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Current Risks of Occupational Blood-Borne Viral Infection

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Abstract

Background: Human immunodeficiency virus (HIV), hepatitis B virus (HBV), hepatitis C virus (HCV), and other viruses remain occupational risks for both surgeons and patients in the operating room environment. In the past, this concern attracted great attention, but recently, this subject has been given much less attention.
Methods: Review of the literature over the past 50 years on occupational risks of viral infection in the operating room.
Results: Transmission of HIV still looms as a potential pathogen in the operating room, but no case has been documented in the United States. Infection with HBV can be prevented by a safe and effective vaccine. Chronic HCV infection is present in more than three million U.S. residents and remains a risk that can be managed only by adhering to strict infection control practices and avoiding blood exposure.
Conclusions: The risks of viral infection in the operating room remain the same as a decade ago even though attention to this issue has waned. The avoidance of blood exposure to prevent transmission of both known and unknown blood-borne pathogens continues to be a goal for all surgeons.

Healthcare workers and, especially, surgical personnel are at risk for occupational viral infections from human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV) from various types of blood contacts [1]. Cuts from scalpels, punctures from bone fragments, injuries from needle sticks, and eye/mucocutaneous contact are potential sources of transmission [2]. Furthermore, transmission of these viral pathogens to the patient during surgical, dental, dialysis, and endoscopic procedures from infected healthcare workers or from cross-transmission from other infected patients attributable to breaches in infection control practices continues to be a source of concern [3–9]. This article reviews the status of the viral blood-borne pathogens and the continued threat they pose for patients and healthcare workers.

Historical Perspectives

For nearly 60 years, healthcare workers have been acquiring occupational infections. "Serum hepatitis" cases were reported in the early 1950s [10,11], and at one point, it was estimated that nearly 250 healthcare workers died annually from occupationally-acquired HBV infection [12]. Surgeons were recognized as being at particular risk for infection with this virus. The HBV infections commonly were occult, with only about 5% resulting in chronic disease, and indifference was the general attitude [13].

However, in 1981, the recognition of *Pneumocystis* pneumonia in young men without clinical reason for immunosuppression led to the recognition of HIV as the putative cause of the acquired immunodeficiency syndrome (AIDS) [14]. Transmission of the infection was identified quickly as the consequence of exposure to blood and body fluids. In contrast to the reaction to HBV infection, the social stigma of AIDS led to inappropriate responses at multiple levels of society. Many people called for mandatory screening of patients and even healthcare providers for HIV and HBV. The identification of a third pathogen, HCV, formerly known as non-A, non-B hepatitis, and the development of a serologic assay in 1989 confirmed that HCV had a greater prevalence in society than HIV and HBV together, adding to social anxiety [15].

In 1991, the U.S. Centers for Disease Control and Prevention (CDC) reported possible transmission of HIV infection to a cluster of six patients during invasive dental procedures by a single infected dentist [5]. These cases impacted federal and state policy directly because of public concern that there would be an outbreak of HIV infections transmitted from physicians to patients. In 1991, the CDC recommended that healthcare workers infected with HIV or HBV inform their patients of their serologic status and be reviewed by an expert panel before engaging in exposure-prone procedures [16]. Later that year, Congress enacted a statute requiring each state, as a condition of receiving Public Health Service funds, to certify that CDC guidelines "or their equivalent" had been instituted [17]. All 50 states responded with written policies. The Occupational Safety and Health Administration (OSHA) then issued requirements governing certain behaviors in the operating room [18].

The furor over HIV and HBV as occupational risks reached a crescendo in the mid-1990s, but by the end of the decade, the furor had subsided. Operating room rates of HIV transmission were minuscule, with no case of transmission documented in the United States. The American College of Surgeons (ACS) took a strong position that the risk of transmission from patients, or to patients, in the operating room was negligible when appropriate infection control practices were employed [19,20]. As of 1996, marked declines were reported in the incidences of new HIV infections and deaths as a consequence of education programs and the use of highly-active anti-retroviral therapy (HAART) in the treatment of established infections [21,22].

Unfortunately, attitudes about occupational infection have returned to the indifference of the pre-AIDS era. Public and professional discussion of occupational infection in healthcare providers or risks to patients has quieted, being ignited only sporadically by the occasional cluster of HCV infections when infection control practices are applied poorly or ignored. Are eye shields or double gloves worn with the same frequency today as in the mid-1990s? Probably not! The pathogens in the surgical population are still there, and the risks are still real. Continued awareness and sensitivity to the specific viral pathogens and to easily applied preventive strategies still are needed.

HIV Infection

There are approximately one million people living with HIV infection in the United States, with about 35,000–38,000 new cases and 16,000–18,000 deaths per year [23]. There has been little change in the number of cases of documented occupational infections of healthcare workers or of epidemiologically suspected cases since 2001 [24]. There have been 57 *documented* cases of occupational transmission of HIV where individuals seroconverted after having negative serology at the time of the index exposure event (Table 1). An additional 140 healthcare workers with HIV infection *possibly* acquired in the work place. These persons did not have non-occupational risk factors for the development of the infection. No surgeon has been documented to have HIV conversion after exposure, although six surgeons have been identified as possible transmissions on the basis of exposure history. Studies of patients undergoing invasive procedures by surgeons with HIV infection have demonstrated no transmission [25]. On the basis of these observations combined with the serological surveillance study done with a large population of orthopedic surgeons that demonstrated no HIV infection in the absence of non-occupational risk factors [26], it can be concluded that surgical activity is associated seldom with HIV transmission to surgeons or to patients.

Table 1. Occupations of Healthcare Workers with Documented or Possible HIV Infection Transmitted in Healthcare Environment[a]

	No. documented	*No. possible*
Nurses	24	35
Clinical laboratory workers	16	17
Physicians, non-surgical	6	12
Surgical physicians	0	6
Non-clinical laboratory workers	3	0
Housekeeping/maintenance workers	2	13
Surgical technicians	2	2
Embalmer/morgue technician	1	2
Health aide/attendant	1	15
Respiratory therapist	1	2
Dialysis technician	1	3
Emergency medical technicians	0	12
Other technicians/therapists	0	9
Dental workers/dentists	0	6
Others	0	5
Total	57	139

[a]Documented cases are those in which the individual had negative serology for HIV at the time of the index event and subsequently seroconverted. Possible cases are those with HIV infection, an exposure history, and no non-occupational associations to explain contraction of the infection.

In prospective studies of healthcare workers, the average risk for HIV transmission after a percutaneous exposure to HIV-infected blood has been estimated to be approximately 0.3% (95% confidence interval [CI] 0.2%, 0.5%) [27] and after a mucous membrane exposure, approximately 0.09% (CI 0.006, 0.5%) [28]. Most transmissions have occurred in nurses and medical technologists. Most injuries in which transmission has occurred have been dramatic, not superficial needle sticks. Either mucus membrane or percutaneous injury requires consideration for post-exposure prophylaxis (PEP) with anti-retroviral chemoprophylaxis.

Recommendations for PEP are summarized in Table 2 [29]. Percutaneous injuries to patients with known HIV infection should trigger a basic two-drug regimen if the disease was asymptomatic in the index patient or a three-drug (or more) regimen when the index patient has symptomatic infection. The drug choices recommended are listed in Table 3, and the number of antiretroviral agents continues to expand. Prophylaxis should be initiated as soon as possible after exposure and be continued for four weeks. Because of indeterminate issues of severity of disease in the index patient, the volume of inocula in mucous membrane exposure, the vast choices of different antiretroviral drugs, and the potential toxicity of PEP, it usually is necessary to have an infectious disease specialist knowledgeable in HIV infection manage the course of PEP. Serologic post-exposure testing for HIV and other blood-borne viruses is recommended at six weeks, 12 weeks, and six months after the exposure.

Hepatitis B Infection

There are more than one million people in the U.S. with chronic HBV infection [30]. The infection became widely disseminated by intravenous drug abuse, sexual transmission, and, prior to 1970, blood transfusions. Hepatitis B has been a particularly common occupational infection for surgeons, with 25–30% of surgeons in the >60-year-old group having serologic evidence of prior acute infection [31]. Fortunately, only a small minority developed chronic infection. However, chronic infection is a serious situation because it leads to end-stage liver disease, hepatocellular carcinoma, and portal hypertension. Because 70–75% of acute HBV infections are clinically occult, many surgeons were unaware of chronic infection until clinical sequelae occurred with advanced disease, often 20 or more years after acute infection [13].

Unlike HIV infection, HBV transmission occurs quite efficiently to healthcare personnel from infected patients. Per-

Table 2. Recommendations by U.S. Centers for Disease Control and Prevention for Post-Exposure Prophylaxis (PEP)

Type of exposure[a]	HIV-positive Class 1[b]	HIV-positive Class 2
Percutaneous injury		
Less severe	Two-drug	≥Three-drug
Severe	Three-drug	≥Three-drug
Mucous membrane or non-intact skin		
Small volume	Two-drug	Two-drug
Large volume	Two-drug	≥Three-drug

[a]Severity of percutaneous injury or volume of mucous membrane exposure is a subjective decision, and no guidelines for differentiation are available.
[b]Class 1 is an asymptomatic patient, and Class 2 is a symptomatic patient with clinical acquired immunodeficiency syndrome.

cutaneous needle sticks are associated with a 30% risk of transmission of acute infection [32]. Numerous clinical reports have identified that surgeons who have high viral titers, commonly identified by the presence of the e antigen, are infectious for their patients [33–35].

A highly effective HBV vaccine has been available for 25 years and has reduced dramatically the risks of chronic HBV infection for healthcare personnel [36]. The current vaccine is produced by recombinant technology and has an excellent record of safety. Vaccination is achieved by administration of a three-dose regimen, with the second and third doses being given one and six months after the initial dose. It is important that a surface-antibody response be documented, because 5% of individuals do not respond to the initial vaccination series. Non-responders should undergo a second series of three vaccinations [37]. It is now mandated by OSHA regulations that all healthcare personnel be offered the HBV vaccine by their employers, and there is no legitimate reason for any surgeon not to be immunized. Nevertheless, a recent study of transplant surgeons found that 10% had not been, and another 20% had not completed the full three-dose regimen [38].

Effective PEP after exposure to blood of an infected patient requires that surgeons know their status for HBV antibodies [39]. A strongly positive surface antibody test means that the surgeon is protected from the virus. If immunization has been performed and the surgeon is weakly positive for the surface antibody or is non-reactive, administration of a dose of HBV immunoglobulin is necessary, and a booster dose of HBV vaccine should be given immediately. If the surgeon or other exposed healthcare worker has not been immunized at the time of an exposure and the exposed individual is seronegative for HBV surface antibody, then a dose of HBV immunoglobulin should be given; the full vaccination series should be started immediately. The unvaccinated surgeon positive for the HBV core antibody has had a prior infection and does not need PEP. However, the antibody-positive but unvaccinated surgeon should have followup studies to determine if there is chronic HBV infection.

Should the surgeon with HBV infection continue to practice surgery? If he or she is antigen-negative, the prior acute infection has resolved, and there are no health risks for the surgeon or the patients. Antigen-positive surgeons should be tested for the e antigen. If positive, they should consult with a locally convened group of experts to advise them about continuing surgical practice [20]. Whether positive or not for the e antigen, treatments for chronic HBV are now available, and the chronically-infected surgeon should receive appropriate care.

Hepatitis C Infection

Hepatitis C is by far the most serious blood-borne viral infection of the current era. There are some 3–4 million people in the U.S. with chronic HCV infection [40]. It is associated with intravenous drug abuse, multiple sexual partners, and blood transfusion prior to 1992 [41] (Table 4). As with HBV, it is an occult acute infection for the majority of patients, but unlike HBV, more than 60% of acute events result in chronic disease. The infection is associated with a 2% frequency of transmission with percutaneous exposure in the healthcare setting [42]. Surgeons have higher rates of chronic HCV

Table 3. Antiretroviral Agents Commonly Used for Post-Exposure Prophylaxis[a]

Drug	Preferred dose
Basic regimen	
Zidovudine/Lamivudine	600 mg daily (two or three doses)
	300 mg daily (one or two doses)
Zidovudine/Emtricitabine	600 mg daily (two or three doses)/200 mg daily
Tenofovir/Lamivudine	300 mg daily/300 mg daily (one or two doses)
Tenofovir/Emtricitabine	300 mg daily/200 mg daily
Preferred expanded regimen (third drug)	
Lopinavir/ritonavir	400/100 mg twice daily
Alternate expanded regimens (third drug)	
Atazanavir ± ritonavir	300 g daily ± 100 mg daily
Fosamprenavir ± ritonavir	700–1400 mg twice daily ± 100–200 mg daily
Indivavir ± ritonavir	800 mg ± 100 mg twice daily
Saquinavir ± ritonavir	1000 mg ± 100 mg twice daily
Nelfinavir	1250 mg twice daily
Efavirenz	600 mg daily

[a]The basic regimen is the two-drug recommended PEP, and the preferred and alternate expanded regimens are those choices added to the basic regimen when three or more drugs are used for severe exposures or for exposures to Class 2 patients.

Table 4. Risk Factors for Hepatitis C Virus (HCV) Infection[a]

Past transfusion
HIV infection
IV drug injection
Hemodialysis
Organ transplantation
Percutaneous injury (healthcare workers)
Multiple sex partners
Household exposures (episodic cases)
Tattoos
Body piercing
Incarceration in jail/prison

[a]A large number of HCV infection do not have a readily identified cause.
HIV = human immunodeficiency virus; IV = intravenous.

infection than the public in general, and percutaneous operating room exposure is believed to be the cause. Although the efficiency of transmission is less with HCV than with HBV, the greater number of people in society who carry chronic HCV infection and the higher rates of chronic infection that follow an acute episode make HCV a greater source of concern for surgeons.

Yet another source of concern is that no effective vaccine exists to prevent HCV infection. Moreover, resolved acute infection does not appear to confer long-term immunity, and reinfection may occur in the same host. There are multiple serotypes of HCV that add to the problems of vaccine development. Also, unlike the immunoglobulin preparation for HBV, the HCV immunoglobulin has not been demonstrated to prevent infection after exposure in either experimental [43] or clinical [44] studies.

Prevention of exposure in the operating room is the mainstay of prevention of this occupational infection. Immediate use of anti-viral treatment has not been demonstrated to be of value in preventing HCV infection after percutaneous exposure and is not recommended [45]. Rather, exposed individuals are followed and if infection has been transmitted, therapeutic anti-viral treatment is initiated.

Table 5. Factors that Need To Be Considered in Making a Decision about Post-Exposure Prophylaxis and Need for Followup after Occupational Exposure

Type of exposure
Percutaneous injury
Pin prick
Major cut/laceration
Mucous membrane exposure
Non-intact skin exposure
Type and amount of exposure
Pure blood
Bloody fluids/irrigation solutions
Non-blood body fluids
Vaginal secretions
Cerebrospinal fluid
Pleural/peritoneal fluid
Amniotic fluid
Infectious status of index patient
Positive for hepatitis B virus antigen
Positive for hepatitis C virus antibody
Positive for human immunodeficiency virus antibody
Susceptibility of exposed healthcare worker
HBV vaccination status

HBV = Hepatitis B virus.

The high-risk exposure event should be handled in a systematic fashion. The HCV status of the source patient should be either known or documented by antibody testing. Baseline HCV antibody and alanine aminotransferase activity of the exposed surgeon should be obtained at the time of the event. Followup antibody testing should be performed at 4–6 months, because seroconversion may require this long. Anxiety of the exposed individual may lead to reverse transcriptase testing for HCV ribonucleic acid (RNA) 4–6 weeks after the event.

It is generally believed that the surgeon who is infected chronically with HCV is not a risk to patients if standard infection control practices are maintained. Two individual cases of transmission have been reported from cardiac surgeons to patients [46,47], and single cases of transmission by a gynecologist [48] and an orthopedic surgeon [49] have been published. The bigger risk of healthcare-associated transmissions to patients appears to be from contamination of multidose vials for intravenous drug administration combined with lapses in standard infection control practices [50,51].

Prevention of Blood Exposure

From the above discussion, it should be apparent that the surgeon and others in the operating room are at risk for bloodborne viral infection. The principal method of prevention of occupational infection is avoidance of blood contact with skin and mucous membranes and strong vigilance in the prevention of percutaneous injury. Studies in the last 20 years have identified blood exposure events in 25%–50% of major operations, which commonly involve more than one member of the operative team [52–55]. Percutaneous injuries occur less often but are of greater importance for viral transmission. The volume of blood loss during the operation and the duration of the procedure are clinical variables associated with a higher risk of blood exposure. Trauma procedures, cesarean sections, and cardiac operations are associated with the highest incidences of blood exposure.

Barriers

Prevention of virus transmission by the use of barriers has received the greatest attention for prevention of blood exposure in the healthcare setting, especially in the operating room. Eye protection in the operating room, an OSHA mandate, can be achieved by enhancement of conventional glasses with lateral shielding or by wearing specially-designed goggles and other removable eye covers. Shields that are attached to the superior margin of the face mask have been another popular method. Eye protection is available in all operating rooms but continues not to be worn uniformly despite the federal mandate.

The greatest amount of study has been focused on the value of double gloving in avoiding exposure of the hands. Punctures, tears, and fatigue of glove material make blood exposure after two hours of operating time a virtual certainty. In the late 1980s [56] and early 1990s [57], double gloving was demonstrated to be of value, and a recent review identified the multiple studies that have validated the view that double gloving reduces blood exposure and may reduce the transmission of viral pathogens [58]. An indicator double gloving system has been developed to facilitate recognition that the outer glove has been violated [59]. Despite the clear evidence that double gloving prevents blood exposure of the hands, it still is not employed uniformly. Presumed restriction of hand movement, reduced tactile sensation, and "claudication" of the digits are common reasons for not double gloving. The practice of placing a half-size larger glove underneath with the correct glove size over the top has been useful to enhance the comfort of double gloving.

Other tactics include sleeve re-enforcements for operations in the chest or abdomen, where blood breakthrough above the proximal extension of the glove is a risk. Plastic aprons underneath the gown will prevent torso breakthrough but commonly are unbearably hot. Trauma boots to cover the lower extremity to the upper shin or knee are used when large-volume blood loss is anticipated.

Technique

Technical considerations in the prevention of injury and blood exposure in the operating room require constant awareness of sharp instruments and the potential for harm. Double gloving for tying large monofilament suture under tension when closing the abdomen and chest will avoid shearing injuries of the digits. Swaged needles need to be removed before tying the suture. Spent needles need to be introduced tip-down into a polystyrone foam block or some similar medium to eliminate accidental puncture wounds. Blunt needle technology that has been recommended by the ACS should be employed [60]. Blind suturing techniques that employ palpation of needle tips should be avoided. When frequent exchanges of loaded needle holders are required, a Mayo stand can serve as a convenient "way station" to avoid injury in passing the loaded needle holder (hands-free technique) [61]. Selected operations may be performed without sharp instrumentation on the surgical field [62].

Response to exposure event

Despite adherence to all barrier and technical tactics, exposure events will occur inevitably. Blood breakthrough onto the hands should result in immediate rescrubbing. Unfortunately, this commonly is impractical in the middle of a procedure, in which case, the glove is removed, the local site is irrigated with povidone-iodine solution or isopropyl alcohol, and the procedure is completed. These antiseptics are viricidal in the laboratory, but no clinical evidence demonstrates effectiveness in the prevention of transmission of viral infections. Blood exposure from penetration of the surgical gown requires removal of the gown, local irrigation, and regowning.

Multiple parameters should be considered in concluding that a given exposure is high risk (Table 5). High-risk events should be followed by immediate serologic testing and PEP strategies as described above. Criteria for "high-risk exposure" are measured in terms of the likelihood of the patient harboring infection, the magnitude of the exposure event, and the concern that the exposed individual has for potential transmission.

Future Considerations

The transmission of blood-borne pathogens continues to be a risk for members of the surgical team. Whereas HBV infection can largely be prevented with vaccination and HIV has not been documented to have been transmitted in the operating room to the surgeon, HCV infection remains a real risk. It is likely that additional unserotyped hepatitis viruses exist [63]. Additional acute infections such as with West Nile virus, coronovirus of severe acute respiratory syndrome, and the Asian avian influenza virus have a viremic phase that can pose a risk [64]. Recent evidence of transfusion-associated prion disease creates yet another potential risk [65,66]. The lassitude and indifference of recent years must be reevaluated in the context of the numerous known and unknown infectious agents that are borne in blood.

Avoidance of blood exposure is an important objective in surgical care, and it is the responsibility of surgeons to avoid exposing themselves and others in the operating room environment. We can hope that newer technology in glove design and gown barriers can provide additional protection in the future. Until that time, blood exposure is a personal health risk to the surgeon that must be avoided.

Author Disclosure Statement

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References

1. Fahey JB, Koziol ED, Banks MS, Henderson KD. Frequency of nonparenteral occupational exposures to blood and body fluids before and after universal precautions training. Am J Med 1991;90:145–153.
2. U.S. Centers for Disease Control and Prevention. Case-control study of HIV seroconversion in health-care workers after percutaneous exposure to HIV-infected blood—France, United Kingdom, and United States, January 1988–August 1994. MMWR Morbid Mortal Wkly Rep 1995;44:929–933.
3. Do NA, Ciesielski AC, Metler PR, et al. Occupationally acquired human immunodeficiency virus (HIV) infection: National case surveillance data during 20 years of the HIV epidemic in the United States. Infect Control Hosp Epidemiol 2003;24:86–96.
4. Lot F, Seguier JC, Fegueux S, et al. Probable Transmission of HIV from an orthopedic surgeon to a patient in France. Ann Intern Med 1999;130:1–6.
5. U.S. Centers for Disease Control and Prevention. Update: Transmission of HIV infection during an invasive dental procedure–Florida. MMWR Morbid Mortal Wkly Rep 1991;40(RR-2):21–27, 33.
6. Thompson ND, Novak RT, Datta D, et al. Hepatitis C virus transmission in hemodialysis units: Importance of infection control practices and aseptic technique. Infect Control Hosp Epidemiol 2009;30:900–903.
7. Lessa F, Tak S, Devader SR, et al. Risk of infections associated with improperly reprocessed transrectal ultrasound-guided prostate biopsy equipment. Infect Control Hosp Epidemiol 2008;29:289–293.
8. Germain JM, Carbonne A, Thiers V, et al. Patient-to-patient transmission of hepatitis C virus through the use of multidose vials during general anesthesia. Infect Control Hosp Epidemiol 2005;26:789–792.
9. U.S. Centers for Disease Control and Prevention: Acute hepatitis C virus infections attributed to unsafe injection

practices at an endoscopic clinic–Nevada, 2007. MMWR Morb Mortal Wkly Rep 2008;57:513–517.
10. Trumbell ML, Greiner DJ: Homologous serum jaundice: An occupational hazard to medical personnel. JAMA 1951;145: 965–967.
11. Kuh C, Ward WE. Occupational virus hepatitis: An apparent hazard for medical personnel. JAMA 1950;143:631–635.
12. U.S. Centers for Disease Control and Prevention. Guidelines for prevention of transmission of human immunodeficiency virus and hepatitis B virus to health-care and public-safety workers—a response to P.I. 100–607. The Health Omnibus Program Extension Act of 1988. MMWR Morbid Mortal Wkly Rep 1989;38(S-6):3–37.
13. Fry DE. The ABCs of hepatitis. Adv Surg 1999;33:413–437.
14. Gottlieb MS, Schroff R, Schanker HM, et al. *Pneumocystis carinii* pneumonia and mucosal candidiasis in previously healthy homosexual men: Evidence of a new acquired cellular immunodeficiency. N Engl J Med 1981;305:1431.
15. Choo Q-L, Kuo G, Weiner AJ, et al. Isolation of a cDNA clone derived from a blood-borne non-A, non-B viral hepatitis genome. Science 1989;244:359–362.
16. Recommendations for preventing transmission of human immunodeficiency virus and hepatitis B virus to patients during exposure-prone invasive procedures. MMWR Morb Mortal Wkly Rep 1991;40(RR-8):1–9.
17. Public Health and Welfare Act, 42 USC §300ee-2 (1994).
18. Occupational Safety and Health Administration. Occupational exposure to bloodborne pathogens: Final rule. Fed Reg 1991;56:64175.
19. American College of Surgeons. Statement on the surgeon and HIV infection. Available at www.facs.org/fellows_info/statements/st-13.html
20. American College of Surgeons. Statement on the surgeon and hepatitis. Available at www.facs.org/fellows_info/statements/st-22.html
21. Bartlett JA, Fath MJ, Demasi R, et al. An updated systematic overview of triple combination therapy in antiretroviral-naïve HIV-infected adults. AIDS 2006;20:2051–2064.
22. U.S. Centers for Disease Control and Prevention. HIV and AIDS—United States, 1981–2000. MMWR Morbid Mortal Wkly Rep 2001;50:430–434.
23. U.S. Centers for Disease Control and Prevention. HIV and AIDS in the United States: A picture of today's epidemic. Available at www.cdc.gov/hiv/topics/surveillance/united_states.htm
24. U.S. Centers for Disease Control and Prevention. Surveillance of occupationally acquired HIV/AIDS in healthcare personnel since 2006. Available at www.cdc.gov/ncidod/dhqp/bp_hcp_w_hiv.html
25. Robert LM, Chamberland ME, Cleveland JL, et al. Investigation of patients of health care workers infected with HIV. Centers for Disease Control and Prevention database. Ann Intern Med 1995;122:653–657.
26. Tokars JI, Chamberland ME, Schable CA, et al. A survey of occupational blood contact and human immunodeficiency virus infection among orthopedic surgeons. The American Academy of Orthopaedic Surgeons Serosurvey Study Committee. JAMA 1992;268:489–494.
27. Bell DM. Occupational risk of human immunodeficiency virus infection in health-care workers: An overview. Am J Med 1997;102(5B):9–15.
28. U.S. Centers for Disease Control and Prevention. Public Health Service guidelines for the management of health-care worker exposures to HIV and recommendations for post-exposure prophylaxis. MMWR Morbid Mortal Wkly Rep 1998;47(No. RR-7):1–33.
29. Panlilio AL, Cardo DM, Grohskopf LA, et al. Updated U.S. Public Health Service guidelines for the management of occupational exposures to HIV and recommendations for postexposure prophylaxis. MMWR Morbid Mortal Wkly Rep 2005;54(RR09):1–17.
30. Lee WM. Hepatitis B virus infection. N Engl J Med 1997; 337:1733–1745.
31. Shapiro CN, Tokars JI, Chamberland ME; American Academy of Orthopaedic Surgeons Serosurvey Study Committee: Use of hepatitis-B vaccine and infection with hepatitis B and C among orthopaedic surgeons. J Bone Joint Surg 1996;78A:1791–1800.
32. Shapiro CN. Occupational risk of infection with hepatitis B and hepatitis C virus. Surg Clin North Am 1995;75:1047–1056.
33. Heptonstall J. Outbreaks of hepatitis B virus infection associated with infected surgical staff. CDR Weekly 1991;1:R81–R85.
34. Harpaz R, von Seidlein L, Averhoff FM, et al. Transmission of hepatitis B virus to multiple patients from a surgeon without evidence of inadequate infection control. N Engl J Med 1996;334:549–554.
35. Spijkerman IJB, van Doorn L-J, Jansssen MHW, et al. Transmission of hepatitis B virus from a surgeon to his patients during high-risk and low-risk surgical procedures during 4 years. Infect Control Hosp Epidemiol 2002;23:306–312.
36. Zajac BA, West DJ, McAleer WJ, Scolnick EM. Overview of clinical studies with hepatitis B vaccine made with recombinant DNA. J Infect Dis 1986;13(Suppl):39–45.
37. Hadler SC, Francis DP, Maynard JE, et al. Long term immunogenicity and efficacy of hepatitis B vaccine in homosexual men. N Engl J Med 1986;315:209–214.
38. Halpern SD, Asch DA, Shaked A, et al. Inadequate hepatitis B vaccination and post-exposure evaluation among transplant surgeons: Prevalence, correlates, and implications. Ann Surg 2006;244:305–309.
39. U.S. Centers for Disease Control and Prevention. Updated U.S. public health service guidelines for the management of occupational exposure to HBV, HCV, and HIV and recommendations for postexposure prophylaxis. MMWR Morbid Mortal Wkly Rep 2001;50:1–42.
40. Sheppard CW, Finelli L, Alter MJ. Global epidemiology of hepatitis C virus infection. Lancet Infect Dis 2005;5:558–567.
41. Howard RJ, Fry DE, Davis JM, et al. Hepatitis C virus infection in healthcare workers. J Am Coll Surg 1997;184:540–552.
42. U.S. Centers for Disease Control and Prevention. Recommendations for prevention and control of hepatitis C virus infection and HCV-related chronic disease. MMWR Morbid Mortal Wkly Rep 1998;47:1–39.
43. Krawczynski K, Alter MJ, Tankersley DL, et al. Effect of immune globulin on the prevention of experimental hepatitis C virus infection. J Infect Dis 1996;173:822–828.
44. Alter MJ. Occupational exposure to hepatitis C virus: A dilemma. Infect Control Hosp Epidemiol 1994;15:742–744.
45. U.S. Centers for Disease Control and Prevention. Updated U.S. Public Health Service guidelines for the management of occupational exposures to HBV, HCV, and HIV and recommendations for postexposure prophylaxis. MMWR Morbid Mortal Wkly Rep 2001;50(RR11):1–42.
46. Esteban JI, Gomez J, Martell M, et al. Transmission of hepatitis C virus by a cardiac surgeon. N Engl J Med 1996; 334:555–560.

47. Duckworth GJ, Heptonstall J, Aitken C. Transmission of hepatitis C virus from a surgeon to a patient: The incident control team. Commun Dis Public Health 1999;2:188–192.
48. Ross RS, Viazov S, Thromahlen M, et al. Risk of hepatitis C virus transmission from an infected gynecologist to patients: Results of a 7-year retrospective investigation. Arch Intern Med 2002;162:805–810.
49. Ross RS, Viazov S, Roggendorf M. Phylogenetic analysis indicates transmission of hepatitis C virus from an infected orthopaedic surgeon to a patient. J Med Virol 2002;66:461–467.
50. Allen M. Report on Las Vegas hepatitis C outbreak released. *Las Vegas Sun*, December 21, 2009. Available at www.lasvegassun.com/news/2009/dec/21/report-las-vegas-hepatitis-c-outbreak-released/
51. Bunch J. 5,700 may be at risk for hepatitis C in Colorado due to medical tech. *Denver Post*. July 3, 2009. Available at www.denverpost.com/news/ci_12746614
52. Tokars IJ, Bell MD, Culver HD, et al. Percutaneous injuries during surgical procedures. JAMA 1992;267:2899–2904.
53. Panlilio LA, Foy RD, Edwards RJ, et al. Blood contacts during surgical procedures. JAMA 1991;265:1533–1537.
54. Tokars IJ, Culver HD, Mendelson HM, et al. Skin and mucous membrane contacts with blood during surgical procedures: Risk and prevention. Infect Control Hosp Epidemiol 2003;16:703–711.
55. Popejoy SL, Fry DE. Blood contact and exposure in the operating room. Surg Gynecol Obstet 1991;172:480–483.
56. Matta H, Thompson AM, Rainey JB. Does wearing two pairs of gloves protect operating theatre staff from skin contamination? Br Med J 1988;297:597–598.
57. Quebbeman EJ, Telford GJ, Wadsworth K, et al. Double gloving: Protecting surgeons from blood contamination in the operating room. Arch Surg 1992;127:213–217.
58. Tanner J, Parkinson H. Double gloving to reduce surgical cross-infection. Cochrane Database Syst Rev 2006;3:CD003087.
59. Florman S, Burgdorf M, Finigan K, et al. Efficacy of double gloving with an intrinsic indicator system. Surg Infect 2005; 6:385–395.
60. American College of Surgeons. Statement on blunt suture needles [ST-52]. Available at www.facs.org/fellows_info/statements/st-52.html
61. Berguer R, Heller PJ. Preventing sharps injuries in the operating room. J Am Coll Surg 2004;199:462–467.
62. Makary MA, Pronovost PJ, Weiss ES, et al. Sharpless surgery: A prospective study of the feasibility of performing operations using non-sharp techniques in an urban, university-based surgical practice. World J Surg 2006;30:1224–1229.
63. Narayanan Menon KV. Non-A to E hepatitis. Curr Opin Infect Dis 2002;15:529–534.
64. Alter HJ. Emerging, re-emerging and submerging infectious threats to the blood supply. Vox Sang 2004;87(Suppl 2):S56–S61.
65. Aguzzi A, Glatzel M. Prion infections, blood and transfusions. Nat Clin Pract Neurol 2006;2:321–329.
66. Ironside JW. Variant Creutzfeldt-Jakob disease: Risk of transmission by blood transfusion and blood therapies. Haemophilia 2006;12(Suppl 1):8–15.

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