

# Acute Dysbaric Disorders: A Case Series in The Hyperbaric Center in Lombok 2016-2020

Eustachius Hagni Wardoyo<sup>1\*</sup> and Devi RM Tarigan<sup>2</sup>

<sup>1</sup> Department of Archipelago Medicine, University of Mataram, Mataram, Indonesia

<sup>2</sup> Diving Health and Hyperbaric Center, Mataram General Hospital, Mataram, Indonesia

\*Corresponding author. Email: wardoyo.eh@unram.ac.id

## ABSTRACT

This study aimed to describe acute dysbaric disorder (ADD) in the hyperbaric center in Lombok during 2016-2020. All types of ADD diagnosis which attend to Diving Health and Hyperbaric center Mataram General Hospital (DHM) 2016-2020 were included in the study. Secondary data of Medical Record then analyzed: patient characteristic, clinical status, and number of recompression therapy. An excel template was designed to be filled: identity, manifestation, risk factors, type of divers, and type of diagnosis. ADD cases was 114/835 (13.6%) among hyperbaric center's admissions. Types of ADD were: Type I DCI 80 (70.2%), type II DCI 31 (27.2%), Cerebral arterial gas embolism 2 (1.8%) and HAPE/HACE 1 (0.9%). The number of male patients is higher than females (86;28). Type of occupation: SCUBA divers 76 (66.7%); traditional divers 36 (31.6%), surfer and hiker each 1 (0.9%). The number of recompression therapy 4 or more 14 (12.3%) and less than four 100(87.7%). The top five manifestations are: fatigue, numbness, headache and muscular weakness and muscular pain and top five risk factors include: multiple dives per day, yo-yo profile, unexperienced, excessive physical activity, and anxiety. The incidents of acute dysbaric disorders incidents were low during 4 years. Type I DCI is the most common diagnosis followed by type II DCI, cerebral arterial gas embolisms and high altitude pulmonary/ cerebral edema. Scuba divers is the most affected occupation of ADD. Number of recompression therapy dominated less than 4 sessions. Neurological manifestation is commonly found, and multiple dives per day as the most prevalent risk factors for ADD.

**Keywords:** Acute dysbaric disorder, Decompression illness, cerebral arterial gas embolism, recompression therapy, hyperbaric oxygen therapy.

## 1. INTRODUCTION

West Nusa Tenggara (WNT) Province, Indonesia is an archipelagic province consisting of two main islands, namely Lombok Island and Sumbawa Island and 278 small islands. WNT has at least 4 registered dive centers and 7 dive spots and will continue to increase along with underwater exploration and mapping that is still being carried out. WNT province was also equipped with 3 HBO centers located in Diving Health and Hyperbaric center Mataram General Hospital (DHM) (multilock type, 8 seats), WNT Province General Hospital (monoplace chamber) and Lombok Utara General Hospital (multilock type, 8 seats).

Types of dysbaric disorders that we have known so far: decompression illness/sickness, cerebral arterial gas embolism, barotrauma, nitrogen narcosis, oxygen toxicity, high altitude pulmonary (cerebral) edema, and

dysbaric osteonecrosis [1-2]. Acute dysbaric disorders (ADD) in our center come in 4 types of diagnosis: Decompression Illness (DCI), Cerebral arterial gas embolism (CAGE), high-altitude pulmonary edema (HAPE), and high-altitude cerebral edema (HACE). The pathophysiology of ADD involved the excessive nitrogen load and inadequate decompression to remove accumulated nitrogen [3-4]

The study aimed to describe Acute dysbaric disorders characteristics profile of in hyperbaric center in Lombok between 2016-2020.

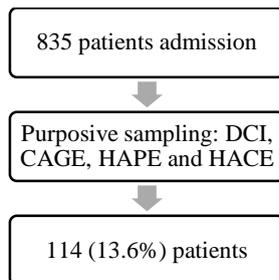
## 2. METHOD

All types of ADD diagnosis which attend to DHM 2016-2020 was included in the study. Secondary data of Medical Record then analyzed: patient characteristic, clinical status, and the number of recompression therapy.

An excel template was designed to be filled: identity, manifestation, risk factors, type of divers, and type of diagnosis.

### 3. RESULTS

As many as 835 cases were admitted for HBOT between the study period with 111 (13.3%) related to DCI, 2 (0.2%) cerebral arterial gas embolism and 1 (0.1%) HAPE/HACE. One hundred eleven cases DCI consisted of: 80 Type I DCI and 31 Type II DCI.



**Figure 1** Cases selection process. DCI=decompression illness; HAPE=high altitude pulmonary edema; HACE=high altitude cerebral edema

#### 3.1. Sex Distribution, Age, and Type of Divers

It is consisting of 86 males (75.4%) and 28 females (24.6%), with median age of 30 years [18-78]. Type of occupation: 36 traditional, 76 recreational divers, 1 surfer and 1 hiker.

#### 3.2. Type of Diagnosis

In our center diagnosis type I DCS was the highest number (80), followed by Type II DCI (31), CAGE (2) and HAPE/HACE (1) (Table 1).

**Table 1.** Type of diagnosis. DCI=decompression illness; CAGE=cerebral arterial gas embolism; HAPE/HACE=high altitude pulmonary /cerebral edema

No	Type of diagnosis	Frequencies (n=114)	Remark
1	Type I DCI	80 (70.2%)	
2	Type II DCI	31 (27.2%)	
3	CAGE	2 (1.8%)	1 surfer with near drowning experienced, deceased
4	HAPE/HACE	1 (0.9%)	
	Total	114 (100%)	

#### 3.3. Sex and Type of Diagnosis

**Table 2.** Diagnosis and sex distribution

	Type I DCI	Type II DCI	CAGE	HAPE/HACE	
Male	57	28	0	1	86 (75.4%)
Female	23	3	2	0	28 (24.6%)
	80 (70.2%)	31 (27.2%)	2 (1.8%)	1 (0.9%)	114 (100%)

Table 2 showed that overall males were higher number in Type I DCI, Type II DCI and HAPE/HACE. Two cases of CAGE all were female.

Diagnosis based on occupation distribution, there were 4 occupations of ADD patients, 76 SCUBA divers, 36 traditional divers, 1 surfer and hiker. The high number of SCUBA divers filled higher compared to traditional divers in type I DCI 63 vs 17, type II DCI 12 vs 19 and CAGE 1 vs 0, (table 3).

**Table 3.** Diagnosis and Occupation distribution

	Type I DCI	Type II DCI	CAGE	HAPE / HACE	
SCUBA Diver	63	12	1	0	76 (66.7%)
Traditional diver	17	19	0	0	36 (31.6%)
Surfer	0	0	1	0	1 (0.9%)
Hiker	0	0	0	1	1 (0.9%)
	80 (70.2%)	31 (27.2%)	2 (1.8%)	1 (0.9%)	114 (100%)

If the risk was compared between traditional divers (high risk) and SCUBA divers (low risk) with the outcome of type II DCI (case) and I DCI (control) resulted in OR=5.868 (p=0.000; 95% Confidence interval of =2.387-14.426). Which interpreted that traditional divers had a risk of 5.8 times higher than SCUBA divers in getting of type II DCI

**Table 4.** The number of recompression therapy

	Type I DCI	Type II DCI	CAGE	HAPE/HACE	
≥4	5	7	1	1	14 (12.3%)
<4	75	24	1	0	100 (87.7%)
	80 (70.2%)	31 (27.2%)	2 (1.8%)	1 (0.9%)	114 (100%)

The number of recompression therapy was divided into two 4 or higher and less than 4 (1-3 sessions). Less than 4 sessions are higher than 4 or higher sessions,

indicating that effective recompression therapy was successfully achieved by less than 4 sessions (table 4).

If the risk was compared between type II DCI (high risk) and type I DCI (low risk) with the outcome of 4 or higher sessions (case) and less than 4 sessions of recompression therapy resulted in OR=4.375 ( $p=0.013$ ; 95% Confidence interval of 1.271-15.062). Meaning, having type II DCI was riskier 4.3 times higher to higher sessions compared to type I DCI.

### 3.4. Manifestation

**Table 5.** Clinical manifestation of ADD

		Frequencies n=114 (%)
1	Fatigue	89 (78.1%)
2	Numbness	77 (67.5%)
3	Headache	46 (40.4%)
4	Muscular weakness	42 (36.8%)
5	Muscular pain	34 (29.8%)
6	Anuria	27 (23.7%)
7	Joint pain	25 (21.9%)
8	Nauseous	23 (20.2%)
9	Abdominal discomfort	17 (14.9%)
10	Tingling	13 (11.4%)
11	Out of breath	12 (10.5%)
12	Skin rash	12 (10.5%)
13	Itchy in the skin	11 (9.6%)
14	Vertebral pain	8 (7%)
15	Loss of appetite	6 (5.3%)
16	History of unconsciousness	4 (3.5%)
17	Dizziness	3 (2.6%)
18	Vomitus	2 (1.8%)
19	Convulsion	2 (1.8%)
20	Loss of coordination/ tremors	2 (1.8%)
21	Haemoptoe	1 (0.9%)
22	Muscular tick	1 (0.9%)

Fatigue, numbness, headache and muscular weakness were the four most frequent, while convulsion, loss of coordination/tremors, hemoptoe and muscular tick were the least frequent manifestations (table 5).

### 3.5. Possible Risk Factors

Risk was unmeasurable in the study due to lack of control cases. So, we call it possible risk factors. Multiple dives perday, yo-yo profile, unexperienced, previous excessive physical activity were risk factors that frequent in our center (table 6).

**Table 6.** Possible risk factor related to acute dysbaric disorders

	Risk Factors	Frequency (n=114)
1	Multiple dives perday (less than 3 dives)	44 (38.6%)
2	Yo-yo profile (three dives up per day)	36 (31.6%)
3	Unexperienced	18 (15.8%)

	Risk Factors	Frequency (n=114)
4	Previous excessive physical activity	17 (14.9%)
5	Anxiety	13 (11.4%)
6	Alcohol hang-over	9 (7.9%)
7	Panic underwater	7 (6.1%)
8	Breath-hold dive	5 (4.4%)
9	Previous DCI events	4 (3.5%)
10	New dive site	4 (3.5%)
11	High-altitude activities	2 (1.8%)
12	Hipotermia	2 (1.8%)
13	Near drowning	1 (0.9%)
14	Dangerous water current	1 (0.9%)
15	Patent foramen ovale	1 (0.9%)

## 4. DISCUSSION

A total of 114 (13.6%) patients with acute dysbaric disorder (ADD) from 835 patient visits to the HBO center where the dividing cases were diving cases and clinical cases that had been referred/indicated to require HBO therapy. This is in line with one study by Kadriyan et al [5], although population focused on dive-related injury, which reported as many as 110 cases of dive-related illness on the island of Lombok, as many as 15/110 (13.6%) need hyperbaric therapy.

The male diver population predominates over women, like one study in Norway by Irgens et al [6]Theoretically, women's body constitution has a body fat composition of 10% higher than men with the same BMI [7]. On the other hand, this study found that the incidence of DCI was higher in men than women, which similar with a study by Cooper & Hanson [8] which stated that the risk of DCI in men was 2.5 times higher than women. The number of female divers is 23.7%, which is higher than the DAN Europe study of 16.7% in 5 years [9].

Traditional dives in Lombok mostly dominated by fishermen, diving is make a living by catching as many fish as possible. This condition tends not to pay attention to the safety aspect of diving. They used cheap diving equipment such as surface air compressor and hose connector (up to 60 meters long), goggles, flashlight. Diving at night is the best time to catch fish and lobster [10]. A total of 36 traditional divers use air compressors on the surface to help breathe underwater, without using an air regulator/mouth piece (table 3). Dives that use pressurized air without using an air regulator, are very risky for inhalation of excess air, exceeding the volume of inhaled lungs. Where mouthpiece works by reducing the air pressure down to ambient pressure, follow your inhale breathing evenly. Without it, over-inflation of the lungs, (trapped air will expand according to Boyle's law) which can cause pulmonary barotrauma at risk of air entering the pulmonary veins through pulmonary

parenchymal tears, mediastinal emphysema or pneumothorax. The entry of inert gas (nitrogen) into the pulmonary veins which is carried by the left ventricle to the systemic circulation causes cerebral arterial gas embolism [11]. While SCUBA diving in Lombok is carried out by tourists with the aim of exploring the underwater beauty and is guided by a diver instructor so that it is enough to anticipate diving safety. Even so, in our study with the proportion of 16% (12/75) suffered from type II DCI rather than type I DCI indicates there is other factors added to diving safety anticipation. In the New Zealand setting, SCUBA divers there were one case of Decompression illness per 24,386 dives for 7 years period [12]. In our observation, traditional divers tend to have type DCI compare to SCUBA divers is due to several reasons, they are: 1. No safety guidance to follow; 2. Diving with no dive plan; 3. No diving suits used.

Interestingly, when we measure risk compared between traditional divers (high risk) and SCUBA divers (low risk) with the outcome of type II DCI (case) and I DCI (control) resulted that traditional diver had a risk 5.8 times to have type II DCI instead of type I DCI ( $p=0.000$ ; 95% Confidence interval of =2.387-14.426). In Lombok traditional diver is risky job with no insurance covered.

There was one case with diagnosis of HAPE/HACE. A 24 y.o males comes to our hospital with loss of consciousness after hike Rinjani mountain. CT-scan result concluded there are brain swelling and pulmonary edema. After acute injury of the brain and lungs is reducing, he referred to hyperbaric and receive 5 sessions of US Navy table 5 therapy. HAPE/HACE is one form of ADD that is not dive-related injury, but the pathophysiology is alike with similar loss of ambient pressure after fast ascent to the heights.

In our data, number of recompression therapy was related to the number of clinical manifestations or diagnosis, duration between onset of symptoms to recompression therapy, age of the patients, type of dive profile and previous DCI events (data not shown). In our setting, diagnosis of type II DCI was 4.3 times to be commenced multiple sessions (4 or higher) of recompression therapy ( $p=0.013$ ; 95% Confidence interval of 1.271-15.062).

List of symptoms of ADD in this study was collected regardless of type of diagnosis. In describing symptoms related to most common type of diagnosis type I and II DCI and arterial gas embolism (AGE) is not always consistent [13]. Four most common manifestations in our study were fatigue, numbness, headache and weakness of extremities, while in Finland showed tingling/ itching, joint pain, constitutional symptoms and numbness [14] and DAN America presented numbness, pain, paresthesia and malaise [15]. In general, numbness was predominated manifestation.

Possible risk factors in ADD event is not able to be measured, especially when control at a given period of time was not available. Multiple dives per day/ yo-yo profile, unexperienced, excessive physical activity and anxiety is the most prevalence. Lundell et al [14] reported multiple day diving, multiple dives per day, flying after diving, yo-yo profiles, dehydration, cold, physical activity and others.

We conclude that among of our total hyperbaric center's patients, acute dysbaric disorders incidents were low during 4 years. Type I DCI is the most common diagnosis followed by type II DCI, cerebral arterial gas embolisms and high altitude pulmonary/ cerebral edema. Scuba divers is the most affected occupation of ADD. Number of recompression therapy dominated less than 4 sessions. Neurological manifestation is commonly found, and multiple dives per day as the most prevalent risk factors for ADD.

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