FACTORS ASSOCIATED WITH HEARING LOSS IN HELICOPTER AIRCREW OF INDONESIAN ARMY AVIATION CENTER, SEMARANG

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ABSTRACT

Introduction: Hearing loss and tinnitus may occur in pilots due to exposure of the high noise level (ranges from 104-110 dB) generated by aircraft/helicopters. In addition, flying time, acoustic trauma, diabetes mellitus, hypertension and smoking are risk factors of hearing loss. **Objective**: to identify the factors associated with hearing loss in the crew of the Indonesian Army Aviation Center, Semarang

Methods: in the cross-sectional research, 114 military helicopter aircrews aged 20-58 years, working for the Army Aviation Center in Semarang were included. The exclusion criteria were history of previous ear surgery, infection of the outer and middle ear, the use of ototoxic drugs (kanamycin, cisplatin and carboplatin). The level of hearing loss and tinitus was assessed by otoscopy and audiometry. Whereas, tinnitus was obtained from the history taking. Data were analyzed using chi-square test and fisher's exact and Yates's correction.

Results: One hundred and fourteen subjects (mean age of 26.54 + 4.72) were included. Several factors such as flight time (p = 0.698), acoustic trauma (p = 0.151), diabetes mellitus (p = 0.596), smoking (p = 0.222), hypertension (p = 0.356) were not associated with sensorineural hearing loss. Several factors such as flight time (p = 0.706), acoustic trauma (p = 0.5160), diabetes mellitus (p = 0.789), smoking (p = 0.495), hypertension (p = 0.112) were not associated with tinnitus.

Conclusion: There is no association between flight time, acoustic trauma, diabetes mellitus, hypertension, and smoking and hearing loss.

Key words: Hearing loss, tinnitus, helicopter crew.

ABSTRAK

Latar belakang: Gangguan pendengaran dan tinitus dapat terjadi pada penerbang akibat paparan bising dengan intensitas tinggi (berkisar 104-110 dB) dari pesawat/helikopter. Selain itu, jam terbang, trauma akustik, DM, hipertensi, dan merokok dapat mempengaruhi kejadian gangguan dengar.

Tujuan: Mengevaluasi berbagai faktor yang berhubungan dengan gangguan pendengaran pada kru Helikopter Militer Pusat Penerbangan Angkatan Darat, Semarang.

Metode: dalam penelitian cross-sectional, sebanyak 114 subjek sampel pria dari kru penerbang helikopter Puspenerbad Semarang, usia 20-58 tahun dievaluasi tingkat pendengarannya. Kurang pendengaran dinilai dengan pemeriksaan otoskopi dan audiometri, sedangkan tinitus didapatkan dari anamnesis. Kriteria eksklusi meliputi pernah operasi telinga sebelumnya, infeksi pada telinga luar dan telinga tengah, serta riwayat atau pernah mengkonsumsi obat-obatan yang bersifat ototoksik (kanamisin, cisplatin dan carboplatin). Analisis data menggunakan uji chi-square dan fisher's exact serta yates's correction

Hasil: Seratus empat belas sampel dengan rerata umur 26,54+4,72 semua berjenis kelamin laki laki. Beberapa faktor seperti jam terbang (p=0,698), trauma akustik (p=0,151), diabetes melitus (p=0,596), merokok (p=0,222), hipertensi (p=0,356) tidak berhubungan dengan kurang dengar sensorineural. Beberapa faktor seperti jam terbang (p=0,706), trauma akustik (p=0,5160), diabetes melitus (p=0,789), merokok (p=0,495), hipertensi (p=0,112) tidak berhubungan dengan tinitus.

Kesimpulan: Tidak terdapat hubungan antara jam terbang, trauma akustik, diabetes melitus, hipertensi, dan merokok dengan gangguan pendengaran.

Kata kunci: Kurang dengar, tinitus, kru helikopter

INTRODUCTION

More than 2,000 hours of flight time has been associated with hearing loss in both ears (Dewi, 2012). Another study states that helicopter generates higher level of noise than aircraft with propellers such as the Hercules. While the Hercules generates a noise level of 94 dB, helicopters generate noise of 104-110 dB. Therefore, pilots of helicopters have 2.67 times greater risk to develop hearing loss compared to those of the aircrafts (Dewi, 2012). In other studies, it was found that aircraft noise is associated with hearing impairment in technicians (Choirunisa, 2017). The previous studies included pilots and technicians. However, there have been limited studies on the association between noise and hearing loss conducted in helicopter aircrew.

Hearing loss is the partial or complete inability to hear sounds in one or both ears. Hearing loss can occur in pilots due to the high intensity of noise generated by the aircraft (Eryani et al., 2017). The hearing loss include sensorineural hearing loss (SNHL) and tinnitus. Tinnitus is generally associated with hearing loss, acoustic trauma, age and stress and metabolic diseases such as diabetes mellitus and hypertension. Noise-induced hearing loss and tinnitus are the two most prevalent disabilities in veterans. The ear, specifically the tympanic membrane (TM), is the most sensitive organ to primary blast injury. Blasts can perforate the TM. The ossicular chain may be injured as a result of primary blast injury, with fracture of the ossicles or

disarticulation of the chain, both of which can result in conductive hearing loss (CHL) with or without SNHL. (Esquivel et al., 2018; Hecht et al., 2019; L. E. Humes et al., 2006; Yehudai et al., 2017).

Some risk factors for SNHL were diabetes mellitus and hypertension. Previous study in motorcyclists with metabolic syndrome (MetS) showed a significant incidence of SNHL. This is probably caused by the damage of morphology and function of the cochlea (Aghazadeh-Attari et al., 2017). A research in China also found that there was a significant relationship between the incidence of MetS and SNHL. The possible causes of SNHL remain unknown (Han et al., 2018).

The purpose of this study was to determine the factors associated with hearing loss in the military helicopter crews of the Indonesian Army Aviation Center, Semarang.

METHODS

This was a cross-sectional study conducted between July and August 2020. This study included 114 crews of the Indonesian Army Aviation Center, Semarang using protective equipment (ear plugs, earmuffs, helmets). The inclusion criteria in this study were 20-58 years of age and willing to take part in the study and signing an informed consent.The exclusion criteria were a history of previous ear surgery, an external and middle ear infection, a history of use of ototoxic drug (kanamycin, cisplatin, carboplatin). The military crews were given information about this research and asked their willingness by filling out and signing an informed consent form. Ethical clearance was obtained from the Health Research Ethics Commission (KEPK) of Faculty of Medicine, Diponegoro University, Semarang (156/EC/H/FK-UNDIP/VII/2020)

Measurement of Hearing Loss

ENT physical examination was performed with an otoscope. The subjects meeting the research criteria were subjected to audiometric examination of both ears in a room with a noise level of less than 40 dB.

The independent variables of this study were flight time, acoustic trauma, diabetes mellitus, hypertension, smoking, while the dependent variable were SNHL and tinnitus. Data on flight time, acoustic trauma, diabetes mellitus, hypertension, smoking and tinnitus were obtained using questionnaires. The duration of flight time was divided into two groups: <180 hours and ≥ 180 hours. Flight time was defined as the period of the aircraft crew and pilots start reporting for the flight service until the aircraft stops and all engines are turned off. Assessment of the number of hours was based on records of helicopter crew flight time. To become a pilot, they must have minimum 180 hours of flight time. Acoustic trauma was evaluated based on the history of shooting exercise among subjects.The sensorineural hearing loss (SNHL) was evaluated using

audiometer and defined as PTA> 25 dB accompanied by decreased air conduction (AC) and bone conduction (BC) and there is no AB gap between the two (AB gap <10 dB). The interpretation of the degree of hearing loss was based on the American Speech-Languange-Hearing Association.

Statistical Analysis

Data analysis was performed descriptively and analytically using bivariate analysis with Chi-Square test, with p <0.05 and 95% confidence interval (CI). Multivariate logistic regression analysis was performed on variables. The statistically significant level was set as P values less than 0.25.

RESULTS

The results of the study obtained 114 subjects with a mean age of 26.54 + 4.72 years, all were male.

Table 1. The Characteristic of subjects

Variable	F	%
Age		
Young adults (26-35 years old)	108	94,7
Older adults (36-45 years old)	6	5.3
Years of service		
≤ 5 years	76	6.,7
5 – 10 years	28	24.6
10 – 15 years	6	5,3
≥ 20 years	4	3.5
Total flight time		
≥ 180 hours	32	28.1
< 180 hours	82	71.9
History of acoustic trauma (shooting practice)		
Yes	102	89,5
No	12	10.5
Tinnitus		
Yes	24	21.1
No	90	78.9
Diabetes Mellitus		
Yes	1	0.9
No	113	99.1
SNHL		
Hearing Loss	46	40.4
Normal	68	59.6
Smoking		
Yes	64	56.1
No	50	43.9
Hypertension		
Yes	3	2,6
No	111	97.4
Crew		
Pilot	60	52.6
Avionic	18	15.8
Mechanic	31	27.2

Variable	F	%
FE	5	4.4

Table 2. Factors associated with SNHL

Variable	SNHL				P	RP	CI 95%	Yates
	+		-					
	N	%	N	%				
Total flight time (hours)								
≥ 180	12	26.1	20	29,4	0.698[¥]	0,85.	(0.37-1,96)	
< 180	34	73.9	48	70.6				
Acoustic trauma								
Yes								
No	39	848	63	92.6	0.151[£]	0.44	(0.13-1.49)	-
	7	15.2	5	7.4				
DM								
Yes	0	0	1	1.5	0.596[£]	-	-	1.000[€]
No	46	100	67	98.5				
Smoking								
Yes	29	63.0	35	51.5	0.222[¥]	1.61	(0.75-3.46)	-
No	17	37	33	48.5				
Hypertension								
Yes	2	4.3	1	1.5	0.356[£]	3.05	(0.27-34.6)	-
No	44	95.7	67	98.5				

note: *significant (p<0,05), [¥]chi-square,[£]Fisher's exact,[€]Yates correction

Table 2 shows the results, among subjects with > 180 hours of flight time based on the audiometric results, 12 subjects (26.1%) had sensorineural hearing loss. Meanwhile group with <180 hours of flight time, 34 subjects (73.9%) experienced SNHL (p = 0.698; RP: 0.85, 95% CI). History of acoustic trauma was not associated with SNHL. There were 39 subjects (84.8%) with a history of acoustic trauma who experienced SNHL and 7 subjects (15.2%) without a history of acoustic trauma experienced SNHL. Sixtythree subjects (92.6%) with a history of acoustic trauma did not experience SNHL, and 5 subjects (7.4%) without a history of acoustic trauma did not experience SNHL (p = 0.151; RP; 0.44, 95% CI).

There was 1 subject (1.5%) with type 1 diabetes (DM) had no SNHL and, 67 subject (98.5%) without DM had no SNHL. There were no subjects with DM who experienced SNHL, and it was found that 46 (100%) subjects without DM experienced SNHL. Based on yates correction or continuity correction with a value of 1000, the value obtained was greater than the value of p = 0.596 (p = 0.596; 95% CI). Twenty nine subjects (63%) with smoking status had SNHL and 17 non subjects (37%) without smoking status had SNHL. There were 35 subjects

(51.5%) with smoking status had no SNHL, while 33 subjects (48.5%) without smoking status had normal hearing (p = 0.222; RP; 95% CI).

In term of correlation between hypertension and SNHL, the study showed that 2 subjects (4.3%) with hypertension had SNHL, while in 44 subjects (95.7%) without hypertension had SNHL. One subject (1.5%) with hypertension did not have SNHL and 67 subjects (98.5%) without hypertension had normal hearing (p = 0.356, RP: 3.05; 95% CI).

Table 3. Factors associated with tinnitus

Variable	Tinnitus				P	RP	CI 95%	yates
	+		-					
	N	%	N	%				
Total flight hours								-
≥180	6	25	26	28.9	0,706¥	0.82	(0.29-2.30)	
<180	18	75	64	71,1				
Acoustic trauma								
Yes	22	91,7	80	88.9	0.516£	1.38	(0.28-6.74)	-
No	2	8.3	10	11.1				
DM								
Yes	0	0	1	1,1	0,789£	-		1.000€
No	24	100	89	98.9				
Smoking								
Yes	12	50	52	57.8	0.495¥	0.73	(0.30-1.80)	-
No	12	50	38	42,2				
Hypertension								
Yes	2	8,3	1	1,1	0,112£	8.09	(0.70-93.3)	-
No	22	91.7	89	98.9				

note: *significant (p<0,05), ¥chi-square, £Fisher's exact,€Yates correction

In regard to the relationship between total flight time history and tinnitus, the results showed that 6 subjects (25%) with ≥ 180 hours of flight time had tinnitus, and 18 subjects (75%) with <180 hours of flight hours also had tinnitus. In 26 subjects (28.9%) with ≥ 180 hours of flight time, tinnitus was not found. Sixtyfour subjects (71.1%) with <180 hours of flight time had no tinnitus (p = 0.706, RP: 0.82, 95% CI).

In the content of acoustic trauma, history of shooting exercise and tinnitus, there were 22 subjects (91.7%) with acoustic trauma had tinnitus, 80 subjects (88.9%) with acoustic trauma and without tinnitus and 10 subjects (11.1%) without acoustic trauma and tinnitus (p = 0.516; RP: 1,38; 95% CI).

Table 3 also shows that there were no subjects with DM (0%) who had tinnitus, and there were 24 subjects (100%) without DM but had tinnitus. One person (1.1%) with DM type 1 had no complaint of tinnitus, and 89 subjects (98.9%) did not suffer from DM nor complaint of tinnitus. Based on Yates correction or continuity correction with a value of 1.000 resulting in value greater than the p value = 0.789, there was no significant relationship between diabetes mellitus and tinnitus in military helicopter crews (RP; 95% CI :)

Twelve smokers (50%) had tinnitus, while 12 non smokers (50%) also had tinnitus. On the other hand, 52 subjects (57.8%) who smoked developed no tinnitus, also for 38 subjects (42.2%) who did not smoke, and did not get tinnitus (p = 0.495; RP; 0.73; 95% CI).

Two hypertension patients (8.3%) had tinnitus, while 22 subjects (91.7%) without hypertension also had tinnitus. There was 1 subject (1.1%) with hypertension but had no tinnitus, and 89 subjects (98.9%) were not hypertension, yet tinnitus (P = 0.112; RP; 8,09; 95% CI)

Table 4. Crews with flight time <180 who experienced hearing impairments and tinnitus

Crews	SNHL		Tinnitus
	Mild	Moderate	
Pilot	15	0	6
Avionic	4	1	5
Mechanic	13	1	7
FE	0	0	0
Total	32	2	18

Among subjects with less than 180 hours of flight time, mild SNHL was found in 32 subjects and was mostly found in pilots (15) subjects. Among crews with less than 180 hours of flight time, tinnitus was found in 18 subjects and it was mostly found in mechanics (7 subjects). SNHL and tinnitus were prevalent among pilots and mechanics

DISCUSSION

The study was conducted in 114 military helicopter crews divided into two groups: ≥ 180 hours and <180 hours of flight time, showing no correlation between flight time and hearing loss (p = 0.698). This study is in accordance with previous research showing no hearing loss among pilots with 200-1000 hours of flight time. However, among pilots with 1000-3000 flight hours, noise induced hearing loss was found (Atalay et al., 2016) (Kartika, 2017). This can be due to the sample under study having a total flight time of less than 200 hous of flight time leading to lack of intensity and time of exposure to noise and irregular flight schedule. This study also showed that there was no relationship between total flight time and tinnitus. This can be due to the fact

that the subjects examined were junior members who have low number of flight time, leading to small number of the incidence of tinnitus. Previous study showed that the higher intensity and duration of noise exposure was associated with the greater the risk of hearing loss such as tinnitus will be. Tinnitus is associated with hearing loss. Tinnitus is an early sign of impaired sensorineural hearing loss (Choirunisa, 2017).

In the group with acoustic trauma (history of shooting drill), there were 39 subjects (41.2%) with hearing loss and 5 subjects were in normal limits of hearing with a ($p = 0.151$). This results similar to that of previous research conducted at the state police school in Surabaya showing that out of 50 students, 28 subjects (56%) had hearing loss related to acoustic trauma (Purnami et al., 2020). Hearing loss can be caused by damage to the end of the stereocilia and actin filaments of stereocilia. The damage to the stereocilia ends is repaired within 24-120 hours, while the damage to the sterociliary actin filaments is repaired in 48 hours, and the stiffness of the outer hair cells will improve in 2 weeks. This also occurs because of the length of noise exposure where the shooting exercises is more frequent in educational students (Atalay *et al.,* 2016). This study showed that there was no relationship between acoustic trauma and tinnitus incidence in military helicopter crews ($p = 0.516$). This can be due to the frequency of shooting drills which was not conducted on daily basis and the use of hearing protection. The results of this study are in accordance with previous studies reporting 17% complaint of tinnitus from 204 personnel Swedish infantry. Tinnitus that occurs can be caused by damage to the hair cells when exposed to loud noises (L. Humes et al., 2010). Short-term exposures ranging from 1-4 hours has been found to cause several levels of hair cell damage. Damage can also be found in buffer cells, blood vessels and afferent fibers. A high intensity of noise in a short time can cause hair cell damage due to cell disruption (Atalay *et al.,* 2016).

Diabetes mellitus was not associated with SNHL ($p = 1.000$) and tinnitus ($p = 0.789$) in military helicopter crews. This is because the study subject is predominantly young adults so that those suffering from DM are less than those in older age. In contrast, other studies in pilots showed that there was a significant relationship between diabetes mellitus and the occurrence of hearing loss, the longer a person has diabetes, the higher the risk of hearing loss will be (Krismanita & Naftali, 2017). Diabetes mellitus can cause disturbances in blood vessels such as microangiopathy leading to hearing loss. Ringing sounds in the ears, discomfort in the ears are the initial complaints commonly found in acoustic trauma (Krismanita & Naftali, 2017).

This study found that smoking was not associated with SNHL ($p = 0.222$) and tinnitus ($p = 0.495$). This finding supports that of previous study showing that there was a significant relationship between smoking behavior and hearing loss, in which smokers were 1.224 times more likely to develop hearing loss than nonsmokers. Another study reported that differences in nicotine levels in *kretek* (clove) cigarettes 1.306 mg and nicotine levels in filter cigarettes 1.140 mg

had a chronic effect on endothelial nicotine exposure related to the process of arteriolar dilation in the form of capillary congestion, endothelial necrosis, stria vascular necrosis, vascular degeneration and cochlear hair cell necrosis leading toso that affect the development of of SNHL (Krismanita & Naftali, 2017). The results of other studies reported a significant relationship between the number of cigarettes consumed and the incidence of hearing loss.Thus, the higher number and more frequent exposure to nicotine and carbon monoxide increase the risk of hearing loss (Krismanita & Naftali, 2017). The limitation of this study was that it did not analyze the nicotine dose in cigarettes and the types of cigarettes smoked. Smoking has ben reported as a direct ototoxic (nicotine effect) and as a trigger for cochlear ischemia through the reproductive mechanism of carboxy hemoglobin, vasospasm, increased blood viscosity resulting in hearing loss (Safitri, 2017; Sari & Adnan, 2017).

This present study showed that hypertension was not associated with SNHL (p = 0.356) and tinnitus (p = 0.112). This was due to the larger number of subjects of young adults in which hypertension is less prevalent. One of the potential causes of association between hypertension- and hearing loss is due to abnormal blood flow to the cochlea, severe hypertension can cause bleeding in the inner ear leading to hearing loss. Poor blood flow due to arteriosclerosis can cause perfusion or inadequate blood flow to the cochlea (Krismanita & Naftali, 2017). Hypertension can cause tinnitus, presumably due to microcirculation damage to the cochlea due to decreased blood flow resulting from impaired autoregulation of blood flow throughout the body. The vessels in the cochlea serve as nourishment for the cochlea, protects the cochlea, and maintains endococcal stability. Vascular damage can cause cochlear ischemia resulting in clinical manifestations of hearing impairment, such tinnitus and hearing loss (Krismanita & Naftali, 2017).

Sensory neural hearing loss/SNHL and tinnitus were shown to be more prevalent among pilots and mechanics with flight time less than 180 hours. This might be due to to the higher noise exposure received and type of ear protection equipment used, as well as hearing protection behaviour.

CONCLUSION

There was no relationship between flight time, acoustic trauma, diabetes mellitus, hypertension, smoking and hearing loss in the military helicopter crews of the Indonesian Army Aviation Center, Semarang.

CONFLICT OF INTEREST

Authors declare that there is no conflict of interest regarading the publication of this manuscript

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REFERENCES

Aghazadeh-Attari, J., Mansorian, B., Mirza-Aghazadeh-Attari, M., Ahmadzadeh, J., & Mohebbi, I. (2017). Association between metabolic syndrome and sensorineural hearing loss: A cross-sectional study of 11,114 participants. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, *10*, 459–465. https://doi.org/10.2147/DMSO.S150893

Atalay, H., Babakurban, S. T., & Aydin, E. (2016). Evaluation of hearing loss in pilots. *Turk Otolarengoloji Arsivi/Turkish Arch Otolaryngol*, *53*(4), 155–162.

Choirunisa, R. (2017). Gangguan pendengaran dan kesehatan teknisi skadron udara 3 Lanud Iswahyudi serta hubungannya dengan tingkat kebisingan pesawat. *J Kesehat Lingkung*, *11*, 61–68.

Dewi, P. (2012). *Pengaruh tingkat kebisingan pesawat herkules dan helikopter terhadap terjadinya gangguan pendengaran pada penerbang TNI AU*. UNS.

Eryani, Y., Wibowo, C., & Saftarina, F. (2017). Faktor risiko terjadinya gangguan pendengaran akibat bising. *Medula*, 112–1716.

Esquivel, C. R., Parker, M., Curtis, K., Merkley, A., Littlefield, P., Conley, G., Wise, S., Feldt, B., Henselman, L., & Stockinger, Z. (2018). Aural blast injury/acoustic trauma and hearing loss. *Military Medicine*, *183*, 78–82. https://doi.org/10.1093/milmed/usy167

Han, X., Wang, Z., Wang, J., Li, Y., Hu, H., Hu, Y., Zhao, X., Zhan, Y., Yuan, J., Wei, S., Liang, Y., Zhang, X., Guo, H., Yang, H., Wu, T., Kong, W., & He, M. (2018). Metabolic syndrome is associated with hearing loss among a middle-aged and older Chinese population: a cross-sectional study. *Annals of Medicine*, *50*(7), 587–595. https://doi.org/10.1080/07853890.2018.1469786

Hecht, Q. A., Hammill, T. L., Calamia, P. T., Smalt, C. J., & Brungart, D. S. (2019). Characterization of acute hearing changes in United States military populations. *The Journal of the Acoustical Society of America*, *146*(5), 3839–3848. https://doi.org/10.1121/1.5132710

Humes, L. E., Joellenbeck, L. M., & Durch, J. S. (2006). Noise and military service: Implications for hearing loss and tinnitus. In *Noise and Military Service: Implications for Hearing Loss and Tinnitus*. https://doi.org/10.17226/11443

Humes, L., Joellenbeck, L., & Durch, J. (2010). *Noise and military service: implications for hearing loss and tinitus. Noise and Military Service: Implications for Hearing Loss and Tinitus*. 1–32.

Kartika, D. (2017). *Hubungan usia ,jam terbang , dan masa kerja dengan ambang dengar penerbang (studi di puspenerbad semarang tahun 2016)*.

Krismanita, N., & Naftali, Z. (2017). Hubungan lamanya menderita diabetes melitus dengan terjadinya peningkatan ambang pendengaran. *Jurnal Kedokteran Diponegoro*, *I*(6), 2.

Purnami, N., Helmi, F., & Herawati, S. (2020). Correlation of malondialdehyde and hearing threshold level at frequency 4000 Hz post gunshot exposure. *Oto Rhino Laryngologica Indonesiana*, *50*(1), 1. https://doi.org/10.32637/orli.v50i1.283

Safitri, A. (2017). *Hubungan antara frekuensi merokok dengan gangguan pendengaran di RSUD Dr Moewardi*. UMS.

Sari, A., & Adnan, A. (2017). Hubungan merokok dengan gangguan pendengaran akibat bising pada pekerja pabrik kelapa sawit X. *Orli*, 47.

Yehudai, N., Fink, N., Shpriz, M., & Marom, T. (2017). Acute acoustic trauma among soldiers during an intense combat. *Journal of the American Academy of Audiology*, *28*(5), 436–443. https://doi.org/10.3766/jaaa.16043