



Risk Factors that Affect the Incidence of Ear Barotrauma in Traditional Diver Fishermen

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ABSTRACT

Barotrauma is a disease or trauma that occurs when a body experiences sudden changes in pressure when diving. One type of barotrauma that is often experienced by divers is ear barotrauma. The purpose of this study is to determine the risk factors (including age, disease history, depth of diving, dive duration, frequency of diving, rest duration, and diving procedures) that influence the incidence of barotrauma in traditional diver fishermen in BulawaSub-District, Bone Bolango Regency. The method conducted in this study is analytical quantitative method with cross sectional study approach. This study is conducted through interview, observation, and measurement of divers' hearing loss in divers. The samples in this study are 34 traditional diver fishermen in BulawaSub-District, Bone Bolango Regency. The results obtained p-value for age=0.039, working period=1,000, depth of diving =0.032, dive duration=1,000, frequency of diving =1,000, rest duration=1,000, and diving procedure=1,000. The conclusion of this study is that there is a relationship between the age and depth of diving toward the incidence of ear barotrauma in traditional diver fishermen, while the factors of working period, dive duration, frequency of diving, rest duration, and diving procedures are not related to the occurrence of ear barotrauma in traditional diver fishermen in Bulawa Sub-district Bone BolangoRegency.

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INTRODUCTION

As a country with almost 70% of the territory, most of Indonesia' sliveliohood of the coastal population is fisherman. As the country grows, this condition actually forms the coastal population (fishermen) to develop their ability to get more fish by diving deeper (Ekawati, 2005).

Diving is generally done by a human with diving equipment such as skin diving, basic diving equipment (snorkels and fins or scuba diving). However, some of them are done without any kind of equipment and only rely on the breath-hold diving method (Suryono, 2012). People who dive with this technique use air supply from sea level and flow it through the air compressor (Surface Supplied Breathing Apparatus), also known as traditional divers (Kemenkes RI, 2013). This becomes a major concern because these traditional divers are not aware of the consequences of their health.

Due to the presumption caused by "sea devils," which are rooted through years in mostly coastal population, adequate health and safety diving method are ignored by the diver, and even they experience disturbance and problem

while diving (Suryono, 2012). Actually, many cases happen to traditional divers because of unsafe diving. They mostly get problems which are generally occurred by hyperbaric or high-pressure environment of more than one atmosphere. The change of pressure in the depth of 17 feet underwater is equal to a change in pressure at an altitude of 18,000 feet above the earth. Thus, change in environmental pressure occurs faster at the time of diving. The 1st 10 meters has relatively large changes of pressure in diving (PKHI, 2000). Hence, many injuries mostly occur at this shallow depth (4.3-17.4 feet or 1.3-5.3 meters), where it can cause rupture of the lymphatic membrane (Benz BG, et al., 2012).

According to Riyadi (2016), changes in air pressure can cause damage to body tissues called barotrauma that can occur in hollow parts of the body, including the lungs, paranasal sinuses, and ears (Riyadi, 2016). There are several high-risk factors that affect the physical condition of divers, which may lead to pain, paralysis/disability, to death (Ministry of Health, 2012).

The risks that priorly mentioned are not only caused by diving, but also influenced by the underwater environment,

diving techniques and equipment used, physical and mental condition of divers, and also the different pressure (Bofe J, 2014). Some of these risk factors can be described on how the characteristics of the dive fishermen are related to age, nutritional status, working period, education or knowledge, environmental conditions or changes in air pressure, adherence to correct diving procedures, depth of diving, type of diving performed, tools used, dive duration, frequency of diving, speed up to surface, and rest duration before re-dive and other factors.

Diving sickness, which traditional divers mostly experience, requires serious attention due to the short-term and long-term risks. Symptoms and signs are very diverse such as pain in ears (which may lead to a hearing loss), chest, and teeth. In long-term risk, the symptom mostly refers to lung disease (shortness of breath, coughing or blood coughing), paralysis or symptoms of stroke, vertigo, vision impairment, joint pain, muscle, and nose (sinus problems).

Regarding those risks mentioned, the specific data of health and safety knowledge of traditional diver fishermen are not provided yet. However, the information can be obtained from related research or study regarding the working condition of traditional diver fishermen. There are also some researchers and studies from the Ministry of Health in 2006 about the disease and accidents that experienced by traditional diver and fishermen. In Bungin Island, Nusa Tenggara Barat, there are 57.5% of traditional divers, and fishermen who experienced joint pain and hearing loss. Further, data from the Ministry of Health (2008) releases data that in Kepulauan Seribu, Pulau Panggang, dan Pulau Pramuka from 1994 to 1996, there are 41.37% of traditional diver fishermen experience ear barotrauma. Further, a study from Prasetyo et al (2011) states that there are 32.4% from 74 divers who experience the incident of barotrauma in Banyuwangi, and divers who experience barotrauma in middle ear cavity are 83.3%, and research from Bofo J (2014) also elaborates that there are 60 respondents suffered early symptoms of diseases such as dizziness/headache (21.2%), nasal and ear bleeding (7.5%).

Based on preliminary studies conducted on traditional diver fishermen located in Bulawa Sub-district Bone Bolango Regency, the equipment used in diving is quite limited. The equipment mostly consists of compressors which are commonly used to pump tires, fins, masks, hoses with regulators, and ballast from lead. From respondents observed, there are 3 respondents who are suffering from common illnesses caused by diving. These respondents are diagnosed with diving diseases, including ear barotrauma, decompression, and environmental diseases in the water. Some traditional diver fishermen (respondents) also suffer from deafness. Thus, one of the common health cases that arises from diving activities is hearing loss.

In concerning the risk factors that affect the occurrence of barotrauma in traditional diver fishermen, it encourages researchers to conduct this study with an aim to find out the risk factors that affect the occurrence of barotrauma in traditional diver fishermen in Bulawa Sub-district Bone Bolango Regency.

METHOD

This study applies an analytical quantitative method with a cross sectional study approach. To collect the data, it uses

observation and measurement of divers' hearing loss through questionnaires and observation sheets. In this study, the dependent variables and independent variables are observed at the same time. Respondents in this study are 34 traditional diver fishermen in Bulawa Sub-district Bone Bolango Regency that are taken by purposive sampling techniques.

FINDINGS AND DISCUSSION

Table 1.
Distribution of Respondents' Frequency based on Age, Working Period, Diving Depth, Diving Duration, Diving Frequency, Rest Duration and Diving Procedure

Variables	f	%
Age		
low risk (≤ 40 years)	27	79,4
High Risk (> 40 years)	7	20,6
Working Period		
Old (> 5 years)	26	76,5
New (≤ 5 years)	8	23,5
Depth of diving		
Shallow (0-10 meter)	27	79,4
Medium (> 10 -30 meter)	6	17,6
Deep (> 30 -40 meter)	1	2,9
Dive Duration		
long (≥ 25 minutes)	2	5,9
short (< 25 minutes)	32	94,1
Frequency of Diving		
often (≥ 3 times)	33	97,1
rarely (< 3 times)	1	2,9
Rest Duration		
Enough (> 10 minutes)	1	2,9
less (≤ 10 minutes)	33	97,1
Diving Procedure		
Implemented / According to SOP	2	5,9
Not Implemented / Not in accordance with SOP	32	94,1

In table 1, the distribution of age frequency of respondents (fishermen) ≤ 40 years is 27 people (79.4%), the working period of fishermen more than 5 years is 26 people (76.5%), the variable of depth of diving on shallow dives (0-10 meters) is 27 people (79.4%), the dive duration less than 25 minutes consists of 32 people (94.1%), the frequency of fishing which is done more than 3 times consists of 33 people (97.1%), rest duration which is done less than 10 minutes consist of 33 people (97.1%) and there are 32 people (94.1%) fishermen who do not comply the diving procedure based on SOP.

Table 2.
Distribution of Respondents' Frequency based on Barotrauma

Variables	f	%
Barotrauma Occurrences		
Intake	31	91,2
Perforation	3	8,8
Total	34	100

In table 2, there are 31 respondents (31%) experience the incidence of barotrauma intake compared to barotrauma perforation (3 respondents or equal to 8.8%)

Table 3
Age Relationship with Barotrauma

Age	Barotrauma Incident				Total	P value	Odds Ratio (OR)	
	Intake		Perforation					
	n	%	N	%				
Low risk (≤ 40 years)	26	83,9	1	33,3	27	79,4	0,039	0,069
High risk (> 40 years)	5	16,1	2	66,7	7	20,6		
Total	31	100	3	100	34	100		

In table 3, there are 26 respondents (83.9%) who have low risk of barotrauma. These respondents are categorized as low risk due to the age classification (≤ 40 years). The rest 2

respondents (66.7%) are classified as high risk due to the age level (> 40 years). On statistical tests through Chi Square, it obtains p value = 0.039 and odds ratio (OR) = 0.069.

Table 4
The correlation of Working Period and Barotrauma

Working Period	Barotrauma incident				Total	P value	Odds Ratio (OR)	
	Intake		Perforation					
	N	%	N	%				
> 5 years	8	25,8	0	0	8	23,5	1,000	0,885
≤ 5 years	23	74,2	3	100	26	76,5		
Total	31	100	3	100	34	100		

In table 4, none of the respondents who have working period of more than > 5 years are experiencing barotrauma. Whereas there are 3 respondents (100%) who have working period less than ≤ 5 years experiencing barotrauma. Through

the statistical test of Fisher's Exact Test, it obtains p value = 1,000 and odds ratio (OR) = 0.885.

Table 5
The correlation of Depth of Diving with Barotrauma

Depth of Diving	Barotrauma incidents				Total	P value	Odds Ratio (OR)	
	Intake		Perforation					
	n	%	n	%				
0-10 meters	27	87,1	0	0	27	79,4	0,032	3,636
$>10-30$ meters	4	12,9	2	66,7	6	16,6		
$>30-40$ meters	0	0	1	33,3	1	2,9		
Total	31	100	3	100	34	100		

In table 5, there is one respondent (33.3%) who has perforation barotrauma with a depth of diving is more than 30-40 meters, and 2 respondents (66.7%) who have

barotrauma with moderate dives ($>10-30$ meters). Through statistical tests of Kolmogorov-Smirnov Z, it obtains the p value = 0.032 and odds ratio (OR) = 3.636.

Table 6
The correlation of dive duration with Barotrauma Incident

Dive duration	Barotrauma Incident				Total	P value	Odds Ratio (OR)	
	Intake		Perforation					
	n	%	n	%				
≥ 25 minutes	2	6,5	0	0	2	5,9	1,000	0,078
< 25 minutes	29	93,5	3	100	32	94,1		
Total	31	100	3	100	34	100		

In table 6, there are two respondents (6.5%) with barotrauma intake who have a diving duration of more than 25 minutes. Whereas, the respondents with barotrauma perforation who have diving duration less than 25 minutes

only consist of 3 people (100%). Through the data analysis by using statistical tests Fisher's Exact Test, it obtains p value = 1,000 and odds ratio (OR) = 0.078.

Table 7. The correlation of frequency of diving with Barotrauma Incident

Diving Frequency	Barotrauma Incident				Total	P value	Odds Ratio (OR)	
	Intake		Perforation					
	n	%	n	%				
often (≥ 3 times)	2	6,5	0	0	2	5,9	1,000	0,054
rarely (< 3 times)	29	93,5	3	100	32	94,1		
Total	31	100	3	100	34	100		

In table 7, there are 2 (6.5%) respondents with barotrauma intake who have frequency of diving more than 3 times. Respondents with barotrauma perforation with the frequency of dives less than 3 times only consist of 3 people

(100%). Processing the data by using statistical tests of Fisher's Exact Test, it obtains p value = 1,000 and odds ratio (OR) = 0.054.

Table 8
correlation of Rest duration with Barotrauma Incident

Rest duration	Barotrauma incident				Total		P value	Odds Ratio (OR)
	Intake		Perforation		n	%		
	n	%	n	%				
Enough (>10 minutes)	1	3,2	0	0	1	2,9	1,000	0,054
less (≤ 10 minutes)	30	96,8	3	100	33	97,1		
Total	31	100	3	100	34	100		

In table 8, there is 1 respondent (3.2%) with barotrauma intake who has sufficient rest duration (>10 minutes). Whereas there are 3 respondents (100%) with barotrauma

perforation who have less rest duration (≤ 10 minutes). Analyzing the data by using statistical test of Fisher's Exact Test, it obtains p value = 1,000 and odds ratio (OR) = 0.054.

Table 9
The Correlation of Diving Procedure with Barotrauma Incident

Diving Procedure	Barotrauma Incident				Total		P value	Odds Ratio (OR)
	Intake		Perforation		n	%		
	n	%	n	%				
According to SOP	2	6,5	0	0	2	5,9	1,000	0,078
Not accordance with SOP	29	93,5	3	100	32	94,1		
Total	31	100	3	100	34	100		

In table 9, there are 2 respondents (6.5%) who have barotrauma intake yet still comply with the Standard Operational Procedure. On the contrary, there are 3 respondents (100%) who experience barotrauma incidents due not to comply with the operational standards of diving procedures. Through the data analysis by using statistical test, it obtains p value = 1,000 and odds ratio (OR) = 0.078.

ability of the body organs to adjust changes in pressure in the middle ear cavity.

a. Age Risk Factors on Barotrauma Incident

Based on the statistical tests using Chi Square, it obtains the p value = 0.039 and Odds Ratio (OR) = 0.069. This message can be a risk factor toward the incidence of barotrauma. This is relevant with Campos M research (2018) which states that age is one of the main factors that causes barotrauma in traditional divers. According to the Director General of PPM-PL, the ideal age of diver is between the ages of 16-35 years. Actually, there is no strict age limitation in diving as long as s/he meets the requirements of physical health and diving ability. The ideal age for divers with regular and continuous diving activities must be at least 35 years old and have excellent physical and mental health.

b. Risk Factor of Working Period with Barotrauma Incident

In this variable, ear barotrauma is experienced by 26 respondents with a working period of more than 5 years. Meanwhile, respondents who have working period of fewer than 5 years only consist of 8 people. This working period variable is actually giving both positive and negative performance on divers. In terms of performance, working period contributes a lot due to the longer the working period is, the more experience and ability the diver gets. However, this working period creates a negative effect if the diver does not do the job properly. It potentially harms the diver's body, such as barotrauma and other diseases.

However, Avongsa (2012) explains that the function of people's vital organs is slightly decreasing when they turn more than 35 years old. It also affects the ability to perform diving techniques and equalization techniques. Considering the risk factor and age of traditional diver fishermen, there are 24 respondents in this study who are under 40 years old, and 7 respondents are > 40 years old. 2 of 7 respondents in this study have membrane timpani damage. It is related to Sugianto theory (2017) which states that elderly divers have 6.25 times to experience barotrauma compared to young divers potentially.

Based on bivariate analysis, the risk factor of working period actually has no significant correlation. Statistical test with $\alpha = 0.05$ resulted in Cramer's value with $V = 0.224$ (Approx. value. Sig > 0.05). Therefore, the result is coherent with Ekawati's theory where the p value = 1.00 (p value > 0.05), which means there is no correlation between working period with ear barotrauma in traditional diver fishermen.

c. Risk Factor of Depth of Diving with Barotrauma

This variable is analyzed by statistical tests Kolmogorov-Smirnov Z and obtains p value = 0.032 as well as odds ratio (OR) = 3,636. The p value and the ratio are vividly proved the correlation between depth of diving with barotrauma. This significant result is in line with the research of Nafisah SF (2016) which states that there is a correlation between the depth of diving and the incidence of barotrauma.

The correlation of age factor and the incidence of ear barotrauma is also in line with the theory presented by Iskandar (2012). It elaborates that age will affect stamina and decrease physical fitness, particularly in divers. It affects the

Based on the findings, divers who experience barotrauma are those who dive more than 10 meters. Ekawati T (2016) states that 90% of ear barotrauma occurs in diver fishermen with the depth of diving is more than 10 meters. In every 10 meters, there is an increase in pressure of 1 ATA. Boyle also

elaborates that the deeper the seawater, the higher the pressure. This means when a diver is getting deeper, and the atmosphere also increases and suppress the body condition, which may lead to decompression (Duke HI, 2017).

d. Risk Factor of Dive Duration with Barotrauma

From Fisher's Exact Test, it obtains p value = 1,000, which explains that there is no correlation between the dive duration with barotrauma. This is in accordance with Martinus (2019), where the dive duration variable is not statistically proven as an influential factor that affects the incidence of barotrauma. It is possibly due to the brief exposure to environmental pressure because they often do not dive for such a long duration. This is in accordance with the study where the average dive duration of respondents is about 5 to 10 minutes. The longer it stays below the surface of the water, the longer it is exposed to repeated pressure. The ability to equalize techniques is indispensable in this case. If the ear fails to equalize the pressure, it will be at risk of barotrauma.

e. Risk Factor of Dive Frequency with Barotrauma

Through the analysis of Fisher's Exact Test, it obtains p value = 1,000 which means that there is no correlation between dive frequency and barotrauma. This study is different from some previous studies, where Fatimah (2019) states that there is an influence of the frequency of diving with the incidence of barotrauma. When a diver dives more often, s/he will experience repeated pressure trauma to the middle and inner ears, and the eustachian tube will be depressed (Martinus I, 2019). This tends to cause eustachian tube shrinkage and causes the balance organs in the inner ear to experience tissue swelling and blockage in the eustachian tubes so that they fail to open. If the eustachian tube is blocked, then the pressure inside the middle ear is different from the air pressure outside the eardrum. This causes the perforation of the eardrum and even can cause ear bleeding. The ear bleeding happens because of the tearing of a thin membrane that separates the middle ear from the outer ear which leads to rupture of the eardrum. This can happen due to an increase in environmental air pressure. If the pressure difference between the middle ear cavity and the surrounding environment becomes too large (about 90 to 100 mmHg), the cartilage part of the eustachian tube will significantly shrink. If no air is added through the eustachian tube to divert the volume of the middle ear, then the structures in the middle ear and nearby tissues will be damaged. At first, eardrum is attracted inward that causes the membrane to stretch and ruptures the small blood vessels so that the image of injection and hemorrhagic bullae appears in the eardrum. As pressure increases, the blood vessels in the middle ear mucosa will also circulate and rupture, causing hemotympanum or the absence of blood in the tympanic cavity. The more frequent the divers dive, the more pressure they receive, and they have to equalize the pressure in the cavity.

In this study, the risk factor of diving frequency has no correlation with barotrauma. It can be correlated if there is a major factor that supports such as the depth of diving. Based on findings, respondents in this research are only diving in about 5 to 6 meters under the surface which means they are still safe due to the high risk of barotrauma incident may be happened if they dive more than 10 meters (Ekawati, 2015).

f. Risk Factor of Rest Duration after Dive with Barotrauma

Based on the statistical test of Fisher's Exact Test, it obtains p value = 1,000 which means that the factor of rest duration has no effect on the incidence of barotrauma. This is in accordance with the explanation of Ekawati (2005) that there is no correlation between rest duration after dive with the occurrence of tympanic membrane barotrauma in traditional divers in Semarang Utara Sub-District of Semarang City with a p-value only 0.646. A similar result was also published by Fatimah (2019), where it is stated that there are many divers who do not experience barotrauma after diving with only a short duration of rest. It is caused by there are no major factors that support the incident of barotrauma, such as dive duration, depth of diving, and other factors.

Based on several literature, it needs to have rest after diving to decrease the level of nitrogen in the body, which may cause limp or faintness, dizziness, and chills. From what was obtained from the analysis, all respondents dive for at least 60 minutes. In most cases, symptoms of diving diseases such as decompression will occur after 6 hours, and which often occur within the first hour after diving. Common symptoms that mostly happen are pain in the joints, reddish skin, chest tightness, dizziness, and in the severe decompression condition, it causes difficulty of speaking and shaking when nitrogen bubbles attack the small brain. This research is also in line with Alfred A. Bove in his article entitled "Decompression Sickness" that the dive duration in a pressurized environment is one of the risk factors for diving disorders, especially decompression (Rahmadayanti, Budiono, Yusniar 2017).

g. Effect of Diving Procedure Factors on Barotrauma

Using statistical test of Fisher's Exact Test to analyze the diving procedure variable, it obtains that p value = 1,000. This means this variable has no effect on the occurrence of barotrauma.

In the research of Rahmadayanti Budiono, and Yusniar (2017), It was explained that a traditional diver who undergoes 1 atm deeper, s/he will experience different pressure on the physiology of the body. An important effect of depth is the positioning of the gas into an increasingly small volume. The deeper the diver goes, the air shrinking the space in the diver's body includes her/his lung. This allows the rupture of an alveolus in the lungs, which results in the lack of elasticity of the lungs. According to information obtained from divers, they still do not pay attention to safety procedures by rising to the surface quickly without doing a safety stop. They rely only on feelings when reaching the surface because they are afraid of running out of oxygen. It is also due to the lack of standard diving equipment.

CONCLUSION

Through the analysis, it obtains factors such as age, working period, depth of diving, dive duration, frequency of diving, and rest duration majorly influence the incident of barotrauma meanwhile diving procedure does not.

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