AUTOPSY

Contents

Procedures and Standards

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Introduction

The need to establish the cause and manner of death has always existed. It is vitally important to know whether a death is due to natural causes (i.e., where there are no signs of violence), an accident, by the hostile action of a community member or enemy troops, or, perhaps an act of God (i.e. unavoidable).

The historical development of postmortem procedures shows two distinct paths to our present-day systems. The earliest system, the external examination of a dead body, began in ancient China more than 2000 years ago. Even today, it is the prevailing method of postmortem examination in many parts of Asia. It is worth noting that at that time medical doctors did not participate in postmortem examinations, which were conducted by government officials.

The history of "necropsy," the investigative dissection of a dead body, or the more extensively used term "autopsy," literally, seeing for oneself, is much shorter. According to our present knowledge, the earliest anatomical dissections took place in the first known school of anatomy in Alexandria, Egypt, around 320 BC; the earliest medicolegal dissections were at the University of Bologna, Italy, between 1266 and 1275, and hospital autopsies came considerably later, in the fifteenth century.

External Postmortem Examination

According to Tao and coworkers, the early development of ancient forensic medicine originated in the period of warring states (475–221 BC) in China. The earliest known written instructions, dealing with investigations of the scene of death in cases of death by hanging, were engraved on bamboo slips and found in Yun-meng subprefecture in Hubei province in 1975 from a tomb dating from the Qin dynasty (221–207 BC). These documents also revealed that failure to report suicide to the authorities or any interference with the corpse before it had been examined were punishable offences. McKnight assumes that the interest in state-ordered and officially conducted forensic assessments dates from the time when the state first began to prosecute homicides. The system was developed further during the Song dynasty (AD 960–1279). The key decree establishing the inquest system was issued in AD 995, specifying that, in all unnatural cases of death or serious injury where there was any indication of foul play, the competent authority had to dispatch a government official who was to proceed immediately (within 4 h) to the scene to conduct an inquest (i.e., an investigation of a dead body or a wounded individual). Failure to do so was punishable. Particular attention was called to deaths in prison, as judicial torture to the point of death and subsequent cover-up were not uncommon. A reinquest, performed by officials of a neighboring subprefecture, was mandatory in all nonnatural deaths resulting from illegal acts. The use of official documents and prescribed forms to record the injuries in a body were introduced during the Song dynasty. They included a written request for a postmortem examination reporting the case to the higher authorities, external examination, and conclusions of the examination, including both a front and a back sketch of the body with drawings of the injuries. These were public documents, which had to be signed by the parties involved and certified by the official assigned to the case.

Many of the earlier publications on forensic medicine in ancient China have been lost but extensive information about investigative techniques acquired in the course of several centuries has been compiled in the oldest surviving systematic handbook of forensic medicine, the *His Yuan Chi Lu* (Collected Writings on the Washing-Away of Wrongs), written by Sung Tz'u (1186–249) and published in 1247. In 1440 the book

was first published outside China in Korean and, thereafter, numerous translations of various versions of the book were published in Japan, Europe, and the USA.

The statutory basis for the English coronial system was established in September 1194 by article 20 of the Articles of Eyre, which stated: "In every county of the King's realm shall be elected three knights and one clerk, to keep the pleas of the crown." The resemblance between the English practices and the Chinese pattern has suggested a possible cultural influence, which, according to McKnight, may have existed through close contact with the Norman empire of Sicily and the cosmopolitan group of courtiers at the Sicilian court, especially under Roger II.

In continental Europe, the Justinian Code (AD 529–564) stated the principle that the function of medical experts is to assist the judiciary by impartial interpretation and opinion. The use of medical expertise (barber-surgeons) in the examination of violent deaths was also mentioned in the Canon law of 1209 by Innocent III and in the municipal laws, e.g., in Freiburg since 1220. The examination of violent deaths was carried out by barber-surgeons and was reported orally to the judges. Subsequently, the surgeons had to give expertise also on injuries of living persons.

Anatomical Dissection

The prerequisite for the idea of an autopsy was the knowledge of human anatomy. King and Meehan have quoted Sigerist, stating: "In all archaic civilisations the chief sources of anatomical knowledge were the kitchen and the cult." For example, the practice of haruspicy or hepatoscopy, the process of foretelling of the future by examining the entrails of sacrificial animals, was widespread in ancient times and practiced in Babylon in 3500 BC.

The history of autopsy shows three partly overlapping paths of development. The first lasted almost 2000 years from the first known school of anatomy in Alexandria around 320 BC, where human dissections were carried out, till the publication of the great textbook of anatomy *De Humani Corporis Fabrica* in 1543 by Andreas Vesalius (1514–1564), the "father of anatomy," marking the overthrow of traditional Galenic anatomy. The possibility of dissecting human bodies varied greatly at times. In Vienna the first anatomical dissection took place in 1404. In 1410, Pope Alexander died suddenly and was autopsied by Pietro D'Argelata. Pope Sixtus IV (1471–1484) issued a bill permitting studies on human bodies by students at Bologna and Padua. Felix Platter I, the famous anatomist in Basle, Switzerland, was said to have performed more than 300 autopsies since 1559.

Medicolegal Autopsy

Analogous to the external postmortem examination, the medicolegal autopsy was introduced as a result of the requirements of the judicial system. According to Singer, the earliest medicolegal dissections took place at the University of Bologna, Italy, from 1266 to 1275, though McKnight claims that there is evidence that autopsies had been performed in China several centuries earlier, but the Chinese did not continue this line of exploration. In France, Ambroise Paré performed the first medicolegal autopsy in 1562.

Our knowledge of the old autopsy procedures is rather scanty. With few exceptions, detailed written autopsy records mainly exist for relatively recent times. Exceptions are the reports of the autopsy of Emperor Maximilian II from 1576 and of Markgrave Jakob III of Baden, who died in 1590 and was autopsied by two professors of the Freiburg University in the presence of the personal physician of the deceased.

The principles of the modern medicolegal investigation were developed based on the codes of sixteenth-century Europe: the Bamberg Code (Constitutio Bambergensis) in 1507, the Caroline Code (Constitutio Criminalis Carolina) in 1532, and later the Theresian Code (Constitutio Criminalis Theresiana) in 1769.

The Austrian decree of 1855 contains detailed instructions in 134 paragraphs on the performance of medicolegal autopsy, and it is worth mentioning that even today this is valid legislation in Austria. The Prussian edict of 1875 is similar, although not as detailed. Both of these instructions can be considered as the culminating point of legislation, dealing with the performance of medicolegal autopsy.

Clinical Autopsy

Before the mid nineteenth century, autopsies were greatly affected by the prevailing medical concepts and the pathologist could not see what he did not know. The clinical autopsy, as we understand it today, took much longer to develop and first became meaningful after the introduction of modern concepts of pathogenesis of diseases by Carl von Rokitansky (1804–1878) and cellular pathology by Rudolf Virchow (1821–1902).

The concept of a "complete" autopsy changed over the centuries: at the beginning of the nineteenth century increased attention was paid to the actual autopsy technique. Prost, a French physician, insisted in 1802 that all organs of the body should be examined and declared that 3 h was the minimum length of time for a postmortem examination. In 1846 Rudolf Virchow, then a prosector in Berlin, insisted

on regularity and method and definitive technique. The classical techniques that are still in use today are more or less modifications of those introduced by Rokitansky, Virchow, Ghon, and Letulle, among others.

In 1872 Francis Delafield's *A Handbook of Postmortem Examination and Morbid Anatomy* was published in New York, and German and English editions of Rudolf Virchow's book on autopsy technique were published in 1876.

The Present Use of the Autopsy

Objectives of Autopsy

An autopsy is a detailed systematic external and internal examination of a corpse carried out by a pathologist or one or more medicolegal experts to ascertain the underlying and possible contributing causes of death and, depending on the jurisdiction, also the manner of death. Before the pathologist can begin the examination, authorization to perform the autopsy on that particular body is necessary. An assessment of possible risks that may be involved with the autopsy must also be considered and necessary health and safety precautions taken. The autopsy and all related measures must be carried out in a manner consistent with medical ethics and respecting the dignity of the deceased.

An autopsy is performed to achieve one or more of the following objectives:

- to identify the body or record characteristics that may assist in identifying the deceased
- to determine the cause of death or, in the newborn, whether live birth occurred
- to determine the mode of death and time of death, where necessary and possible
- to demonstrate all external and internal abnormalities, malformations, and diseases
- to detect, describe, and record any external and internal injuries
- to obtain samples for any ancillary investigations
- to obtain photographs or retain samples for evidential or teaching use
- to provide a full written report and expert interpretation of the findings
- to restore the body to the best possible cosmetic condition before release.

In addition to the anatomical dissection there are two main types of autopsy:

1. The medicolegal or forensic autopsy, which is ordered by the competent legal authority (coroner, medical examiner, procurator-fiscal, magistrate, judge, or the police) to investigate sudden unexpected, suspicious, unnatural, or criminal deaths. Also unidentified bodies or deaths occurring in special circumstances, such as deaths in police custody or during imprisonment, are often subjected to a medicolegal autopsy. In most jurisdictions, permission of the relatives is not required and the medicolegal autopsy takes priority over the clinical.
2. The clinical (hospital) autopsy is to investigate the extent of a known disease and the effectiveness of treatment and it is sometimes also performed for medical audit or research purposes. Almost invariably, the consent of relatives is needed unless the deceased has given consent antemortem.

Medicolegal Autopsy

Further developments in medicolegal autopsy have been characterized and greatly influenced by the judicial system adopted in any given country, the main emphasis being on the detection and investigation of criminal and other unnatural or unexpected deaths. Due to different legislations, there exists great variation in the medicolegal autopsy rates and practices between countries. In addition to national measures to create guidelines and harmonize medicolegal autopsy, there has been an increasing international interest in achieving uniform and internationally recognized rules concerning the methods of carrying out autopsies. This has become imperative, especially with respect to human rights issues. The mass killings in Cambodia, Rwanda, Bosnia, and Kosovo should have made it quite clear, even to the general public, what implications a medicolegal investigation, or the lack of it, may have on human rights.

In May 1989, the United Nations Economic and Social Council adopted in its resolution 1989/65 the Principles on the Effective Prevention and Investigation of Extra-Legal, Arbitrary and Summary Executions, which had been created by cooperation with intergovernmental and nongovernmental organizations, in particular the Minnesota Lawyers International Human Rights Committee. Later, in 1991, the General Assembly of the United Nations endorsed the Model Autopsy Protocol of the United Nations.

The European Council of Legal Medicine (ECLM) is an official body, with its seat in Cologne, Germany, that deals with scientific, educational, and professional matters in Europe. It has delegates nominated by the national medicolegal associations from all European Union and European Economic Space (EES) member countries. Since the early 1990s the ECLM has also been active in this field and its document *Harmonisation of the Performance of the*

Medicolegal Autopsy was adopted by the General Assembly in London in 1995.

The Council of Europe is an intergovernmental organization that aims, among other things, to protect human rights and a pluralist democracy. It should not be confused with the European Union. The two organizations are quite distinct; however, all the European Union states are also members of the Council of Europe, which currently has 45 member states. In its 43rd Ordinary Session, the parliamentary assembly of the Council of Europe adopted recommendation 1159 (1991) on the harmonization of autopsy rules. Following this recommendation, a working party of international experts in legal medicine and law, with representation from Interpol as well as the International Academy of Legal Medicine, was established in 1996 under the Committee of Bioethics to make a proposal for the autopsy rules. Among the guidelines used in the work was the autopsy rule produced earlier by the ECLM. The working party finished its work in November 1998 and this new Pan European recommendation R (99) 3 on the "harmonisation of medicolegal autopsy rules and its explanatory memorandum" was adopted by the committee of ministers on February 2, 1999 at the 658th meeting of the ministers' deputies. Although the document is a "recommendation" by nature and hence not strictly legally binding, it has, however, legal implications because all 45 Council of Europe member countries have agreed to implement these principles in their national legislation.

Clinical Autopsy

Despite increasingly sophisticated investigative and imaging techniques, the clinical autopsy has been shown to have maintained its value and has remained an essential factor in the quality assurance of medical care. Regardless of this, there has been a progressive decline in autopsy rates throughout the world. The mandatory 20% autopsy rate required for accreditation of postgraduate training in the USA was withdrawn in 1971, on the grounds that each institution should set its own rate but that ideally it should be close to 100%. According to the World Health Organization (WHO) statistics published in 1998, the total autopsy rates in Europe in 1996 varied between 6% (Malta) and 49% (Hungary). In other parts of the world reported to the WHO, the rates varied between 4% (Japan) and 21% (Australia) (Table 1).

The reasons for this decline are many and complex: overreliance on new diagnostic techniques, lack of appreciation of autopsy work, poorly performed autopsies by inexperienced trainees without proper supervision, long delay of autopsy reports, economic factors, fear of malpractice litigation, to name just a few.

The standardization and harmonization of clinical autopsy have taken place primarily on the national level and professional organizations, for example, the Royal College of Pathologists, has published guidelines on autopsy practice for postmortem reports and audit. The quality of healthcare and quality assurance and audit has become increasingly important and these procedures have been introduced even for autopsies.

Autopsy Techniques

Both clinical and medicolegal autopsies may involve different strategies and techniques, depending on the questions they are expected to answer. Autopsy techniques in adults are generally different from those employed for pediatric autopsies.

Table 1 Reported information on autopsy rates 1996

Country	*Autopsy rate (%), all ages*
WHO region of the Americas	
Canada	20
USA	12
WHO European region	
Albania	Not available
Austria	27
Belgium	Not available
Bulgaria	25
Czech Republic	31
Denmark	32
Finland	36
France	Not available
Germany	8
Greece	Not available
Hungary	49
Iceland	38
Ireland	7
Israel	Not available
Italy	Not available
Luxembourg	Not available
Malta	6
Netherlands	8
Norway	9
Poland	9
Portugal	Not available
Romania	7
Spain	Not available
Sweden	37
Switzerland	19
United Kingdom; England + Wales	24
United Kingdom; Northern Ireland	11
United Kingdom; Scotland	15
WHO Western Pacific region	
Australia	21
Japan	4
New Zealand	16
Republic of Korea	Not available
Singapore	16

The scope of medicolegal autopsy is often much broader than that of clinical autopsy and may also include the investigation of the scene of death. All background information on the circumstances of death is of paramount importance for the choice of the right approach. In a medicolegal autopsy, the examination of clothing is often an essential part of the external examination, whereas in a clinical autopsy it is generally not. Both types of autopsy should consist of full external and internal examination of the body, including the dissection and investigation of all three body cavities.

The external examination An external description of the body includes:

1. the age, sex, build, height, ethnic group, and weight, nutritional state, skin color, and other characteristics of the deceased, such as scars or tattoos
2. a description of postmortem changes, including all essential details relating to rigor mortis, hypostasis, and decomposition
3. careful investigation and description of all body surfaces and orifices, including color, length, density, and distribution of hair, color of irises and sclerae, presence or absence of petechiae, or any other abnormalities or injuries. The examination should be carried out systematically and include head, neck, trunk, upper and lower extremities, and the back.

The internal examination Examination of the body cavities includes description of the presence of gas (pneumothorax), fluids (effusions or exudates) or foreign bodies, and the measurement of their volume, appearance of the internal surfaces, and anatomical boundaries as well as the location and external appearance of organs.

The classical autopsy techniques vary mainly in the order in which the organs are removed:

1. the organs may be removed one by one (Virchow's technique)
2. cervical, thoracic, abdominal, and pelvic organs can each be removed as separate blocks (Ghon's technique)
3. they may be removed as one single block, which is then subsequently dissected into organ blocks (Letulle's technique)
4. all organs are dissected *in situ* (Rokitansky's technique).

All organs must be dissected, the outer appearance as well as the cut surfaces described, and the weight of the major organs recorded. The hollow organs must be opened and their contents described and measured. All relevant vessels, arteries, and veins as well as ducts should be dissected. All abnormalities must be described by location and size.

Sampling Histological examination of the main organs should be performed in all autopsies. The need for further ancillary investigations may depend on whether the cause of death has been established with the necessary degree of certainty, and, if not, additional samples should be taken for toxicological or other investigations. For toxicology, this may include peripheral blood, vitreous humor, cerebrospinal fluid, bile, hair samples, or other relevant tissues. When retaining tissues, one has to take into consideration the possible restrictions depending on national legislation.

Special procedures Sometimes special procedures and modifications of normal dissection techniques are necessary. If there is suspicion of air embolism, chest X-ray should be performed before autopsy. Where neck trauma is suspected, the brain and the organs of the chest cavity must be removed before dissection of the neck to drain the blood from the area, to avoid artifactual bleeding. Postoperative autopsies may present various problems with medicolegal implications, such as complications of anesthesia, surgical intervention, or postoperative care. New radiological imaging techniques, such as magnetic resonance imaging (MRI) and multislice computed tomography (MSCT), have recently been applied to particular medicolegal problems, such as the investigation of charred or decomposed bodies as well as the visualization and analysis of patterned injuries. However, a detailed description of these special dissection procedures and techniques is beyond the scope of this article.

Autopsy Report

The report is an essential part of the autopsy. It should be full, detailed, and comprehensive. A medicolegal autopsy report, in particular, should also be comprehensible for nonexperts. In addition to the factual, positive and negative gross, microscopic, and analytical findings, the pathologist should conclude with a discussion of the significance of the findings. Where the findings are of uncertain nature and there are several competing causes, the pathologist should attempt to give an opinion as to their probability.

See Also

Autopsy: Medico-legal Considerations; Pediatric; Adult

Further Reading

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Medico-legal Considerations

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Introduction

Autopsies are a part of the health and justice systems that have generally been poorly understood by the community, including the medical profession in more recent times. As far as the general community is concerned, this is not surprising, given that many people are uncomfortable talking or thinking about death, and autopsies directly confront the physical mechanisms of death in a very intimate way. To a certain extent, this could also be true of doctors whose focus is on promoting health and prolonging life, and for whom the details of pathology practice and the purposes and outcomes of autopsies have been of limited interest. A definite lack of awareness about autopsy processes – amongst the public, clinicians, and some pathologists – was exposed during the inquiries into organ retention procedures in the UK (at the Bristol Royal Infirmary and the Alder Hey Hospital in Liverpool), and subsequently in Australia and elsewhere in the world. The practice of not providing details to next of kin about autopsy procedure, including the retention of organs, and the fact of the retention itself, was seen as ethically and, in some instances, legally blameworthy.

When autopsy problems surface in the public domain as they do from time to time, they touch very sensitive nerves. Consequently, the problems often acquire a political dimension – aggrieved, recently bereaved relatives are easily identified with. Also, even ethically performed autopsies can readily be described in terms amounting to disrespect. What makes such description a false characterization is essentially the justification for the examination and the motivation or ethical stance of the prosector. It is easy, however, for an autopsy institution to adopt a defensive posture in relation to how it might handle the risk of problems surfacing in public. We would like to suggest that clarity about the principles that drive the institution, and the development of policies and procedures which give effect to those principles, enable a positive approach from the outset that also serves as the institution's best defense, should it come under scrutiny. Such principles might include what the World Health Organization suggested in a 1999 publication, *Ethical Practice in Laboratory Medicine and Forensic Pathology*:

> It is generally agreed that an autopsy is a procedure of ethical significance, as it interferes with the body. This significance is such that the community has a right to expect that systems are developed, within legal and resource constraints, and with community input and understanding, to ensure that the substantial potential benefits of performing an autopsy are realized and that the autopsy is not meeting only narrowly defined needs.

Thus, it is possible to conclude that simply performing an autopsy in a presumed natural-cause death to "find the cause of death" in fulfillment of an obligation in a coroner's or other act, writing a brief report which is not discussed with anyone, of which the family does not receive a copy, and the results of which are only of bureaucratic significance, does not meet this principle.

So, while this article relates to the medicolegal aspects of autopsies, these aspects are defined from more fundamental considerations and it is with these that we will be most concerned. This article will therefore provide an overview of the context and purposes for autopsies, and other aspects of their performance, including the role of pathologists.

What is an Autopsy?

"Autopsy" means "to see for oneself," and is also known as "a postmortem examination." One needs to distinguish the whole process of an autopsy from its physical performance. The former includes:

- familiarization with the medical record and/or the supposed circumstances of the death
- possible attendance at the scene
- using the results of the autopsy to contribute to reconstruction of the circumstances surrounding death or the reconstruction of the clinicopathological course of the patient's illness.

The actual performance of an autopsy entails a thorough external and internal examination of a body, using techniques similar to those employed during major surgery – certainly a modern, well-designed and well-built mortuary bears some resemblance to an operating theater. During a full autopsy all internal organs, including the brain, are removed, weighed, examined, and small samples taken for processing so they can be looked at under a microscope. Other tests may also be performed, including checking for the presence of drugs, chemicals, or toxic substances. In some cases it may be necessary to retain a whole organ for further examination, in order to investigate more fully how the person died.

In some instances partial autopsies may be undertaken. For example, where myocardial infarction or coronary artery atherosclerosis is suspected as the cause of death, a family may authorize an autopsy that is limited to examination of the chest cavity. However, the value of such limited examination is controversial. On the one hand, there is the view that the suspected cause of death may be "confirmed." On the other hand, this confirmation will always be suspect if all other possibilities, only discoverable by a full autopsy, are excluded.

The Importance of Autopsies

Forensic pathology is increasingly relied upon by judicial systems, even in countries with strong religious and cultural opposition to the performance of autopsies. There are very few, if any, countries in the world where no autopsies for forensic purposes are performed. The numbers and types of deaths investigated by autopsy vary considerably from country to country. While the disinclination on cultural or religious grounds to perform more autopsies than are absolutely necessary must be respected, this must be accompanied by caution.

In many countries, major reliance is placed on the external examination of a body by a local medical officer when investigating the cause of death. While this is clearly a reasonable screening process, it is only that. Without autopsies, there will be many cases where it will not be possible to say why death occurred: it will not be possible to disentangle and distinguish, say, between natural and accidental deaths or suicides and homicides. Even with autopsies, some cases remain enigmatic. There must be acknowledgment that coming to correct conclusions about the cause and manner of death based simply on history and external examination is a process which is inherently and substantially flawed. Judicial decisions based on conclusions about the cause and manner of death reached without the benefit of an autopsy will have a high rate of error.

Context and Purpose of Autopsies

There are normally two different contexts in which an autopsy is performed: in a hospital, or as part of a medicolegal (forensic) investigation.

A hospital autopsy is usually performed to answer questions that the family and the deceased person's doctors may have about the course of the illness, cause of death, and/or any coexisting conditions. (These are important purposes, but institutions undertaking such autopsies should also seriously consider what capacity they have to bring about some of the additional benefits associated with autopsies, see below.) In most jurisdictions a hospital autopsy must be authorized by the deceased person, before death, or by the next of kin after death. This issue of consent to hospital autopsies constitutes the main medicolegal consideration in this context.

Depending on the death investigation system in operation, a medicolegal autopsy is authorized by a coroner, medical examiner, investigating magistrate, police, or other responsible official. These autopsies are to meet particular needs, which normally are to:

- identify the deceased
- determine the medical cause of death
- determine how the death occurred.

Again the same caveat applies as for hospital autopsies in relation to delivering other potential benefits.

The circumstances in which a medicolegal autopsy is carried out vary from jurisdiction to jurisdiction. However, they normally include some or all of the following:

- homicide or suspected homicide
- sudden, unexpected death, including sudden infant death
- violation of human rights such as suspicion of torture or any other form of ill treatment

- suicide, or suspected suicide
- suspected medical malpractice
- accidents, whether transportational, occupational, or domestic
- occupational disease and hazards
- technological or environmental disasters
- death in custody or death associated with police or military activities
- unidentified remains.

This list is taken from the Recommendation on the Harmonization of Medicolegal Autopsy Rules adopted by the Committee of Ministers of the Council of Europe (no. R (99)3).

During the course of meeting the (relatively narrow) needs of both the hospital and the medicolegal autopsy, the autopsy itself or tissue or information gained from the autopsy may be of further value. The examples are given as follows:

1. For hospitals and clinicians. Providing an accurate cause of death and characterizing the pathology are essential components of clinical audit (i.e., a process to ensure that illness is being correctly diagnosed and treated). Information from autopsies also contributes to the characterization of poorly understood diseases, and the evaluation of new medical therapies, new surgical techniques and procedures.
2. For families. Diseases with genetic components may be identified so that accurate reproductive and other healthcare advice can be provided, if requested, to close family members. Also, having a cause of death provides a factual basis for counseling relatives, particularly in relation to anxiety that any action or inaction on the relatives' part contributed to the death. (These issues commonly do not surface as problems until some time after death.)
3. For administering justice. Where the issues to be decided in the civil and criminal justice systems relate to matters of illness, injury, and death, it is invaluable to be able to compare objective medical evidence with the apparent circumstances of the death and confirm or establish identity.
4. For public health. The most obvious contribution autopsies make to public health is via medical and paramedical education and research. Another contribution is through provision of more accurate causes of death, allowing mortality statistics to be a more accurate source of information for formulating government health policy. Also, investigating deaths of vulnerable individuals behind closed doors, such as in hospitals or prisons, contributes to public confidence in, and accountability of, those institutions. Information from autopsies may also be used as an early-warning system for issues of public health and safety, contributing to the prevention of disease and accidents.

Role of the Pathologist

To whom does the pathologist owe a duty? The answer to this question can sometimes be confused because the subject of the pathologist's examination is dead. The issues for most other doctors are clearer because there is a living patient. However, there is at least the argument to be made (and it is the instinctive feeling of many pathologists) that a duty is owed to the deceased, or at least to the memory or reputation of the deceased, that the true cause and circumstances of the death be revealed. If such a duty is doubted, a stronger case can be made that the forensic pathologist has a duty to the community at large, because of the trust that the community (including the deceased's relatives) has in the integrity of the medical profession generally. On that basis the forensic pathologist has a duty not to collude in wrongly hiding or obscuring the cause and circumstances of death.

The forensic pathologist's broad duty is to make sure that the cause and circumstances of the death are revealed. As with other health professionals, the more specific content of the forensic pathologist's duty is to exercise at least a reasonable degree of care and skill in his/her work, i.e., in the production of valid and useful observations and conclusions. In assessing what is a reasonable degree of care and skill, reference can be made to the practice of colleagues of similar training and expertise. However, such practice is substandard if it does not produce reliable and valid results. What this means in practical terms requires an understanding of the basic aims of the autopsy. These are:

- to discover, describe, and record all the pathological processes present in the deceased that could contribute to understanding the cause and circumstances of the death
- to relate these processes to the known medical history of the deceased to draw conclusions about the cause of symptoms and signs observed in life, and then to draw conclusions about the cause of death and other medical and nonmedical factors contributing to death
- to contribute to the reconstruction of the circumstances surrounding the death. Where these circumstances are important or likely to be in dispute, this will require consideration of the scene of the death as well as the relevant autopsy

observations, many of which may be of trivial medical consequence
- in accordance with good medical practice, to record all the relevant observations and negative findings, and to retain specimens, so that another pathologist at another time is in as good a position as possible to come to his or her own conclusions about the death
- on completion of all of the scientific and medical tests, to complete an autopsy report that contains the results of the autopsy findings together with the results of any specialist tests that may have been undertaken. In medicolegal cases, this report may be used, together with witness statements, to arrive at a legal finding with respect to the death. The pathologist may also be involved in giving evidence at any subsequent legal hearing into the death (an inquest) or other proceedings, such as a murder trial or civil proceedings relating to the death.

In terms of attendance in court, there are many pitfalls awaiting practitioners as they give evidence of their observations and conclusions. The pitfalls, or the mistakes that can be made, occur in the following areas:

- providing opinions that are at the edge of, or beyond, the expertise of the witness
- providing opinions that are based on false assumptions or incomplete facts
- providing opinions based on incomplete or inadequate scientific or medical analysis
- where failures of communication occur between expert witnesses, police, and lawyers
- providing opinions that are biased, consciously or unconsciously, in favor of one side or other in the proceedings.

The giving of evidence may be the culmination of the pathologist's work in a particular case and there is an obligation to bring to this task the same reasonable care and skill as to other aspects of the practitioner's craft. After all, it is on the basis of the evidence that important decisions will be made affecting the life and liberty of accused persons (in criminal matters) or affecting liability and compensation (in civil matters).

Managing the Mortuary

As has been alluded to, the autopsy is a unique procedure in medicine. Virtually all other procedures in almost every other aspect of medicine are performed for the benefit and with the consent of the individual. In a forensic pathology context, the deceased person's body has been taken out of the control of the relatives and the autopsy is often performed without the express consent of the deceased person (whilst alive) or the next of kin. These two factors alone place a heavy responsibility on forensic pathology systems to ensure that the autopsy is carried out in a dignified way with appropriate respect for the deceased person and the interests of the next of kin. This obligation is often expressed in relevant legislation dealing with autopsies. In discharging this obligation the following should be considered carefully:

- facilities and equipment available for the receiving and proper storage of bodies and the subsequent performance of autopsies
- facilities for the viewing of bodies by relatives
- the performance of the autopsy competently within a reasonable time of receipt of the body
- the ability of next of kin, or other properly interested parties, to be represented by an appropriately qualified person at the autopsy
- the reconstruction of the body after the autopsy
- the availability of the body for funeral purposes within a reasonable time
- the provision of the formal report within a reasonable time and its availability to next of kin and properly interested parties.

In managing the mortuary, considerable responsibility is usually given to scientific and technical staff. Historically, problems have arisen when financial relationships have developed between funeral directors (or undertakers) and mortuary staff. Such relationships are intended to ensure that the mortuary delivers funeral business to a particular undertaker, which is normally to the detriment of the next of kin. Other problems include the handling of personal property arriving with the deceased at the mortuary. This includes clothing, jewelry, and, not infrequently, considerable quantities of money. Unless the mortuary has well-documented and reliable procedures to record such property, false accusations against the mortuary can easily be made and will be difficult to refute. Such allegations, if not properly refuted, will adversely affect the reputation and credibility of the mortuary, its staff, and its work.

Retention of Tissue Samples and Whole Organs for Diagnostic Purposes

To a large extent the pathologist performing an autopsy must be relied upon to use appropriate discretion to conclude what tissue is necessary to be retained for the purposes of the autopsy. This may include both small samples of tissue and whole organs. Diagnosis is the main reason why whole organs removed at autopsy may be retained. The

necessity for this is well established. If it is suspected that there is pathology which is complex, not visible with the naked eye, otherwise difficult to find or particularly important to characterize in detail, then larger parts, the whole organ or numbers of organs, may need to be retained. For example, the examination of a fresh brain is much less satisfactory in terms of diagnostic yield than examination after formalin fixation. Efforts to speed fixation, for example with microwave techniques, have not been widely accepted or adapted. In medicolegal contexts, tissue or organs may need to be retained in case a pathologist later instructed by an interested party, or the defense, would be assisted by having access to it. It may only be in this way that the first pathologist is able to put the second pathologist in the best possible position to come to his or her own views about the death. Sometimes, retention for later more careful examination is necessary because of shortage of time at the autopsy or the need to involve treating or interested clinicians.

However, the pathologist's discretion to retain tissue must be tempered by family sensitivity to the issue of organ retention. The recent controversy has highlighted to pathology services the need to provide next of kin with information about the reasons for retaining tissue and/or organs (for hospital autopsies) to seek their consent, and involve them in decisions about their disposal once diagnostic testing is completed. (Indeed, the Human Tissue bill introduced into the UK parliament in early 2004 purports to make failure to obtain appropriate consent to retention of tissue a criminal offense.) In accordance with the wishes of the family, and where practicable, arrangements may be made to reunite organs with the body before burial or cremation. In other instances, organs may be returned for separate disposal, or with family approval, disposed of by the pathology service by its normal procedures (usually incineration as medical waste).

With respect to retention of smaller tissue samples, in most cases it seems that families are less sensitive about and are more accepting of histology blocks and slides being retained by pathology services on an ongoing basis (for accreditation purposes and in medicolegal cases, in the event of further testing or evaluation being required by a court). (In any event, in the UK, if the Human Tissue bill is passed, consent will also be required from next of kin for retention and storage of these samples.) In places where this issue is not regulated, it would be prudent for pathology services to develop and publish policies to deal with those families who are concerned about all forms of tissue retention. In this context, it is normal for the following tissue samples to be retained (where the relevant equipment and expertise are available):

- Some small specimens are retained for various tests relevant to the particular case, the results of which are available as part of the pathologist's file in the case. (The testing may be toxicological, microbiological, biochemical, immunological, endocrinological, tissue culture, histological, radiological, forensic odontological, anthropological, neuropathological, or genetic (molecular biological). Either macroscopic or microscopic photography may be employed to advance the characterization of the pathology and the recording of any of the testing. Models or casts may also be created to advance these as well.)
- Small samples of all internal organs examined are also retained to be made into histology blocks and slides for later examination under the microscope to detect conditions not visible to the naked eye, or to characterize and/or record pathology visible with the naked eye. Increasingly, these samples are required to be kept for specified periods for laboratory accreditation purposes.
- If toxicological analysis is required, then samples of blood, urine, bile, liver, and stomach contents may be retained. In special toxicological or biochemical circumstances, other fluids or tissue may be retained, e.g., lung (inhalation of volatiles), vitreous humor (alcohol level, glucose, ketones, electrolytes), kidney, hair, bone, fat, skin, or other organs or tissues.
- To cover the possibility of later requests, a small sample of blood may be retained in all nontoxicology cases.

Conclusion

The very nature of an autopsy, as well as its substantial potential benefits, makes it a significant event. In this context, the community has a right to expect that systems are developed to ensure that the wider benefits are being realized and that autopsies are not meeting only narrowly defined needs. Plainly, community understanding and input are required to ensure that autopsy procedures and the systems developed to realize their wider value accord with the law and reflect current values. This was repeatedly made clear by public concern voiced when autopsy issues reach the public domain, as in the recent "organ retention scandal" in the UK, with parallel concerns in Australia and elsewhere. The court of public opinion may not exhibit much in the way of merciful qualities. In any event, the days of "pathologist knows best," if not gone, are rapidly disappearing.

Autopsy institutions would do well, whatever the strict legalities might allow, to act on principles and follow policies which are in advance of local public expectations.

See Also

Autopsy: Procedures and Standards; Pediatric; Adult; **Death Investigation Systems:** China; Japan; Nordic Countries; Certification of Death and the United Kingdom System; United States of America

Further Reading

College of American Pathologists website at www.cap.org

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Pediatric

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Introduction

The autopsy examination may be thought of as the final history and physical conducted by a physician. It represents the last examination by a trained specialist – thus it further represents the last opportunity to document findings and procure necessary samples for laboratory testing. The autopsy examination should never be conducted as a "black box" exercise in which no information is provided. Just as in the living patient (in whom a "history" and physical are routinely conducted), a thorough postmortem examination includes a detailed account of both the recent or immediate events leading to death (the postmortem equivalent of the "history of present illness") and an account of prior pertinent events and findings (the postmortem equivalent of "review of systems, past medical history, and social history").

Because the autopsy represents the last time the patient/decedent will be examined, adequate documentation of all findings is important. It is recommended that findings be documented in multiple forms, to provide a clear representation to persons reviewing the case days, months, or years later. Most cases should be documented diagrammatically, photographically, and in written form. Many cases should be documented radiographically as well. Written documentation may take many forms, depending on the style and philosophy of the particular office and the individual pathologist. Either detailed checklists or dictated descriptive reports may suffice. Whatever the preferred style, it should be kept in mind that the goal of the written record is to allow independent interpretation by adequate description of all pertinent findings. Further documentation by photographs, radiographs, and diagrams provides other forms of illustrative documentation, and thus these serve as further records of the findings on which the pathologist relied to render medicolegal opinions. Adequate sampling of tissues for histological examination and proper procurement of tissues or fluids necessary for ancillary testing further allow adequate investigation and documentation. In general, a postmortem investigation will include three elements: (1) scene examination/investigation; (2) case history review (**Table 1**); and (3) autopsy examination. Each of these is assessed and given proper weight by the pathologist rendering an opinion regarding cause and manner of death. The individual components of a complete autopsy will vary depending on the individual case. Specific tests necessary in one particular scenario may not be germane to another case. In general, most cases will require the following components:

- gross examination and dissection
- microscopic examination of tissues
- toxicologic screening of blood and/or other body fluids.

Table 1 General definitions

Prematurity	Delivery at less than 37 weeks' gestation
Low birth weight	Birth weight less than the fifth percentile expected for gestational age
Gestational age	Age at birth measured from the first day of the last menstrual period
Postconceptional age	Total age measured from the estimated day of conception and including the postnatal age
Postmaturity	Delivery at or after 42 weeks' gestation
Neonatal period	First 28 days of life
Early neonatal period	First 7 days of life
First trimester	First 12 weeks of gestation
Second trimester	12th to 24th week of gestation
Third trimester	24th to 42nd week of gestation

Of course, there are always exceptions – for instance, microscopic examination is of no value in severely decomposed remains, and toxicologic evaluation may not be relevant in cases involving a long hospitalization interval between the precipitating event and death. In pediatric postmortem examinations, additional testing not usually undertaken in investigations involving autopsies on adults may be necessary. Such specialized tests may include postmortem metabolic screening, and radiographic skeletal surveys.

General Dissection

Gross Examination

Although the autopsy of an adult and child share certain similarities, there are important differences. The lethal diseases of infancy differ significantly from those of older children and adults, and not infrequently may require some specialized dissection techniques. The external appearance, developmental features, nutritional state, and measurements and weights of the organs and body are critically important in infants. Standard external measurements in infants and young children, in addition to the routine length and weight obtained in all postmortem examinations, may include head circumference, chest circumference, abdominal circumference, crown–rump length (CRL), and foot length. Also in addition to the weights of major organs routinely recorded in the postmortem examinations, the weights of the thymus and adrenals are recorded. Weights and proportions taken at autopsy examination are easily compared to standard tables and charts available in many reference texts.

External examination Regarding the gross description of the external body surface, examination of the infant requires notation of some parameters not routinely mentioned in older children and adults. These unique descriptors include the following:

- condition of the cranial sutures and fontanelles
- distribution of the scalp hair (premature babies may display hair over the forehead and face)
- formation and location of the ears (low-set ears may be seen as a part of Potter's facies due to oligohydramnios)
- patency of nares (newborns are typically obligate nose-breathers)
- developmental quality of the facies (abnormal facies are seen in many congenital syndromes and diseases)
- configuration of hard and soft palates
- development of nails (abnormalities are seen in ectodermal dysplasias)
- configuration of palmar creases (simian creases are seen in a higher percentage of some chromosomal abnormalities, including some trisomies)
- development of solar creases (assessment of gestational maturity)
- patency of anus.

Developmental characteristics and growth parameters are important not only to the accurate identification of certain syndromes, but may also provide clues to underlying metabolic disorders. Because many congenital syndromes may be difficult to recognize in early infancy, frontal and lateral photographs are recommended in the event that consultation with a medical geneticist is necessary.

It is important to demonstrate the spectrum and ages of all injuries not related to medical therapy by observations, diagrams, photographs, gross dissection, and microscopic examination as indicated.

Adequate gross description of injuries includes description of location in relation to stable anatomic landmarks; documentation of size, shape, and color of the injury; and proper use of terminology to define blunt-versus-sharp-force injuries. The eyes should be carefully examined to rule out the presence of conjunctival and scleral petechiae. The nasal and oral cavities should be carefully examined with an otoscope (if available) to document any injury of the mucosal surfaces. Often, it is necessary to place additional incisions along the longitudinal axes of the extremities and dorsal trunk to document blunt-force trauma. Extensive subcutaneous dissections of the chest, abdomen, and back, and limbs, if required, can assist in the identification of occult trauma. The posterior soft-tissue dissection may be accomplished through a "double Y"-shaped incision, with the first Y over the scapular region and the additional Y inverted over the buttocks.

Body weight and length The reference tables for the body weight and length are found in standard reference texts. The weight and external measurements are obtained after the body is undressed and all paraphernalia have been removed.

Body measurements The crown–heel length (CHL) is the length measured from the top of the head to the bottom of the heels with the infant fully extended in a supine (face-up) position. The CRL is measured when the infant is supine and is the distance between the top of the head and the bottom of the buttocks when the hips are flexed vertically. The head circumference is more accurately described as the

occipitofrontal circumference (OFC). The OFC is the maximum circumference of the head and is taken by positioning the measuring tape at the frontal and occipital prominence. The foot length should be obtained when estimation of gestational age is in question in a neonate. Microscopic examination of the skin, lungs, and kidneys assists in determining gestational age.

Internal examination The internal examination of the thoracic and abdominal cavities is undertaken in the same manner as that conducted in older children and adults. The procedure begins with the standard Y-shaped incision over the thorax, extending down to the symphysis pubis. An oval incision is extended around the umbilicus, which is kept in continuity with the urachal remnant, umbilical arteries, and bladder.

Body cavities and serosal surfaces The organs are examined first *in situ* – as they sit in the body cavities. The volumes and appearances of fluids in the body cavities are described. These fluids may provide information relative to the presence or severity of disorders, including cardiac failure, infections, hepatic dysfunction, renal disease, or thoracic duct injury. During the *in situ* inspection, the pathologist assesses the anatomic relations of the vessels and major organs. Specific areas of note in the examination of the infant include the distribution of the great vessels, the rotation of the gut, and the locations and relative sizes of the thymus, the liver, and the spleen.

The presence and distribution of petechial hemorrhages on the parietal and visceral serosal surfaces are noted. Petechiae limited to the thoracic cavity are a frequent and important positive, but not pathognomonic finding in sudden infant death syndrome (SIDS). Conversely, petechiae in the thoracic and abdominal cavities may signify a disturbance in coagulation, oxygenation, or acid–base imbalance.

Removal of the neck, thoracic, and abdominal organs The complete tongue is removed in continuity with the hyoid and other neck organs, including larynx, proximal esophagus, and thyroid and parathyroid glands. After removal of the thymus gland and isolation of the carotid arteries, the tongue, neck organs, thoracic, abdominal, and pelvic viscera are removed *en bloc*. This technique maintains important anatomic relationships and aids in ensuring recognition of anomalies such as total anomalous pulmonary venous connection below the diaphragm, as well as high airway obstruction or foreign bodies.

Examination of the head Examination of the head is a routine element of the autopsy in any case of sudden unexpected infant death, as an infant may be the victim of homicidal blunt head trauma without any external signs of trauma. After reflection of the scalp, any injuries visible on the inner aspect of the scalp should be documented. The cranial cap should be removed by, or under the direct observation of, the pathologist (rather than the autopsy assistant), so that parafalcine subdural hemorrhages are not missed, and so that artifactual subarachnoid blood is not overinterpreted.

Routine examination of the spinal cord is preferred, and is especially critical in cases of suspected shaking. The spinal cord and supporting musculoskeletal elements should be examined via a posterior approach in order to eliminate artifacts of dissection.

In cases of intracranial trauma, the globes and optic nerves should be examined to rule out hemorrhages of the retina, optic nerve sheath, and perineural sclera. The globes are easily removed via a superior approach through bone windows in the orbital plates. A superior approach ensures adequate optic nerve preservation.

Organ weights and measurements Organ weights are best noted while the organs are in a fresh state. The measured organ weights should be compared to the tabulated expected weights of infants with the same CHL, rather than with infants with the same weight or postnatal age. Since infant body weight can change dramatically over a short time, it is not a reliable reference for comparing organ weights. Also, since prematurely born infants will have postnatal measurements that differ from those of infants born at term, the infant's age at death is unsatisfactory for comparison of organ weights.

Cardiac valve circumferences and ventricular myocardial thicknesses may be measured for comparison to standard reference charts.

Microscopic Examination

Except in cases of severe decomposition, microscopic examination of tissues is a standard part of a complete infant autopsy. It is worth remembering, however, that microscopic sections in cases with decomposition may still yield valuable information, hence, it must be kept in mind in special circumstances. Standard sections of all major organs are routinely submitted. In the infant, these sections will be more numerous than in the standard adult autopsy. To complement the usual heart, lungs, liver, and kidney, sections in infant autopsies include three

sections of the heart (right ventricle, left ventricle, and septum), and sections of each pulmonary lobe, the thymus, spleen, skin, muscle, tracheal ring, adrenal, and costochondral junction. Additionally, the pathologist is encouraged to sample all grossly recognized pathologic processes.

Accurate pathologic diagnoses are made from optimal gross observations and high-quality microscopic sections. High-quality sections can be achieved when tissues are adequately and appropriately fixed, thinly cut, and optimally stained. All sections should be stained with hematoxylin and eosin (H&E) and other stains when indicated. Ideally, the number of sections per glass slide should be as few as economically feasible. Again, recommended blocks unique to the infant/young child include a cross-section of the larynx, the thymus, the costochondral junction of a rib, two to three sections from the heart, and sections from each lobe of the lungs. The tissues are to be fixed in 10% buffered formalin with a fixative volume to tissue ratio of 10:1.

If central nervous system pathology is suspected or the cause of death is uncertain, the brain should be fixed in 10% or 20% formalin prior to examination. Addition of a small amount of glacial acetic acid to the formalin will increase the firmness of the parenchyma, and thus facilitate sectioning.

It is important to demonstrate the spectrum and ages of all injuries not related to medical therapy by observations, diagrams, photographs, gross dissection, and microscopic examination as indicated. If timing of an injury may be important, the injury should be sampled for microscopic examination, as dating of a contusion by color is imprecise and often inaccurate.

Microscopic examination of the thymus, costochondral junction, and adrenals is recommended since they provide histopathological evidence of the alleged duration and/or severity of illness before death and allow comparison of the autopsy findings with the clinical history and death scene investigation findings. Each of these organs will show involutional changes secondary to stress from any cause over a relatively short period of time.

Discretionary microscopic sections include both hippocampi, midbrain at the inferior colliculi, pharyngeal soft tissue rostral to the hyoid, diaphragm, gastroesophageal junction, distal ileum with ileocecal valve, and colon.

Microscopic examination of the cervix, vagina, distal rectum, and anus is indicated when abnormalities or injuries are grossly identified. Postmortem dilation of the anus, with exposure of the pectinate line, should not be misinterpreted as trauma.

Toxicology and Postmortem Chemistry Studies

Postmortem toxicology studies may be invaluable in establishing a cause of death. Since the presence of many substances cannot be discerned at the time of gross autopsy examination, appropriate specimens must be obtained and retained for subsequent analysis if indicated. Obtaining blood and urine samples is mandatory, and collection of brain and liver samples is recommended. If retained, brain and liver should be frozen at –20 °C. When the death appears unnatural or suspicious, then collection of cerebrospinal fluid, bile, vitreous humor, gastric contents, and kidney tissue should be considered.

If a closed head injury is suspected, vitreous humor should not be collected until the pathologist has examined the globes to rule out retinal hemorrhages. Therefore, it is preferable to delay collection of vitreous humor until the cranial contents and vault have been examined.

Essentially all toxicology specimens require refrigeration. Blood should be stored at 4 °C and not frozen. The preservative, sodium fluoride, should be added to the blood sample. In general, other liquids and tissues may be retained in a frozen state.

Routine toxicologic screening analyses include (but are not necessarily limited to) alcohol, cocaine, narcotics, and amphetamines, and many commonly prescribed and over-the-counter drugs including acetaminophen (paracetamol), diphenhydramine, and many others. Other tests may be performed as required or indicated by the history and/or pathological findings. Results of toxicological analysis should be interpreted in light of specimen source, laboratory procedures, standard toxicological reference ranges, and clinical history and death scene investigation findings.

Vitreous humor is very useful in the postmortem evaluation of the hydration status of the decedent, as vitreous electrolytes are stable for a longer period of time than those in blood. Urea nitrogen and creatinine are quite stable in the early postmortem period. Previous studies have shown that infants dying of acute dehydration display statistically significant elevations of vitreous sodium and urea nitrogen values, thereby allowing its diagnosis.

If the globes are to be examined to rule out retinal hemorrhages, then consultation with an ophthalmologic pathologist, if available, prior to collection of vitreous fluid is recommended. We recognize that many institutions do not have access to an ophthalmologic pathologist; therefore, the prosecting pathologist must exercise careful judgment as to the best course of action to obtain and preserve important

diagnostic data. The vitreous fluid may be collected using a 20-gauge needle attached to a 5-ml or 10-ml syringe. The needle is inserted at an angle of 45°, lateral to the iris, and directed medially. The aspirated fluid should be clear and colorless. Care must be taken to prevent the needle tip from abutting the retina on the medial side.

Microbiology

All cultures and other microbiologic tests initiated prior to the infant's death should be completed in the original laboratory. Results of these studies should be reported to the forensic pathologist performing the postmortem examination.

In selected jurisdictions, microbiologic studies can be initiated in a hospital setting prior to reporting the death to the medical examiner. This is encouraged where allowed, but it is important to remember that, in other jurisdictions, no studies can be initiated until the medical examiner assumes jurisdiction and authority over the body.

During the initial stages of the autopsy, a blood culture may be collected by sterile technique. Other microbiology specimens are collected as dictated by the history and physical findings noted during the autopsy. It is recommended that blood be collected from the left heart in order to reduce the chance of postmortem contamination from intestinal flora. Direct touch preparations obtained from involved organs may be retained for Gram stain determinations or for evaluating the presence of inflammatory infiltrates. Whenever indicated, serum is retained and frozen to permit the serological identification of suspected pathogens.

Microbiologic studies, when indicated, include analysis for aerobic and anaerobic bacteria and viruses. Serum for serological analyses and tissues collected for viral cultures may be kept frozen until subsequent analysis.

When investigating deaths occurring suddenly and unexpectedly in an outpatient setting, the pathologist must remember that the body has often been exposed to room temperature conditions for an unknown postmortem interval. Previous studies have shown that the proportion of positive blood cultures increases in a linear fashion with increasing postmortem interval. Cautious interpretation of positive culture results is advised if multiple organisms are recovered, or if a site of infection is not demonstrable histologically.

Spinal Fluid by Cisternal Tap

Blind puncture of the cisterna magna is not recommended if there is a possibility of central nervous system trauma. If, however, infection of the central nervous system is suspected and trauma has been excluded, then a cisternal tap may be performed. The skin of the lower posterior skull and upper neck is sterilized with Betadine followed by 70% isopropyl alcohol or other technique. Using a sterile needle (spinal, or at least 4 cm (1½ in) long), the midline at the level of the second cervical posterior spine is punctured, angling upward 10°, aiming for the foramen magnum. Usually, a slight "give" will be felt when the needle enters the subdural space. Deeper penetration should be avoided. Typically, 5–10 ml of sterile spinal fluid can be aspirated. If trauma of the central nervous system cannot be excluded prior to intracranial examination, then, if indicated by examination, a direct culture of the meninges may be obtained upon removal of the skullcap. The meninges are incised with a sterile blade, and a sterile swab is then inserted between the meninges and the cortical surface.

Examination of the Middle Ears

The middle ears may be a source of sepsis. To examine the middle ears, remove the petrous portions of the temporal bones. Incise the lateral aspect of the petrous ridge where it is continuous with the temporal bone with bone scissors or, if necessary, a mechanical saw. Incise the bone near the sella: extend the incision anteriorly and laterally to meet the lateral incision. After these incisions are completed, the petrous bone may be removed, exposing the middle-ear cavity. Take cultures of purulent exudates if they are present.

Storage and Transportation

If specific microbiologic transport containers are unavailable for use, place tissue samples for bacterial, mycobacterial, fungal, or viral cultures in sterile containers to which 1–2 ml of preservative-free sterile saline solution has been added. Refer the sample for analysis as quickly as possible after collection.

Microbiologic results should be interpreted in light of clinical history, death scene investigation results, premortem culture results if available, specimen source, collection technique, multiplicity of organisms isolated, and the pathogenicity of the isolated organisms, as well as appropriate current medical literature.

Metabolic Disorders

Metabolic disorders must be kept in mind, especially in those cases where a cause of death is not apparent upon completion of the gross postmortem

examination. Defects in fatty acid oxidation are the most common of these disorders associated with sudden unexpected death in infancy and early childhood.

A defect of fatty acid oxidation causing an infant's death is suggested by any or all of the following features:

- acute life-threatening events (ALTEs)
- fasting hypoglycemia
- myopathy
- previous sibling affected with ALTEs, myopathy, or Reye's syndrome
- family history of "SIDS."

It is imperative, therefore, that the autopsy pathologist is aware of the medical history and carefully examines the tissues for evidence of lipid accumulation, and collects appropriate samples for definitive biochemical tests. Screening for multiple metabolic disorders can be performed if a blood standard card is collected. In cases of sudden unexpected infant death, it is recommended that two such cards be collected – one may be submitted for metabolic screening while the other may be retained as a standard in case issues of paternity or other questions arise subsequently.

The cut surfaces of the liver, heart, and muscles may be pale yellow, alerting the pathologist to fatty infiltration and the necessity to collect appropriate material for further analysis. However, in some cases postmortem tissues may not be grossly abnormal; therefore, it is recommended that routine metabolic screening be performed in all suspected SIDS cases.

Even microscopic examination of skeletal and cardiac muscle, liver, and kidney with routine H&E staining may reveal little, if any, cytoplasmic lipid. Therefore, if the history suggests a disorder of fatty acid oxidation, then staining of frozen sections of fresh tissues with oil red O may be performed. Because the laboratory results of histochemical staining of frozen tissues become available some time following the postmortem examination, it is recommended that tissues and fluids from patients suspected of having a fatty acid oxidation disorder be collected and stored in an appropriate fashion, as described below. If further investigations do not suggest a particular defect, those materials can eventually be discarded.

Due to advances in technology, it is now possible to screen for the major metabolic defects from a blood sample collected on a blood standard card. If an abnormality in β-oxidation of fatty acids is discovered on screening, suggesting medium-chain acyl-coenzyme A dehydrogenase (MCAD) deficiency, then confirmatory testing for the various mutations can be performed on retained blood, or even on paraffin-embedded tissue.

Urine

Analysis of abnormal fatty acid metabolites in urine is a diagnostic tool that may be used to detect a disorder of mitochondrial fatty acid oxidation. Only 0.1 ml is required. Most of the defects present with dicarboxylic aciduria; the only exceptions are CT and CPT deficiencies. Some defects (e.g., MCAD deficiency) have, in addition, a characteristic excretion pattern of acylglycines and acylcarnitines. Unfortunately, urine is often not available at postmortem examination; in a recent study of SIDS, urine was found to be present in only 40% of subjects even when the bladder was opened at autopsy. Personal experience of both of the authors has shown urine to be absent in the overwhelming majority of SIDS cases. However, swabbing the bladder wall with a cotton ball often provides sufficient material for metabolite analysis. If collected, urine and swab samples should be stored at –20 °C.

Blood

Blood is conveniently and safely stored on blood standard cards, which are now widely commercially available. After the blood has dried, the card may be placed in a glassine envelope or other suitable container, and stored in a cool, dry place. If a wet specimen is desired, collect 20 ml of blood into a tube with anticoagulant, then centrifuge it and store separately the plasma and cells at –20 °C. Such samples (both wet and dry) are useful for making a postmortem diagnosis of MCAD deficiency, the most common disorder of fatty acid oxidation. In such cases acylglycine and acylcarnitine conjugates are present. Blood may also be used to assist in the diagnosis of other metabolic disorders, since abnormal metabolites are likely to accumulate in the plasma.

Vitreous Fluid

Vitreous fluid has been postulated as a useful alternative body fluid for the detection of abnormal metabolites in the diagnosis of diseases presenting with organic aciduria. Analysis of this fluid for metabolites has not been evaluated completely, but a number of metabolic disorders have been identified by this means, including MCAD deficiency and glutaric acidemia type II. As stated earlier, vitreous humor should be collected after the cranial contents have been examined. If there is evidence of traumatic injury, the case should be discussed with the pathologist who will perform the microscopic examination of the globes prior to collection of vitreous.

Skin Biopsy

For genetic studies and for the evaluation of some defects that cannot be performed in other tissues, a small skin biopsy specimen should be collected under sterile conditions into tissue culture medium containing 1% dimethyl sulfoxide and frozen at –70 °C. Skin stored in such a manner can often be successfully cultured.

With an appropriate protocol of collection, storage, and sample analysis, it should be possible to ensure correct diagnosis of disorders of fatty acid oxidation presenting to the pathologist. Appropriate counseling of affected families will lead to presymptomatic sibling diagnosis of these frequently treatable disorders, which, in turn, can prevent the catastrophic metabolic consequences of the disorders.

Additional Procedures

Photographs, radiographs, and collection of trace evidence are encouraged when warranted by the investigation of the scene where the infant was found lifeless, the findings of the deputy coroners or medical examiners, or the pathological abnormalities identified during the postmortem examination.

Photography

Photographs include the case number, and a measuring device (ruler). A color code may be included when appropriate, for example, with bruises. Photographs include distant "scanning" photographs, and closer, detailed "spot" photographs of the injury or finding of interest. In the closer views, the lesion should largely fill the frame of view of the camera. The camera is held perpendicular to the body surface, so that distortion of the injury or finding is minimized. If a pattern injury is being documented, it is important to have the scale in the same plane, and immediately adjacent to the pattern injury. Documenting the injury in this way will allow future computer-generated overlay comparisons with possible items. The field of view should be considered – although the pathologist or photographer may be accustomed to seeing various dissecting instruments, blood on the autopsy table or cutting board, and other such items, these will be distracting, if not frankly disturbing to others who view the photographs later. The field of view should be "coned down" as much as possible to eliminate such distracting findings. Additionally, the background or surroundings should be cleaned of blood and tools. Further, distracting findings such as genitalia, medical hardware, or autopsy incisions may be covered with surgical towels, so that the photograph concentrates only on the physical finding of interest. Photographs showing normal body cavities and organs are of diagnostic value in excluding disorders, and enhance effective consultation by pathologists not performing the postmortem examination. They are also useful adjuncts in testimony provided during depositions and trials.

Radiography

Use of radiographs as part of the pediatric autopsy examination has several purposes and benefits. First, radiographs serve as yet another form of documentation of findings seen by the pathologist at the time of examination. Radiographic examination allows the documentation of natural normal or abnormal osseous findings. In cases of possible physical abuse, radiographs may detect otherwise occult fractures of the extremities. In cases involving abandoned newborns, radiographs document the presence of air or gas within the lungs, gastrointestinal tract, and body cavities. These findings, along with others, are used by the pathologist in rendering an opinion regarding the central question of live birth versus stillbirth. In years past, whole-body radiographs or "baby grams" were seen as helpful adjuncts to the autopsy, but these are of limited value, as this type of study does not allow the visualization of small but important findings such as injuries to the metaphyseal regions, known as classic metaphyseal lesions. Rather than a single-view "babygram," a skeletal survey, consisting of multiple views of the head, torso, and each extremity, is recommended. The skeletal survey identifies and more finely characterizes abnormalities, and allows detection of subtle but important findings such as classic metaphyseal lesions. The radiographs are appropriately permanently marked with case identifiers. If any questions or concerns arise, these studies should be interpreted with the assistance of a radiologist with expertise in pediatric and forensic medicine.

Trace Evidence

Trace evidence is to be collected in compliance with national, state, and county investigative and police policies and procedures. Proper identification and chain of evidence need to be maintained at all times. These specimens are to be collected and retained by approved methods. Examples of trace evidence that may be routinely collected by law enforcement agencies include: identification prints (of the soles of the feet in the neonate), scalp hair standards, identification photographs, and a DNA standard card. Other trace evidence will be collected as dictated by the circumstances of the individual case.

See Also

Children: Sudden Natural Infant and Childhood Death; Non-inflicted Causes of Death; **Imaging:** Radiology, Pediatric, Scintigraphy and Child Abuse

Further Reading

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Adult

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Introduction

The purpose of this article is to review the practical aspects of the adult forensic or medicolegal autopsy. It is important to recognize that in many cases a careful analysis of the interrelationship between the medical history and any prescribed treatments may provide important information required for the accurate reconstruction of the circumstances of death. In contrast to the hospital autopsy, which has as its primary object the evaluation of natural disease processes and correlations with clinical presentation, evolution of disease processes and effect of medical and surgical treatments, the adult medicolegal autopsy (forensic) has as its principal aims the determination of a series of distinct but often interrelated objectives:

1. to determine the identity of the deceased, including a description of the weight, length, physique, racial characteristics, and any physical abnormalities
2. to determine the time and place of death
3. to determine the mode of dying and the time interval between the episodes of assault and death
4. to determine the medical cause for death
5. to document in detail any and all injuries to the body and direct the photographing of such injuries
6. to determine the manner of death (murder, suicide, natural causes, etc.)
7. to collect and preserve evidence that might link an assailant with the victim
8. depending on the rules governing the consent for autopsy, to retain tissues and organs that may be required for evidential purposes
9. to collect samples that may be required for further specialist forensic examinations such as microbiological, toxicological, and DNA analysis
10. to provide a complete written report documenting all of the autopsy findings and an expert interpretation of these findings
11. to restore the body to a cosmetic condition that is in keeping with the religious and cultural traditions of the family.

In most jurisdictions the medicolegal autopsy is performed on the properly authorized instructions of a legal authority such as a coroner, medical examiner, procurator fiscal, or magistrate. The pathologist must ensure, prior to the postmortem examination, that all of the available details of the circumstances of the death are provided. The history of the circumstances of death may require modification of the autopsy procedures and will often focus attention on a particular aspect of the postmortem examination.

The actual postmortem examination has two distinct but equally important phases: the external and internal examinations.

Documentation of Findings

Comprehensive notes are essential and if dictation is used the tapes should be retained as required by the local judicial standards. Handwritten notes and diagrams must also be retained in a master file.

Pathologists are required to document all of their findings and the format of their record and autopsy protocol is often dictated by the jurisdiction in which the case is being investigated. This may be in the form of a standard preprinted format. Such printed formats, however, do not allow for the wide variations and extent of descriptions required in the forensic autopsy and should be strongly discouraged. As with the autopsy examination, the report format should allow for flexibility but should include all of the information derived from the autopsy examination, including the negative findings since in the forensic autopsy these may be as significant as positive findings. This degree of flexibility and variability of report format is readily accommodated with any of the modern forms of computer-based word-processing systems.

Most hospital autopsy reports catalog the findings based on organ systems such as respiratory system and cardiovascular system. This form of protocol is principally of value in correlating disease and treatment but may be very difficult for lawyers and lay juries to understand. A much easier format to present in court, and certainly easier for the nonmedical individual to understand, is to document the findings anatomically in much the same way that the dissection is performed. The report can be divided in to, "Head," "Neck and Chest," and "Abdomen." For example, documentation of a stab wound through the chest wall, right lung, and heart is much easier to visualize than to expect a lay juror to link apparently unrelated injuries to the skeletal system, the respiratory system, and the cardiovascular system. It is important to remember that the underlying purpose of a forensic autopsy is to communicate the findings to all of those whose role is the investigation of the death.

An autopsy protocol is provided in Figure 1; the key to any such report is complete and comprehensible documentation.

Autopsies should only be conducted in mortuaries that have adequate facilities and safety procedures. Since in many cases a full medical history may not be available, in order to protect all the staff and attendees from the possibility of infection, universal safety precautions should be applied. Photographic and X-ray facilities should be available and there should be adequate space for the examination, documentation, and if necessary, temporary storage of exhibits, and clothing.

Handling and Preservation of Evidence

It is appropriate to assume that almost all cases of trauma or unnatural death, be they murder, motor vehicle accident, or industrial accident, may be eventually the subject of either a criminal investigation or civil litigation. Because of the sophistication and extreme sensitivity of modern forensic science techniques, any material related to such cases that may be required for examination in a forensic science laboratory must be handled in such a way that it is free from contamination. The purpose of these forensic examinations may be to determine if a known and unknown sample had a common origin and it becomes the responsibility of any individual who has possession of these samples to ensure that they are properly identified, preserved, and packaged for transportation. Failure to do this may result in loss or deterioration of the exhibit and an inability to prove continuity of the sample may result in its inadmissibility in court. The normal packaging, labeling, and transportation of tissue and body fluid samples in a hospital environment will meet most of these requirements. However, problems tend to arise in connection with clothing and other nonbiological samples.

Any clothing on the body must be removed carefully, preferably without cutting, and placed in appropriate bags for drying and storage. Although it is usually not the role of the pathologist to carry out detailed examination of clothing, it is often valuable for the pathologist to identify damage such as cuts or bullet holes and relate these to injuries and marks on the body.

Each item must be separately identified in such a way that this marking does not interfere with or destroy the evidence to be examined. If it is not possible to mark the items directly, they must be placed in appropriate containers and each container sealed and marked for identification.

Every effort must be made to preserve the object (such as clothing) in the condition in which it was found. To prevent decomposition, items that are stained with blood and other body fluids need special handling. Wherever possible they should be air-dried before packaging, otherwise they should be packaged in paper containers and transferred as soon as possible to a special storage area. Blood, body fluids, and internal organ samples should be refrigerated or sent immediately to the laboratory for testing and storage.

Every item recovered must be properly packaged and labeled with the following information:

- what the item is (blood, urine, bullet)
- where it was taken from (bullet from left chest cavity)

- when it was taken (8:30 p.m., July 4, 2004)
- who took it.

The initials or signatures of all persons who have had custody of each item should be placed on the label. When samples are handed over to a police officer or investigator, a record of the name of the person to whom the exhibits are handed must be maintained by the autopsy facility, together with the date and time that the exhibits were handed over. Records of all the procedures involving the handling of autopsy exhibits in relation to any particular case should be retained as a permanent record and also incorporated in the autopsy report. Special sample kits are frequently available from forensic laboratories which take into account the particular sampling needs and technical requirements of that laboratory.

Identification

How was the body identified to the pathologist and what were the date and time of this identification?

External Examination

This phase of the autopsy may provide the only opportunity to collect contact trace evidence and

REPORT OF AUTOPSY

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Ardbeg
Tel: 08-3124-785

Date of Examination _____

Commenced at _____

Coroner _____

Autopsy Number _____ Coroner's Number _____

Deceased's Name _____ Age _____ Sex _____

Date of Death _____ Estimated Time of Death _____

PRINCIPAL PATHOLOGICAL FINDINGS:

1. Major disease or injury directly leading to death.

2, 3, 4, etc. Other major findings.

CAUSE OF DEATH:

Part 1 *a.* Terminal Event (i.e. Bronchopneumonia)
due to or as a consequence of

b. Underlying disease process or injury.
due to or as a consequence of

c. Underlying disease process or injury.

Part 2 *a.* Conditions contributing to death but not directly related to the disease process listed under Part 1.

Date: _____ Signed:

Figure 1 Standard autopsy protocol.

document and photograph injuries. It is at this stage of the postmortem examination that the nature, extent, and direction of the later internal examination may be decided. In some special cases the autopsy may be limited to external examination only without full internal examination. This should only occur in exceptional circumstances since most forensic pathologists have encountered many cases where subsequent full internal dissection has revealed injuries or disease that have significantly altered the course of the case investigation.

At the end of each postmortem examination the pathologist should be able to state that there was no evidence of any natural disease process which could have caused or accelerated death or caused collapse. If any such disease was found, then its role in the death should be considered and either included or excluded as a factor. Limited external examinations

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General Preamble:

This should include the names of all of the persons present such as police officers, witnesses, staff etc. and their roles. In routine non-criminal cases such a name list may not be required.

Identification:

How was the body identified to the pathologist including the date and time.

External Examination:

All external features should be listed as described above, including any possible identifying marks, scars or tattoos.

External injuries should be listed separately and in some cases the **internal injuries** should be described separately from the remaining of the internal examination.

SPECIAL EXAMINATIONS SUCH AS RADIOLOGICAL EXAMINATION, LASER SCANNING, OR SPECIAL FINGERPRINT STUDIES:

The results of any specialized examinations of the body should be included in the autopsy report and the phase of the autopsy examination at which any such examinations were made should be noted.

EXHIBITS:

At this point in the documentation, all external exhibits should be listed and the person to whom the exhibits were handed should be named, i.e.

The following samples were taken from the body and handed to

1.
2.
3.

INTERNAL EXAMINATION:

Head:

Scalp: Presence or absence of bruising on its under surface.

Skull: Thickness and density. Distribution and direction of fractures. Dura.

Brain: Weight, meninges. Location and extent of injuries, hemorrhages or natural disease. Cerebral vessels.

Spinal Cord: Was it examined?

Pituitary Gland:

Figure 1 Continued

should only occur with the full consent of the pathologist and authorizing legal authority and such decisions should only be made in the light of pathology staff health concerns, religious or cultural traditions of the next of kin, or resource constraints. Limiting the extent of postmortem examination should never be simply for the convenience of the parties involved.

The external examination should document and detail everything on the outside of the body, including the clothing, evidence of medical treatment, scars, tattoos, and all injuries. Patterns of blood stains on the skin and clothing should be recorded, as well as all other marks on the clothing that might correlate with patterns of injury. In all cases of suspicious death and in most cases of motor vehicle accidents the clothing should be examined prior to removal from the body for trace evidence. Routine stripping of all bodies admitted to a forensic mortuary facility by anyone other than a pathologist or qualified mortuary staff is inappropriate and may result in the loss of vital evidence.

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Neck and Chest:

Neck Musculature: Presence or absence of bruising.

Hyoid Bone and Laryngeal Cartilages: Presence or absence of fractures.

Thyroid Gland: Size and colloid content.

Pharynx and larynx: Presence of foreign material.

Rib cage: Presence or absence of fractures.

Pericardial Sac and Pleural Cavities: Presence and amount of blood or effusions.

Trachea and Main Bronchi: Presence or absence of blood, froth, mucus, etc.

Lungs: Separate weights. Presence or absence of emphysema, pneumonia, embolism, or infarction. Extent of inflation or collapse and the amount of edema fluid.

Heart: Weight, general size. Extent of dilatation of each chamber. Condition of valves and valve orifices. Thickness of right and left ventricles in millimeters and an assessment of the degree of hypertrophy. Presence or absence or scarring or infarction. The condition and distribution of the coronary arteries and the location of areas of stenosis or thrombosis. Old or recent?

Aorta and Great Vessels: (peripheral veins if required).

Esophagus:

Diaphragm:

Abdomen:

Peritoneal Cavity:

Stomach and Duodenum: Contents, presence or absence of ulcers.

Intestines:

Liver: Weight, presence or absence of cirrhosis or fatty change.

Gallbladder and Bile Ducts:

Spleen: Weight. Appearance of capsule and cut surface.

Pancreas:

Figure 1 Continued

A complete general external examination of the body is required, including:

1. documentation of height and weight
2. distribution and grading of rigor mortis
3. distribution of postmortem lividity, with a comment on any areas of pressure pallor
4. secondary lividity
5. apparent degree of fixation
6. hair color, eye color
7. presence or absence of petechial hemorrhages on the conjunctiva, eyelids, and face
8. appearance of the ears and nose
9. presence of blood or vomitus in both the nose and mouth
10. nature of dentition
11. presence of any foreign material
12. appearance of the neck, trunk, limbs, and external genitalia, including a list of needle marks, scars, tattoos, and skin rashes.

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Mesenteric and abdominal lymph nodes:

Adrenal Glands: Cortical lipid content, presence or absence of hemorrhage.

Kidneys: Separate weights. Subcapsular surfaces. Evidence of cortical thinning and or scarring.

Bladder and Ureters: Presence and approximate amount of urine.

Uterus, Tubes and Ovaries or Prostate Gland and Testes:

Skeleton:

List any bone disease or evidence or old or recent fractures.

EXHIBITS:

TOXICOLOGY RESULTS:

OTHER LABORATORY TESTS:

MICROSCOPIC EXAMINATION:

COMMENTARY:

Date: _____ Signature:

Figure 1 Continued

Any evidence of medical treatment or resuscitation, including endotracheal and nasogastric tubes, airways or surgical marks, or incisions on the body should be fully documented. It is strongly advised that all such evidence of medical intervention should remain undisturbed until the body has been viewed by a pathologist and that all medical appliances should remain with the body until that time.

Injuries should be described separately.

External Injuries

Since documentation of injuries is a key part of the autopsy examination, it is usually advisable to shave the scalp hair so that all scalp wounds can be visualized. Palpation of scalp wounds through the hair is not sufficient and will not allow for the recognition and documentation of patterned scalp bruises. These should be listed systematically by anatomical location and numbered. The exact location should be related to a particular part of the body, i.e., head, right arm, front of trunk, left leg, and the specific site of injury should be measured from a fixed part of the body, i.e., sternoclavicular joint, elbow, ankle.

The description should include the size, shape, color, and nature, i.e., bruise, abrasion, laceration, stab wound.

For example, a horizontal linear abrasion 6.0 cm long on the left side of the neck extending from a point 5.0 cm below the chin to the left jaw angle; or a stab wound 1.8 cm long situated on the left side of the chest, 4.0 cm below and 3.0 cm to the right of the right sternoclavicular joint. (This wound was directed downwards to the left at approximately 45° to the horizontal, gaping by 5.0 mm with a narrow rim of abrasion 1.0 mm wide. Its medial end curved vertically downwards and was pointed. Its lateral end was rounded.)

Internal Injuries

In some circumstances, it is appropriate to describe the internal injuries separately from the general internal examination, e.g., when relating to the effects of stab wounds which may have passed through several organ systems. The same may apply to gunshot wounds. This decision should be based on the ease of a nonmedical person's ability to understand the extent of internal injury.

Internal Examination

The nature and extent of internal examination in a forensic autopsy are similar to that for the hospital autopsy, although the order in which the body cavities will be examined is determined by the nature of the case and the needs of the particular investigation. For example, it is important that the brain be removed before dissecting the neck structures in a case of suspected neck injury.

The chest and abdomen are usually opened by a Y-shaped incision from the tip of the shoulders to the sternomanubrial joint and then carried vertically downwards to the symphysis pubis. In hospital cases the Y-shaped incision is often made below the breasts. This is inappropriate for a forensic autopsy, since it does not allow for proper examination of the neck structures. The chest plate is removed as a triangle, including the costal cartilages and the sternum. Whether the internal organs are removed as a single block or in separate organ groups will depend on the practice and training of individual pathologists and the needs of the particular case.

In practice, it is often best to remove the neck and chest organs as a single block and then, after ligating the jejunum, the liver, spleen, pancreas, stomach, and duodenum can be removed as a separate block. The gastric contents should be described and appropriate samples of body fluids taken for toxicological analysis as required. The aorta and retroperitoneal tissues can then be removed and the pelvic organs may be left *in situ* for further dissection if required.

Access to the brain is achieved by a coronal incision across the top of the scalp from behind each ear. If this incision is well behind the vertex, reflection of the scalp is often made easier and the final cosmetic result much better. It is important to expose the posterior subscalp tissues so that all subscalp and galeal injuries can be recorded.

A pathologist must be prepared to defend any decision not to undertake a particular part of the postmortem examination, including histological examination and radiology.

Special Dissection Techniques

As far as possible, all special dissections should be performed in a bloodless field, i.e., the brain should be removed before neck dissection, and in pelvic dissections the pelvis should be elevated after the thoracic and abdominal organs have been removed by placing a block under the lumbar vertebrae. Representative sections from all areas of injury should be taken and labeled specifically for the site of origin. It is also important that photographs should be taken at all stages of these dissections and the autopsy report should reflect the nature and extent of the special dissections that have been performed.

Anterior neck dissection This should be performed in all cases of suspected neck injury.

- The skin should be reflected to expose the sternomastoid muscles and the external jugular veins. This is best achieved with lateral neck incisions extending from the mastoid processes vertically downwards and then carried anteriorly and medially below the sternoclavicular joints to the midline below the manubrium. In many jurisdictions such incisions are unacceptable and it may be necessary to perform the traditional Y-shaped incision from the front of the shoulder to the sternum. Unfortunately, in cases of severe obesity this will not allow a good exposure of the higher anterior neck structures. The other traditional opening incision under the breasts should not be used for careful neck dissection.
- Layer-by-layer dissection of the neck musculature *in situ* should commence with reflection of the sternomastoid muscles and by incising their sternal and clavicular insertions. The omohyoid, sternohyoid, and sternothyroid muscles should then be removed to expose the thyroid gland.
- The thyroid gland should next be removed to expose the cricothyroid muscle and any bruising or injury to the hyoid bone or laryngeal cartilages should be noted and sampled.
- Next, identify the common carotid arteries and their bifurcations and note any associated adventitial bruising or hemorrhage.
- Incise the digastric muscles, free the tongue from the mandible, and remove the neck structures by retracting on the tongue. Do not hold or compress the laryngeal structures.
- Finally note any injury or bruising on the posterior pharyngeal or laryngeal structures or on the anterior surface of the cervical vertebrae.

Posterior neck dissection This is a valuable technique to examine for posterior neck injury or to expose the vertebral arteries either for angiography or for evidence of traumatic subarachnoid hemorrhage.

- Expose the posterior neck musculature by a vertical midline posterior incision with bilateral extensions at the level of the occipital protuberance.
- Perform a layer-by-layer dissection from above downwards, cutting the splenius capitis, the semispinalis capitis, the posterior insertion of the sternocleidomastoid muscle, and the trapezius.
- The vertebral arteries are seen within a deep triangle formed by the superior oblique muscle laterally, the rectus capitis posterior major medially, and the upper border of the posterior arch of the atlas with the inferior oblique muscle covering the lower border of this bony arch.
- The first cervical nerve may be seen immediately below the vertebral artery crossing the upper border of the posterior arch of the atlas.

This is a difficult dissection and, if the body has been lying on its back for some time after death, the tissues may be edematous and very congested due to lividity. If necessary, leave the body on its front for at least 30 min after dissecting the skin before continuing to expose the deeper neck structures.

Facial Dissection

In suspected cases of smothering, facial fractures, or other facial injury, this technique allows for a good demonstration of the extent of injury in the periorbital or maxillary areas. It also allows for the reconstruction of the facial tissues after dissection without significant disfigurement. Dissect only one side of the face at a time.

- Join the inferior ends of the coronal scalp incisions to the upper lateral extensions of the chest incisions.
- Dissect forwards, incising the external auditory canal and in a vertical plane dissect off the skin to expose the parotid gland and the zygomatic arch and then dissect anteriorly, superficial to the fatty tissue over the facial musculature.
- Carefully enucleate the eye from behind the skin flap, taking great care not to buttonhole the eyelids or to perforate the eyeball.
- Dissect along the margin of the mandible to the midline and dissect off the lips by cutting through the buccal mucosa behind the skin flap.
- Complete the dissection by exposing the lateral aspects of the nasal bones and nasal cartilage.
- It is most important that the lateral dissection should not be extended across the midline to allow for a vertical line of fixation of the facial structures essential for the reconstruction of the face without disfigurement.

Pelvic Dissection

This technique is essential in any case of alleged pelvic injury, rape, or sodomy. Using this technique it is possible to visualize and photograph not only mucosal injuries to the vagina and rectum but also perivaginal and perirectal injuries and injuries to the sphincters and the muscle floor of the pelvis. Speculum examination alone does not provide this degree of visualization.

- In order to ensure a bloodless field, all of the internal organs, except the pelvic organs, should be removed and the pelvis should be elevated by placing a block under the sacrum.
- Extend the abdominal incision vertically downwards to the root of the penis or clitoris and reflect laterally to expose the symphysis pubis and pubic rami.
- With a saw, cut through the superior pubic rami and then extend the saw cut downwards and medially through the inferior pubic rami. Removal of this central wedge of bone will expose the bladder and urethra intact.
- Open the urethra into the bladder and then dissect off the bladder and urethra to expose the anterior wall of the vagina.
- Open the vagina and expose the cervix. At this stage it will be possible to visualize the state of the hymen and any old or recent vaginal injuries. It is also possible to take additional vaginal swabs if necessary.
- Next, dissect the vagina from the anterior surface of the rectum and remove together with the uterus, tubes, and ovaries.
- The final stage is to open the anus and rectum and then remove them to display the posterior aspect of the floor of the pelvis.

Exhibits

At this point document all internal samples such as blood, urine, and gastric contents as in the external exhibit list and check against the list of exhibits prepared by the individual responsible for receiving all of the exhibits.

Toxicology Results

Since these results are not necessarily going to form a part of the evidence of the forensic pathologist in homicide cases, such results should not be automatically included in the autopsy report.

Other Laboratory Tests

Biochemistry results, microbiology and viral studies, and diatom studies should be included if they form a part of the opinion as to the cause or manner of death.

Reports by special consultants such as neuropathologists should either be appended to the autopsy report or incorporated into the report.

Microscopic Examination

In most cases microscopic examination of all of the major organs should be carried out. Histology will not only confirm the gross findings but will allow for the evaluation of natural disease processes and in the case of injuries allow for an assessment of the age of the injury and compare it with other injuries to the body. While the accurate timing of injuries may be difficult, this microscopic comparison may be very important in the overall evaluation of the significance of injuries.

Summary Opinion or Commentary

The purpose of the commentary is to combine a medicolegal opinion of the autopsy findings with an explanation of the disease or injury processes leading to death. This should be written in such terms that the findings and conclusions can be readily understood by a nonmedical person and yet should be scientifically accurate. Such a commentary should be able to be read out in court so that a jury will have a complete understanding of the medical aspects of the case, the significance of any injuries, and how these relate to the death and any assault.

This commentary should start with a statement as to whether or not the death was natural and, if unnatural, whether or not there was any natural disease that may have contributed to the death. It should be possible for the pathologist to state that there was no natural disease to cause or accelerate death or to cause collapse, and if the pathologist cannot make this statement, he/she should explain why.

The next part of the commentary should explain the disease process or injuries which directly led to the death and should represent a simple explanation of the sequence of events already listed in the "Principal Pathological Findings" shown on the front page of the report and also listed under Part 1 of the "Cause of Death" (Figure 1).

Any contributory conditions or injuries should be described next and how these may or may not have contributed to death or the assault.

Any other major disease processes should be explained and if they did not play a part in the death, this should be stated.

Did the toxicological analysis reveal any findings such as evidence of alcohol intoxication which could have contributed to death?

See Also

Autopsy: Medico-legal Considerations; Pediatric

Further Reading

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Infectious

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Introduction

The infectious autopsy, or high-risk autopsy, is defined as the postmortem examination of a deceased person who has had, or is likely to have had, a serious infectious disease that can be transmitted to those present at autopsy, thereby causing them serious illness and/or premature death. Many infectious diseases present autopsy prosecutors and laboratory personnel with risks for postmortem acquisition of infections (**Table 1**). The prevalence of human immunodeficiency virus (HIV) infection, hepatitis B, and hepatitis C in forensic autopsy populations is much higher than in the general public because of an overrepresentation of intravenous drug abusers among decedents subjected to autopsy. In addition, these infectious diseases and tuberculosis are frequently asymptomatic or clinically undiagnosed and may be present without morphological evidence at autopsy. In fact, occupational infections of HIV, hepatitis B virus (HBV), hepatitis C virus (HCV), and *Mycobacterium tuberculosis* have been realized as a serious concern among forensic autopsy workers. In forensic investigations, however, autopsy of the victims is deemed essential to determine the cause and manner of death even when the deceased person had highly contagious pathogens. Furthermore, forensic autopsy plays an important role in diagnosing such infectious diseases and thus provides vital information on the epidemiology and pathogenesis. This section reviews the current state of our knowledge of the frequently concerned occupational infections, HIV infection in particular, and provides preventive measures, including postexposure managements.

HIV Infection

Background

Since the first case reports of acquired immunodeficiency syndrome (AIDS) appeared in 1981, HIV infection and AIDS have become a global pandemic with an estimated 42 million people living with the virus worldwide in 2002. Although many countries have developed national strategies to prevent HIV infection, the number of infected people is still increasing, notably in sub-Saharan Africa, where

Table 1 Infectious diseases and agents that can be transmitted at autopsy

Viruses
Human immunodeficiency virus (HIV)
Viral hepatitis (hepatitis B virus, hepatitis C virus)
Human T-cell lymphotropic virus (HTLV)
Viral hemorrhagic fevers (Lassa, Marburg, Ebola, and Crimean-Congo hemorrhagic fevers)
Rabies
Smallpox
Bacteria
Tuberculosis
Meningococcal infections
Streptococcal infections
Anthrax
Plague
Tetanus
Legionnaires' disease
Typhoid fever
Paratyphoid
Tularemia
Diphtheria
Erysipeloid
Glanders
Scrub typhus
Fungi
Blastomycosis
Coccidioidomycosis
Protozoon
Toxoplasmosis
Prion
Creutzfeldt–Jakob disease

Table 2 Risk factors of human immunodeficiency virus (HIV) infection

Unprotected sexual contacts (homosexual and heterosexual)
Intravenous drug abuse
Transfusion of blood or blood products
Newborn baby of mother at risk of HIV infection
Occupational exposure to blood or body fluids (healthcare and autopsy workers)

29.4 million people are infected with the virus. Currently, two types of HIV are known: HIV-1 and HIV-2. HIV-1 infection constitutes the majority of patients in the world. HIV-2 infection is primarily seen in West Africa. Both types of HIV are transmitted through sexual contact and exposure to infected blood or blood components and perinatally from mother to neonate (Table 2).

HIV infection is diagnosed by detecting antibodies specific to the virus, or by detection of the virus itself, through the p24-antigen, by nucleic acid-based tests, or if necessary by culture and virus isolation. HIV-infected individuals develop an antibody response to HIV proteins, and detection of these antibodies is the basis of screening assays. The usual combination of diagnostic assays is an initial screen with enzyme-linked immunosorbent assay (ELISA) followed by confirmatory testing of reactive specimens with a Western immunoblot. ELISA is a reliable screening method with high sensitivity and specificity. A false-negative result can occur if the patient has not yet seroconverted, following acquisition of HIV infection, during the so-called window period. The other cause of a false-negative is very advanced HIV disease, when the patient may lose the ability to make HIV antibodies. Following the occasional detection of HIV-2 outside the geographical regions with the highest prevalence of HIV-2, HIV-2 detection has been incorporated into many commercial ELISA systems.

HIV primarily infects $CD4^+$ T-lymphocytes and cells of the monocyte/macrophage lineage. The loss of $CD4^+$ T lymphocytes plays a role in the pathogenesis of immune deficiency related to HIV infection. As the number of $CD4^+$ T-lymphocytes declines, immune dysfunction eventually becomes apparent in infected persons. Following transmission, there are three clinical stages of infection: (1) primary infection; (2) a clinically latent asymptomatic period; and (3) clinical progression leading to AIDS. AIDS is defined by a $CD4^+$ T-lymphocyte count of less than 200 cells per μl or the clinical or histopathological presence of opportunistic diseases indicative of profound immunodeficiency.

HIV and Forensic Autopsy

In forensic autopsy, the prevalence of HIV infection is considered to be higher than expected from health statistics, mainly because intravenous drug abusers are one of the risk groups of the infection, and their lifestyle brings them into the medicolegal jurisdiction. The detection of HIV infection, identification of route of infection, and diagnosis of AIDS have medicolegal significance to determine and document the cause and the manner of death. Autopsy could also reveal clinically undiagnosed infectious diseases and neoplasms other than the primary cause of death and help in epidemiological studies, quality assurance activities in assessing diagnostic, or treatment modalities. For example, the forensic autopsy is the only means of determining the range and prevalence of opportunistic diseases and has an immediate impact on patient management where the hospital autopsy is rarely performed. The forensic autopsy of asymptomatic persons who died of unsuspected causes of death other than AIDS has contributed to the understanding of the pathogenesis of HIV disease progression. Furthermore, the identification of HIV-infected subjects at autopsy affords the opportunity for surviving sexual or needle-sharing partners to undergo early testing and counseling and to commence an early therapeutic intervention, thus avoiding further dissemination of infection within the community.

At autopsy, collection of blood and tissue samples is of value for the diagnosis of HIV infection and AIDS. Because immunoglobulins are less likely to be affected by postmortem changes, HIV antibody testing is effective in serum samples taken from bodies even with putrefaction due to prolonged postmortem intervals. A study shows that ELISA is consistently repeatedly positive in cadaveric sera from AIDS patients, with postmortem intervals ranging from 5 h to 58 days; a false-positive result is not observed in specimens from noninfected persons despite prolonged postmortem intervals producing hemolysis. Histopathological diagnosis of AIDS is made according to the criteria in HIV-infected persons with specific opportunistic infections, neoplasms, or AIDS dementia complex (Table 3). Legal guidelines for HIV testing and reporting to public health authorities, where applicable, should be followed. Pathologists should maintain the confidentiality of HIV status on autopsy reports to the greatest extent possible.

The potential for occupational transmission of HIV is a serious concern among pathologists and mortuary staff as well as laboratory personnel who may deal with postautopsy samples. In clinical settings, most occupational HIV infections among healthcare providers are the result of needlestick or other sharps

Table 3 Opportunistic infections, neoplasms, and acquired immunodeficiency syndrome (AIDS) dementia complex in AIDS

Opportunistic infections
Viruses
Cytomegalovirus disease and retinitis
Progressive multifocal leukoencephalopathy (papovavirus infection)
Herpes simplex (chronic ulcer, bronchitis, pneumonitis, or esophagitis)
Bacteria
Recurrent pneumonia
Mycobacterium tuberculosis (pulmonary or extrapulmonary)
Mycobacterium avium complex or *M. kansasii* (disseminated or extrapulmonary)
Mycobacterium, other or unidentified species (disseminated or extrapulmonary)
Recurrent *Salmonella* septicemia
Fungi
Candidiasis of esophagus, bronchi, trachea, or lungs
Cryptococcosis (extrapulmonary)
Histoplasmosis (disseminated or extrapulmonary)
Coccidioidomycosis (disseminated or extrapulmonary)
Protozoa
Pneumocystis carinii pneumonia
Toxoplasmosis of brain
Cryptosporidiosis (chronic intestinal)
Isosporiasis (chronic intestinal)
Neoplasms
Kaposi's sarcoma
Lymphoma
Cervical cancer of uterus, invasive
AIDS dementia complex
HIV encephalitis
HIV leukoencephalopathy
Diffuse poliodystrophy
Vacuolar leukoencephalopathy
Cerebral vasculitis
Other
Wasting syndrome

HIV, human immunodeficiency virus.

injuries. A small number of HIV seroconversions following mucous membrane or nonintact skin occupational exposure have also been reported. A scalpel injury during hospital autopsy and seroconversion thereafter in a pathologist has also been reported. Although the estimated risk of HIV infection following occupational exposure to blood or body fluids is only 0.3%, the risk of transmission in a specific situation is likely to vary, depending on the circulating viral titer in the source case, volume of blood injected, depth of penetration, and immune status of the exposed person.

The corpses of infected persons remain potentially contagious with HIV even after a prolonged postmortem interval and have no safe time at which they cease to be an infective risk. Viable HIV is successfully isolated from the blood of nonrefrigerated cadavers at least 36 h after death and of refrigerated cadavers kept at 2 °C at least 17 days postmortem. Autopsy specimens such as blood, body fluids, and fresh tissues are also a potential source of infection. An experimental study shows that HIV suspended in serum remains infectious for several weeks at room temperature (20–28 °C); infectivity remains evident for several days even when dried on a glass coverslip. HIV is inactivated after being exposed to commonly used chemical germicides. A solution of sodium hypochlorite (household bleach) is also an effective germicide; concentrations ranging from 500 ppm (1:100 dilution of household bleach) to 5000 ppm (1:10 dilution of household bleach) are effective depending on the amount of organic material (e.g., blood, mucus) present on the surface to be cleaned and disinfected.

Forensic pathologists can safely examine patients with HIV infection by using well-established techniques for autopsy performance. However, creating a zero risk of blood exposure due to cut or needlestick injuries is not a realistic possibility in routine forensic practice. The prophylactic effect of antiretroviral drug is proved by a clinical trial in which treatment of HIV-infected pregnant women with zidovudine significantly reduced the rate of transmission of HIV to their babies. A three-drug regimen, including two nucleoside analog reverse transcriptase inhibitors and a protease inhibitor, effectively reduces the HIV replication in blood. Based on these rationales, postexposure prophylaxis with at least two antiretroviral drugs is recommended for individuals who have been exposed to blood infected with HIV. All antiretroviral drugs are associated with adverse events, especially gastrointestinal symptoms. Pathologists who have suffered a significant parenteral or mucous membrane exposure should carefully weigh the low rate of becoming infected with HIV and the adverse events of chemoprophylaxis.

In forensic autopsy, the identification of HIV-infected patients is difficult without knowing clinical information or the result of preautopsy serological testing. Chemoprophylaxis should be considered when the percutaneous blood exposure occurred during autopsy of individuals with gross clues of HIV infection such as generalized ill appearance, lymphadenopathy, or needle tracks. Chemoprophylaxis should be initiated promptly, preferably within 1–2 h postexposure, to maximize the chance of efficacy. This means that forensic pathologists cannot afford the time to consult individuals who have expertise in antiretroviral therapy once the exposure event has occurred. Although the frequency of occupational exposure of HIV-infected blood in forensic autopsy must be quite low and HIV is not highly infectious, forensic institutions should communicate in advance

with the local hospital regarding the postexposure chemoprophylaxis. Postexposure counseling and follow-up intervention by experienced care providers familiar with the special medical and psychologic needs are also essential for exposed persons.

Hepatitis Viruses

Acute viral hepatitis is caused by one of the five viral agents: (1) hepatitis A virus; (2) HBV; (3) HCV; (4) hepatitis D virus; and (5) hepatitis E virus. In these, HBV and HCV can be transmitted by occupational percutaneous inoculation or transmucosal exposure to blood or body fluids of infected cadavers at autopsy. HBV and HCV are more infectious than HIV; the risk of infection following a percutaneous exposure to infected blood is 5% for HBV (HBeAg-negative source), 19–30% for HBV (HBeAg-positive source), and 1.8–10% for HCV, as compared to 0.36% for HIV. The most feared complication of viral hepatitis is fulminant hepatitis (massive hepatic necrosis): the mortality rate of fulminant hepatatis is greater than 80% in patients with deep coma. Fulminant hepatitis is a rare event and is primarily seen in HBV infection. Over 90% of individuals with acute hepatitis B have a favorable course and recover completely. However, acute hepatitis C has a poor prognosis, with at least 80% of infected individuals progressing to a carrier state leading to chronic liver disease with cirrhosis and even hepatocellular carcinoma.

Effective vaccines and specific immunoglobulins are widely employed to offer protection against HBV infection. For preexposure prophylaxis against hepatitis B, all personnel involved in autopsy work should have their HBs antibody status checked and should receive hepatitis B vaccine. Postexposure prophylaxis with hepatitis B immunoglobulin and/or hepatitis B vaccine should be considered for exposure to HBV after evaluation of the vaccination and the vaccine response status of the exposed person. No equivalent vaccine or immunoglobulin has been developed against HCV infection to date.

Tuberculosis

Tuberculosis caused by *Mycobacterium tuberculosis* usually affects the lungs, although in up to one-third of cases other organs are involved. Beginning in the mid-1980s in many industrialized countries, the number of tuberculosis case notifications, which had been falling steadily, stabilized or even began to increase. A major factor in this upsurge is an epidemic of tuberculosis among immunocompromised persons with HIV infection and the emergence of multidrug-resistant strains. Transmission of *M. tuberculosis* usually takes place through the airborne spread of droplet nuclei produced by patients with infectious pulmonary tuberculosis. It is estimated that staff of laboratories and autopsy rooms are between 100 and 200 times more likely than the general public to develop tuberculosis.

Because infectious aerosols are likely to be present in autopsy rooms, such areas should be at negative pressure with respect to adjacent areas, and the room air should be expelled directly to the outside of the building. Downdraft autopsy tables, ultraviolet irradiation to the air, and high-efficiency particulate air filtration are also recommended in autopsy rooms. The mask is particularly important to prevent tuberculosis. These masks should not be the standard surgical masks, but instead a high-efficiency particulate air-filtered respirator (N-95 respirator). Cutting into tissues, especially lungs, is particularly hazardous. Inflating both lungs with formalin and postponing dissection for 48 h can reduce the spread of infectious aerosols. All persons involved in autopsy work should have periodic purified protein derivative (PPD) skin testing. For individuals with latent tuberculosis infection identified by PPD skin test, intervention with isoniazid greatly reduces the risk of progressing to active disease.

Risk Reduction: Infection Control

Healthcare providers in hospitals can reduce their risk of exposure to blood and body fluids through the use of basic safety measures, barrier precautions, and technologically safer instruments. In 1985, a set of infection control guidelines known as “universal precautions” was issued to prevent or minimize the risk of occupational exposure to bloodborne pathogens. Universal precautions are based on the premise that all patients are potentially infectious, and include: (1) the use of gloves for procedures where contact with blood and body fluids might occur; (2) the use of masks and protective eyewear when splatter of body fluids is anticipated; and (3) the use of gowns or other protective garments when clothing is likely to be soiled. In 1989, another system of infection control procedure called “body substance isolation” was proposed, which implemented barrier precautions to all moist body substances, including tissue and feces, not just certain body fluids and blood-tinged body fluids. Both universal precautions and body substance isolation emphasize the prevention of sharp injuries and the use of barrier protection to avoid exposure to potentially infectious materials, and neither requires labeling of patients

or specimens for implementation. In 1996, guidelines for isolation precautions in hospitals were developed, which synthesized the major features of universal precautions and body substance isolation into a single set of precautions called "standard precautions," and added transmission-based precautions designed to reduce the risk of airborne, droplet, and contact transmission in hospitals.

Forensic autopsy workers can minimize their risk of occupational infections by following the policy of standard precautions:

1. All cadavers should be treated as potentially infectious, regardless of their known infectious states, as should all surfaces and equipment used during autopsy.
2. All fluid and tissue specimens should be considered potentially infectious.
3. Postmortem procedures for all patients should include complete protective wear for anybody in the autopsy room who is at risk for fluid or tissue contamination.
4. Instruments and surfaces contaminated during postmortem procedures should be decontaminated with an appropriate chemical germicide.
5. All specimens should be put in a well-constructed container with a secure lid to prevent leaking during transport. Requisition forms attached to the cadaver or specimens need not contain any reference to the patient's infectious status, since standard precautions procedure should be used by all mortuary attendants and laboratory personnel.

Autopsy precautions should be directed at the prevention of sharps injuries, mucocutaneous contact with body fluids, and aerosol inhalation. Exposure may be prevented by using appropriate gloves, goggles, or face shield, cap, gown, apron, and shoe covers. The rate of occupational injury sustained during performance of autopsies is reported to be one in 11 autopsies performed by residents and one in 53 autopsies performed by staff pathologists. Injuries to the hands are most common, particularly on the palmar surfaces of the thumb, index finger, and middle finger of the nondominant hand, which typically retract tissue during autopsy. Metal and synthetic mesh gloves mitigate the risk of scalpel injuries, but may not protect against needle punctures. Additional measures, such as the use of round scalpel blades, blunt-tipped scissors, and placement of towels over sharp bony projections, are recommended. A vacuum-equipped oscillatory saw should be used to remove the calvarium to prevent aerosolization of bony dust and pathogens. In high classifications of airborne infections, a high-efficiency particulate air-filtered respirator or a powered air-purifying respirator should be worn. Training and education in the prevention of sharps injuries, respiratory protections, and adherence to standard precautions help to prevent occupational infections at autopsy.

Postexposure Management

For postexposure management, wounds and skin sites that have been in contact with blood or body fluids should be washed with soap and water; mucous membranes should be flushed with water. No evidence exists that using antiseptics for wound care or expressing fluid by squeezing the wound further reduces the risk of bloodborne pathogen transmission. Serology testing of the source and the exposed person for HIV, HBV, and HCV should be examined. Baseline serology for the exposed person will show the individual to be previously uninfected by any of the viruses and the existence of protective immunity for HBV. Occupational exposure should be considered an urgent medical concern to ensure timely postexposure management and administration of hepatitis B immunoglobulin, hepatitis B vaccine, and/or HIV chemoprophylaxis (Table 4).

Table 4 Transmission, risk of infection, and pre- and postexposure prophylaxis of postmortem-associated acquisition of infections

	HIV infection	*Hepatitis B*	*Hepatitis C*	*Tuberculosis*
Transmission	Bloodborne	Bloodborne	Bloodborne	Airborne
Risk of infection	0.3%	5% (HBeAg-negative source) 19–30% (HBeAg-positive source)	1.8–10%	High
Preexposure prophylaxis or precaution[a]	None	Hepatitis B vaccine	None	Negative-pressure N-95 respirator PPD skin testing
Postexposure prophylaxis or intervention	Antiretroviral drugs	Hepatitis B immunoglobulin Hepatitis B vaccine	None	Isoniazid

HIV, human immunodeficiency virus; HBeAg, hepatitis Be antigen; PPD, purified protein derivative.
[a]All bodies should be placed into standard precautions.

Prevention of Other Infections

Creutzfeldt–Jakob disease (CJD) is a neurodegenerative disease that is caused by infectious proteins called prions. CJD typically presents with progressive dementia and myoclonus, and usually results in death within a year of onset. Sporadic, genetic, and infectious forms of CJD have been recognized. Accidental transmission of CJD appears to have occurred with corneal transplantation, contaminated electroencephalogram electrode implantation, and surgical procedures. Epidemiological studies show no increased risk for healthcare workers. Because prions present at highest levels in the neural tissue, the main concern for infection in the context of autopsy is accidental parenteral inoculation with neural tissues at autopsy and neuropathological examinations. Precautions against possible infection should be taken to the autopsy of patients with rapidly progressing dementia; the brains of patients with CJD frequently have no recognizable abnormalities on gross examination. Prions are extremely resistant to common inactivation procedures. Inactivation of prions is not completed with formalin, but only with formic acid in formalin-fixed tissues. Autoclaving at 132 °C for 5 h or treatment with 2 N NaOH for several hours is recommended for sterilization of instruments.

Viral hemorrhagic fevers (Lassa, Ebola, and Marburg hemorrhagic fevers) are endemic in sub-Saharan Africa, but can be imported into other countries by infected international travelers. Prosecutors have died of autopsy-transmitted viral hemorrhagic fever. Moreover, the potential use of Ebola hemorrhagic fever, anthrax, and plague as biological weapons is of great concern. Strict standard precautions should be used at autopsy of bodies suspected with these infectious diseases. Negative-pressure rooms and high-efficiency particulate air-filtered respirators are also recommended in cases of viral hemorrhagic fever and plague.

See Also

Autopsy: Procedures and Standards; Medico-legal Considerations; **Occupational Health:** Autopsy

Further Reading

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