Gastric Rupture in a Diver Due to Rapid Ascent

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A 37-year-old, experienced female diver developed gastric rupture due to rapid ascent from a depth of 37 meters. The incident was preceded by a heavy meal, intake of soda beverages, swallowing of air and water under water, and panic. Sharp abdominal pain was present immediately after surfacing and afterwards. Full abdominal distension developed within two hours after the ascent. No other diving-related pathology was found. Surgery was performed around three hours after the accident and revealed pneumoperitoneum, gastric rupture, gastric content in the abdomen cavity, and signs of acute peritonitis. On surgery, a 4-cm rupture of the lesser curvature was found and sutured. The patient was discharged eight days after the event.

Key words: aerophagy; barotrauma; diving; gastric rupture

Stomach rupture is an extremely rare diving incident. If it is not recognized in time, it may have serious consequences. According to the work published so far, only 13 cases of gastric rupture in divers have been described since 1969 (1). Air swallowing (aerophagy), which commonly occurs during diving, results in belching and abdominal discomfort. The incidence of gastrointestinal disturbances due to aerophagy in divers upon ascent is 13% (2). However, most such problems are mild and remain undetected. Intragastric pressure has to be at least 12.8 kPa (96 mm Hg) to cause gastric rupture (3).

Early diagnosis and treatment of gastric rupture are life-saving (4-8). According to the data available, male divers were involved in 92% of cases (1,8), their age ranged from 22 to 54 years (mean±SD, 35.2±9.9), and 85% of them had extensive diving experience. The dives associated with stomach rupture were deep (mean±SD, 43±12 m) and brief (8±5 min) (8).

The simplest possible scenario in diving-related gastric rupture would include air swallowing while breathing under the water, in combination with rapid ascent. In most cases described, stomach rupture was provoked by fast ascent because of panic caused by failure or malfunction of the equipment (1,4-8). The expansion of air in the stomach during ascent causes abdominal discomfort, pain, and, in extreme cases, gastric or intestinal rupture, leading to the leakage of the gastric or intestinal content into the abdominal cavity, which results in acute peritonitis. Gastric rupture is a diagnostic problem, because pneumoperitoneum may occur even without stomach or intestinal rupture, merely due to pulmonary air leakage. In such cases, alveolar rupture may cause pneumomediastinum and the air can find its way to the abdomen through the esophageal or aortic opening of the diaphragm (5,9).

It seems that the rupture typically occurs at the lesser gastric curvature, probably because the lesser curvature has a single muscular layer and fewer mucosal folds, which makes it less elastic than other gastric structures. Increased air volume in the stomach causes significant gastric distension and closes the esophageal opening (Fig. 1), thus blocking the release of air through the mouth (10,11).

Case Report

A 37-year-old experienced female diver was diving with her partner to the depth of 37 meters in the vicinity of a remote Croatian island in the Adriatic Sea. Around 2 h before the dive, she had a heavy meal based on meat, during which she also consumed almost 1.5 L of mineral water. This was her second dive that day, the first dive being within no-decompression limits (12). Descent time was 7 min. Within 2 min after reaching the bottom, she started panicking because of equipment failure and headed rapidly for the surface. The efforts of her diving partner to halt her failed. Immediately after reaching the surface, she felt sharp abdominal pain and made a comment that “...something must have ruptured in my belly...”. The doctor who responded to the emergency call arrived within half an hour. The only possible diagnosis taken into account at that time was decompression sickness, so the diver was given 100% oxygen via a close-fitting face mask, in accordance with the standards of care (13).

Without prior consultation, the patient was immediately transported by a helicopter to the recom-
pression center, where the attending diving physician suspected gastric rupture because of the strong abdominal pain and increasing abdominal distention. There were no apparent neurological disturbances. The patient was immediately transferred to the hospital. The patient’s chest X-ray appeared normal, but the X-ray of the abdomen showed gas-filled abdominal cavity, with the diaphragm pushed upwards (Fig. 2). The white blood cell count was 14.2x10^9/L, and the body temperature 37.1 °C. The patient was referred to the abdominal surgeon, who commenced with the surgery 3 h after the accident.

On surgery, a 4-cm rupture of the lesser curvature was found and sutured. During the postoperative period, the patient’s condition was normal, with the exception of slightly increased body temperature during the first two postoperative days. Second generation of cefalosporines, H2-blockers, and total parenteral alimentation, as well as constant gastric suction via a nasogastric tube, were included in the therapy from the first day. Peristaltic activity normalized 54 h after the operation. Nasogastric suction was discontinued 72 h after the operation. Five days after the operation, the patient started eating normally and was discharged eight days after the accident.

**Discussion**

At sea level, an average atmospheric pressure is 101 kPa. With each meter of descent, hydrostatic pressure increases by 10 kPa, so the absolute pressure (atmospheric + hydrostatic) at 37 meters is 471 kPa. According to the Boyle’s law (p x V = Constant), rapid ascent from 37 meters would result in a 4.7-fold increase in gas volume in the stomach, provided that the gas is captured and no release through the esophagus is possible.

In our patient, the gas from a soda beverage taken before the dive and released from the liquid during the dive was the most probable origin of gas in the stomach (Fig. 1), although aerophagy could not be absolutely ruled out. The patient stated she had not swallowed air under the water, although this might have happened during the first seconds of equipment failure, when she started to panic and rapidly ascended to the surface. What puzzles is that she went diving after a heavy meal. However, it has been shown that the experience in diving does not influence the number of diving fatalities, and even highly experienced dives are often victims of their own mistakes (14). Our diver spent a short time at the bottom and ascended after a dive profile within no-decompression limits for repetitive dives (12).

The decompression dose was small enough not to cause any decompression sickness. Although urgent helicopter transport was organized because of the wrong reason, ie, suspected decompression sickness, it later appeared to be a lucky circumstance. Even a worse scenario might have occurred upon ascent: at the same time the diver might have had spinal or cerebral decompression sickness; pulmonary barotrauma, with or without cerebral arterial gas embolism; and gastric and/or intestinal barotrauma. Rapid ascent in panic might have also led to water inhalation and a “near-drowned” situation. This would have complicated the entire treatment since urgent abdominal exploration and surgical treatment have to be done in the case of gastric and/or intestinal rupture to save life (1,5-8).

The dilemma about what to treat first should not exist in the case of gastric rupture and concomitant cerebral arterial gas embolism. Recompression treatment in case of cerebral arterial gas embolism is life saving, and the time spent in recompression chamber should not significantly influence the development of peritonitis. Antibiotics would definitely slow down
the onset and spreading of infection, and the rupture of abdominal viscera could be treated conservatively while the patient is in the chamber.

In case of spinal or cerebral decompression sickness with delayed treatment, it might be difficult to decide what to treat first, especially if abdominal symptoms would appear together with pronounced neurological lesions. To improve general condition of the patient by increasing respiratory and circulatory efficiency, some authors applied abdominal paracentesis before recompression, if recompression procedure was the first therapeutic option (8). Recompression treatment of milder forms of decompression sickness would probably be undertaken after surgery. An exact algorithm still remains an open issue and varies from case to case. Valuable time is lost if recompression is the only treatment considered and other differential diagnoses not taken into account. Urgent transport to the nearest hospital is strongly advised, as well as consultation with a recompression center (Fig. 3).

It seems that it cannot be predicted by the severity of signs who would benefit from the operation (8). In our patient, all signs and symptoms led the surgeons to the correct diagnosis and procedure. Although the common opinion of divers is that such incidents occur only in diving medicine textbooks, stomach rupture in diving is rare but definitely possible incident. More similar cases are expected in the future due to the increasing number of divers every year. In the Croatian Adriatic, heliports on almost every island and a network of recompression chambers covering the entire coast are an important diving safety factor contributing to rapid responses even in the most complicated diving accidents.

References

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Figure 3. Algorithm of events and procedures in case of suspected diving-related gastrointestinal barotrauma.