Risk Factors for Underlying Bilateral Vestibular Weakness in Cochlear Implant Candidates

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Abstract

Intro: Cochlear implantation (CI) has been associated with postoperative vestibular dysfunction in the implanted ear, however, limited data on baseline vestibular function in these patients exists. Previous investigation by this research team found that 39.4% of traditional cochlear implant candidates demonstrate some vestibular weakness on caloric testing and that one quarter of these have some degree of underlying bilateral weakness. We have shown in our previous work, that vestibular weakness is associated with poorer low tone hearing but have not evaluated patients with bilateral weakness as an independent subgroup. Studies have reported that bilateral vestibular weakness is associated with detrimental effects on quality of life including decreased social engagement and difficulty performing activities of daily living. As such, it is important to identify patients with a preexisting bilateral weakness and consider this information in surgical planning.

Methods: Retrospective cohort study (2012-2022) of the CI candidate population. All patients underwent routine preoperative vestibular evaluation, irrespective of symptoms. Patients found to have a bilateral preoperative vestibular weakness were included in this study for further analysis.

Results: Of a total of 180 preoperative VNGs, 39.4% showed vestibular weakness as determined by caloric testing. Of these, 26.8% exhibited a bilateral weakness. Patients with bilateral weakness had higher BMI (31.6 kg/m^2) than those with unilateral weakness or normal function (26.2 and 27.4 kg/m^2, p=0.007). Age approached significance with bilaterally weak patients tending to be younger (58.9 yrs) compared to unilateral weakness or normal function (68.1 vs 66.3 yrs, p=0.089). No comorbidities including history of MI, peripheral vascular disease, or diabetes were found to be associated with a bilateral weakness. Further analysis of the audiologic data in the worse hearing ear revealed worse hearing at 250, 500 and 1000 Hz (p<0.05). Hearing threshold of 60 dB or worse at 250 Hz was found to be the best prognostic indicator for bilateral weakness. At a threshold of 60 dB at 250 Hz, all patients with bilateral weakness are captured (100% sensitivity), with a specificity of 34.5%.

Conclusion: More than one third of CI candidates have some degree of underlying vestibular dysfunction and 10.5% exhibit a pre-existing subclinical bilateral weakness. The results of this study indicate that audiologic data may be a useful prognostic indicator of preexisting bilateral vestibular weakness, with a pure tone threshold of 60 dB or worse at 250 Hz, in the worse hearing ear, as a cutoff point to identify patients that should undergo vestibular testing, with 100% sensitivity and 34.5% specificity. Given the well documented detrimental effects of bilateral vestibular weakness on quality of life, we recommend that all patients who meet this cut off undergo vestibular testing to assess for an underlying weakness and that this information be considered in surgical planning.

Introduction

Cochlear implantation (CI) has been associated with postoperative vestibular dysfunction in the implanted ear. Advances in surgical approach and electrode types have allowed for less traumatic implantation with better preservation of neural elements and hearing. Despite this, there has been concern that manipulation of the inner ear and placement of a foreign body can cause significant inflammation and possible damage to the vestibular system.

Traditionally in a preoperative CI evaluation, the audiologic data is the driving factor for surgical planning of which ear to implant. Although iatrogenic postoperative vestibular dysfunction is a known risk of this procedure, preoperative evaluation of the vestibular system is not common practice. Patients with preexisting vestibular dysfunction, particularly those with weakness bilaterally, may be at higher risk for increased morbidity as a result of implantation. Studies have reported that bilateral vestibular weakness is associated with detrimental effects on quality of life including poorer quality of life, decreased social engagement and difficulty performing activities of daily living. As such, it is important to identify patients with a preexisting subclinical bilateral weakness who may be at an elevated risk for development of symptomatic vestibular dysfunction postoperatively and consider the vestibular function of the ear to be implanted as a factor in surgical descion making as well.

This study aims to evaluated the prevalence of underlying bilateral vestibular weakness in CI candidates and identify demographic and audiologic risk factors that may be associated with a higher risk.

Materials and Methods

A retrospective cohort study of the traditional CI candidate population evaluated at a single institution over 10 years (2012-2022). Demographic, audiologic and videonystagmogrophay (VNG) data was obtained via electronic medical record query and subsequent chart review. All patients evaluated for CI candidacy underwent routine preoperative VNG testing as part of routine standard of care in this practice, irrespective of symptoms. Patients found to have bilateral preoperative vestibular weakness were included for further analysis.

Preoperative audiologic data including pure tone thresholds at 250, 500, 1000, 2000, 4000 and 8000 Hz were included in analysis, as well as the pure tone average (PTA) (mean of 500,1000, 2000 Hz) and low pure tone average (LPTA) (mean of 250,500 Hz), which were calculated manually. Comprehensive VNG was performed for all patients, with caloric testing as the specific test of interest in this study. Bilateral weakness was determined by combining at the maximum slow phase velocity (SPV) for both ears and was defined as as 24 degrees/ second for both ears combined.

Results

- **39.4%** of traditional CI candidates had a pre-existing vestibular weakness as determined by caloric testing and of these, **26.8%** exhibited a **bilateral vestibular weakness**.
- Patients with bilateral weakness had a **higher BMI** (**31.6 kg/m2**) than those with unilateral weakness or normal function (26.2 and 27.4 kg/m2, p=0.007)
- Bilaterally weak patients tended to be younger (58.9 years) compared to unilateral weakness or normal function (66.9 years, p=0.036)
- No comorbidities investigated were found to be associated with bilateral vestibular weakness
- Patients with bilateral vestibular weakness were found to have **worse hearing at 250, 500 and 1000 Hz** (p<0.05)
  - Using **a threshold of 60 dB at 250 Hz** as an indicator for bilateral weakness and need for further vestibular testing, all patients are captured (100% sensitivity), with a specificity of 34.5%.

VESTIBULAR FUNCTION IN TRADITIONAL CI PATIENTS

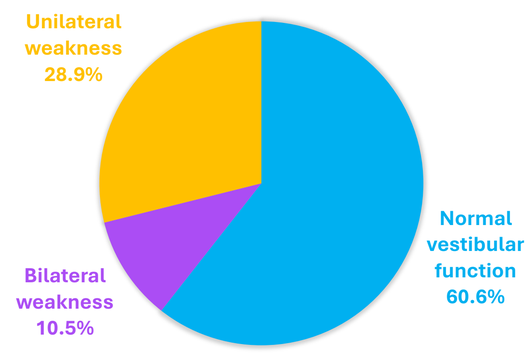

Figure 1. Vestibular status of traditional cochlear implant candidates

Audiologic Data for CI Candidates			
	Bilateral Weakness		
	Yes	No	
# Patients (%)	161 (89.5%)	19 (10.5%)	
250 Hz (Mean, SD)	88.5 dB (14.7)	68.5 dB (24.8)	0.001*
500 Hz	92.1 dB (14.8)	77.0 dB (24.7)	0.015*
1000 Hz	97.9 dB (14.4)	84.7 dB (20.5)	0.011*
2000 Hz	94.7 dB (16.1)	91.1 dB (19.6)	0.462
4000 Hz	97.9 dB(13.0)	103.0 dB (83.5)	0.805
8000 Hz	96.8 dB (10.1)	93.4 dB (13.3)	0.321
LPTA	90.3 dB (14.3)	72.7 dB (24.0)	0.004*
PTA	94.9 dB (13.1)	84.3 dB (18.8)	0.024*

Table 1. Preoperative audiologic data for cochlear implant candidates. LPTA - low pure tone average (mean of 250, 500 Hz). PTA – pure tone average (mean of (mean of 500, 1000, 2000 Hz).

Demographic Characteristics of CI Candidates			
	Bilateral Weakness		
	Yes	No	p-value
# Patients	161 (89.5%)	19 (10.5%)	
Male	52.9%	43.3%	0.448
Female	47.1%	56.7%	
Age (Mean, SD)	58.9 years (16.8)	66.9 years (14.6)	0.036*
BMI (kg/m^2)	31.6 kg/m^2 (7.1)	27.0 kg/m^2 (5.4)	0.003*

Table 2. Demographic characteristics of cochlear implant candidates. BMI – body mass index.

Discussion

Cochlear implantation is a common surgical technique for hearing restoration in adult patients with moderate to profound sensorineural hearing loss. Although the literature has described vestibular dysfunction as a possible complication of cochlear implantation, it is not common practice amongst otolaryngologists to obtain routine preoperative evaluation of the vestibular system. This study highlights the prevalence of underlying vestibular weakness in this patient population and found that more than 10% of patients who undergo cochlear implantation will exhibit some degree of bilateral weakness. This is significant as patients with underlying bilateral weakness may be unable to compensate for further vestibular insult as a result of surgery and may be at risk for the detrimental effects of quality of life including imbalance, oscillopsia, depression, memory and concentration impairment.[2,3] Patients suffering from bilateral vestibular hypofunction may decrease their social engagement, change their driving habits and have difficulties with performing activities of daily living due to the symptoms.[3]

This study adds to a small body of literature existing regarding vestibular function in CI candidates. Nayak and colleagues described 21.5% of their CI population had preoperative bilateral vestibular hypofunction and found that patients with either bilateral or unilateral dysfunction were more likely to experience long lasting postoperative dizziness.[1] This is the first study to our knowledge to correlate a patient's audiologic data with their vestibular health and provide a clinical tool for the identification of patients at risk for bilateral vestibular weakness. We were able to define a cutoff point of 60 dB at 250 Hz as an indicator for possible preexisting bilateral vestibular weakness, that we would recommend warrants further vestibular testing.

Conclusions

More than one third of CI candidates have some degree of underlying vestibular dysfunction and 10.5% exhibit a pre-existing subclinical bilateral weakness. The results of this study indicate that audiologic data may be a useful prognostic indicator for the risk of underlying bilateral vestibular weakness and that a pure tone threshold of 60 dB or worse at 250 Hz may be used as a cutoff point to help identify these patients with 100% sensitivity and 34.5% specificity. Given the well documented detrimental effects of bilateral vestibular weakness on quality of life, we recommend that all patients who meet this cut off undergo vestibular testing to assess for an underlying weakness and that this information be considered in surgical planning.

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