Acoustic Trauma Associated With Howitzer 105 Artillery Weapon Gunner

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ABSTRACT---- ***The military is an environment with high risk of occupational deafness. Acoustic trauma is a sensorineural hearing disorder on frequency 2-6 kHz, caused by impulsive loud noise. This study aims to assess the occurrence of acoustic trauma on a Howitzer 105 gunner. Indonesian military currently doesn't have hearing conservation program.***

The study used prospective period method from 7-10 July 2014, which the subject is new recruit soldiers in Artillery Academy of Indonesian Army. Subjects were divided into 2 groups that, consist of exposed with 17 gunners and non-exposed group(stae the number of subjects). The identity of subjects, their medical history and symptoms after firing were recorded on questionnaire. Sound intensity and frequency of sound were measured using Integrating Sound Level Meter and Real Time Analyzer. Hearing function was recorded using pure tone audiometry. The data significance ($p<0.05$) was tested by Fisher Exact test.

The result of the study shown that the sound pressure level of Howitzer 105 artillery weapon sum of 148.6 dBA with frequency that decays to 60 dBA for 2 seconds, while the impulsive sound intensity received at a distance of one meter, crossed the limit of the 1998th National Institute for Occupational Safety and Health (NIOSH) criteria. The incidence of acoustic trauma on the gunner without ear protection is significant at 23.5% ($p\leq0.05$), with symptoms of tinnitus and temporary hearing disorders (1 day) is only 6% and was not significant ($p>0.05$).

Keywords--- Acoustic trauma, Howitzer 105 artillery weapon, noise dose

1. INTRODUCTION

Ear is a hearing organ for all God's creations that must be well maintained to function optimally. The Indonesian Ministry of Health has created a National Strategy Plan in treating hearing disorders and hearing loss. Implementing this program by 2030 may make Indonesian citizens to have rights of having an optimal degree of ear health and hearing function. (WHO, 2004; Keputusan Menteri Kesehatan Republik Indonesia, 2006; Bashiruddin, 2009)

Acoustic trauma (AT) is a sensorineural hearing disorder on frequency 2-6 kHz, caused by impulsive loud noise. (Alberti, 1997; Dobie, 1998)

The work environment of the armed forces places military personnels to be at risk of suffering occupational hearing loss caused by the use of main equipments for system of defense as one of the skill requirements. The level of noise allowed in a work environment is limited to 85 dB (according to Indonesian Ministry of Manpower regulations established in 1999). The United State Occupational Safety and Health Administration *(*US–OSHA*)* obligates activities with high level of noise (90 dBA or more) to implement the Hearing Conservation Program / HCP. Indonesia only has a threshold value for high level of noise and this shows the lack of law and regulations, which worsens the noise management in Indonesia. (Direktorat Bina Kesehatan Kerja, 2006; Bashiruddin, 2009)

According to international occupational health policies, the military environment should already establish regulations/policies and form organizations that implements hearing conservation programs for its personnels. For example, the United States of America's Ministry of Defense or the land component of Armed Forces has written policies to protect the hearing of the soldiers or associated civilians when at work, training, and in the battlefield. (Army hearing program. ST 4-02.501, February 1, 2008 ; Hearing Conservation Program (HCP). DoDI 6055.12, December 3, 2010)

Currently, the Indonesian National Armed Forces (INAF) has not yet established work regulations/policies or even instituted occupational health organizations that handles hearing conservation programs for the soldiers.

The arising issue was whether acoustic trauma occurs in gunners after firing the Howitzer 105 artillery weapon ?

The general purpose of this research is to assess the risks of acoustic trauma in the Howitzer 105 artillery weapon gunners, with a specific objective of measuring the audiometric function of gunners, before and after firing practice at the Artillery Academy of Indonesian Army in Cimahi, West Java.

The scientific benefits from this study is to support the pathogenic theory of acoustic trauma associated with pure tone audiometry frequency measurements, also to add epidemiologic data of occupational hearing loss events in the

military, meanwhile the practical benefit is to increase the awareness of the risks of acoustic trauma, so as to prevent permanent hearing loss, as a reference for future studies of acoustic trauma preventions associated with the hearing conservation program, and to also give input to the INAF board of leadership in establishing education, practice, and operational policies for the soldiers.

2. MATERIAL AND METHODS

The subjects of this study are new private soldiers that are in training of the Howitzer 105 artillery weapon firing at the Artillery Academy of Indonesian Army in Cimahi, West Java, that were divided into two groups, of exposed and non-exposed groups respectively on the basis of simple randam sampling.

Inclusion Criteria of the research is new soldiers in the Artillery Academy of Indonesian Army with normal health status data from the early data of the applicants selection, and the exclusion criteria of this research is 1) found an abnormality in the otoscopy and audiometric examination, 2) previous history of chronic otitis media, 3) previous history of ear surgery, 4) history of chronic ototoxic drug use, 5) history of hearing disorder since an early age, 6) suffers from tympanic membrane perforation due to artillery weapon firing practice, 7) previous history of head trauma, 8) history of familial deafness, 9) previous history of chronic neurologic disease, 10) suffers from diabetes mellitus, 11) history of alcohol abuse and addiction. 11) suffers from malignant diseases

Research methods is a quantitative study with a cross sectional design, towards the exposed and the controlled non-exposed group. The case and control group are taken from the same population, where the samples are determined by using the simple random sampling method. The size of the sample is determined by using the Kastebaum curve (Madiyono et al, 2008).

3. RESULTS AND DISCUSSION

Sound pressure level of Howitzer 105 artillery weapon was conducted in two ways by using four BSWA – MPA416 microphones with Yoshimasa software and using an Integrating Sound Level Meter and Real Time Analyzer RION NA – 28 Class I.

The measurement shows that sound pressure level from Howitzer 105 artillery weapon with a one meter distance beside the cannon was 148.6 dBA, with time required after explosion to disintegrate until 60 dBA was approximately for two seconds. Noise dosage (% dose) received by the firing soldiers at a one meter distance beside the cannon was 381.43% to 850.49% (NIOSH rules).

Auditory function examination results of the subjects before and after the Howitzer 105 artillery weapon firing exercise that was held in the Audiology Division, Otorhinolaryngology Department of Dustira Army Hospital, using an Grasson Stadler audio-tympanometer type (GSI-38) USA 2010 that was calibrated in soundproof space.

From Table 1 shown above it is demonstrated that the total of firing soldiers (exposed group), who experienced acoustic trauma (AT) were 4 out of 17 persons (23.5%), compared to the control group. To see the AT comparison, hearing disturbance and tinnitus in exposed group, it is listed in the Table 2. From Table 2, it is shown that the Acoustic Trauma (AT) incidence occurred to 23.5% gunners (exposed group), which is statistically significant ($p \leq 0.05$), and was not a coincidence. Meanwhile, the incidence of hearing disturbance and tinnitus was not statistically significant ($p>0.05$).

Based on the sound pressure level measurement at a distance 1 meter beside the cannon which was 148.6 dBA, with time required after the explosion until it disintegrates to 60 dBA was approximately for 2 seconds. This fact was different with the theory that sound pressure level of the Howitzer 105 artillery weapon should be 183 dBA, also with another research conducted in 2003 with the same type of artillery weapon which stated the pressure level to be 173.4 dBA. This difference is caused by the amount of gunpowder component used in the current firing exercise (year 2014), which was 6 from maximum filling amount of 10; meanwhile, in the year 2003 used 7 filling from maximum of 10, and most probably the 183 dBA theory was gained by use of maximum filling.

Regarding the 2002 NIOSH rules concerning noise impulse deriving from gun explosions, the calculation of the allowed amount of explosion in a day applies the formula from the magnitude of L peak :

N = 10^((140-PI)/10); where PI = L peak – attenuation of hearing protection instruments.

According to NIOSH regulations, not even once a soldier can safely fire artillery weapons without hearing protection equipments. (Bashiruddin, 2009)

Based on The Indonesian Ministry of Manpower, Rule Number Per.13/Men/X/2011 in 2011 about the threshold level of physical and chemical factors in the workplace, no one is allowed to be exposed to any noise more than 140 dBA, even only for just a moment.

The results of pure tone audiometry examination on exposed group after firing artillery weapon exercise are 23.5% firing soldiers who experienced Acoustic Trauma (AT).

This result shows that there is damage of the hair cells in the cochlea, especially at the frequency of 4000 Hz in the right ear (according to the soldier's position to the detonator rope). This is in accordance to the theory, which is that AT classified in group of occupational hearing loss has a characteristic depiction of a 4 KHz dip in an audiogram, and this also matches the graphics of equal loudness contour in every frequency. (Sataloff and Sataloff, 1993; Dobie, 1998; Henderson et al, 2006)

The 4000 Hz frequency is the lowest point of the human ear from all the other frequencies because the human ear response to noise is different at every frequency, in the middle and high frequency the ear is more sensitive compared to the low frequency. (Dobie, 1998)Exposure to high frequency noise will cause damage on basal hair cells, meanwhile exposure to low frequency noise will cause damage on apical hair cells. (Sataloff and Sataloff, 1993; Nilland and Zenz, 1994)

The pure tone will travel as sound waves starting from the oval foramen towards the apical cochlea, where each frequency has its own special location in the cochlea. The high frequency is located in the basal cochlea and the low frequency in the apical cochlea. If there is damage, the high tone frequency will cause damage near the oval foramen and the low frequency cause damage at the apex. (Sataloff and Sataloff, 1993; Alberti, 1997)

Continuous noise exposure causes the notch to deepen and widen, subsequently forming the temporal plateau. This signals that the outer hair cells are damaged. (Nilland and Zenz, 1994)

This research is limited to new soldiers and according to the main duty of soldiers, a gunner should be in the private rank, but it can also be done by soldiers in the non-commissioned officer or officer rank, or soldiers who has long served the military.

The Howitzer 105 artillery weapon is the only type of the main equipment of the defense system that has been studied, but there are other weapons with bigger calibers and higher sound pressure levels.

4. CONCLUSION AND RECOMMENDATION

Acoustic trauma occurred to firing soldiers after firing of the Howitzer 105artillery weapon, especially :

1) The incidence of acoustic trauma in firing soldiers is 23,5%.
2) The sound pressure level of Howitzer 105 artillery weapon is 148,6 dBA with time required after the explosion disintegrate to 60 dBA is approximately for 2 seconds.
3) Noise dosage (% dose) received by the firing soldiers at a distance of 1 meter beside the cannon is 381,43 to 850,49% (NIOSH)

We recommended for :

(1) The artillery weapon shooters at risk of acoustic trauma should wear hearing protection equipment.
(2) There should be an institution and a hearing conservation program in the Indonesian National Armed Forces, as one of the work environment which places the personnels at risk of occupational hearing loss.

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Table 1 Pure Tone Audiometry Results in Soldiers After Firing

No	N A M E (AGE)	E/C	Audiometry *PRE* (R / L)				Audiometry *POST* (R / L)				Tinnitus	HD	Note
			500	1000	2000	4000	500	1000	2000	4000			
03	M. S (20 yo.)	E	25/25	15/15	15/15	20/20	25/20	20/15	20/20	35/30	No	No	AT
21	H (21 yo.)	E	25/25	15/10	20/15	15/15	20/25	20/20	30/20	40/20	No	No	AT
24	J A (22 yo.)	E	10/10	10/10	10/10	10/10	20/20	20/20	20/20	40/30	Yes (1 day	Yes (right)	AT
27	A A F. (20 yo.)	E	10/10	10/10	10/10	10/10	25/20	20/20	20/25	40/20	No	No	AT

Description :
E = Exposed Group (exposed to artillery weapon explosion)
C = Control Group (did not conducted artillery weapon firing)
R/L = Right / Left
AT = Acoustic Trauma
HD = Hearing Disorders

Table 2 Comparison of Acoustic Trauma (AT), Hearing Disturbance (HD) and Tinnitus between Two Groups

Group	TA (+)	TA (-)	Tinnitus (+)	Tinnitus (-)	HD (+)	HD (-)
Exposed Group (E) n = 17	4 (23,5%)	13 (76,5%)	1 (5,9%)	16 (94,1%)	1 (5,9%)	16 (94,1%)
Control Group (C) n = 17	0 (0%)	17 (100%)	0 (0%)	17 (100%)	0 (0%)	17 (100%)
p*)	0,05		0,5		0,5	

*) based on Exact Fisher method