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Sudden sensorineural hearing loss after COVID-19 vaccination
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A B S T R A C T
Coronavirus disease 2019 (COVID-19) spread rapidly and was declared a pandemic (Kilic et al., 2020, Iftekhar et al., 2021). At present, more than 200 million people worldwide have been infected, among whom more than four million have died. In this situation, vaccination for COVID-19 is important and is being prompted in many countries.

Rare serious adverse events, including Guillain-Barré syndrome, thrombosis with thrombocytopenia syndrome after adenovirus-vector Janssen COVID-19 vaccination, and myocarditis after messenger ribonucleic acid (mRNA) Pfizer-BioNTech and Moderna COVID-19 vaccinations have been reported (Rosenblum et al., 2021). Otolaryngologic adverse events after COVID-19 vaccination were observed, including several cases of sudden sensorineural hearing loss (SSNHL) reported in the Centers for Disease Control and Prevention (CDC) Vaccine Adverse Events Reporting System (VAERS) in the United States (Formeister et al., 2021).

SSNHL is defined as hearing loss ≥30 dB over three consecutive frequencies within three days (Okhovat et al., 2015, Chandrasekhar et al., 2019, Kolarov et al., 2019). The etiology of SSNHL usually is idiopathic, but it can be attributed to viral infection, vasculitis, autoimmune disease, and tumor (Baxter et al., 2016, De Marco et al., 2018, Chandrasekhar et al., 2019). We report three patients with SSNHL within three days after COVID-19 vaccination and consider an association between them.

CASE PRESENTATION

Case 1

A 64-year-old female visited our clinic for sudden hearing loss in the right ear, which had occurred two days prior. The symptom occurred one day after her first dose of COVID-19 vaccination with adenovirus vector Oxford-AstraZeneca. Initial hearing threshold with a weighted four-frequency average ([500 Hz + 1000 Hz × 2 + 2000 Hz × 2 + 4000 Hz] / 6) was 86 dB in the right and 17 dB in the left ear on pure tone audiometry (Figure 1A). She received high-dose oral steroid (prednisolone 60 mg per day for five days, which was tapered for the next five days). Temporal magnetic resonance imaging showed normal findings.

After five days of treatment, hearing threshold improved to 30 dB in the right ear on pure tone audiometry. Due to incomplete recovery and residual symptoms of hearing loss in the right ear, salvage treatment with intratympanic steroid injection (dexamethasone 5 mg every third day for three cycles) was performed. After

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that, the hearing threshold recovered completely to 16 dB in the right ear on pure tone audiometry.

Case 2

A 42-year-old male visited our clinic for sudden hearing loss in the left ear, which had occurred two weeks previous, with no symptoms of vertigo. The symptom occurred on the day of the first dose of COVID-19 vaccination with Pfizer-BioNTech. Initial hearing threshold with weighted four-frequency average was 13 dB in the right and 9 dB in the left ear on pure tone audiometry, but there was acute hearing loss at low frequencies in the left ear (40, 45, and 30 dB at 125, 250, and 500 Hz, respectively) (Figure 1B). He received high-dose oral steroid (prednisolone 60 mg per day for five days, which was tapered for the next five days).

After treatment with systemic steroid, hearing threshold at low frequencies recovered partially, but symptoms of hearing loss remained. Thus, salvage treatment with intratympanic steroid injection (dexamethasone 5 mg every third day for five cycles) was performed. After intratympanic steroid injection, hearing threshold at low frequencies improved (25, 30, and 10 dB at 125, 250, and 500 Hz, respectively).

Case 3

An 18-year-old male visited our clinic for sudden hearing loss in the right ear, which had occurred two weeks prior. The symptom occurred two days after the second dose of COVID-19 vaccination with Pfizer-BioNTech. Initial hearing threshold with weighted four-frequency average was 89 dB in the right and 13 dB in the left ear on pure tone audiometry (Figure 1C). He received high-dose oral steroid (prednisolone 60 mg per day for five days, which was tapered for the next five days). Intratympanic steroid injection (dexamethasone 5 mg every third day for five cycles) was administered simultaneously due to severe hearing loss. Temporal magnetic resonance imaging showed normal findings.

After treatment with oral and intratympanic steroid, hearing threshold worsened to 100 dB in the right ear on pure tone audiometry.

DISCUSSION

Several cases of SSNHL after vaccination have been reported, including after influenza vaccination (Huang et al. 2010, Baxter et al. 2016, Kolarov et al. 2019), tetanus and diphtheria vaccination as well as meningococcal polysaccharide vaccination (De Marco et al., 2018), and rabies vaccination (Güçlü and Dereköy, 2013, Okhovat et al., 2015). The etiology of SSNHL after vaccination is unknown (De Marco et al., 2018). In Baxter et al.’s large-scale study, there were no associations between SSNHL and previous vaccination, including trivalent inactivated influenza vaccine and others (Baxter et al., 2016, Formeister et al., 2021).

For the relation of SSNHL and COVID-19 vaccination, Formeister et al. reported that there were no associations between two mRNA COVID-19 vaccinations with Pfizer-BioNTech or Moderna and SSNHL (Formeister et al., 2021). In previously reported SSNHL cases after vaccinations other than the COVID-19 vaccine, the etiologies were unclear. Viral antigens after vaccination could induce immunologic response resulting in release of antibodies and cytokines. Immunocomplex mediation could cause autoimmune response directing antibodies to the cochlea (Okhovat et al., 2015). Immunologic and inflammatory responses might result in vasculitis and vascular ischemia of the cochlea. However, these etiologies including viral infection, vascular ischemia, and autoimmune response are known suspicious causes of SSNHL regardless of vaccination. Nonetheless, SSNHL within three days after COVID-19 vaccination has the possibility that vaccination is the significant cause.

Referring to the association between COVID-19 vaccination and Bell’s palsy, which is an acute idiopathic peripheral facial palsy with similar etiologies to SSNHL, might be useful. There have been more reported cases of Bell’s palsy after COVID-19 vaccination than those of SSNHL after COVID-19 vaccination. However, the association between facial palsy and COVID-19 vaccination remains unclear (Renoud et al., 2021, Shemer et al., 2021).

The treatment of SSNHL after COVID-19 vaccination is the same as that in the absence of the vaccine. Clinical practice guidelines for SSNHL indicated that corticosteroids can be offered within two weeks as initial therapy (Chandrasekhar et al., 2019). Immediate systemic steroid use in patients with SSNHL after vaccination can inhibit antibody formation in response to the vaccination. However, the effect of systemic steroid use in those patients has not been investigated thoroughly. Corticosteroids, immunosuppressive agents, and immunosuppressive diseases of vaccine recipients can affect the antibody response. For prevention of insufficient immunization after vaccination, intratympanic steroid rather than systemic steroid can be considered, as it might not suppress the immune system systemically (Güçlü and Dereköy, 2013). If systemic high-dose steroid was administered during the vaccination period, the measurement of antibody titer after completion of the vaccination might be necessary.

SSNHL can occur after COVID-19 vaccination, but the mechanism is unclear. Like in SSNHL unrelated to vaccination, prompt
systemic or intratympanic steroid administration is necessary in SSNHL after COVID-19 vaccination.

**CONCLUSION**

Although there is no direct evidence of the association between vaccination and SSNHL, the adverse event of SSNHL after COVID-19 vaccination should be kept in mind because viral infection could be the etiology of SSNHL.

**Declaration of interests**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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**Ethical Approval**

The Institutional Review Board of the authors’ institution exempted the review of this study (NHIMC 2021-09-028). Written informed consent was exempted by the Institutional Review Board because this study was retrospective.

**References**

Baxter R, Lewis N, Bohrer P, Harrington T, Aukes I, Klein NP. Sudden-onset sensorineural hearing loss after immunization: a case-centered analysis. Otolaryngol Head Neck Surg 2016;155(1):81–6.

Chandrasekhar SS, Tsai Do BS, Schwartz SR, Bontempo LJ, Faucett EA, Finestone SA, et al. Clinical practice guideline: sudden hearing loss (Update). Otolaryngol Head Neck Surg 2019;161(1_suppl):S1–45.

De Marco F, De Cesare DP, Di Folco F, Massoni F, Tomesi G, Di Luca NM, et al. Post-vaccinal temporary sensorineural hearing loss. Int J Environ Res Public Health 2018;15(8):1780.

Forneister TJ, Chien W, Agrawal Y, Carey JP, Stewart CM, Sun DQ. Preliminary analysis of association between COVID-19 vaccination and sudden hearing loss using US centers for disease control and prevention vaccine adverse events reporting system data. JAMA Otolaryngol Head Neck Surg 2021;147(7):674–6.

Güçlü O, Derıköy FS. Sudden hearing loss after rabies vaccination. Balkan Med J 2013;30(3):327–8.

Huang HH, Huang CC, Hsieh PY, Lee TJ. Bilateral sudden deafness following H1N1 vaccination. Otolaryngol Head Neck Surg 2010;143(6):849–50.

Iftikhar H, Noor SMU, Masood M, Bashir K. Bell’s Palsy After 24 Hours of mRNA-1273 SARS-CoV-2 Vaccine. Cureus 2021;13(6):e15935.

Kılıç O, Kalcıoglu MT, Çağ Y, Tuysuz O, Pektas E, Caskurlu H, et al. Could sudden sensorineural hearing loss be the sole manifestation of COVID-19? An investigation into SARS-COV-2 in the etiology of sudden sensorineural hearing loss. Int J Infect Dis 2020;97:208–11.

Kolarov C, Löbermann M, Fritzschke C, Hemmer C, Mlynarski R, Reisinger EC. Bilateral deafness two days following influenza vaccination: a case report. Hum Vaccin Immunother 2019;15(1):107–8.

Okhovat S, Fox R, Magill J, Narula A. Sudden onset unilateral sensorineural hearing loss after rabies vaccination. BMJ Case Rep 2015:2015 bcr2015211977.

Renoud L, Khouri C, Revel B, Lepelley M, Perez J, Roustit M, et al. Association of facial paralysis with mRNA COVID-19 vaccines: a disproportionality analysis using the World Health Organization Pharmacovigilance database. JAMA Intern Med 2021;181(9):1243–5.

Rosenblum HG, Hadler SC, Mouila D, Shimabukuro TT, Su JR, Tepper NK, et al. Use of COVID-19 vaccines after reports of adverse events among adult recipients of janssen (Johnson & Johnson) and mRNA COVID-19 vaccines (Pfizer-BionTech and Moderna): update from the advisory committee on immunization practices - United States, July 2021. MMWR Morb Mortal Wkly Rep 2021;70(32):1094–9.

Shechter A, Pras E, Einan-Lifshitz A, Dubinsky-Pertzov B, Hecht E. Association of COVID-19 vaccination and Facial Nerve Palsy: a case-control study. JAMA Otolaryngol Head Neck Surg 2021;147(8):739–43.