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Autopsy: Infectious and Serious Communicable Diseases

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Abstract

The infectious autopsy is the postmortem examination of a decedent who is likely to have a serious infectious disease that can be transmitted at autopsy. Human immunodeficiency virus (HIV), viral hepatitis B and C, and tuberculosis infections are common in forensic autopsy populations. Autopsy and laboratory personnel are at risk for acquiring these postmortem infections. As the autopsy often is essential to determine the cause and manner of death and/or help the living, the use of certain standard precautions can minimize the risk of occupational infections. This chapter reviews frequently encountered occupational infections and provides preventive measures including postexposure management.

Introduction

The infectious autopsy, or high-risk autopsy, is defined as the postmortem examination of a decedent who has had, or is likely to have had, a serious infectious disease that can be transmitted at autopsy (Claydon, 1993; Nolte, 2002). Autopsy prosectors and laboratory personnel are at risk for acquiring these postmortem infections (Table 1; Johnson *et al.*, 1997; Klatt and Noguchi, 1988; Nolte *et al.*, 2002). The prevalence of human immunodeficiency virus (HIV), viral hepatitis B and C, and tuberculosis infection in forensic autopsy populations is high because drug abusers, prisoners, and certain infectious deaths are reportable to the medical examiner/coroner (ME/C). In addition, these infectious diseases may be asymptomatic or clinically undiagnosed and may have little or no morphological evidence at autopsy. In fact, occupational infections of HIV, hepatitis B virus (HBV), hepatitis C virus (HCV), and *Mycobacterium tuberculosis* have been described as a serious concern among forensic autopsy workers. In forensic investigations, however, the autopsy often is essential to determine the cause and manner of death. Furthermore, the autopsy plays an important role in diagnosing such infectious diseases and provides vital information on epidemiology and pathogenesis. Identification of infections at autopsy also may benefit the living by identifying people at risk of exposure and the early use of preventative treatments. This chapter reviews the current state of our knowledge of frequently encountered occupational infections and provides preventive measures including postexposure management (Nolte *et al.*, 2002; Hanzlick *et al.*, 2009). Although many decedents among ME/C practices are infected with potentially transmissible infections, proper precautions minimize the risk of infection. Therefore, the concern of contracting an infection while performing an autopsy is an inadequate reason not to perform an internal examination on the overwhelming majority of deaths that most pathologists encounter in daily practice.

Human Immunodeficiency Virus Infection

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

Table 1 Infectious diseases and agents of concern for autopsy exposure

<i>Viruses</i>
Human immunodeficiency virus
Viral hepatitis (hepatitis B virus and hepatitis C virus)
Human T-cell lymphotropic virus
Viral hemorrhagic fevers (Lassa, Marburg, Ebola, and Crimean-Congo hemorrhagic fevers)
Rabies
Influenza (e.g., H1N1)
Severe acute respiratory syndrome
Smallpox
West Nile virus
Middle Eastern respiratory syndrome
<i>Bacteria</i>
Tuberculosis
Meningococcal infections
Streptococcal infections
Anthrax
Plague
Tetanus
Legionnaires' disease
Typhoid fever
Paratyphoid
Tularemia
Diphtheria
Erysipeloid Glanders
Scrub typhus
<i>Fungi</i>
Blastomycosis
Coccidioidomycosis
Protozoan Toxoplasmosis
<i>Prion</i>
Creutzfeldt–Jakob disease

35.3 million people living with the virus worldwide in 2013. Of these, 50% were women and 10% were children under age 15. Although the number of new HIV infections has dropped by 33% in 2012 compared to 2001, and AIDS-related deaths have been reduced by 30% compared to 2005, it is still the sixth leading cause of death among people ages 25–44 in the United States (decreased from number one in 1995) (Johnson *et al.*, 1997; Klatt and Noguchi, 1988).

In forensic autopsy practice, 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 for infection and suspected acute intoxication deaths frequently place them in medicolegal jurisdictions. The detection of HIV infection, identification of route of infection, and diagnosis of AIDS are needed to determine the cause and the manner of death. The autopsy also may reveal clinically undiagnosed infectious diseases and neoplasms other than the primary cause of death (Table 2). This may benefit epidemiological studies and quality assurance activities in assessing diagnostic or treatment modalities. The forensic autopsies of asymptomatic people who die 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

early therapeutic interventions, thus avoiding further dissemination of infection within the community. At the Office of Chief Medical Examiner of New York City, all decedents in which a blood sample is obtained at autopsy are tested for HIV infection. A confidential process is in place that allows the Department of Health to notify living contacts that may have been unknowingly put at risk for transmission. Due to this surveillance, in some years the New York City Office of Chief Medical Examiner identified and referred as many people unknowingly at risk for HIV as did all of the other practicing physicians in New York City combined.

The potential for occupational transmission of HIV is a concern among pathologists and mortuary staff as well as laboratory personnel who may deal with post-autopsy samples. In clinical settings, most occupational HIV infections among healthcare providers are the result of needlestick or other sharps injuries. Small numbers of HIV seroconversions following mucous membrane or non-intact skin occupational exposure also have been reported. A scalpel injury during a hospital autopsy and seroconversion thereafter in a pathologist has been reported. Although the estimated risk of HIV infection following occupational exposure to blood or body fluids is 0.3%, the risk of transmission in a specific situation is likely to depend upon the circulating viral titer in the source case, volume of blood injected, depth and type of penetration (cut vs. puncture), and immune status of the exposed person.

Decedents 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 has been successfully isolated from the blood of non-refrigerated cadavers for at least 36 h after death and from refrigerated cadavers kept at 2 °C for at least 17 days after death. Autopsy specimens such as blood, body fluids, and fresh tissues also are a potential source of infection. An experimental study showed that HIV suspended in serum remains infectious for several weeks at room temperature (20–28 °C); infectivity remains for several days even when dried on a glass coverslip. HIV is inactivated after being exposed to common chemical germicides. A solution of sodium hypochlorite (household bleach) is 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 and mucus) on the surface to be disinfected.

The prophylactic use of antiretroviral drugs has been demonstrated to be beneficial with HIV-infected pregnant women treated with zidovudine as it reduces the rate of transmission of HIV to their babies. As multidrug-drug regimens effectively reduce the HIV replication in blood, postexposure prophylaxis has been recommended for individuals who have been exposed to blood infected with HIV. Antiretroviral drugs are associated with

Table 2 Opportunistic infections and neoplasms in acquired immunodeficiency syndrome

Opportunistic infections
Viruses:
Cytomegalovirus disease and retinitis
Progressive multifocal leukoencephalopathy (papovavirus infection)
Herpes simplex
Bacteria:
Recurrent pneumonia
<i>Mycobacterium tuberculosis</i>
<i>Mycobacterium avium</i> complex or <i>Mycobacterium kansasii</i>
<i>Mycobacterium</i> , other or unidentified species
Recurrent <i>Salmonella septicemia</i>
Fungi:
Candidiasis of esophagus, bronchi, trachea, or lungs
Cryptococcosis
Histoplasmosis
Coccidioidomycosis
Protozoa:
<i>Pneumocystis carinii</i> pneumonia
Toxoplasmosis
Cryptosporidiosis
Isosporiasis
Neoplasms
Kaposi's sarcoma
Lymphoma
Cervical cancer of uterus, invasive

adverse events so exposed individuals need to weigh carefully the low rate of infection with HIV and the adverse effects of chemoprophylaxis. This decision is best made in consultation with a clinician experienced in occupational health and/or infectious disease. As a rapid initiation of treatment may be warranted, autopsy facilities already should have a plan in place for immediate treatment. There are HIV-test kits approved for use with postmortem blood. This testing may need to be done by specialized laboratories and therefore the turn-around-time may be days. Postexposure counseling and follow-up intervention by experienced care providers familiar with the special medical and psychologic needs also are essential for exposed persons.

Hepatitis Viruses

Acute viral hepatitis is caused by one of the five viral agents: (1) hepatitis A virus, (2) hepatitis B virus (HBV), (3) Hepatitis C virus (HCV), (4) hepatitis D virus, and (5) hepatitis E virus. Of 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 severe acute complication of viral hepatitis is fulminant hepatitis (massive hepatic necrosis): the mortality rate of fulminant hepatitis is greater than 80% in some patients. Fulminant hepatitis is a rare event and primarily occurs with HBV infection. Over 90% of individuals with acute HBV infection have a favorable course and recover completely. Acute hepatitis C, however, has a worse prognosis with approximately 80% of infected individuals progressing to a carrier state leading to chronic liver disease with cirrhosis and increased risk for hepatocellular carcinoma (Nolte, 2002; Nolte *et al.*, 2002).

Effective vaccines and specific immunoglobulins are widely employed to offer protection against HBV infection. For preexposure prophylaxis, all personnel involved in autopsies should have their HBsAb status tested and should receive hepatitis B vaccine. Postexposure prophylaxis with hepatitis B immunoglobulin and/or hepatitis B vaccine may 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. Assays are available for HBV and HCV testing on postmortem blood.

Tuberculosis

Tuberculosis is caused by *M. tuberculosis* and usually affects the lungs although in up to one-third of patients

other organs are involved. Beginning in the mid-1980s in many industrialized countries, the number of tuberculosis notifications, which had been falling steadily, stabilized or even began to increase. A major factor for this change was tuberculosis among immunocompromised persons with HIV infection and the emergence of multidrug-resistant strains. Transmission of tuberculosis usually takes place through the airborne spread of droplet nuclei produced by patients with infectious pulmonary tuberculosis. It is estimated that laboratory and autopsy personnel are between 100 and 200 times more likely than the general public to develop tuberculosis (Nolte *et al.*, 2002; Nolte, 2005b; Wilkins *et al.*, 1994; Templeton *et al.*, 1995).

The old adage that ‘dead people don't cough’ and therefore autopsy staff are not at risk for transmissible pulmonary infections from a decedent, is incorrect. It creates a false sense of security that has been refuted by several clinical studies. Although decedents do not cough, their infections can be aerosolized during an autopsy. Infectious aerosols are airborne particles (1–5 μm diameter) which can become suspended in air and inhaled. Due to their small size, these particles will reach the pulmonary alveoli when inhaled. There may be a greater risk at autopsy than in a clinical setting for transmission. A reported patient who did not transmit tuberculosis before death did transmit tubercle bacilli during autopsy. Of the healthcare workers caring for this patient for 3 weeks on an open medical ward, none of the 40 skin-test negative staff showed a skin-test conversion, even though they had not used respiratory precautions. But all five nonreactors at the 3-h autopsy, converted from negative to positive. Two of these had a positive sputum culture 8 weeks later and DNA fingerprints of all three isolates were identical (Templeton *et al.*, 1995). Another study reported an outbreak of tuberculosis in medical students at the University of Sydney (Wilkins *et al.*, 1994). Eight of 35 skin-test negative students who attended the autopsy (1 h of exposure) of an immunosuppressed patient with unsuspected active tuberculosis became infected and one developed clinical disease.

Water sprayed onto tissues, oscillating saws (e.g., used to cut through the chest plate or skull), and various fluid aspirator devices can cause infectious agents to become aerosolized (Nolte *et al.*, 2002). Infectious aerosols have been demonstrated during standard autopsy dissection of the lungs and HIV has been recovered in aerosols generated by applying oscillating saws to infected blood (Nolte *et al.*, 2002; Johnson and Robinson, 1991). Because infectious aerosols are likely to be 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. Down-draft autopsy tables, ultraviolet irradiation of the air, and high-efficiency particulate air filtration are recommended in autopsy rooms. The respiratory mask is

particularly important to prevent tuberculosis. These masks should not be 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

Pathologists can safely examine patients with HIV infection by following universal safety techniques for autopsies and assuming that everyone is potentially infectious (Claydon, 1993; Klatt and Noguchi, 1988; Nolte *et al.*, 2002; Hanzlick *et al.*, 2009; Gamage *et al.*, 2005).

Healthcare providers 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 blood borne pathogens. Universal precautions are based on the premise that all patients are potentially infectious, and include: (1) the use of gloves and arm protection for procedures where contact with blood and body fluids might occur; (2) the use of masks and protective eyewear when spatter of body fluids is possible; and (3) the use of gowns or other protective garments when clothing is likely to be soiled.

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 patient 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.

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 post-mortem 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.

Creating a zero risk of blood exposure due to cut or needlestick injuries is likely impossible in routine autopsy practice. 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 retracts tissue during autopsy. Dissected rib edges can be sharp and are capable of injuring the skin of the hand or forearm.

Autopsy precautions should be directed at the prevention of sharp injuries, mucocutaneous contact with body fluids, and aerosol inhalation. Exposure may be prevented by using appropriate gloves, forearm protection, goggles or face shield, cap, gown, apron, and shoe covers. The use of self-contained-scalpel-blade removal devices and not holding a specimen blood tube while injecting a blood sample, are appropriate routine preventative safety practices. Needles should not be recapped or self-capping needles may be used. 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-tipped scalpel blades, blunt-tipped scissors, and placement of towels over sharp bony projections, are recommended. A vacuum-equipped oscillatory saw is suggested to remove the calvarium to prevent aerosolization of bony dust and pathogens. Yearly 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. Emergency eye washes should be readily available. Antiseptics are commonly applied after an exposure although no evidence exists that they further reduce the risk of blood

borne pathogen transmission more than washing with soap and water. Serology testing of the source and the exposed person for HIV, HBV, and HCV should be done. Baseline serology for the exposed person will show the individual to be previously uninfected by any of the viruses and possibly the existence of protective immunity for HBV. Occupational exposure should be considered an urgent medical concern to ensure timely (within 1–2 h of exposure) postexposure management and administration of hepatitis B immunoglobulin, hepatitis B vaccine, and/or HIV chemoprophylaxis.

Prevention of Other Infections

Creutzfeldt–Jakob disease (CJD) is a neurodegenerative disease that is caused by infectious proteins called prions. CJD typically presents with a relatively rapid, 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 implants, and surgical procedures. Epidemiological studies show no increased risk for healthcare workers. Because prions are at highest amounts in neural tissue, the main concern for infection in the context of autopsy and neuropathological examinations is inadvertent parenteral inoculation with neural tissues. Precautions against infection should be taken during 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 accomplished with formalin, but is 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. There are national investigative agencies who will accept suspected CJD brains for evaluation and diagnosis (e.g., National Prion Disease Pathology Surveillance Center) (Nolte, 2005a; Gamage *et al.*, 2005; Inglesby *et al.*, 2000; Hilgenfeld and Peiris, 2013; Gill and Melinek, 2002; Casillas *et al.*, 2003).

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 recent concern (Nolte, 2000; Nolte *et al.*, 2007). Strict standard precautions should be used during the autopsy of bodies suspected with these infectious diseases. Negative-pressure rooms and high-efficiency particulate air-filtered respirators also are recommended in cases of viral hemorrhagic

fever and plague. Most recently, severe pulmonary infectious outbreaks caused by highly pathogenic human coronaviruses (SARS, MERS) have occurred with high mortality rates. Severe acute respiratory syndrome (SARS) was first reported in Asia in 2003. It spread to more than two dozen countries in North America, South America, Europe, and Asia and a total of 8098 people worldwide became sick with 774 deaths. SARS begins with a high fever, headache, and body aches. Some patients also have mild respiratory symptoms at the outset and most will develop pneumonia. Middle East Respiratory Syndrome (MERS) was first reported in Saudi Arabia in 2012. Most people confirmed to have MERS-CoV infection developed severe acute respiratory illness (fever, cough, and shortness of breath) and approximately 50% died. Clinically, these viruses are thought to be transmitted mostly by respiratory droplets in the air or when a person touches a surface or object contaminated with infectious droplets and then touches his or her mouth, nose, or eye(s).

See also: Autopsy: Medicolegal Considerations, Including Organ Retention and Handling. Autopsy: Procedures and Standards. Occupational Health: Autopsy – Occupational Health and Safety

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