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Human Immunodeficiency Virus Infection, Transmission and Prevention among Health Care Workers

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Abstract: *Exposure to blood borne pathogens poses a serious risk to health care workers(HCWs).The first case of documented seroconversion after occupational exposure to HIV was reported in 1984.The average risk of HIV transmission after percutaneous exposure to HIV- infected blood is approximately 0.3%,however the risk believed to be higher for exposures involving and increased volume of blood or high viral load. Occupationally acquired HIV infection is usually classified as 'definite' or 'possible'. A 'definitive' is the one with documented evidence of HIV seroconversion.The 'possible' case implies where a health care worker (HCW) was found to be HIV infected but investigations revealed no risk factor other than occupational exposure Nosocomial HIV transmission have been reported frequently, involved breaches in proper infection-control practices and disinfectionprocedures.Post exposure chemoprophylaxis is recommended for HCWs who being exposed to HIV.The CDC recommends for treatment after occupationally HIV exposure with two drugs zidovudine,lamivudine and a protease inhibitor. Prevention is the key to transmission of HIV,require education of HCWs including other staff in the health care facility, provision of essential equipment and strict adherence to standard precautions. The golden rule is prevention is better than cure.*

Keywords: *HIV, Occupational exposure, Needlestick,Post exposure, Prophylaxis*

I. Introduction

Hospital associated transmission of hepatitis had been identified as a problem since 1940s[1].The epidemic of human immunodeficiency virus(HIV) infection in the United States in the 1980s focused the attention of healthcare providers or healthcare workers(HCWs) and regulators on this important issue.Since then, researchers have learned that HIV can be transmitted from patient to healthcare worker, from healthcare worker to patient, and from patient to another in healthcare settings [2,].HCWs are at risk for occupational acquisition of HIV infection, primarily due to percutaneous exposure to infected blood.The average risk of HIV transmission after percutaneous exposure to HIV-infected blood is approximately 0.3%;however, the risks believed to be higher for exposures involving an increased volume of blood and/or high viral load[3,].Evans and associates in 1997, reported ninety-five definitive and 191 possible cases of occupationally acquired HIV infections worldwide [4].As of 2010,57 documented transmission and possible transmission had been reported in the United States. No confirmed cases of occupational HIV transmission to HCWs have been reported since 1999.Underreporting of cases to CDC is possible,however, because case reporting is voluntary[5].During 1985-2013, 58 confirmed and 150 possible cases of occupationally acquired HIV infection among HCWs were reported to CDC;since 1999,only one confirmed case(a laboratory technician sustaining a needle puncture while working with a live HIV culture in 2008) has been reported[6].A possible case of occupationally acquired HIV infection is defined as an infection in an HCW whose job duties might have exposed HCW to HIV but who lacks documented workplace exposure. If HIV status of the source patient is unknown or HCWs seroconversion after exposure was not documented as temporally related,occupational acquisition of HIV is possible but cannot be confirmed [6].CDC recommends the use of standard(universal) precautions to prevent exposure of HCWs to potentially infectious body fluids when working with anypatient, whether known to be infected with HIV or not[7].Guidelines for the management of occupational exposures to HIV and recommendations for post-exposure prophylaxis have been published[8].Post-exposure chemoprophylaxis is now recommended for HCWs who experience certain kinds of exposure to HIV in the workplace. Substantial information has emerged in the last few years that supports, but does not prove, the efficacy of antiretroviral agents in preventing HIV infection after occupational exposure [9].The paper reviews the current literature, HIV infection, and prevention in health care workers.

II. Transmission of HIV Infection

In the United States by December 2008,57 instances of occupational transmission to HCWs had been reported to the Centers of Disease Control and Prevention(CDC)[10].In all but one of these cases, occupational transmission was documented by demonstrating HIV antibody seroconversions that occurred after discrete HIV exposure. In the single exception, occupational infection in a scientific laboratory worker was documented by demonstrating that the HIV genetic sequence of the worker's virus isolate was nearly identical to the laboratory

strain with which the individual was working. In addition the 57 documented cases of occupational infection in the United States "possible" occupational infections in 138 health care workers have been reported to the CDC,and 100 more such cases have reported worldwide[10].Baseline HIV serologic tests were not performed in these individuals at the time of known or potential exposure to HIV,and so the temporal relationship between exposure and seroconversion could not be confirmed.However, none of the individuals non-occupational behaviors associated with risk for HIV infection, and all recalled at least one exposure to blood or body fluids before HIV infections were diagnosed. The demographic of this population suggest that some but not all these individuals probably had confounding community based risks [11].

Health care HIV infection or occupational HIV infections that have been documented in the United States have been associated with parenteral injuries infected by hollow-bored needles that had been used in veins or arteries but other sharp instruments have also been involved in transmission. Six instances of HIV infection have occurred after either exposure of breaks in the skin to HIV contaminated fluids or exposure of mucous membranes to HIV-contaminated materials. Each of these six instances involved a large-volume exposure, an extended duration of exposure, or both. In one case of mucous membrane exposure in Europe, theinoculum was smaller [12.].One reported case was associated with several exposures, over and extended period[13].To date, contamination of intact skin with blood or other infectious material, close personal contact with infected patients, and contact with contaminated environmental surfaces or fomites have not been linked to occupational HIV transmission.Aerosolization of blood can occur during dental pathologic, laboratory, and surgical procedures and conventional surgical masks do not prevent inhalation of aerosols.Nonetheless,to date, no data indicate aerosol exposures is route of HIV transmission in any setting [14].Exposure to blood from HIV infected patients account for all but 4 of the 57 documented occupational infections in the United States.0f these four, one occupational HIV infection resulted from exposure to bloody pleural fluid, and two involved exposure to concentrated preparation of HIV in scientific laboratories for the fourth ,the source material was not reported[14].

Health care exposure by definition.The instances of documented occupational HIV transmission have been helpful in developing a definition of what constitutes an exposure that is associated with risk for HIV transmission.HIV transmission include(1) percutaneous injury(e.g. needle puncture-needle stick injury or cut caused by a needle or other sharp object);(2) mucous membrane contamination; and(3)contamination of noncontact skin(e.g.,skin that is chapped, abraded, or afflicted with dermatitis)[15].Even though HIV-infected blood contamination of intact skin has not been implicated in occupational infection, exposure of intact skin to contaminated blood for extended periods(several minutes or longer) or exposure involving extensive areas of skin should be considered potentially infective, largely because unrecognized areas of inadequate skin integrity serve as portal of entry for virus[14].Sources of HIV that may pose a risk of transmission through these routes include blood; visibly bloody fluids, tissues;and other body fluids, including semen,vaginal secretions, and cerebrospinal,synovial,pleural,peritoneal,pericardial, andamniotic fluids [13]. In addition any direct cutaneous or mucosal contact (i.e. without barrier protection) to concentrated HIV in a scientific or research laboratory or production facility should be considered an exposure[13].Although nonoccupational episodes of HIV transmission have been attributed to contact with blood-contaminated saliva, these incidents were not analogous to the contact with saliva that occurs during dental or medical care[15].In the absence of visible blood in the saliva, exposure to saliva from person infected with HIV is not thought to pose a risk for HIV transmission. Exposure to products that are not visibly bloody(tears,sweat, urine or feces)from infected patients does not constitute exposure to HIV. Whereas human breast milk has been implicated in perinatal transmission of HIV,thus route of transmission is not analogous to occupational exposure, and contact with breast milk from a patient infected with HIV does not constitute an occupational exposure[15].Kennedy and associates classified cases of occupationally acquired HIV infection are usually as 'definitive' or 'possible'. A 'definitive' case is defined as one for which there is documented evidence of HIV seroconversion associated in time with a specific occupational exposure to an identified source of HIV.The definition of a 'possible' case implies that a healthcare worker was found to be HIV infected and that subsequent investigations revealed no factors other than occupation exposure [9].

Occupational HIV exposure transmission risk[14].Worldwide, more than 20 prospective studies helped quantify the transmission risk associated with discrete occupation HIV exposures(summarized by Henderson and Gerberding[2] and by Ippolito and associates)[16],In each of thesestudies, health care workers who sustained occupational HIV exposures were tested for HIV antibody at the baseline(i.e.,at the time of exposure) and periodically thereafter, at regular follow-up intervals, to detect new infections.Pooled data from these studies suggest that the average risk of HIV transmission associated with percutaneous exposures to blood contaminated sharp objects that have been used on HIV-infected individuals is 0.32%(21 infection associated

with 6498 exposures,95% confidence interval of 0.18% to o,46%[2].The estimated risk of mucocutaneous transmission is 0.03%(1 infection associated with 2885 HIV exposures involving mucous membranes or nonintact skin),but this estimate may be biased because the single transmission event was actually reported before prospective data were collected from the involved institution [17].The risk of infection if any, in association with intact skin exposure to HIV is too low to be detected in these studies[18].

HIV infection risk factors.The average of transmission derived from prospective studies is helpful in evaluating populations of exposed persons but does not necessarily reflect the risk associated with specific exposures experienced by an individual health care worker [14].The inoculum of virus is related both to the volume of material involved in the exposure and the titer of virus in that material.Laboratory models of needle stick exposure demonstrate that exposure volume increases with needle size and depth of penetration and that hollow needles generally transmit more blood than do suture needs of comparable size[19].In one model, when needle passed through one ormore layers of latex or vinyl gloves before contracting the skin the volume of blood transferred to the skin was reduced by more than 50% for hollow needles and more than 80% for suture needles[20].The amount of infectious virus present in the source material may vary by several logarithm,depending on patient's stage and severity of viral titer is probably very important predictor of transmission risk[21].In some studies, higher viral load has been associated with an increased risk for perinatal transmission[22].Conversely,HIV transmission from persons with plasma viral loads below the limits of quantification(based on the assays in use at the time the data were collected)has been reported in instances of mother-to-infant transmission and in one occupation infection[22,23].The immunologic responses of the exposed health care workers also appear to affect the probability of HIV transmission. At least three outcomes are believed to follow HIV exposure:(1)infection(HIV antibody seroconversion and long-term systemic infection);(2) no infection, no immunologic response; and(3)"aborted infection"(limited cellular infection detected T-cell response to HIV antigen no long-term systemic, no HIV antibody seroconversion).Immunologic evidence supporting the concept "aborted infection" comes from the studies of uninfected prostitute[24], from studies of sexual partners of infected persons[25],from studies of children born to HIV infected mothers[26],from patients inadvertently exposed to blood from infected patients during provision of health care who remain uninfected[27],and from studies of occupationally exposed but uninfected ,health care workers[28]. Similarly T lymphocytes derived from the peripheral blood of some uninfected health care workers who were exposed to HIV through needle-related injuries can be stimulated to proliferate and secrete cytokines when exposed to HIV antigens in vitro [28].The precise role of the cellular immune response in host defense against HIV infection is not delineated, and it is not known why some individuals appear to be able to clear or abort the infection. Nonetheless, the observation is consistent with the hypothesis the cellular immune system is one important determinant of exposure outcome [14].

Exposures and HIV seroconversion in HCWs[14].For the 51 instances of occupational infection for which data concerning the characteristics and timing of HIV seroconversion have been reported to CDC,81% were associated with illnesses compatible with primary HIV infection(i.e., the seroconversion illness) a median of 25 days after exposure[15].The clinical syndrome occurring in HCWs who were seroconverters was indistinguishable from that observed in patients with primary HIV infection acquired through non-occupationalexposures. The median interval from exposure to documentation of a positive result of an HIV antibody test was 46 days(mean,65 days).The estimate was limited by the fact that testing is performed at variable intervals after exposure and the precise date of seroconversion is often not known with certainty. Overall, of HCWs who became infected as a result of occupational exposures,95% are expected to undergo serconversion within 6 months of the exposure[29].This estimate is basically identical to that for infection associated with other exposures[14].Three cases of delayed HIV seroconversion among HCWs have been reported[23,29,30].For each of these HCWS the result of HIV antibody testing was negative 6 months after an occupational exposure, but it became positive sometime in the ensuring 1 to 7 months. For one of these cases DNA sequencing confirmed that the infection was occupationally acquired interestingly, two of these HCWS were also infected with hepatitis C virus (HCV) as a result of the index needlestickexposure. In both instances HCV infection was unusually severe in one case; the disease course was rapidly fatal.It is not clear whether coinfection with these two viruses directly influences the timing or severity of either HIV or HCV infection.Nonetheless,most experts agree that until more data are available, if HCWs are exposed to both viruses and develop serologic evidence of HCV infection 6 weeks to 9 months after occupationally exposure, they should be carefully monitored for late HIV seroconve5rsion up to a year after exposure.

III. HIV Infection Transmission From HCWS To Patients

Since the onset of the AIDS epidemic in the early 1980s, only four instances of HIV transmission from infected HCWs to one or more patients have been reported[31]Of these instances of transmission, one occurred in the United States in1990[32];two were reported from France[31];and the fourth was reposted from Spain[33].The episode in the United States involved a cluster of six patients whose HIV infections were linked epidemiologically and through DNA sequencing to a dentist who had AIDS.Although the investigation indicated that HIV infection transmission occurred in the Dentist's office and probably represented transmission from dentist to patient rather than from patient to patient, the precise mechanism of transmission were not determined[14].The second episode of iatrogenic HIV transmission involved an orthopedic surgeon in France whose HIV transmission to one patient was confirmed through DNA sequence of viral isolates obtained from the surgeon and the patient[31].The surgeon in this case probably became infected as a result of an occupational injury sustained during a surgical procedure in 1983.The surgeon was not aware of his infection until AIDS was diagnosed in 1994.Investigators initiated a retrospective investigation of 3004 patients who had undergone at least one invasive procedure that was performed by the infected surgeon since 1993.The investigators were able to contact 2458 of these 3004 patients and were able to assess the HIV infection status of 983 of these 2458 patients.

In a subsequent retrospective study of7580 patients of the infected nurse, investigators were able to notify 5308 of the patients concerning the potential exposure [34].No additional HIV infections were detected in the 2293(of these 5308 patients)who were tested. The nurse who was identified as the probable source of the patient's infection was co -infected with HCV and was found to have a high HIV viral burden, as well as advanced HCV induced hepatic disease, including clotting abnormalities [32].In the fourth case of iatrogenic transmission of HIV [33], a woman was infected with HIV by her gynecologist, presumably during the conduct of a caesarian section. Spanish officials conducted a retrospective study in which 250 of 275 gynecologist's patients were tested no additional infections were identified [33].

Case detection patients treated by HIV infected HCWs. In March 1992, the CDC developed a database to monitor the results of retrospective investigations of HCWs infected with HIV to assess the risk for this mode of HIV transmission. Excluding the patients from the Florida dental practice, as of December 1998,the CDC has obtained information from the investigations of 66 HIV-infected HCWs in the United States[35].In the United States,persons who have AIDS or in some states those infected with HIV who have reported to state and local health department with no identified risk for HIV infection are studied to determine the likely mode of HIV acquisition[36,Id,47].

In general, three conditions are necessary to create a risk for provider(HCW) to-patient HIV transmission[14]:

(a)The HCW must be infected with HIV and have infectious HIV circulating in the bloodstream.

(b)The HCW must be injured or have a condition (e.g., weeping dermatitis) that provides some other source for direct exposure to infected blood or body fluids for patient.

(c)The injury mechanism or condition must present an opportunity for the HCW's blood or body fluids to contact a patient's mucous membranes, wound, or traumatized tissue directly (i.e.,"recontact").

The risk of blood- borne pathogen transmission to patients during recontacts is not known but is believed to be lower than that associated with most occupational exposures. Most HCW(provider) injuries potentially associated with blood exposures to the patient that have been reported in observational studies involved the penetration of a surgeon's glove by a solid sharp(e.g.,suture needle, bonespicula)[37].

Hospital acquired HIV transmission. Hospital acquired or nosocomial episodes of HIV transmission from one patient to another have most frequently involved breaches in proper infection-control practices and disinfection procedures. Reuse or improper sterilization of blood contaminated injection needles or syringes has been linked to HIV transmission for hospitalized children in Russia,Libya,Romania,several countries in Africa[38-41],and probably in other developing countries. Medical errors in three institutions(two in the United States and one in Netherlands) resulted inadvertent exposures of patients to HIV as a result of injection of blood from a HIV –infected patients during nuclear medicine procedures[42).Contamination of multidose vials frequently has been incriminated as a vehicle for transmission of HIV and other blood- borne pathogens in several instances in both industrialized and developing countries[43].Five patients in Australia who underwent minor outpatient surgical procedures necessitating local anesthesia that were performed on the same day by an HIV-negative surgeon were subsequently found to be HIV positive[44].The first infected patient had known risk factors for HIV and was the probable source of infection for other four patients. The exact mode of patient- to- patient transmission in this practice has not been elucidated. No cases of patient-to –patient transmission of HIV have been reported from hemodialysis centers in the United States. Conversely HIV transmission to at least nine patients in a

hemodialysis centers in Colombia has been reported and was attributed to inadequate disinfection and reuse of contaminated access needles; similar cases have been reported from Argentina and Egypt[45].

IV. Prevention

Universal precautions.In 1985 the CDC recommended that the blood of all persons be regarded as infectious, because identification of all patients carrying blood-borne pathogen was not possible [46].In 1987 the term universal precautions was coined to communicate this concept.Universal precautions were designed to prevent direct contact with blood, bloody body fluids, and certain other fluids (amniotic fluid,semen,vaginal fluid, cerebrospinal fluid, serous transudates and exudates, and inflammatory exudates) that were either known or likely to be associated with blood- borne pathogen transmission. Body substance isolation (or body substance precautions) is highly similar alternative system of infection control that is practiced by many institutions [47].In 1996, the CDC recommended the adaptation of an infection control system standard precautions, that effectively merged the most beneficial aspects of the universal precautions and body substance isolation approaches [48].In several studies that evaluated the efficacy of universal precautions in preventing blood contact. Implementation and enforcement resulted in a significant reduction in exposure frequency [49].Control measures to prevent needlestick injuries following the traditional hierarchy of controls from most effective to least effective include:[50,51].(a)Elimination of hazards-substitute injections by administrating medication through another route(b)Engineering control-such as needles that retract, sheath, or blunt immediate after use(c)Administrative control-policies and training programs aimed to limit exposure to hazard (d)Work practice control-examples include no re-capping ,placing sharps container at eye level and at arms' reach and(e) Personal protection equipment's(PPE)-barriers and filters between worker and the hazard., eye goggles, face shield, gloves, masks, and gowns. In healthcare setting, prevention of HIV transmission requires education of all healthcare workers and ancillary staff, provision of necessary equipment, and strict adherence to general infection control practices[52].

Post occupational exposure management[14].Employers of health care workers and other employees at risk for occupational HIV exposure and infection are required to provide a system for reporting exposures and prompt access to medical care[53].Many institutions have developed "needle stick hotlines" or other rapid-response system to direct exposed persons to triage and to initiate immediate treatment[54].However, even in facilities with excellent reporting mechanisms and on-site clinical expertise,many exposures are not reported. In fact,underreporting remains a problem in myriads clinical settings and in health care institutions around the world[55].Wounds and skin sites that have been in contact with blood or body fluids should be washed with soap and water. Exposed mucous membranes should be flushed with tap water. Eye should be flushed with sterile water or commercial eye irrigant. Antiseptics can be used to flush the wound [15].The emotional impact of a known or suspected HIV exposure is usually significant, especially in the first hours to days after the episode [56].Health care workers who sustain exposure to HIV should be counselled to avoid transmission to others during the follow up period, especially during the first 6 to 12 weeks after exposure, when seroconversion is most likely to occur [15].

Postexposure prophylaxis(PEP).Current USPHS(U.S.Public Health Service) guidelines for post exposurechemoprophylaxis reflect a balance between the estimated risk of HIV transmission associated with specific exposures and potential risks associated with treatment[57].Society for Healthcare Epidemiology of America(SHEA) guideline provides the updated recommendations regarding the management of healthcare providers who are infected with hepatitis B virus(HBV),hepatitis C virus(HCV),and/or the human immunodeficiency virus(HIV).SHEA emphasizes that,because of the complexity of these cases,each such will be slightly different from the next, and each should be independently considered in context[5].In general, chemoprophylaxis is recommended for exposures known to confer a transmission risk, should be considered for exposure with a" negligiblerisk" and may not be warranted for exposures that do not pose a known transmission risk[56].Treatment should be initiated as soon as possible after exposure. In most animal studies, efficacy is reduced when treatment is delayed for more than 24 hours [59].Follow up of post exposure include baseline HIV testing, serologic testing for a documented occupational HIV exposure is usually performed 6 weeks to 3 months, and 6 months after exposure[57].

Prophylaxis with antiretroviral drugs.Several factors influence the selection of antiretroviral drugs for prophylaxis regimen :(1)the type of exposure and the estimated risk of HIV transmission(2) the probability that drug- resistant virus strains are currently circulating in the source patient and are likely to be present in the exposure inoculum(3)the safety profile and likelihood of the healthcare worker's adherence to the proposed treatment regimens; and(4) the cost of the agents[15].The "basic regimen" currently recommended by the CDC for treatment after occupation HIV exposure that confer an infection risk includes(1) a combination of zidovudine with either lamivudine oremtricitabine or(2) a combination of tenofovir with lamivudine or

emtricitabine[57].the CDC recommends an"expended regimen" that include a protease inhibitor or a non-nucleotide reverse transcriptase inhibitor in addition to the basic regimen. The regimen is recommended for exposures for which the risk of HIV infection is increased (i.e.,high volume of inoculum or exposure to materials containing a high virus titer)[60].

V. Conclusion

Health care workers (HCWs) are at risk for occupational exposure to HIV infection, due to percutaneous exposure to infected blood and body fluids.In health- care settings, prevention of HIV transmission needs education of allHCWs, availability of equipment,and strict compliance of standard precautions. When. HCWs are exposed to the risk of HIV infection, immediate treatment with antiretroviral drugs is recommended to prevent infection.

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