Research Article

Hearing Loss Characteristics of Workers with Hypertension Exposed to Occupational Noise: A Cross-Sectional Study of 270,033 Participants

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Objectives. This study investigated the hearing loss characteristics among occupational noise exposure workers with hypertension and the link between hypertension and hearing loss when exposed to occupational noise. Methods. A total of 267,766 occupational noise-exposed workers were enrolled, including 29,868 workers with hypertension and 240,165 without hypertension. Hypertension was diagnosed according to WHO criteria. Hypertension was classified into four grades based on blood pressure. Assessment of hearing was performed through measurement of an unadulterated tone threshold at different frequencies, which ranged between 250 and 8,000 Hz. Results. A substantial link was observed to exist between hypertension and the increment in the hearing limit. The increase in the hearing threshold was substantially higher among those having grade 2 hypertension. Conclusion. The current investigation suggested patients with hypertension exhibit a substantial rise in hearing loss in comparison with patients without hypertension. The rise in hearing loss was significant in patients with grade 2 hypertension. Efficient and practicable measures are required to decrease the hearing loss in workers with hypertension and work-related noise exposure.

1. Introduction

Hearing loss (HL) is regarded as an element that influences the quality of life irrespective of the commitment level. As adults acquire the same, HL exhibits gradual appearance and might give rise to spoken language issues [1, 2].

Noise is the most important environmental factor and the most frequent occupational hazard, predominantly found among industrial workers [3]. According to information originating from the American Speech Language Hearing Association (ASHA) [4], 28 million persons in the US have various kinds of HL, of whom 80% cannot be reversed. In addition, the data illustrates that 4.6% of persons 18–44 years of age face hearing loss. In contrast, 14% of persons 45–64 years of age and 54% of persons > 65 years of age encounter HL because of various elements, such as severe and/or continual noise contact, breathing poisonous materials, absorption of ototoxic medicines and contaminants, injuries, and genetic inheritance.

Arterial hypertension is associated with significant morbidity and mortality [5]. Arterial hypertension is related to stroke, heart disease, kidney disease, and vascular disease [6]. To maintain proper function, every living cell is dependent on an adequate provision of both oxygen and nutrients. Moreover, delivery of oxygen and nutrients is dependent on functional, as well as structural veracity of the heart and blood vessels [7]. Hypertension, which is considered to be the most common vascular syndrome, is likely to extend
The subjects in this investigation were 267,766 employees who were exposed to work-related noise. The recruitment of the subjects was carried out from the key occupational-disease monitoring information system of the work-related noise coverage in Jiangsu Province, China. In the key occupational-disease monitoring information system, the subjects were employees recruited in noise-exposed workplaces, as recommended for the purpose of enhancing the standard of treatment and recovery in HL patients.

2. Methods

2.1. Subjects. The subjects in this investigation were 267,766 employees who were exposed to work-related noise. The recruitment of the subjects was carried out from the key occupational-disease monitoring information system of the work-related noise coverage in Jiangsu Province, China. In the key occupational-disease monitoring information system, the subjects were employees recruited in noise-prone manufacturing units of mechanical tools, domestic appliance production, steel construction, and cigarette manufacture/packaging in Jiangsu Province, China. The workers who wore auditory aids or had drug-induced deafness were excluded from the study. The subjects faced work-related noise for a period > 1 year where the noise exposure had an intensity > 80 dB (A) (LEX, 8h). Determination of the intensity of noise in the working environment was performed with the help of a noise statistical analyser (AWA6218; Westernization Instrument Technology Co., Ltd., Beijing, China). Evaluation of the noise exposure was carried out using the equivalent continuous dB (A) weighted sound pressure levels (LEX, 8h), as recommended by the Occupational Health Standard of the People's Republic of China: Measurement of Noise in the Workplace [GBZ/T 189.8–2007] (China, 2007).

2.2. Blood Pressure Measurement and Definition of Hypertension. As per the standard protocol, subsequent to > 12h of noise contact, recording of the systolic blood pressure (SBP) and diastolic blood pressure (DBP) was carried out by trained physicians. The measurement was performed with the use of a mercury sphygmomanometer with the subjects sitting following ≥ 15 min of rest. Reporting the SBP and DBP made the average of 4 recurring calculations using 30 sec intervals. The definition of hypertension was a SBP ≥ 140 mmHg and/or a DBP ≥ 90 mmHg. Analysis of the data included by the medical examination report was performed. Subjects were categorized by different levels of hypertension in accordance with the blood pressure recordings, as stated by the WHO with respect to hypertension. In general, the diagnosis of hypertension is carried out on the bases of a consistently elevated blood pressure. As evident from Table 1, the WHO/ISH blood pressure classification integrates four levels of hypertension.

2.3. Pure Tone Audiometry. An otolaryngologist inspected the ears of each subject who had undergone pure tone audiometry testing in a sound-adjusting cabin with a contextual noise level < 25 dB (A). Testing of both ears was carried out through the use of a pure tone at frequencies of 0.5, 1, 2, 3, 4, and 6 kHz. The subjects were required to avoid a loud atmosphere for > 12 h prior to the test. Repetitions of the trials were performed a minimum of 3 times for determination of the least signal severity, which served as the ultimate threshold value for all ears. The use of mean threshold values at 0.5, 1, and 2 kHz was made for determination of the low-frequency hearing position. In contrast, the mean threshold values at 3, 4, and 6 kHz were utilized for determination of the high-frequency hearing position. In addition, a nick of the noise-induced hearing loss (NIHL) was displayed at approximately 3-6 kHz. Moreover, the threshold values at high frequency were considerably worse compared with the threshold values at low frequency. Definition of the audiometric shortcoming or HL was put forward as a hearing threshold > 25 dB, subjected to the high frequency or high and low frequencies. The diagnostic criteria of work-related NIHL were developed on the bases of the Chinese work-related health standards (GBZ49-2014, http://www.zybw.net). On a specific test frequency, the definition of normal hearing was designated as the binaural hearing level ≤ 25 dB. Furthermore, the definition of unilateral hearing loss was made as monaural hearing > 25 dB. In addition, the bilateral hearing loss was termed binaural hearing level > 25 dB.

2.4. Statistical Analysis. Ascertainment of the cumulative noise exposure (CNE) was performed as follows: CNE = 10 × log(10 SPL/10 × years of noise exposure), wherein the SPL indicates the sound pressure level [dB (A)] of the noise contact. Expression of the continued variables for the normal distribution was the mean ± standard deviation (SD). Expression
Table 2: Demographic characteristics of hypertension of the subjects with occupational noise exposure.

| Variable                        | No HT  | Grade 1 HT | Grade 2 HT | Grade 3 HT | Grade 4 HT | p value |
|---------------------------------|--------|------------|------------|------------|------------|---------|
| No. of workers                  | 240165 | 12723      | 1990       | 585        | 12303      | <0.01   |
| Age (yr)                        | 33.30(9.19) | 39.91(9.79) | 42.79(9.36) | 43.55(8.70) | 38.35(11.12) | <0.01   |
| Mean (SD)                       |        |            |            |            |            |         |
| Gender (No.)                    |        |            |            |            |            |         |
| Male                            | 181497 | 10829      | 1665       | 503        | 10184      | <0.01   |
| Female                          | 58668  | 1894       | 325        | 82         | 2119       | <0.01   |
| Working age (yr)                | 9.65(8.55) | 14.03(10.08) | 15.80(10.43) | 16.06(10.51) | 12.68(10.26) | <0.01   |
| Mean (SD)                       |        |            |            |            |            |         |
| Work age of noise exposure (yr) | 5.21(6.37) | 7.93(8.07)  | 8.39(8.41)  | 8.58(8.49)  | 7.20(7.73)  | <0.01   |
| Mean (SD)                       |        |            |            |            |            |         |
| No. of Hearing loss workers (%) | 100247(41.74) | 5860(46.06) | 997(50.10)  | 277(47.35)  | 6089(49.49) | <0.01   |

Figure 1: Blood pressure of the subjects with occupational noise exposure, *P<0.05, **P<0.01, in comparison with the No HT group.

3. Results

An aggregate of 267,766 subjects were enrolled in our investigation, of whom 240,165 comprised the control subjects with no hypertension and 27,601 were diagnosed with hypertension. In addition, 12,723 patients were diagnosed with grade 1 hypertension in accordance with the WHO categorization for hypertension. Moreover, 1990, 585, and 12,303 patients were diagnosed with grade 2, 3, and 4 hypertension, respectively. Patients with grade 2 hypertension had the largest proportion of HL workers (P<0.05; Table 2).

The mean levels of SBP were as follows: 119.89 ±11.22 mmHg (No HT); 145.96±5.58 mmHg (grade 1 HT); 165.55± 5.21 mmHg (grade 2 HT); 190.91±12.23 mmHg (grade 3 HT); and 145.29±6.74 mmHg (grade 4 HT). The mean levels of DBP were as follows: 76.04±8.74 mmHg (No HT); 93.27±3.04 mmHg (grade 1 HT); 103.40±3.05 mmHg (grade 2 HT); 120.66±10.00 mmHg (grade 3 HT); and 82.87±6.03 mmHg (grade 4 HT). Figure 1 shows the percentages of subjects with hypertension, together with systolic hypertension and diastolic hypertension, which were substantially greater in the hypertension cohort in comparison with the No HT cohort (P<0.05).
Despite the similarity between the confounding factors, the link existing between HL and hypertension was observed in the current cross-sectional inspection.

Overall, the hypertension, together with systolic hypertension and diastolic hypertension, was more frequent in the occupational noise-exposed workers. There might be an augmented HL in response to the hypertension levels. This outcome could be predicted by an earlier examination [18–21]. The stria vascularis is located in the lateral cochlear wall and is responsible for sending auditory signals from the cochlea to the central nervous system [15]. Vascular supply to the stria vascularis is derived from terminal arteries with no collateral supply. Therefore, the stria vascularis is particularly sensitive to events that compromise the vascular supply. Animal studies have shown reduced endocochlear potential and HL after an anoxic event [16, 17]. It is hypothesized that hypertension may compromise the vascular supply to the stria vascularis, thereby leading to HL [7]. In the current study, the hypertension group exhibited the highest risk of HL in comparison with the No HT group \((P<0.05)\). The mechanism underlying the impact of hypertension on hearing is not clear. This relationship between HL and arterial hypertension has been the subject of investigations in recent decades, but the findings are inconsistent [18–21].

With aging there is a substantial increase in the number of chronic diseases [22–24]. Systemic arterial hypertension, together with HL, is common in the elderly [25]. Different investigations provide justification that sensorineural HL occurs with aging and is associated with microcirculatory inadequacy, secondary to vascular occlusion from emboli, haemorrhage, or vasospasm. Moreover, sensorineural HL is associated with hyperviscosity or microangiopathy stemming from diabetes or hypertension, and the latter condition gives rise to sensorineural HL [26–28]. We investigated the higher age range as an independent risk factor for hypertension and HL [4]. With the specific goal for the removal of confounding factors, such as age, we carried out binary logistic regression analysis. We showed that hypertension is a risk factor for HL in noise-exposed workers \((P<0.05)\). As revealed by the findings, the impact of grade 1 hypertension, grades 2 and 3 hypertension, and isolated systolic hypertension on hearing impairment was quite evident \((P<0.05)\). Moreover, the subjects with noise exposure were at substantially higher risk for HL in comparison with the No HL group \((P<0.05)\).

4. Discussion

**Table 3:** Binary logistic regression analysis of hearing loss and hypertension adjusted for age, gender, and SBP (OR: odds ratio; CI: confidence interval).

| Hearing loss (vs No HL) | OR (95% CI) | \(P\)    |
|------------------------|------------|--------|
| Age                    | 1.050(1.050-1.051) | <0.01  |
| Gender                 |            |        |
| Male                   | 1.438(1.426-1.461) | <0.01  |
| Female                 |            |        |
| DBP                    | 1.046(1.032-1.060) | <0.01  |

**Figure 2:** Mean pure tone thresholds by hypertension severity, \(* P<0.05, ** P<0.01\), in comparison with the No HT group.

**Table 4:** Binary logistic regression analysis of hearing loss and hypertension adjusted for age, gender, and DBP (OR: odds ratio; CI: confidence interval).

| Hearing loss (vs No HL) | OR (95% CI) | \(P\)    |
|------------------------|------------|--------|
| Age                    | 1.05(1.050-1.052) | <0.01  |
| Gender                 |            |        |
| Male                   | 1.442(1.422-1.463) | <0.01  |
| Female                 |            |        |
| DBP                    | 1.003(1.001-1.005) | <0.01  |
In comparison with the No HL group, the subjects in the HL group and gender were at higher risk \((P<0.05)\). The mean arterial pressure was higher in males compared to females \([29, 30]\). Pulsatile pressure primarily predominates in females, especially the elderly, as a consequence of short stature \([31, 32]\). Male gender was confirmed to be an independent risk factor for HL \((P<0.05)\).

The current research work had a number of limitations. The size of the cohort work was greater in comparison with former research. The research subjects in this case-control study were Chinese. Our study was a case-control and did not explain whether or not hearing loss was caused by high blood pressure or high blood pressure was caused and did not explain whether or not hearing loss was caused.

Conflicts of Interest
The authors have no conflicts of interest to declare.

Authors’ Contributions
Boshen Wang and Lei Han contributed equally to this article.

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