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# Decompression sickness in urban divers in France

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## ABSTRACT

***Background:*** *Decompression sickness (DCS) can occur in SCUBA divers. DCS is treated with oxygen, preferably given under hyperbaric conditions. Although Paris (France) is located at a distance from the sea or lakes, some injured divers require hyperbaric oxygen treatment (HBOT) in this city, sometimes within a specific time frame. Thus, this study investigated the epidemiology and outcomes of such urban divers.*

***Aim:*** *We conducted an observational study of SCUBA divers admitted to the Raymond Poincaré Hyperbaric centre near Paris from 1993 to 2003.*

**Materials and methods:** We prospectively enrolled 69 consecutive SCUBA divers presenting DCS. Common risk factors were reported, especially aeroplane flight and training dives. Symptoms are very often atypical (63%) and onset time of symptoms is often too long (59% after 2 h) due to denial of symptoms. First aid is generally inadequate, with only 23% of victims receiving oxygen, fluid loading and aspirin together. HBOT was given for 42 (61%) patients although their examination results were considered as normal.

***Conclusions:*** *Diving pits and diving travel agencies should do more to warn divers of the need for treatment with normobaric oxygen and hydration pending HBOT. Moreover, hyperbaric physicians should better clarify HBOT indications for both symptoms of late onset and atypical presentations.*

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**Key words: SCUBA diving, decompression sickness, diving pit, yo-yo dive profile, aeroplane flight, hyperbaric oxygenation therapy (HBOT), recompression chamber**

## INTRODUCTION

Self-contained underwater breathing apparatus (SCUBA) diving is increasingly popular. Although decompression sickness (DCS) is a rare complication of diving, it can lead to neurologic sequelae despite treatment. The reference treatment is at best 100% oxygen, preferably applied under hyperbaric conditions [1]. Other treatments include fluid loading, while corticosteroids and aspirin remain more controversial [1, 2].

Raymond Poincaré Teaching Hospital is located in a western suburb of Paris, not a notable spot for diving (400 km and 700 km from the Atlantic and Mediterranean coasts, respectively). Nevertheless, there are 4 diving pits within a 20-km radius with depths exceeding 15 m. Moreover, short diving trips to the Red Sea, the Maldives, and the Caribbean have become a popular hobby among some Parisian divers. During such short trips, people dive as much as they can without resting and almost up to the boarding deadline of their flight back to Paris. Consequently, some injured divers present at the Raymond Poincaré Hyperbaric Centre with clinical signs evocative of DCS. We aimed here to describe the epidemiology of this widely known population of injured urban SCUBA divers.

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## MATERIALS AND METHODS

### PURPOSE

We aimed to evaluate the epidemiological data of DCS divers admitted in a hyperbaric centre at a distance removed from the sea and lakes.

### STUDY DESIGN AND PATIENTS

We collected observational data from 1 January 1993 to 31 December 2003 at a university hyperbaric centre near Paris in France. Garches is located in the Paris region and has the only 24-h public recompression chamber in the entire region (12 million inhabitants). A second military hyperbaric centre is available in Paris and can also offer care to civilian divers. Our hyperbaric activity deals almost entirely with emergency injuries (DCS, carbon monoxide poisoning, iatrogenic gas embolism, and severe necrotising fasciitis). In rare cases, we provide hyperbaric oxygen treatment (HBOT) for chronic patients suffering from wounds, osteomyelitis, or osteoradionecrosis. This limited activity has been chosen because of our local organisation. All consecutive patients with a possible history of DCS according to the International Classification (I and II types) and admitted for HBOT during this 11-year period were prospectively enrolled [3].

### DATA COLLECTION

For each patient, we used medical reports (history, clinical examination) and standard forms (circumstances of dive, treatment, sequelae, and resumption of diving). The outcome is reported wherever known (there were some losses to follow-up).

## RESULTS

We included 69 patients from January 1993 to December 2003. Among these 69 patients, in 30 (43%) and 17 (25%) DCS occurred particularly in spring and autumn, respectively. Unfortunately, we do not have complete data for the 69 patients because of loss to follow-up or incomplete data collection.

### BASELINE CHARACTERISTICS OF PATIENTS

There were 14 (20%) women, mean age was 34 years (range: 17–57 years). There were 11 (30%) novices divers (Open Water Diver or equivalent), 7 (19%) intermediate divers (Advanced Open Water Diver or equivalent), 9 (24%) advanced divers (Rescue Diver or equivalent) and 10 (27%) instructors among the 37 divers answering this question, as shown in Figure 1.

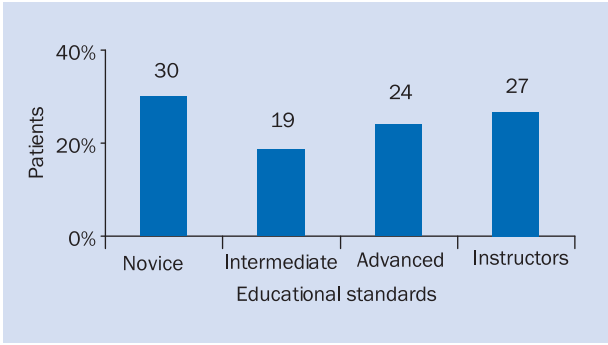


**Figure 1.** Levels of training among victims

### MAIN CAUSES OF DCS

Fourteen DCS (20%, n = 69) occurred in diving pits with 6 (9%, n = 69) of these resulting from repeated yo-yo dive profiles (repetition of several descents and come back up to surface). Thirty-one cases (45%, n = 69) were related to major errors in decompression procedure: in particular an excessive ascent rate or the non re-immersion followed by a 5 min stop at mid depth after major procedure error recommended by the French Navy in its decompression tables. Among other risk factors for DCS, 31 patients (45%, n = 69) had a body mass index > 25 (all were men), 12 patients (17%, n = 69) dived despite exhaustion, 3 patients (4%, n = 69) dived after drinking alcohol, and 8 patients (12%, n = 69) had a past history of DCS (1 spinal cord DCS, 3 cerebral DCS, 3 cochleovestibular disorders, 1 case of limb pain).

The diving depth exceeded 40 msw (meters of sea water) in only 12 cases (17%, n = 69) and only 6 patients (9%, n = 69) had dived in cold water (< 19°C). The mean dive depth was 28 msw (SD: 14.85 msw, SEM 1.79). Most divers were unable to assess bottom time. In 26 cases (38%, n = 69), DCS followed repeated dives with less than 8 h surface interval, and a yo-yo dive profile was seen in 18 patients (26%, n = 69).

Finally, 10 cases (15%, n = 69) occurred when divers in training underwent examinations for different certificates and degrees (yo-yo dive profile or rapid ascent).

### CLINICAL SIGNS: APPEARANCE AND TIME TO ONSET

DCS symptoms were recognised in the water or within the first hour in 9 cases (13%, n = 69) and 37 cases (53%, n = 69), respectively. In the remainder, DCS was clinically evident after an interval of between 2 and 48 h. Among them, 18 divers (26%, n = 69)

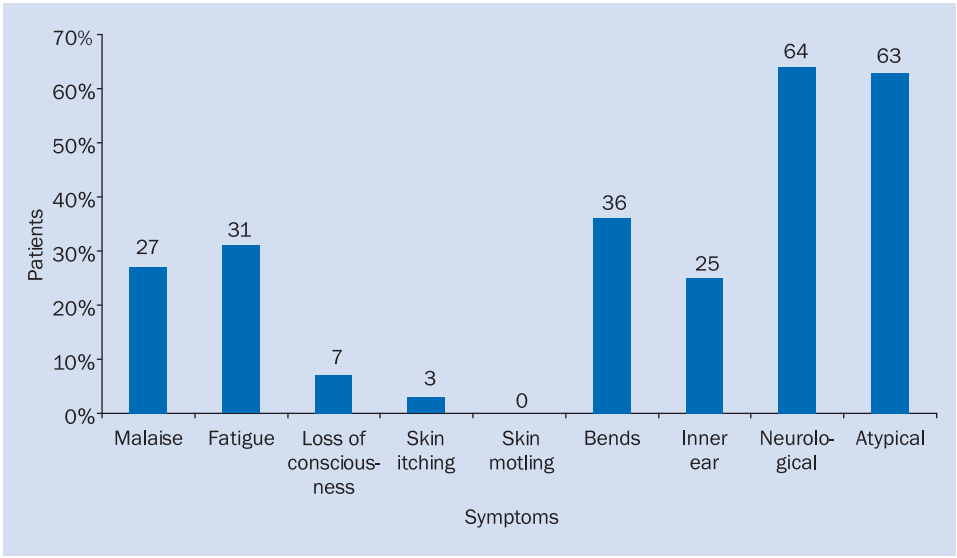


**Figure 2.** Variety of symptoms presented

presented initial DCS symptoms during the return flight to Paris. Symptoms were strongly suggestive of DCS in only 25 cases (36%, n = 69). In the other cases (64%), symptoms were clearly atypical (fatigue, anxiety, non-systematised paresthesiae) and were attributable to DCS only because of post-dive appearance. Discernible objective signs were seen in 8 patients (12%, n = 69), and motor deficiency was described in 5 patients (7%, n = 69) (1 tetraplegia, 3 paraplegias, and 1 monoplegia). All reported symptoms are shown in Figure 2.

## MANAGEMENT OF DCS

First aid for patients at the scene of a diving accident was generally insufficient: 18 patients received aspirin (38%, n = 47) while 18 received oxygen (38%, n = 47). Eighteen others received an infusion of saline (38%, n = 47). The 3 treatments together ("French triad") were given to only 11 divers (23%, n = 47). Combined oxygen plus rehydration, about which there is a broader consensus worldwide, was given to only 19 divers (40%, n = 47). Most patients (84%) received a single HBOT session. An identical procedure HBOT was used for all patients. We used a multiplace hyperbaric chamber (Cx PRO, Comex, Marseille, France) pressurised with compressed air at 2.8 atmospheres absolute (ATA) for 60 min. All patients received 100% oxygen during the full session via a tight-fitting facemask. Eleven (16%, n = 69) patients had repeated sessions (2 sessions per day in this case), 2 sessions (7%), 3 sessions (1.5%), 5–10 sessions (4.5%), and up to 15 sessions (3%), with 1 patient receiving 30 sessions.

## OUTCOME

In the symptomatic group (37 divers), various neurological sequelae persisted in 12 divers (32%, n = 37) despite repeated HBOT sessions, with 9 of these (24%, n = 37) having problems in daily life one year after the accident. Thirteen patients (19%, n = 69) have stopped diving while 38 (55%, n = 69) continue to dive and have not changed their diving habits.

## DISCUSSION

Our study reveals several points, some already well known, others less well known. Firstly, DCS can affect all levels of diver, from novice to expert. Secondly, classical risk factors are often present but yo-yo dive profiles and aircraft flight seem to be preponderant in our region after some errors in decompression procedure that are the first cause of DCS. In the majority of cases, first-aid treatment is inadequate in relation to French guidelines (i.e. a triad of therapy consisting of normobaric oxygen, aspirin, and oral/intravenous rehydration). Although there is no evidence to support the efficiency of antiplatelet agent in DCS, aspirin is nevertheless widely recommended in France [4].

Surprisingly, we reported an exceedingly high number of accidents (15%) occurring when divers underwent examinations for different certificates and degrees (yo-yo dive profile or rapid ascent).

Time until appearance of the initial symptoms was not longer than that usually reported [5, 6]. One HBOT session was given for 42 patients (61%, n = 69) although their examination results were strictly normal. In fact, diagnosis of DCS was made solely in

a post-dive context. The long time to recompression of symptomatic divers is probably responsible for the large number of sequelae observed in 32% of these subjects.

Obviously, some patients (61%) are wrongly given HBOT at our hyperbaric centre while divers with sequelae requiring HBOT may not receive sufficient HBOT, or may receive it too late.

## CONCLUSIONS

Diving pits and diving travel agencies should do more to warn divers of the need for treatment with normobaric oxygen and hydration pending HBOT. Moreover, hyperbaric physicians should better clarify HBOT indications for symptoms of late onset and atypical presentations. Re-evaluation of some diving practical examination procedures should be promoted. Preventive measures like breathing enriched air nitrox and the necessary rapid recognition of DCS symptoms should be promoted, especially after training dives.

## FUNDING

None declared.

## CONFLICTS OF INTEREST

None declared.

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