Cochlear dysfunction with acoustic trauma in fire shooting training

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Abstract. Acoustic trauma risk for athlete shooter is huge. Continuous exposure to firearms may further increase the risk of acoustic trauma. Continuous exposure causes damage to hair cells in the cochlea that cause cochlear dysfunction and will increase the hearing threshold. The aim of this study was to determine the difference of hair cell damage in cochlea which can cause cochlear dysfunction due to acoustic trauma after shooting practice based on duration and frequency of training. There was no statistically significant difference in audiogram results between the first group and the second group (Mann-Whitney U Test, p<0.05). The distortion product of otoacoustic emission (DPOAE) showed a significant difference between the first group and the second group (Mann-Whitney U Test, p<0.05). Different test results on audiogram and DPOAE between right and left in each group showed no significant difference (Wilcoxon Signed Ranks Test, p<0.05). There was a significant difference in the incidence of hair cell damage in cochlea with the duration and frequency of training.

1. Introduction

Large acoustic energy (explosions, gunfire, bombs) can cause acoustic trauma. This can cause mechanical damage in the form of tympanic membrane rupture, ossicular damage, hydrolimfatic rupture, basilar cell membrane damage, and hair cell injury can also cause metabolic damage in the form of oxidative stress in Corti organs [1], [2]. Oxidative stress is a condition of stress in the cells due to an unbalanced amount of increased reactive oxygen species (ROS) production with an inexpensive intracellular system of superoxide dismutase (SOD) and glutathione peroxidase (GPx) [3]. Oxidative stress on cochlea that accumulates in the long term causes apoptosis and ends with cochlear dysfunction [4].

The hair cells of Corti's organs are essential for converting acoustic energy into electrical stimuli that are channeled into the hearing center of the brain. Sensorineural hearing loss (SNHL) is the most common type of hearing loss due to hair cell damage in the Corti organ. It is a disability affecting one person and over 48 million Americans. The causes of SNHL are numerous, one of which is acoustic trauma [5]. A pure tone audiometric examination (ANM) is a subjective examination that can assess the auditory function at the overall level of the auditory system from the outer ear to the auditory cortex. Examination of distortion product of otoacoustic emission (DPOAE) is an objective examination useful for assessing hearing function at the level of outside hair cells in the cochle [6].
World Health Organization (WHO) data in 2005 showed that there were 278 million (4.2%) of the world’s population suffering from hearing loss. According to the Southeast Asia Multi Center Study survey, Indonesia is one of 4 countries with a high prevalence of deafness that is 4.6% of the total population of Indonesia [7]. This prevalence can cause social problems in the community. This prevalence is high enough to create social problems in the community. Hearing disorders experienced by veterans in the United States is in the third ranks after mental disorders and musculoskeletal disorders [8].

Study in Magelang, shows the incidence rate of acoustic trauma at the police academy was 12.4%. Study in Makassar police department found an acoustic trauma event of 16.67% [9]. A study of young soldiers in France who were observed for 15 days using DPOAE showed a high frequency hearing loss with persistent tinnitus, which occurred 24 hours after exposure to an automatic machine-gun blast. Research in Brazil with DPOAE showed significant hearing loss at 3-6 kHz at 24-72 hours after noise trauma, accompanied by persistent tinnitus symptoms [10].

The more exposed to the sound of firearms, will increasing the risk of acoustic trauma. The aim of this study was to determine the difference of hair cell damage of the hearing organ (cochlea) due to acoustic trauma after shooting practice based on duration and frequency of exercise.

2. Methods
This study compared two groups that performed once shooting practice with hair cell damage after doing 5 shooting exercises. Samples include a student of the Sekolah Polisi Negara (SPN) of East Java which has undergone shooting practice. It was random sampling. Both was taken 100 students from 700 students of the academic year 2017-2018. Students who are unwilling to attend research and students with disorders in the middle ear are not included in the study. Intensity of short guns and the long-barreled guns was measured in December 2016, at 1 meter and 10 meters.

Definitions of the hearing loss are permanent hearing loss due to the strong acoustic exposure and abrupt energy, which by examination of pure tone audiometry has obtained a threshold increase of 15 dB or more at 500, 1000, or 2000 Hz; or 20 dB or more at a frequency of 3000, 4000 or 6000 Hz, or acquired an acoustic notch at a frequency of 4000 Hz without or accompanied by an increase in the 500 Hz, 1000 Hz, 2000 Hz frequency threshold that occurs in SPN students. On DPOAE examination obtained referral results that show hair cells damage at a frequency of 3000-6000 Hz, especially the frequency of 4000 Hz. Sound level meters are placed 10 meters and 1 meter from the shooter.

Materials and tools consist of letter of agreement, stationery, ENT examination tool. Sound level meter, pure tone audiometry, DPOAE examination tool. The results were descriptive frequency distribution data. The audiogram results are rated at 4000 Hz. DPOAE results are also rated at 4000 Hz.

3. Results
The sound intensity of guns recorded on the sound meter level was 91 to 106 dB, compare the long barrel of 97 to 106 dB. In 1 meter, gun intensity level was 111 to 128 dB, while the long barrel was 117 to 126 dB. Conclusion from the results explain that all sound intensity levels reach more than 90 dB could damage to hair cells. Audiogram result shows that the first group that got increase of hearing threshold was 7 students (7%), left ear was 15 students (15%). The second group got increase of hearing threshold was 5 students (5%), the left ear was 7 students (7%). Refer DPOAE results to first group; right ear 17 students (17%) compare to 30 students (30%). The second group of references on the right ear 61 students (61%) compare to 59 students (59%).

There was no statistically significant difference in audiogram results between the first group and the second group (Mann-Whitney U Test, p <0.05). The DPOAE results showed a significant difference between the first group and the second group (Mann-Whitney U Test, p <0.05) (Table 1). Different test results on audiogram and DPOAE results between right ear and left ear in each group showed without significant difference (Wilcoxon Signed Ranks Test, p <0.05) (Table 2).
Table 1. Test result for the first and second group.

|                | OAE_KA | OAE_KI | AUDIO_KA | AUDIO_KI |
|----------------|--------|--------|----------|----------|
| Mann-Whitney U | 2800.000 | 3550.000 | 4900.000 | 4550.000 |
| Wilcoxon W     | 7850.000 | 8600.000 | 9950.000 | 9600.000 |
| sZ             | -6.363 | -4.116 | -0.594 | -1.990 |
| Asymp. Sig. (2-tailed) | .000 | .000 | .553 | .047 |

Table 2. Formatting sections, subsections and subsubsections.

|             | OAE_KI - OAE_KA | AUDIO_KI - AUDIO_KA |
|-------------|-----------------|---------------------|
| z           | -2.600b         | -2.324b             |
| Asymp. Sig. (2-tailed) | .009 | .020 |

4. Discussion

This study shows that the intensity level generated by the gun, measured at 10 meters with 100 dB, and 1 meter with 120 dB. The average intensity level of the long-barrelled gun at 10 meters was 102 dB, and at 1 meter was 122 dB. This is contrast due to another reference which is the average intensity level of long-barrelled gun is 162 dB and for a 158 dB [10]. This difference is due to the intensity measured at 10 meters and 1 meter from the source of the eruption, not on the tip of the gun. The measurement is also done in the open airfield so that the results are influenced by wind, and there was less objects that reflect sounds like trees, building walls, and other hard objects. Some references showed that the intensity of gun lies at the tip of the gun and the noise exposure depends on the intensity, direction and the presence of objects that reflect or muffle the sound [11], [12], [13].

From this research, the result of audiogram in the first group as many as 19 students (19%) experienced an increase of hearing threshold. The right ear 7 students (7%) and the left ear 15 students (15%), and both ears as many as 4 students. There were 10 (10%) students who experienced an increase in the threshold. right ear 5 students (5%), left ear 7 students (7%), and both ears 1 student (1%). From the results of this study showed that the left ear has more hearing threshold increase, but there is no significant difference. This is consistent with Budiyanto's research at Akpol Semarang reporting 11% left ear acoustic trauma and right ear 6.2%, while both ear (1.4%). Acoustic trauma events in the left ear are more than the right ear, this can be caused by the position of the body when firing, where the gun is placed right with the gun body attached to the right shoulder, allowing ear distance closer to the source of the explosion than the right ear. so that the intensity of gun eruptions that affect the ear is larger than the right ear and also the result of a head-shadow effect, in which the head obstructs or protects the eruption of guns on the right and left [9].

From the results of this study there was no significant difference in audiogram results between two groups. There is a significant difference of DPOAE results between the first group and the second group. Audiometry examination is a subjective examination that assesses hearing function at the overall level of the auditory system from the outer ear to the auditory cortex. The DPOAE examination is an objective examination that is useful for assessing hearing function at the level of the hair cell in the cochlea [14]. The results of this study indicate that DPOAE is more sensitive than audiometry in assessing cochlear dysfunction. Exposure to continuous noise causes a shift in basilar membrane and damages stereo cilia, hair cells, and organ of Corti. This explains why in the second group more damaged hair cells, especially at the frequency of 4000 Hz. Cochlear damage due to frequency and high intensity centred on the frequency of 4000 Hz. Approximately 10 mm from the oval window is the area with the weakest anatomical structure and 4000 Hz receptor is the largest amplitude hair cell and receives the greatest energy from noise exposure. This place is the weakest point on the organ of Corti.
5. Conclusion
Exposure to gunshot explosion sound over a long period of time can damage the hair cells in the auditory organs, especially at 4000 Hz frequency that can be detected by DPOAE examination. There were significant differences in hair cells damage in cochlea caused by acoustic trauma with duration and frequency of exercise. SPN students are advised to use ear protection while undergoing shooting exercises. There was time limitations of this study. Further research is needed to investigate more about these case.

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