CASE STUDY

# Decompression Illness Secondary to Occupational Diving: Recommended Management Based Current Legistation and Practice in Malaysia

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**SUMMARY**

**Occupational divers are exposed to hazards which contribute to the risk of developing decompression illnesses (DCI). DCI consists of Type I decompression sickness (DCS), Type II DCS and arterial gas embolism (AGE), developed from formation of bubbles in the tissues or circulation as a result of inadequate elimination of inert gas (nitrogen) after a dive. In Malaysia, DCI is one of the significant contributions to mortality and permanent residual morbidity in diving accidents. This is a case of a diver who suffered from Type II DCS with neurological complications due to an occupational diving activity. This article mentions the clinical management of the case and makes several recommendations based on current legislations and practise implemented in Malaysia in order to educate medical and health practitioners on the current management of DCI from the occupational perspective. By following these recommendations, hopefully diving accidents mainly DCI and its sequalae among occupational divers can be minimized and prevented, while divers who become injured receive the proper compensation for their disabilities.**

**KEY WORDS:**
*Occupational divers, Decompression illness (DCI), Inert gas, Occupational diving, Decompression sickness (DCS)*

## INTRODUCTION

In occupational diving activities, divers are exposed to certain hazards such as inert gas (nitrogen) which may increase the risk to develop decompression illness (DCI)[1]. DCI results from formation of bubbles in the tissues or circulation as a result of inadequate elimination of inert gas after a dive. Originally, DCI was divided into mild Type I decompression sickness (DCS) (pain only, skin or lymphatic) and serious Type II DCS (cardiopulmonary or neurological involvement). The term Type III DCS has been proposed to describe a situation in which a diver has symptoms of cerebral arterial gas embolism (CAGE) and severe cerebral and spinal DCS, however this term has never been well accepted. Currently, DCI is generally accepted and used to encompass Type I DCS, Type II DCS and arterial gas embolism (AGE)[2].

In the United States, Barratt *et al*[2] estimated the prevalence of DCI among recreational divers was 13.4 Cases and 1.3 fatalities in warm water, and 10.5 cases and 2.9 fatalities respectively in cold and deep water for every 100 000 dives. This prevalence was much higher among commercial (occupational) divers and submarine escape trainees.

In Malaysia, Loke *et al* (1998), Khairuddin Husain (1999) and Abd Halim Mohamed (2001) reported some observations on DCI and its sequelae among occupational divers. Loke *et al*[3] reported six cases of DCI related to underwater logging in Kenyir Lake treated at a state government hospital. The divers presented with severe cardiorespiratory and neurological disturbances, resulting in two deaths, while the others survived after recompression treatment. Khairuddin Husain [4] reported 21 cases of DCI treated at the military hospital in the Royal Malaysian Navy (RMN) Base in Lumut from November 1996 to 1999, which were also related to underwater logging in Temenggor Lake and Kenyir Lake. A technical report by Abd Halim Mohamed[5] found that out of 118 diving accidents treated at a military hospital in RMN Base in Lumut from November 1996 and December 2000, majority were DCI (91.5%; n=108). DCI cases were mainly contributed by commercial diving activities (60.0%) as compared to recreational (30.0%) and military (10.0%). Underwater logging contributed 86.2% (n=56) of DCI as compared to other commercial diving. Forty-seven underwater loggers (83.9%) presented with Type II DCS with severe neurological involvements and 14 (26.9%) of them suffered permanent residual disability with limbs weakness, paralysis and bladder dysfunction.

There are no published materials on managing DCI from the occupational perspective in Malaysia. We have therefore selected a case of DCI (Type II DCS with neurological sequelae) related to occupational diving from the admission medical records in a military hospital-based recompression chamber facility in RMN Base in Lumut. The aim of this paper is to highlight the standard management based on the current legislations and practise in Malaysia. We also make recommendations that could become a management practise guideline from occupational perspective in handling any diving accidents leading to DCI. Further management of injured divers will also involve appropriate compensation for their disabilities.

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## CASE PRESENTATION

The patient was a 42 year old Malay man who worked as a commercial diver in a registered private company for the past ten years. He claimed that his company sent him for basic training in diving to handle underwater construction. Although a pre-employment medical assessment was done before joining the company, he had not undergone any further periodic medical examination. He had many dives without any complications prior to this incident. He also registered and contributed to the Social Security Organisation (SOCSO).

The patient started his diving work at Pantai Remis, at 8.00am using SCUBA (self-contained underwater breathing apparatus) with a single compressed air tank to secure a tending line for salvage work, with several other divers. He did multiple dives at the depth of 48 meters and made decompression stops at 10 meters and 5 meters intervals before surfacing from each dive. During the third dive, he suddenly noticed that he had run out of air in his tank. He ascended immediately to the surface without doing any decompression stops. On reaching the surface boat, he was found to be drowsy and was brought ashore. He was rushed by his fellow workers to the nearest recompression chamber facility in RMN Base in Lumut at 2.30 in the afternoon for recompression treatment. However, he lost his consciousness on the way to the hospital.

On admission, he was unconscious (Glasgow Coma Scale 5/15). He was intubated and ventilated. Vital signs were stable, with no sign of pneumothorax, or any external injuries. CT scan of the brain showed no intracranial bleed, no midline shift and normal ventricles. Cerebral oedema was minimal.

He was diagnosed with Type II DCS with neurological involvement and was treated with hyperbaric oxygen therapy (HBOT) at 2.8 ATA (atmosphere absolute) for four hours and 45 minutes. He was subsequently treated in the Intensive Care Unit (ICU) with mechanical ventilation and daily recompression therapy. His condition improved subsequently and he was finally extubated three weeks later. By then he had completed 30 sessions of recompression therapy with some progress and improvement.

A pre-discharge assessment on the seventh week of admission found a patient who was alert, rational and oriented with intact higher cerebral function. There was paraparesis with upper limbs power 3/5 bilaterally, paraplegia with lower limbs power 0/5 bilaterally, loss of sensation downwards of thoracic 10 and urinary incontinence. On his request, he was referred to a government hospital near his house for continuation of rehabilitation programme.

## DISCUSSION

This diver suffered from DCI Type II DCS with neurological (brain and spinal cord) involvement. DCI of the brain is most usually due to cerebral AGE as a result of bubbles becoming lodged in small arteries of the cerebral circulations. DCI of the spinal cord is due to bubbles formation in the white matter as well as bubbles obstructing arterial or venous flow in the spinal cord, most commonly at the lower thoracic area, followed by lumbar and cervical levels[2]. This explains the upper limb paraparesis, lower limb paraplegia, loss of sensation below T 10 and bladder dysfunction of patient.

The definite treatment is to recompress in a compression chamber as soon as possible. Delay in treatment may lead to permanent residual morbidity or death. The outcome is more likely to be successful if treatment is begun within six hours after the onset of symptoms[6]. However, this depends on the availability and accessibility of recompression chamber facilities, as well as the expertise of handling the chambers. In Malaysia, there are several recompression chamber facilities available to treat diving accidents mainly in the military setting as well as in a hospital university and private health centres[7].

### Recommendations

Based on the reported incident, this paper puts forward several recommendations:

### 1. Role of the Employer

The management of diving activities as an occupation in Malaysia should involve mainly the role of the employer, who must comply with the legislative regulations on diving currently enforced in Malaysia. There is a need for standards of good practice in diving, which must be regulated and enforced to ensure diving injuries can be prevented or minimized. A standard guideline for initial DCI treatment must be introduced and taught to all dive operators, in order to enhance the success of recompression treatment. Furthermore, an injured diver with disability must continue to undergo rehabilitation for improvement of function and possible re-employment.

### 2. Code of Good Practice

The Occupational Safety and Health Act (OSHA) 1994 clearly states that the role of the employer is to secure the safety, health and welfare of persons at work against risks to safety or health arising out of the work activities[8]. The employer is required to determine and secure all diving equipments as safe, ensure their divers follow standard diving protocols on safety as well as send their divers for appropriate dive training. These measures are done to ensure that diving work is done and completed with minimal risk of injuries and fatality. It is therefore the responsibility of a diving supervisor to regulate and monitor all diving activities at any diving site. In the case of commercial diving, the dive supervisor must determine the daily dive schedules, and ensure all divers carry out the necessary pre-dive checks prior to getting into the water. All SCUBA divers must have the basic necessary diving equipments which include depth gauge and pressure gauge.

In Malaysia, there are only a few training facilities for commercial / industrial occupational divers. The Terengganu Safety and Training Centre (TSTC) is one of the registered training centres which have provided courses such as Occupational Diving Course since 2004, in collaboration with International Technical Diving Agency (ITDA)[9].

### 3. Medical Assessment Prior to Diving

The employer must also carry out pre-employment and periodic medical assessments prior to diving to ensure that divers are fit to perform underwater work. It should be noted

that there is still as yet no legal obligation in Malaysia to do medical assessment prior to diving for occupational diving activities. This situation also involves recreational SCUBA divers, who do not have the legal obligation to undergo medical assessment [10]. However, professional training bodies require divers to declare their health status by filling a standard questionnaire and medical opinion is only required if there are uncertainties about their fitness to dive [11].

As a step to enhance safety in diving activities, the National Institute of Occupational Safety and Health (NIOSH) has introduced the "Diving Medical Examiner's Course", beginning in 2005 for registered medical practitioners to conduct pre-employment and periodic medical examination for commercial diving in accordance to industry standards [12]. In addition to that, the Department of Safety and Health (DOSH) has published a protocol for underwater logging activities which contains procedures and checklists for the enforcement OSHA 1994 for underwater logging activities as well as the requirement of pre-employment and periodic-employment medical examination and medical surveillance [13].

### 4. Notification of Decompression Illness (DCI)

The OSHA 1994 requires an employer to notify the nearest DOSH office of any occupational disease that has occurred in the place of work, within seven days of the incident. The Act also requires every registered medical practitioner or medical officer attending to a patient whom he believes to be suffering from an occupational disease and injury to report the matter to the Director General (DG) of DOSH. In this particular incident, although no report to the DOSH was forwarded by the employer, case notification was done by the medical facility administering recompression treatment.

Upon receiving a report of diving-related illness or injury, the DOSH has to determine the underlying cause of the incident in order for remedial action to be taken, mainly to prevent similar occurrences in the future. The enforcement officers have to investigate for further information regarding the incident and daily diving schedule, the repetitive diving profile, as well as inspect the workplace and relevant equipments. Recommendation and corrective actions to administer and enforce the law have to be taken to ensure that the employer complies with standard safety and health regulations [8, 14].

### 5. Social Security Organisation (SOSCO) Claims and Benefits

The employer must also ensure that their divers have registered and contribute to the SOSCO for their social security benefits[15]. Under the Workmen's Compensation Act 1952 amended in August 1996 (Section 26 (2), it is mandatory for every employer to ensure that even foreign workers who are employed are covered under the Foreign Worker's Compensation Scheme (FWCS) [16].

The SOCSO was set up to implement, administer and enforce the Employee's Social Security Act, 1969 and the Employee's Social Security (General) Regulation, 1971. Both the Act and regulations cover the spectrum of medical care, cash benefits, provision of artificial aids and rehabilitation for any worker who become diseased or injured as a result of his occupation. Since it is clearly stated that any disease or injury related to underwater work (Schedule 5) are categorized as occupational diseases, occupational divers are protected by social insurance to reduce their suffering and to provide financial guarantees and protection to the family if they become disabled [15].

In this case, the patient contributed to SOCSO, and is therefore eligible to get medical benefits from any Ministry of Health (MOH) hospitals such as admission to second class ward, or receive treatment from clinics appointed by SOSCO. He is also eligible for other benefits like temporary and permanent disablements, constant attendance allowance and rehabilitation benefits (Employment Injury Scheme). For the impairment which involves the upper limbs, lower limbs and bladder dysfunction, he must be assessed by a registered medical practitioner, who has gone through appropriate training and qualify with the Certificate Independent Medical Examiner (United States), or the Certificated Medical Independent Assessor (Malaysia) or its equivalent, as well as registered with SOCSO[17].

Impairment is considered permanent when it has reached Maximal Medical Improvement (MMI) level, meaning it is well-stabilized and unlikely to change substantially in the next one year with or without medical or surgical treatment. Overall percentage for whole person impairment can be assessed by using the latest guidelines published by using the 2005 SOCSO's 'Guidelines on Impairment and Disability Assessment of Traumatic Injuries, Occupational Diseases and Invalidity – Second Edition' [17]. Evaluation by the SOSCO Medical Board or SOCSO Special Medical Board is needed to determine the final overall percentage of whole body impairment to be awarded to the diver [15].

## CONCLUSION

In this diving incident, repetitive dives, failure to perform decompression stops, rapid ascent to the surface, poorly maintained breathing equipments and vigorous underwater activities were risk factors which contributed to the development of DCI in the diver. Although the employer claimed to have provided proper training in diving and appropriate diving equipment facilities for him, as well as carried out a pre-dive medical examination, none of these were adequately investigated and verified.

Companies which employ divers must comply to the OSHA 1994, while the DOSH must ensure and enforce all regulations pertaining to commercial diving are strictly followed and appropriate action be taken against employers who fail to comply. Injured divers must be duly compensated according to their degree of impairment through the SOCSO scheme.

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