Cochlear implants in children: A cross-sectional investigation on the influence of geographic location in Saudi Arabia

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Abstract:
INTRODUCTION: The role of the family in detecting a child’s hearing difficulty and the age at which an implantation is done have been identified as strong predictors of the outcomes of pediatric cochlear implantation. In the absence of screening programs for hearing loss in Saudi neonates, the family’s role is of paramount importance. The aim of this study was to investigate the influence of geographic location on the course of identification, examination, and cochlear implantation in children in Saudi Arabia.

MATERIALS AND METHODS: Pediatric patients who had received either unilateral or bilateral cochlear implantation at King Abdulaziz University Hospital in Riyadh, Saudi Arabia, between January 1, 2012, and December 31, 2014, were surveyed.

RESULTS: A total of 156 pediatric patients have had a cochlear implant between January 1, 2012, and December 31, 2014. The one-way analysis of variance test to compare the means of the independent sample groups in various geographic zones showed that with a hundred percent access to primary health care, the geographic location of the population had an influence on the detection of hearing loss but not on the cochlear implantation.

CONCLUSION: This study found that the geographic location of the population has an influence on the time of detection of hearing loss in children but not on the time of cochlear implantation. Raising parental awareness of the importance of early detection of hearing loss is necessary. Further research is also required to define the role of factors such as the income and the educational level of parents on the early detection of neonatal hearing loss.

Keywords: Children, cochlear implant, Saudi Arabia

Introduction
Problems pertaining to hearing diminish a child’s ability to learn, and hearing-impaired (HI) children have little self-confidence because of inadequate language and communication skills, especially in their perceived social acceptance by peers, parental attention, physical appearance, and overall self-esteem.¹ Speech comprehension and production in children is a multistage process: in the first stage, the child has a closed-set words by which he/she recognizes and produces a finite number of words that are in his/her set of options presented by situational questions. This is usually affected by hearing. A more advanced stage consists of an open set of words, whereby a child recognizes and produces an infinite number of words prompted by situational cues. Finally, full speech comprehension and production is achieved when the child understands and uses words by herself/himself without any external cues. Studies have shown that the

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A cochlear implant device supplies electrical stimulation directly to the auditory nerve circumventing the damaged hair cells in the cochlea, providing a perceived sensation of hearing. Thus, a cochlear implant does not restore normal hearing but provides a sensory neuronal stimulation for sound vibration, resulting in sound perception and subsequent motor neuronal reaction.

Extensive auditory, speech, educational, and psychological testing are performed before and after implantation. There has been an increase in cochlear implants in children in the recent years, particularly, in those implanted within the first year of life.

Recent studies have identified the role of the family and the age of implant as strong predictors of the outcome of pediatric cochlear implantation. Therefore, delays in cochlear implantation should be lessened to have better implant outcomes. Studies to evaluate the influence of the introduction of newborn hearing screening programs on the age at which children have cochlear implantation have shown a significant decline in the age at implantation and a simultaneous increase in the number of children getting implants within the first year of life.

In the absence of such screening programs for hearing loss in Saudi neonates, the child’s family is the first to detect the child’s hearing difficulty. The problem is subsequently reported to a primary healthcare provider or local ENT specialist, who in turn refers them to the Regional Health Council, which in turn directs the family to a specialized center for cochlear implantation.

Consequently, the geographic factors have much influence on the efficiency of this sequential process of identification, examination, and cochlear implantation. The geographic factors include the urban, semi-urban, or rural domicile.

This research, the first such an investigation, aimed to determine the influence of geographic factors on the course of identification, examination, and cochlear implantation in children in Saudi Arabia. It is hoped that this research will aid the decisions that guide the implementation of the hearing screening program of the newborn.

Materials and Methods

This cross-sectional study included a total of 156 pediatric patients who had received either unilateral or bilateral cochlear implantation at King Abdulaziz University Hospital (KAUH) in Riyadh, Saudi Arabia, between January 1, 2012, and December 31, 2014. The study included children between 3 and 144 months of age with hearing impairment caused by defects in the inner ear and related sensory structures, specifically, defective hair cells in the cochlea (sensorineural hearing loss [SNHL]), and have had either a unilateral or bilateral cochlear implant. Children <3 months of age were not included since due to safety, cochlear implants were not routinely performed at this age. Children older than 12 years were also excluded as they did not normally have an implantation done at our center.

Data was abstracted by retrospective chart review of these 156 cases. The information obtained included the age at which hearing impairment was first observed by the family, age at which hearing impairment (SNHL) was first diagnosed at a primary healthcare facility, age at which hearing impairment (SNHL) was evaluated by extensive audiologic examination at KAUH, and the age at which the cochlear implant was performed.

Data on the patient’s geographic location comprised the parents’ region of residence. The data on residence were assigned to one of the five major regions of Saudi Arabia, namely, central, southern, northern, western, and eastern regions. Ethical approval by the Research and Statistics Committee at KAUH and informed consent from the patient’s parents were obtained.

Statistical analysis was accomplished using SAS version 9.4 (SAS Institute, North Carolina, USA). Data were presented in the form of mean scores and standard deviations for continuous variables, and frequencies and percentage for categorical variables, with 95% confidence intervals. A one-way analysis of variance (ANOVA) was performed to compare the means of the independent sample groups.
Results

Of the total 156 cases, 58.3% were females and 41.6% males. The mean age in months at which hearing impairment was first observed was 7.0 (±11.3); the mean age at which hearing impairment (SNHL) was first diagnosed was 7.0 (±11.3); the mean age at which hearing impairment (SNHL) was medically evaluated for implant was 22.0 (±15.4); and the mean age at which cochlear implant was performed was 45.09 (±21.3) [Table 1].

Table 2 shows the mean age of children (±SD) by region. The mean age at which the cochlear implant was performed was 44.76 (±1.99) months for the central region, 45.29 (±1.85) for the southern region, 44.79 (±1.52) for the northern region, 45.16 (±2.08) for the western region, and 45.43 (±1.12) for the eastern region. Data on the parental access to primary health care showed that there was 100% access in all the five regions of the country [Table 3].

Discussion

ANOVA test was performed to compare the means of the independent sample groups in the five geographic zones. The one-way ANOVA test in the five geographic zones shows two different outcomes. ANOVA for the geographic distribution of mean age at which hearing loss was first observed had a p-value= <0.0001 for the F-test which indicates that there was a significant difference in the age at which hearing loss was first observed in the five geographic regions and that the geographic, regional location had an influence on the age at which the hearing loss is first observed in children in Saudi Arabia [Table 4]. However, ANOVA for the geographic distribution of the mean age of cochlear implant a p-value = 0.5557 for the F-test which indicate that there was no significant difference in the age at which cochlear implant is done in the five different geographic locations and that the geographic, regional location had no influence on the age at which cochlear implantation is done in children in Saudi Arabia [Table 5]. It seems, therefore, that although there is a time difference (in months) among the various geographic regions in Saudi Arabia in the detection of hearing impairment in children, there is no such time difference (in months) for cochlear implants. This could be the result of such factors as parents’ education and level of income. Since the data on accessibility to primary health care were 100% in all the geographic zones, parental access to primary care had little significance in the analysis of the data.

Besides, the overall mean age of cochlear implantation in Saudi Arabia is 45.7 (±21.3) as compared to a mean of 21.5 months in the United States,[14,15] This seems to indicate an excessive waste of time between the time of observation of the impairment by the family and the time of implantation of the device, which severely holds back the child’s learning and language acquisition. Thus, there is a need to address urgently these issues in a population that has excellent access to primary health care. The introduction of newborn hearing screening programs that would enable them to have an implant within their first year of life and educational programs that would inform parents on the significance of an early implant and consequences of a delay should effectively address the issue of delayed implantation.

Conclusion

The entire population of the country has easy access to primary health care, geographic location of domicile has a definite influence on the time of detection of hearing loss in children, but not on the time of cochlear implantation. There is an urgent need for the introduction of newborn hearing screening programs in Saudi Arabia together with educational programs for parents on the importance of an early cochlear implantation.

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Table 4: Analysis of variance for the geographic distribution of the sample and mean age at which hearing loss was first observed

| Group   | n (count) | Mean  | SD   | SE   |
|---------|-----------|-------|------|------|
| Group 1 | 66        | 7.76  | 1.3  | 0.16 |
| Group 2 | 38        | 6.24  | 1.12 | 0.187|
| Group 3 | 27        | 7     | 1.08 | 0.2078|
| Group 4 | 15        | 6.1   | 1    | 0.2582|
| Group 5 | 10        | 7.9   | 1.12 | 0.3542|

ANOVA table

| Source of variation | Sum of squares | df  | Mean square | F-statistics | p*   |
|---------------------|----------------|-----|-------------|--------------|------|
| Between groups      | 78.5155        | 4   | 19.6299     | 13.9889      | <0.0001|
| Within groups       | 211.879        | 151 | 1.40317     |              |      |
| Total               | 290.394        | 155 |             |              |      |

Test for equality of variance

\[ \chi^2 = 2.5586 \] df 4 \[ p = 0.6341 \]

P value significant when <0.05, *0.05. SD = Standard deviation, SE = Standard error, ANOVA = Analysis of variance

Table 5: Analysis of variance for the geographic distribution of the sample and mean age at cochlear implantation

| Group   | n (count) | Mean  | SD   | SE   |
|---------|-----------|-------|------|------|
| Group 1 | 66        | 44.76 | 1.99 | 0.245 |
| Group 2 | 38        | 45.29 | 1.85 | 0.3001|
| Group 3 | 27        | 44.79 | 1.52 | 0.2925|
| Group 4 | 15        | 45.16 | 2.08 | 0.5371|
| Group 5 | 10        | 45.43 | 1.12 | 0.3542|

ANOVA table

| Source of variation | Sum of squares | df  | Mean square | F-statistics | p*   |
|---------------------|----------------|-----|-------------|--------------|------|
| Between groups      | 10.329         | 4   | 2.58226     | 0.755706     | 0.5557|
| Within groups       | 515.969        | 151 | 3.41701     |              |      |
| Total               | 526.298        | 155 |             |              |      |

Test for equality of variance

\[ \chi^2 = 6.11248 \] df 4 \[ p = 0.1909 \]

P value significant when <0.05, *0.05. SD = Standard deviation, SE = Standard error, ANOVA = Analysis of variance

Conflicts of interest
There are no conflicts of interest.

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