

# The world as it is

## Treatment preferences for decompression illness amongst Singapore dive physicians

Valerie Huali Tan<sup>1</sup>, Kenneth Chin<sup>2</sup>, Aravin Kumar<sup>3</sup>, Jeremiah Chng<sup>4</sup>, Chai Rick Soh<sup>5</sup>

<sup>1</sup> National University Health System, Singapore

<sup>2</sup> Diagnostic Radiology, Singapore General Hospital, Singapore

<sup>3</sup> Yong Loo Lin School of Medicine, National University of Singapore, Singapore

<sup>4</sup> Hyperbaric Medicine Section, Navy Medical Service, Republic of Singapore Navy, Singapore

<sup>5</sup> Surgical Intensive Care Unit, Hyperbaric and Diving Medicine Centre, Singapore General Hospital

**Corresponding author:** Valerie H Tan, Hyperbaric and Diving Medicine Centre, c/o 16 College Road, Block 4 Level 1, Singapore General Hospital, Singapore 169854  
valerie.tan2@mohh.com.sg

### Abstract

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**Introduction:** Owing to the scarcity of randomized controlled trials to guide treatment for decompression illness (DCI), there are many unanswered questions about its management. Apart from reviews and expert opinion, surveys that report practice patterns provide information about useful management strategies. Hence, this study aimed to identify current treatment preferences for DCI amongst diving physicians in Singapore.

**Methods:** An anonymous web-based questionnaire was sent to known diving physicians in Singapore. The demographics of the respondents were captured. Respondents were asked about their preferred management for five different DCI scenarios.

**Results:** The response rate was 74% (17 of 23 responses). All respondents chose to recompress patients described in the five scenarios. Regarding the number of recompression sessions, “one additional session after no further improvement in signs and symptoms” was the most common end point of treatment across all the scenarios (47 of 85 responses). Analgesics would be used by five physicians, three would use lidocaine and two steroids as adjuvant therapies.

**Conclusions:** Apart from the general agreement that recompression is indicated for DCI, there was no strong consensus regarding other aspects of management. This survey reinforces the need for robust RCTs to validate the existing recommendations for DCI treatment.

### Key words

Decompression sickness; Cerebral arterial gas embolism (CAGE); Hyperbaric medicine; Hyperbaric oxygen therapy; Recompression; Survey

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### Introduction

Singapore is geographically located in the popular tropical recreational diving region of South East Asia and treats an average of 20 patients with decompression illness (DCI) annually.<sup>1</sup> There are many published guidelines on DCI management such as those of the Undersea and Hyperbaric Medical Society (UHMS) 2011 and the US Navy Diving Manual 2008 (USN).<sup>2,3</sup> However, due to the scarcity of rigorous data from randomized controlled trials (RCTs),<sup>4</sup> these guidelines are often based on retrospective reviews and expert opinion. This study aimed to identify current treatment preferences of Singapore’s diving physicians for DCI to determine if the lack of robust data was associated with variations in practice patterns.

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### Method

Ethics approval was obtained from the Singapore General Hospital Institutional Review Board (2015/2212). An anonymous web-based questionnaire was sent to individual emails of known practicing diving physicians in Singapore. The questionnaire captured the respondents’ demographic data and elicited their management preferences for five different scenarios (Table 1). Two mild decompression sickness (DCS) scenarios included were early presentation of DCS with joint pain only and late presentation of joint-pain DCS. Three more severe DCS scenarios included were cutaneous DCS (*cutis marmorata*), late presentation of mild neurological (sensory only) DCS and severe DCI manifesting as paraplegia or cerebral arterial gas embolism (CAGE). There were also questions on the use of adjunctive therapies. Responses were collated over one month from

**Table 1**

Brief summary of the five scenarios presented to Singapore diving physicians (the full questionnaire is available either from the corresponding author or the DHM office <editorialassist@dhmjournal.com>)

**Scenario 1:** A diver presenting at 4 h with joint pains (pain score 5/10) after diving

**Scenario 2:** A diver presenting at 48 h with joint pains (pain score 5/10) after diving

**Scenario 3:** A diver presenting with cutaneous DCS (*cutis marmorata*) only

**Scenario 4:** A diver presenting with mild sensory deficits at 48 h after diving

**Scenario 5:** A diver presenting with paraplegia or cerebral arterial gas embolism

For each scenario, the physician was asked five questions:

1. What initial treatment would they recommend (recompression/normobaric oxygen/none)?
2. What table would they use as first treatment? (five options presented)
3. If symptoms were unchanged post treatment, what would they recommend? (six options presented)
4. If there was a good response to the first treatment, what would they recommend for follow up? (six options presented)
5. When would they cease treatment? (six options presented)

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February 2015 to March 2015, and a second round of data collection was performed from January 2016 to February 2016. Data were logged in a Microsoft Excel® spreadsheet from which, because of the small sample size, we only report simple descriptive results.

## Results

The response rate was 17 out of 23 (74%). Five physicians had practiced for one to five years, six for six to 10 years and six had more than 11 years of practice. Nine physicians had received training in diving medicine units in the USA, three in Australia, two in both Australia and Canada, one in both Australia and the USA, and two locally in Singapore.

## DIVE TABLES

All 17 respondents recommended recompression for each of the five scenarios. Treatment preferences are shown in

Figures 1 and 2. The majority opted for a US Navy Treatment Table 6 (USN TT6) as the first recompression table for both mild (21 of 34 responses) and severe DCS (39 of 51 responses). The deeper USN TT6A was advocated by about a third of the responders, predominantly for severe DCI.

With respect to the number of recompression sessions, “*one additional session after no further improvement in signs and symptoms*” was the most common option for the end point of treatment across all scenarios (47 of 85 responses), followed by “*till no further improvement*” (25 of the 85 responses). In only eight responses was continued HBOT recommended until “*complete resolution*”.

## ADJUVANTS

Ten of the 17 respondents would not use analgesia for DCS; two recommended paracetamol, two non-steroidal anti-inflammatories (NSAIDs) and one both paracetamol and NSAIDs. Two responses were void. Thirteen would not use steroids. One would use intravenous dexamethasone in severe neurological cases on the basis of potential reduction of oedema and inflammation arising from significant injury.

Thirteen out of 17 would not use lidocaine. Of those who would, one would use it for high pain scores and another only as per resuscitation guidelines, or in arterial gas embolism for its anti-arrhythmia properties. Only one would use aspirin. One respondent would consider gabapentin and pregabalin for neuropathic pain, but acknowledged that this was not evidenced-based.

## Discussion

So far, there has been only one RCT on treatment for DCI.<sup>5</sup> Guidelines are largely based on case reports, case series and animal studies, and these have changed over the last 60 years, especially with respect to first aid and adjuvant treatment.<sup>4</sup>

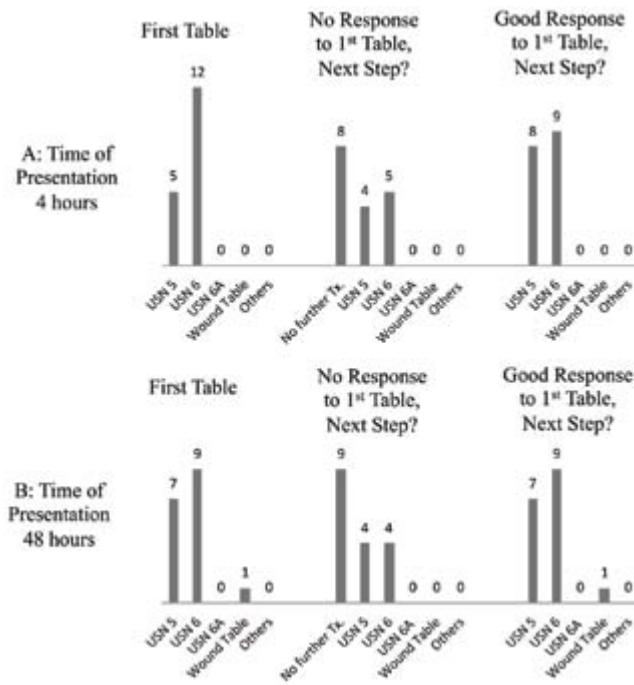
## INDICATIONS TO TREAT

All the respondents decided to recompress the cases described in the five scenarios. This is a more aggressive approach to treatment than that from a Swiss study in which for a pain-only DCI scenario with a delay-to-treatment of more than 24 hours post dive, only half the respondents chose recompression over normobaric oxygen.<sup>6</sup>

Mild DCI can be managed without HBOT, as after a finite period of time, stable mild symptoms rarely progress.<sup>7</sup> An international symposium in 2005 on the management of mild or marginal DCI in remote locations concluded that delays in the treatment were unlikely to adversely affect outcome.<sup>8</sup> Some physicians choose not to recompress patients with pain-only DCI. Using the American Heart Association classification, the use of HBOT for DCI is level C evidence with a Level I recommendation.<sup>9</sup> A Cochrane review also

**Figure 1**

Hyperbaric treatment preferences of 17 physicians for decompression sickness presenting with joint pain only; A – presenting within 4 h; B – presenting at 48 h



concluded that there was insufficient RCT data to support or refute the effectiveness of recompression.<sup>4</sup>

Alternatively, when oxygen treatment tables are used with an initial treatment pressure of 284 kPa and the delay to treatment is not excessive, most DCI symptoms tend to resolve with a high degree of success.<sup>7</sup> The Cochrane review also recommended HBOT as a universally accepted therapy for DCI and for ethical reasons mentioned it is not likely to be compared with placebo.

#### HBOT TREATMENT PREFERENCES

Recompression typically involves pressurization between 203 and 608 kPa for periods ranging from 2 hours (h) to several days.<sup>3</sup> The optimal treatment strategy for different clinical presentations has not been determined. One of the most common recompression profiles is USN TT6, with a 284 kPa maximum pressure while breathing 100% oxygen and lasting 4 h 45 min with the option for extensions. This profile has a low risk of cerebral and pulmonary oxygen-associated toxic effects.<sup>3</sup>

Twenty-one out of the 34 responses for the pain-only scenarios opted to start treatment with USN TT6. This could be because, although patients may present with pain-only symptoms initially, especially in an acute presentation with a post-accident time of 4 h or less, mild DCS may progress in severity after the initial assessment.<sup>11</sup> The preference for

**Figure 2**

Hyperbaric treatment preferences of 17 physicians for decompression illness; A - cutis marmorata; B –mild sensory symptoms at 48 h; C – cerebral air embolism or paraplegia



USN TT6 is supported by others who emphasize that shorter tables such as a USN TT5 are not recommended for initial treatment owing to higher rates of recurrence and post-treatment deterioration relative to USN TT6.<sup>12</sup> Although presentation with pain-only DCS at 48 h is associated with a low risk of symptom progression, USN TT6 rather than USN TT5 is still recommended since clinical response often occurs hours or even days after onset.<sup>12</sup>

#### END-POINT TO TREATMENT

Approximately two-thirds of the respondents chose to treat with one additional session after there was no further improvement as the endpoint to treatment for all DCI. Failure to institute follow-up treatment after initial recompression may cause delayed progression of initial symptoms. In sensory or pain-predominant DCS, symptoms often wax and wane daily.<sup>13</sup> Documenting improvement after each

treatment avoids unnecessarily prolonging the hyperbaric treatment course and reduces the risks of side effects such as oxygen toxicity. This preference is aligned with both the UHMS 2011 guidelines and Republic of Singapore Navy protocols for severe DCI. However, the choice of this option for mild DCS is inconsistent with existing guidelines.

The second most common preference was to stop after there is no further improvement. It is difficult to establish a fixed end point of treatment. This stems from DCS being a clinical diagnosis with a lack of objective diagnostic criteria from laboratory or imaging parameters. Clinical examination remains the best means of assessment despite it being an inadequate surrogate for assessing resolution of reperfusion injury.

Two of our respondents recommended treatment until complete resolution of symptoms. Most patients with residual neurological manifestations need only two or three treatments to reach a clinical plateau. Patients with residual symptoms post treatment may also remain anxious and stressed, and prefer to continue HBOT sessions in the hope for complete resolution, despite having reached a clinical plateau. This is further complicated by the nature of DCS symptoms often being sensory or pain sensations, which tend to fluctuate.

## TREATMENT ADJUVANTS

### *Analgesia*

About a third of our respondents would use analgesia in HBOT treatment. In pain-only DCS, physicians are only able to ascertain the success of treatment by resolution of pain. As analgesia may mask pain, physicians may feel that they are unable to accurately judge whether the symptoms of DCS have resolved. This hinders treatment decisions as to whether there is a need to continue HBOT. However in an RCT, tenoxicam was shown to reduce the number of recompressions needed to achieve symptom resolution, but did not change the final outcome.<sup>5</sup> It is surprising, then, that NSAIDs were not advocated more often by this group.

### *Steroids*

Only a few respondents would use steroids in HBOT. Two respondents qualified their usage to only in cases of severe DCI. As well as reducing tissue oedema, steroids help to reduce ischaemia and intravascular platelet aggregation. However, steroids are generally not recommended in the treatment of DCI.<sup>12</sup>

### *Lidocaine*

A quarter of respondents would use lidocaine in DCI. Lidocaine has been effective only in animal studies for AGE.<sup>14</sup> There is insufficient clinical evidence to recommend

its use in DCS, although anecdotally its use may be justified in serious neurological DCI, when the response to recompression is poor.<sup>15</sup> The anti-inflammatory effect of lidocaine, coupled with its beneficial effects of membrane stabilisation, favourable haemodynamic properties in the ischaemic brain and increased cerebral blood flow, make lidocaine a good, yet unproven candidate for adjuvant use in DCI.<sup>16</sup>

### *Aspirin*

Possible reasons why aspirin was little advocated in these scenarios may include concerns about its potential to cause or worsen central nervous system bleeding. There are possible bleeding complications associated with barotrauma during recompression. The ability of aspirin to inhibit platelet aggregation may be useful in prophylaxis for DCS but there is no convincing evidence that it is effective in therapy.<sup>17</sup> However, there are schools of thought that still consider aspirin as a mainstay of treatment. For example, many French hyperbaric centres, as of 2009, still prescribed aspirin routinely, possibly on the basis of preclinical trials that showed that the inhibition of platelet aggregation using aspirin or clopidogrel attenuates the clinical course of DCS.<sup>18</sup>

## Conclusions

There was clear agreement amongst diving physicians in Singapore for a need for recompression, mainly using a USN TT6, for all cases of DCI of whatever severity or delay to treatment. However, there was no consensus regarding other aspects of management. This is consistent with previous surveys and reinforces the need for robust RCTs to validate the existing recommendations for DCI treatment.

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