

Descriptive study of diving injuries in the Canary Islands from 2008 to 2017

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Key words

Diving incidents; Epidemiology; Scuba diving; First aid; Hyperbaric oxygen therapy; Tourism

Abstract

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Introduction: This research reports the epidemiology of diving injuries managed in the Hyperbaric Medicine Unit of the Canary Islands University Hospital.

Methods: Data were extracted from the clinical records of all divers injured and admitted to the unit for treatment of dysbaric diving injuries between 2008 and 2017, inclusive.

Results: One-hundred and thirty diving injuries were recorded. Most (71%) occurred in men and 43% were foreigners. Eighteen per cent either had no diving certification or that information was not recorded in the clinical chart. Only a third of the 40% of divers who had some form of on-site first aid treatment received oxygen and oral rehydration. Type 1 decompression sickness (DCS) was diagnosed in 56 divers (43%) and Type 2 in 67 (52%), whilst seven were treated for omitted decompression. At discharge, 122 (94%) were asymptomatic, whilst 5% experienced some residual sensory or other changes. One diver who presented late remained quadriparetic and one, admitted in a state of coma, died. Only 76% of the injured divers had specific diving accident insurance and, of those, 58% were foreign divers.

Conclusions: Over half of the injured divers did not receive any on-site first aid. The majority (94%) of treated injured divers were discharged without sequelae. Based on these data, several public health recommendations for the Canary Islands are made.

Introduction

Hyperbaric oxygen treatment (HBOT) has a number of indications that may be divided into established, experimental and unestablished.^{1–4} Amongst the established indications are decompression sickness (DCS) and arterial gas embolism (AGE) secondary to pulmonary barotrauma, collectively termed decompression illness (DCI). These conditions can affect all divers whether professional or not. HBOT is the gold standard treatment for these conditions.^{2,4}

The Canary Islands, located in the Atlantic Ocean between latitudes 29°24'40" N and 27°38'16" N and longitudes 13°19'54" W and 18°09'38" W, form an archipelago of Macaronesia. The islands are of volcanic origin, consisting of eight major inhabited islands (Tenerife, La Palma, La

Gomera, El Hierro, Gran Canaria, Lanzarote, Fuerteventura and La Graciosa) and five smaller islets. A coastline of over 1,500 kilometres, the existence of pleasant, spring-like temperatures throughout the year and clear waters makes them an excellent open-water dive site.⁵ The main economy is tourism, with approximately 15 million visitors annually. A large number of these visitors wish to dive, so require adequate staff and facilities.^{6,7} In Tenerife, there is a Hyperbaric Medicine Unit (HMU) with a hyperbaric chamber linked to the Canary Islands University Hospital (acronym in Spanish, HUC) that provides care for diving injuries that may occur throughout the whole of Macaronesia.

According to international statistics, the number of diving injuries in proportion to the number of dives and divers is very low when compared to the morbidity of other sports

Table 1

Diving injury locations in the Canary Islands over a decade, 2008 to 2017

Location	Number	Percentage
Tenerife	92	71
Gran Canaria	16	12
El Hierro	9	7
La Palma	5	4
Other	4	6
Total	130	100

activities.^{8–10} However, although of low incidence, 35% of diving injuries are severe and 5–10% may be life-threatening.^{10,11} The objectives of this paper were to report the nature of the diving injuries that have been treated at the HMU and their outcome at discharge.

Methods

This was a retrospective review carried out in accordance with the Helsinki Declaration and approved by the Human Ethics Committee of the Canary Islands University Hospital (2017_15 EPIBUCAN01).

Admission for treatment of a diving injury to the HUC was the only selection criterion applied. The data were extracted from the HMU's clinical records, transcribed to a standard form and then entered into a Microsoft Excel® database. The medical records of all patients admitted to the HMU between May 2008 and December 2017 were reviewed. This period was chosen because a new modern chamber was installed in May 2008, and patient records prior to this date were insufficient for review.

From this data base, only those patients diagnosed with dysbaric injuries were extracted and the following data recorded for each case: age; gender; nationality; date of the diving accident; date of arrival at the UHC Emergency Service; type of diving activity; diver certification; diving accident insurance; diving incident location; type of dive; DCS type; maximum depth; total dive time; latency between last dive and symptom onset; on-site first aid measures; means of transport used; type of treatment administered; recovery status at discharge.

Traditionally, DCI has been classified into DCS Type 1 (DCS with cutaneous symptoms, 'bends' or musculoskeletal pain and lymphatic system symptoms), DCS Type 2 (DCS with neurological, cardiovascular, pulmonary or inner ear involvement) and AGE.¹² In our study we found that DCI was classified in the clinical records only into DCS Type 1 and DCS Type 2.

Table 2

Means of transport used in the Canary Islands to evacuate injured divers to the recompression chamber on Tenerife

Mode of transport	Number	Percentage
Own means	50	38
Ambulance	35	27
Helicopter/fixed wing	34	26
No data	11	9
Total	130	100

The statistical package SPSS v.23 was used to produce simple descriptive statistics.

Results

The study includes 130 divers with dysbaric injuries. The number of diving injuries ranged from six in 2010 to 23 in 2017, with an obvious increase over the last four years (Figure 1). Seventy-one per cent were male and 29% female; median age was 38 years (range 17–70 years). Local divers comprised 57% of the sample while 43% were foreigners, with some variability in the ratio from year to year. Table 1 shows the number of incidents in various Canary Islands locations.

In relation to diving activity, 26 (20%) of incidents involved professional divers and 104 (80%) involved recreational divers. Surprisingly only 82% of the subjects had a diving certificate, either professional or recreational, the remaining 18% either having no certificate or no data existed in the clinical record. Only 76% had specific diving accident insurance and, of these, roughly half were locals and half foreign divers.

With respect to the type of diving being undertaken, 90 (69%) followed a single dive and 33 (25%) followed repetitive dives. Other types of diving included two divers following multiple breath-hold dives. On-site first aid was provided to 40%; 47% did not receive first aid and data were missing for the remainder (13%). Only normobaric O₂ was given to 24 divers (18%), normobaric O₂ and fluids (oral or intravenous) to 17 (13%) and other measures to seven. Injured divers were transported to the HUC in various ways: by their own means (50, 38%; 48 in Tenerife); by ambulance (35, 27%; 33 in Tenerife), or by helicopter or fixed wing aeroplane (34, 26%), with no data recorded for the remaining 11 (see Table 2).

The diagnoses presented in the clinical charts were Type 1 DCS in 56 divers (43%) and Type 2 DCS in 67 (52%) whilst seven presented following omitted decompression without symptoms. Treatment at HUC was observation

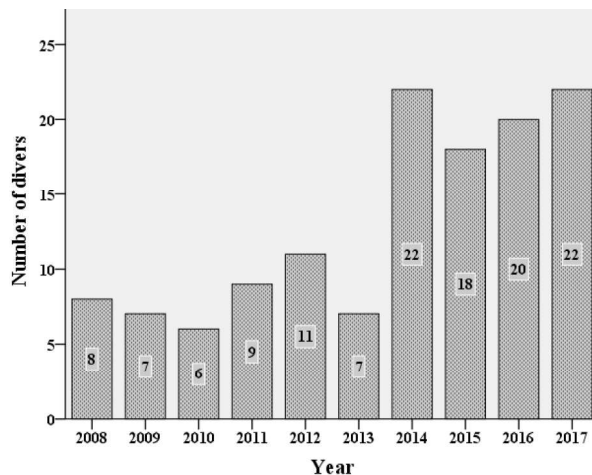
Table 3

Initial hyperbaric treatments administered in relation to the clinical diagnosis; USN TT5 – US Navy Treatment Table 5; USN TT6 – US Navy Treatment Table 6; the 243 kPa/60 min table was used for delayed referrals

Diagnosis	Initial hyperbaric oxygen treatment				
	USN TT5	USN TT6	243 kPa/60 min	Observation	Total
DCS Type 1	44	1	2	9	56
DCS Type 2	15	47	4	1	67
Omitted decompression	3	0	0	4	7
Total	62	48	6	14	130

Figure 1

Number of reported diving injuries in the Canary Islands by year



sensory or other changes. In addition, one diver injured at Cabo Verde took several weeks to present for HBOT and remained quadriparetic, whilst another, an American diver injured at Lanzarote, was admitted in a state of coma and died.

Discussion

It is important to know the epidemiology of diving injuries for a variety of reasons, such as to establish guidelines for injury prevention in divers and to develop effective public health strategies. From a public health viewpoint, there has been a large increase in the number of diving injuries in the Canaries from 2014 onwards compared to previous years (Figure 1). This requires a major study in order to establish the main contributing factors and to mitigate identified risk factors. It is possible that it simply reflects the increasing diving activity in the Canary Islands, but this is unknown.

or HBOT. Observation was carried out with normobaric oxygen and fluid therapy. Initial HBOT for DCS was a United States Navy Treatment Table 5 (USN TT5) or Table 6 (USN TT6). The choices of treatment for the various diagnostic categories are shown in Table 3.

If symptoms and/or signs of the dysbaric pathology persisted once initial HBOT was completed, the diver was admitted to hospital. Additional HBOT was given over the following days (one per day), consisting of 60 minutes of HBOT at 243 kPa, with a five-minute air break after 30 minutes of treatment and a decompression time of seven minutes. These additional sessions were conducted with the diver joining other patients undergoing elective HBOT for other pathologies. Forty-three patients (33%) were treated with extra HBOT either until they were symptom-free or their condition had stabilised, (median 5, range 1 to 13). Furthermore, six patients diagnosed as ‘non-acute DCS’ were also treated on these 243 kPa HBOT sessions.

At discharge from the HUC, 122 of 130 divers (94%) were asymptomatic and six (5%) experienced some residual

Over 90% of the injured divers treated at the HUC were aged 25 to 64 years or more. This differs from data reported by the Divers Alert Network (DAN) in its Annual Diving Report, 2012–2015, which reports only 62% in this range.⁸ It needs to be established whether this reflects a real difference from the international data. The gender distribution in this study (71% men, 29% women), is similar to that from other studies – 72% male; 28% female in one,⁸ and 81% male, 19% female in another.¹¹ It is important to point out the high proportion (43%) of foreign divers present in our study. This likely reflects the Canary Islands as a very popular tourist destination, surrounded by sea and with many possibilities for the pursuit of recreational diving (with and without scuba).

Another important observation is that almost a quarter of the injured divers did not appear to have a diving certificate. These data are similar to those obtained by others (18% for no certification, training or unknown).¹¹ Lack of diving experience and knowledge could be behind many of the diving incidents. Likewise, less than half of the foreign divers had diving accident insurance; one could assume that insurance cover is not regarded as important by these divers.

The low rate of provision of on-site first aid amongst this cadre of divers is of equal concern. Some of this may reflect the latency of onset of symptoms; only 68 individuals (52%) reported symptom onset before 40 minutes post dive, by which time they may have been separated from potential first-aid providers. The failure to provide on-site first aid may also reflect a lack of appropriate equipment or reluctance to use it. This seems likely since only 13% of injured divers who received some on-site assistance, actually received the first aid recommended in relevant guidelines.^{8,13} Three injured divers received in-water recompression with air as the initial treatment gas, a practice that is discouraged strongly in our environment.^{13,14} Enhancing knowledge about first-aid procedures when a diving incident occurs and its impact regarding diver outcome is needed in the Canaries.

Although there are similar-sized populations in Gran Canaria and Tenerife,¹⁵ only 12% of the diver referrals were from Gran Canaria. It is possible that a greater number of accidents may have occurred in Gran Canaria but were not referred to Tenerife, where the only hyperbaric facility is situated, because of logistical difficulties with inter-island transfer. Almost half of the divers (48%) on the island of Tenerife arrived at the HUC by their own means. In contrast, most of the injured divers from other islands came by helicopter. Air transport is the most efficient and timely means of transferring injured divers between islands. The situation of the Canary Islands as a fragmented territory of many islands with diving activities distributed over a wide area necessitates the development in the future of transportation protocols for injured divers.

Finally, we suspect that some cases in our study e.g., the American diver injured in Lanzarote admitted in a state of coma, might be AGE. The difficulty to tell the difference between DCS Type 2 (DCS with neurological involvement) and AGE, could be behind this misclassification.^{12,16,17}

This study has some weaknesses that should be acknowledged. In particular, there were a variety of missing clinical and other data. Also, no post-hospital discharge outcomes were evaluated.

The following public health and clinical management recommendations are made, based on these data and their analysis:

- establishment of a central registry of diving accidents;
- improved training in and use of appropriate first-aid procedures for diving injuries;
- improved clinical documentation;
- post-discharge follow-up of the HBO-treated divers;
- development of an evacuation protocol for diving accidents for the Canary Islands in order to accelerate the transportation to the HUC hyperbaric chamber.

Conclusions

Decompression illness was more common in men than women, with nearly half the injured divers being foreigners. About a quarter appeared to have no diving certificate or no relevant data existed on their clinical record, and a similar proportion did not carry specific diving accident insurance (almost half of the foreigner divers). Two thirds did not receive any on-site first aid or no data on this was available on their clinical record. Because the hyperbaric chamber is located on Tenerife, diving injuries that occurred in other islands may have been under-reported. Over 90% of the injured divers treated were discharged without sequelae. In fragmented territories like the Canary Islands, it is desirable to have an evacuation protocol for injured divers, based on air transport (helicopter preferably).

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