Guidelines on autopsy practice

Investigation of recreational diving deaths

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Foreword

The autopsy guidelines published by the Royal College of Pathologists (RCPath) are guidelines that enable pathologists to deal with non-forensic consent and Coroner's/Procurator Fiscal post-mortem examinations in a consistent manner and to a high standard. The guidelines are systematically developed statements to assist the decisions of practitioners and are based on the best available evidence at the time the document was prepared. Given that much autopsy work is single observer and 1-time only in reality, it has to be recognised that there is no reviewable standard that is mandated beyond that of the FRCPath Part 2 exam or the Certificate of Higher Autopsy Training (CHAT). Nevertheless, much of this can be reviewed against ante-mortem imaging and other data. This guideline has been developed to cover most common circumstances. However, we recognise that guidelines cannot anticipate every pathological case type and clinical scenario. Occasional variation from the practice recommended in this guideline may therefore be required to report an autopsy in a way that that maximises benefit to the pathologist, coroner/procurator fiscal and the deceased's family.

There is a general requirement from the General Medical Council (GMC) to have continuing professional development (CPD) in all practice areas, and this will naturally encompass autopsy practice. Those wishing to develop expertise/specialise in pathology are encouraged to seek appropriate educational opportunities and participate in the relevant external quality assurance (EQA) scheme.

The guidelines themselves constitute the tools for implementation and dissemination of good practice.

The following stakeholders will be consulted for this document:

- DDRC Healthcare
- British Dive Safety Group
- British Hyperbaric Association
- UK Diving Medical Committee
- British Sub Aqua Club – Jim Watson
- Coroners Society of England and Wales
- Crown Office and Procurator Fiscal Service

- Coroners Service for Northern Ireland
- The Human Tissue Authority.

The information used to develop this document was derived from medical literature. Most of the practice is based on expert consensus as robust evidence in this field is lacking given the relative rarity of these cases. All evidence included in this document has been graded using modified SIGN guidance (see Appendix B). The sections of this document that indicate compliance with each of the AGREE II standards are indicated in Appendix C.

No major organisational changes or cost implications have been identified that would hinder the implementation of the guidelines.

A formal revision cycle for all guidelines takes place on a 5-yearly cycle. The College will ask the authors of the guideline, to consider whether the guideline needs to be revised. A full consultation process will be undertaken if major revisions are required. If minor revisions or changes are required, whereby a short note of the proposed changes will be placed on the College website for 2 weeks for members’ attention. If members do not object to the changes, the short notice of change will be incorporated into the guideline, and the full revised version (incorporating the changes) will replace the existing version on the College website.

The guideline has been reviewed by the Professional Guidelines team, Death Investigation Committee, Forensic Pathology Specialty Advisory Committee and Lay Advisory Group. It will be placed on the College website for consultation with the membership from 26 February to 26 March 2026. All comments received from the membership will be addressed by the author to the satisfaction of the Clinical Lead for Autopsy Guidelines.

This guideline was developed without external funding to the writing group. The College requires the authors of guidelines to provide a list of potential conflicts of interest; these are monitored by the Professional Guidelines team and are available on request. The authors have declared no conflicts of interest.

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1 Introduction

1.1 Background

Recreational diving is a popular hobby in the United Kingdom and carries with it a significant risk of morbidity and mortality if not practiced in a safe and controlled manner.

‘Recreational diving’ in this context refers to underwater diving using conventional open circuit techniques, technical diving with gas mixtures other than air and rebreathing apparatus.

The purpose of the autopsy is to ascertain whether the death was due to or exacerbated by medical disease including diving-specific pathologies, equipment failure, marine hazards, misadventure or suicide. This list is not exhaustive; accurate determination of the cause of death is dependent on the availability of other information sources including, but not limited to, witness accounts and the results of diving equipment testing.

Drowning is the most common mechanism of death in these cases. Establishing the sequence of events prior to this requires evidence from the autopsy, post-mortem imaging (if available), dive history, witness statements, toxicology, equipment testing and any other information that may become available following death. Simply giving ‘drowning’ alone as a cause of death risks missing valuable information that may assist in identifying risk within the activity and preventing future deaths.

There are multiple potential pitfalls, including the interpretation of gas bubbles in the post-mortem setting. It is recommended that these autopsies are performed by a pathologist with a specific interest in diving-related/hyperbaric pathology.

The most value comes from a prompt and complete post-mortem examination, ideally conducted within 24 hours of death, although post-mortem computed tomography (PM-CT) scanning also provides valuable information and may be able to be conducted more rapidly than the conventional autopsies. It is recognised that most autopsies will be conducted outside this time window. The quality of information available generally diminishes as the post-mortem interval increases.

Close communication between the pathologist, coroner’s/procurator fiscal’s service and tertiary services (including hyperbaric medicine centres) may allow recreational diving autopsies to be expedited. Local news websites can be valuable for identifying potential cases to be flagged to the relevant services, as information may be available more rapidly than through traditional channels.

A diver carries their life support system and any faults in the equipment can mean the difference between life and death. Specialist examination of the diving equipment by an appropriately qualified independent technician is essential. This should be comprehensive in nature. Depending on local protocols, this may be co-ordinated by the police, Health and Safety Executive (HSE), or other organisations. It is not uncommon to find natural disease in recreational divers, particularly with an ageing cohort. Without routine equipment examination, these cases may be erroneously labelled as drowning due to an acute cardiac or other natural pathology.

See Appendix A for more information on the epidemiology of diving-related death in the United Kingdom.

1.2 Diving pathophysiology/terminology

Terminology within diving pathophysiology can be confusing and somewhat conflicting. Decompression illness (DCI) refers to injuries associated with decompression following a period of exposure to increased ambient pressure. DCI includes both decompression sickness (DCS), more commonly known as 'the bends' or 'caisson disease', and pulmonary barotrauma and cerebral artery gas embolism (CAGE).

DCS results from inadequate decompression following a period of exposure to increased pressure while breathing compressed gas and involves 'evolved' right-sided (venous) gas. At depth, inert gases, primarily nitrogen from breathing gas, are dissolved in the tissues and blood. While the diver remains at pressure this is not an issue. If the ambient pressure drops too quickly, these gases can bubble out of solution causing injury to the tissues depending on the location of bubble formation. Putative mechanisms for DCS include occlusion of blood vessels by bubbles, mechanical tissue disruption, platelet activation, endothelial dysfunction and capillary leakage.[1]

DCS is typically associated with prolonged and deep dives, although rarely can occur in shallow dives.[2] Joint pain and skin rashes are common. More serious neurological symptoms can manifest with spinal DCS. Bubbles that form in the bloodstream on the right side of the circulation are less of an issue as they tend to be filtered out by the pulmonary circulation. If a patent foramen ovale is present, this provides a right-to-left shunt which can result in gas bubbles in the arterial circulation and more serious manifestations.

Severe cardiopulmonary DCS (colloquially known as the ‘chokes’) can also be fatal if not treated rapidly.[3]

Pulmonary barotrauma and CAGE result from ‘escaped’ left-sided gas and can occur in water as shallow as around 1 metre.[4] Boyle’s law describes the relationship between pressure and volume of a gas provided temperature is kept constant. Pressure and volume are inversely proportional; if ambient pressure decreases then the volume of a gas will increase. If a breath of compressed gas is taken at depth followed by a rapid ascent with breath-holding, this can result in pulmonary over-expansion and rupture of the lungs, and escape of gas into the pleural space (pneumothorax) and arterial circulation. This escaped gas can block coronary arteries resulting in myocardial infarction, or cerebral vessels resulting in cerebral infarction (CAGE). A history of rapid uncontrolled ascent is a necessary condition in these cases; this is commonly followed by loss of consciousness soon after surfacing.

These individuals may have also received treatment in a hyperbaric chamber in the pre/peri-mortem period. Although there is no evidence derived from prospective, randomised controlled trials, early hyperbaric treatment is the accepted treatment for DCS. Treatment involves compressing to a set depth and administration of 100% oxygen (with or without air breaks). This is thought to lead to reduction in bubble volume (and, hence, the damage caused by bubbles), increased diffusion gradient from the inert gas in the bubble to the surrounding tissue, improved tissue oxygenation and a reduction in central nervous system oedema.[1] Hyperbaric treatment is also used for the management of CAGE, with the underlying principles being the same.

[Level of evidence – GPP.]

1.3 Target users and health benefits of this guideline

This guideline has been compiled to provide advice to autopsy pathologists who may be required to perform examinations on individuals who have died while, or following, engaging in recreational diving. By the nature of the circumstances, such examinations will generally be instructed by the coroner, procurator fiscal or similar legal authority. This does not include commercial diving-related fatalities which fall under the remit of the Health and Safety Executive.

Please also refer to the guideline *Autopsy for bodies recovered from water* (G157), which provides information relevant to these cases.

The recommendations will also be of value to trainees preparing for the Certificate of Higher Autopsy Training (CHAT) and the FRCPath Part 2 or the Diploma in Forensic Pathology.

2 The role of the autopsy

- To identify potentially suspicious findings and thereby diminish or exclude the risk of undetected crime or homicide.
- To document injuries present and other relevant findings to permit accurate interpretation, including by others, at a later stage if required.
- To determine the medical cause of death.
- To identify contributory factors, if it is drowning, including circumstantial/environmental factors, pre-existing disease (asthma, COPD, heart disease, hypertension, congenital heart issues including patent foramen ovale), equipment-related issues and toxicological considerations.
- To assist with identification, particularly in cases of prolonged immersion with decomposition or mutilation.

3 Imaging

Imaging-based post-mortem examination should never be undertaken without an expert external examination of the body having first been performed by an appropriately trained and experienced individual.

Although recreational diving deaths should have a full invasive autopsy, imaging techniques are a useful adjunct if available. PM-CT scanning is the most useful modality for detection of gas bubbles, pneumothorax and mediastinal gas within 24 hours of death. Chest X-ray can also be helpful for the detection of pneumothorax where PM-CT is unavailable, but it is less sensitive for smaller volumes of gas.[5]

PM-CT scans should be reported by a radiologist (or pathologist) with training and experience in post mortem imaging to minimise over-interpretation of artefactual findings including post-mortem off gassing and decomposition-related phenomena.[6] See section 4.5 ‘Gas bubbles’ for more information.

For further information on PM-CT, please refer to the joint RCPath and Royal College of Radiologists *Guidelines for post-mortem cross-sectional imaging in adults for non-forensic deaths*.

[Level of evidence – D.]

4 Pathology encountered at autopsy

There is significant overlap between the investigation of diving deaths and bodies recovered from water, and the information provided in the guideline *Autopsy for bodies recovered from water* (G157) will not be replicated here where possible.

4.1 Findings suggestive of drowning

As described in the *Autopsy for bodies recovered from water* (G157) guideline, there are no specific findings of drowning. For further detail see the specific guideline.

Petrous and mastoid temporal bone haemorrhage may be seen but this is not specific for drowning, although it is supportive in the context of other findings. Putative mechanisms for this include barotrauma or negative pressure from submersion with an intact tympanic membrane.[7–9]

The foam cone or 'champignon de mousse' describes abundant froth around the nose and mouth[10]. This is commonly associated with drowning victims but the finding is non-specific (caused by the mixture of air, fluid, mucus and surfactant) and can be seen in any setting where there is acute pulmonary oedema. The foam is easily lost following resuscitation and potentially during body handling, so the presence of the finding should be documented as early as possible. This is also relevant in cases of suspected immersion pulmonary oedema (sudden onset of pulmonary oedema associated with immersion in water) where coughing of pink frothy sputum is described.[11]

4.2 Injuries

Refer to the *Autopsy for bodies recovered from water* (G157) guideline.

Injuries found on the body may be pre- or post-mortem. Post-mortem injuries are common due to bodies making contact with shore/banks/seabed. Evidence of scavenging by aquatic organisms may be identified. Identification of a vital response can help distinguish between pre- and post-mortem injury and, if in any doubt, histology can be taken. Post-mortem scavenging can be significant so care should be taken to discriminate between these changes, damage due to the environment, and inflicted injuries due to a third party, with a low threshold for forensic pathology input if any significant unexplained injuries are present.

Diving-specific injuries including suit squeeze (failure to add sufficient air to the dry suit resulting in linear bruising/lesions) and mask squeeze (facial barotrauma, from a failure to equalise the air space in the mask resulting in facial petechial haemorrhages and subconjunctival haemorrhage) should be noted. Any rashes, marks or subcutaneous emphysema should be documented and correlated with the history. These can provide supportive evidence of DCS/illness.[12]

Tympanic membrane rupture is commonly seen and can be indicative of ear barotrauma. Middle ear haemorrhage may also be seen. Bubbles in the retinal vessels have been described but ophthalmoscopy is often not informative by the time of autopsy due to rapid blurring of the cornea following death.[13]

Injuries related to resuscitation efforts are common and can include traumatic pneumothorax if chest compressions have been performed. Lung injuries should also be correlated with the position of chest drain tubes to avoid over-interpretation of artefactual perimortem findings.

[Level of evidence – GPP.]

4.3 Decomposition

Recovery of bodies from deep water can take weeks to months (or longer, in some cases). The rate of decomposition is variable and often slowed due to cold water. Other changes are frequently seen including maceration of the skin (whitening and wrinkling).

Refer to *The decomposing cadaver* (G171) guideline for further information.

4.4 Interaction between natural disease and diving

Natural disease plays a key role in many diving-related fatalities. Diving and immersion in water entails significant physiological strain and may exacerbate natural disease including cardiac and respiratory disease, increasing the chance of developing an acute event. This includes individuals with coronary artery disease and ischaemic heart disease, and the less common cardiomyopathies and channelopathies.[14]

The presence of any respiratory disease should be noted, particularly lung disease with formation of bullae (such as chronic obstructive pulmonary disease and asthma), as these are a risk factor for development of pulmonary barotrauma/pneumothorax. These also carry a potential reduction in exercise tolerance. Sarcoidosis has also been associated with pulmonary barotrauma.[15] Marfan syndrome[16] and Birt-Hogg-Dubé syndrome also carry an increased risk of pneumothorax and should be taken into consideration.

[Level of evidence – D.]

4.5 Gas bubbles

Gas bubbles are commonly encountered in bodies recovered from water. The significance of these is dependent on the timing of the autopsy and the location of the bubbles. Gas bubbles may be evolved (inert gas bubbling out of solution through decompression), escaped (air entering the bloodstream following pulmonary barotrauma or ruptured bulla) or may result from decomposition.[17]

Bubbles in the left-sided circulation are more likely to be significant in an autopsy conducted soon after death and with a history supportive of pulmonary barotrauma or CAGE (rapid ascent from depth with breath holding). Right-sided bubbles may be relevant if there is a history supportive of DCS. Bodies of divers recovered from depth that have breathed compressed gas will have accumulated inert gas within the blood and tissues, and as the ambient pressure decreases more gas will bubble out of solution, although this tends to be right-sided.

Right-sided gas bubbles can cause systemic problems in individuals with a patent foramen ovale; the presence of a patent foramen ovale must be assessed and documented at the time of autopsy.

Gas produced by bacterial fermentation as part of decomposition may also create a false positive result for bubbles, although this gas also tends to be right-sided and of smaller volume.

The key factor in the assessment of gas bubbles is performing the autopsy as quickly as possible following death (ideally within 24 hours, if possible, but this is unrealistic in most jurisdictions). PM-CT is the most sensitive method for detecting gas bubbles although many centres will not have access to this.[18] Gas bubbles may develop rapidly post mortem within the intraosseous vessels (particularly in vertebrae)[19] and portal tract,[6,20] which should not be misdiagnosed as evidence for embolism. X-ray imaging can be helpful in the detection of pneumothorax where PM-CT is unavailable.

Relevant case scenarios where gas bubble interpretation is key include divers who have experienced a rapid ascent to the surface while breath-holding, then collapsed shortly after surfacing. Finding gas bubbles in the left sided circulation in this context (ideally with evidence of pneumothorax and pulmonary haemorrhage) is indicative of CAGE. The witnessed component is essential in these cases.

DCS tends to present less acutely although significant episodes can lead to fatal complications[21] with neurological and cardiorespiratory DCS. In these cases, the gas bubbles are composed of inert gas and will be predominantly right sided.

[Level of evidence – GPP.]

5 Specific health and safety aspects

There is nothing specific beyond standard autopsy health and safety considerations.

[Level of evidence – GPP.]

6 Clinical information relevant to the autopsy

- A complete history of the events surrounding the death, including witness statements and details of the dive history in the days prior to death.
- If a diving computer was used, then a formal dive profile should be supplied (and diving buddy's profile, if available).
- The dive qualifications and experience of the deceased including the number of dives completed and whether the current dive was within their experience range.
- The type of dive (depth, duration) attempted, including any wreck penetration or attempt at recovery of objects from the dive site.
- The diving medical history of the deceased, including details of any previous incidents requiring medical intervention (including recompression/hyperbaric oxygen) or any previous episodes of unexplained pulmonary oedema (indicating possible immersion pulmonary oedema).
- The type of diving system should be ascertained (open circuit, rebreather, surface compressor) alongside the breathing gas mix(es) (air, trimix, nitrox). A description of diving equipment may be enhanced by scene photographs of the recovered body. This

is important as the equipment is usually seized by the police for testing so will not be present at the time of autopsy.

- Complete medical history with prescribed and over-the-counter medications, respiratory disease (asthma, chronic obstructive pulmonary disease), cardiac disease, drug or alcohol misuse or any other chronic disease.
- Health of the deceased prior to the dive, including any coughs or cold symptoms and ear infections.
- Post-mortem imaging if available. PM-CT scan within 24 hours of death is the most sensitive method for assessment of intravascular gas. Decomposition-related gas may develop early depending on the conditions around death; CPR can also introduce gas into vessels artefactually. Chest X-ray can be helpful but is less sensitive.

[Level of evidence – GPP.]

7 The autopsy procedure

The autopsy procedure for diving deaths is similar to a standard invasive post-mortem examination with the addition of precautions to reduce the introduction of artefactual gas, which could lead to erroneous interpretation of findings. A full autopsy including examination of the brain is essential.[22,23]

- If present, any clothes and equipment on the body should be documented and photographed, and their condition noted. This may not be possible if already removed during resuscitation or seized by police; correlation with scene photographs can be helpful in these cases.
- Full examination and documentation of the condition of the skin, including assessment for subcutaneous crepitus/emphysema, predation and any external injuries. Have a low threshold for consideration of involvement of forensic pathology services in injuries out of keeping with the history.
- Ophthalmoscopy and otoscopy: examine the eyes for retinal vascular gas bubbles and ears for tympanic membrane perforation. This can also be demonstrated on PM-CT or with middle ear dissection.
- A 'Y' incision allows access to the carotid arteries, which should be tied or clamped just above the clavicle to reduce artefactual introduction of air into the circulation.

- Ideally, the brain is removed next, following clamping of the internal carotid arteries and basilar artery. The vasculature is then assessed for gas bubbles with the caveat that opening the skull cavity may introduce air into the cerebral veins. PM-CT is preferred for the assessment of cerebral vascular gas.
- The pleural cavities should be tested for pneumothorax. Various methods have been described, including the water pocket method (creating a pocket of water between the reflected chest wall and ribs then incising intercostal muscle). A layered dissection of the intercostal muscles may also be undertaken to expose intact pleura and assess whether the lung is inflated.
- Aspiration of the chambers of the heart (left ventricle then right) should be performed with the heart in-situ to assess for circulatory gas. This can be performed using a needle and 50mL syringe or creating a water pocket within the pericardium. Testing gas composition is not of significant practical value.
- Sampling of blood, urine and vitreous humour for toxicology, including carboxyhaemoglobin concentration, should be performed routinely in all cases.
- Consider taking samples for microbiology if the history indicates a prior/prodromal illness. Possible sites of sampling include nasal, deep bronchial and middle ear swabs, and blood cultures in relevant cases. Sampling should be collected in a sterile manner. Results with mono-microbial growth are likely to be more relevant than poly-microbial growth, which may represent contamination.[24]
- Fluid may also be aspirated from the para-nasal sinuses. This is a sensitive finding in drowning cases, but it is non-specific and can be seen in other conditions including sinusitis, regurgitation and may occur passively in post-mortem submersion.

[Level of evidence – GPP.]

8 Specific organ systems to be considered

The findings described here incorporate drowning/immersion-related phenomena, hyperbaric injury and relevant pre-existing natural disease. There are no specific findings to recreational diving death, however; these require close correlation with the circumstances of death.

- Mediastinum
  - hyperbaric injury: pneumomediastinum.

- Pleural cavity
  - hyperbaric injury: pneumothorax.
- Lungs
  - hyperbaric injury: pulmonary haemorrhage, pleural haemorrhage
  - drowning/immersion-related: emphysema aquosum (over-inflation), water inhalation, aspirated material, vomit aspiration, silt/sand in airways, pulmonary oedema
  - pre-existing disease: emphysema, bullae, pleural effusion, asthma.
- Heart
  - hyperbaric injury: gas bubbles (left or right sided)
  - pre-existing disease: coronary artery disease, left ventricular fibrosis, acute myocardial infarction, left ventricular hypertrophy, cardiomyopathy, patent foramen ovale
- Stomach
  - drowning/immersion-related: fluid and debris content.
- Brain
  - hyperbaric injury: arterial gas embolism (gas bubbles in vessels, parenchymal haemorrhage).
- Pre-existing disease: epilepsy, Alzheimer's/dementia-related changes.

[Level of evidence – GPP.]

9 Organ retention

Consideration should be given to retention of the brain for expert neuropathological examination, as findings may be subtle and relevant to the cause of death. Examination of the spinal cord should also be considered if DCS is suspected. Consideration should also be given to retention of the heart for expert dissection and examination, given the variety of cardiac pathologies that may be relevant and exacerbated by recreational diving, including ischaemic heart disease, cardiomyopathies and channelopathies.

The author advocates for retention of both heart and brain (plus spinal cord in suspected DCS) to avoid missing subtle pathologies that may be materially significant in formulation of the cause of death. Consent from the coroner or procurator fiscal should be undertaken.

[Level of evidence – GPP.]

10 Histological examination

The College supports and encourages histological examination of autopsy material. If applicable, histological samples should be guided by specific details of the case with reference to other College autopsy guidelines. A refusal by the coroner or procurator fiscal to sanction the taking of histology should be documented.

Routine examination of the lungs, liver, kidney and heart may yield findings relevant to the cause of death, for example hypertensive vascular changes in the kidney indicative of systemic hypertension or emphysema in the lungs.

There are no specific histological findings of drowning in the context of recreational diving. Pulmonary haemorrhage, alveolar overdistension, intraparenchymal pseudocysts and pleural cysts may be seen in cases of pulmonary barotrauma, although most of the description of these findings is outside the context of divers.[25,26] Pulmonary trauma may also result from CPR/resuscitation.

Post-mortem histology may be further complicated by autolysis, putrefaction and resuscitation, for example contraction bands in cardiac myocytes due to adrenaline administration or bone marrow embolus due to rib fracture following chest compressions.

The *Autopsy for bodies recovered from water* (G157) guideline provides a list of possible histological findings seen in drowning.

[Level of evidence – D.]

11 Toxicology

Toxicology samples should be taken in all cases of death associated with recreational diving, except for cases of severe decomposition or refusal by the coroner or procurator fiscal.

Specimens recommended for best practice include the following (although advice should be sought from the local toxicology provider):

- peripheral blood (femoral blood), unpreserved (plain) and preserved in fluoride
- urine, preserved and unpreserved (plain) in fluoride
- vitreous humour.

A liver sample may be taken in the event blood is unavailable, and rarely psoas muscle, although these should be confirmed with the local toxicology provider and may be of limited utility as published reference ranges are based on peripheral blood samples.

An alcohol and drug screen should be requested as standard. History including any prescribed, over-the-counter, or illicit drugs should be provided to the toxicologist.

Carboxyhaemoglobin analysis (carbon monoxide) is essential. Carbon monoxide contamination of breathing gas mixtures may occur due to faulty compressors or poor ventilation.[27] Low concentrations of carbon monoxide at the surface may become fatal at depth due to the effect of increasing partial pressure (of a gas in a mixture) with increased ambient pressure.

Sample type for carboxyhaemoglobin testing should be confirmed with the local toxicology provider.

[Level of evidence – D.]

12 Other relevant samples

- Samples for genetic analysis, e.g. muscle, spleen.
- Microbiological samples, e.g. bronchial swabs, nasal swabs, middle ear swabs, blood cultures, may be relevant if there was a history of prodromal illness.
- Analysis of liver, lungs, bone marrow and kidneys for diatoms is of limited utility and not recommended in routine practice. See *Autopsy for bodies recovered from water* (G157) guideline for more detail.

[Level of evidence – GPP.]

13 Equipment examination

As mentioned in the opening paragraphs, comprehensive equipment examination is essential in cases of recreational diving death. This should be undertaken by a suitably qualified independent technician/company and carried out promptly to preserve evidence and prevent degradation. A refusal by the coroner or procurator fiscal to sanction the testing of equipment should be documented.

Testing varies depending on the type of equipment used and includes, but is not limited to, visual inspection of equipment, checking gas cylinder gauges and contents (including contaminants), buoyancy and suit systems, breathing circuit integrity, CO_2 scrubber capacity, and oxygen sensor function. It is not unusual to find poorly maintained and out of service equipment still in use.

Information from the dive computer, including the profiles of recent dives, should be provided to the pathologist as soon as possible after death. This may be facilitated as part of equipment testing, but local diving shops may also be able to download the relevant information. There are often significant delays in accessing the data due to police operational pressures.

The gas mixture used by the diver may be relevant in establishing the cause of death. The gas mixtures commonly encountered are air and Enriched Air Nitrox, and less commonly mixed gas such as trimix (oxygen, helium, nitrogen) in technical diving. Nitrox refers to any mixture of nitrogen and oxygen with additional oxygen, which allows divers to extend the amount of time spent at depth without increasing the theoretical risk of DCS. Owing to the increased fraction (proportion) of oxygen and, hence, increased partial pressure, diving with nitrox carries an increased risk of oxygen toxicity seizures at depth, which usually results in drowning.[28] Correlation with the dive profile is essential in these cases as the seizure may have been unwitnessed.

Gas purity testing may be a key factor in establishing the cause of death where there has been contamination by a noxious component, for example carbon monoxide (as discussed in section 11 Toxicology).

Deaths occur in rebreather divers at about 10 times the rate of those diving with open-circuit equipment.[29] There is a higher risk of mechanical and computer failure due to the complexity of the equipment, although this risk can be offset by carrying adequate redundant bailout cylinders. Examples of death occurring in this setting include from human error (failure to turn on gas cylinders supplying the breathing circuit) and computer failure (due to water ingress from damaged casing).

[Level of evidence – GPP.]

14 Clinicopathological summary

14.1 Factual summary

- Summarise all relevant background, autopsy and additional findings (including diving equipment examination).

14.2 Interpretation of findings

- If possible, establish the sequence of events that led to death.
- Decide whether death resulted from drowning or a non-drowning cause.
- If drowning has occurred, are there any significant contributing factors including evidence of natural disease, intoxication or equipment malfunction?
- If intravascular gas is present at autopsy, do the post-mortem appearances fit with the clinical scenario, e.g. for a diagnosis of pulmonary barotrauma and arterial gas embolism there should be a rapid ascent.
- In cases with negative pathological findings and insufficient circumstantial evidence, an 'unascertained' opinion may be appropriate.

[Level of evidence – GPP.]

15 Examples of cause of death opinions/statements

Ia Drowning
Ib Ischaemic heart disease

or

Ia CAGE
Ib Rapid uncontrolled ascent from depth

or

Ia Cardiorespiratory DCS
Ib Missed decompression stops

or

Ia Drowning
Ib Insufficient diluent gas for buoyancy
Ic User error with a rebreather diving system

or

Ia Drowning

Ib Carbon monoxide toxicity

Ic Breathing gas contamination from faulty air compressor

or

Ia Drowning

Ib Hyperoxic seizure

or

Ia Drowning

Ib Immersion pulmonary oedema

or

Ia Acute myocardial infarction

16 Criteria for audit

The following standards are suggested criteria that might be used in periodic reviews to ensure a post-mortem report for coronial autopsies conducted at an institution comply with the national recommendations provided by the 2006 NCEPOD study:

- supporting documentations:
  - standards: 95% of supporting documentation was available at the time of the autopsy
  - standards: 95% of autopsy reports documented are satisfactory, good or excellent.
- reporting internal examination:
  - standards: 100% of the autopsy report must explain the description of internal appearance
  - standards: 100% of autopsy reports documented are satisfactory, good or excellent.
- reporting external examination:
  - standards: 100% of the autopsy report must explain the description of external appearance
  - standards:100% of autopsy reports documented are satisfactory, good or excellent.

A template for coronial autopsy audit can be found on The Royal College of Pathologists' website (www.rcpath.org/profession/quality-improvement/conducting-a-clinical-audit/clinical-audit-templates.html).

17 References

1. Moon RE. Hyperbaric oxygen treatment for decompression sickness. *Undersea Hyperb Med* 2014;41:151–157.

2. Reissman P, Shupak A, Nachum Z, Melamed Y. Inner ear decompression sickness following a shallow scuba dive. *Aviat Space Environ Med* 1990;61:563–566.

3. Mendez N, Huchim-Lara O, Rivera-Canul N, Chin W, Tec J, Cordero-Romero S. Fatal cardiopulmonary decompression sickness in an untrained fisherman diver in Yucatan, Mexico: a clinical case report. *Undersea Hyperb Med* 2017;44:279–281.

4. Lindblom U, Tosterud C. Pulmonary barotrauma with cerebral arterial gas embolism from a depth of 0.75-1.2 metres of fresh water or less: A case report. *Diving Hyperb Med* 2021;51:224–226.

5. Giaconi C, Manetti AC, Turco S, Coppola M, Forni D, Marra D *et al.* Post-mortem computer tomography in ten cases of death while diving: a retrospective evaluation. *Radiol Med* 2022;127:318–329.

6. Laurent PE, Coulange M, Bartoli C, Boussuges A, Rostain JC, Luciano M *et al.* Appearance of gas collections after scuba diving death: a computed tomography study in a porcine model. *Int J Legal Med* 2013;127:177–184.

7. Kaga K, Nitou T, Suzuki JI, Tsuzuku T. Temporal bone pathology findings due to drowning. *Rev Laryngol Otol Rhinol (Bord)* 1999;120:27–29.

8. Kumar A, Kamalakannan G. Histopathological study of changes in temporal bone in cases of drowning. *J Indian Acad Forensic Med* 2020;42:103–108.

9. Dhakar R, Baraw R, Tomar M, Singh S. Unveiling the significance and incidence of middle ear hemorrhage in drowning cases: An insight from autopsy observations conducted in a tertiary centre of Central India. *Int J Pharma Clin Res* 2024;16:924–927.

10. Papadodima SA, Athanaselis SA, Skliros E, Spiliopoulou CA. Forensic investigation of submersion deaths. *Int J Clin Pract* 2010;64:75–83.

11. Banham N, Smart D, Wilmshurst P, Mitchell SJ, Turner MS, Bryson P. Joint position statement on immersion pulmonary oedema and diving from the South Pacific

Underwater Medicine Society (SPUMS) and the United Kingdom Diving Medical Committee (UKDMC) 2024. *Diving Hyperb Med* 2024;54:344–349.

12. Divers Alert Network. *Identifying Skin Bends.* Accessed 8 May 2025. Available at: https://dan.org/alert-diver/article/identifying-skin-bends
13. Amberg R, Pollak S. Postmortem endoscopy of the ocular fundus. A valuable tool in forensic postmortem practice. *Forensic Sci Int* 2001;124:157–162.
14. Tso JV, Powers JM, Kim JH. Cardiovascular considerations for scuba divers. *Heart* 2022;108:1084–1089.
15. British Thoracic Society Fitness to Dive Group, Subgroup of the British Thoracic Society Standards of Care Committee. British Thoracic Society guidelines on respiratory aspects of fitness for diving. *Thorax* 2003;58:3–13.
16. Viveiro C, Rocha P, Carvalho C, Zarcos MM. Spontaneous pneumothorax as manifestation of Marfan syndrome. *BMJ Case Rep* 2013;2013.
17. Edmonds C, Caruso J. Recent modifications to the investigation of diving related deaths. *Forensic Sci Med Pathol* 2014;10:83–90.
18. Laurent PE, Coulange M, Mancini J, Bartoli C, Desfeux J, Piercecchi-Marti MD *et al*. Postmortem CT appearance of gas collections in fatal diving accidents. *AJR Am J Roentgenol* 2014;203:468–475.
19. Sapienza D, Cicero G, Asmundo A, Mondello C, Spagnolo EV, Bottari A *et al*. Intraosseous gas distribution as a marker of postmortem interval. *Forensic Imaging* 2020;23:200414.
20. Asamura H, Ito M, Takayanagi K, Kobayashi K, Ota M, Fukushima H. Hepatic portal venous gas on postmortem CT scan. *Leg Med (Tokyo)* 2005;7:326–330.
21. Ninomiya K, Ihama Y, Yamagata K, Fukasawa M, Nagai T, Fuke C *et al*. An autopsy case of decompression sickness: Hemorrhages in the fat tissue and fat embolism. *Rom J Leg Med*;10.4323/rjlm.2013.23.
22. Divers Alert Network. *Medical Examination of Diving Fatalities.* Accessed 8 May 2025. Available at: https://dan.org/health-medicine/health-resource/health-safety-guidelines/medical-examination-of-diving-fatalities/

23. The Royal College of Pathologists of Australasia. *Fact File: Autopsy & the Investigation of Scuba Diving Fatalities.* Accessed 8 May 2025. Available at: www.rcpa.edu.au/getattachment/91b66d2c-4682-4e09-ad61-aed2c1008567/Autopsy.aspx

24. Riedel S. The value of postmortem microbiology cultures. *J Clin Microbiol* 2014;52:1028–1033.

25. Rouby JJ, Lherm T, Martin de Lassale E, Poete P, Bodin L, Finet JF *et al.* Histologic aspects of pulmonary barotrauma in critically ill patients with acute respiratory failure. *Intensive Care Med* 1993;19:383–389.

26. Casadesus JM, Nieto-Moragas J, Serrando MT, Boadas-Vaello P, Carrera A, Aguirre F *et al.* Pulmonary barotrauma in SCUBA diving-related fatalities: a histological and histomorphometric analysis. *Forensic Sci Med Pathol* 2023;19:541–550.

27. Allen H. Carbon monoxide poisoning in a diver. *Arch Emerg Med* 1992;9:65–66.

28. Lawrence CH. A diving fatality due to oxygen toxicity during a "technical" dive. *Med J Aust* 1996;165:262–263.

29. Fock AW. Analysis of recreational closed-circuit rebreather deaths 1998-2010. *Diving Hyperb Med* 2013;43:78–85.

30. British Sub-Aqua Club. *BSAC Diving Incident Report 2023.* Accessed 8 May 2025. Available at: www.bsac.com/document/bsac-diving-incidents-report-2023

31. British Sub-Aqua Club. *BSAC Diving Incident Report 2022.* Accessed 8 May 2025. Available at: www.bsac.com/document/bsac-diving-incidents-report-2022

Appendix A Epidemiological information

The British Sub-Aqua Club (BSAC) compiles an Annual Diving Incident Report that details UK diving incidents occurring to divers from all agencies and backgrounds.

Deaths in the sport are rare. The BSAC incident reports from 2023 recorded 9 fatalities, and the 2022 report recorded 6 fatalities.[30,31] Themes that emerge from these reports include advancing age of the diving population (mean age of people who died diving in 2023 was 58 years), equipment faults, unsafe practices and pre-existing medical conditions. The number of fatalities has remained relatively stable over the last decade. The fatalities also spanned from student divers through to those with extensive experience. Diving deaths tend to peak in the summer months, given the relatively cold temperatures of water in the United Kingdom.

Appendix B Summary table – explanation of grades of evidence

(modified from Palmer K *et al. BMJ* 2008; 337:1832)

Grade (level) of evidence	Nature of evidence
Grade A	At least 1 high-quality meta-analysis, systematic review of randomised controlled trials or a randomised controlled trial with a very low risk of bias and directly attributable to the target population or A body of evidence demonstrating consistency of results and comprising mainly well-conducted meta-analyses, systematic reviews of randomised controlled trials or randomised controlled trials with a low risk of bias, directly applicable to the target cancer type.
Grade B	A body of evidence demonstrating consistency of results and comprising mainly high-quality systematic reviews of case-control or cohort studies and high-quality case-control or cohort studies with a very low risk of confounding or bias and a high probability that the relation is causal and which are directly applicable to the target population or Extrapolation evidence from studies described in A.
Grade C	A body of evidence demonstrating consistency of results and including well-conducted case-control or cohort studies and high-quality case-control or cohort studies with a low risk of confounding or bias and a moderate probability that the relation is causal and which are directly applicable to the target population or Extrapolation evidence from studies described in B.
Grade D	Non-analytic studies such as case reports, case series or expert opinion or Extrapolation evidence from studies described in C.
Good practice point (GPP)	Recommended best practice based on the clinical experience of the authors of the writing group.

Appendix C AGREE II guideline monitoring sheet

The autopsy guidelines of The Royal College of Pathologists comply with the AGREE II standards for good quality clinical guidelines. The sections of this autopsy guideline that indicate compliance with each of the AGREE II standards are indicated in the table.

AGREE standard	Section of guideline
Scope and purpose	
1 The overall objective(s) of the guideline is (are) specifically described	Introduction
2 The health question(s) covered by the guideline is (are) specifically described	Introduction
3 The population (patients, public, etc.) to whom the guideline is meant to apply is specifically described	Foreword
Stakeholder involvement	
4 The guideline development group includes individuals from all the relevant professional groups	Foreword
5 The views and preferences of the target population (patients, public, etc.) have been sought	Foreword
6 The target users of the guideline are clearly defined	Introduction
Rigour of development	
7 Systematic methods were used to search for evidence	Foreword
8 The criteria for selecting the evidence are clearly described	Foreword
9 The strengths and limitations of the body of evidence are clearly described	Foreword
10 The methods for formulating the recommendations are clearly described	Foreword
11 The health benefits, side effects and risks have been considered in formulating the recommendations	Foreword and Introduction
12 There is an explicit link between the recommendations and the supporting evidence	2–15
13 The guideline has been externally reviewed by experts prior to its publication	Foreword
14 A procedure for updating the guideline is provided	Foreword
Clarity of presentation	
15 The recommendations are specific and unambiguous	2–15

16 The different options for management of the condition or health issue are clearly presented	2–15
17 Key recommendations are easily identifiable	2–15
Applicability	
18 The guideline describes facilitators and barriers to its application	Foreword
19 The guideline provides advice and/or tools on how the recommendations can be put into practice	2–15
20 The potential resource implications of applying the recommendations have been considered	Foreword
21 The guideline presents monitoring and/or auditing criteria	16
Editorial independence	
22 The views of the funding body have not influenced the content of the guideline	Foreword
23 Competing interest of guideline development group members have been recorded and addressed	Foreword