A Case of Abnormal Impedance Fluctuations in a Patient with AIED following Cochlear Implantation

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ABSTRACT

Cochlear implants directly stimulate the auditory nerve, bypassing the hair cells of the inner ear damaged as a result of disease, trauma, or other etiologies. Measuring impedances is an essential part of ensuring a properly functioning cochlear implant, as impedance values indicate the resistance of the signal transmission from the electrode to the surrounding tissue. In this case study, we explored patterns of impedance measurements in one patient with Autoimmune Inner Ear Disease (AIED), thereby documenting an occurrence of widely fluctuating impedance values over several years. We demonstrated how these fluctuations differed from those of patients implanted for SNHL due to non-immune related causes. In this case, we encountered impedance fluctuations in a patient with AIED, we examined a feature that may aid in characterizing AIED and help better understand this condition.

INTRODUCTION

Autoimmune Inner Ear Disease (AIED) is often characterized clinically as a rapidly progressive, fluctuating SNHL occurring bilaterally, often asymmetrically, with or without dizziness, and running a course of within a few days to within weeks or months.1 The symptoms may begin unilaterally and progress to the other ear or may be sudden in onset.1 The first reported cases that linked auto-immune related functions to hearing loss were those documented by McCabe in 1979 in a study where 18 patients with hearing disorders showed improvement upon treatment with immunosuppressive therapy.2 Although the efficacy for cochlear implantation for AIED patients has been reported several times, little is reported with regards to the optimization aspects of these implants, which is an important step towards improving outcomes.3 Methods of decreasing or stabilizing impedance levels are important to increase effectiveness of cochlear implants in patients and optimize the function of the implant.4 This becomes increasingly important in AIED patients whose only treatment option when the hearing loss reaches profound impairment is cochlear implantation, but whose impedance levels can fluctuate unpredictably due to their disease. It is also important, therefore, when atypical cases of physiologically induced impedance fluctuations occur, that they be identified rather than being ascribed to device failure.

LITERATURE REVIEW

A retrospective study by Bovo et al. explored the effects of AIED, specifically Cogan’s syndrome, on the functional outcomes of cochlear implantation, measured via audiological means such as loudness and speech perception as well as word identification.1 One concern for Cogan’s syndrome patients, as well as patients with other forms of AIED with regards to cochlear implantation is the possibility of fibrosis or ossification that can interfere with the function of the implant. All patients’ impedance levels were within normal ranges.

Another study done by Wang, et al. compared the outcomes post-implantation in AIED patients with pets who had SNHL due to other causes and found that both groups attained high levels of post-implantation speech perception and performed above average, advocating for the use of cochlear implants as a treatment for hearing loss in AIED and Cogan’s syndrome patients. Although this study looked at a larger cohort (25 patients) than most other studies on the same topic, the paper by Wang et al. failed to document changes in impedance measurements over time for the patients, whereby the impedances documented in the Bovo et al. paper were within normal limits.1,3 Wolfe et al. also presented a similar case of a patient in whom fluctuations in impedances measurements occurred as a result of physiological mechanisms and not due to device failure.4 This study showed that there may be other physiological mechanisms at play for the aberrant impedance values in certain patients with immune-mediated inner ear disease previously overlooked.

METHODS

Patient: 65 year old female with AIED attributed to meningitis, lumbalgia and responsive to steroids implanted with Cochlear Nucleus Freedom cochlear implant for her R ear at 61 years of age. L ear also implanted.

Controls: 3 non-AIED patients; mean age of 72 years (range: 64 years to 80 years). Two male and two female. All implanted with Cochlear Freedom Contour Advance devices.

All patients were in the clinical caseload of Columbia University Medical Center (CUMC)/ New York-Presbyterian Hospital. CI surgeries were performed at CUMC.

PROCEDURE

Intensive case study with retrospective serial impedance measurements from an AIED patient with implants compared to serial measurements in implanted individuals with non-AIED etiologies. Postoperative impedance values obtained from Cochlear, research program, Custom Sound v.4.1. Extracted from Columbia University Medical Center’s electronic medical record. For the non-AIED patients, one year’s impedance measurements post-implantation were used.

Impedances were measured using the manufacturers’ default modes: common ground (CG) and all 3 monopolar modes (MP1, MP2, or MP1+2). Due to the large amount of data, CG was the only mode examined in the present report. The median, mode, minimum, maximum, and +/- 2 standard deviations were found for all 22 electrodes for all patients and comparisons were made to determine the extent of fluctuation in the case study patient compared to the controls. Specific electrodes 3, 7, 11, 16, and 20 were picked for comparison. Furthermore, the AIED patient’s clinical records from CUMC’s electronic medical records were reviewed for relevant medical conditions or treatment regimens the patient was undergoing during time periods of impedance fluctuations.

RESULTS

Figure 1 (A-E): Showed are graphs comparing the patient’s data for selected electrode sites, +/- 1 and +/- 2 standard deviations from the controls’ median and mean. Irrespective of time period or electrode chosen, there appear to be significant fluctuations in the AIED patient compared to both the median and the mean calculated from 3 control patients. Electrodes 11, 16, and 20 show at least 2 standard deviation increase from the controls’ median and mean whereas electrodes 3 and 7 show more than 1 standard deviation fluctuation from the control median and mean. The numbers on the x axis of the graph correspond to visit numbers.

Figure 2: Reduction in fluctuation patterns in response to steroid therapy. In addition to the fact that this graph shows large amounts of fluctuations (greater than +/- 2 standard deviations from both the median and the mean) at many visit points (y-axis), the graph also shows stabilization of the impedance values towards the median after the administration of immunosuppressive medications such as prednisone, dexamethasone and the chemotherapeutic cocktail (highlighted in orange) confirming the immune-mediated nature of the hearing loss and indicating that the patient’s fluctuations may also be due to an immune-mediated process.

DISCUSSION

This case report describes a woman who demonstrates abnormal fluctuations in impedance values in multiple electrodes. All evidence points to her underlying AIED as causative of these fluctuations. The apparent stabilization of the patient’s impedance levels while on steroids (Fig 2 labeled in orange) further attests to her AIED as the likely cause of her abnormal impedances. Other possibilities include medications she was taking, such as furosemide or Klor-con, however there is no data that these medications cause impedance fluctuations. The blood labyrinth barrier is a highly sensitive location and disruptions for electrolyte homeostasis in this region may have disruptive effects on cochlear implant function. Thus, it may be possible that drugs known to alter this delicate balance of electrolytes would contribute to impedance fluctuations in patients. To our knowledge, no studies, however, have been done to support that use of furosemide as an anti-diuretic in patients produce the fluctuations in impedance measurements characteristic of our patient. Similarly, our patient was also on Klor-con, a treatment for hypokalemia, which is known to affect systemic electrolyte levels; however it is not documented as having an effect on cochlear implant impedance values either. Therefore, it appears more likely that our patient represents a case of a physiologic condition that is causing her abnormal impedance values but which is not attributable to either of her medications alone or the device itself. There have been studies documenting higher impedances values and more frequently fluctuating measurements are often found within the higher frequency electrodes of cochlear implants.6 Our study differs in that our patient exhibits fluctuations at all electrodes indicating another possible, likely systemic, physiological mechanism for the aberrant values. Thus, because the impedance fluctuation patterns in our patient are not consistent with device failure nor can they be attributed to device functionality or other medications she was on, coupled with the stabilization of values during steroid regimen, this case therefore documents an instance of a patient who possesses a physiologic condition that potentially caused the fluctuated values irrespective of the device functioning itself, similar to Wolfe et al.’s patient.

REFERENCES