

DETECTION OF CIRCULATING BUBBLES IN BREATH HOLD DIVERS

A BOUSSUGES *, S ABDELLAOUI *, B GARDETTE **, JM SAINTY *,

* Service de réanimation médicale et d'hyperbarie.

Hopital SALVATOR. Marseilles FRANCE

** COMEX SA, 36 Bd. des Océans

13009 Marseilles - FRANCE.

Since the sixties, when Cross (1) and Bagnis (2) published articles on Taravana in Polynesian pearl divers, decompression sickness following breath hold diving has been a widely debated subject. In this type of dive, the quantity of dissolved nitrogen is very low and repeated exposure for several hours is required for the tissues to be oversaturated for any length of time. Nitrogen desaturation in SCUBA divers leads to the production of circulating air bubbles which can be detected by ultrasound investigation during the decompression period and the following minutes. Currently there is no study which gives any insight into the extent of nitrogen saturation in breath hold divers after underwater fishing competitions and thus there is no data available to illustrate the real significance of decompression sickness. Our study was designed to research circulating air bubbles in top level breath hold divers during training periods, using two-dimensionnal (2D) echocardiography and continuous Doppler ultrasound recordings.

Material and Methods

The divers submitted to exploration were ten breath hold divers belonging to the French underwater fishing team. (mean age : 29 +/- 7 years, mean height : 181 +/- 8 cms, mean weight 74 kgs +/- 10 kgs. The study was carried out during the deep underwater fishing event that was held at Minorca (Spain) from the 5 to the 15 October 1995. The three diver's diving curves were recorded on a "Maestro Pro" type Beuchat computer during a one day training session. Two methods were used to screen for air bubbles :

Continuous Doppler : The equipment used is marketed by the Comex Company, it used a continuous ultrasound beam on a 5 Mega-Hertz wavelength. The Doppler probe is placed along the left edge of the sternum to assess the bloodflow in the pulmonary artery. The recordings are picked up on magnetic tape to be listened to later by two independent investigators. We used the Spencer (3) method to classify the bubble production rate. The divers were screened at rest and during flexion of the lowers limbs.

2D Echocardiography : The screening tests were performed using a Kontron Sigma 1 apparatus with a 3.5 Mhz probe. The angles recorded included a longitudinal view of the short axis, a longitudinal view of the right chambers and an apical four chambers view. In order to increase the sensitivity of the method, the diver was asked to perform an isometric contraction of the quadriceps muscles. The bubbles were graded according to Brubbak's (4) team's scale. To screen for bubbles as soon as possible after the last breath hold, the 2D echocardiography was placed on board a boat equipped with a generator. Each exam was registered in video tape and analysed by two independent investigators.

Results

Fifteen bubble detection tests were performed on the 10 breath hold divers. These underwater fishing divers had held their breath at a mean max depth of 32 msw (between 24 and 40 msw) for a mean duration of fishing of 3 hours 15 minutes (2h - 6h). Three of the divers' patterns were recorded on a computer. The technical features of the hardware enabled us to draw the depth curves according to the time parameters, using an interface and a PC program. The three divers explored yielded the following diving curves :

- Breath hold diver n° 1 performed 48 breath holds which lasted on average 2 minutes 12 seconds during a 4 hours underwater fishing period. The duration of these periods of apnea was 43 percent of the total time. The mean depth for the breath hold dives was 28 msw (17 - 39).

- Breath hold diver n° 2 performed 39 periods of apnea of a mean duration of 2 minutes 41 seconds during a total period of 3 hours 38 minutes of underwater fishing. The duration of apnea was 48 percent of the total time. The mean depth for the breath hold dives was 31 msw (24 - 40).

- Breath hold diver n° 3 performed 39 breath holds of an average duration of 2 minutes and 47 seconds during an underwater fishing period of 5 hours and 9 minutes. The total duration of apnea amounted to 35 percent of the total time. The mean depth of apnea was 30 msw (17 to 38).

The 2D Echocardiography and Doppler examinations were performed in 73% of the cases within a half an hour of the last breath hold for the day (extremes 3 to 75 mn).

We did not find any evidence of circulating air bubbles with either of the procedures used (2D Echocardiography and Doppler).

Conclusion

During the last few years, an extraordinary increase in the performance of underwater fishing divers has been recorded. The use of recordings of diving curves

processed on a computer has enabled us to visualize a fast succession of dives between 30 and 40 msw in depth over a period of several hours in underwater fishing divers. If we refer to these data two divers out of three did not have sufficient time to recover according to the security graph set out by Lanphier (5). Then these diving should theoretically expose the divers to neutral gas saturation with a risk of decompression sickness as a result. The use of two high performance techniques (continuous Doppler and 2D Echocardiography) has not permitted us to demonstrate circulating air bubbles in breath hold divers. This study, performed on the terrain is, however, not sufficient to eliminate the hypothesis of saturation in neutral gas, especially for short period tissues and a complementary study should therefore be envisaged.

References

1. Cross E.R. Taravana, diving syndrome in the tuamotu divers In *Physiology of breath holding and the ama of japan*. Rahn H, Yokoyama T. Nat. Acad. Sc./ Nat. Res. Council, public. 1341, Washington DC. 1965, pp 207-220
2. Bagnis R. Les accidents neurologiques de la plongée libre au cours de la pêche de l'huitre perlière dans les îles Tuamotu. *Rev. Intern. Océanog. Med.* 12 : 123-139, 1968.
3. Spencer MP. Decompression limits for compressed air determined by ultrasonically detected blood bubbles. *J Appl. Physiol.* 40 : 229-235, 1976.
4. Eftedal O, Kotens S, Brubak AO. Bubble grading in ultrasonic images Undersea Hyperbaric Med. 20 (Suppl) : 79, 1993.
5. Lanphier EH. Application of decompression tables to repeated breath hold dives In *Physiology of breath holding and the ama of japan*. Rahn H, Yokoyama T. Washington DC. 1965, pp 227-236