



Guidelines on autopsy practice

Aviation-related fatalities

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Series authors: Dr Esther Youd, Clinical Lead for Autopsy Guidelines

Dr Ben Swift, Forensic Pathology Services, Oxon

Specialist authors: Dr Mike Biggs, East Midlands Forensic Pathology Unit, University of Leicester

Dr David Bailey, Peterborough and Stamford Hospitals NHS Foundation Trust (NHSFT)

Professor Norman J Carr, Faculty of Medicine, University of Southampton

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Dr Brian Rous

Clinical Lead for Guideline Review

The Royal College of Pathologists
6 Alie Street, London E1 8QT
Tel: 020 7451 6700
Fax: 020 7451 6701
Web: www.rcpath.org

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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 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 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 were consulted for this document:

- Air Accidents Investigation Branch (AAIB)
- Civil Aviation Authority (CAA).

The information used to develop this document was derived from current medical literature and a 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 A). The sections of this autopsy guideline that indicate compliance with each of the AGREE II standards are indicated in Appendix B.

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 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 (SAC) and Lay Advisory Group. It was placed on the College website for consultation with the membership from 28 October to 25 November 2024. All comments received from the membership were addressed by the authors 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

Aircraft accidents remain relatively infrequent events but, when they do occur, information obtained by pathological examination can be crucial to the subsequent enquiry. Relevant expertise previously existed within the Royal Air Force (RAF) to conduct autopsies, provide advice or carry out subsequent specialist review. While the RAF Centre of Aviation Medicine (currently located at RAF Henlow but scheduled to relocate to RAF Cranwell from 2026 onwards) may still be able to offer some specialist advice in relation to aviation medicine, there are no longer any active RAF aviation pathologists. It is therefore much more likely nowadays that such cases will be examined by pathologists who may have no prior experience of aviation pathology. A pathologist who does not specialise in aviation fatalities is not expected to encounter such cases frequently, and so specific guidelines are justified to inform where there is unfamiliarity, and to ensure consistent standards between different practitioners. This document is intended to provide an approach that will yield sufficient information to answer the types of investigative questions commonly encountered in such cases. It is not intended to replace more comprehensive texts that already exist on the specialist subject of aviation pathology.¹⁻⁷

The scenario of a mass fatality incident is beyond the scope of this document, which is intended only to assist practitioners encountering occasional cases among their routine autopsy workload. Depending on the circumstances of the incident, there is the potential for a level of investigative scrutiny that may not be immediately apparent at the time of autopsy. For this reason, these examinations should be conducted to a level of detail that may seem excessive for a 'routine' case. If a pathologist feels that they do not have the available time or resources to achieve a sufficiently high standard, then it is safer not to commence the examination, rather than risk becoming involved with a case in which inadequate documentation or sampling might result in future difficulty. The likelihood of such cases occurring within a pathologist's routine practice may be greater if situated in close proximity to an aerodrome, but it should be remembered that aircraft can crash anywhere, and therefore autopsy pathologists working in any geographical location could potentially be called on to participate in this type of work.

1.1 Target users of these guidelines

The target primary users of these guidelines are pathologists who currently conduct autopsies, and who may wish to seek specific information about aviation-related pathology before commencing a case that is not normally encountered in their routine workload. The recommendations will also be of value to trainee pathologists looking to acquire knowledge in preparation for examinations. In addition, any individuals tasked with investigating a fatal aircraft crash (e.g. coroners, procurators fiscal, police officers or air accident investigators) may seek to determine the information needed before, or to be expected following, pathological examination.

2 The role of the autopsy

The investigative reasons for conducting a post-mortem examination following an aviation fatality are to:

- assist with ensuring correct identification of the deceased
- determine the cause of death
- detect any underlying natural disease or intoxication in flight crew
- analyse patterns of injury
- assess the effectiveness of safety equipment

- assess the efficacy of aircraft crashworthiness.

Some of these roles extend beyond the remit of the autopsy pathologist, but detailed documentation of findings and appropriate sampling will allow all aspects of the case to be investigated subsequently by other individuals, if necessary.

The relevant coroner, procurator fiscal or equivalent will authorise the type of examination considered necessary to fulfil the requirements of the subsequent legal process. In doing so, they may also take into account additional requirements of the accident investigators involved. It is therefore important that the pathologist determines the extent and nature of the information required before the autopsy commences. As an example, an invasive autopsy might not be authorised if confirmation of a traumatic cause of death on the balance of probabilities is all that is deemed necessary. However, if a potential medical episode affecting a pilot's flying capability is suspected from the circumstances of the incident, then additional information of importance to the wider investigation might be missed if internal examination with histological sampling and toxicological sampling are not authorised. Early communication between the individuals involved is therefore essential.

[Level of evidence – GPP.]

3 Pathology encountered at autopsy

Consequences of rapid deceleration, direct blunt force trauma, penetrative injuries and burns are commonly encountered, and there will be some overlap with the types of injuries more commonly seen in cases of road traffic or other transportation-related fatalities. For a more detailed discussion, please refer to section 13.

[Level of evidence – GPP.]

4 Specific health and safety aspects

The nature of air crash fatalities means that bodies are often severely traumatised. This can result in the production of sharp fragments of bone that can remain hidden deep within body cavities. Bone fragments may come to lie in unexpected positions, and foreign bodies such as sharp metal or broken glass may also present hazards. In incidents where ejection seats or other pyrotechnic safety devices have been involved, this equipment should have been rendered safe by appropriate personnel before the autopsy. However caution should still be exercised when removing any clothing or other item that has the potential to cause injury. The possibility of chemical or other contamination should be

considered, depending on the aircraft, cargo and crash site involved. Post-crash fires involving aircraft constructed using glass-reinforced plastic or carbon fibre composites are likely to result in remnants of these materials being present on the occupants' bodies, meaning that a respirator device with filtration may be indicated during mortuary operations.

[Level of evidence – GPP.]

5 Clinical information relevant to the autopsy

5.1 Incident circumstances

As much background information as possible should be obtained beforehand to plan a thorough examination and to avoid potential loss of sampling opportunities. Varying levels of detail may already have been provided by the instructing authority (e.g. HM Coroner or Procurator Fiscal's office), but additional information may be available from other sources, such as police and/or air accident investigators. The Air Accidents Investigation Branch (AAIB), a part of the Department for Transport, is legally responsible for air accident investigations in the UK. Their investigators can provide the pathologist with relevant information and will be able to advise them on specific information that the AAIB may require to assist with their investigation. It is worth noting that fatalities resulting from sporting and recreational activities, such as hang gliding and paragliding, may not attract the attention of the AAIB or police, but similar principles apply in such cases and the information laid out in this document remains of benefit. Specialist technical advice can be sought in advance from the British Hang Gliding and Paragliding Association (BHPA), and liaison with this organisation's technical investigation division is encouraged.

All such information will provide some indication of the type of incident being dealt with. Knowing in advance whether the incident involved military, commercial or private aircraft, and distinctions between rotary (helicopter) or fixed-wing aircraft, glider or powered aircraft, etc. will be of benefit when considering the types of injuries likely to be encountered. The occurrence of a post-crash fire will also affect the conduct of the autopsy, and so advance notification of this eventuality should be sought. An understanding of scene factors may be crucial, since mechanisms of death such as positional or crush asphyxia may be overlooked entirely if the examination is restricted solely to the mortuary findings. It is anticipated that a visit to the crash scene by the pathologist may not be feasible in the context of a routine case, but scene photographs

taken by police, for example, may provide a useful alternative. Such photographs should therefore be requested by, and provided to, the pathologist. Discussion with the AAIB investigator assigned to the incident will assist in establishing initial circumstances, and whether any specific factors need to be explored (e.g. potential for medical incapacitation or likelihood of carbon monoxide fumes having entered the cockpit).

When aviation-related fatalities have occurred abroad, any repatriated bodies may arrive following varying levels of prior examination and/or embalming. As far as possible these cases should be dealt with in the same manner so that important findings are not missed.

5.2 Pilot medical examinations

Commercial pilots are required to undergo regular aviation medical examinations, and the records of these examinations should be made available. In addition to indicators of natural disease, other information may be contained within these records that is of relevance to the investigation (e.g. a pilot may have been required to wear or carry spectacles while flying, therefore any evidence of spectacle wear should be documented). It should be noted that the aeromedical examiner (AME) who carried out a pilot's medical examination may not have had access to the GP's records or any hospital notes. These should be obtained via the instructing authority's office, as they could reveal vital information that was not known to the AME. The possibility that pilots, out of reluctance to lose flight medical classification, may have withheld information during these examinations should not be overlooked.

The majority of pilots flying light aircraft including balloons, gliders, microlights, small helicopters and fixed wing aircraft below 2,500 kg will have made a pilot medical declaration about their fitness to fly. This requires a medical standard like that required to drive a car. The UK CAA is continuing to gather data about the safety of this and fatal accidents where a medical cause was contributory. The AAIB will have access to the declaration, and any other relevant past medical history, but this area remains under close scrutiny and the contribution of pathologists is therefore important.

[Level of evidence – GPP.]

6 The autopsy procedure

A methodical approach should be adopted to document the presence of all injuries in a detailed manner. While this may not seem strictly necessary to establish the medical

cause of death, key information about circumstances and contributory factors can be lost if sufficient detail is not recorded during the examination. During the initial stages of an investigation it will not yet be known how much reliance will ultimately be placed on the interpretation of injury patterns, and information of vital importance cannot be retrieved after the body has been released. Once the information has been recorded it will be available for future specialist appraisal if necessary, even if the significance of specific positive or negative findings was not immediately apparent at the time of the autopsy. A severely traumatised and/or burned body may present a daunting prospect to anyone unaccustomed to dealing with such cases, but meticulous documentation will preserve the necessary information for any subsequent analysis that may become necessary.

6.1 Clothing

It is standard practice to include the body weight in an autopsy report, but it is also worth documenting a clothed weight. Investigators may wish to conduct centre-of-gravity calculations for certain aircraft types, and their accuracy will be improved by recording this information before removal of clothing and equipment worn at the time of the incident. This will vary with the type of aircraft and could include specialist aviation garments or simply reflect everyday items of clothing. Particular attention should be paid to any safety equipment, such as helmets, parachutes and harnesses, etc. that may remain with the body. Evidence of damage to or failure of these items will be of benefit to the subsequent investigation, and so-called 'witness marks' may help with reconstruction of events at a later date. Whether a sleeve or strap was torn during the impact sequence, or subsequently cut by emergency medical personnel attempting resuscitation at the scene is a distinction worth making to inform the wider investigation. While it is certainly not within the remit of the autopsy pathologist to attempt to interpret all this information, accurate documentation of any visible damage during the removal of clothing and equipment should still be carried out to ensure a detailed, high-quality report. The soles of shoes/flying boots may bear rudder pedal imprints or other damage, and such detail could easily be missed if a methodical approach is not adopted. As noted previously, spectacle use may have been a requirement of a pilot's flying status, so the presence or absence of glasses (or contact lenses), even if carried within a pocket, should be described. The effectiveness or otherwise of fireproof or flame-retardant materials should be considered, and the presence of survival clothing such as the dry suits worn during flights over water should be considered in the event that hypothermia or hyperthermia is thought to be of potential relevance to the incident being investigated.

6.2 External examination

As it is unlikely to be immediately apparent which specific injuries will prove crucial during the subsequent investigation, documentation of all injuries should be to a forensic level of detail. (For the avoidance of doubt, this is not a suggestion that only 'forensic' pathologists should undertake these examinations but refers instead to the thoroughness of the injury description required.) The locations, appearance and dimensions of all bruises, abrasions, lacerations and incised wounds should be documented. Particular attention should be paid to patterned marks that may provide evidence of contact with a specific item or surface. Marks resulting from harnesses, straps, etc. are of prime importance, as they will provide some evidence of correct or improper use. Injuries can occur to the head, arms and legs when the body 'flails' during crash deceleration. Over the years, advances in seat design, restraint systems and elimination of potential hazards from the so-called 'flail envelope' (i.e. the entire region of space through which a flailing head, torso or limb physically could move during a crash, rather than the more limited space through which normal, functional movements occur) have improved outcomes for occupants involved in air crashes. Meticulous documentation of injuries provides the necessary evidence for accident investigators to continue this essential work. Similarly, it can sometimes be necessary for accident investigators to establish whether or not a pilot would have physically been capable of reaching a particular switch, or producing a control input of a specific magnitude, making functional limb length measurements extremely valuable. This information can be derived from CT scan data, if available, but simple measurement in the mortuary is straightforward and not time-consuming.

Amputations and areas of thermal damage should also be documented in a detailed manner. It is worth noting that skin that has been in contact with aviation fuel for a period of time can develop artefactual erythema and epidermal slippage, mimicking burns. The back of the body must not be neglected and should be described in as much detail as the front.

Photography of injuries is strongly advised wherever possible, as this will provide a superior resource for subsequent review, but at the very least body diagrams should be completed to keep a visual pattern reference in addition to the textual descriptions of injuries. A recommended photographic sequence would be to begin with a wide view to provide anatomical location context, followed by closer views (both with and without a measurement scale) to provide more detail. Several images from different angles may be required to capture the entirety of large injuries. Right-angled measurement scales are

preferable during photographic documentation, but in the absence of such an item, a standard mortuary ruler will at least provide some dimensional reference within injury photographs. This will assist any subsequent correlation with aircraft components or structures that may become necessary. Consideration can also be given to making use of any hospital medical photography services that may be available locally.

6.3 Internal examination

Practice varies with geographical location, and in some jurisdictions the legal authority to carry out an invasive internal examination may not have been granted. Provided that authority has been given for an invasive autopsy, this should proceed as for a standard examination. A detailed inventory of all skeletal trauma should be made, as this will allow subsequent correlation with forces occurring during the crash sequence. The presence (and absence) of traumatic injuries and natural disease processes within the various organ systems and soft tissues of the body should be detailed thoroughly, and if this is not possible owing to severe destruction (or complete absence) of a particular structure then this observation should explicitly be recorded for the avoidance of doubt at a later stage. If ante-mortem medical records are available, any known medical history can be correlated with the pathological findings. Interpretation should be cautious in the context of trauma. For example, a traumatic coronary artery lesion may obscure (or simulate) genuine pathology.

[Level of evidence – GPP.]

7 Specific organ systems to be considered

All organ systems should be considered in every case, with particular attention being paid where incident circumstances or background medical history suggest potential medical incapacitation.

[Level of evidence – GPP.]

8 Organ retention

As for section 7, referral to an organ-specific specialist pathologist may be indicated based on the circumstances of the incident or background medical history.

[Level of evidence – GPP.]

9 Histological examination

The legal framework surrounding authority to retain human tissue will vary depending on geographical location, and local practices will vary within each region. It may be that no authority is granted for histological sampling in cases where an obvious traumatic cause of death has been established. Similarly, under certain circumstances in some jurisdictions, no authority will be granted for an invasive examination to be undertaken at all. In many cases histological examination will not significantly affect the ultimate conclusions of the examination. However, if the investigators consider medical incapacitation to have been a potential factor, then as thorough a search as possible should be made to identify any evidence of this. Expanding on a previous example, coronary artery histology may be necessary to determine the difference between genuine pathology and traumatic artefact. As discussed above, correlation with ante-mortem medical records will be of benefit, and in specific instances it may be desirable to retain the heart or brain so formal specialist opinion can be obtained. Even pilots who have been certified as being medically fit to fly may still show evidence of occult natural disease, and its relevance in the cause of death and wider circumstances must be considered.

[Level of evidence – GPP.]

10 Toxicology

Several considerations are worthy of note in relation to aviation.

10.1 Sampling

Sampling can be hampered by severe disruption of bodies, especially following high-energy impact sequences. If the crash scene is in a remote location, or extrication of bodies is complex, disrupted bodies may be exposed to ambient conditions for a prolonged period of time, with resultant exacerbation of artefacts such as post-mortem redistribution and putrefactive ethanol production. These factors must be borne in mind when interpreting any toxicological results obtained.

In many cases it will still be possible to obtain blood, urine and vitreous samples even in the context of severe traumatisation of the body. Vitreous fluid may resist the effects of decomposition for a longer period of time than other fluids and should be sampled if available. In addition to the detection of toxicological substances, vitreous biochemistry

can be analysed, possibly providing evidence of ketoacidosis or poor glycaemic control, for example, although any such interpretation also requires caution and careful consideration.

When these samples cannot be obtained, a sample of liver or skeletal muscle can be submitted for analysis. If there is apparent surface contamination and/or decomposition, a better-preserved sample may often be obtained from central or deeper portions of the tissue. Homogenates prepared from these samples in the laboratory may provide an indication of the presence or absence of substances, but meaningful quantitation cannot be attempted.

10.2 Request form details

As with all toxicology requests, the laboratory should be provided with all available relevant information so that processes can be prioritised and modified if necessary, and to enable optimal interpretation of the generated results. Certain substances may not be included in routine screens. If the possible presence of a specific drug is of potential significance, then this information must be expressly conveyed to the analysing laboratory. Lists of prescription medication can be obtained from medical records, and over-the-counter medications may have been found at the scene or within the deceased's residence. In addition to medications, screens for illicit drugs and ethanol should be carried out in all cases.

10.3 Ethanol

The current UK legal limit for flying an aircraft is a blood ethanol concentration of 20 mg/100 ml (considerably lower than for driving a motor vehicle).⁸ Such a level can be produced artefactually during putrefaction, and so caution must be exercised when interpreting the results obtained. The presence of impurities (such as acetone, propanol or butanol) may help to indicate that post-mortem production has taken place. Ethyl glucuronide is not formed after death, and so its presence provides an indication of genuine ante-mortem ethanol exposure. However, persistence in the body from previous consumption may give a false impression of blood ethanol elevation at the time of death, further complicating toxicological interpretation.

10.4 Products of combustion

When determining the relevance of any post-crash fire in the cause of death, measurement of carboxyhaemoglobin (and other products of combustion such as cyanide) should be requested when it has been possible to obtain a sample of blood from the

deceased. Even in incidents where no fire has occurred, carbon monoxide contamination within the cockpit (from the engine or heating system) may prove to have been a factor in the cause of the crash. It is therefore prudent to establish carboxyhaemoglobin levels in all cases of powered flight, but especially in small, piston-engined aircraft. Detection of cyanide or other products of combustion will help to distinguish between fumes resulting directly from a fire, and cockpit carbon monoxide contamination from other sources. However, it is recognised that the ability to test for cyanide locally is not guaranteed, therefore discussions about alternative arrangements for retention and transport of specific samples to answer this specific question may be required, as well as commentary in the report about potential limitations if this cannot be facilitated.

10.5 Prescription medications

When interpreting toxicological findings, it should be remembered that medications that may seem innocuous on the ground could have exaggerated effects at altitude or while operating in the high workload environment of an aircraft cockpit. If a pathologist is unsure of the significance of a detected medication, advice can be sought from the UK CAA Medical Department.

Any medications identified may provide clues as to underlying medical conditions, and these conditions may not have been disclosed previously to medical examiners. A pilot may not need to be fully incapacitated for a crash to ensue, as distraction alone at a critical moment may prove sufficient. The potential must be considered not only for medical incapacitation, but also for side effects of medication. Medications, and their associated medical conditions, could be the cause of a crash, significant contributory factors or merely a coincidence. It may not be possible to determine this significance with certainty, but cautious consideration should be given alongside the other pathological findings and overall circumstances of the incident. The possibility of suicide may need to be considered by the instructing authority, depending on the circumstances of the case, and toxicological findings may therefore provide an important indication to the wider investigation.

[Level of evidence – GPP.]

11 Imaging

Radiological imaging is an excellent method of identifying, documenting and demonstrating not only skeletal trauma, but also the presence or absence of foreign bodies. Post-mortem computed tomography (PMCT) scanning is already established as an

investigative tool, and even if this is not something that is regularly carried out at the facility where the autopsy is due to take place, the benefits available in the case of an aviation-related fatality justify additional effort to optimise the recording of information. The logistical burden necessary to acquire a scan will be offset by the rapidity and superiority of skeletal injury documentation. Additional advantages include the ability to plan the examination thoroughly, the limitation of extensive or complicated dissection, and the identification of hazards before entering the mortuary. Furthermore, the scan information will be archived and available for subsequent future review, if required.

The joint Royal College of Radiologists (RCR) and RCPATH statement on standards for medico-legal post-mortem cross-sectional imaging in adults⁹ can be consulted for advice when arranging such imaging, if this is not something that is already carried out routinely. It is appreciated that many autopsy practitioners will not yet have had experience of PMCT scanning in relation to post-mortem investigation. Readers are encouraged to explore local possibilities to facilitate scanning and should be reassured that support and advice are available to assist if required.

In contrast to routine practice, where scanning usually takes place after an external examination has deemed PMCT to be appropriate to the case, it is advisable to complete the scan before opening the body bag in cases of aviation-related fatality, as this will preserve the body, clothing, etc. in an undisturbed state. Severely fragmented and/or charred remains are fragile and susceptible to artefactual damage and potential loss of evidence, so capturing this detail at the earliest possible opportunity is preferable, even if this is not the normal sequence of events locally.

Under certain circumstances it may be deemed appropriate by the instructing authority for the invasive internal component of the post-mortem examination to be omitted entirely, relying solely on radiologically-reported imaging to provide the internal autopsy findings. If this is the case, possible underlying natural disease leading to medical incapacitation may not be visualised. If the circumstances of the incident suggest that confirmation or exclusion of natural medical disease might become important then a preference for fully-invasive examination with appropriate laboratory sampling should be expressed and the potential limitations of a non-invasive examination highlighted in reports when invasive examination has not been authorised. As with any other imaging-based post-mortem examination, radiology should never be undertaken in isolation, and a thorough external examination of the body must also be performed by an appropriately trained and experienced pathologist.

12 Clinicopathological summary

The vast majority of fatalities arise as a result of rapid deceleration, blunt force impact, direct penetration injuries, the effects of fire or some combination of these categories. Head injuries are very common, and if no safety helmet was worn then a pathologist may be asked to express an opinion as to whether the addition of a helmet may have influenced the outcome in a particular case. As mentioned previously, it may be necessary to correlate the pathological findings with scene factors, as the injuries identified may not account for death and an alternate explanation may need to be found. If an individual was not fatally injured by impact trauma, but subsequently failed to escape from fire, drowning, etc., then potential reasons for incapacitation (e.g. head injury, intoxication, limb injury or entrapment) may need to be explored. If dealing with an incident that occurred over water, the RCPATH document *Guidelines on autopsy practice: Autopsy for bodies recovered from water* is available to assist with additional considerations when encountering bodies recovered from water.¹⁰

Several pathological deductions are likely to be of assistance to the overall investigation. Confirmation of the deceased having been alive at the time of impact is useful, but it may not always be possible to determine this fact with certainty. For example, significant accumulation of blood in association with injuries implies a period of post-injury survival with an active circulation (but the potential for simple gravitational leakage of blood into a body cavity should be excluded before drawing this conclusion). Any reasons for potential incapacitation or distraction (whether natural disease, drug-induced or due to inhalation of toxic fumes) should be considered in the commentary of the report. Although it may seem unlikely, altercations can occur in the air,¹¹ and so attention should be drawn to any injury that suggests that a pilot may have been assaulted before ground impact. When there is burning of the body, differentiation between ante-mortem and post-mortem fire damage should be made (and qualified with the degree of certainty). An elevated carboxyhaemoglobin level and soot deposition within the lower airways provides good evidence of breathing within a fire environment. Rapid death due to burns, or anoxia due to intense fire within a confined space, may potentially account for a low carboxyhaemoglobin level, so interpretation should be carried out with care, and on a case-by-case basis.

At all stages the interpretation of pathological findings should be cautious. So-called ‘control injuries’ (damage to the hands and feet caused by contact with flight controls) are often taken into consideration when discerning if an individual was actively attempting to manoeuvre the aircraft at the time of impact.¹² Such injuries may arise spontaneously during the impact sequence, and do not necessarily indicate that an individual was making a conscious effort to fly. Likewise, injuries are not guaranteed to occur, and so their absence does not exclude the possibility that an individual was actively operating the controls at the time of ground impact. Careful documentation of the presence and absence of such injuries will assist in the overall interpretation of the incident, even if the pathologist is not personally in a position to comment directly upon this specific matter. To this end, preservation of this information in three-dimensional form via PMCT scanning is invaluable.¹³

The AAIB investigator may be able to provide estimates of likely impact velocity and angle based on scene findings, and where possible this information should be correlated with the observed injuries. Comments correlating the injuries sustained with the suggested impact sequence will be helpful, and an assessment of the forces experienced by aircraft occupants in relation to human tolerances may assist with the determination of survivability. If the initial impact was survived, but death occurred later, additional detail such as the inevitability of certain injuries leading to death, or any potential role that might have been played by delays in rescue or medical treatment, should be considered.

[Level of evidence – GPP.]

13 Examples of cause of death opinions/statements

Aviation-related fatalities often exhibit numerous sharp force, blunt force and thermal injuries throughout the body, and it may seem convenient to record the medical cause of death simply as ‘multiple injuries’. Such oversimplification is to be avoided, and a more informative prioritisation of the immediately fatal injuries provides a more useful report to both the medico-legal and accident investigations. For example, if death at the point of impact was solely the result of a catastrophic head injury, then this can be stated explicitly, rather than diluting this important fact by grouping it together with all the other lacerations and fractures around the body under a non-specific label.

[Level of evidence – GPP.]

14 Summary

The aim should be to carry out a complete post-mortem examination, including toxicological sampling. There should be a full and detailed description of the types of injuries, their location and their relation to the cause of death. Photographic documentation of these injuries is strongly encouraged. Natural disease processes should be documented and consideration given to the potential for medical incapacitation. Every effort should be made to arrange a PMCT scan before the examination, even if this is not currently considered a part of local routine autopsy practice, to preserve as much information as possible in an undisturbed state for any future detailed analysis that may become necessary. Even if an autopsy practitioner feels they have no particular expertise in relation to aviation fatalities, documentation and sampling to the standards described above will ensure that pertinent information is preserved for subsequent specialist analysis.

[Level of evidence – GPP.]

15 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 complies with the national recommendations provided by the 2006 National Confidential Enquiry into Patient Outcome and Death (NCEPOD) study:¹⁴

- 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 autopsy reports explain the description of internal appearance
 - standards: 100% of autopsy reports documented are satisfactory, good or excellent
- reporting external examination:
 - standards: 100% of autopsy reports 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 RCPATH website.¹⁵

16 Acknowledgements

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17 References

1. Mason JK. *Aviation accident pathology*. London, UK: Butterworths, 1962.
2. Cullen SA, Drysdale HC. Aviation accidents. *In: Mason JK, Purdue BN (eds). The Pathology of Trauma (3rd edition)*. London, UK: Hodder Arnold, 2000.
3. Dembo MH, Seli H. Airplane crashes. *In: DiMaio D, DiMaio VJ (eds). Forensic Pathology (2nd edition)*. Boca Raton: CRC Press, 2001.
4. Dolinak D, Lew E, Matshes E. Aviation. *In: Dolinak D LE, Matshes E, (ed) Forensic Pathology: Principles and Practice*. London, UK: Elsevier Academic Press, 2005.
5. Maidment G. Air crash investigations for histopathologists. *In: Ruttly GN (ed) Essentials of Autopsy Practice: New Advances, Trends and Developments*. London UK: Springer, 2008.
6. Veronneau SJH, Ricaurte EM. Aircraft accidents: Investigation and prevention. *In: Davis JR, Johnson R, Stepanek J, Fogarty JA (eds). Fundamentals of Aerospace Medicine (4th edition)*. Philadelphia, USA: Lippincott Williams & Wilkins, 2008.
7. Lewis ME, Maidment G. Aviation pathology and accident investigation. *In: Gradwell DP, Rainford DJ (eds). Ernsting's Aviation and Space Medicine (5th edition)*. Boca Raton, USA: CRC Press, 2016.
8. HM Government. *Railways and Transport Safety Act 2003*. Accessed August 2024. Available at: www.legislation.gov.uk/ukpga/2003/20/contents
9. The Royal College of Pathologists. *Guidelines for post-mortem cross-sectional imaging in adults for non-forensic deaths*. Accessed August 2021. Available at: www.rcpath.org/profession/guidelines/autopsy-guidelines-series.html
10. The Royal College of Pathologists. *Guidelines on autopsy practice: Autopsy for bodies recovered from water*. Accessed August 2024. Available at: www.rcpath.org/profession/guidelines/autopsy-guidelines-series.html
11. Gunther D, Ast FW, Troger HD, Kleemann WJ. Unexpected findings in the investigation of an airplane crash. *Forensic Sci Int* 1999;104:189–194.
12. Campman SC, Luzi SA. The sensitivity and specificity of control surface injuries in aircraft accident fatalities. *Am J Forensic Med Pathol* 2007;28:111–115.
13. Folio RL, Harcke HT, Luzi SA. Aircraft mishap investigation with radiology-assisted autopsy: Helicopter crash with control injury. *Aviat Space Environ Med* 2009;80:400–404.
14. National Confidential Enquiry into Patient Outcome and Death. *The coroner's autopsy: Do we deserve better?* London, UK: NCEPOD, 2006.
15. The Royal College of Pathologists. *An audit of compliance with national guidelines for external and internal examination at coronial autopsy*. Accessed August 2024. Available at: www.rcpath.org/profession/patient-safety-and-quality-improvement/conducting-a-clinical-audit/clinical-audit-templates.html

Appendix A 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	<p>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</p> <p>or</p> <p>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.</p>
Grade B	<p>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</p> <p>or</p> <p>Extrapolation evidence from studies described in A.</p>
Grade C	<p>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</p> <p>or</p> <p>Extrapolation evidence from studies described in B.</p>
Grade D	<p>Non-analytic studies such as case reports, case series or expert opinion</p> <p>or</p> <p>Extrapolation evidence from studies described in C.</p>
Good practice point (GPP)	<p>Recommended best practice based on the clinical experience of the authors of the writing group.</p>

Appendix B 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	2–14
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	2–14
16 The different options for management of the condition or health issue are clearly presented	2–14
17 Key recommendations are easily identifiable	2–14
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	2–14
20 The potential resource implications of applying the recommendations have been considered	Foreword
21 The guideline presents monitoring and/or auditing criteria	15
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