Infective Agents in Fixed Human Cadavers:
A Brief Review and Suggested Guidelines

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Cadavers remain a principal teaching tool for anatomists and medical educators teaching gross anatomy. Infectious pathogens in cadavers that present particular risks include *Mycobacterium tuberculosis*, hepatitis B and C, the AIDS virus HIV, and prions that cause transmissible spongiform encephalopathies such as Creutzfeldt-Jakob disease (CJD) and Gerstmann-Straussler-Scheinker syndrome (GSS). It is often claimed that fixatives are effective in inactivation of these agents. Unfortunately cadavers, even though they are fixed, may still pose infection hazards to those who handle them. Specific safety precautions are necessary to avoid accidental disease transmission from cadavers before and during dissection and to decontaminate the local environment afterward. In this brief review, we describe the infectious pathogens that can be detected in cadavers and suggest safety guidelines for the protection of all who handle cadavers against infectious hazards.

**KEY WORDS:** cadaver dissection; education; medical curriculum; gross anatomy; infection; mycobacterium tuberculosis; hepatitis; AIDS; HIV; prion; spongiform encephalopathy; Creutzfeldt-Jakob Disease; CJD

**INTRODUCTION**

Like all other occupations, being a member of an anatomy department has its own risks. The potential infection hazard of human cadavers is one of them. Cadavers are the main studying materials of anatomists (Aziz et al., 2002) but may pose infection risks to people who handle them during embalming procedures or dissections. Infectious pathogens in the cadavers that present particular risks include *Mycobacterium tuberculosis*, hepatitis B and C viruses, HIV, and prions that cause transmissible spongiform encephalopathies (Weed and Baggengstoss, 1951; Brown et al., 1986; Roth et al., 1992; De Craemer, 1994; Healing et al., 1995; Kappel et al., 1996; Catteneo et al., 1999). The embalming fluid used in anatomy departments contains fixatives, disinfectants, glycerol, salts, and water. There are inadequate data in the literature about the disinfectant efficiencies of fluids used for embalming. The purpose of this review is to draw attention to the infective agents that can be detected in fixed human cadavers and to suggest safety guidelines for the protection of all who handle cadavers.

**INFECTIOUS DISEASES AND THEIR AGENTS**

**Tuberculosis**

Tuberculosis is a slowly progressive, chronic infection usually of the lungs, but many other organs can become affected. The infective agent, *M. tuberculosis*, is an acid-fast, slender, beaded bacillus and can be cultured on Löwenstein-Jensen medium as rough, dry, and yellow colonies (Sleigh and Timburry, 1998). Tuberculosis was one of the biggest killers among the infectious diseases in the past. The annual number of tuberculosis cases continues to increase due to its emergence in HIV infections. The risk of acquiring tuberculosis varies according to occupation, and anatomy department workers are at particular risk of contracting tuberculosis carried by cadavers (Smith, 1953; Kappel et al., 1996; Sterling et al., 2000). Of particular concern is the growing number of multiple-drug-resistant strains that have evolved in recent years.

Transmission of *M. tuberculosis* is thought to occur primarily by exposure to aerosolized infectious bacilli.
Infected particles and splashes containing tuberculous material can be acquired during respiration (Sloan, 1942; Harrington and Shannon, 1976). The increased risk of tuberculosis among employees who handle cadavers was demonstrated through tuberculin skin testing (McKenna et al., 1996; Gershon et al., 1998).

It is generally thought that the risk of transmission is decreased by fixation, and some authors agree with a commonly held belief that formalin is tuberculocidal (Weed and Baggenstoss, 1951; Johnson et al., 1953; Smith, 1953). Although it was previously reported that tubercle bacilli from cadavers were not infectious (Meade and Steenken, 1949) and trials from cadavers were not infectious (Smith, 1953). Although it was previously reported that tubercle bacilli from cadavers were not infectious (Meade and Steenken, 1949) and trials for culturing M. tuberculosis from a cadaver to an embryo were unsuccessful (Kappel et al., 1996), it has been shown that bacilli remain viable and, therefore, infectious for at least 24 to 48 h after an infected cadaver has been embalmed (Weed and Baggenstoss, 1951). There is also a case report describing the transmission of M. tuberculosis from cadaver to an embalmer during the embalming process, with the subsequent development of active tuberculosis (Sterling et al., 2000). Based on the contradictory published data, the disinfection properties of fixatives for tuberculosis infected tissue remain unclear.

Viral Hepatitis

Hepatitis can be seen in many viral diseases such as yellow fever, cytomegalovirus and Epstein-Barr infection, and congenital rubella. However, viral hepatitis is caused by infections by viruses that primarily target the liver. There are six types of hepatitis viruses: A, B, C, D, E, and F types. Hepatitis A is transmitted by the oral route by means of food contaminated with fecal matter. Hepatitis B is extremely infectious. It might be transmitted by blood or blood products, sexual transmission, and skin penetration through contact with infected material. Hepatitis C is transmitted by the same routes as hepatitis B but is probably less infectious (Timburry, 1997).

Most of the studies made on cadaveric tissue donors revealed that the availability of cadaveric tissue as a transplantation material is often limited by pathogenic organisms which it may contain. Specific serologic markers of hepatitis B and C viruses can be detected in cadaveric tissue banks (hepatitis B surface ag 18.1% and hepatitis C ab 14.3%) (Barnett et al., 2001) and in postmortem blood tests for body donation programs (Roth et al., 1992; Watkins et al., 1998). The prevalence of HIV and hepatitis C markers has been studied among a cadaver population, and the cases represented a high prevalence of serologic markers for HIV and hepatitis C virus infection (Catteneo et al., 1999). It has been reported that organ transplantation from cadavers can transmit hepatitis (Lutwick et al., 1983). Workers in morbid anatomy also face the risk of contamination (Smith, 1953), which raises serious questions about the infective hazards of cadaver.

Can an individual who died of AIDS still be infectious at the time of arrival in the anatomy department as a cadaver? Unfortunately, the answer is YES.

AIDS

HIV, the cause of AIDS, is one of the most intensively investigated viruses. The cytopathic effect of HIV on T4 helper lymphocytes causes the failure of the immune system and results in AIDS. Human immunodeficiency virus is an RNA virus with typical retrovirus structure, and it is transmitted by similar routes as hepatitis B (Timburry, 1997).

Can an individual who died of AIDS still be infectious at the time of arrival in the anatomy department as a cadaver? Unfortunately, the answer is YES. Infectious HIV has been reported in pleural fluid, pericardial fluid, and blood of such deceased patients after storage at 2°C for up to 16.5 days after death (Douceron et al., 1993). Viable HIV was also isolated from bone fragments, spleen, brain, bone marrow, and lymph nodes from a patient with AIDS at autopsy 6 days postmortem (Nyberg et al., 1990). Although in suspension tests, 25% ethanol and 0.5% formaldehyde were shown to be effective against HIV (Sattar and Springthorpe, 1991), it is not clear whether these concentrations are also effective in cadavers (De Craemer, 1994). On the other hand, cadavers infected with HIV are often infected with opportunistic infections, such as tuberculosis, which may be more infectious than HIV infection itself (Healing et al., 1995).

Prion Diseases and Transmissible Spongiform Encephalopathies

The transmissible spongiform encephalopathies (TSEs) are degenerative diseases of the central nervous system. Two of these found in humans are Creutzfeldt-Jakob disease (CJD) and Gerstmann-Straussler-Scheinker (GSS) syndrome. GSS is distinct from CJD; GSS is thought to be familial but is known to occur sporadically as well. CJD is characterized by loss of motor control, dementia, paralysis, and death secondary to pneumonia.

The infectious agent that causes CJD has been called a prion and can be defined as small proteinaceous infectious particles resistant to inactivation by procedures that modify nucleic acids. It might be transmitted by diet or after medical procedures such as surgery, cadaver pituitary-derived growth hormone injections, and cadaveric dural grafts or cornea transplants (Billette de Villemeur and Pradel, 1994; Budka et al., 1995).

Prion is highly resistant to conventional methods of sterilization and disinfection (Brown et al., 1982). It has been shown that a related agent that causes scrapie survived internment for 3 years with infectivity (Brown and Gajdusek, 1991). The CJD agent has been shown to survive well in formalinized tissue, and it has been experimentally demonstrated that transmission of prion from formalinized brain tissue to mice is possible (Brown et al., 1986). Also, the CJD...
causative agent has been shown to stay infective in ash at 360°C after formaldehyde fixation (Brown et al., 1990). The evidence of risk to those who handle infected tissue has been supported by case reports of this disease in morbid anatomy workers (Miller, 1988).

**PROCEDURES AND PRECAUTIONS**

The information given above indicates that a cadaver might be still infectious at the time of arrival in an anatomy department for subsequent educational purposes. Therefore, specific safety precautions are mandatory from the moment of the cadaver’s arrival at the facility.

**Preparation for Dissection**

The corpse must have a detailed file, indicating the reason of death and containing previous hospital records if possible. Working on cases known to be infectious with *M. tuberculosis*, hepatitis B and C, HIV, and prions should be avoided. Every cadaver should be regarded as an infectious material. During the transportation process, disposable body bags must be used. The risk to department personnel of respiratory tract pathogens from the deceased is probably remote, even from the single exhalation of air that occurs when the body is first moved. Covering the face of the body with a cloth would be a simple precaution (Healing et al., 1995).

Proper protective clothing must be used by the department personnel for avoiding accidental transmission (CDC, 1988). Single-use latex examination gloves must be worn whenever handling bodies; they should be used once only and then discarded. Safety gloves (e.g., Teflon-made from spectra, or metallic gloves) should be worn over examination gloves to protect from longer term exposure to chemical hazards and accidental penetrating wounds. Filter masks must be used for respiratory protection from specific hazards, such as lead dust, fungal spores, and aerosols. Face visors should be worn for protection against hazardous splashes to eyes, nose, and mouth. Disposable aprons or gowns must be used for protection against splashes to the body. Contamination of the dissection table should be avoided by a nonpermeable, disposable plastic sheet or similar material (Budka et al., 1995; Healing et al., 1995).

**Embalming Chemicals**

Although embalming is thought to reduce the infectious risks, there is inadequate information about the disinfectant properties of fluids commonly used to embalm cadavers. The embalming fluid used in anatomy departments contains fixatives, disinfectants, surfactants, buffers, glycerol, salts, and water. The most frequently used fixatives and disinfectants are formalin, ethanol, and phenol. Formalin, a 37% aqueous solution of formaldehyde gas, inactivates infectious agents by forming covalent cross-links with several organic functional groups on proteins. Although formaldehyde is known to be a high-level germicide that has the capacity to kill all microbes and viruses, it is ineffective against the CJD agent as mentioned above.

In suspension tests, these fixatives and disinfectants were shown to be effective against most of the bacteria and viruses (Rutala, 1996). However, it is not clear whether they are also effective in cadavers, for several reasons. First, in suspension tests, the cell-free infectious agent is tested, whereas in humans, some infectious agents (such as HIV) can localize within cells. Second, the concentration of the embalming fluid components decreases as they diffuse throughout the human body. Third, several classes of products, including formalin, alcohols, and phenolic agents, are partially inactivated by the presence of protein. This sensitivity to organic load suggests that the efficiency of the disinfectants will be much lower in cadavers than in vitro tests (De Craemer, 1994). Fourth, although a certain fixative at certain levels may be cidal to a single agent or even a group or class of infectious agents, other agents that co-exist may survive as mentioned above; thus, complete disinfection may not be accomplished.

**Every cadaver should be regarded as an infectious material.**

Ethanol is one of the most commonly used alcohols to control microbial growth. Its mechanism of action involves protein denaturation and lipid dissolution. Ethanol can be used alone in concentrations of 60 to 95% or in combination with other antimicrobial agents in lower concentrations. It is known to be effective against bacteria and fungi but not endospores, nonenveloped viruses, or prions.

Phenol and its derivative phenolics exert antimicrobial activity by inactivating essential cell enzymes and injuring lipid-containing plasma membranes, which results in leakage of cellular contents. At concentrations above 1%, phenol and phenolics have an antibacterial effect. They have a broad spectrum of activity against bacteria, viruses, and fungi, but they are ineffective against prions.

**Postdissection Decontamination**

After the dissection is completed, tissue remnants, cutting debris, the sheet covering the table, and all the disposable material should be discarded within a plastic container as infectious hospital waste. All instruments that came into contact with potentially infectious material must be decontaminated. Although the conventional methods of sterilization and disinfection are effective for most of the infective agents, they do not decontaminate prions (Miller, 1988). Specific measures must be used for prions, and these measures will also be adequate for other infective agents. One of the most effective procedures is steam autoclaving (instruments, safety gloves, etc.) at 134°C with 30 lbs psi for 60 min (Committee on Health Care Issues, 1986). Chemical decontamination with 2 N NaOH for 1 h or 1 N NaOH for 2 h is an alternative for nonautoclavable materials and surfaces. It is not recommended to use NaOH for aluminum material. Boiling of instruments in 3% sodium dodecyl sulfate (SDS) at least 3 min is another option. Autoclaving can be
used either alone or in combination with using SDS or NaOH. Alternatively, 5% NaClO (at least 20,000 ppm free chloride) can be used for 2 h, but this chemical is very irritating and corrosive to steel (Tateishi et al., 1991).

The environment should be cleaned with a phenolic disinfectant (containing 3–5% active ingredient) daily. This method is preferred to hypochlorite for several reasons: hypochlorite is a corrosive chemical and may damage surfaces or instruments; cleaning large areas with hypochlorite may liberate unacceptable amounts of chlorine; and formaldehyde reacts with hypochlorite to produce a potent carcinogen, bis-chloromethyl ether (Gamble, 1977).

**CONCLUSION**

The potential infection hazard from human cadavers is one of the risks of being a member of an anatomy department. Special care must be taken to reduce risks to a minimum. Safe working conditions for handling cadavers can be provided through proper education, use of protective clothing, and practice of hygienic measures. Although following the recommendations mentioned can reduce the risk of infectious hazards of cadavers, vaccination of all who handle cadavers against hepatitis B and M. tuberculosis (Sterling et al., 1999) is another important precaution that should not be missed. Finally, dissection laboratory directors must stay up to date on the most recent literature in the field to help ensure the safety of all educators, researchers, and students under their charge.

**LITERATURE CITED**


