



## Original Article

### Type 2 Decompression Sickness in a Traditional Diver: A Case Report and Treatment with Hyperbaric Oxygen Therapy

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#### Abstract:

Decompression sickness (DCS) type 2 is a medical emergency frequently experienced by traditional divers due to inadequate diving procedures. Hyperbaric Oxygen Therapy (HBOT) is the definitive standard treatment for DCS with neurological manifestations. This case report describes the management of a 37-year-old male patient who developed type 2 DCS after diving to a depth of 30 meters for two hours using a compressor. The patient underwent staged HBOT using the US Navy Table 6, Table 5, and Kindwall Table protocols at a pressure of 2.8 ATA at RSAL dr. Wahyu Slamet Bitung from June 14 to June 21, 2025. Neurological evaluation was performed using the Neurological Deficit Score (NDS) before and after therapy. The patient showed significant neurological improvement after eight HBOT sessions within eight days, as indicated by a decrease in NDS from 8 to 2 and improvement in lower extremity motor strength from 2/5 to 5/5. Neurological symptoms, including limb weakness, muscle cramps, and urinary retention, gradually improved, with meaningful clinical improvement beginning at the seventh therapy session and complete recovery achieved after the eighth session. Hyperbaric oxygen therapy using a staged protocol was effective in managing type 2 DCS with severe neurological manifestations in traditional divers. Early management using an appropriate therapeutic protocol resulted in excellent clinical outcomes with complete neurological functional recovery.

**Keywords:** Decompression Sickness (DCS), Hyperbaric Oxygen Therapy (HBOT), Traditional Divers, Neurological Deficits, US Navy Treatment Table

#### Abstrak:

Penyakit dekompresi (Decompression Sickness/DCS) tipe 2 merupakan kondisi darurat medis yang sering dialami penyelam tradisional akibat

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prosedur penyelaman yang tidak adekuat. Terapi oksigen hiperbarik (Hyperbaric Oxygen Therapy/HBOT) merupakan standar terapi definitif untuk DCS dengan manifestasi neurologis. Laporan kasus ini mendeskripsikan penatalaksanaan seorang pasien laki-laki berusia 37 tahun yang mengalami DCS tipe 2 setelah menyelam pada kedalaman 30 meter selama 2 jam menggunakan kompresor. Pasien menjalani terapi HBOT dengan protokol bertahap menggunakan US Navy Table 6, Table 5, dan Table Kindwall pada tekanan 2,8 ATA di RSAL dr. Wahyu Slamet Bitung selama periode 14-21 Juni 2025. Evaluasi neurologis dilakukan menggunakan Neurological Deficit Score (NDS) sebelum dan sesudah terapi. Pasien mengalami perbaikan neurologis signifikan setelah 8 kali sesi terapi HBOT dalam 8 hari dengan penurunan NDS dari 8 menjadi 2 dan peningkatan kekuatan motorik ekstremitas bawah dari 2/5 menjadi 5/5. Gejala neurologis seperti kelemahan anggota gerak, kram, dan retensi urin membaik secara bertahap, dengan perbaikan klinis bermakna dimulai pada terapi ke-7 dan mencapai kesembuhan lengkap pada terapi ke-8. Terapi oksigen hiperbarik dengan protokol bertahap efektif dalam mengatasi DCS tipe 2 dengan manifestasi neurologis berat pada penyelam tradisional, dan penanganan dini dengan protokol terapi yang tepat menghasilkan outcome klinis yang sangat baik dengan pemulihan fungsi neurologis yang sempurna.

**Kata Kunci:** Penyakit Dekompresi, Terapi Oksigen Hiperbarik, Penyelam Tradisional, Defisit Neurologis, US Navy Table

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## Introduction

Decompression sickness (DCS) is a condition caused by the formation of nitrogen gas bubbles within body tissues and the circulatory system when there is a rapid decrease in ambient pressure. DCS poses a significant risk to divers, particularly traditional divers who often do not use adequate diving equipment and fail to follow proper decompression protocols. In Indonesia, with its vast maritime territory and intensive traditional diving activities, DCS remains an important public health concern.

DCS is classified into two main types based on its clinical manifestations. Type 1 DCS is characterized by relatively mild musculoskeletal and cutaneous symptoms, whereas Type 2 DCS involves more severe neurological, vestibular, and cardiopulmonary systems and requires immediate medical management. Neurological manifestations of Type 2 DCS may include motor weakness, sensory disturbances, autonomic dysfunction, and decreased level of consciousness. Without prompt and appropriate treatment, this condition may lead to permanent disability or even death.

Hyperbaric Oxygen Therapy (HBOT) is the definitive standard treatment for DCS. HBOT works by increasing ambient pressure and administering 100% oxygen, which aims to reduce the size of gas bubbles, enhance nitrogen elimination from tissues, and improve oxygenation of ischemic tissues. Various treatment protocols have been developed, with the US Navy Treatment Tables being the most widely used protocol internationally.

Dr. Wahyu Slamet Naval Hospital in Bitung, as a naval hospital in Eastern Indonesia, is equipped with hyperbaric therapy facilities that manage DCS cases from various regions. This study reports a case of Type 2 DCS in a traditional diver successfully treated with HBOT using a stepwise protocol, aiming to evaluate the effectiveness of the therapy and to provide an overview of optimal management for similar cases.

## Research Method

### Patient Identity and Anamnesis

A 37-year-old male patient, identified as Mr. Sunaryo, presented to Dr. Wahyu Slamet Naval Hospital Bitung on June 14, 2025, with complaints of vomiting, dizziness, body cramps, difficulty urinating, and weakness in both legs that occurred immediately after surfacing from a diving activity. The patient is a traditional diver who performed a dive to a depth of 30 meters using an air compressor for 2 hours. The symptoms appeared acutely after the patient surfaced without performing adequate decompression procedures.

### Physical Examination

On initial physical examination, the patient was fully conscious (GCS 15) with vital signs within normal limits. Neurological examination revealed significant motor deficits in the lower extremities. Muscle strength assessment showed normal motor strength in the upper extremities, graded 5/5 bilaterally, while severe weakness was noted in the lower extremities with motor strength graded 2/5 in both legs. The patient also complained of generalized body cramps and experienced difficulty in urination (urinary retention), indicating autonomic dysfunction.

Based on a comprehensive neurological examination, an assessment using the Neurological Deficit Score (NDS) was performed prior to initiating therapy. The patient's initial NDS score was 8, indicating significant neurological deficits requiring immediate intervention with hyperbaric oxygen therapy.

### Diagnosis

Based on the patient's history, physical examination, and diagnostic criteria, the patient was diagnosed with Type 2 Decompression Sickness (DCS) with neurological manifestations. The diagnosis was established based on the following inclusion criteria:

1. History of exposure to high pressure, namely diving to a depth of 30 meters for 2 hours;
2. Acute onset of symptoms within less than 24 hours after surfacing;
3. Neurological manifestations including lower extremity weakness (paresis), sensory disturbances (cramps), and autonomic dysfunction (urinary retention);
4. NDS = 8, indicating significant neurological deficits.

### Management

The patient immediately received hyperbaric oxygen therapy (HBOT) according to the US Navy protocol for Type 2 DCS. The therapy was conducted in the hyperbaric chamber at Dr. Wahyu Slamet Naval Hospital Bitung from June 14, 2025, to June 21, 2025, using a stepwise protocol as follows:

Table 1. Hyperbaric Oxygen Therapy Protocol

Day	Treatment Protocol	Pressure	Duration
1	US Navy Table 6	60 fsw (2.8 ATA)	4 hours 45 minutes
2	US Navy Table 6	60 fsw (2.8 ATA)	4 hours 45 minutes
3	US Navy Table 6	60 fsw (2.8 ATA)	4 hours 45 minutes
4	US Navy Table 5	60 fsw (2.8 ATA)	2 hours 15 minutes
5	US Navy Table 5	60 fsw (2.8 ATA)	2 hours 15 minutes

6	US Navy Table 5	60 fsw (2.8 ATA)	2 hours 15 minutes
7	Kindwall Table	60 fsw (2.8 ATA)	90 minutes
8	Kindwall Table	60 fsw (2.8 ATA)	90 inutes

During therapy, the patient was closely monitored for clinical progress and therapeutic response. Neurological evaluations were performed serially on a daily basis to assess improvement in motor, sensory, and autonomic functions.

## Result and Discussion

The patient showed a very good therapeutic response to the administered HBOT protocol. Clinical improvement was observed gradually starting from the first treatment session, with significant improvement becoming evident from the seventh session onward. Evaluation of clinical outcomes revealed the following:

Table 2. Comparison of Neurological Status Before and After HBOT

Parameter	Before HBOT	After HBOT
Neurological Deficit Score (NDS)	8	2
Upper Extremity Motor Strength	5/5	5/5
Lower Extremity Motor Strength	2/5	5/5
Ambulation Ability	Unable to walk	Able to walk normally
Autonomic Function (Urination)	Urinary retention	Normal
Sensory Symptoms (Cramps)	Present	Absent

The most significant clinical improvement was observed on the seventh and eighth days of therapy. During the seventh session, the patient began to demonstrate increased lower extremity motor strength and a reduction in sensory complaints. By the eighth session, all neurological symptoms had resolved; the patient was able to walk independently, and lower extremity muscle strength had fully recovered to 5/5. Autonomic function also fully recovered, as indicated by the resolution of urinary retention. The total recovery time was 8 days, with an excellent final clinical outcome.

## Discussion

This case demonstrates the effectiveness of hyperbaric oxygen therapy (HBOT) in managing Type 2 decompression sickness (DCS) in a traditional diver with severe neurological manifestations. Traditional divers in Indonesia are at high risk of developing DCS because they frequently perform dives without adequate equipment and without adhering to proper decompression procedures. In this case, the patient experienced significant motor weakness of the lower extremities, sensory disturbances, and autonomic dysfunction, which are characteristic features of Type 2 DCS involving both the central and peripheral nervous systems.

### Pathophysiology and Mechanisms of Action of HBOT

Decompression sickness occurs when nitrogen dissolved in tissues and blood under high pressure forms bubbles as a result of a rapid decrease in ambient pressure. These gas bubbles may obstruct blood vessels and cause tissue ischemia or directly damage tissues through activation of inflammatory cascades. In the nervous system, gas emboli can cause injury to the spinal cord and brain, which explains the neurological manifestations observed in this patient.

HBOT exerts its therapeutic effects through several key mechanisms. First, increased ambient pressure reduces the size of gas bubbles in accordance with Boyle's law, thereby decreasing vascular obstruction and mechanical compression of tissues. Second, the administration of 100% oxygen at high pressure creates a large diffusion gradient that

accelerates nitrogen elimination from tissues and gas bubbles. Third, the resulting tissue hyperoxia enhances oxygen delivery to ischemic areas. Fourth, HBOT has anti-inflammatory and neuroprotective effects that help reduce edema and secondary injury to neural tissues.

### **Treatment Protocol and Rationale for Selection**

The treatment protocol used in this case followed the US Navy Treatment Tables, which have been internationally validated and are also widely applied in Indonesia. US Navy Table 6 was selected as the initial therapy because it is the standard protocol for Type 2 DCS with neurological symptoms. Table 6 uses a pressure of 60 feet seawater (fsw), equivalent to 2.8 ATA, with a duration of 4 hours and 45 minutes, providing sufficient time for gas bubble reduction and reoxygenation of ischemic tissues.

Table 6 was applied during the first three days to ensure adequate resolution of gas bubbles and to prevent symptom recurrence. Subsequently, therapy was continued with US Navy Table 5 from days 4 to 6, which has a shorter duration (2 hours and 15 minutes) and is appropriate for follow-up treatment once acute symptoms have begun to improve. On days 7 and 8, therapy was continued using the Kindwall Table for 90 minutes to ensure complete recovery. This stepwise protocol allowed adjustment of treatment intensity according to the patient's clinical response while minimizing the risk of adverse effects associated with hyperbaric therapy.

### **Outcome Evaluation and Prognostic Factors**

The improvement in the Neurological Deficit Score (NDS) from 8 to 2 indicates an excellent therapeutic response. A 75% reduction in the NDS reflects near-complete recovery of neurological function. The improvement in lower extremity motor strength from 2/5 to 5/5 represents a highly favorable outcome and suggests complete resolution of neuronal injury or ischemia. The relatively rapid recovery within 8 days indicates that the injury was largely reversible, likely due to early intervention before permanent structural damage occurred.

Several factors contributed to the excellent outcome in this case. First, the relatively short interval between symptom onset and initiation of therapy allowed intervention before irreversible neurological damage developed. Second, the patient's relatively young age (37 years) and the absence of significant comorbidities supported a better recovery. Third, strict adherence to the treatment protocol played a crucial role. The patient completed the entire course of therapy without interruption, ensuring complete elimination of gas bubbles and preventing symptom recurrence.

### **Implications for Traditional Divers in Indonesia**

This case highlights the importance of the availability of hyperbaric therapy facilities in regions with high levels of traditional diving activity. In Indonesia, many traditional divers or fishermen perform dives using minimal equipment and without adequate formal training. The use of air compressors without proper supervision and failure to follow appropriate decompression tables significantly increase the risk of DCS.

Education on DCS risk factors, safe diving techniques, the importance of adhering to decompression tables, and early recognition of DCS symptoms must be strengthened, particularly among traditional divers. The implementation of diving certification programs and stricter supervision may help reduce the incidence of DCS in the future. In addition, the development of efficient referral systems for DCS cases from remote areas to facilities equipped with HBOT is essential to minimize treatment delays and improve patient outcomes.

## Conclusion

This case report demonstrates the effectiveness of hyperbaric oxygen therapy using a stepwise protocol (US Navy Table 6, Table 5, and Kindwall) in managing Type 2 decompression sickness with severe neurological manifestations in a traditional diver. The patient achieved complete neurological recovery within 8 days, with improvement in the Neurological Deficit Score (NDS) from 8 to 2, recovery of lower extremity motor strength from 2/5 to 5/5, and complete resolution of autonomic and sensory symptoms. The therapeutic success in this case emphasizes the importance of early recognition of DCS symptoms, accurate diagnosis, prompt initiation of HBOT, appropriate selection of treatment protocols, and consistent adherence to therapy protocols. This case also highlights the importance of the availability of adequate HBOT facilities in regions with high traditional diving activity, as well as the need to improve diving safety education for the prevention of DCS.

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