

## REVIEW

## Health and safety at necropsy

J L Burton

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<sup>1</sup>), visitors to the mortuary (clinical staff and students), and those involved in handling the body (relatives, funeral directors,<sup>2,3</sup> embalmers,<sup>4,5</sup> and crematoria staff), or material derived from it (laboratory workers<sup>3</sup>) after necropsy. The decline in mortuary 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.<sup>6–9</sup>

There is a considerable body of literature and legislation pertaining to the design and provision of a safe working environment<sup>10,11</sup> and safe working practices within the mortuary.<sup>12–20</sup> It is not my intention to focus on this, because such general principles have been discussed in detail elsewhere.<sup>21–23</sup> 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<sup>24,25</sup>; injuries (with the concomitant dangers of haemorrhage and sepsis) and electro-

cution; 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.<sup>13,21</sup>

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.<sup>21</sup>

**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.<sup>26,27</sup> 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.<sup>28,29</sup>

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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".<sup>30</sup> 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 hepatitis, HIV, and agents responsible for transmissible spongiform encephalopathies (TSE), such as variant Creutzfeldt-Jakob disease (v-CJD).<sup>3</sup> All of these pathogens retain their infectivity after death.<sup>31–35</sup>

Such diseases are frequently asymptomatic and may be present without morphological evidence at necropsy.<sup>34</sup> 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.<sup>36–38</sup> For example, it is estimated that there are more than 11 000 cases of undiagnosed HIV infection in the UK.<sup>39</sup> The presence of such pathogens may not become known until after the gross examination.<sup>34 40</sup> This becomes less worrisome if all staff in the mortuary regard every necropsy as a potential source of these pathogens, regardless of whether or not an infection has been documented in the medical notes, and irrespective of whether the patient is known to belong to a high risk group. This is especially prudent in medicolegal cases, where the pathologist often has to rely on the brief non-medical notes provided by the coroner's officer.<sup>41</sup>

Let us consider first the risks of acquiring such pathogens at necropsy, before discussing strategies for reducing such risks.

### **Mycobacterium tuberculosis**

It has long been known that staff working in the mortuary are at risk of occupational infection with *M. tuberculosis*. The literature abounds with reported cases of acquired pulmonary<sup>40 42–46</sup> and cutaneous infection.<sup>47</sup> Indeed, René Laennec (1781–1826; inventor of the stethoscope) died of the disease, having acquired it from the dissection of tuberculous cadavers.<sup>48</sup> 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.<sup>49</sup>

Pulmonary tuberculosis accounts for approximately 90% of cases and is acquired by inhalation of aerosols or dried material.<sup>43</sup> 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.<sup>47</sup> Mucocutaneous transmission of tuberculosis at necropsy has not been reported.<sup>43</sup> The resurgence of tuberculosis, especially in HIV positive patients, and the emergence of multidrug resistant strains<sup>3 50 51</sup> reinforce the importance of this disease in any consideration of necropsy health and safety.<sup>43</sup> It is estimated that some 12 500 laboratory workers face occupational risk of exposure in the UK alone.<sup>43</sup> 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.<sup>34</sup> 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.<sup>45</sup>

Teppo *et al* noted that the incidence of tuberculosis among pathologists engaged in postmortem practice (10%) was greater ( $p = 0.00157$ ) than in general physicians (1%) and specialists in tuberculosis and respiratory medicine (4%).<sup>52</sup> That tuberculosis poses a serious threat to postmortem room workers is further highlighted by Collins and Grange<sup>43</sup> 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.<sup>43</sup>

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 and two of these developed positive sputum cultures.<sup>40</sup> Kantor *et al* observed a similar preponderance of nosocomial infection among postmortem workers.<sup>34</sup>

### **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.<sup>53</sup> HIV serophobia has been documented among staff working in mortuaries handling high risk cases since the 1980s,<sup>53–57</sup> 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.<sup>53 58</sup> Indeed, Gottfried<sup>57</sup> 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),<sup>53</sup> have uncovered wounds, weeping skin lesions, or other dermatitides.<sup>58</sup>

Most health care workers found to be HIV seropositive have a history of behavioural (male homosexual contact or intravenous drug use) or transfusional exposure.<sup>59</sup> Occupational exposure to HIV is uncommon,<sup>60 61</sup> and the overall risk of seroconversion after contact with HIV positive blood is low (seroconversion rate, 0–0.42%).<sup>28 29 62 63</sup> Most documented cases of HIV seroconversion after occupational exposure occurred after needlestick injuries (the most common source of exposure<sup>20 28 64</sup>). The estimated HIV transmission rate after a single percutaneous inoculation (needles contain approximately 1 µl of blood) is 0.10–0.36%.<sup>28 53 65</sup> (This may underestimate the risk associated with accidental deep scalpel injuries.<sup>66</sup> More blood is inoculated by deeper injuries than superficial injuries, and by hollow bore needles than by solid suture needles.<sup>59 67</sup>) The seroconversion rate after mucocutaneous exposure is 0.04–0.63%.<sup>28 65</sup> A meta-analysis<sup>28</sup> of 6170 exposures in prospective studies demonstrated a seroconversion rate of 0.25% (95% confidence interval (CI), 0.12% to 0.47%) after percutaneous exposure and 0.09% (95% CI, 0.006% to 0.50%) after mucocutaneous exposure. The aerosol transmission rate has not been documented.<sup>53 68</sup> There is only one well documented case of HIV transmission at necropsy, in which a scalpel blade injury to the hand<sup>68</sup> led to seroconversion in a consultant pathologist. A similar injury, occurring in a surgeon, has also led to occupational exposure to HIV and seroconversion.<sup>69</sup>

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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).<sup>59 70</sup> 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).<sup>70</sup> 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<sup>71</sup> and during the final stages of the disease,<sup>72</sup> when an increasing viral load is associated with a decline in CD4+ T cells and a rapidly deteriorating clinical course.<sup>73</sup> 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.<sup>33</sup> Other studies have shown that viable HIV can be isolated from cranial bone, brain, cerebrospinal fluid,<sup>74</sup> lymph node, spleen,<sup>74–75</sup> and blood<sup>75–76</sup> 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.<sup>75</sup>) Furthermore, HIV remains viable in spleen at room temperature for at least 14 days.<sup>75</sup> 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.<sup>58–77</sup> (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.<sup>3</sup>)

### Hepatitis B and C

The epidemiology and routes of transmission of the category 3 risk viral hepatitis (HBV and hepatitis C (HCV)) closely mirror those of HIV.<sup>3</sup> HBV is highly infectious, and transmission can occur following exposure to extremely small volumes of infected blood.<sup>3</sup> 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.<sup>78</sup> Staff who have not been vaccinated against HBV should not engage in postmortem work.<sup>79</sup>

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%.<sup>79–80</sup>

### 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.<sup>3–21–81</sup> Furthermore, v-CJD can be transmitted from archived, formalin fixed, paraffin wax embedded tissues,<sup>82</sup> and can survive reduction to ash at 360°C.<sup>3</sup> 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.<sup>3</sup> 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.<sup>83</sup>

### 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*,<sup>84</sup> gastrointestinal organisms (including hepatitis A), and potentially *Neisseria meningitidis*.<sup>3</sup> Such pathogens give rise

to potentially curable disease but nonetheless may result in considerable morbidity.<sup>84</sup>

### Hazard group 4 risk pathogens

Necropsies on patients with hazard group 4 pathogens<sup>24</sup> (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.<sup>19</sup> 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)<sup>85</sup> 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.<sup>85</sup> 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,<sup>21</sup> poliomyelitis,<sup>21</sup> tuberculosis,<sup>43</sup> and hepatitis B.<sup>79</sup>

(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)<sup>20–85</sup> 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).<sup>20–39</sup> 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.<sup>20–86</sup>

(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).<sup>11–20–22–53–79–87–88</sup> Some pathologists choose to wear a disposable water repellent body suit over their surgical shirt and trousers and to tape their gloves to this forming a waterproof seal.<sup>58</sup> 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.<sup>55</sup> 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.<sup>89</sup> Among pathologists, O’Brian<sup>89</sup>



found that cuts are twice as common as needlestick injuries. The frequency of injury is inversely related to one's clinical experience. Mast *et al* have shown that wearing surgical gloves significantly reduces the volume of blood transferred during a needlestick injury by 63% and 86% for suture and hollow needles, respectively.<sup>67</sup> Weston and Locker<sup>88</sup> have shown that gloves, especially those of anatomical pathology technicians, are frequently punctured at necropsy and that 31.8% of such punctures go unnoticed. Double gloving and frequent changing of gloves during the necropsy (whether or not they appear damaged) is recommended by some,<sup>58 90</sup> but felt to be an unnecessary expense by others.<sup>91</sup> However, it should be noted that with double gloving the outer glove protects and reduces the frequency of perforations of the inner glove.<sup>92</sup> The outer glove should fit closely to the hand.<sup>58</sup> The frequency of glove perforations can also be reduced by advising staff to remove rings before donning gloves—multiple perforations are often found at the base of the ring finger.<sup>93</sup> Additional protection can be obtained by wearing a gauntlet on the non-dominant hand. Such gauntlets, made of metal mesh<sup>58 94 95</sup> or Kevlar,<sup>96</sup> provide protection against cuts but will not prevent needlestick injuries. However, these gloves can feel cumbersome, reduce sensation, and can reduce manual dexterity.<sup>58 94</sup>

(4) Reduce aerosol formation: this is essential for reducing the risk of acquiring airborne infections such as tuberculosis<sup>97</sup> and enteric pathogens,<sup>98</sup> and for necropsies on patients suspected of having HIV or TSE. It should be realised that most airborne bacteria in mortuaries are derived from the skin of the staff present.<sup>98 99</sup> Down draught ventilation tables reduce the particle transmission of microorganisms<sup>34 98 99</sup> (and have the added advantage of reducing odours). The hazards for the formation of aerosols relate principally to the use of saws (especially power saws)<sup>98</sup> and opening of the intestines (which should be performed under water<sup>21</sup>). Care should be taken when removing, handling and/or washing organs to avoid splashing and aerosol formation.<sup>98</sup> High pressure water sprays should not be used.<sup>21</sup> Some authors have recommended eviscerating the infected body organ by organ, rather than with the more traditional Letulle technique, in which the organs are removed en bloc.<sup>55</sup> A reduction in aerosol dissemination during cranial necropsy can be achieved by placing clear plastic bags over the head while eviscerating the brain,<sup>100</sup> although specific tents have been developed to cover the head and neck of the patient.<sup>100</sup>

(5) Equipment: the equipment used to perform the necropsy should be kept to a minimum, and be kept in clear view at all times. Scalpels and scissors with pointed ends should not be used.<sup>53 55</sup> Instruments (and especially sharps) should never be passed from hand to hand.<sup>58</sup> For necropsies on patients where a TSE is suspected, disposable instruments should be used. Non-disposable instruments require prolonged disinfection as described above.<sup>58</sup>

(6) Circulators: it is not necessary to carry out necropsies on patients suspected or known to be infected with a category 3 risk pathogen in a specialist mortuary, but the number of staff present during the procedure should be kept to a minimum.<sup>55 101</sup> Therefore, in practice, the pathologist should be accompanied by an anatomical pathology technician, who assists in the evisceration and dissection, and a circulator. The pathologist and technician are "dirty", whereas the circulator avoids direct contact with potentially infected or contaminated tissues, fluids, and surfaces and so remains "clean".<sup>55 102</sup> The roles of the circulator include: labelling specimen containers and holding them so that the prosector may deposit specimens without coming into contact with the outside of the container; completion of paperwork associated with such specimens; recording organ weights and any other contemporaneous notes desired by the prosector; adjustment of overhead lighting where necessary; monitoring the practice of the prosector and technician to ensure they follow health and

safety guidelines; and liaison between the prosector and clinicians, so that the contaminated prosector does not have to handle clean surfaces such as telephone receivers.<sup>102</sup>

(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 *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.<sup>103</sup> Therefore, the use of an electric saw to open the chest may reduce the potential for sharps injuries. However, such saws may produce aerosols,<sup>103</sup> and it has also been suggested that prolonged and repeated use may be a cause of vibration induced white fingers among mortuary assistants.<sup>104</sup> 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.<sup>20 55</sup> 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,<sup>105</sup> 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.<sup>105</sup>

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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 cervicoclavicular 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.<sup>106 107</sup> Needle fragments have also been discovered in the myocardium of intravenous drug users.<sup>108</sup>

### 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.<sup>109</sup> 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).<sup>110</sup> It is clear that such devices can discharge after the patient's death and at necropsy.<sup>109</sup> Although there are no documented cases of electrocution occurring at necropsy, Prahlow *et al* report numerous anecdotal cases.<sup>110</sup> 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.<sup>109–110</sup> 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.<sup>109–110</sup>

### 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.<sup>111–112</sup> 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.<sup>111</sup> 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.<sup>111–112</sup> 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.<sup>113</sup>

### 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 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.<sup>114</sup> However, in two subsequent reported cases of necropsies on cyanide related deaths, no increase in blood cyanide values was detected in the postmortem workers.<sup>115–116</sup> However, one pathologist experienced headache and a burning throat sensation and one technician reported lightheadedness and throat discomfort.<sup>115</sup> 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.<sup>115–116</sup> One should not rely on the smell of "burnt almonds" to detect cyanide—many people are anosmic to this.<sup>117</sup>

To my knowledge, there have been no reported cases of secondary toxicity caused by organophosphates among postmortem staff, but there is a theoretical risk (for example, deaths following industrial accidents or terrorist attacks). Occupationally acquired organophosphate toxicity has been reported among health care workers who failed to take appropriate precautions when treating organophosphate poisoning.<sup>118</sup> Health care workers handling the bodies of those contaminated by organophosphates should use chemical barrier protection (latex gloves afford little protection).<sup>118</sup>

### Take home messages

- Staff involved in postmortem practice face risks of life threatening infections and serious injury. The nature of these risks may not be apparent before (or during) the necropsy
- Hazards associated with the body pertain to infection, foreign objects within the body, and the contaminated body
- Many accidents in the mortuary can be avoided by careful practice

### Radioactive contaminants

Bodies may be contaminated by radioactive materials deliberately, as a consequence of medical treatment,<sup>119</sup> or as a consequence of the explosion of atomic devices or working in the nuclear industry.<sup>120</sup> Necropsies on radioactive bodies that had been recently dosed with strontium-89-chloride before death have been reported.<sup>119</sup> 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.

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