Review

Occupational Exposure to Blood and Body Fluids

M Bahadori,[1] G Sadigh[2]

Abstract

Occupational exposure to blood and body fluids is an important hazard for health care workers, which places them at a high risk for blood-borne infections including hepatitis B virus, hepatitis C virus and human immunodeficiency virus and results in psychological and emotional stresses. Several preventive measures have been proposed including pre-exposure (e.g., education, use of standard precautions, use of needle protective devices, and vaccination) and post-exposure (e.g., post-exposure prophylaxis and early detection of disease) prevention. In this article, the importance of occupational exposure to blood and body fluids and the basic concepts of exposure prevention and management are reviewed.

Keywords

Occupational disease; Health personnel; Occupational health; Blood-borne pathogens; Prevention; Safety

[1]Department of infectious disease, National Iranian Oil Company (NIOC) Hospital, Tehran, Iran

[2]Tehran University of Medical Sciences, Tehran, Iran

Introduction

Health care workers (HCWs) are at risk of exposure to more than 60 different pathogens or species including 26 viruses, 18 bacteria/rickettsia, 13 parasites, and three yeasts[1,2] resulting from contact with blood and body fluids (BBF) from patients. Human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV) are the three most important causes of occupational-related infections.[1] An exposure that might place HCWs at risk for these infections can be in the form of either a "percutaneous injury" (*e.g.*, a needle stick or cut with a sharp object), or contact of mucous membrane or non-intact skin (*e.g.*, exposed skin that is chapped, abraded, or afflicted with dermatitis) with blood, tissue, or other body fluids that are potentially infectious.[3-5] Despite published guidelines and training programs to prevent infection transmission,[6] exposure to BBF remains a major concern in hospitals even in developed countries such as the United States.[7]

HCWs include emergency medical service, dental, laboratory, and autopsy personnel, nurses, nursing assistants, physicians, technicians, therapists, pharmacists, students and trainees, contractual staff not employed by the health care facility, and persons not directly involved in patient care but potentially exposed to BBF (*e.g.*, clerical, dietary, housekeeping, maintenance, and volunteer personnel).[3,6]

Epidemiology

Incidence

It has been estimated that more than

Correspondence to Gelareh Sadigh, MD, No 2, 5th West Alley, Ajoudanieh St, Tehran 19567, Iran.
Tel: +98-21-2280-1762, +98-912-347-2295
Fax: +98-21-2281-3269
E-mail: gelarehsadigh@yahoo.com

three million HCWs experience percutaneous injuries with contaminated sharp objects each year.[8] Of these exposures, approximately 385 000 occur in the US.[9] The overall sharps injury rate per 10 000 HCWs per year ranges from 113 (1%) to 623 (6.2%), with a mean of 405 (4%);[10] however, the Exposure Prevention Information Network (EPINet™) surveillance program reported the rate of percutaneous injury, defined as the number of injuries per 100 occupied beds per year, to be 26.8 in teaching hospitals and 18.7 in non-teaching hospitals.[4]

Regarding the Canada Communicable Disease Report (CCDR) on 2621 registered occupational exposures to BBF, needle stick injuries account for the highest BBF exposures among HCWs (65.7%), followed by splashes from patients (13.7%), cuts with sharp objects (8.6%), sticks other than needle stick (7.2%), scratches (1.9%), touching patients directly (1.8%), and bites (1.2%).[11] In the CCDR, hypodermic needles, suture needles, winged needles, venous catheter needles, and blood collection needles caused two-thirds of the percutaneous exposures.[11,12] Of the mucocutaneous exposures, 70.5% occurred on mucous membranes and 22.3% on non-intact skin.[12] While splashes often involved multiple parts of the body, fingers were the most commonly reported anatomical location (77%) for needle stick injuries.[13] The predominant body parts affected by splashes were "eyes alone" and "face or mouth." Bodily fluids (*e.g.*, urine, sweat, blister, and saliva) were the predominant type of splash, followed by blood spatter.[6] Across all health care settings, the needle stick injuries and splashes occurred predominantly at the patient's bedside,[14] while sharp injuries occurred most frequently in the operating rooms.[6]

Nurses, medical doctors, and laboratory technicians were the three professional groups that most frequently reported exposures.[7,11] The higher number of reports from nurses partly reflects the relative number of nurses to doctors in health care setting.[15] It also shows the reticence of doctors to report injuries due to potential subsequent restrictions on their practice.[7,15] Moreover, most of the doctors believe that they can handle the issue themselves.[7] Lack of experience in many procedures, insufficient training, work overload and fatigue were the probable causes that led to occupational sharp injuries.[10,14]

A recent analysis of needle stick injuries in navy medical personnel from the Naval Safety Center Injury Tracking System (INJTRAK) illustrated that most BBF injuries occur among men and HCWs younger than 30 years of age,[13] while other studies reported that female HCWs had more injury rate than their male counterparts.[6,7]

Under-reporting

For a variety of reasons, it is important that workers report exposures to BBF. HCWs who do not report their exposures run the risk of seroconversion and morbidity and put others, especially their sexual partners, at risk of infection, if timely post-exposure medical evaluation and treatment are not sought. Furthermore, if an exposure is not formally documented and reported, an infected worker may not be eligible for workers' compensation if a claim is filed. In addition, underestimation of exposure incidence and poor information on risk factors by the employer may decrease his incentive to implement safer equipment or work practices or to seek product engineering upgrades from device manufacturers.[9]

The under reporting rate has been es-

timated between 26% and 85% in previous studies.[15] Reasons for not reporting exposures have included "the belief that the risk of infection was low," "being too busy," "not knowing the reporting procedure," and "not wanting to appear careless."[9] A clear inverse association between the frequency of recent injury and reporting likelihood was documented in a recent study.[7] In a study by Lymer, *et al*, of 1181 incidents of injury, only 9% had been officially reported.[16,17]

There was a significant difference between various professional groups with regard to the frequency of incident reporting. Physicians reported only 3% of the incidents whereas medical laboratory technicians reported almost 36% of them.[16] This finding was confirmed in other studies.[7]

In a study by Askarian, *et al*, on medical, dental, nursing and midwifery students in Shiraz University of Medical Sciences, Iran, 82% (401 of 489) of all needle stick injuries went unreported; most of which attributed to the uncertainty of the injured student about the reporting process.[14] Similarly, another Iranian study reported that 80% of the surgeons had never or rarely reported their needle stick injuries.[18]

Economic impact

A recent economic analysis of the costs associated with the management of occupational exposure to BBF including post-exposure prophylaxis (PEP) showed that the overall cost ranged from US$ 71–4838.[19] Moreover, HCWs experience such a significant fear, anxiety and emotional distress following a needle stick injury that sometimes results in occupational and behavioral changes.[20] According to O'Malley, *et al*, the mean total costs varied greatly by the infection status of the source patient. The overall mean cost for exposures to HIV-infected source patients (including those co-infected with HBV or HCV) was US$ 2456 (range: US$ 907–4838), for exposures to source patients with unknown or negative infection status, was US$ 376 (range: US$ 71–860), and for source patients infected with HCV was US$ 650 (range: US$ 186–856).[19]

The risk of transmission of blood-borne pathogens

Hepatitis B

The risk of HBV infection is primarily related to the level of contact with blood and also to the hepatitis B e antigen (HBe Ag) status of the source person. According to the Center for Disease Control and Prevention (CDC) report, the risk of developing clinical hepatitis after percutaneous exposure to a blood sample positive for both hepatitis B surface antigen (HBs Ag) and HBe Ag is 22% to 31%, whereas the risk of developing serologic evidence of HBV infection is 37% to 62%. However, the risk of developing clinical hepatitis from a needle contaminated with HBs Ag-positive, HBe Ag-negative blood is 1% to 6%, and the risk of developing serologic evidence of HBV infection is 23% to 37%.[5]

Blood contains the highest HBV titers of all body fluids. Therefore, blood is the most important vehicle for transmission of HBV in the health care setting; other body fluids, including breast milk, bile, cerebrospinal fluid, feces, nasopharyngeal washings, saliva, semen, sweat and synovial fluid are not efficient vehicles for transmission because they contain low amounts of infectious HBV, despite the presence of HBs Ag.[5]

Hepatitis C

HCV is not easily transmitted through

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exposure to blood. The mean incidence of anti-HCV seroconversion after accidental percutaneous exposure from an HCV-positive patient is 1.8% (range: 0% in those with negative HCV-PCR to 10% in those with positive PCR).[1,5] One study showed that the transmission occurred only by hollow-bore needles rather than other sharps. Transmission rarely occurs from mucous membrane exposures to blood—no transmission in HCWs has been reported from intact or non-intact skin exposures to blood. The risk for transmission from exposure to fluids or tissues other than HCV-infected blood though has not been measured yet, is expected to be low.[5]

HIV

The average risk for HIV transmission after a percutaneous exposure to a blood sample positive for HIV is approximately 0.3%. It is almost 0.09% after a mucous membrane exposure. Although episodes of HIV transmission after non-intact skin exposure have been reported, the average risk for transmission by this route has not been quantified yet. However, the risk is estimated to be less than that for mucous membrane exposures. Besides, the risk for transmission after exposure to fluids or tissues other than HIV-infected blood is considerably lower than for blood exposures.[3]

Numerous studies suggest that multiple factors might influence the risk for HIV transmission after an occupational exposure. These factors include the volume of blood inoculated (*e.g.*, deep needle stick, injury caused by a visibly bloody device, and injury caused by a needle that had been directly in the source patient's blood vessel) or the number of infective agents (high viral load such as in newly-infected patients or those in a terminal stage illness).[1,3,4,21]

Documented occupationally-acquired infections

The overall number of HCWs annually exposed to sharp injuries contaminated with HCV, HBV, and HIV was estimated to reach 926 000, 2.1 million, and 327 000, respectively.[8] Nonetheless, there are minimal data collected on occupational transmission of these infections. In 1987, the CDC estimated that each year, approximately 12 000 HCWs were becoming occupationally infected with HBV in the US. Among these people 700 to 1200 would become chronic carriers, and 200 to 300 deaths would occur as a result of infection.[1] However, in 1995, there were 800 occupationally HBV-infected HCWs in the US, showing a sharp decline of 95% since implementation of the vaccination program in 1983. At the same time, there were no reported cases of hepatitis B in the UK.[15]

There is no comprehensive registry for documented cases of HCWs occupationally infected with hepatitis C. Between July 1997 and December 1999, 360 cases of occupational exposure to hepatitis C were reported in England and Wales, with only one known seroconversion. Over the same

period in Scotland, 41 exposures to hepatitis C with no known seroconversions were reported.[15] In 2001, 43 occupational seroconversions for HCV were documented in France.[1]

Occupational transmission of HIV is divided into definite cases (*i.e.*, confirmed occupational transmission) and possible cases (*i.e.*, no identified risk of infection other than occupational exposure).[15] A total of 106 definite and 238 possible cases of occupationally-acquired HIV had been reported worldwide by the end of December 2002.[1,2]

The November 2002 World Health Report revealed that 2.5% of hepatitis B and 40% of hepatic C cases among HCWs worldwide were the result of occupational exposure.[8,22] Similarly, 4.4% of HIV cases among HCWs are thought to be attributed to occupational exposures.[7]

Finally, the annual number of infections attributable to sharp injuries among HCWs worldwide in year 2000 was almost 16 000 (range: 6000–86 000) for HCV, 66 000 (range: 2400–240 000) for HBV, and 1000 (range: 200–5000) for HIV. These infections are thought to result in 145 (range: 53–766) premature deaths from HCV, 261 (range: 86–923) deaths from HBV and 736 (range: 129–3578) deaths from HIV in HCWs between the years 2000 and 2030;[8] half of these deaths would occur in Sub-Saharan Africa.

Prevention

Primary prevention of occupational exposures is an important issue, and preventive efforts should not be only focused on post-exposure prevention. Although PEP may substantially reduce the risk of transmission following an occupational exposure to an infected patient, it does not eliminate the risk of transmission. Furthermore, it cannot completely relieve the anxiety that many HCWs experience following an exposure.[4]

It is suggested that prevention of sharp injuries be aimed at nurses and doctors.[15] Health care organizations should provide an appropriate system to their personnel and make available suitable written protocols for prompt reporting, evaluation, counseling, treatment, and follow-up of those occupational exposures that might place them at risk for acquiring a bloodborne infection.[5] Effective prevention of needle stick injury include administrative and work practice controls such as educating workers about hazards, implementing standard precautions (*e.g.*, hand hygiene and the use of personnel protective equipment such as gloves, gowns, and face mask), eliminating needle recapping, providing sharps containers for easy access that are within sight and arm's reach[4,6,8,21] and the introduction of needle protective devices.[15]

In a study involving three hospitals in Virginia, US, Jagger reported a 59% reduction in intravenous (IV) access needle injuries after establishment of an educational program and implementation of standard precautions. There was also an 84% reduction in injuries after implementation of a safety IV catheter.[21] Surprisingly, the CDC identified that over a four-year period within a group of hospitals, 5% of all sharp injuries were sustained while using a needle protective device. This finding underlines the fact that these devices do not provide complete protection.[15]

Poor compliance with standard precautions has been found to be associated with factors such as inaccessibility or discomfort of the protective equipment, how urgent the patients' needs are, influence of co-workers, and sub-optimal working

conditions.[17]

In a study conducted in 2007, Moghimi, *et al*, reported that only 74 (12.9%) of 574 surgeons in Iran always used double gloves,[18] demonstrating poor compliance with the standard precautions among Iranian surgeons and the need for education.

Any person who performs tasks involving contact with blood, blood-contaminated body fluids, other body fluids, or sharps should be vaccinated against hepatitis B free of charge.[5,6,8] Pre-vaccination serologic screening for previous infection is not indicated for persons being vaccinated because of occupational risk, unless the hospital or health care organization considers screening cost-effective.[5] The ongoing vaccination program against HBV has led to considerable reduction in the use of high-titer immunoglobulin against HBV which is an expensive treatment and decreased the anxiety of HCWs after needle stick and sharp injuries.[7]

HCWs who have contact with patients or blood, and are at ongoing risk for percutaneous injuries should be tested 1–2 months after completion of the three dose vaccination series for anti-HBs.[5] Once the appropriate antibody level achieved, booster doses of hepatitis B vaccine are not necessary, and periodic serologic testing to monitor antibody levels after completion of the vaccine series is not recommended.[5] According to Prüss-Ustün, *et al*, regional estimates for the coverage of hepatitis B immunization among HCWs worldwide ranges between 18% and 77%.[8] According to a study conducted by Moghimi, *et al*, although 93.3% of surgeons in Iran are vaccinated against HBV, only 56.8% had checked their anti-HBs level.[18] This study shows an acceptable coverage rate of hepatitis B immunization among HCWs in Iran.

We suggest that HCWs should be tested free of charge for anti-HBs 1–2 months after completion of vaccination, so that the antibody response to vaccine is being assessed. This will decrease the anxiety and psychological stress after exposure to BBF, when the HCW knows his/her antibody response. Additionally, it will be more cost-effective when the PEP is administrated and unnecessary administration of immunoglobulin against HBV is prevented. Unlike hepatitis B there is no immunization available for HIV or HCV.[21]

Post-exposure management

The first step in post-exposure management is to wash wounds and skin sites that have been in contact with BBF with soap and water; mucous membranes should be flushed with water. No evidence exists in favor of using antiseptics for wound care or expressing fluid by squeezing the wound in order to reduce the risk of blood-borne pathogen transmission; while the use of antiseptics is not contraindicated, they are not injected into the wounds.[5]

The person whose BBF is the source of an occupational exposure should be evaluated for HBV, HCV, and HIV infection. If the exposure source is unknown or cannot be tested, information about where and under what conditions the exposure has occurred should be assessed epidemiologically for the likelihood of transmission of HBV, HCV, or HIV. Testing of needles or other sharp instruments implicated in an exposure, regardless of whether the source is known or unknown, is not recommended.[5] We recommend an anti-HCV and anti-HIV testing after exposure to a source patient who has been considered likely to have HCV/HIV infection. In this way, a previously-infected HCW can be differentiated from one who acquires infection after an occupational exposure to BBF.

Post-exposure prophylaxis

Effectiveness of PEP varies from 75% to >90% to prevent HBV infection;[14] however, PEP for HIV is generally considered to reduce the risk of transmission by approximately 80%;[4] there is no known way for preventing HCV acquisition following BBF exposure.[14]

HBV

PEP for unvaccinated HCWs following an exposure includes initiating vaccine series. When the source patient is HBs Ag-positive, one dose of hepatitis B immunoglobulin should be additionally administered. A previously-vaccinated HCW who is a known responder (serum anti-HBs ≥ 10 mIU/mL 1–2 months after completion of three doses of vaccination) does not need any PEP. A previously-vaccinated HCW who is a known non-responder or has an unknown antibody response does not need any PEP after exposure to HBs Ag-negative patients; however, after exposure to HBs Ag-positive or unknown source patient, the non-responders should receive either one dose of hepatitis B immunoglobulin plus revaccination or two doses of hepatitis B immunoglobulin (if they have previously completed a second three-dose series of vaccination). HCWs with unknown antibody response should be tested for serum antibody titer. If the titer is inadequate, they should receive a booster dose and in case of HBs Ag-positive source patient, they should also receive one dose of hepatitis B immunoglobulin.[5] As it will be time-consuming to wait for the serum antibody titer results, the authors suggest beginning with a booster dose and one dose of hepatitis B immunoglobulin to reduce the stress of the exposed HCW which may influence his/her private and occupational life and decrease his/her efficacy at work. It can then be waited for the test results to choose the appropriate PEP according to the CDC guidelines.

When hepatitis B immunoglobulin or vaccine is indicated, it should be administered as soon as possible after the exposure (preferably within 24 hours). The effectiveness of hepatitis B immunoglobulin when administered more than seven days after exposure is unknown.[5]

HCV

There is no immunoglobulin or post-exposure use of antiviral agents (*e.g.*, interferon with or without ribavirin) available to prevent HCV infection. The present data suggests that an established infection might need to be present before interferon can be treated as an effective treatment.[5] While there is no PEP for HCV, recommendations for post-exposure management are intended to achieve early identification of chronic disease and, if present, referral for evaluation of treatment options.[5]

HIV

PEP should be initiated in HCWs who have been exposed to a source patient with suspected HIV infection. If the source is found to be HIV-negative after the initiation of PEP, it should be discontinued. Although concerns have been expressed regarding HIV-negative sources being in the window period for seroconversion, no case of transmission involving an exposure source during the window period has been reported in the US.[3]

Normally, a two-drug (basic) or three-drug (expanded) PEP regimens, depending on the level of risk for HIV transmission—as determined by the level of exposure (*e.g.*, type and severity of exposure, the source patient's HIV status and/or risk factors for HIV infection, and the prevalence of

HIV in the local population [if source patient's HIV status is unknown])[4]—is recommended.[3] When the source person's virus is known or suspected to be resistant to one or more of the drugs considered for the PEP regimen, choosing those drugs to which the source person's virus is unlikely to be resistant is recommended. Combinations which can be used for PEP include zidovudine (ZDV) and lamivudine (3TC) or emtricitabine (FTC); stavudine (d4T) and 3TC or FTC; and tenofovir (TDF) and 3TC or FTC. Addition of a third or even a fourth drug should be considered for exposures that pose an increased risk of transmission or that involve a source patient in whom antiretroviral drug resistance is likely.[3]

PEP should be initiated immediately, preferably within one hour of exposure[3,21,23] and continued for a month to be most effective;[21] starting PEP even after two weeks post-exposure may still be beneficial.[23] Nonetheless, some reports indicate that if PEP is delayed more than 72 hours, it is not effective.[5,21] If a question arises concerning which antiretroviral drugs to be used, or whether to use a basic or expanded PEP regimen, the basic regimen should be started immediately and not delay the PEP administration.[3]

Reevaluation of the exposed HCW should be strongly encouraged within 72 hours after the exposure, especially as additional information about the nature of the exposure or source person becomes available. HCWs with occupational exposure to HIV should receive follow-up counseling, post-exposure testing, and medical evaluation regardless of whether they receive PEP. HIV-antibody testing by enzyme-linked immunosorbant assay (ELISA) should be used to monitor HCWs for seroconversion six months after occupational HIV exposure. After baseline tests at the time of exposure, follow-up tests could be performed at six weeks, 12 weeks, and six months post-exposure.[3]

Counseling for HCWs after Exposure

Counseling the exposed HCWs is a critical component of any evaluation of an occupational exposure to potentially infectious substances. Topics to be considered in the discussion include the risk of acquisition of each of the blood-borne pathogens, side effects of any treatments initiated, measures that can reduce the risk of secondary transmission (*e.g.*, abstinence or use of condoms), signs and symptoms of acute infection, and recommendations for follow-up evaluation and testing.[4]

HCWs exposed to HBV- or HCV-infected BBF do not need to take any special precautions to prevent secondary transmission during the follow-up; however, they should refrain from donating blood, plasma, organs, tissue, or semen. The exposed person does not need to modify sexual practices or refrain from becoming pregnant. If an exposed woman is breast feeding, she does not need to discontinue.[5]

Conclusion

Occupational exposure to BBF is an important and common hazard for HCWs, placing them at risk for blood-borne pathogens (HBV, HCV and HIV) and resulting in psychological stress, occupational diseases and loss of financial and human resources. Pre- and post-exposure management helps in decreasing the incidence of acquisition of infections. Pre-exposure preventions include educating HCWs, using standard precautions, and vaccination. Post-exposure prevention includes PEP and early identification of disease. Early and easy

access to written protocols for prompt reporting, evaluation, counseling, treatment, and follow-up of occupationally-exposed HCWs should be prepared by the health care organization. HCWs should be aware of the support of their employers if an occupational event occurs, so that they can feel secure in their job.

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