Institute of Experimental Morphology, Pathology and Anthropology with Museum
Bulgarian Anatomical Society

Acta Morphologica et Anthropologica, 31 (1-2)
Sofia ● 2024

The Titan Submersible Tragedy: physiopathology of the death mechanism and the necessity of prevention for Deep Sea Explorations

Matteo Antonio Sacco[1a], Francesco Maria Galassi[2a], Elena Varotto[3], Pietrantonio Ricci[1], Isabella Aquila[1]*

[1] Institute of Legal Medicine, Department of Medical and Surgical Sciences, "Magna Graecia" University of Catanzaro, Catanzaro, Italy
[2] Department of Anthropology, Faculty of Biology and Environmental Protection, University of Lodz, Lodz, Poland
[3] Archaeology, College of Humanities, Arts and Social Sciences, Flinders University, Adelaide, SA, Australia

***** Correspondence to Francesco M. Galassi, MD PhD, Associate Professor, e-mail: francesco.galassi@biol.uni.lodz.pl
[a] Shared first authorship.

This paper examines the physiopathology of death in the tragedy of the Titan submersible in the light of knowledge on barotrauma and established forensic literature. It also offers practical views on preventive measures against such public health risks. The aim of the work is to reconstruct from a medico-legal point of view the plausible manner of death considering the location and the high depth in the sea reached by the submersible. The case shows the significant environmental risks related to the marine environment at great depths, such as barotrauma and hypothermia, emphasizing the need to prevent these events with strict and suitable safety measures.

Key words: Titan; deep sea exploration; prevention; forensic anthropology; barotrauma

Introduction

The Titan submersible was a groundbreaking creation designed to delve into the depths of the ocean up to 4,000 meters, accommodating up to five individuals [2]. This submersible marked a significant advancement in underwater exploration technology, offering researchers and adventurers the opportunity to explore the mysteries of the deep sea. However, despite its advanced design and capabilities, the Titan submersible encountered a tragic accident during one of its missions. In fact, on June 18, the Titan

began its scheduled dive. The operation seemed to be proceeding smoothly, however after an hour and 45 minutes, the submarine no longer sent the communications that were scheduled every 15 minutes. The submarine was supposed to surface at 2.00 pm EDT without ever doing so. The accident involving the Titan submersible has once again highlighted the risks of deep-sea exploration. Despite the presence of various safety features, the missing submersible still underwent, as per the latest reports, a catastrophic implosion, leading to the presumed fatality of its pilot and four passengers. This occurrence has prompted inquiries regarding the existing safety protocols for deep-sea submersion and the physiological impact of extreme pressure and temperature on the human body. In this paper, we shall investigate the plausible reasons behind the Titan submersible tragedy, the physiological consequences of extreme pressure and extreme low temperature on the human body, as well as methods for avoiding submersible accidents and enhancing safety precautions.

Case presentation: the Titan submersible

The reasons behind the tragic event involving the Titan submersible remain unknown and are currently under investigation. Nonetheless, specialists have been expressing concerns about the safety and development of the Titan submersible since 2018 [5]. Although the submersible had multiple mechanisms designed to bring it to the surface in case of an emergency, but these mechanisms failed to prevent the tragedy [5]. According to experts, the Titan submersible collapsed catastrophically due to the extreme pressure and temperature at the deep-sea level, leading to the instantaneous death of its pilot and four passengers [1, 8]. While the investigation is still ongoing, this incident underlines the possible dangers of deep-sea expeditions.

Discussion

The effects of extreme pressure and temperature on the human body are significant and can pose a threat to life. When an individual submerges in water, the pressure increases with depth and can lead to barotrauma. Barotrauma can cause damage to various parts of the body, including middle ear and paranasal sinuses, pneumothorax, pulmonary hemorrhage, decompression sickness and arterial gas emboli. This damage can be caused by the compression of gas-filled spaces in the body due to the increased pressure. During ascent, gases in the body expand, which can also lead to barotrauma. In such cases, overexpansion of the lungs can occur, resulting in pulmonary barotrauma [3].

There are several factors that are attributed to mechanisms of death related to submersion-related barotrauma. A common cause of death in self-contained underwater breathing apparatus (SCUBA) diving is pulmonary barotrauma. When a diver resurfaces, overexpansion of the lungs can lead to significant injury and death [7]. Tension pneumothorax, which can result in death in just a few minutes, is another cause [7]. Additionally, barotrauma of descent can cause injury in closed spaces in contact with the diver, such as the ear, teeth, and sinuses [3]. We know that the depth of placement of the Titanic is approximately 4,000 m on the bottom of the North Atlantic Ocean. At 4000 meters deep, the pressure is 400 bar [6]. The analysis of the event makes it possible to hypothesize several plausible scenarios from a forensic point of

view. The first detects a possible confinement due to lack of oxygen with accumulation of carbon dioxide and saturation of the rooms of the Titan occupied by passengers.

The second, more likely than the published news, instead concerns a mechanism mainly related to the pressure reached at great depths. In particular, the implosion hypothesized in the last few days by the news would necessarily reveal, from a forensic point of view, a rupture of the Titan such as to allow the achievement of a sudden and very strong pressure imbalance. Such a dynamic would therefore plausibly cause a very high mechanical energy on the victims exerted by the amount of high-pressure water on the passengers, thus determining from a forensic point of view a rapid traumatic crushing with simultaneous drowning. In the dynamics of the events, it is likely to hypothesize a laceration of organs with leakage from the respective anatomical cavities with respect to the greater integrity of other tissues such as the skin and muscles.

In any case, although it is possible to hypothesize a greater integrity of more resistant tissues such as bone, muscles and skin, it is necessary to consider the marine macrofauna at great depths, with the mechanical action of the currents and the thermal variations of the Atlantic Ocean. At these depths, in fact, the macrofauna includes various species of large dimensions, considering the phenomenon of deep-sea gigantism, such as the jellyfish known as *Stygiomedusa gigantea*, the giant isopod, big red jellyfish, giant sea spider, giant ostracod [9]. Finally, as regards the effects of low temperature, the marine depth of 4000 meters would include temperatures between 3/4°C with risk of death in a few minutes due to hypothermia mechanisms. In fact, the human body placed in water loses heat at a much greater rate (about 25 times) than a subject in air. The effects of hypothermia occur when the body temperature drops below 35°C, becoming severe below 28°C with consequent sharp increase in blood pressure, bradycardia, fatal arrhythmias, coma and loss of reflexes [4].

It is crucial to comprehend these mechanisms of death so that prompt and effective treatment can be administered. To prevent accidents involving submersibles and enhance safety measures, it is essential to employ effective strategies such as proper training, equipment maintenance, and safety protocols. Deep-sea exploration entails a considerable level of risk, and safety training is crucial for submersible pilots and passengers to understand these associated risks [10]. By employing adequate safety protocols and maintaining equipment in good condition, it is possible to prevent accidents and promote the safety of submersible expeditions.

Conclusions

The accident involving the Titan submersible evidences to date the perils that accompany deep-sea exploration. The investigation into the causes of the tragedy is still ongoing, but the deleterious effects of extreme pressure and temperature on the human body are widely recognized. To prevent future mishaps, it is crucial that we establish more stringent safety protocols and implement preventative measures to safeguard the well-being of submersible pilots and passengers alike.

References

1. **Associated Press News**. Live updates. Titan's catastrophic implosion likely killed 5 occupants instantly, experts say. June 20th 2023. https://apnews.com/article/missing-sub-titanic-search-live-updates-c2470ab6159caf32ca11010d4f4ce5e7
2. **Bakhtiari, M**. Lessons from the Titan submersible: A wake-up call for radiation oncology. – *J. Appl. Clin. Med. Phys.,* **25(2**), 2024, e14121.
3. **Battisti, A. S., A. Haftel, H. M. Murphy-Lavoie.** Barotrauma. – *StatPearls (Internet)*. June 20th 2023. available at: https://www.ncbi.nlm.nih.gov/books/NBK482348/.
4. **Hleșcu, A. A., A. Grigoraș, V. Ianole, C. Amalinei.** Advanced diagnostic tools in hypothermia-related fatalities – a pathological perspective. – *Diagnostics (Basel),* 2024, **14(7),** 739.
5. **Houston Public Media**. A former passenger details what it's like inside the missing Titan submersible. June 20th 2023. https://www.houstonpublicmedia.org/npr/2023/06/20/1183273102/a-former-passenger-details-what-its-like-inside-the-missing-titan-submersible/
6. **Hu, X., Z. Ma, Z. Gong, F. Zhao, S. Guo, D. Zhang, Y. Jiang**. A Highly sensitive deep-sea hydrodynamic pressure sensor inspired by fish lateral line. – *Biomimetics (Basel),* **9(3),** 2024, 190.
7. **Kennedy-Little, D., T. Sharman.** Pulmonary barotrauma. – *StatPearls (Internet)*, June 20th 2023. available at: https://www.ncbi.nlm.nih.gov/books/NBK559293/
8. **Pittman, R. N.** The circulatory system and oxygen transport. *In: Regulation of tissue oxygenation*, San Rafael, CA, Morgan & Claypool Life Sciences, 2011.
9. **Timofeev, S. F.** Bergmann's principle and deep-water gigantism in marine crustaceans. – *Biology Bulletin,* **28,** 2021, 646–650.
10. **United States Department of Labor**. Occupational safety and health administration, 2023. https://www.osha.gov.