●原　著

Nitrox application for leisure diving in Japan

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Introduction

Nitrox (Enriched Air Nitrox; EAN_X) is a gas consisting of more than 21% oxygen compared with air. Since the 1950's, this gas has been used in diving work by the US Navy, and its use for leisure diving started in U.S.A. in 1988[1),2)]. In Japan, Nitrox has been approved for use in leisure diving since 1996. Recently Nitrox has been well recognized to decrease the risk of DCS (decompression sickness) after diving, but it may be associated with some risk of serious oxygen toxicity, if used inappropriately[1)~5)]. To promote the more widespread use of Nitrox for leisure diving, this paper clarifies the present state of Nitrox application for leisure diving in Japan.

Methods

1. Questionnaire survey of leisure divers

We filled out a questionnaire by random interview of people who participated in diving in the Osezaki area of Izu peninsula. Osezaki is one of the most popular diving spots in Japan, where about 3,000 divers enjoy diving in every weekend. The subjects of this survey were limited to divers who already had a certification card (C-card: diving license). The survey was carried out in the Osezaki area in May and November 1998 and June 1999. We carried out another survey in the Yahatano area (one of the most famous diving spots) in Izu peninsula in August 1999. The subjects at Yahatano included only divers who had been diving using Nitrox ("Nitrox divers").

2. Questionnaire survey of diving shops

In June 1999, we sent out questionnaires to all diving shops' staff who knew how to manage Nitrox, over the whole of Japan. We focused on some questions regarding Nitrox if the shops had already dealed in Nitrox tanks.

Results

Evaluable answers were obtained from 278, 261 and 260 leisure divers in May 1998, November 1998 and June 1999, respectively. **Figure. 1** shows the percentage of divers who knew about "Nitrox". **Figure. 2** demonstrates the percentage of divers who had used "Nitrox" for leisure diving. We obtained information from 62 divers with Nitrox diving experience. **Figure. 3** shows the replies to the question, "How many times have you ever dived with Nitrox?" **Figure. 4** indicates which type of dive computers, for Nitrox or for air.

This study revealed that 84 in 118 (71.2%) shops already supplied Nitrox tanks to leisure divers. **Figure. 5** presents the distribution of shops dealing in Nitrox tanks in each prefecture in Japan. **Figure. 6** shows the number of Nitrox tanks supplied at 84 shops in a week. The mean number of Nitrox tanks supplied per week by each shop was 5.5 (data not shown). We could find out their opinions on both the advantages and disadvantages of Nitrox use for leisure diving (**Figs. 7 and 8**). **Figure. 9** shows the opinions on the safety of Nitrox regarding DCS obtained from 118

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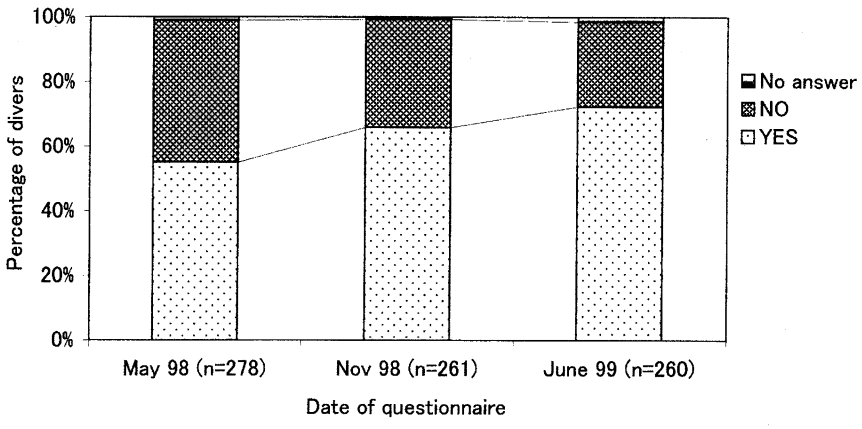

Fig. 1 Do you know about Nitrox ?

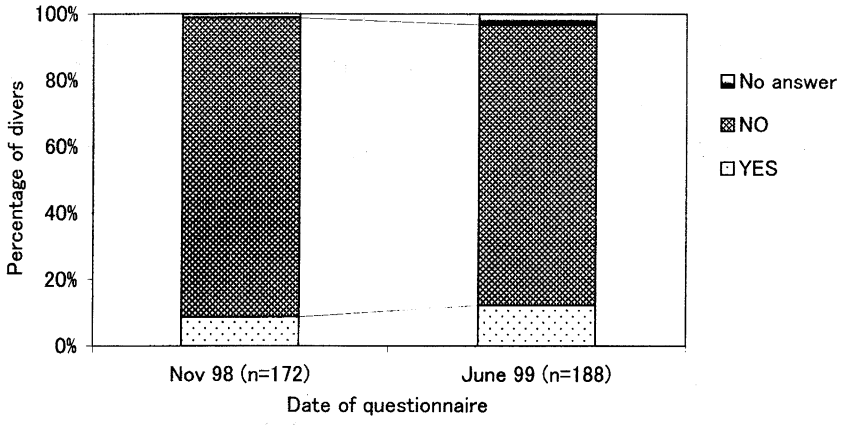

Fig. 2 Have you ever used Nitrox ?

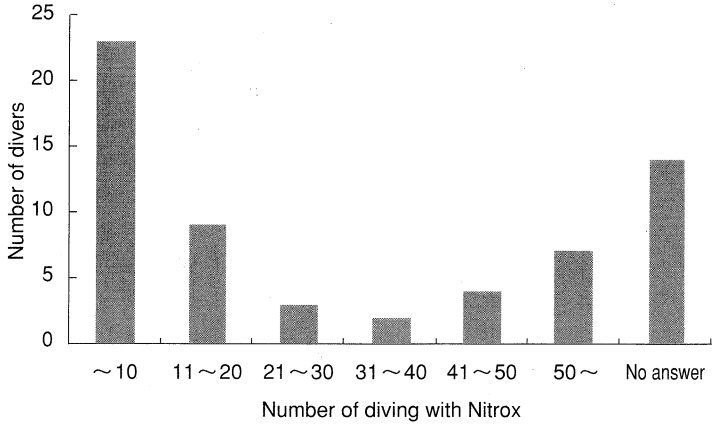

Fig. 3 How many times have you ever dived with Nitrox ?

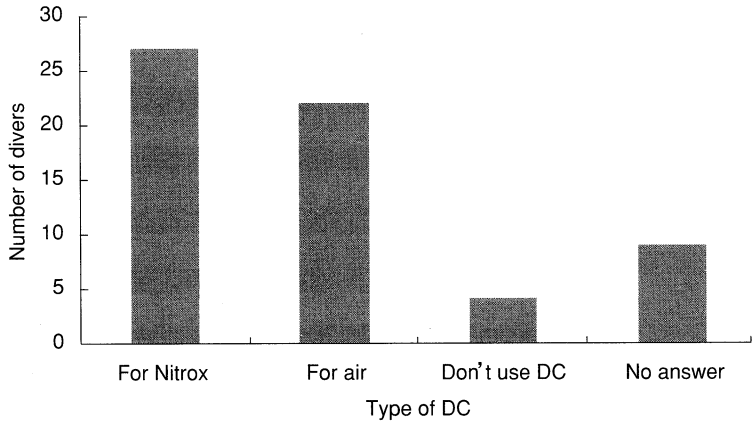

Fig. 4 Which type of dive computers (DC) do you use when you dive with Nitrox ?

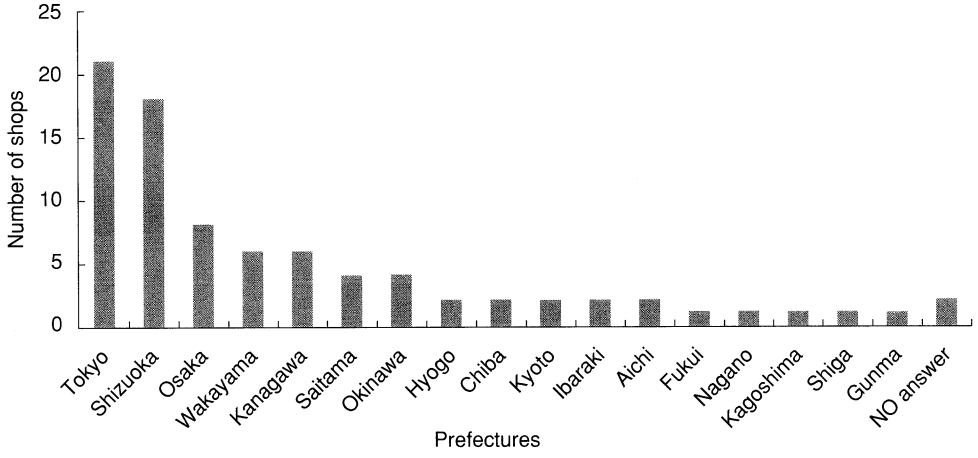

Fig. 5 In Which prefecture is your shop ?

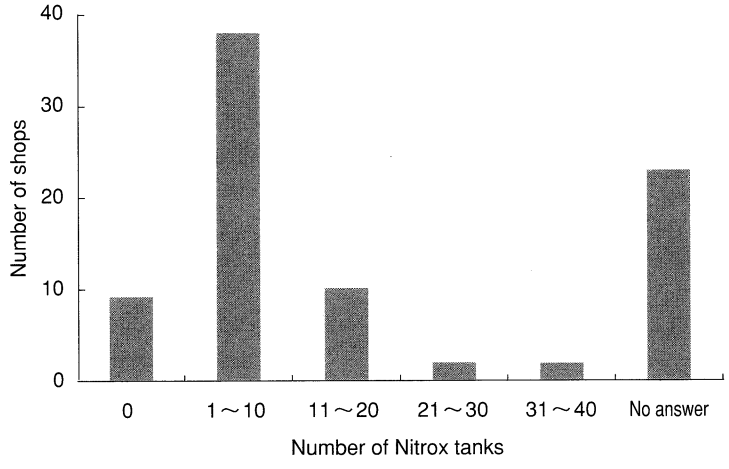

Fig. 6 How many Nitrox tanks dose your shop supply to divers in a week ?

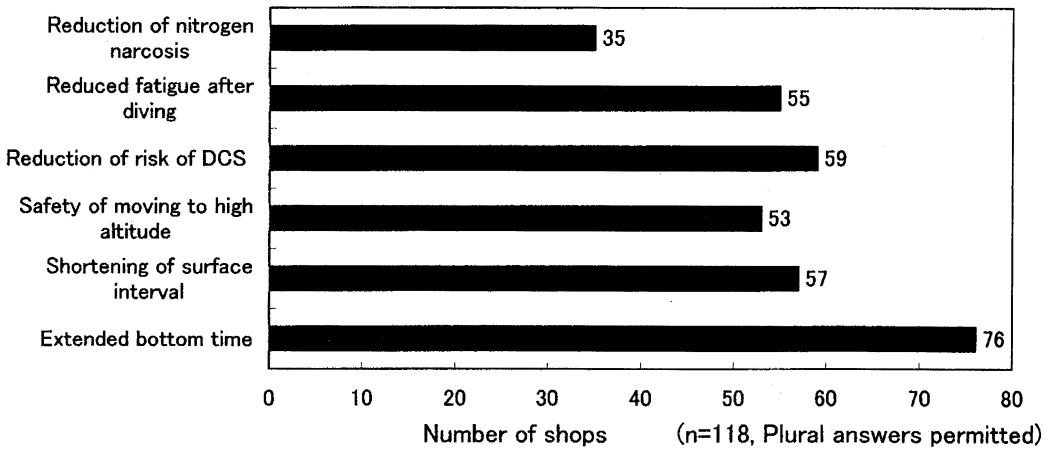

Fig. 7 What are the advantages of Nitrox ?

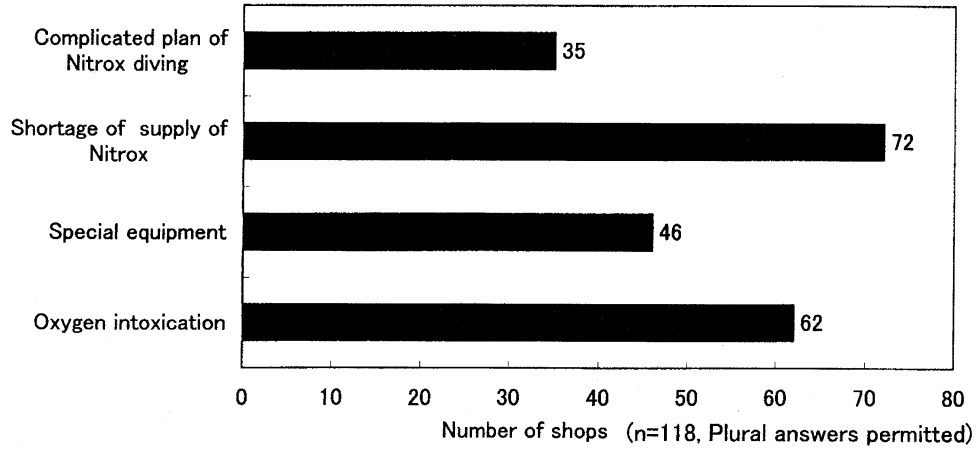

Fig. 8 What are the disadvantages of Nitrox ?

shops.

Discussion

We performed the present investigation in 1998 (two years after approval of Nitrox use for leisure diving in Japan). The results of this study demonstrate the increase of divers number who knows about Nitrox (Figure. 1), but only 23 (12%) in 188 divers had experienced Nitrox diving in the June 1999 survey (Figure. 2). Among them, 40% had used Nitrox less than 10 times. Even at Osezaki, which is one of the most popular diving spots in Japan, only 12% of divers had ever experienced in Nitrox diving. From this fact, a much smaller population of divers must enjoy Nitrox diving in the whole country. On the other hand, in U.S.A., IANTD (one of the mixed gas-managing groups) certificated "Nitrox card" to 17,780 divers from 1985 to 1996[3]. Since Nitrox was introduced for leisure diving in Japan 10 years later than in U.S.A., Nitrox is still not popular in Japan.

The lack of information and economical problems of Nitrox seem to prevent its more widespread use for diving. We should promote Nitrox

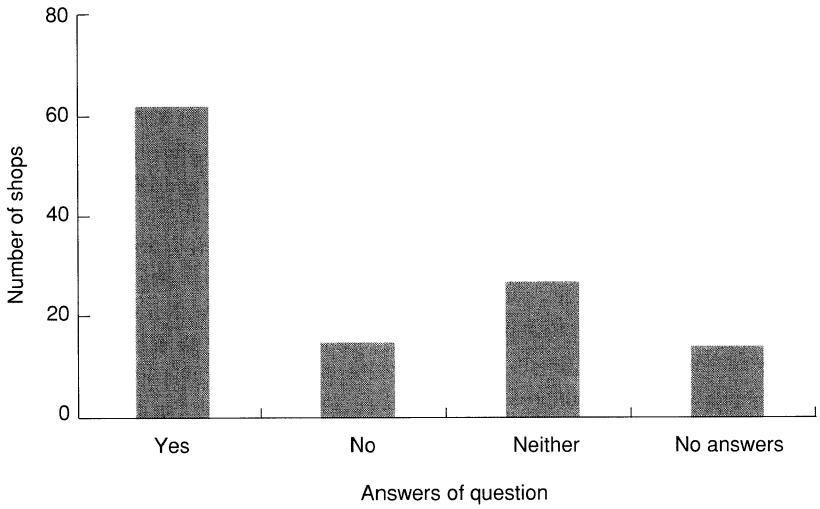

Fig. 9 Do you expect Nitrox to Decrease the risk of DCS ?

for leisure diving to ensure a safe diving system, and as the need arises, we have to offer a better environment for all Japanese leisure divers.

DCS occurs when excessive nitrogen foams into bubbles in the body following inadequate decompression[6),7)]. According to our investigation of DCS, one out of near 16,000 dives' times results in DCS[8)]. Based on this DCS incidence, one DCS accident could be recognized in every weekend at Osezaki area where 3,000 persons enjoy diving. Furthermore, because of the lack of divers knowledge of DCS diagnosis, we cannot determine the exact number of DCS accidents[9)]. The situation is still too serious for comfort and steps are urgently needed to reduce the incidence of DCS.

Because of the geographical features of diving spots in Izu peninsula, approximately 76%[10)] of divers have to return home through regions at altitude (about 400～1000 m above sea level; 970～900 hPa[11)]) immediately after going scuba diving[12),13)]. It is well known that exposure to a lower atmospheric pressure after diving may increase the incidence of DCS[8),10)～17)]. So, we need to emphasize that actual investigations should be promptly introduced to deal with the increased risk of DCS. To decrease the risk of DCS, a dive schedule including Nitrox use should be recommended to divers who need to travel via roads at altitude after diving. Since Nitrox use for the last dive of the day can reduce the residual nitrogen level in the body and an "oxygen window effect" by Nitrox can be expected, the risk of DCS related to high altitudes after diving can be consequently decreased.

Recently, dive computers that allow a diver to perform multilevel diving have become popular[18)]. However, overestimation of the advantages of Nitrox may simultaneously increase the risk of DCS. It seems that the main reason for introducing Nitrox is to prolong the diving period without increasing the risk of DCS[1)～5),19)]. To reduce the incidence of DCS, we recommend Nitrox use for all divers in the Nishi-Izu area. If the diving profile with Nitrox is similar to that with air, Nitrox has less risk of DCS than air, but Nitrox may pose a danger of DCS when a diver is beyond the margin of safety of diving with a dive computer. According to the diving manuals advocated by diving organizations, the majority of Japanese divers should carry out leisure diving with an appropriate dive computer for Nitrox.

At present, we are unsure of the numbers and locations of shops that are dealing with Nitrox, so we included 118 shops known to deal with Nitrox in this investigation. From the results of this study, only 84 out of 118 (71.2%) shops offered Nitrox to divers, 46.3% of which were located in Tokyo and

the Shizuoka area. Forty-six of 84 (55%) shops supplied fewer than 10 tanks a week (average 5.5 tanks). Based on this fact, to reduce the risk of DCS, it is necessary to increase the number of shops that can deal with Nitrox and also to improve the facilities of the Nitrox supply system. To promote its use, we must educate divers and shops about the advantages and safety of Nitrox through propaganda and informational activities concerning Nitrox for leisure diving. In this investigation, many shops answered that Nitrox has merits of "prolongation of bottom time without decompression" as well as "reduction of the risk of DCS", but there is the danger of possible serious misunderstanding, because we cannot simultaneously obtain both "prolongation of bottom time without decompression" and "reduction of the risk of DCS".

Furthermore, if Nitrox using divers try to do multilevel diving beyond the margin of safety of Nitrox, they may also be in danger of "oxygen toxicity". Indeed, many accidents have occurred during Nitrox diving, more frequently than with air diving in U.S.A[3]. With the familiarity of leisure divers with Nitrox, there has been a misunderstanding that Nitrox provides "prolongation of bottom time without decompression". So it is feared that accidents with Nitrox diving will increase in Japan as well as in U.S.A.

We would like to emphasize that education on the correct application of Nitrox based on the table for air diving is very important, to promote the safety of Nitrox for leisure diving. Many shops pointed out that the insufficient supply of Nitrox was one of its disadvantages of. Many divers will consider that Nitrox seems expensive for leisure diving. In the present situation, we cannot easily use Nitrox for leisure diving in Japan, but once there is a large demand for Nitrox, the price will decrease and the sit uation will improve, and Nitrox will become very popular with leisure divers in Japan in future.

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