

## Fatal scuba diving accident. A case report

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**Abstract:** Deaths during SCUBA (Self-Contained Underwater Breathing Apparatus) diving activities are becoming more frequent. As written in literature, death can occur both to professional divers and to those who practice recreational diving. The latter activity is becoming very common. Even if new advances and equipment improvements have made SCUBA diving safer, there is a high risk of injury, or even death.

A 41-year-old Spanish male, professional scuba diver, died while he was working to clear the wreck of a cruise ship. The death was due to his being crushed between the side of the ship and the arm of the crane. The autopsy was performed 48 hours later. No foamy content was found in the trachea and main bronchi; no alcohol was found in the blood of the deceased; neither signs of pulmonary barotrauma nor cerebral arterial gas embolism were found; conjunctiva haemorrhage was absent; mild brain oedema was observed. A deep lacerated wound was seen on the pelvic floor, and the pelvic organs and the colon were protruding through the wound. The autopsy confirmed that the cause of death was the massive haemorrhage subsequent to the wound caused by the crush.

In the daily routine of a forensic institute, lethal SCUBA diving accidents are not common to observe. This is a particular manner of death during SCUBA diving, even because, although the patient suffered from huge injuries, the final cause of death was not stated to be due to drowning, as is usually what happens in SCUBA diving related deaths.

**Key Words:** forensic science, occupational diving, scuba diving, fatal accident, professional divers.

Self-Contained Underwater Breathing Apparatus (SCUBA) diving is widely popular [1]. It can be distinguished in recreational diving (snorkelling spearfishing, scuba diving for sport, and leisure), and occupational diving (military diving, scientific diving, police diving) [2]. SCUBA consists of a cylinder of compressed air, carried on the diver's back, with a pressure reducer that minimises the high pressure of the air into the cylinder to a value between 7 and 10 bar. By gently biting down on a mouthpiece, the air pass into a hose that is connected to a combined second stage reducer that the diver holds in his mouth. Due to the negative pressure within the mouthpiece, when the diver inhales, the diaphragm is pulled inwards opening a valve

that releases medium pressure air into the mouthpiece. When the diver exhales, the diaphragm returns to its original position closing the air inlet valve. The increase in pressure within the mouthpiece that results from exhalation opens another valve within the mouthpiece, that release the exhaled air to the surrounding water [1]. The mechanism is relative secured, and over the past 10 years new advances and improvements in equipment have made SCUBA diving safer compared to the past [3].

The deaths which occur during scuba diving activities can be a result of many factors such as barotrauma as well as decompression illness, pulmonary oedema and toxic effects of increased partial pressure of gases; natural death during immersion and even trauma [4, 5].

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Non-lethal accidents resulting in tetraplegia and paraplegias are comparatively higher: for example Steinburk *et al.* [6] reported a study about a total of 139 diving accidents in a 11-years period where the majority of diagnosis was fracture of the fifth cervical vertebra.

However, to our knowledge, there aren't reports of death of a professional diver due to a crush injury.

### CASE REPORT

We report a case of a 41-years-old professional scuba diver, died while he was working in the context of the operation to right the wreck of a cruise ship. This hit a rock and capsized in Tuscany, Italy, in 2012. Removal of the wreck was complicated by two important factors: the ship was the largest passenger ship in history, and it ran aground in a protected marine environment. For these reasons, the Italian government selected an expensive two-step process that has never been done on this scale: parbuckling and re-floating, the most complex and costly maritime salvage operation ever attempted. Initially, a floating accommodation support vessel tethered next to the wreck was installed. Huge stabilisers named as "sponson" flotation tanks were installed to give the ship buoyancy. This floated in September 2013, exposing the severely damaged side that had been submerged for months. In 2014, many others divers started to work around the wreck. The operations included water sampling; removal of debris from the sponsons already installed on the left side of the wreck; preparation of the wreck for the installation of other 15 sponsons to be placed on the submerged right side; and installation of electric-pneumatic systems for the re-floating of the wreck.

During this phase, a professional diver with a SCUBA apparatus, was cutting a bar called davit weighing tons which held the lifeboat. The davit is necessary in order to haul down the lifeboats in case of emergency. Similar to other artefacts of the ship, even this element, remained prominent, had to be removed to facilitate the application of sponsons to re-float the ship.



**Figure 1.** Details of the lesion of the pelvic floor.

The divers team was working at a depth of six meters. Usually the team is composed of three members, two of them go underwater in immersion while the other is on a ship close to the immersion site as a stand-by diver for emergency. They are equipped with a diving suit, a helmet with a camera and a communication system, a scuba apparatus, gloves and safety ropes.

The two divers immersed themselves to cut the portion of the davit that prohibited the re-floating of the ship. In this action one of the diver was working and the other one was on site for the safety of his own colleague. The diver who was performing the cut between the davit and a cylinder was caught. The safety diver alerted the rescue immediately as he subsequently tried to free his colleague. Meanwhile the stand-by diver went underwater in order to help the two colleagues. After some manoeuvres succeed in freeing the injured diver and bringing it to the surface following the safe-line. The injured diver was conscious until the two colleagues put him on the rescue ship. They then realized that the diver was bleeding and was no longer conscious. Paramedics performed RCP and by cutting the diving suit observed a wide fracture in the pelvic floor with a major haemorrhage and leakage of the testicles, due to the crushed trauma. No longer able to revive him the paramedic proclaimed him dead on the scene.

At the autopsy no foamy content was found in the trachea and main bronchi. No alcohol was found in the blood of the deceased. Neither signs of pulmonary barotrauma nor cerebral arterial gas embolism were found. Conjunctiva haemorrhage was absent. Mild brain oedema was seen. A deep lacerated wound in size of 5x2 cm was seen on the pelvic floor, the pelvic organs and the colon were protruding through the wound (Figs 1, 2). There was a massive retroperitoneal haemorrhage as well as pinpoint haemorrhages in the kidneys and the bladder. As far as the histology is concerned, it substantiated the poli visceral anaemia due to the considerable haemorrhage caused by the trauma, hence the autopsy confirmed that the cause of death was the massive haemorrhage subsequent to the wound caused by crush.



**Figure 2.** The laceration of the pelvic floor with the testicles protrusion.

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## DISCUSSION

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In the daily routine of a forensic institute, lethal accidents of scuba divers are not infrequent [7].

From the autopsies cases examined above, it is possible to observe that there is a variation of different types of death that can occur during the practice of SCUBA diving. It often happens that the death is essentially due to drowning where sometimes it is due to an illness, and it is also possible that an accident/trauma underwater that can directly kill the diver or resulting ultimately to drowning. Other conditions causing equally as much discomfort, such as a myocardial infarction, can also be a direct cause of death or the victim again can be led to drowning. This case is a clear death due to trauma that caused a fatal haemorrhage to the individual. This individual was a professional SCUBA diver who died due to trauma by compression that has broken through the pelvic floor making the internal organs protruded. On this occasion, with a trauma of this entity, the diver would be dead practicing any other activity apart from diving. Furthermore, another incident that occurs frequently in the practice of this activity, especially during the ascent phase of immersion, is when the diver is struck by a boat and then s/he might die either due to blunt force trauma given by the impact or due to lacerations caused by the propeller. The latter displays special features [8]. The cases like these one reported in the literature are enough [9, 10] as well as cases of divers who have been bitten by sharks, which happen mainly in the Australian waters [11].

Nevertheless, the size of all these injuries would have not allowed to live, even out of the water.

Although not reported in the literature, it is possible that an illness of small entity happens during a dive such as muscle cramp and a panic attack. This can lead the diver to drowning resulting in death, and that is what emphasizes the difference of the dangerousness of the dive itself.

Another type of lethal accidents is the attack from large marine animals. This is largely depending

on the geographical location of the accident. Between 1974 and 2013, 77 shark bites in the coastal Western Australia were recorded. Total reported shark bites for coastal Western Australia appear to have grown by over 30 per cent every 5 years over the 40 years with number of fatalities showing a similar exponential growth [11].

Also an improved diver education in these years has been important: diving certification agencies have established uniform training standards through membership in the Recreational SCUBA Training Council [3].

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## CONCLUSION

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As aforementioned, the end stage of most fatal diving accidents is drowning, even if in most cases an underlying chain of events has taken place. Drowning occurs as a result of exogenous/external and endogenous/internal factors. It is very important to identify the causative factors of the drowning [9] because it is surely a frequent cause of death among divers [7]; a previous author reports that the majority of diving deaths were caused by drowning [12]. For these reasons, although it can be difficult, it is of paramount importance to determine the cause of drowning.

In the end, while there may be numerous factors causing fatalities in this activity, there is a general consensus that many of these cases are caused by panic [13].

Also if most of the fatal diving accidents are the result of poor technical maintenance or risky diving manoeuvres, such as diving alone [7], it is also necessary for divers to realize that unexpected risks are hidden in their vicinity [9]. Post-mortem examination is mandatory to identify or exclude other possible causes of death. Investigation of these accidents requires collaboration of forensic doctors, police and technical examiners. In order to correctly interpret findings it is necessary that forensic staff understand important physiological rules [7].

**Conflict of interest.** The authors declare that they have no conflict of interest concerning this article.

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