Utopia Exploration 2019-2020

From a medical and physiological perspective

To our knowledge, this is the first time in history that a cave dive of this dimension will be performed. Archeologists, speleologists, physicians and scientists are actively involved in the preparation and execution of the dive. The aim is not a mere record dive with uncalculated risks, but a reliable and well-prepared exploration. Thorsten “Toddy” Wälde will do the push dive, accompanied on his return by a professional team of safety divers and monitored during decompression by diving medicine physician Dr. Frank Hartig. In the decompression habitat, which can be raised from 12m to the surface, Toddy will be examined and treated with the newest state of the art decompression methods and supervised with medical tools like live bubble detection with ultrasound. The professional supervision is not an emergency medical backup for an untreatable disaster scenario, but a real preventative concept based on the results of research in the field of decompression physiology.

From this point of view, attention should be paid to the following topics:

Exploration depth/length/decompression

This cave dive is a multilevel dive with a maximum operating depth (MOD) of 120m, non-linear decompression and an estimated dive time of 20-22 hours. The penetration depth in the cave system is up to 5 km at the moment.

To our knowledge, such a profile has not been dived yet and pushes the human organ systems to their limits. As we know, the challenge is not the MOD, but the long multilevel exploration time. Compared to 200m bounce dives with short bottom times, straight ascending profiles, and without yoyo’s, this dive is quite complex and requires difficult management. Based on the latest findings in decompression and diving physiology research, such a dive and decompression can be done with an acceptable, calculated, minimum risk.

The setting of gradient factors in different depth segments plus the adaption of M-values and ascent rates during the multilevel yoyo ascent is quite complex and may break new grounds. Also the adaption of the set point remains crucial and is a compromise between rapid decompression and oxygen toxicity. Other strategies such as OPT (Oxygen precondition time) before the descent are performed to minimize the micro-bubble formation and to reduce AHS (active hydrophobic

spots). In the habitat the decompression will be measured with live echocardiography to evaluate the progress of decompression and to set the optimum gas breaks.

The lung

The lungs are presumably the crucial target organ for such a dive. The pulmonary oxygen toxicity will be enormous. Due to the high and long oxygen exposure, atelectases (collapsing areas of lung tissues with impeded gas exchanges) will form, shunting mechanism and bronchial spasms are also issues. The gas diffusion capacity will decrease and change during the decompression. Very important is the elimination of water immersion in the habitat, which will improve significantly the decompression. Other important factors are gas breaks, medications and a special designed breathing mask (flow safe II) to minimize atelectases. The deco in the habitat can be performed without a regulator in the mouth, which is very comfortable after hours of rebreather diving with a scooter.

The brain/central nervous system

The commonly known CNS toxicity in such a dive is also a risk factor that is controlled with special designed breathing gases and adaptations of the dive plan together with special medications. Here we can refer to pharmacologic results of former studies and research projects of our team, where divers were exposed up to 10 bar pO2.

The cardiovascular system

The cardiovascular system will be challenged to its limit during this extremely long dive. Fortunately Spiroergometry allows for a relatively exact calculation of scrubber consumption of the rebreather systems. An excellent performance grade and an optimal maximum oxygen consumption uptake rate must be guaranteed. Due to the hours of in-water immersion combined with physical stress we also expect blood pressure peaks that are a big burden to the cardiovascular system and the lungs. In our first stress tests at the Institute for Cardiovascular research for elite athletes the results were good but not good enough. Special breathing muscle training, tested by the US Navy Seals, was mandated because coping with hypercapnia is critical.

The blood gases and the blood ions

Hypercapnia is a problem during the habitat decompression. Measurements confirmed the fast CO_2 increase in the habitat that has to be prevented by special absorbing soda curtains from submarine technologies. Medicine, technique and equipment are working hand in hand to allow non-regulator breathing in the habitat.

In such long-range dives we found a significant change in tissue/cellular shifts of blood ions (potassium, saline, magnesium and phosphate) that can trigger cardiac arrhythmias. A special substitution with supplementation on the fly, during decompression in the habitat and post surfacing is therefore prepared and we borrow the tremendous experience of our Austrian elite long-range athletes (Peeroton is the leader of high quality supplemental substitution of elite athletes).

The cardiac aerobic endurance must be stable and resilient against the influence of immersion effects. The right heart function is especially challenging on long-range underwater activities. Therefore, this complex training requires quite a few months of pre-dive professional training.

Metabolic aspects and medication

Eating, drinking and calorie balance is crucial to keep the metabolic system in balance. Several 24 hour diving experiments showed that after 16 hours a critical point is reached, where metabolic decompensation can occur. This must be done with specially prepared food and substances that can help regain mental focus on the dive. Newly designed, non-caffeinated supplements increase the psychological concentration and prevent severe tiredness. Their compatibility and ability to pass through the blood brain barrier has to be tested in the next dives. An additional anti-oxidative support will be started days before the dive, not too early to prevent biochemical counter compensations.

Blood aspects

Decompression in such dives is influenced by many other factors (beyond gradient factors or tissue compartments) that are not represented in the physical decompression algorithms. Intravasal blood lipid status as well as the coagulation system are important and are influencing decompression. Also the immune system and the anti-oxidative system can trigger micro-bubble formation and those systems can harm or protect the outcome of overall decompression of the tissues. Also the changes of blood cells and proteins that are induced by tiredness and sleep-deprivation have to be calculated, which trigger more than just CNS toxicity with the risk of cerebral convulsions.

Thermic effects

Thermic effects such as central hypothermia have to be minimized. A decrease of just 0.5°C stimulates the coagulation system that in turn influences decompression. Special designed heating systems are used in this project during the dive. On the other side, we must take care of

solar exposure before and after the dive. This can be tricky, because the dive starts at night and the planned surface time is in the afternoon, where we have temperatures of about 40°C.

Rescue plan

A rescue plan for emergency in-water recompression (IWR) in the mobile habitat has to be organized and trained as well as a rescue plan in case of even more severe emergencies like respiratory or cardiovascular failures. A helicopter transport to the next hyperbaric chamber in Cagliari had to be planned and we have our friends from DAN Italy that are on standby mode to arrange such transports. The ascending time has to be in the day light, otherwise the helicopter cannot fly to Cagliari. That is why we have to start the project in the late evening. Another problem is a possible emergency situation of other divers than Toddy (the support divers). A special emergency plan for those support divers is independently prepared and guaranteed by another experienced doctor who is responsible for minor problems of the support team. Dr. Hartig is responsible for Toddy and his rescue chain is not influenced by a possible emergency of one of the team members. This rescue plan does not differ from other serious and professional rescue plans, but one fact is unique. Dr. Frank Hartig is not only a trained intensive care physician but also a diving medicine physician and active exploration diver and he can perform an IWR (in-water recompression) with Toddy in case of severe DCI. All the necessary equipment for an IWR to 12m is prepared. So Toddy has his private hyperbaric physician onboard. Special designed breathing apparatus with PEEP and NIV ventilations has already been tested in the Tyrolean mountain lakes under pressure in the habitat.

Conclusion

In such a project the push diver must be in exceptionally good physical and of course psychological shape. Therefore, we did an extensive assessment of Toddy's fit for dive status. We performed inert gas diffusion gas analyses, special exercise physiologic testing and many more examinations and evaluations of all the above described organ systems. Our university clinic for emergency medicine, radiology, cardiology, pulmonology, exercise physiology and the Olympic athletes institute is supporting this project with special diagnostics and professional recommendations.

There is no doubt that after months of testing and training Toddy has a huge and strict training plan and he will be optimally prepared to do the push dive in 2020. To our opinion it is not enough that Toddy is just a sportive spare time athlete. Toddy has to train hard; he must further minimize his body fat percentage, reduce his intravascular lipid-status and increase his

cardiovascular performance to more than 140%. His lungs and his ventilation performance must be optimized and improved and his medication has to be tested under pressure.

Last but not least: Toddy and his team must train every single movement, every single communication, and every single piece of equipment, blind and under stress. Some test dives with the complete team must be conducted to optimize the procedures.

In conclusion, Toddy does not dive solo, but with a whole team that must develop excellent verbal and non-verbal communication that does not falter under increased stress and pressure.

All the above explained aspects require a sequential splitting of the dive into three dives:

July 2019: Training dives in one week to the beginning of the chamber core (MOD est. 80 m, DT est. 10 h) with decompression in the habitat starting at 9m. Simulation of the habitat decompression for 6-8 hours. Training and simulation of the rescue plans as well as testing of an in-water recompression with lowering the habitat to 12m. Adaptation of the deco plan and evaluation of lung and cardiovascular function. Post surfacing strategies and boat transfers. Adaptations of ascent speed in the middle segments. Measuring of the pulmonary toxicity and lung function. Testing of different medication during long-range dives.

September 2019: First push dive to the end of the chamber core to 120m. Until then the habitat decompression and the individual training as well as the maximum oxygen consumption and the anaerobic threshold are further increased and Toddy is then able to manage this dive with a minimum risk.

Project Utopia 2020: Exploration push dive Utopia 2020 beyond the chamber core with 22-24 hour dive time and world record exploration. In the month before this dive, further clinical visits und special trainings will be performed at our university clinic. The documentation of lung functions and other parameters of the cardiovascular systems are planned. After the push dive Toddy will be coached and treated for the following months. A medical publication is planned as well as a video documentation and a speleological description of Utopia project findings.

In case of a timeline like described above, we would not hesitate to accompany this challenging project with our medical know-how of the university clinic Innsbruck. We would not recommend

the primarily date of the final push dive in July 2019 because of lack of training scenarios and the yet suboptimal physiological status of the push diver.

Sincerely,

Frank J. Hartig and Andrea Köhler