Health and safety at necropsy

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The postmortem room is a source of potential hazards and risks, not only to the pathologist and anatomical pathology technician, but also to visitors to the mortuary and those handling the body after necropsy. Postmortem staff have a legal responsibility to make themselves aware of, and to minimise, these dangers. This review focuses specifically on those hazards and risks associated with the necropsy of infected patients, with foreign objects present in the body, and with bodies that have been contaminated by chemicals or radioactive sources.

“Quidquid agis, prudenter agas, et respice finem.” (Whatever you do, do cautiously, and look to the end.) Anon.

“The chapter of knowledge is very short, but the chapter of accidents is a very long one.” Lord Chesterfield, 1694–1773.

The mortuary can be a dangerous place. Most dangerous in this environment is the individual who is ignorant of, or who ignores, the potential hazards at necropsy. Such people are a liability to themselves, colleagues working in the mortuary (pathologists and anatomical pathology technicians (who have the highest rate of necropsy related morbidity)), visitors to the mortuary (clinical staff and students), and those involved in handling the body (relatives, funeral directors, embalmers, and crematoria staff), or material derived from it (laboratory workers) after necropsy. The decline in mortality acquired infections such as tuberculosis and blood borne hepatitis in the past 25 years can be largely attributed to the increased awareness and adoption of safe working practices.

There is a considerable body of literature and legislation pertaining to the design and provision of a safe working environment and safe working practices within the mortuary. It is not my intention to focus on this, because such general principles have been discussed in detail elsewhere. Neither will I discuss general aspects of laboratory health and safety, such as handwashing, how to handle sharps, or the prohibitions on eating, drinking, smoking, and the application of cosmetics that apply in the mortuary. Instead, this review will focus on specific dangers faced at necropsy. Such dangers include: the acquisition of “category 3” risk pathogens; injuries (with the concomitant dangers of haemorrhage and sepsis) and electrocution; and finally (but rarely) poisoning, as a result of chemicals and/or radiation. Consequently, this review discusses the “high risk” (of infection) necropsy, dangerous foreign objects, and the contaminated body. First, however, it is useful to consider the nature of risks and hazards.

RISKS AND HAZARDS

Although these terms are often used interchangeably, they are not synonymous in the context of health and safety. The danger of injury posed by a slippery floor, the sharp corner of a table, the blade of a knife or saw, or the point of a needle represents a hazard. In contrast, the chance of acquiring a blood borne infection such as hepatitis B virus (HBV) or human immunodeficiency virus (HIV) from a sharps injury represents a risk.

Pathogens may be acquired by inhalation of aerosols, ingestion, direct inoculation, entry through pre-existing breaks in the skin, and through the mucous membranes of the eyes, nose, and mouth. Any procedure that may result in infection through one of these routes constitutes a hazard.

THE HIGH RISK (OF INFECTION) NECROPSY

Occupationally acquired infections, particularly “hazard group 3” risk infections, can have a devastating impact on the health care worker. Knowledge of the risks of infection is therefore essential. Accidental exposures to high risk pathogens are uncommon but not infrequent, and many could be prevented.

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The high risk necropsy can be 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 the necropsy, thereby causing them serious illness and/or premature death.”

The principal biological risks faced by mortuary

Abbreviations: CI, confidence interval; HBV, hepatitis B virus; HCV, hepatitis C virus; HIV, human immunodeficiency virus; OR, adjusted odds ratio; TSE, transmissible spongiform encephalopathy; v-CJD, variant Creutzfeldt-Jakob disease.
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workers are the infections caused by Mycobacterium tuberculosis, the blood borne hepatitides, HIV, and agents responsible for transmissible spongiform encephalopathies (TSE), such as variant Creutzfeldt-Jakob disease (v-CJD). All of these pathogens retain their infectivity after death.31-35

Such diseases are frequently asymptomatic and may be present without morphological evidence at necropsy.36 The social stigma attached to those in groups at high risk of acquiring such infections means that both the clinical team and the mortuary staff (including the pathologist) may be unaware of the risk associated with the necropsy.37 For example, it is estimated that there are more than 11 000 cases reported.38

Temperatures abounds with reported cases of acquired pulmonary tuberculosis in their specialists in tuberculosis and respiratory medicine (4%).39 Other documented cases of tuberculosis developing after exposure at work are themselves immunosuppressed (and hence at risk of acquiring opportunistic pathogens from such cases),39 have uncovered wounds, weeping skin lesions, or other dermatitides.50

Most health care workers found to be HIV seropositive have a history of behavioural (male homosexual contact or intravenous drug use) or transfusional exposure.51 Occupational exposure to HIV is uncommon,52 and the overall risk of seroconversion after contact with HIV positive blood is low (seroconversion rate, 0-0.42%).53-61

The literature abounds with reported cases of acquired pulmonary tuberculosis.62-65 and cutaneous infection.66 Indeed, René Laennec (1781-1826; inventor of the stethoscope) died of the disease, having acquired it from the dissection of tuberculosis cadavers.67 Xavier Bichat (1771-1802), regarded as the “Father of Histology” and performer of some 600 necropsies in the year of his death, also succumbed to the disease.68

Pulmonary tuberculosis accounts for approximately 90% of cases and is acquired by inhalation of aerosols or dried material.69 Cutaneous infection (“prosector’s paronychia”, “prosector’s wart”, or “verruca necrogenica”) accounts for 5-10% of cases, the bacillus being introduced into previously traumatised skin or via a skin puncture.70 Mucocutaneous transmission of tuberculosis at necropsy has not been reported.71 The resurgence of tuberculosis, especially in HIV positive patients, and the emergence of multidrug resistant strains72 reinforce the importance of this disease in any consideration of necropsy health and safety.73 It is estimated that some 12 500 laboratory workers face occupational risk of exposure in the UK alone.74 Kantor et al have suggested that staff coming into contact with patients with open tuberculosis have a 17.8 fold increased risk of acquiring the disease, but do not distinguish between clinical and postmortem staff.75 Well documented cases of tuberculosis developing after exposure at necropsy exist—for example, 25% of Mantoux negative students who attended a necropsy on an immunocompromised patient in Australia developed tuberculosis.76

Teppo et al noted that the incidence of tuberculosis among pathologists engaged in postmortem practice (10%) was greater than in general physicians (1%) and specialists in tuberculosis and respiratory medicine (4%).77 That tuberculosis poses a serious threat to postmortem room workers is further highlighted by Collins and Grange in their recent definitive review which found that, in contrast to patients with open tuberculosis, even very brief exposure during a necropsy carries a very high risk of infection. Tubercle bacilli have been isolated from glass plates held 10 cm above lungs sliced at necropsy, and from various sites around the postmortem suite up to 24 hours after the examination of a tuberculous cadaver.78

It has been suggested that the patient with tuberculosis may be more infectious at necropsy than during life. Templeton et al reported that none of 40 Mantoux negative clinical staff caring for a patient who died of unsuspected tuberculosis showed a skin test conversion, whereas all five non-reactors present at the necropsy converted from negative to positive after two of these developed positive sputum cultures.79 Kantor et al observed a similar preponderance of nosocomial infection among postmortem workers.80

**Human immunodeficiency virus**

The necropsy is a valuable investigation in patients who have died from AIDS because it permits clinicopathological follow up, elucidation of the descriptive clinical pathology and epidemiology of HIV disease, validation of endpoints in clinical trials, assessment of drug efficacy and toxicity, accumulation of tissue for further research, and medical education.51 HIV serophobia has been documented among staff working in mortuaries handling high risk cases since the 1980s,51-57 although there is no evidence that HIV is readily acquired in the mortuary. Consequently, it is difficult to justify refusal to undertake necropsies on patients with such infections.51-54 Indeed, Gottfried has suggested that “those individuals who remain unwilling to expose themselves to high risk patients or specimens, even after expert counselling, should be advised to seek a change of career”. However, pathologists (and other mortuary workers) should not undertake such cases if they are themselves immunosuppressed (and hence at risk of acquiring opportunistic pathogens from such cases),75 have uncovered wounds, weeping skin lesions, or other dermatitides.50

Individuals who have suspected or confirmed high risk infections should be advised to have postexposure prophylaxis.28 70 As there is no evidence of HIV transmission from blood to the skin, shell gloves are not mandatory.70

The risk of seroconversion after occupational exposure will depend upon the viral load within the patient, the volume of fluid inoculated/ingested (discussed below), and the susceptibility of the health care worker (including whether or not they receive postexposure prophylaxis with zidovudine).28 70 Factors known to increase the risk of seroconversion include: deep injury (adjusted odds ratio (OR), 16.1; 95% CI, 6.1 to 44.6); terminal illness in the source patient (OR, 6.4; 95% CI, 2.2 to 18.9); visible blood on device (OR, 5.2; 95% CI, 1.8 to 17.7); and procedures involving the direct placement of needles into
blood vessels (OR, 5.1; 95% CI, 1.9 to 14.8). Those working in the postmortem room should be aware that the viral load in peripheral blood CD4+ T cells is greatest during the acute phase of the infection and during the final stages of the disease, when an increasing viral load is associated with a decline in CD4+ T cells and a rapidly deteriorating clinical course. Consequently, HIV titres at necropsy may be greater than in many living patients with HIV.

Several investigators have questioned whether postponement of the necropsy of patients known to be HIV positive reduces the risk of infection. In fact, feasible necropsy delays do not reduce the risk—viable HIV-2 has been isolated from blood obtained 16.5 days after death. Other studies have shown that viable HIV can be isolated from cranial bone, brain, cerebrospinal fluid, lymph node, spleen,74 and blood75 up to five days after death, when stored at 6°C. (Interestingly, HIV could not be isolated from bone dust obtained with a hand saw from the calvarium of seropositive patients.)76 Furthermore, HIV remains viable in spleen at room temperature for at least 14 days.77 Outside the body, the virus is not hardy, and is inactivated by drying and by several disinfectants, including a 0.5% solution of sodium hypochlorite, 4% buffered formaldehyde solution, 50% ethyl alcohol, 1% glutaraldehyde, 3% hydrogen peroxide, phenolic compounds, and iodophor compounds.78 79 (Phenolic disinfectants are preferable to hypochlorite, which is corrosive, may liberate harmful amounts of chlorine, and reacts with formaldehyde to produce bischloromethyl ether, a potent carcinogen.)

**Hepatitis B and C**

The epidemiology and routes of transmission of the category 3 risk viral hepatitides (HBV and hepatitis C (HCV)) closely mirror those of HIV. HBV is highly infectious, and transmission can occur following exposure to extremely small volumes of infected blood. However, the risk of occupational acquisition of HBV is extremely low (and indeed fell steadily between 1985 and 1993), largely as a consequence of routine pre-exposure vaccination among health workers. Staff who have not been vaccinated against HBV should not engage in postmortem work.70

In contrast, HCV is probably less infectious than HBV, but no vaccine exists. Occupational acquisition of HCV has been reported in health care workers and the rate of transmission after percutaneous exposure is 2.7–10%.71 72

**Transmissible spongiform encephalopathies**

The risk of acquiring other category 3 risk pathogens, notably the prions responsible for TSE (including v-CJD) is considerably less. However, it should be remembered that the agents responsible for TSE are extremely resilient. They are not “killed” by formalin or phenolised formalin fixation, and are resistant to routine methods of physical and chemical decontamination.11 12 13 14 Furthermore, v-CJD can be transmitted from archived, formalin fixed, paraffin wax embedded tissues,15 and can survive reduction to ash at 360°C.16 Decontamination requires disinfection with sodium hypochlorite (20 000 parts per million chlorine for at least one hour), 1–2M sodium hydroxide, or steam autoclaving at 134°C for at least 18 minutes.17 Given the prolonged latency of these disorders, evidence of an occupational risk to postmortem room workers remains circumstantial. However, a single case of v-CJD has been reported in a laboratory technician whose work included handling formalin fixed brains.18

**Miscellaneous infections**

In addition to the infections discussed above, it should be remembered that at necropsy the cadaver is a potential source of infection with other organisms, notably *Streptococcus pyogenes*, gastrointestinal organisms (including hepatitis A), and potentially *Neisseria meningitidis*. Such pathogens give rise to potentially curable disease but nonetheless may result in considerable morbidity.

**Hazard group 4 risk pathogens**

Necropsies on patients with hazard group 4 pathogens (for example, the viral haemorrhagic fevers) should only be performed where absolutely necessary. In the UK, necropsies on such cases are prohibited unless performed in a designated mortuary.9 Such cases will not be discussed further in this review.

**MINIMISING THE RISKS POSED BY THE INFECTED CADAVER**

Although much has been written on how to perform necropsies on infected cadavers safely, there are remarkably few studies from which one can draw evidence upon which to base a “safe” postmortem practice. The most recent guidelines on postmortem practice published by the Royal College of Pathologists (London, UK)90 recommend that mortuaries adopt health and safety protocols for the performance of postmortem examinations for all necropsies performed on cadavers known or suspected to be infected with a hazard group 3 pathogen. Detailed examples of such protocols are presented in these guidelines.91 Such detail falls beyond the scope of this review but the basic principles are presented here.

1. **Immunisation**: all staff involved in the necropsy or coming into contact with materials derived from it should be vaccinated against tetanus,72 poliomyelitis,71 tuberculosis,80 and hepatitis B.79
2. **Pre-necropsy testing**: this should be considered in cases where there is reason to suspect that the body may be infected with a previously undetected category 3 pathogen. Given the diagnostic purpose of the investigation, working parties of the Royal College of Pathologists (London, UK)92 93 have noted that pre-necropsy HIV testing is appropriate in hospital (consented) cases. In such cases, prior consent for testing is not required. Similarly, the coroner may give consent for HIV serology. In the UK there seems little epidemiological justification to test all bodies for HIV before necropsy, except where the deceased is known to have been exposed to particular high risk activities (such as intravenous drug use).39 40 In cases where such testing proves positive, the pathologist has a duty of care to the patient and his/her relatives and sexual partners to disclose the information; this is usually achieved via the patient’s physician.20 88
3. **Clothing**: in surgery, protective clothing is worn to reduce the risk of transmitting pathogens from the health care workers to the patient. At necropsy, the protective clothing serves the opposite function. The currently recommended clothing for performing (all) necropsies includes: a cap/hood that completely covers the hair; eye protection (ideally a visor that provides full face protection); a face mask (a tight fitting micro-filter mask is necessary for cases of suspected tuberculosis); surgical shirt and trousers; waterproof boots (ideally with steel toecaps to prevent penetration by dropped sharps); a full length gown; a waterproof apron that is long enough to reach below the tops of the boots, and at least one pair of gloves (discussed below).11 20 22 23 43 57 68 79 Some pathologists choose to wear a disposable water repellent body suit over their surgical shirt and trousers and to tape their gloves to form a waterproof seal.82 Overly cumbersome clothing is itself hazardous—for example, the advantages of down draught ventilation headgear in reducing aerosol transmission may be outweighed by a reduction in field of vision and communication.95 As noted above, penetrating injuries are a common route of transmission for pathogens at necropsy. Injuries to the hands are most common, particularly on the palmar surfaces of the thumb, index finger, and middle finger of the non-dominant hand.80 Among pathologists, O’Brian et al.82
found that safety guidelines; and liaison between the prossector and clinicians, so that the contaminated prossector does not have to handle clean surfaces such as telephone receivers.\textsuperscript{89}

(7) Safe sharps practice: It is essential that a safe sharps practice is meticulously followed at all times. Hazards are posed both by equipment used to perform the necropsy (scalpels, scissors, needles, and saws) and by the body itself (bone fragments and unsuspected objects within the body (discussed below). “Blind” dissection should be avoided. Only one study has evaluated the safety of evisceration techniques. Walker \textit{et al} found that the use of rib shears to open the thorax is most likely to produce potentially dangerous sharp rib ends, whereas an electric saw produces the smoothest ends.\textsuperscript{91}

Therefore, the use of an electric saw to open the chest may reduce the potential for sharps injuries. However, such saws may produce aerosols,\textsuperscript{101} and it has also been suggested that prolonged and repeated use may be a cause of vibration induced white fingers among mortuary assistants.\textsuperscript{94} For reconstruction of the infected body some authorities recommend that sutures are not used (given that protective gauntlets will not protect from penetrating injuries caused by suture needles) and that the body instead be closed with staples, tissue adhesives, or even left unreconstructed and sealed in a leakproof body bag.\textsuperscript{105} However, there are no studies or guidelines as to which method represents best practice.

**DANGEROUS FOREIGN BODIES**

The body may contain objects whose presence may or may not be known at the start of the examination, and which may be hazardous to the pathologist and the anatomical pathology technician. The literature focuses on three specific areas, namely hidden sharp objects, implanted cardioverter defibrillators, and exploding bullets.

**Hidden sharp objects**

In addition to the care taken when handling the sharp objects used to perform the necropsy, consideration should be given to the possibility that the body contains “occult” sharps. Such objects may be a legacy of previous medical intervention, as in the case of vena-caval (Greenfield) filters,\textsuperscript{106} the presence of which may not be documented in the medical notes. The fine anchoring points of the filter are sharp and may cause deep puncture wounds.\textsuperscript{105}

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Sharp objects within the body may alternatively be a consequence of the patient’s lifestyle. Hutchins and colleagues have recently reported a series of four patients with seropositive HIV infection who came to necropsy and were found to have retained fragments of needles in the subcutaneous tissues of the neck. Such needle fragments (which were between 10 and 45 mm long) were the legacy of long term intravenous drug use in patients who resorted to deep cervicocavicular injection when peripheral access became difficult. These cases were (fortunately) not associated with needlestick injury, but staff performing necropsies on those with a history of intravenous drug use must be aware of this potential (albeit rare) hazard. Radiographic screening has been suggested for cases where retained needle fragments are suspected.\textsuperscript{106-107} Needle fragments have also been discovered in the myocardium of intravenous drug users.\textsuperscript{110}

**Implanted cardioverter defibrillators**

These devices are similar to cardiac pacemakers, and are used in the treatment of malignant tachyarrhythmias such as ventricular tachycardia and ventricular fibrillation.\textsuperscript{112} The electric
pulse delivered by the defibrillator to the myocardium is approximately 20–40 J (one million times greater than that of a cardiac pacemaker). It is clear that such devices can discharge after the patient’s death and at necropsy. Although there are no documented cases of electrocution occurring at necropsy, Prahlov et al report numerous anecdotal cases. It is recommended that care is taken to deactivate these devices (ideally, done by the manufacturer or, if unavailable, with a doughnut shaped magnet placed over the pulse generator) before handling them. As with cardiac pacemakers, the batteries within such devices can detonate when heated, and therefore implantable defibrillators must be removed from bodies that are to be cremated and must not be disposed of by incineration.

Exploding bullets

Those working in mortuaries where deaths as a result of shootings are investigated face the potential hazard that the deceased was shot with explosive ammunition. Such bullets are designed to fragment upon contact with the victim, thus slowing the bullet and imparting more of its kinetic energy to the body. In addition to causing severe injury to the victim, such bullets pose a hazard to the surgeon and the pathologist if they fail to explode. In cases where explosive ammunition is suspected, goggles should be worn and long handled instruments used to minimise the risk of injury to eyes and fingers. Once removed, the bullet must be handled with rubber coated forceps, kept in a padded container to shield it from excess vibration and heat, and must be kept away from sources of microwave radiation. The Winchester “Black Talon” bullet is designed so that its jacket expands by peeling back to form “petals” that slow its path through tissue. These petals are sharp and may cause glove puncture.

THE CONTAMINATED BODY

Staff involved in postmortem practice should be aware that, on rare occasions, they may be faced with a request to undertake a necropsy on a body that has been contaminated either chemically or by radioactive sources.

Chemical contaminants

The literature that relates to the hazards posed by chemical contaminants at necropsy focuses primarily on the necropsy of patients who have died from cyanide poisoning. It has been suggested that cyanide liberated from such bodies may poison postmortem personnel. However, in two subsequent reported cases of necropsies on cyanide related deaths, no increase in blood cyanide values was detected in the postmortem workers. However, one pathologist experienced headache and a burning throat sensation and one technician reported lightheadedness and throat discomfort. The occupational exposure to cyanide can be minimised by performing the necropsy in a well ventilated environment, using down draught ventilation. The risk is proportional to the amount of cyanide present in the stomach. Cyanide salts liberate hydrogen cyanide when they come into contact with gastric acid. The upper gastrointestinal tract should be dissected out unopened and intact and examined in a fume cupboard. Although there are no documented cases of electrocution occurring at necropsy, Prahlov et al report numerous anecdotal cases. It is recommended that care is taken to deactivate these devices (ideally, done by the manufacturer or, if unavailable, with a doughnut shaped magnet placed over the pulse generator) before handling them. As with cardiac pacemakers, the batteries within such devices can detonate when heated, and therefore implantable defibrillators must be removed from bodies that are to be cremated and must not be disposed of by incineration.

Radioactive contaminants

Bodies may be contaminated by radioactive materials deliberately, as a consequence of medical treatment, or as a consequence of the explosion of atomic devices or working in the nuclear industry. Necropsies on radioactive bodies that had been recently dosed with strontium-89-chloride before death have been reported. In the reported case, whole body and hand exposures were recorded as 0.000 for all personnel involved (although this is not surprising because strontium is concentrated in the bones). Staff engaging in the necropsy of patients who have been treated with radioisotopes should liaise with their local department of nuclear medicine before starting the necropsy to seek advice and appropriate monitoring.

CONCLUSION

Those involved in postmortem practice have a statutory duty not only to ensure that they are aware of the hazards and risks associated with such work, but also to take steps to minimise these risks. The hazards present within a body are often unknown at the start of the necropsy. Meticulous practice in all cases, and not just those where a risk has been identified, is essential. The principal risks relate to the acquisition of occupationally acquired infections, either by sharps injury or by inhalation. Many such cases are avoidable. Local health and safety policies should be made available to all staff, and should be followed. Specialist advice may be needed in rare cases.

REFERENCES

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