The Royal College of Pathologists
Pathology: the science behind the cure

Guidelines on autopsy practice

Autopsy for bodies recovered from water

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	In accordance with the College's pre-publications policy, this document was on the Royal College of Pathologists' website for consultation with the membership from 24 July to 21 August 2024. Responses and authors' comments are available to view at https://www.rcpath.org/profession/publications/documents-in-development.html. **Dr Brian Rous** **Clinical Lead for Guideline Review**

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Foreword

The autopsy guidelines published by the Royal College of Pathologists (RCPath) are guidelines which enable pathologists to deal with non-forensic consent and coroner's/procurator fiscal's 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 one-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 stakeholder were consulted for this document:

- The Human Tissue Authority and its Histopathology Working Group, which includes representatives from the Association of Anatomical Pathology Technologists and Coroner's Society of England and Wales.

The information used to develop this document was derived from current medical literature and the previous version of this guideline. Much of the content of the document represents custom and practice and is based on the substantial clinical experience of the authors. All evidence included in this guideline has been graded using modified SIGN guidance (see Appendix D.) The sections of this autopsy guideline that indicate compliance with each of the AGREE II standards are indicated in Appendix E.

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 changes 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, the Death Investigation Committee, the Forensic Pathology Specialty Advisory Committee and the Lay Advisory Group. It was placed on the College website for consultation with the membership from 24 July to 21 August 2024. All comments received from the membership were 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.

1 Introduction

It is important to appreciate that, while drowning is a common cause of death in bodies being recovered from water or other liquid, it is a diagnosis based on the exclusion of all other possibilities. This is due, in part, to the relative lack of specific signs in the context of drowning. The circumstantial information must, therefore, be considered and a thorough post-mortem examination undertaken to exclude underlying medical or traumatic causes of death.[1]

Bodies may be recovered from water in a range of different circumstances, each providing their own challenges. Bodies from the domestic environment, including ponds, swimming pools, baths or buckets, will usually be relatively fresh, as will bodies recovered quickly from open water. By contrast, some bodies recovered from rivers, lakes or the sea will have been in the water for prolonged periods and may demonstrate variable degrees of decomposition; post-mortem scavenging and mutilation may occur relatively quickly after entry of the body into water, depending on the circumstances.

The recovery of a body from water will raise the possibility of drowning, but other possibilities exist. The victim may have:

- died of a natural cause before entering the water
- died of an unnatural cause before entering the water
- died of a traumatic or natural cause in the water
- died of consequences of immersion other than drowning (e.g. hypothermia, ‘dry drowning’ – please refer to section 3.2).

It is essential to consider each of these possibilities, to be confident in differentiating between true ante-mortem injuries and post-mortem artefacts, and to bear in mind that other non-drowning causes of death (e.g. trauma, effects of intoxication, cardiovascular disease, hypothermia) either before or after the body entered the water represent a proportion of autopsies performed on bodies recovered from water.[2,3] The interaction between these can be challenging. Victims who have descended into the water from a height may sustain injury in the fall, raising the possibility of death from impact or unconsciousness contributing to inability to self-rescue/survive.

The pathophysiology of drowning can be broadly split into 2 events: submersion and immersion. Submersion is defined as when the upper airway is below liquid and the physiological defences of laryngospasm, ciliated epithelium, cough/gag reflex and surfactant are overcome. Immersion, defined as the upper airway being above the liquid, describes the cardiovascular response to skin cooling (cold shock) and then deep tissue cooling (hypothermia) as a prelude to eventual submersion.[4]

Further information on the epidemiology of drowning is available in Appendix A.

1.1 Target users of this guideline

The target audience for this guideline is pathologists and trainees conducting routine autopsy work on behalf of the Coroner or Procurator Fiscal. It is not aimed at the forensic pathologist. A low threshold of suspicion of foul play and the consequent early involvement of a forensic pathologist is essential. Deaths specifically related to underwater diving are not covered by this guideline and require specialist input at post mortem. A guideline pertaining to deaths related to underwater diving is currently being drafted by the College and will be available for review in due course.

2 The role of autopsy

- To identify potentially suspicious issues 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.
- To identify non-drowning causes of death in bodies retrieved from water.
- To assist with identification, particularly in cases of prolonged immersion with decomposition or mutilation.

3 Pathology encountered at autopsy

The pathological findings encountered can be subdivided into those encountered owing to drowning, those identified owing to a body being immersed in water (independent of the underlying cause of death) and other non-immersion, non-drowning findings.

3.1 Findings due to drowning

These signs are non-specific and are suggestive of drowning. None of these findings are considered pathognomonic.[2,5]

- Froth or plume around the nostrils and mouth – so called Champignon de mousse – is suggestive of submersion. This can, however, fade with time or be eliminated due to resuscitation. The wider mortuary team should document such findings upon receipt of the body. It is seen in other clinical scenarios, including opiate overdose, seizures or congestive cardiac failure.
- Extrinsic material in the upper airway, such as sand, silt and weeds.
- Lung weight over 1000 g is supportive of submersion; however, resuscitation is a potential confounding variable. Normal weight does not exclude drowning.
- Lung distension, sometimes to the extent where the lungs overlap. This feature is also seen in deaths secondary to asthma.

- Paltauf spots are bluish-red patches on the anterior surface of the lung secondary to alveolar haemorrhages secondary to high pressures.
- Emphysema aquosum: alternating segmental over-distention and collapse, with a characteristic ‘doughy’ nature to palpation.

Other signs described, but of limited value, include:

- water, frequently found in the stomach but considered a non-specific feature.
- pleural effusion: more pleural fluid tends to be produced in saltwater versus freshwater drowning.[6]
- middle ear and mastoid congestion and haemorrhage due to asphyxia.[7]
- haemolytic staining of the left side of the endocardium, endothelium, aorta and carotids – particularly related to freshwater drowning and presumed hypo-osmolar haemolysis. This will also occur with decomposition.[8]

3.2 Deaths due to immersion in water

- ‘Dry drowning’ refers to the cardiovascular response due to immersion, particularly in cold liquid. Facial immersion leads to a parasympathetic response and a bradycardia, whereas immersion of the skin produces a sympathetic response and a tachycardia. This autonomic conflict increases the risk of arrhythmia and cardiac arrest. This risk is greatly increased in individuals with pre-disposing factors, such as channelopathies, atherosclerosis, myocardial hypertrophy and ischaemic heart disease.[9,10]
- Hypothermia – it should be recognised that hypothermia may be a significant factor in causing death in cold water.
- Hyperthermia – it should be recognised that hyperthermia may be a significant factor in causing death, for example after prolonged immersion in a hot tub. It is prudent to take toxicology in such cases as alcohol consumption may be a contributing factor.

3.3 Possible findings in a body recovered from water (not specifically associated with drowning)

The findings below are influenced by a multitude of factors that include duration of immersion, water temperature and whether water was saltwater or freshwater, still or flowing, and clean or polluted. Immersion modifies most changes observed after death.[11]

- Lividity – this should match the known position of the body.

- Variable decomposition – cold water will tend to refrigerate the body, retarding decomposition, but allowing an increased amount of time for post-mortem predation and damage from the environment, including shipping. In extreme circumstances, only skeletal fragments may be recovered.
- Maceration of the skin secondary to immersion of that part of the body in liquid – first identified as whitening, soddening, thickening and wrinkling. With time, the epidermis loses integrity and is lost. (The term ‘washerwoman change’ is not deemed to be appropriate terminology in current practice).
- Haemorrhages in the soft tissues of the neck – these are occasionally found in victims recovered from water but, when encountered, a forensic pathologist should be consulted as a priority, given the potential significance of the finding in relation to homicidal injury to the neck.[12]

  [Level of evidence – D.]

3.4 Injuries and other diseases

Immersion in water commonly leads to post-mortem injuries, including those due to contact with the bed/floor/shoreline, contact with natural or manmade objects, or predation/scavenging by aquatic organisms.[11] Such injuries need to be distinguished from those acquired in the ante-mortem period. Pre-existing natural disease should be recorded. If there is any question over the identity of the victim/subject, any identifying features should be recorded in detail (e.g. tattoos).

3.5 Interaction of natural disease and immersion in water

Physical exertion or struggle while in the water can unmask/expose morbidity or elicit previously undiagnosed conditions. This is particularly true of cardiac pathology, ranging from the common complications of coronary artery disease to the less common but important genetic causes of sudden cardiac death, including cardiomyopathies and channelopathies. Among others, catecholaminergic polymorphous ventricular tachycardia, a channelopathy, may be triggered by entry into water, especially cold water.[13]

Natural disease may have an effect on survival and always needs to be considered. It may become particularly relevant to an inquest when other witness, circumstantial and medical evidence becomes known to the pathologist. However, it may be impossible to determine their contribution to death.

[Level of evidence – GPP.]

4 Specific health and safety aspects

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

[Level of evidence – GPP.]

5 Pre autopsy preparation

These pieces of information are essential prior to commencing the autopsy:

- a complete and appropriate history, which is imperative to the investigation and a prerequisite to undertaking the post mortem. The context of a death in water will inform the overall autopsy investigations, particularly whether the case should be referred for a forensic autopsy.
- police documentation, to include relevant details regarding the location of the body, its situation relative to tidal water, currents, etc. and the disposition of the clothing, and to confirm that, in their opinion, the death appears non-suspicious. Even with such documentation, the pathologist remains responsible for determining the presence or absence of suspicious findings.

The following are desirable, but are not essential prior to the autopsy:

- previous medical history, especially history of epilepsy[14] and cardiovascular disease
- psychiatric history, including suicidal ideation
- drug and alcohol history
- family history, especially of sudden cardiac death.

[Level of evidence – D.]

6 The autopsy procedure

- Full documentation of clothes on the body in situ and their general condition.
- Once the clothes are removed, a full documentation of the condition of the skin, including evidence of predation and any external injuries with a low threshold for consideration of involvement of forensic pathology services.

- A full invasive autopsy is essential. Sampling of blood and urine for toxicology should be done early in the examination.

[Level of evidence – GPP.]

6.1 Specific significant organ systems

- Lungs – emphysema aquosum, pulmonary oedema, pleural haemorrhage, frothy admixture of bronchial secretions with aspirated liquid and foreign material in airways; evidence of pre-existing pulmonary disease and any pleural effusions.
- Heart – evidence of underlying cardiac pathology, e.g. coronary artery disease, cardiomyopathy.
- Stomach – fluid and debris content.
- Brain – consideration of neuropathology, e.g. underlying epilepsy.

[Level of evidence – D.]

7 Organ retention

No organ retention is required, although it may be desirable in some circumstances, e.g. brain or heart. Consent from the Coroner or Procurator Fiscal should be undertaken.

8 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.

The interpretation of histological findings must be correlated with the history and other post-mortem findings, as there is no specific histological feature for drowning. The histology could also be confounded by autolysis, putrefaction, cardiopulmonary resuscitation or other interventions. In addition, submersion in a water depth of 4 m or more may produce similar pulmonary findings.[15]

Possible findings seen in drowning include:

- lungs – intra-alveolar oedema, aspirated extrinsic materials, thinned or ruptured alveolar septae with dilated alveolar spaces and compressed septal capillaries due to lung overexpansion (emphysema aquosum). Ruptured elastic fibres may be observed on Elastin van Gieson staining. These changes are, however, not always detected[15,16]
- stomach – necrosis and hemorrhage in gastric mucosa with neutrophilic infiltration, corresponding to Wischnewsky spots secondary to hypothermia in cold water drowning.

[Level of evidence – D.]

9 Toxicology

Toxicology samples should be taken from all cases of bodies recovered from water. The only exception is in cases of severe decomposition or refusal by the Coroner or Procurator Fiscal.

Specimens recommended for best practice include the following, although advice should always be sought from the local toxicology provider:[17]

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

An alcohol and drug screen should be requested as standard; information regarding specified drugs as indicated from the history should be provided to the toxicologist.

A note of caution should be made as to the interpretation of toxicology in drowning cases, as haemodilution in freshwater drowning, post-mortem redistribution and other factors may affect results. There should be a low threshold for discussing cases with a relevant expert.

[Level of evidence – D.]

10 Other samples to consider

- Consider measuring carboxyhaemoglobin or methaemoglobin concentration if indicated by the circumstances, e.g. presence of a faulty water heater producing carbon monoxide, or in some confined spaces.

- Samples for genetic analyses, e.g. muscle, spleen.
- Analysis of liver, lungs, bone marrow and kidneys for diatoms is of limited utility.
- Samples of historical interest are presented in Appendix B. Samples that might be of future value in Appendix C.

[Level of evidence – D.]

11 Imaging

Post-mortem imaging, in particular post-mortem computed tomography (PMCT), is increasingly used in death investigation in the United Kingdom. This is supported by the Chief Coroner.[18] The use of PMCT is fully covered in guidelines for post-mortem cross-sectional imaging in adults for non-forensic deaths.[19]

The aim of using PMCT on bodies recovered from water is to search for traumatic findings and exclude other causes of death. As with invasive examination, PMCT cannot conclusively distinguish drowning from post-mortem submersion. PMCT should be interpreted in the context of the circumstances around death.

PMCT cannot reliably be used to assess superficial skin and soft tissue abnormalities. A low threshold of suspicion should be adopted to perform full dissection of soft tissues, particularly those of the neck in bodies being recovered from water.

PMCT can demonstrate the severity of coronary artery and valvular calcifications but is poor at identifying the presence and degree of cardiac hypertrophy. If a body is recovered from water and an underlying cardiac cause is suspected, in particular cardiomyopathy or channelopathy, autopsy of the heart and additional (genetic) testing should be considered.[10,13]

As with findings in drowning cases at invasive post mortem, imaging findings described are non-specific. Fluid in paranasal spaces and major airways, for example, is frequently seen in non-drowning cases. The lungs may show relative overinflation with a variable pattern of ground-glass opacities, sometimes with centrilobular nodules or larger consolidations.[20]

It is considered best practice to assess the need for invasive examination on a case-by-case basis based on the available scene information, circumstances surrounding death

and medical history. PMCT is a valuable adjunct in the process of death investigation but should not considered to be a replacement of an invasive procedure.

[Level of evidence – C and D.]

12 Clinicopathological summary

12.1 Factual summary

- Summarise all relevant background, autopsy and additional findings.

12.2 Interpretation of findings

- Decide whether death was non-drowning related or if there is sufficient supporting evidence that drowning has occurred.
- If drowning has occurred, are there any significant contributory factors that have been identified?
- In cases with negative pathological findings (without evidence of water aspiration), certification as ‘unascertained’ may be appropriate. However, depending on the history and supporting evidence provided, certification as ‘immersion in water’ may still be justified on the balance of probability. This is in acknowledgment of the well-documented lack of physical and laboratory findings available for definitive confirmation of drowning as the cause of death.

[Level of evidence – GPP.]

13 Examples of causes of death statements

1a. Drowning

or

1a. Drowning

1b. Ischaemic heart disease

or

1a. Immersion in water

In the first example, ‘1a. Drowning’ indicates when circumstances around death and physical features revealed at post mortem are in keeping with drowning in the absence of underlying pathology. In the second example, features and circumstances support ‘1a. Drowning’, but important potentially causative pathology is also revealed at post-mortem examination, such as in the example: ‘1b. Ischaemic heart disease’. The final example, ‘1a. Immersion in water’ is reserved for an essentially normal post-mortem examination but there is compelling circumstantial evidence of water immersion as being the cause of death.

14 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 documentation:
  - 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.

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Appendix A Epidemiological information

The National Water Safety Forum (NWSF) report from 2022 provides an accurate picture of water-related deaths in the UK.[21] There was a total of 226 water-related deaths from accidents or natural causes across the UK in 2022. Similar to the 2014 report, more than half of these deaths were in inland waters, such as canals, rivers and lakes, while fatalities at sea, on the beach or at the shoreline accounted for nearly a third. An additional 11 deaths occurred in harbours, docks, marinas or ports. 7 deaths occurred in the bath and 2 in swimming pools. 8 deaths happened in streams, ditches or burns.

The NWSF's Water Incident Database (WAID) is a valuable resource for understanding the related activities, age and location of drowning or water-related deaths. It reveals that, in 2022, the demographic group with the highest number of fatalities was males aged 20–29. Meanwhile, 0–19-year-olds accounted for 16% of deaths. More than 82% of deaths occurred in males. In the youngest age bracket of 10 years old and under, 11 children drowned. The peak summer months of July and August witnessed the most deaths, with 85 during this period.

The leading activities were walking or running, swimming and motorboating. 58% of deaths resulted from recreational activities.[22]

The presence of drugs or alcohol was recorded in 58 accidental fatality reports.[22]

Appendix B Samples of historical interest

1. Diatom testing of major organs (e.g. kidney, liver and brain) may be undertaken, although the validity of the diatom test for the diagnosis of drowning remains controversial. The finding of diatoms in lungs and other organs from bodies of non-drowned human beings and the existence of false negatives makes interpretation in the drowned individual precarious, with studies to date yielding conflicting results.[2,8,19] More recent approaches to improve diatom testing include different chemical digestion reagents, microwave digestion-vacuum filtration-automated scanning electron microscopy (MD-VF-Auto SEM), polymerase chain reaction (PCR) and diatom detection using artificial intelligence.[23] Based on the MD-VF-Auto SEM method, the ratio of diatom numbers in the lung tissues to the drowning medium (L/D ratio) was proposed to be higher in drowning than that in post-mortem immersion.[24] The technology and difficulty in obtaining a valid drowning medium will, however, preclude its use in a routine autopsy.
2. Difference in blood chloride content/specific gravity in the left and right ventricles is considered to be of no practical utility for the diagnosis of drowning.
3. A difference in blood strontium or other elemental concentration between the left and right ventricle of >75 mg Sr/l may support a diagnosis of drowning in seawater but is not diagnostic.

Appendix C Samples of potential future value

The detection of bacterioplankton using PCR probes has been described as a potential supportive test for the diagnosis of freshwater, brackish and saltwater drowning. PMCT-guided coaxial cutting needle biopsy was raised as a possible minimally invasive method to sample organs for bacterioplankton PCR analysis.[25] However, this test is yet to be used in routine practice and is unlikely to be available in most centres.

Appendix D 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 E AGREE II compliance monitoring sheet

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

AGREE II standard		Section of guideline
Scope and purpose		
1	The overall objective(s) of the guideline is (are) specifically described	Foreword
2	The health question(s) covered by the guideline is (are) specifically described	Foreword, 1
3	The population (patients, public, etc.) to whom the guideline is meant to apply is specifically described	Foreword, 1
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	1
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	n/a
12	There is an explicit link between the recommendations and the supporting evidence	2–13
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	2–13
16	The different options for management of the condition or health issue are clearly presented	Foreword
17	Key recommendations are easily identifiable	2–13

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	Appendices B and C
20	The potential resource implications of applying the recommendations have been considered	Foreword
21	The guideline presents monitoring and/or auditing criteria	14
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