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Clinical Record

Cochlear implantation in children with Jervell, Lange-Nielsen syndrome

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Abstract

Jervell, Lange-Nielsen syndrome is a condition that causes profound hearing loss and disruption of the normal cardiac rhythm. This disorder is a form of long QT syndrome, a cardiac disorder that causes the cardiac muscle to take longer than usual to recharge between beats. A retrospective case study was performed to document cochlear implantation in three profoundly deaf children (two of them siblings) with Jervell, Lange-Nielsen syndrome. We discuss diagnosis and management of this syndrome and also the long-term performance of cochlear implantation in these Iranian patients, referring especially to the role of the ENT specialist in diagnosis and treatment. The collected data show that cochlear implantation can be relatively safely performed in patients with Jervell, Lange-Nielsen syndrome and that these children received significant benefit from cochlear implantation.

Key words: Jervell and Lange-Nielsen Syndrome; Cochlear Implants; Sensorineural Deafness

Introduction

The first case of long QT syndrome was probably reported by Friedrich Ludwig Meissner in 1856 in Germany. He described the case of a deaf girl who collapsed and died while being publicly admonished at school. When the parents were informed, they revealed that two brothers of the girl had also died suddenly after a violent fright or rage.

In 1957, Anton Jervell and Fred Lange-Nielsen published the first complete description of long QT syndrome. The disease became known as Jervell, Lange-Nielsen syndrome, a condition causing profound hearing loss and disruption of the normal cardiac rhythm. This disorder is a form of long QT syndrome, in which cardiac muscle takes longer than usual to recharge between beats.[1–5] If untreated, the arrhythmia can lead to recurrent syncope and sudden death.

Jervell, Lange-Nielsen syndrome is caused by mutations in the KCNE1 (potassium voltage-gated channel, Isk-related family, member 1) is a gene associated with Long QT syndrome and KCNQ1 (potassium voltage-gated channel, KQT-like subfamily, member 1) is the gene's official symbol genes (responsible for 10 and 90 per cent of cases, respectively). The proteins produced by these two genes work together to form a channel that transports positively charged potassium ions out of cells. The movement of potassium ions through these channels is critical in maintaining the normal functions of the inner ear and cardiac muscle. Mutations in the KCNE1 and KCNQ1 genes alter the usual structure and function of potassium channels or prevent the assembly of normal channels. These changes disrupt the flow of potassium ions in the inner ear and in cardiac muscle, leading to hearing loss and irregular cardiac rhythm.[6–9]

Despite these advances in the molecular genetic understanding of the condition, a diagnosis of congenital long QT syndrome is still based on electrocardiography (ECG) and clinical characteristics. Beta-blockers remain the mainstay of treatment. For high risk patients, an implantable cardioverter-defibrillator offers an effective therapeutic option to reduce mortality. Gene-based specific therapy is still preliminary. Further studies are required to investigate new strategies for targetting the defective genes or mutant channels.[10] The prevalence of this syndrome in deaf children was found to average 0.21 per cent, with a range of 0–0.43 per cent.[11] All children with congenital sensorineural hearing loss who have suffered unexplained syncopal attacks or convulsions should be screened for Jervell, Lange-Nielsen syndrome. Cochlear implantation is a treatment option for adults and children with bilateral severe-to-profound sensorineural hearing loss who do not benefit from traditional amplification.

Because of the potential for cardiac arrhythmias and sudden death, additional risks are involved in cochlear implantation in deaf patients with Jervell, Lange-Nielsen syndrome. Cochlear implantation can be relatively safely performed in such patients; however, special pre- and peri-operative precautions are required, including cardiac monitoring for 48 hours, peri-operative beta-blockade, and special anaesthetic considerations.[12–14]

The current research aimed to document the effect of cochlear implantation in three profoundly deaf children (two of them siblings) with Jervell, Lange-Nielsen syndrome. We discuss the diagnosis and management of this syndrome and the long-term performance of cochlear implantation in these Iranian patients, especially regarding the role of the ENT specialist.

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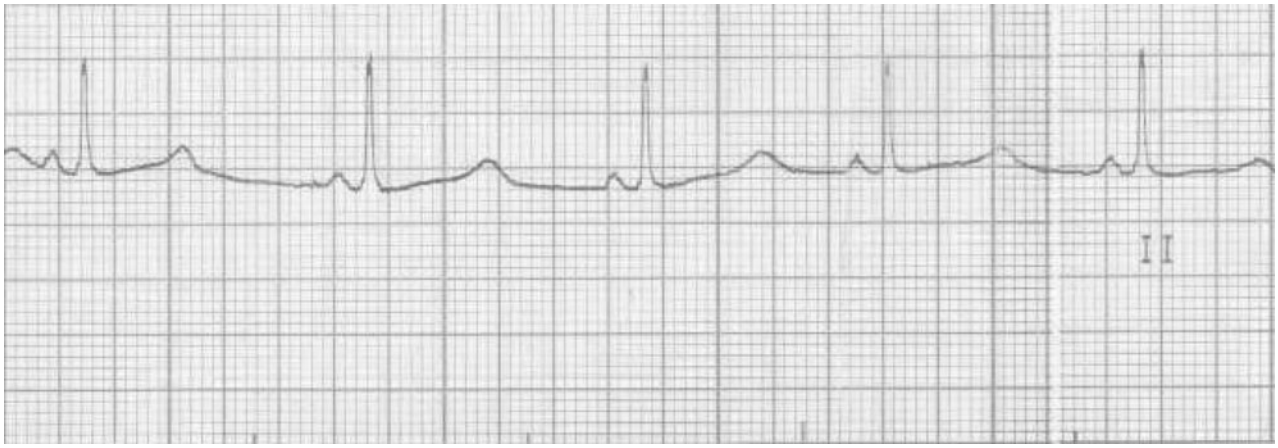

FIG. 1
Electrocardiogram of case one.

Case one

A two-and-a-half-year-old girl, the only child of her non-consanguineous parents, was referred to our cochlear implantation centre due to profound, congenital, sensorineural hearing loss. She had not benefited from conventional hearing aids. During the pre-operative assessment, the mother stated that, over the previous year, the child had experienced syncopal attacks, along with paleness and fainting. These attacks, which usually happened during the child's bath or play time, lasted 3–5 minutes each. Since the first syncope, the child had been under treatment with pirimidone; however, the condition was not adequately controlled.

The patient's electroencephalogram revealed no abnormalities. Her ECG tracing indicated a heart rate of 60 per minute, a normal axis and a regular rhythm; however, a prolonged QT segment was seen (0.545 ms based on the Bazett formula), with a biphasic T wave (Figure 1). Electrocardiograms were also performed on the patient's father and mother, revealing QT segments of 0.43 and 0.45 s, respectively. There was no history of hearing loss or sudden death in the family.

The combination of long QT segment and congenital deafness was diagnosed as Jervell, Lange-Nielsen syndrome.

Treatment was commenced with propranolol. Medical evaluations after five months revealed no further episodes of syncope.

The child was referred for cochlear implantation, while receiving propranolol. She was implanted with a Med-El Combi 40+ prosthesis (Med-El Company, Vienna, Austria), taking special cardiological precautions. Twelve electrodes were inserted in the cochlea. All electrodes were activated in programming of the speech processor (Table I). The categorisation of auditory performance scale[15] and the speech intelligibility rating scale[16] were used to measure the patient's speech perception and speech production, respectively, at 12-month intervals, for the first four years after implantation (Tables II and III).

Four years after cochlear implantation, the patient was placed into regular schooling. She was able to understand conversation without lip-reading, and her speech was intelligible to a listener with limited experience (Table IV). Treatment with propranolol continued, and she had suffered no further syncopal episodes.

Cases two and three

Two further cases of Jervell, Lange-Nielsen syndrome were siblings.

The first child was a three-year-old boy, the child of consanguineous parents. He had been diagnosed with severe to profound sensorineural hearing loss at six months of age and fitted with a powerful conventional hearing aid at seven months. However, he showed no auditory perception or language development. Thus, he was referred to the cochlear implantation centre.

During medical evaluation, the mother reported that, from the age of 40 days, the child had suffered syncopal attacks along with cyanosis of the lips, usually following crying. Phenobarbital treatment had been prescribed, and the number of attacks had decreased within one month; therefore, the mother had discontinued the medication. However, from the age of two years, these attacks had recurred, usually during the day time and each lasting less than two minutes.

Psychological evaluation indicated symptoms of attention deficit/hyperactivity disorder in the child.

TABLE I
FITTING PARAMETERS FOR CASE 1* AT LAST PROGRAMMING

Channel	1	2	3	4	5	6	7	8	9	10	11	12
MCL/CU	445	483	483	513	513	547	547	609	640	655	678	748
THR/CU	199	199	220	225	233	239	239	254	316	332	332	355
DYN/dB	7.0	7.7	6.8	7.2	6.8	7.2	7.2	7.6	6.1	5.9	6.2	6.5
PD/μS	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7

P rate/channel: 977.2 Pps = Pulse rate/channel: 977.2 Pulse per second; strategy: CIS = continued interval stimulus. *Med-El Combi40+ implant. MCL = most comfortable level; CU = current; THR = threshold; DYN = dynamic; PD = pulse duration; μS = microsecond

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TABLE II

CATEGORIES OF AUDITORY PERFORMANCE SCALE

Level	Description
0	Unaware of environmental sounds
1	Aware of environmental sounds
2	Responds to some speech sounds
3	Identifies environmental sounds
4	Discriminates some speech sounds without lip-reading
5	Understands common phrases without lip-reading
6	Understands conversation without lip-reading
7	Uses the telephone with a known speaker

He was referred for cardiac investigations. An ECG indicated a heart rate of 60 per minute, a normal axis and a regular rhythm; however, a prolonged QT segment (0.490 ms) with biphasic T wave were noted (Figure 2). The patient showed no cyanosis, clubbing or thrill. The cardiac rhythm was sinuous, and the size of the chambers was normal.

The second child was a one-and-a-half-year-old boy with severe to profound congenital deafness who had not benefited from conventional hearing amplification. He had never suffered any syncope or seizure attacks. On referral to a cardiologist, the ECG tracing indicated a heart rate of 75 per minute, a normal axis and a regular rhythm, but also a prolonged QT segment of 0.583 ms; this was considerably greater than the normal value (Figure 3). No ventricular heave, cyanosis, thrill or clubbing were noted. The heart chambers were of normal size.

Both children were diagnosed with Jervell, Lange-Nielsen syndrome. Electrocardiography traces performed on their father and mother revealed QT segments of 0.46 and 0.43 s, respectively.

In both cases, treatment with propranolol was commenced after diagnosis. Both boys underwent implantation with Med-El Combi 40+ prostheses, under cardiological monitoring. All electrodes were activated in programming the speech processor.

The boys' performance in speech perception and speech production tests at 12-monthly intervals following implantation are presented in Table IV. Following cochlear implantation, no syncope attacks were reported. Treatment with beta-blocker was continued. At the time of writing, both children were attending mainstream preschool.

TABLE III

SPEECH INTELLIGIBILITY RATING SCALE

Level	Description
0	Pre-verbal
1	Sign language
2	Unintelligible
3	Intelligible to an experienced listener
4	Intelligible to a listener with limited experience
5	Intelligible to all

TABLE IV

RESULTS FOR SPEECH PERCEPTION AND SPEECH PRODUCTION DEVELOPMENT* BEFORE AND AFTER COCHLEAR IMPLANTATION

Case	Scale	Pre-CI	Post-CI (months)				
			0†	12	24	36	48
1	CAP	0	1	4	5	6	6
	SIR	0	0	2	2	4	4
2	CAP	1	1	5	5	6	6
	SIR	0	0	2	3	3	4
3	CAP	ND	1	5	5	6	6
	SIR	0	0	2	3	4	4

*Measured by the categories of auditory performance (CAP) and speech intelligibility rating (SIR) scales. †At switch-on. CI = cochlear implantation; ND = no data

Discussion

Long QT syndrome was so named due to its appearance on electrocardiography. The QT interval is increased, equal to or greater than 0.44 s in males and 0.46 ms in females.

In the Jervell, Lange-Nielsen syndrome type of inherited long QT syndrome, the person is also deaf. Studies of otherwise healthy people with long QT syndrome have indicated that they have suffered at least one episode of 'blacking out' (i.e. fainting) by the age of 10 years. The majority also have a family member(s) with a long QT interval.[17]

It should be emphasised that people with long QT syndrome do not necessarily have a prolonged QT interval all the time. Thus, the QT interval in a routine ECG may appear normal. Children with this syndrome may show prolongation of the QT interval when provoked by physical exercise, emotions such as fright, anger or pain, or a startling noise.[2–5]

- **Jervell, Lange-Nielsen syndrome is a condition that causes profound hearing loss and disruption of the normal cardiac rhythm, with a prolonged QT interval on electrocardiography**
- **This retrospective case study documented cochlear implantation in three profoundly deaf children with Jervell, Lange-Nielsen syndrome**
- **Cochlear implantation can be relatively safely performed in patients with Jervell, Lange-Nielsen syndrome, and these children received significant benefit from it**

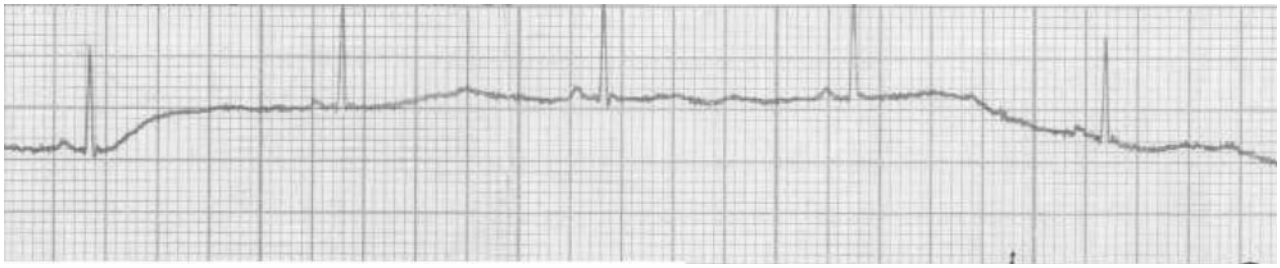

FIG. 2
Electrocardiogram of case two.

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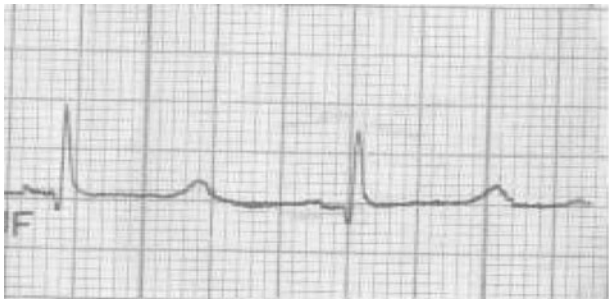

FIG. 3
Electrocardiogram of case three.

Prolongation of the QT interval prevents effective contraction of cardiac muscle; the cardiac output to the body, and especially to the brain, is reduced. If the brain is starved of oxygen, the person will faint within seconds. If the normal cardiac rhythm cannot be regained, ventricular fibrillation may ensue. Without immediate emergency treatment, death follows within minutes. Congenital forms of long QT syndrome usually appear as syncopal attacks or grand mal seizures. A familial history of unexpected deaths or sudden infant deaths may be considered an indication of this syndrome.[10,11]

Provided that special pre- and peri-operative precautions are observed, cochlear implantation can be relatively safely performed in patients with Jervell, Lange-Nielsen syndrome. These precautions include cardiac monitoring for 48 hours, peri-operative beta-blockade and special anaesthetic considerations.[13,14]

We retrospectively assessed speech perception, speech production and educational setting in three profoundly hearing-impaired children with Jervell, Lange-Nielsen syndrome who had undergone cochlear implantation. The data showed that these children had received significant benefit from cochlear implantation. In addition to obtaining improved auditory skills and speech production, all three children were mainstreamed into regular educational settings, where they had a better chance of developing their communication and social interaction skills. At the time of writing, all three children wore their speech processor during all waking hours; this implies that they benefited from cochlear implantation. All three children showed increasing levels of speech perception and speech intelligibility following their cochlear implantation (Table IV). We conclude that these children will continue to benefit from the auditory input provided by their cochlear implant.

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