

## Medical considerations about diving in expeditions in high altitudes

**Eduardo N. G. VINHAES (MD, PhD) 1; Lorenzo EPIS 2**

- 1 - Prof. Doctor of “Serviço de Medicina Hiperbárica – UNICAMP – Università di Campinas” and oficial medici of AKAKOR GEOGRAPHICAL EXPLORING Onlus - Rua Joel Jorge de Melo, 253 / ap.74 - 04128-080 - São Paulo – SP / Brasil, [evinhaes@osite.com.br](mailto:evinhaes@osite.com.br)  
2 - President of AKAKOR GEOGRAPHICAL EXPLORING Onlus - Via Roma, 11 23827 Lierna (LC) Italia, [akakor@tin.it](mailto:akakor@tin.it)

### Abstract

The main problem in high altitude diving expeditions is the decompression and its calculation and operational aspects. All the divers must know the tables currently used.

A plan to be used in an emergency situation including situations outside the water is a must. The amount of available oxygen, the quality of medical services near the exploration site and the possibility of transporting medical equipments and victims by air are crucial issues. The influence of the hyperbaric inspired oxygen in the human beings must also be explored.

During the Expedition Atahualpa 2000 we tried to find if there were the incidence of mountain sickness in the diving group and specific date was collected. The psychological changes in humans during this kind of activity are still in study and the need of further medical researches must be always considered.

### Diving in the high altitudes

Nowadays with the new technics and the development of the diving industry became possible explorations in remote areas with high risk conditions. Explorations underwater realized in high altitudes is a special chapter. The atmospheric pressure which is diminished in relation to the see level affects in many important ways the many aspects of the decompression disease (Van & Thalmann, 1993; Edmonds et al., 1997)

One of the most important problems which can occur in such an expedition is the possibility to contract the Decompression Disease (DD), also called Bents. Although the tables are well calculated, they were made for diving up to 700 m above the see level. When transposed to higher altitudes they became theoretical and turns to a complex mathematical calculation. A calculation table was generally made at the diving places just before going in the water. But today even with the development of diving computers which calculates up to 4000 m. (UWATEC AG, 1999) it is not possible to eliminate all the risks to contract the Decompression Disease.

It is then extremely important the development of specific technics in a way to obtain the maximal security since the medical treatment in a remote place can be difficult and even impossible. In this sense during the Expedition Atahualpa 2000 was realized many divers at the 3800 m when we utilized special procedures in order to obtain the calculation of the decompression in each diving. We used a portable eccodoppler, an instrument which allows to perceive the gas bubbles in the veins very soon. In this way it became possible to accompany the reactions of each diver after each diving (Nishi, 1998).

An important point in expeditions of this kind is an emergency plan including also situations which are not diving related (Arrington, 1994). In this sense was considered the following aspects: the amount of medical and portable oxygen available, the quality of the medical facilities at the local and the possibility to obtain air or ground transportation.

In the specific case of the Expedition Atahualpa 2000 which took place in the Bolivian part of the Titicaca Lake, the amount of portable medical oxygen was satisfactory, although we had some problems in acquiring it. There was only one industry in the whole country. The system was the same we find in hospitals (System DIN) which is not adequate to the use of more specialized and modern equipments (System YOKE) In regard to the quality of the medical assistance next to the diving sites we considered that the better way was to keep a medical doctor ready to act in emergency situations not only inside but also outside the water. Unfortunately our area of exploration was economically and socially underdeveloped, what was reflected in the scarce resources found in the nearest city, N. S. Copacabana. There would also be a problem in paying

the local medical services in case we needed them, what proves the necessity of having a medical doctor among the members of such an expedition. Finally the possibility of transportation was restrict to a ground transportation since there were no possibility of using any kind of airplanes. Hospitals were previously contacted in order to avoid bad surprises in case of a major emergency.



*The medical control with a eccodoppler*

The realization of such an underwater exploration allows also that many important points related to human physiological alterations to be studied. Not many things are known about the level of the oxygen at 100% during the period of acclimatization in elevated altitudes but without doubts the exposure at high quantity of oxygen during divings are a chapter to be studied.

After the first 72 hours of expositore in an altitude over 3800 meters. We realized divings almost every day. We used two types of mixtures: air (21% oxygen) and Nitrox (33% oxygen). We noticed that even in the shallow divings the partial pressure went fast to values above 0,4 absolute atmospheres (ATA) showing pressures higher than those at the see level. In this way, it was as if each diver after the diving were brought to levels under the see level for many days. A question remains still without an answer: would this hyperbaric exposure influences the daily acclimatization?

Basically our work consisted of a daily data about the conditions of each member of the group, regardless if they were or not a diver. This data consisted of a questionnaire where we tried to observed the possibility of having the signs and symptoms of the Mountain Sickness (Hultgren, 1997) This condition is related directly to the continuous exposure to high altitudes and can be observed right in the first days (Hall et al., 1965; Hackett & Rennie, 1976). In this case we had two groups, one with only divers the other without and each group with seven people.

Although his data didn't show differences between the two groups and we didn't notice any occurrence of this disease, further studies must be done. At this moment we feel that it is still too soon to reach a final conclusion. Many other aspects need to be studied and I propose that the future expeditions make further studies of eventual changes in the breathing as a reaction to the hypoxia during the sleep time and the level of the breathing reflection during apnea I would propose also technics more precise than questionaries in order to evaluate the study of these important subjects.

## Acknowledgments

Many thanks to the Serviço de Medicina Hiperbarica at UNICAMP; PRAXAIR and SCUBASUL for all help and for being always supportive of our work.



## Bibliography

- Vann, R. D. & Thalmann, E.D. Decompression Physiology and Practice. In: The Physiology and Medicine of Diving. (Benett, P. & Elliott, E., eds.) W. B. Saunders Co., 1993, 4ª ed., 376-433.
- Edmonds, C.; Lowry, C.; Pennefather, J. Decompression Sickness: Clinical Manifestations. In: Diving and Subaquatic Medicine. Butterworth Heinemann, 1997, 3ª ed., 159-179.
- Aladdin Pro Nitrox Manual. UWATEC AG, 1999.
- Nishi, R.Y. Detection of intravascular bubbles. Doppler ultrasound – theory and practice. Scientific Meeting of the Undersea and Hyperbaric Medical Society, 1998, 49 – 52.
- Arrington, S. Planning an Expedition or Diving Operation. In: The Expedition and Diving Operations Handbook. Best Publishing Co., 1994, 5-7.
- Kobayashi, T.; Masuyama, S.; Kimura, H.; Kuriyama, T.; Honda, Y.; Osa, Y. Effects of O<sub>2</sub> breathing on changes of arterial oxygen saturation and breath-holding time (BHT) during high altitude trekking. Japanese Journal of Mountain Medicine Vol. 16: 59-64, 1996.
- Hultgren, H. Acute and subacute mountain sickness. In: High Altitude Medicine. Hultgren Publications, 1997, 212 – 249.
- Hall, W.; Baril, T.; Matzzer, E.; Gupta, K. A clinical study of acute mountain sickness. Arch. Environ. Health, 1965; 10:747 – 53.
- Hackett, P.; Rennei, D. The incidence, importance and prophylaxis of acute mountain sickness. Lancet, 1976; 627: 1149 – 55.