Occupational Exposure to Bloodborne Pathogens in IR—Risks, Prevention, and Recommendations: A Joint Guideline of the Society of Interventional Radiology and Cardiovascular and Interventional Radiological Society of Europe

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ABBREVIATIONS

BBP = bloodborne pathogen, CDC = Centers for Disease Control and Prevention, HBV = hepatitis B virus, HCV = hepatitis C virus, HCW = health care worker, HIV = human immunodeficiency virus, IR = interventional radiology, NaSH = National Surveillance System for Healthcare Workers, NPA = Needlestick Safety and Prevention Act, OSHA = Occupational Safety and Health Administration

INTRODUCTION

In 2003, the Society of Interventional Radiology (SIR) published a policy and position statement concerning the occupational risks of bloodborne pathogens (BBPs) (1). The members of the SIR subcommittee on human immunodeficiency virus (HIV) and BBPs constructed this document, which detailed the risks of BBP infection in the interventional radiology (IR) environment (patient–to–health care worker [HCW] transmission as well as vice-versa) and proposed various methods to reduce risk, including use of personal protective equipment, adherence to the philosophy of universal precautions (2), and observance of various preventative measures related to performance of procedures, use of equipment, and specimen handling. This subcommittee promoted postexposure prophylaxis (PEP) guidelines and exposure control measures approved by the Centers for Disease Control and Prevention (CDC) and the Occupational Safety and Health Administration (OSHA) at the time of draft approval.

During the past 10 years, changes in the social, legal, and medical environments indicate the need for a new statement from SIR concerning BBPs in the IR work environment. First, OSHA has revised their BBP standard twice since its inception, and CDC recommendations for PEP have similarly changed. These revisions promote new concepts such as "standard precautions" and "safety engineering," which should be explained and incorporated into new SIR standards. Second, at least three surveys regarding individual IR physicians' infection control practices were published in recent years (2–4). These provide insight into not only how well interventional radiologists conform to the published BBP recommendations but also how IR physicians have changed over the years in response to growing threats from these infections.

The purpose of the present document is to inform interventional radiologists of the known or estimated risks of contracting various types of BBP by mode of transmission or exposure. This is followed by a review of federal, state, and societal (eg, SIR) regulations, standards, and precautions pertaining to BBP, including the latest recommendations specific to the practice of IR. Finally, this document reviews several surveys of practicing interventional radiologists to determine how well SIR members conform to best practices and to propose an effective means of improving compliance. At its conclusion, this document establishes an amended set of standards for BBP exposure reduction and PEP in the IR workplace. Support for this document comes from literature searches on PubMed regarding BBPs, US government health-related Web sites, and earlier position statements from SIR.

RISKS

BBPs represent a significant occupational hazard to all HWCs. At particularly high risk are personnel such as surgeons and interventional cardiologists and interventional radiologists because of the invasive nature of their practices. When medical students, residents, nursing staff, and technologists are involved in procedures, they likewise become exposed to these hazards. Physicians and their staff must understand the epidemiology of these pathogens and use all appropriate methods to reduce exposure. The following sections provide information of critical importance to any interventional radiologist. The following section introduces the major pathogens, focusing on their mode of transmission and the risk of physician infection.

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Following this is a discussion of the national and societal efforts to reduce the risk of BBP infections in HCWs and an assessment of the current safe practices and how to improve them.

Hepatitis B Virus

The prevalence of hepatitis B virus (HBV) in developed countries has markedly diminished as a result of the availability of an effective vaccine since the 1980s and the institution of universal blood donation screening. Nevertheless, chronic HBV infection remains endemic in parts of Asia and Africa, where 8% of the population are chronic carriers (5). In these countries, neonatal and pediatric transmission occurs as a rule, with no acute disease and a high conversion to the chronic carrier state (as many as 95% of infections) (6). Adult inoculation with HBV is more likely to cause acute hepatitis and rarely leads to a chronic carrier state. With long-distance travel becoming more commonplace, individuals from HBV-endemic areas mix with those in low-risk countries such that hepatitis B continues to represent a threat to the unimmunized groups in our society. In 1999, a national survey (7) indicated that approximately 0.2% of Americans had chronic HBV infection, and serum markers of previous infection were evident in nearly 5%. A more recent study from 2010 (8) confirms stability among infected adults but diminishing infection rates among children At present, new HBV infections occur in young people via sexual contact or intravenous drug abuse. The US prison population is another fertile area for chronic HBV infections. Hepatitis B and C spread via infectious body fluids including blood, semen, and cerebrospinal, vaginal, synovial, pleural, pericardial, peritoneal, or amniotic fluids. Stool and urine are not considered infectious unless they contain blood (9). HBV transmits easily through mucous membranes or percutaneous inoculation. The development of universal vaccination for HBV was very fortunate, as HBV transmission occurs 10 times more efficiently than HCV transmission and 100 times more so than HIV transmission (10).

HBV is also quite robust, surviving for as long as 1 week in dried blood or on inadequately cleaned surfaces even in the absence of visible blood. The actual risk of HBV infection after percutaneous exposure depends on a variety of factors and is reported to occur in 23%–62% of unvaccinated individuals (11). Increased risk occurs with hollow-bore needle puncture rather than puncture from solid sharp instruments, impaired immune status of the HCW, blood exposure rather than to other body fluids, and high viral titers of the infected patient (high hepatitis B surface antigen and the presence of hepatitis B e antigen indicate high viral loads).

Hepatitis C Virus

Hepatitis C virus (HCV) is responsible for the majority of chronic liver disease worldwide. Although acute infection is often silent, chronic liver disease develops in 74%–86% of infected individuals, and as many as 20% of infections progress to cirrhosis (12). The disturbing characteristics of an invisible acute phase, high conversion to chronic disease, long latency period to cirrhosis development, and lack of a vaccine contrast with HBV infection and ensure that a growing population of HCV-infected patients will seek medical treatment in the foreseeable future.

The estimated prevalences of hepatitis C carriers are 2% in the United States and 1%–1.2% in Europe, although this number varies significantly between regions because of the association of hepatitis with intravenous drug use and blood transfusion (4,9,12). Thus, the prevalence is higher in urban areas, and, as might be expected, within hospitals, where 6%–24% of patients are seropositive to HCV (13,14). Although the incidence of HBV seroconversion among HCWs is fivefold less than in the general population as a result of aggressive vaccination efforts, the number of HCV-positive HCWs mirrors that in the community at 0.5%–2% (15–20). Experts estimate that transmission of HCV occurs in 50–150 HCWs annually (21). As with other chronic viral infections, the risks of HCV transmission are higher with percutaneous injury, especially deep punctures with high-volume blood exposure (22,23). As expected, transmission risk increases with the inoculating viral load and infection is approximately 10 times more likely when the patient's blood contains 10^6 virions per milliliter as opposed to fewer than 10^4 virions per milliliter (24). The estimated risk of HCV seroconversion after percutaneous exposure to infected blood is 1.8% (range, 0%–7%), again underscoring the inefficiency of HCV transmission compared with that of HBV (13,22,25,26).

Human Immunodeficiency Virus

HIV rose to public attention in the 1980s when young homosexual men and intravenous drug abusers in large cities presented with unusual cancers and infections, such as Kaposi sarcoma and *Pneumocystis carinii* pneumonia. Because these conditions are typically seen in immunocompromised individuals, scientists quickly isolated the offending retrovirus from its target: circulating human immune cells. Initially dubbed human T-cell lymphotropic virus type 3 (HTLV-III) in America and lymphadenopathy-associated virus (LAV) in France, the virus came to be known as HIV in 1986. It was immediately apparent that HIV infection spread in a manner similar to HBV and HCV—thus, another BBP was born. Despite intensive research during the ensuing 20 years, a vaccine remains elusive, although AIDS mortality was significantly reduced in the late 1980s with the introduction of azidothymidine therapy. HIV infection is now arguably a chronic condition, managed with a combination of novel antiretroviral drugs, largely protease inhibitors. It is transmitted in an identical manner to HCV and HBV but with the lowest efficiency of the three viral infections. In fact, the estimated risk of HIV infection after needle puncture with an HIV-contaminated needle is only 0.3%, and is only 0.1% after intact mucosal contact with HIV-positive blood (27). As is the case with hepatitis B and C, this risk increases with hollow needles, large volume or high viral load of the blood inoculation, and compromised immune status of the injured HCW.

The **Table** (27,28) summarizes BBP endemic presence, seroconversion risk after needle stick, and current recommendations for PEP and/or testing. More detailed information can be found at the National HIV/AIDS Clinicians Consultation Center Web site (www.nccc.ucsf.edu) and the CDC Web site (www.cdc.gov/hepatitis). Physicians can check these Web sites for updated information and PEP protocols.

NATIONAL EFFORTS TO REDUCE OCCUPATIONAL BBP EXPOSURES

In the early 1990s, the CDC convened an interagency working group from the US Public Health Service . This group issued recommendations and guidelines in an effort to reduce the risk of BBP transmission to HCWs. Updated most recently in 2001, these guidelines standardized PEP and promoted universal hepatitis B vaccination and behavioral modifications to reduce BBP infection among HCWs. Similarly, the OSHA Bloodborne Pathogens Standard was signed into law in 1992 (29). This standard required employers to formulate an exposure control plan for their employees, adhere to universal and standard precautions, promote safe practices in the workplace, and provide free vaccinations, counseling, and treatments to those occupationally exposed to BBP. A significant and persistent level of accidental needle-stick injuries among HCWs prompted the adoption of the 2000 Needlestick Safety and Prevention Act (NPA) to the original OSHA/BBP standards. This amendment required hospitals to use safer needle systems and associated practices to reduce occupational exposures from needle punctures. Additionally, the CDC formed the National Surveillance System for Healthcare Workers (NaSH) from 1995 through 2007. NaSH was then replaced by the Healthcare Personnel Safety Component of the National Healthcare Safety Network (30,31). These networks of participating hospitals voluntarily submitted data about needle-stick injuries and other blood exposures among health care personnel and enabled the CDC to monitor these incidents as well as any treatments rendered.

The recommendations and reporting standards endorsed by OSHA and the CDC reveal several important trends regarding HCWs' attitudes toward BBPs. First of all, passage of the NPA occurred in the face of continued percutaneous injuries by HCWs despite establishment of the BBP standard of 1991, which promoted, among other actions, standard precautions, which are actions taken for all patients regardless

Table. Prevalence, Testing, and Treatment of HCW BBP Infections in the United States (27,28)

Pathogen	Endemic Rate (%)	Seroconversion Risk after Hollow Needle Stick (%)	HCWs Infected	After Exposure: Prophylaxis	After Exposure: Testing
HIV	< 1	0.3	57–138 as of December 2001	Two- vs three-drug protocol, 4-wk regimen*	HIV test at exposure and 6 wk, 12 wk, and 6 mo; CBC and liver function tests at exposure and 2 wk later (check treatment toxicity)
HCV	2–5.8	1.8	1% of HCW (402 new cases estimated in 2009)	No therapy	HCV antibody/liver enzymes after exposure and 4–6 mo later; consider HCV RNA at 4–6 wk
HBV	0.2–5.3	6–30 if not immunized	100 in 2009	HBIG with or without HB vaccine†	Check for immunity in 1–2 mo if vaccinated

BBP = bloodborne pathogen, CDC = Centers for Disease Control and Prevention, HB = hepatitis B, HBIG = HBV = hepatitis B immunoglobulin, HBV = hepatitis B virus, HCV = hepatitis C virus, HCW = health care worker, HIV = human immunodeficiency virus.
*See www.nccc.ucsf.edu for updated HIV postexposure information.
†HB vaccine only if unimmunized.

of their serologic status. Whereas universal precautions assume all patients harbor potential BBPs, standard precautions elaborate the methods used for HCW protection. Standard precautions call for mandatory and consistent use of personal protective equipment (hat, gloves, gown, eye protection, and mask). Additional safety measures stress safe equipment use and specimen handling during IR procedures. In other words, despite adequate barrier protection, personnel involved in IR procedures must still protect themselves from injuries and BBP infection. These common-sense but life-saving maneuvers include the following procedures (1,32):

1. Change gloves every 90 minutes or routinely double-glove;
2. Use scissors rather than scalpels whenever possible;
3. Use disposable scalpels, not metal reusable ones;
4. Avoid recapping or reusing needles and, if necessary, use clamp or forceps to manipulate the needle, not fingers;
5. Keep sharps containers immediately available and discard sharps as soon as possible; use sharps disposal bins that are large enough to accommodate the local IR inventory; if sharps are reused, put them in a protective holding device on the table in a safe position where they will not be knocked or tipped over;
6. Use the "no touch" sharps handoff whereby a sharp is placed on a solid surface and then picked up by the receiving individual rather than passing hand to hand;
7. Suture only with needle holders, never fingers;
8. Use self-sheathing or needle-retraction venipuncture sets for starting intravenous catheters;
9. Stabilize coaxial systems when inserting the inner needle by using a clamp rather than a hand on the outer cannula (ie, coaxial biopsies, transjugular liver biopsies or portosystemic shunt creation), which prevents needle injury from one hand to the other, especially in uncooperative patients;
10. Use Luer-lok rather than "slip-tip" syringes;
11. Avoid the use of glass syringes;
12. Use "bloodless" arterial access devices and closed drainage/flushing systems;
13. Maintain adequate lighting that is controlled or directed by the sterile operator;
14. Immediately clean surfaces that contact body fluids; and
15. Employ meticulous hand hygiene before and after patient contact (ie, "gel in—gel out").

The NaSH report covering five to 64 facilities from 1995 to 2007 detailed almost 31,000 exposure incidents, 82% of which involved a percutaneous injury and 80% of which involved exposure to blood or blood products (30). Interestingly, only 9% of these injuries occurred in procedural areas (eg, IR, cardiology), whereas 36% occurred on the inpatient units and 29% of injuries occurred in the operating room. The most common sharps offender was the hollow-bore needle (55% of cases), which carries the highest risk of BBP seroconversion. Thirty percent of injuries specifically involved a hollow needle mounted on a syringe. Therefore, the NPA went further in 2001 by requiring hospitals to employ safety engineering for sharps devices by using retractable or "sheathable" needles and scalpels and switching to needleless systems wherever possible. The 2007 NaSH data (30) found that fully 56% of needle-stick injuries were preventable by using such safer systems and practices.

The most recent recommendation of SIR regarding BBP avoidance consisted of the policy and position statement from 2003 (1), which mirrored the recommendations of OSHA and the CDC enumerated earlier. Data gathered at that time indicated that interventional radiologists seemed less prone to BBP exposure than their surgical counterparts. A national survey estimated sharps injuries in 0.6% of IR cases as opposed to 1.7%–15% of surgical procedures (33–38). Explanations for reduced risk include the lower volume of blood encountered during IR procedures, less reliance on suture closure of wounds, less time per procedure, and fewer sharp instruments used in IR cases.

CURRENT STATUS OF IR PRACTICE AND BBP

Since 2003, some troubling data have come to light. Numerous surveys of HCWs including medical students, nurses, and physicians indicate that accidental sharps injuries are severely underreported. A 2009 survey of 699 medical students (39) revealed that 415 (59%) sustained a median of two needle-stick injuries during their training, and fewer than half reported such incidents. Another study of medical students in Scotland (40) showed poor compliance with safe needle practices, and only 40% of students reported their needle-stick injuries. Baffoy-Fayard et al (4), in 2003, interviewed 77 IR physicians and found poor compliance with standard precautions, personal protective equipment, and other safety material use. Additionally, 52% of respondents indicated one or more needle-stick injuries at some time during their career. More recently, in 2009, Reddy et al (2) distributed a survey to more than 3,000 SIR members and found that, of the 1,061 respondents, 25%

injured themselves with accidental needle punctures within the previous year and, as noted by other investigators, IR physicians were poorly compliant with safe practices and CDC/OSHA guidelines. As Marx (41) commented in the *Journal of Vascular and Interventional Radiology* in 2003, the risks of BBP infection in IR are likely higher than we think. This risk is calculated as the product of the risk of blood exposure, the prevalence of that BBP in our patient population, and the risk of seroconversion after percutaneous injury. Assuming that the IR community underreports needle sticks and often ignores safety guidelines when intervening on a patient population heavily skewed toward chronic HCV, HBV, and HIV infections, the typical IR physician faces a significantly higher risk than previously thought. Therefore, the estimated risk of needlestick HCV transmission to IR physicians of one in 800 to one in 1,330 may be more like one in 100, or 1%, assuming this worst-case scenario (41).

Despite the numerous improvements in needle and scalpel safety features, there remain a multitude of safety engineering opportunities in IR. Consider the example of inserting a coaxial core biopsy device or transjugular biopsy needle through guiding sheaths or cannulas that fluctuate with respiration. By necessity, interventional radiologists put sharp instruments in the proximity of their hands on a routine basis. IR safety could be improved by new technology that allows the accurate placement of sharps into patients but away from physician appendages.

Since the 2003 SIR policy statement on the prevention of BBP infections in IR, little has changed regarding the risks, avoidance, and management of exposure to these pathogens. What must change, however, is actual physician conduct in the IR laboratory. Safety engineering, sharps management, and protective equipment do not work if they are not used. The "not me" attitude fosters poor compliance with safety measures and excessive sharps injuries that have been historically underreported. Culture changes within IR can improve safety in this regard. Practices should consider appointing one dedicated physician as the safety/quality officer to serve as a liaison between hospital officials and radiology personnel and give that person time devoted to such activities. This individual could be charged with constructing a defined and recurring lecture series or other teaching activity that propagates and updates the safety recommendations meticulously spelled out by OSHA and CDC initiatives. Radiology personnel involved in inventory management must advocate for the adoption of safer devices despite marginally increased supply costs and lobby the appropriate hospital or practice leadership to support the same. Safe practices come at the expense of not just money, but also time. IR groups promoting safety must also devote more time to each procedure and accept longer workdays or fewer cases scheduled per day. Responsible IR physicians who conform to these federal standards speak volumes to impressionable residents, fellows, and colleagues who will help IR maintain a culture of safety now and in the future.

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CME TEST QUESTIONS: MARCH 2014

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The CME questions in the March issue are derived from the article "Occupational Exposure to Bloodborne Pathogens in IR—Risks, Prevention, and Recommendations: A Joint Guideline of the Society of Interventional Radiology and Cardiovascular and Interventional Radiological Society of Europe" by Walser et al.

1. Exposure to which one of the following blood-borne pathogens (BBPs) carries the highest risk of transmission?
   a. Hepatitis B virus (HBV)
   b. Hepatitis C virus
   c. Human immunodeficiency virus
   d. Salmonella

2. Increased risk of HBV infection after percutaneous exposure occurs with all of the following EXCEPT
   a. Hollow-bore needle puncture versus other sharps
   b. Impaired immune status
   c. Blood exposure
   d. High viral titers in the infected patient
   e. Mucosal surface exposure

3. Health care workers (HCWs) are at most risk for developing chronic liver disease and cirrhosis following exposure to which one of the following BBPs?
   a. Hepatitis A
   b. Hepatitis B
   c. Hepatitis C
   d. Hepatitis E

4. Recommendations for reducing BBP exposure in interventional radiology (IR) include all of the following EXCEPT
   a. Double gloving and using protective eyewear
   b. Handing off sharps directly to the assistant to avoid accidental drops
   c. Avoiding recapping of used needles
   d. Keeping sharps containers immediately available and discarding used sharps as soon as possible
   e. Using closed drainage/flushing systems

5. Recent studies suggest that exposure to BBP for HCW in IR is
   a. Severely underreported and, hence, the calculated risk of infection is higher then previously estimated
   b. Lower due to a better understanding of standard precautions
   c. Negligible due to minimal exposure to blood and blood products during IR procedures
   d. Tightly controlled and reported by IR physicians and their safety/quality officer