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VOMITUS AS A CAUSE OF FATAL DIVING ACCIDENT OF A COMMERCIAL DIVER

Novomeský F. Krajčovič J., Štuller F.
Institute of Forensic Medicine and Medical Expertises, Jessenius Faculty of Medicine, Comenius University, Martin, Slovak Republic

Summary

Vomitus as a Cause of Fatal Diving Accident of a Commercial Diver

The forensic expertise of the victim of fatal diving accident (commercial diver), who died in depth of 41 mts due of unknown reasons, had been realised by the authors. One of the authors of the paper was present on site of the diving accident as a diving medicine specialist. The autopsy revealed, that the cause of death of the diver was suffocation due to vomitus and massive aspiration of gastric content to the airways. The commercial diving technology (full-face diving mask with oro-nasal inner mask) was used. The authors point out some peculiarities in interpretation of such a fatal diving accident.

Key words: diving – diving accident – vomitus – suffocation – full-face diving mask

Súhrn

Zvracanie ako príčina smrteľnej nehody potápača z povolania

Autori vykonali forenznú expertízu tela potápača z povolania, ktorý zomrel za nejasných okolností pri pracovnom ponore do hĺbky 41 metrov. Jeden z autorov bol priamym svedkom nehody potápača ako potápačský lekár-špecialista. Pitva jednoznačne preukázala, že príčinou smrti potápača bolo udusenie vdýchnutím žalúdočného obsahu pri použití profesionálnej potápačskej techniky (celotvárová maska s vnútornou oro-nazálnou maskou). Autori poukazujú na niektoré osobitnosti v interpretácii takejto smrteľnej nehody potápača.

Kľúčové slová: potápanie – potápačská nehoda – zvracanie – udusenie – celotvárová potápačská maska

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INTRODUCTION

Vomiting, together with aspiration of gastric content is well known pathophysiological phenomenon, which leads frequently to severe suffocation and fatal asphyxia. The causes of unvoluntary gastroesophageal reflux in the process of vomiting are many, being mentioned later. However, all these situations, which might evoke the process of vomiting with subsequent life-threatening suffocation, develop in daily life, in normobaric environmental pressure. The dangerous process of vomiting has a somewhat different triggering point in divers, while being underwater (in hyperbaric environment). The authors had an opportunity to investigate such a case of uncommon fatal diving accident of the commercial diver.

CASE REPORT

XY 1975, male, commercial diver, dived with the buddy diver to depth of 41 mts to perform a planned task, on the water side of the wall of a hydro electric power station (dam). The bottom time (as registered on personal diving computer) was 10 min.

The equipment used:
- full-face diving mask with internal oro-nasal mask covering the nose and mouth, with ceramic microphone of bilateral acoustic communication
- protective plastic diving helmet with fixed uw light
- air as the breathing medium, open circuit breathing system, (in-water exhalation), surface supplied (hose) system, back-up single tank breathing apparatus on the diver's back
- dry diving suit (membrane type) with internal inflation, latex seals;
- medium gauge undergarment (polypropylene fibers).



Figure 1. The commercial diver fully dressed. A full-face diving mask of a same type as being used in the analysed accident, without the protective diving helmet.

The rescue and medical support:
- back-up diver fully dressed, on site
- medical specialist in diving/hyperbaric medicine, on site

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- monoplace recompression chamber with O^2 inhalation, ready for use, on site
- oxygen resuscitation kit, forced inflation of O^2.

THE DEVELOPMENT AND THE COURSE OF THE ACCIDENT

Before the dive, the diver had declared his health status as very good, no somatic and/or psychic disorders were noticed. There were no signs of nervosity, the diver had dressed himself very carefully, with a high level of routine. The tanks for air supply were filled prior the dive on the open air (no exhaust fumes) by use of high-pressure compressor of the highest technical quality.

After the final dressing of the diver and all necessary checks, the air supply start to fill the breathing system (regulator, full-face diving mask). The diver didn't noticed and reported any difficulties with breathing or gas supply. The descent of the diver was slow, normal, the problems with pressure equalization (ears, sinuses, another body cavities) weren't reported. The minor task (uw photo of a foreign object on the bottom) was also fulfiled. The breathing of the diver had been heard on the surface due of bilateral acoustic voice communication, the breathing excursions were slow, profound and regular.

At the end of a 10th minute of submersion, the diver suddenly sent a verbal signal to the surface about his sudden, non-specified troubles („I feel bad"); since this moment his breathing became irregular, choky, and after a few seconds stopped. The buddy diver contacted the afflicted diver immediately, found him breathless and unconscious. The medical specialist gave an order to both divers to ascent without delay, having in mind the risk of overpressure lung damage of the unconscious diver (recompression chamber on site). The ascent to the surface took 4 minutes, the elevation of both divers with a special platform and crane took approximately 2 minutes. The helmet and full-face diving mask were immediately removed from afflicted diver, his dry diving suit was cut to pieces and removed as well. There was a small amount of reddish semi-liquid mass (gastric content) found in the oro-nasal mask (a part of full-face diving mask).

ON SITE CLINICAL FINDINGS

The profound unconsciousness, no neurological reactions on stimuli, pulseless, no heart activity, no spontaneous breathing. Deep blue colour of the skin in the face and neck area. Wide fixed mydriasis. A small amount of reddish brown liquid (gastric content) in the nostrills. No evident signs of life.

Despite of the facts mentioned above, an intensive complex CPR together with defibrilation and drugs medication had started immediately, however, without any noticeable effect. After 60 mins of intensive CPR, the afflicted diver was declared dead.

ON SITE PRELIMINARY DIAGNOSES

The suffocation of the diver in depth, due of unknown reason (very probably due to vomiting and aspiration of gastric content).

Secondary overpressure barotrauma of the lungs (passive ascent in a breathless state).

Secondary arterial gas embolism (AGE) of the brain vessels.

The death of a diver on ascend.

An unpredictable diving accident.

THE AUTOPSY FINDINGS

The autopsy of the deceased was realised the next day after the accident in the above mentioned institute by the authors of the paper, according the standards of diving fatalities investigation (1, 11, 12, 14). At autopsy, a huge amount of semi-liquid mass in the trachea and peripheral bronchi was revealed, identical with the content of the stomach. Here, the small fragments of undigested tomatoes and green pepper were identified in the total amount of 150 ml of gastric content, together with the small pieces of unidentified food. The tiny gas bubbles were found within cerebral cortical vessels (AGE). The foci of circumscribed ovepressure barotrauma were found in the lung parenchyma. Multiple small hemorrhagies, dispersed in basal ganglia and brain stem were interpreted as the result of extreme rise of blood pressure in the process of suffocation.

Cause of death: Suffocation due to vomiting and unvoluntary aspiration of gastric contents in deep diving.

Complications: Secondary overpressure pulmonary barotrauma. Secondary arterial gas embolism (AGE) of the brain vessels (medium grade).

Another relevant findings: Gastric contents in the trachea and peripheral bronchi. Multiple small bleedings in basal ganglia and brain stem (signs of severe suffocation). Severe hypoxic brain edema.

All the above mentioned diagnoses were fully confirmed by the microscopic investigation.

Blood/urine ethanol: negative in all samples.

Detection of medical/illicit drugs/psychoactive xenobiotics: negative in all samples.

DISCUSSION

Vomiting (*emesis*) is the forceful expulsion of part or all of the contents of the stomach through the mouth, usually in a series of involuntary spasms (3). It is an important reflex, which may be evoked due to many causes. These can be classified (6) as visceral (stomach distension, inflammation, or traction of bowel, kidney, urinary bladder or cervix), intoxications (drugs with emetic properties, alcohol, mushrooms, side effect in anesthesia, radiotherapy), metabolic (pregnancy, uremia, diabetes, Addison's disease), CNS causes (intracranial hypertension, migraine, inner ear disorders), psychic status (unpleasant smell, sight, fear, anticipation, anorexia nervosa). The vomiting reflex is controlled by the vomiting center within the reticular formation of medulla at the level of nucleus olivaris (3, 5). The vomiting center receives afferent nerve fibers from the cerebrum, the vagus, the sympathetic nervous system, and the oculovestibular apparatus (3, 6). Efferent output from the vomiting center passes mainly through the 5th, 7th, 11th, and 12th cranial nerves and the spinal nerves as well. Immediately prior to vomiting, a large breath is taken, glottis is closed and the diaphragm is fixed. Then the forced contraction of abdominal muscles follows. This increases the pressure in the stomach, the cardiac sphincter relaxes and gastric content is expelled (3).

According the recent literary statements, as much as 10% of all cases of fatal accidents in diving might happen due to vomitus, gastric content aspiration and subsequent suffocation

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(8). The causes of vomitus while diving are also many: saltwater aspiration, panic, sudden cardiac disorders, and alcohol or food overindulgence (8) It should be kept in mind, that a diver while being underwater not only breathes the gas of the same pressure as the pressure of the surrounding water, but also physiologically produces saliva in the mouth and swallows it – together with a small gulps of compressed air (9). Thes phenomenon is called *aerophagia* (7). Thus, the stomach of the diver contains not only the rests of the ingested food, but the also a small amount of compressed gas, being swallowed in the course of a dive. Deeper the diver descends, higher is the pressure of the gas „bubble" in his/her stomach (in 40 mts as high as 5 bars). When the diver finishes the dive and has to ascend to the surface, the gas in the stomach, according the gas law of Boyle (2, 9, 13) expands and escapes the stomach cavity in the process of normal breathing. However, some risk of sudden eructation and vomitus still remains.

The divers, staying for some period in aquatic hyperbaric environment, have also a specific needs to food and meals intake. Before the dive, it is absolutely forbidden to eat the meals, which may produce gas in the stomach or bowel in the process of digestion (fresh bread, beans, pea etc.). It is not also recommendable for a diver to eat prior to dive the meals, which are generally difficult to digest, as the abundant cellulose containing vegetables (green/red peppers, tomatoes, onion, cucumbers), also a barbecued of smoked meats, or any meals which may lead to gastric sickness (9).

As the diver moves underwater, being compressed in the diving suit and fixed in the harness of the breathing apparatus with the abdominal belt in particular (1, 9), the risk of unvoluntary, forced eructation increases. This may also lead to vomitus, followed by the accidental aspiration of a gastric content to the upper airways. As the acidic contents of the stomach iritates the laryngeal mucosa, the short period of profound, jerky cough will appear, hence the situation gets even worse. While coughing, the forceful diaphragmatic movements lead to even more profound vomiting and aspiration. Vomiting and coughing while diving thus makes a life-threatening *circullus vitiosus.* Even a small amount of gastric content expelled from the mouth may also damage the exhaust valve of the breathing regulator (leak of water to the mouth) or block the lever system of the breathing regulator with the further hazardous situation (stop of gas delivery or free-flow of the regulator). Both unpredicted situations may lead to panic of a diver and uncontrolled ascent with all its harmful effects (1, 10).

When the process of sudden vomitus hits the recreational diver, holding the mouthpiece of the breathing regulator in his/her mouth, it doesn't necessarily mean the catastrophic scenario. A well-trained diver can remove the mouthpiece from the mouth, expell the bolus of vomit to the surrounding water and continue the normal breathing. *Vice versa*, the full-face diving mask with internal oro-nasal mask (in commercial diving) may become a very risky equipment for a vomiting diver. The oro-nasal mask fits snugly over the nose and mouth, and the whole full-face diving mask is firmly fixed on the diver@s head by the spider head harness (9). The victim of the described accident was equipped even with a special protective diving helmet with attached uw light. Hence, the vomiting diver was in no way able to remove such a complicated equipment from his face and head by a simple manoeuvre, and restore the full-face diving mask back again after finishing the period of vomiting.

The chances for a buddy diver to help the vomiting partner in the commercial diving gear (full-face diving mask, diving protective helmet) are practically none.

The benefits of use of full-face mask with oro-nasal mask in commercial, scientific or military diving are many (9):

- physiological breathing by nose and mouth
- breathing of warm, moisturized gas
- no jaws fatigue from the mouthpiece
- decrease of „dead-space", no carbon dioxide build-up
- improved peripheral vision
- possibility to speak (underwater voice communication)
- no drowning in case of sudden „black-out" of a diver.

Despite all the facts mentioned above, the risk will still remain with the use of a full-face diving mask, which might suddenly change itself to a deadly trap for a diver, who becomes vomiting underwater.

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Address for correspondence:
Prof. František Novomeský, M.D., Ph.D.
State Expert on Diving/Hyperbaric Medicine
Institute of Forensic Medicine and Medical Expertises
Jessenius Faculty of Medicine, Comenius University
Kollárova 10
036 59 Martin, Slovak Republic
e-mail: novomesky@fmed.uniba.sk