TITLE PAGE

Title: Diving-Related Fatalities: Multidisciplinary, Experience-Based Investigation

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Acknowledgements

We gratefully acknowledge the contribution of our colleagues and technical staff of the Institute of Legal Medicine and Forensic Sciences for their help during autopsy conduct. The authors also thank i2e3 Biomedical Research Institute for editing the final version of the manuscript.

Word count of the manuscript: 4824 (5252 including Title page); Abstract word count: 236; Word count Title Page: 428

Abstract

Purpose: To describe the technical characteristics of fatal diving mishaps and to elucidate the causes of death using a sequence analysis and a multidisciplinary investigation of diving-related fatalities.

Methods: The analysis included all cases of diving deaths recorded on the coast of Girona (Spain) between January 2009 and May 2018. The main data were obtained from the police technical report and the forensic pathology service. Each accident was analyzed in order to identify the trigger, disabling agent, disabling injury, and cause of death.

Results: During the studied period 25 diving-related fatalities were recorded. Most of the victims were male aged 50-69 years, and 11 were experienced divers. Almost all victims were using open-circuit SCUBA to breathe and compressed air as their sole gas supply. None of the victims was diving alone. The most common identified triggers included exertion, panic, buoyancy problem, disorientation and confusion. The main factors identified as disabling agents were rapid ascent, cardiac incident, panic and entrapment. Asphyxia, lung overexpansion, and myocardial ischemia were the most frequent disabling injuries. Finally, drowning represented the main cause of death, followed by arterial gas embolism and natural causes or internal diseases.

Conclusions: A differential diagnosis, performed in the setting of a multidisciplinary investigation is essential for elucidating the cause of death in diving-related fatalities. The sequence analysis proposed allows to clarify underlying problems in these cases and to identify risk factors and unsafe behaviors in diving.

Keywords

SCUBA diving, police reports, forensic pathology, autopsy, death causes.

Introduction

The Girona coast in the Northeast of Spain, located 44 miles north of Barcelona, has optimal conditions for recreational diving with more than 150,000 dives using compressed gas registered per year [1]. Diving is one of the most popular and practised underwater activities [2–4], having recently become an important business in many countries all over the world [4,5]. The most common methods used in diving activities are SCUBA (self-contained underwater breathing apparatus) diving, rebreather (recirculating underwater breathing apparatus) diving, and surface-supplied breathing gas.

Although recreational diving is overall safe [6,7], diving accidents are potentially serious and even fatal [4,8]. Despite all the precautions taken by divers, fatalities related to this activity are reported every year. Drowning is the main cause of death, but others have been described, such as arterial gas embolism (AGE), decompression sickness, natural disease processes, and trauma [2,4,5,9].

The large number of events that may lead to a diving fatality challenges the research process to elucidate the actual cause of death. Therefore, a multidisciplinary approach, involving underwater experts such as police divers, underwater physiologists and physicians, as well as forensic pathologists, is essential to have different perspectives on the investigation [10–12]; unfortunately, most of autopsies are performed by pathologists who are not familiar with diving-related injuries [13]. Despite an adequate identification of the main cause of death, it is sometimes difficult to gain additional knowledge about the underlying events that ultimately led to the fatality. In order to establish the characteristics of fatal dives, it is important to know the deceased's dive profile and use specific autopsy techniques and/or post-mortem radiographic imaging [3,10,14,15].

Moreover, due to the difficulties of evaluating the significance of each pathological event, some authors have provided a simple model to detail the sequence analysis of each case, describing the fatality's root causes—also known as trigger causes—, the disabling agent, the disabling injury, and the cause of death [16]. The aim of this study was to describe the technical characteristics of fatal dives and elucidate the causes of death using this sequence analysis and a multidisciplinary investigation of diving-related fatalities.

Materials and Methods

Study Overview and Data Collection

This analysis includes all cases of diving deaths recorded on the coast of Girona (Northeast of Spain) between January 2009 and May 2018. The research was developed in collaboration with the Institute of Legal Medicine and Forensic Sciences of Catalonia (IMLCFC), the Special Group for Underwater Activities (GEAS) of the Spanish Civil Guard, and the Department of Medical Sciences of the University of Girona; it was authorized on October 10, 2013 and on July 14, 2015 by the Teaching and Research Commission of IMLCFC (Registry numbers 0316S-81/13 and 0316S-55/15).

Data Sources

Main sources of information were those obtained from police technical reports and the forensic pathology service. Police technical reports were recorded before the autopsy and consisted of preliminary data about the testing of the diving equipment, the diving plan, the emergency and evacuation plans, and the diver's dive profile. This information was collected from diving computer records and the buddy (diving companion)'s reports. Data related to demographic factors (age and gender), medical history, diving certification and experience, diving equipment (type of breathing apparatus, gas supply, and dive suit) and characteristics of fatal dives (diving time and depth) were also registered. The police laboratory also performed a toxicological analysis of the breathing gas content of the bottles.

All autopsies were conducted at the Forensic Pathology Service of IMLCFC by forensic pathologists with experience in diving fatalities, according to the protocols and specific recommendations for this type of deaths [1,15,17,18]. Data analyses related to autopsy results, together with macroscopically findings, histopathological analyses, and toxicological results were also included.

Sequential Analysis

Each accident was analysed in order to identify the sequence of events described by Denoble et al. [16] as trigger, disabling agent, disabling injury, and cause of death.

Results

During the analyzed period, we recorded 25 diving-related fatalities. All of them were included in the analysis. The number of deaths per year ranged from zero to eight, with the latter number reached in 2012.

Subject Characteristics

Most fatalities corresponded to male subjects (20 divers) and 50-69 years-old subjects (18 divers), although the most prevalent range was found between 55 and 65 years of age (13 divers) (Figure 1). Of all the victims, 14 were foreigners, whereas the other 11 were Spanish citizens. Regarding medical history:~~,~~ 10 divers had no relevant medical history~~,~~ six had ~~a~~ relevant medical history, and in nine cases there were no medical records available or medical history to obtain health information. Most relevant medical histories included cardiovascular disease (three cases), anxiety and depression (two cases) and low back pain (one case). As shown in Table 1, 11 victims were experienced divers, and eleven had little or no experience; in the other three cases, this information was not available. Moreover, 10 subjects were certified as basic open water divers, eight as advanced open water divers, and three as a technical diver. The police could not get this information for the remaining four cases.

Characteristics of the Equipment and Activity

Regarding the diving equipment**,** 22 divers wore wetsuits, two used drysuits, and there was one diver with an unknown protective suit. Most subjects (23) used open-circuit SCUBA to breathe, whereas only two used a rebreather; the police did not find any signs of mechanical failure or manipulation in any of these devices. All victims were dependent on gas supply: 24 used cylinders containing compressed air as their sole gas supply, and only one diver used an additional supply of Trimix (a mixture of nitrogen, oxygen and helium) in separate cylinders. In all cases, the toxicological analysis of the breathing gas content of the bottles was negative according to the safety regulations for the exercise of underwater activities in Spain (BOE n. 280, November 22_{nd}, 1997).

Based on seasonal distribution, there were 13 accidents between June and August nine between March and May, two were reported in September, and one in February. In addition, we have described the characteristics of fatal dives taking into account different aspects:

Dive modality: Twenty-three cases occurred in open waters and two in caves.

Dive purpose: All victims were diving for recreation.

Primary dive activity: Twenty-three victims were diving for pleasure or sightseeing, one was receiving diving instruction, and another one was taking photographs.

Dive platform: Twenty-three fatal dives originated in a charter or private boat, and two in the beach.

Time: All cases occurred during daylight hours: 20 cases in the morning, four in the afternoon and, in one case, the time was unknown.

Dive form and buddy system: None of divers started the diving alone: 15 had one buddy, and 10 had two or more buddies. However, nine of them were alone at time of death.

Dive profile: The dive computer indicated a rapid ascent to the surface (at a higher speed than was planned) of nine victims, and a controlled ascent of 13. This information was unavailable for the other three cases.

Depth of the accident: The fatality happened on the surface or at less than 10 m depth in 11 cases. None of the non-experienced divers reached depths below 40 m, and only one experienced diver (a technical instructor) was below 60 m depth. In one case, the police could not get this information.

Loss of consciousness location: The victim was found on the surface after immersion in 10 cases, on the surface before immersion in one case, underwater in eight cases, and inside a cave in two cases. Loss of consciousness occurred out of the water in three cases: two on a boat and one on the beach.

Rescue time: The body was recovered within the first 24 hours in 22 cases, after 24 hours in two cases, and after one week in one case.

Cardiopulmonary resuscitation (CPR): This maneuver was performed immediately after the accident in 22 divers, with recovery of vital signs in two subjects, who were transferred to a medical center and admitted in the intensive care unit. In three cases, CPR was not performed because the rescue had not been immediate.

Forensic and Pathology Findings

According to the body mass index (BMI) classification of the World Health Organization (Europe, 2018), four victims were classified as normal weighted (BMI of 18.5 to ≤24.9), six as pre-obese (BMI of 25.0 to ≤29.9), five as obese (BMI of 30.0 or higher), and two as severely obese (BMI of ≥40.0). In eight victims, BMI could not be determined.

External autopsy examinations showed five cases of palpable crepitus indicative of subcutaneous emphysema, one of decomposition changes with putrefaction in emphysematous period, and ten with froth cone in mouth and nose. We found hand injuries (Fig. 2) in two victims. Conversely, internal autopsy analyses revealed the presence of pneumothorax in two cases, mass air bubbles in the left side of the heart in seven cases, and air bubbles in the circle of Willis in three cases. Pathologists found heavy lungs (>1 kg) in 14 victims. Regarding the cardiovascular system, atherosclerosis of the coronary arteries and ventricular hypertrophy were described in nine and five cases, respectively. No evidence of primary cerebral disease was found in the autopsies. Cirrhotic liver was reported in one victim.

Moreover, samples of the heart, lung, liver, and kidney were examined microscopically in 13 victims. In one case, the whole brain was studied. Forensics found 10 cases with a pattern of emphysema (Fig. 3), five of moderate-to-severe coronary atherosclerosis, two of acute ischemic changes indicative of myocardial infarction, and three of hepatic steatosis.

A toxicology screening was performed in 23 victims, four of which were positive for alcohol (the highest concentration was 0.31 g/L), one for cocaine metabolites, and another one for benzodiazepines (0.11 mg/L) and tetrahydrocannabinol (THC-COOH). In addition, 10 divers had high carboxyhemoglobin levels, although its concentration was <10% and its level of COHgb poisoning was <0.20. Diatoms and strontium required to be analyzed in one case, with negative results.

Sequential Analysis

Table 2 shows a detailed summary of the sequential analysis of all studied fatalities. Most common triggers accounting for 17 fatalities included exertion, panic, buoyancy problem, disorientation and confusion. Breathing difficulty, low visibility, no formal training, and chest discomfort were the triggers of four deaths, but the others could not be identified. The main factors identified as disabling agents consisted of rapid ascent, cardiac incident, panic and entrapment, accounting for 76% of fatalities. Other disabling agents, detected in 16% of cases, were oxygen toxicity, hypoxia, entanglement and extreme breathlessness. In two cases, the disabling agents could not be determined. For its part, asphyxia, lung overexpansion, and cardiac incidents were the most identified disabling injuries. Finally, the autopsy protocols identified drowning as the main cause of death, occurring in 13 victims, followed by AGE and natural causes or internal diseases, which were found in seven and five victims, respectively.

Discussion

In most diving-related fatalities, the identified cause of death is drowning [3,9,19], but this conclusion may be incomplete, being essential to identify the sequence of events that led to drowning. Therefore, we consider that the investigation of these cases not only must be based on autopsy findings, but must systematically include: relevant death scene information—by visiting the scene or from first responders—

, a police technical report, and a detailed external and internal corpse examination, with special autopsy techniques and radiological, histopathological, toxicological and biological studies [1].

These autopsies represent a big challenge for any forensic pathologist; besides establishing the primary cause of death, it is essential to clarify the underlying problems, factors and sequence of events that made the victims susceptible to fatal incidents. Consequently, the investigation not only has to focus in determining the cause of death, but also in establishing its surrounding circumstances. This compels forensic pathologists to understand the physiopathology of diving and the main technical aspects of the equipment used in the immersion [1,3,10], and a multidisciplinary approach of the problem allows to consider the diving fatal accident as the sum of external and internal factors. Determining external factors requires detailed and accurate information of the diving plan, the equipment used, and the diver’s profile, while determining the internal factors requires a complete autopsy. The individualized analysis of both has allowed us to reconstruct the events in each case.

In our study, drowning was the most frequent cause of death, although we found several events that led to it. For example, entrapment in cases 11 and 16, and entanglement in case 23, were identified as disabling agents in experienced divers, which could have been triggered by disorientation, confusion or excessive personal demands. For the victim of case 11 found in an underwater cave, asphyxia was the disabling injury, but we hypothesized that the trigger was disorientation because the diver's fins had stirred up a dust cloud that hindered visibility. Asphyxia was also recognized as the disabling injury for the victim of case 23, whose body was found in open waters, but we hypothesized that the disabling agent was accidental cord tangling (and lack of a diving knife). In both cases, the testing of the equipment showed excessive gas consumption, and the autopsy revealed hand injuries—presumably in an attempt to find the exit in case 11, or to break free from entanglement in case 23. Therefore, reconstructing the events allowed us to suspect a situation of extreme exertion or anxiety. In case 16, the entrapment also took place inside a flooded cave, but the body was partially outside the water because the diver had found an air cavity. The technical report revealed that the victim and his surviving buddy had emptied the bottles in order to enrichen the cavity’s atmosphere while waiting to be rescued. To our understanding, this example supports the advice by Buzacott et al. [20] that these types of rescue should not be executed by local, non-specialized dive teams. Thus, confusion was identified as the trigger and asphyxia as the disabling injury, which led to loss of consciousness and finally drowning.

In these cases, we could establish a direct causality between the cause of death and the trigger or the disabling agent, but sometimes this association is less apparent, as in cases 6 and 18 in which the victims were using a rebreather. The victim of case 6, whose equipment could not be recovered, was an experienced diver who experienced convulsions at 60 m depth according to the witness statement. Conversely, the victim of case 18 was a non-experienced diver who drowned at 5 m depth. According to studies describing inappropriate breathing of gas as the most prevalent disabling agent when using a rebreather [21,22]—leading to loss of consciousness, water aspiration and drowning—, we hypothesized that in case 6, convulsions were triggered by hyperoxia, but without discarding hypercapnia. However, in case 18 the trigger was the diver's inexperience with the rebreather, and the disabling agent was a hypoxia since the oxygen bottle was closed (it was at 200 bar of pressure).

The relevance of panic in diving fatalities has already been reported [5,23]. In our study, the witness statement has allowed us to identify panic as a disabling agent in three cases. Victims of cases 7, 12, 15 and 21 were divers with little or no experience who were in open waters at less than 12 m depth. The autopsy revealed drowning as the cause of death in cases 7, 12 and 21, and we hypothesized that the trigger was physical or mental stress caused by bad visibility in case 7, a buoyancy problem in case 12 and exertion in case 21. These situations led to hyperventilation, anxiety and finally panic, which we identified as the disabling agent, although the victims did not ascend to the surface quickly. On the contrary, we identified near-drowning as the cause of death for the victim in case 15, and we hypothesized that an unknown trigger caused a panic situation that led to a rapid ascent to the surface, loss of consciousness and death after 48 h of being rescued and admitted to hospital.

We observed that divers without a relevant medical history and with their current medical certificate might undergo physical discomfort and loss of consciousness during the immersion, as we saw in cases 9 and 20. In these incidents, we were not able to identify neither the triggers nor the disabling agents. In cases 9, we could only determine asphyxia as the disabling injury and drowning as the cause of death. Case 20 was deemed near-drowning after a survival period of 96 h, showing bilateral pulmonary condensation in computerized tomography. In these two cases, the dive computer records and the buddy revealed loss of consciousness during the last 15 m of a controlled ascent to the surface without any signs of panic or anxiety. We rejected AGE and decompression sickness because of the characteristics of the ascent and the duration and depth of the immersion, respectively. Besides, the results of the toxicological analyses allowed us to reject alterations of consciousness and/or motor function due to drugs, alcohol or gas toxicity. In these cases, we should always evaluate potential predisposing factors that may act as triggers or disabling agents, such as circulatory arrest (loss of electrical conduction or ventricular fibrillation) or loss of consciousness due to another reason (ischemic heart disease, arrhythmogenic channelopathies such as long QT syndrome, etc.). Requesting genetic studies should also be considered in these cases [1], as performed in other sports activity when sudden death occurs [24].

Moreover, alcohol and certain medications are associated with prolongation of the QT interval and, when combined with extended breath-holding during swimming, they may trigger an incapacitating arrhythmia and precipitate drowning [25]. Particular examples of this were found in victims of cases 2 and 17, where death is due to drowning. The autopsy and histological examination identified a cardiovascular disease (coronary atherosclerosis and left ventricular hypertrophy) as the disabling agent. We hypothesized that the trigger was exertion, probably due to swimming upstream for too long. In case 17 underwater inspection showed the loss of the left diving fin (Fig. 4), worsening the diver's situation.

Besides drowning, we observed two more causes of death: natural disease process and AGE. Regarding the first one, our results show that divers of cases 8, 10, 13, 19 and 25 died due to internal diseases, mainly cardiovascular. Victims of cases 8, 10, 13 and 19 were males with a mean age of 64.4 years and a high body mass index. They died of acute myocardial infarct on the surface after diving, and we hypothesize exertion as the most common trigger. A possible explanation for these incidents is that underlying diseases can be exacerbated during diving [26]. In fact, other authors have described risk factors for cardiovascular disease among adult recreational divers [27]; some of these factors (hypertension, high cholesterol) increase in prevalence with age. However, in Mediterranean countries, an increase in deaths of middle- or advanced aged divers during apparently normal immersions and without any obvious factor has been described as the responsible cause [7]. This is what happened to the victim of case 25, who was also 60 years old, and died on the surface before immersion while he was swimming (moderate exercise). Although the internal autopsy examination showed 1 kg of excess combined lung weight, this finding does not provide definitive evidence of drowning [28]; moreover, specific tests for drowning (diatoms and strontium) yielded negative results. Finally, we did not find any cardiac pathology that could be identified as the cause of death. In this regard, although arrhythmias are often a differential diagnosis in non-monitored sudden deaths [19], based on data from other studies, we hypothesized a sudden death of non-cardiological origin compatible with immersion pulmonary edema [7,19,29].

Arterial gas embolism following pulmonary barotrauma (PBt/AGE) was detected as an important cause of death. Cases 1, 3-5, 14, 15, 19, 22 and 24 had a strongly suggestive history of PBt/AGE based on the technical report, which described a rapid ascent followed by loss of consciousness immediately after immersion. In cases 1, 3-5, 14, 22 and 24, the autopsy revealing the existence of large volumes of intravascular air, which is typical of AGE [3,17]. However, we only observed air within the cerebral arteries in cases 14, 22 and 24. Possible explanations for this include that the bubbles had moved beyond the central vessels or the circle of Willis and injured the end organs; the postmortem interval was significant, resulting in a redistribution of gas in the body; or the pathologist failed to observe the gas load due to lack of experience or use of an improper technique. In this sense, we suggest, to support the diagnosis, whenever possible, with post-mortem imaging and other techniques as described in Casadesús et al. 2018 [30]. For the above-mentioned cases, we established AGE as the cause of death, and high speed ascent as the disabling agent.

In conclusion, we present a representative study of diving-related fatalities, establishing a causality or direct association between police technical reports and pathological findings using a sequence analysis. This task performed by a multidisciplinary team provides enough information, evidence and pathological findings for a high-qualified investigation of the incidents. Moreover, we believe that the forensic pathologist not only has to solve the main medical-legal questions that arise from the investigation, but also use the statistical and clinical information to prevent similar incidents in the future. Therefore, we expect that the data provided in this study can help to avoid unsafe behaviors and prevent future diving accidents.

Key points

1. A qualified investigation of diving-related fatalities requires a multidisciplinary team.
2. Analyses of sequence of events clarify underlying problems in diving fatal incidents.
3. Despite that drowning is the most common cause of death, a differential diagnosis is always mandatory.
4. Whenever possible, risk factors should be highlighted to avoid unsafe behaviors in diving.

Compliance with Ethical Standards

Conflict of Interest

None.

Ethical Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Institutional Research Committee and with the 1964 Helsinki Declaration and its later amendments, or comparable ethical standards.

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Table caption.

Table 1. Summary of data from police technical reports.

Table 2. Sequence analysis of studied diving fatalities.

Figure captions.

Figure 1. Age and sex distribution of cases (N=25)

Figure 2. Image showing hand injuries in two victims. **A.** In an attempt to find the exit in a cave. **B.** To break free from entanglement (accidental cord tangling)

Figure 3. Analysis of pulmonary tissue (haematoxylin & eosin, ×20) of SCUBA diving accident victim, showing a dilation of terminal airway and destruction of alveolar walls forming a pattern of emphysema.

Figure 4. Image corresponding to underwater inspection of SCUBA diving accident victim, showing the loss of the left diving fin.

Table 1. Summary of data from police technical reports.

Case	Age (years)	Sex	Experience	Certification Level	Breathing apparatus	Dive profile (ascent)	Depth (m)	Loss of consciousness
1	41	M	Beginner	Basic	Scuba	Rapid	12	S. post-dive
2	59	M	Beginner	Basic	Scuba	Controlled	0	S. post-dive
3	46	M	Experienced	Basic	Scuba	Rapid	10	S. post-dive
4	60	M	Experienced	Advanced	Scuba	Rapid	26	S. post-dive
5	59	M	Unknown	Basic	Scuba	Rapid	18	S. post-dive
6	41	M	Experienced	Technical	Rebreather	Controlled	65	Underwater
7	54	M	Beginner	Unknown	Scuba	Controlled	12-15	Underwater
8	70	M	Experienced	Technical	Scuba	Controlled	0	S. post-dive
9	59	F	Beginner	Unknown	Scuba	Controlled	15	Underwater
10	69	M	Beginner	Advanced	Scuba	Controlled	6-10	S. post-dive
11	52	M	Experienced	Basic	Scuba	No ascent	15	Cove
12	58	F	Beginner	Basic	Scuba	Controlled	5	Underwater
13	58	M	Experienced	Technical	Scuba	Controlled	0	Out of water
14	57	M	Unknown	Unknown	Scuba	Rapid	12	Out of water
15	63	F	Beginner	Advanced	Scuba	Rapid	12	S. post-dive
16	62	M	Experienced	Advanced	Scuba	No ascent	9	Cove
17	72	M	Experienced	Advanced	Scuba	Unknown	--	Underwater
18	24	F	Beginner	Basic	Rebreather	Controlled	5	Underwater
19	65	M	Experienced	Advanced	Scuba	Rapid	9	Out of water
20	31	F	Beginner	Basic	Scuba	Controlled	10	Underwater
21	52	M	Beginner	Basic	Scuba	Controlled	8	S. post-dive
22	61	M	Experienced	Advanced	Scuba	Rapid	22	S. post-dive
23	66	M	Experienced	Advanced	Scuba	Controlled	29	Underwater
24	59	M	Unknown	Unknown	Scuba	Rapid	12	S. post-dive
25	60	M	Beginner	Basic	Scuba	Controlled	0	S. pre-dive

M: male; F: female. Beginner: non or few experienced diver; Experienced: experienced diver. Depth (in meters): at the moment of the accident; S. pre-dive: in surface before diving; S. post-dive: in surface after diving. --: unknown.

Table 2. Sequence analysis of the studied diving fatalities.

Case	Trigger	Disabling agent	Disabling injury	Cause of death
1	Panic	Rapid ascent	Lung overexpansion	PBt/AGE
2	Exertion	Cardiovascular disease	Asphyxia	Drowning
3	Buoyancy problem	Rapid ascent	Lung overexpansion	PBt/AGE
4	Breathlessness	Rapid ascent	Lung overexpansion	PBt/AGE
5	Panic	Rapid ascent	Lung overexpansion	PBt/AGE
6	Unknown	Oxygen toxicity	Asphyxia	Drowning
7	Low visibility	Panic	Asphyxia	Drowning
8	Exertion	Coronary atherosclerosis	Myocardial ischemia	Heart attack
9	Unknown	Unknown	Asphyxia	Drowning
10	Exertion	Coronary atherosclerosis	Myocardial ischemia	Heart attack
11	Disorientation	Entrapment	Asphyxia	Drowning
12	Buoyancy problem	Panic	Asphyxia	Drowning
13	Exertion	Coronary atherosclerosis	Myocardial ischemia	Heart attack
14	Panic	Rapid ascent	Lung overexpansion	PBt/AGE
15	Unknown	Rapid ascent	Asphyxia	Near-drowning
16	Confusion	Entrapment	Asphyxia	Drowning
17	Exertion	Cardiovascular disease	Asphyxia	Drowning
18	No formal training	Hypoxia	Asphyxia	Drowning
19	Exertion	Coronary atherosclerosis	Myocardial ischemia	Heart attack
20	Unknown	Unknown	Asphyxia	Near-drowning
21	Exertion	Panic	Asphyxia	Drowning
22	Chest discomfort	Rapid ascent	Lung overexpansion	PBt/AGE
23	Confusion	Entanglement	Asphyxia	Drowning
24	Panic	Rapid ascent	Lung overexpansion	PBt/AGE
25	Exertion	Extreme breathlessness	Asphyxia	IPE

PBt/AGE: arterial gas embolism following pulmonary barotrauma.
IPE: immersion pulmonary edema.

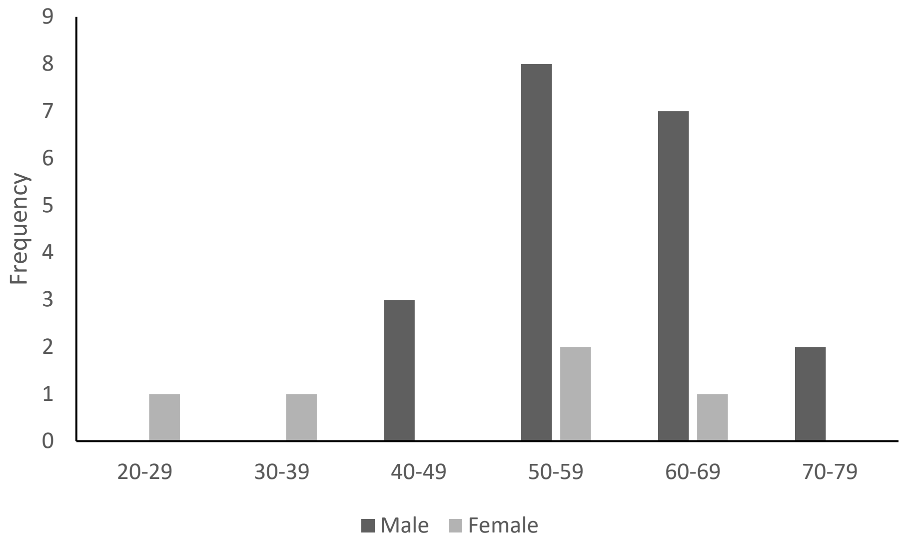
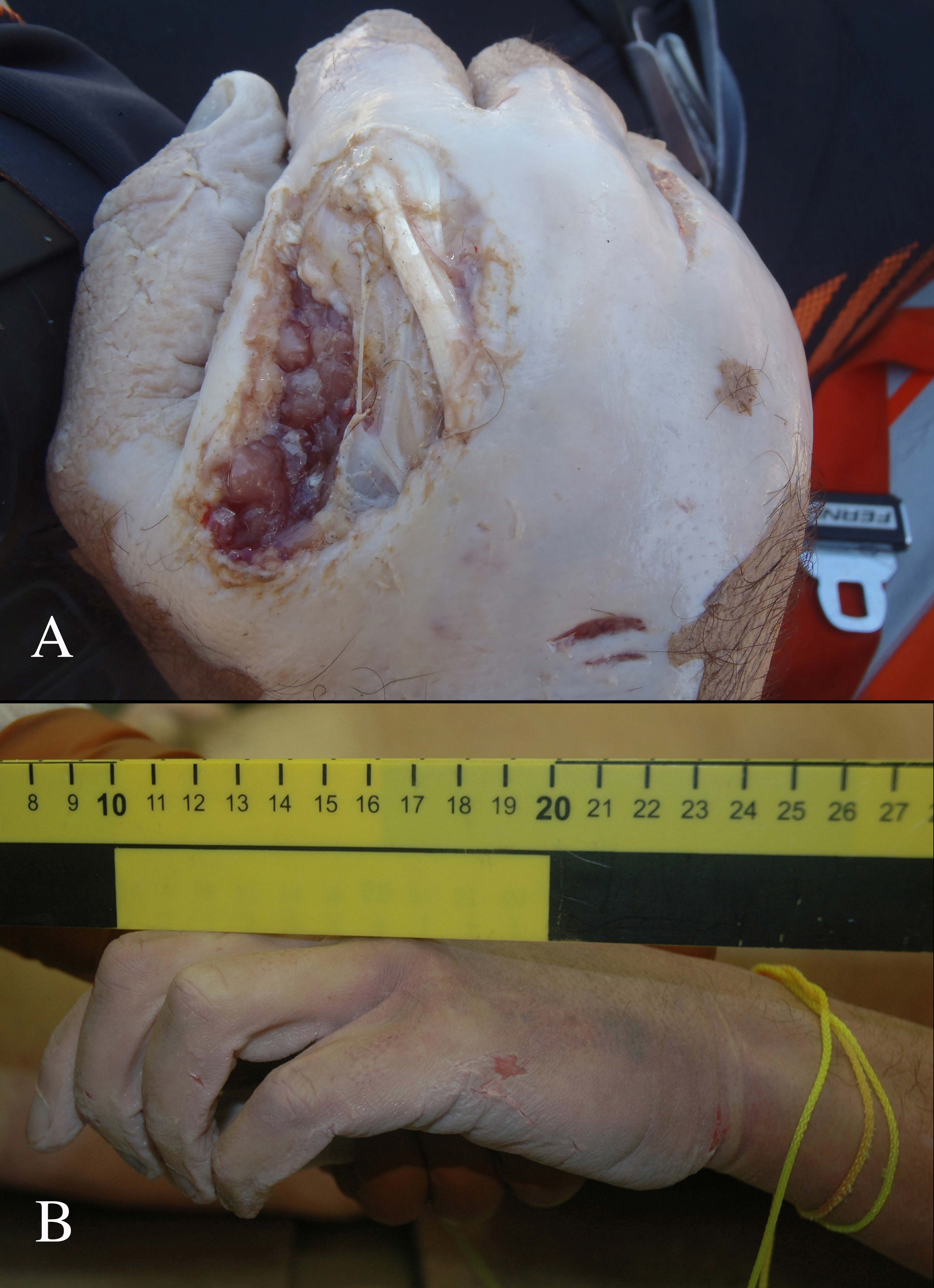


Figure 1. Age and sex distribution of cases (N=25)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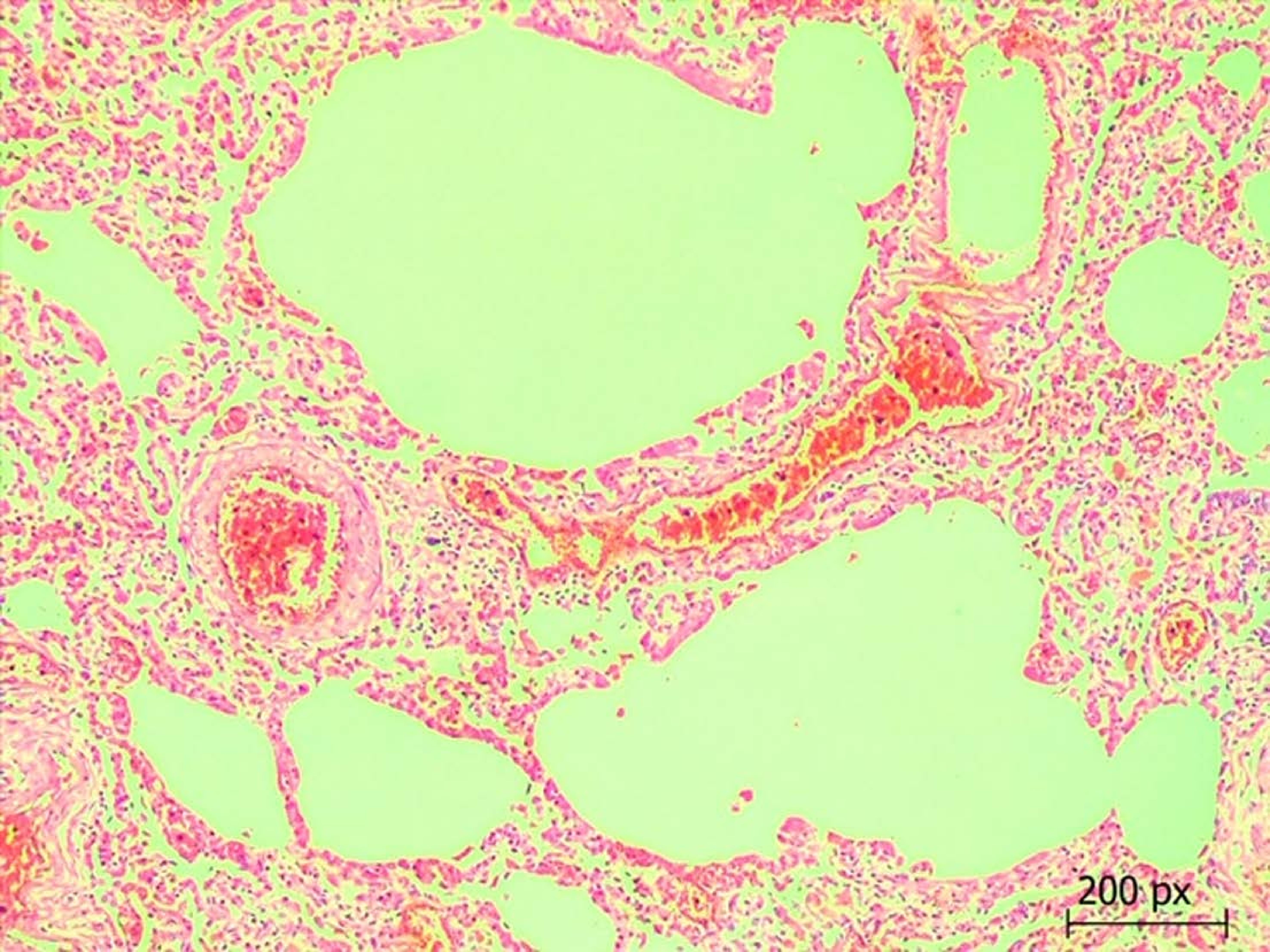
B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