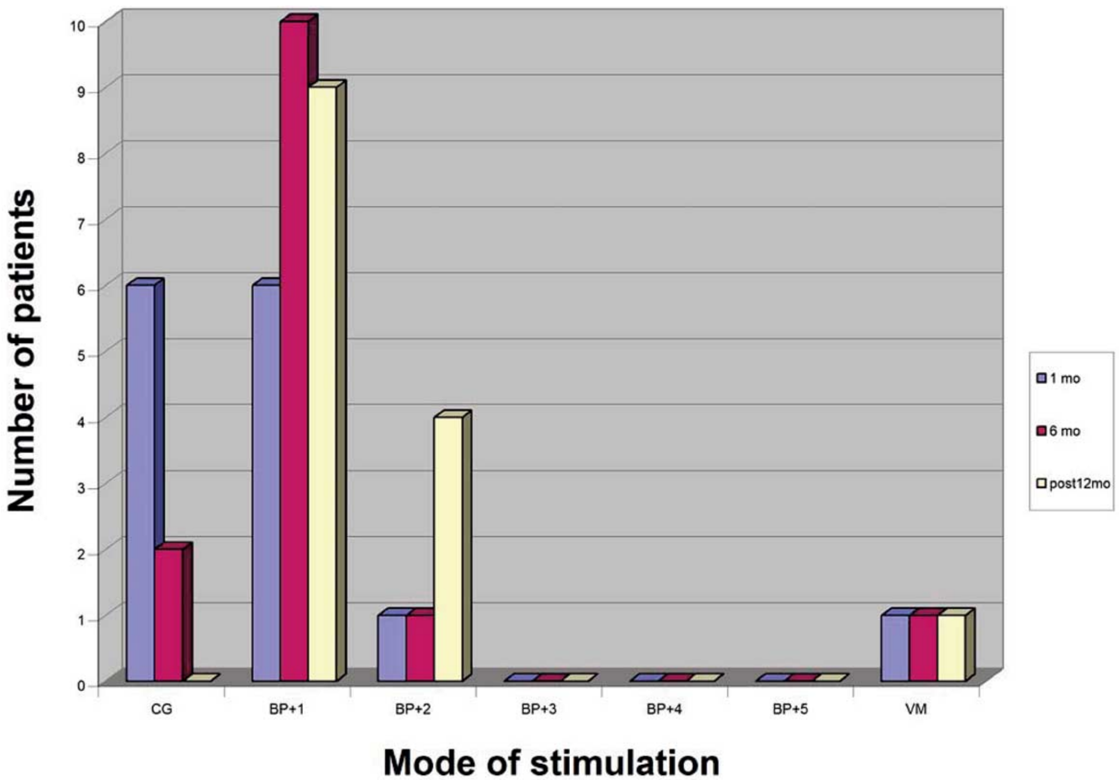

Fig 1. Distribution of stimulation mode of nonmeningitic group. Fewer patients required higher stimulation modes among this group.

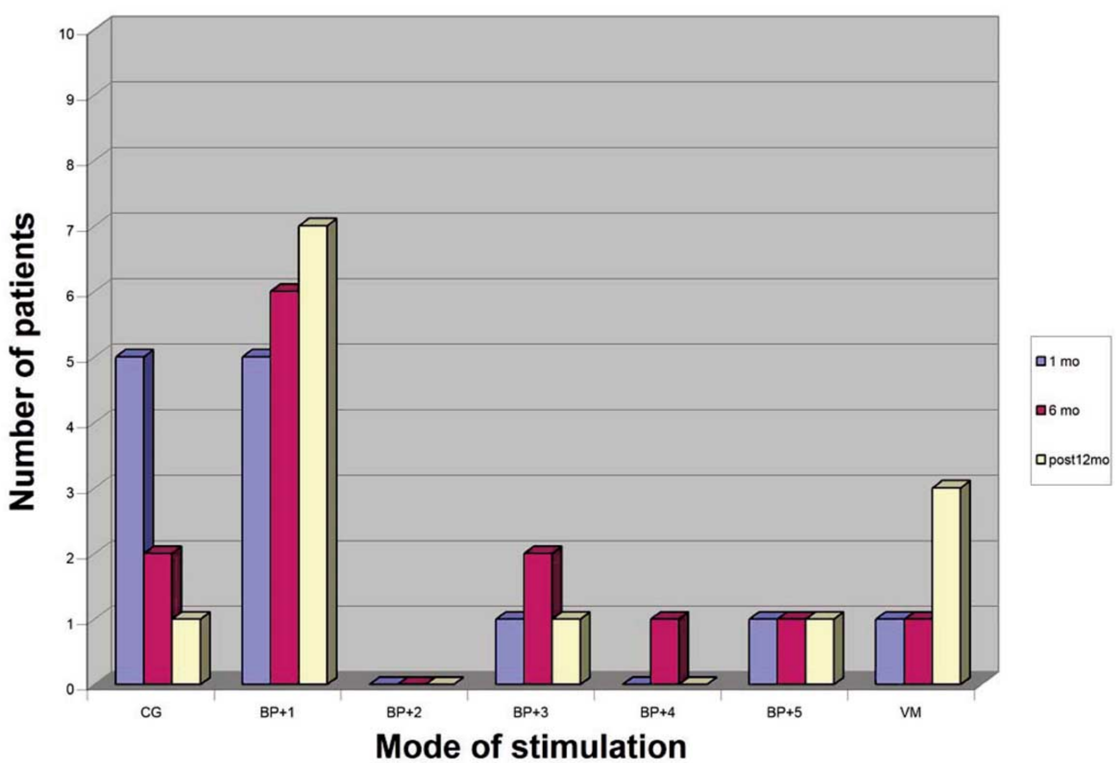

Fig 2. Distribution of stimulation mode of meningitis group. Greater tendency to move to higher stimulation modes within this group.

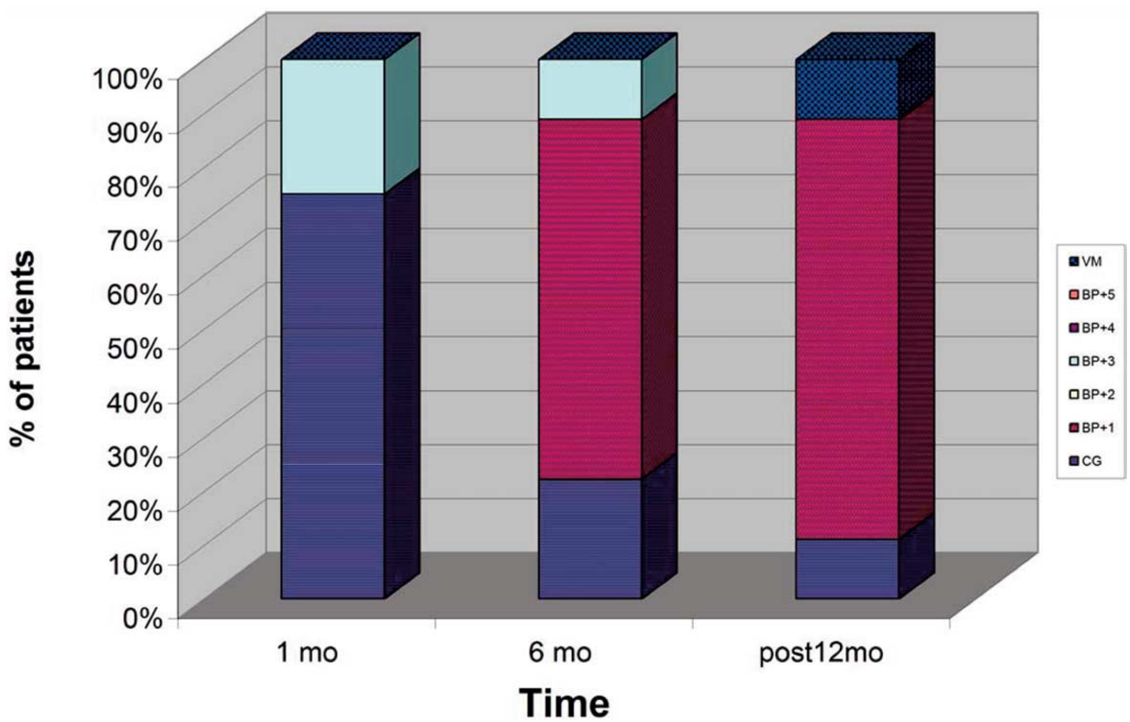

Fig 3. Changes over time of stimulation mode in postmeningitis patients without ossification. These patients required higher mode of initial stimulation but showed little change over time.

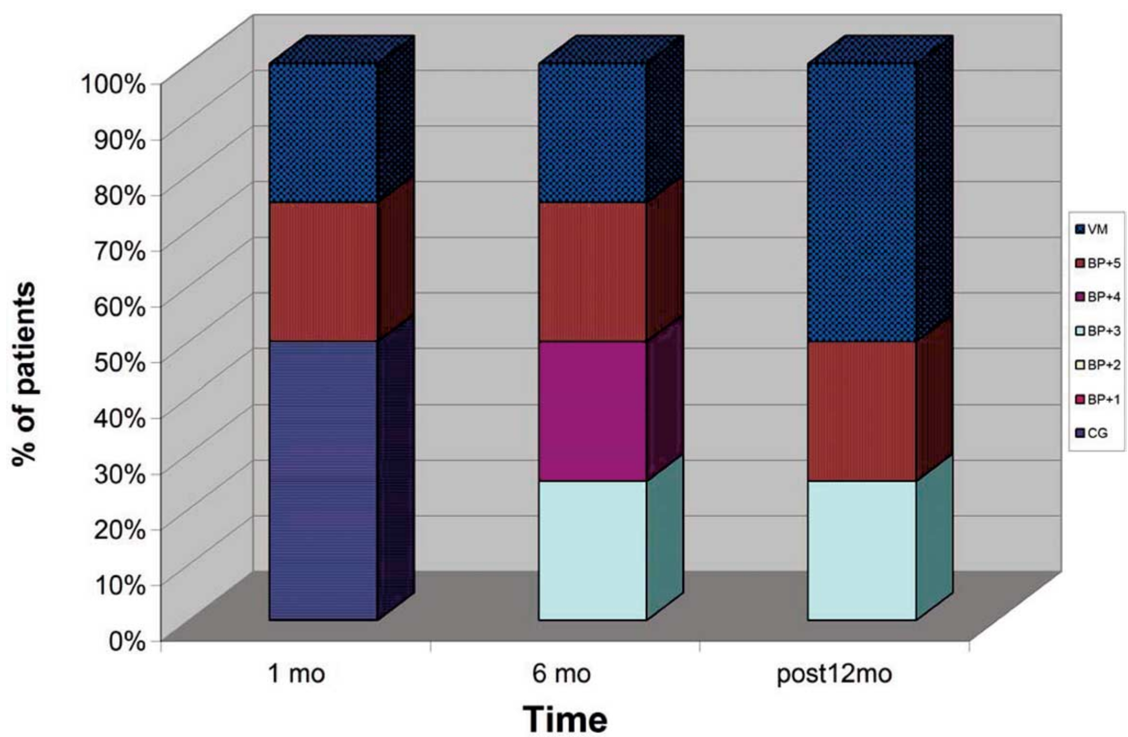

Fig 4. Changes over time of stimulation mode in postmeningitis patients with ossification. These patients tended to begin with lower modes of stimulation that increased over time.

Butts et al reported that although the changes in stimulation levels from one programming session to the next were not significant, significant changes in stimulation levels occurred gradually over time in a mixed group of cochlear implant recipients.[8] Research is not yet available that assesses the changes in electrical stimulation over time in postmeningitis patients at risk of cochlear ossification.

The results of the present study suggest that postmeningitis CI children in general, and those with ossified cochlea in particular, need frequent programming adjustments to maintain performance. Increasing stimulation modes reduces the number of available electrodes, especially for those patients using greater than or equal to BP+3. However, higher modes of stimulation were not found to negatively impact performance in the meningitis group. There were no significant differences in mean performance between the 2 groups, although there was a large range of performance within each group. This finding may be in part explained by the results of previous studies reporting that the communication environment (oral vs total communication) appeared to influence auditory performance more than etiology of deafness.[9]

The noted changes in electrical current requirements may be due to progressive cochlear ossification and future studies of temporal bones using CT scans can test this hypothesis. Patients with new devices based on monopolar stimulation may also require changes over time in programming and need to be investigated.

CONCLUSIONS

Even with labyrinthine ossification caused by meningitis, neural elements are present and can be stimulated if sufficient current can be provided.

In this study, auditory performance was comparable between postmeningitis and control groups of pediatric CI users. However, postmeningitis CI children with ossified or abnormal cochleas either required higher initial stimulation current levels and modes of stimulation or, when they began at lower levels, the current levels and stimulation modes tended to increase over time.

From the results of this study it can be suggested that CI users with deafness postmeningitis need close follow-up for their stimulation levels and programming modes postoperatively.

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