REVIEW

Needle Stick Injuries: An Overview of the Size of the Problem, Prevention & Management

Moazzam A[*1]. Zaidi, Salem A. Beshyah[2], Robin Griffith[3]

1. Occupational & Environmental Health and Safety, Sheikh Khalifa Medical City, Abu Dhabi, United Arab Emirates

2. Department of Medicine, Sheikh Khalifa Medical City, Abu Dhabi, United Arab Emirates

3. Occupational and Aviation Medicine, University of Otago, Wellington, New Zealand

*Corresponding author: Moazzam A. Zaidi Email: mzaidi@skmc.gov.ae
Published: 01 March 2010
Ibnosina Journal of Medicine and Biomedical Sciences 2010, 2(2):53-61
Received: 15 September 2009
Accepted: 31 January 2010
This article is available from: http://www.ijmbs.org

Abstract
Over 20 million dedicated health care providers (HCP) expose themselves to biological, chemical, and mechanical hazards daily. The World Health Organization estimates that approximately three million health care providers are exposed to blood and body fluid due to needle stick or sharps injuries annually. Blood and body fluid exposures have resulted in 57 documented cases of HIV seroconversion among healthcare personnel through 2001. Two thousand workers a year become infected with hepatitis C, and 400 contact hepatitis B. There are more than 20 additional types of infectious agents documented to be transmitted through needle sticks. More than 80% of needle stick injuries are preventable with the use of safe needle
devices. Legislation has been developed in many countries to protect HCPs by encouraging employers to use best practices to prevent these exposures. Many different protocols for post exposure management of needle stick injuries or blood and body fluid exposure have been proposed. Effectiveness of a protocol depends on early initiation of post exposure management. HIV prophylaxis has the smallest window of time treatment and has to be initiated as soon as possible, preferably in the first few hours. Hepatitis B Immunoglobulin (HBIg) could be given within the first seven days. Healthcare institutions should develop policies and procedures to reduce needle stick injuries by proactively instituting these recommendations, vaccinating all HCP for Hepatitis B (HBV), and incorporating improved engineering controls into a comprehensive needle stick injury prevention program. In this review, we present historical background, nature and size of the problem, followed by review of the state of the art of the prevention, clinical management, and corporate responsibilities.

Key words: Needle stick injury, blood & body fluid exposure, prevention, post exposure prophylaxis

Introduction

Needle stick injury is a nightmare that threatens large numbers of health care professionals (HCP) who are

exposed to blood and body fluid worldwide. The cost is huge to both the employers and to the nation, and is immeasurable at personal and social levels. In this review, we will present the historical background followed by a discussion of the nature and size of the problem, including discussion of prevention, corporate responsibilities, and legal issues. The post exposure management in general, and as it relates to hepatitis and HIV infections, will be discussed with a short comment on its relevance to practice in the developing world.

Background

Since mid 1840s when the first needle was used through today, this essential part of healthcare provision has been a source of occupational injury for healthcare providers (HCPs) (1). Disposable syringes which became available in early 1960s reduced the burden slightly as the need to sterilize and reuse the same syringe was no longer required. In 1978, a medical technician at the University of Wisconsin Hospital in Madison, WI, seroconverted to Hepatitis B after occupational exposure to hepatitis B from an accidental needle stick injury. This sentinel event lead Dr. Dennis Maki and Ms. Rita McCormick,RN, CIC, to perform groundbreaking research that brought the hazards of needle stick injury to the attention of the medical community. This research created awareness in healthcare providers regarding blood borne diseases from contaminated needles and sharps. In their report, published in 1981, Maki and McCormick found that the most important cause of needle stick injuries was recapping attempts, and warned HCPs not to recap needles. Despite the knowledge and awareness of the problem in the medical community, HBV, and other bloodborne pathogens frequently spread by accidental needle stick injuries. It was not until the deadly specter of HIV/AIDS came in the early 1980s that attention was focused on blood and body fluid exposure and the need of needle safety devices (1).

Nature and Size of the Problem

Worldwide Threat to HCPs

There are 20 million healthcare providers (HCP) dedicating their lives to improve the health of more than 6.7 billion individuals around the globe (2). Healthcare providers are exposed to biological, chemical and mechanical challenges everyday which are in addition to the emotional and mental stress they face. These HCPs live under fear of contacting infectious diseases by exposure to contaminated blood and body fluid (BBF). Needle stick Injury (NSI) and blood & body fluid has been the reason for 57 documented cases of HIV seroconversion among healthcare personnel through 2001. Two thousand workers a year become infected with Hepatitis C (HCV), and 400 with HBV. More than 20 additional types of infectious agents are documented to have been transmitted through needle sticks, including tuberculosis, syphilis, malaria, herpes, diphtheria, gonorrhea, typhus, and Rocky Mountain spotted fever (3).

The principal safety concern for health care providers is needle stick injury and becoming exposed to blood and body fluid resulting in seroconversion to HBV, HCV, or HIV. According to the World Health Organization (WHO) approximately three million individuals are injured annually due to needle stick or sharps injuries. HCPs may encounter needle stick injuries during common work days (Table 1).

The US alone has had one million needle stick injuries of this type. The estimated number of similar injuries in UK is 100,000 (1). Due to these exposures, approximately 1,000 HCPs are estimated to suffer from serious infections annually (4). US Department of Labor and Occupational Health, Safety, & Administration (OSHA) indicates that in the US, one out of every seven healthcare workers accidentally suffers from a needle stick injury annually. This can be extrapolated to state that in a span of 30 working years every healthcare worker has a possibility of suffering from 4 needle stick injuries. Exposure to blood and body fluid is not limited to physicians and nurses though they are the groups, which suffer from most of the exposures. Exposures are also seen in laboratory technicians, paramedics, nursing assistants, cleaning/housekeeping staff and even family members.

Needle Stick Injury and The Law

The US Congress in their 106th Session made changes to the blood-borne pathogen standards in effect under the Occupational Health and Safety Act of 1970. The Needle Stick Safety and Prevention Act was developed to prevent occupational exposure to blood-borne pathogens. In 1991, the Occupational Safety and Health Administration (OSHA) issued a standard regulating occupational exposure to blood-borne pathogens (5). The Food and Drug Administration (FDA) issued an alert to utilize needleless IV systems wherever possible. These legislative and regulatory changes were a clear indication that blood and body fluid exposure was recognized as a major issue and this subsequently led to the development of safer needle designs. The first safe needle designs were patented in the 1970s. The FDA has approved more than 250 devices for marketing as safety devices since that time (4).

The European Union Directive 2000/54/EC of the European Parliament and the Council of 18 September, 2000, stressed the protection of workers from risks related

Table 1: Common causes of needle stick injuries	
Causes	**Estimated %**
Disposing of needle	35
Administrating injections	20
Drawing blood	18
Recapping needles	15
Handling trash and dirty linens	12

to exposure to biological agents at work (6) and dealt with the use of safe methods to prevent healthcare workers from exposure to blood, body fluids, NSI, and other biological contaminants. It mandated all members to comply with the minimum requirements designed to guarantee an effective and improved standard of safety and health with regard to the protection of healthcare workers from the risks related to exposure to biological agents at work. Essentially, the goal was to ensure the safety and health of workers. After this Directive, member countries have initiated changes in their legislation. Austria's government has started a safety platform. Belgium, France, and Germany have proposed law changes, and Spain has instituted an initiative to address protection of healthcare workers from exposure to needle stick injury and blood and body fluids (7). The United Kingdom's National Health Services, in their recent guide for "the healthy work places," have addressed these issues also.

Prevention

More than 80% of needle stick injuries are preventable with the use of safe needle devices (4). Primary prevention is the replacement of the risk with a less hazardous substitute. In the case of blood and body fluid, it would require replacement of needles and other sharps. This is not always possible but should be implemented where applicable with needle free connectors, blunt needle cannulas, and adhesive strips to close wounds. Needles and other sharps would always be present in one form or another in the healthcare facility. Secondary prevention methods add active or passive safety features such as shielding in the case of needles and other sharps.

According to the CDC, one quarter of the injuries happen when the protective device was not activated (8). Proactive approaches should include immunization for HBV, awareness campaigns, and training of HCPs regarding the grave consequences of letting blood and body fluid exposures go unreported.

Effective Post-Exposure Management

There are many different protocols for post exposure management of needle stick injuries to blood and body fluids. The Centre for Disease Control (CDC), the World Health Organization (WHO), other organizations as well as institutions such as academic hospitals have their own protocols.

General Principles

Initiation of post exposure management to blood and body fluids by needle stick or sharps injury depends on timely reporting of the incident. HIV prophylaxis has the smallest window of time. The treatment has to be started as soon as possible, within the first few hours. After 72 hours most protocols recommend not to initiate HIV prophylaxis. HBV Immunoglobulin (HBIg) could be given within the first seven days and has been shown to be 75% effective in preventing seroconversion. Perceived severity of communicable infections, the perceived efficacy of reporting injuries, and overall motivation to maintain health were the best predictors of reporting compliance. Non-compliant personnel when surveyed emphasized the negative aspects of reporting occupational injuries, mainly that it "takes a lot of time."

The solution to non-compliance of reporting occupational injuries is to invest in training and education designed to sensitize the healthcare providers to the importance of reporting, and its effect on strategic planning to safeguard their health (9). Physicians are least likely to report a needle stick injury compared to other healthcare providers. It is estimated that approximately only one out of three needle

sticks are reported. In the NIOSH study, it was estimated that over 2,100 health care professionals will incur a needle stick related injury at the time of publication; 1999 (10).

Several protocols of post-exposure management exist in the literature. These are exemplified by the algorithm followed at the Sheikh Khalifa Medical City, Abu Dhabi, UAE (Figure 1). According to this protocol, when there is a blood and body fluid exposure the following routine is followed both the source (patient) and staff (individual exposed). Each are assessed for their immune status for HBV, HCV, and HIV. If the source is negative for HBV, HCV, and HIV no further follow-up is mandated. If the source is positive for HBV and the staff has antibody titers for HBV below 10 IU post exposure, prophylaxis (PEP) is started immediately. Both HBV immune globulin (HBIG) and HBV vaccine is given immediately. The second dose of HBIG and HBV vaccine is given four weeks later, followed by the third dose of vaccine at six months from the initial dose. In case the source is positive for HCV, the staff member would be followed to assess if they require treatment according to the protocol which is HCV PCR six week after the exposure with follow up blood work for HCV antibodies and LFTs at three and six months. Advisory Committee on Immunization Practices (ACIP) in 1994 reviewed the available data regarding the prevention of HCV infection with immunoglobulin (IG) as a post exposure prophylactic treatment for HCV exposure. ACIP concluded that they would not support IG or interferon as PEP for HCV (26). Staff members exposed to blood and body fluid infected with HIV are immediately started on the two drug regimen if the exposure was superficial, and blood did not come in contact with the source's blood. In the case of deep prick or cut injuries during surgery, the three drug regimen is started. Blood tests are requested for follow up according to the protocol.

Role of Employers

Policy guidelines should be developed by healthcare facilities for safe working practices for patients with HBV, HCV, HIV infection and AIDS, and should be disseminated across all occupational groups to reduce negative staff attitudes and improve knowledge of occupational transmission. This will establish an appropriate perception of risk, and create a supportive and caring hospital environment for people with HBV, HCV, and HIV. Managers play an integral role in disseminating the policy guidelines and information to all staff on an ongoing basis (11).

Healthcare employers should try to develop policies and procedures to reduce needle stick injuries by proactively vaccinating all HCPs for HBV, and incorporating improved engineering controls into a comprehensive needle stick injury prevention program (Table 2).

Specific Clinical Problems

Hepatitis B

Occupational transmission of HBV in HCPs is well recognized (12). Blood contains the highest titer of HBV in all body fluids. HBV surface antigen (HBsAg) was also found to be present in breast milk, bile, cerebrospinal fluid,

Table 2: Widely accepted components of comprehensive needle stick injury prevention program

1	Analysis of BBFE by needle stick and other sharps-related injuries in the workplace to develop trends.
2	Setting priorities and strategies for sharps injury prevention
3	Vaccination of all healthcare providers for hepatitis B.
4	Ensuring all HCPs are given proper training and refresher training sessions for the safe use and disposal of needles and other sharps.
5	Modifying work practices that potentially create sharps injury hazards to make them safer.
6	Promotion of awareness of safe needle practice in the work environment.
7	Establishing mandatory policy and procedures for reporting all needle stick and other sharps-related injuries.
8	Evaluating utilization and effectiveness of prevention effort and provide feedback on prevention performance

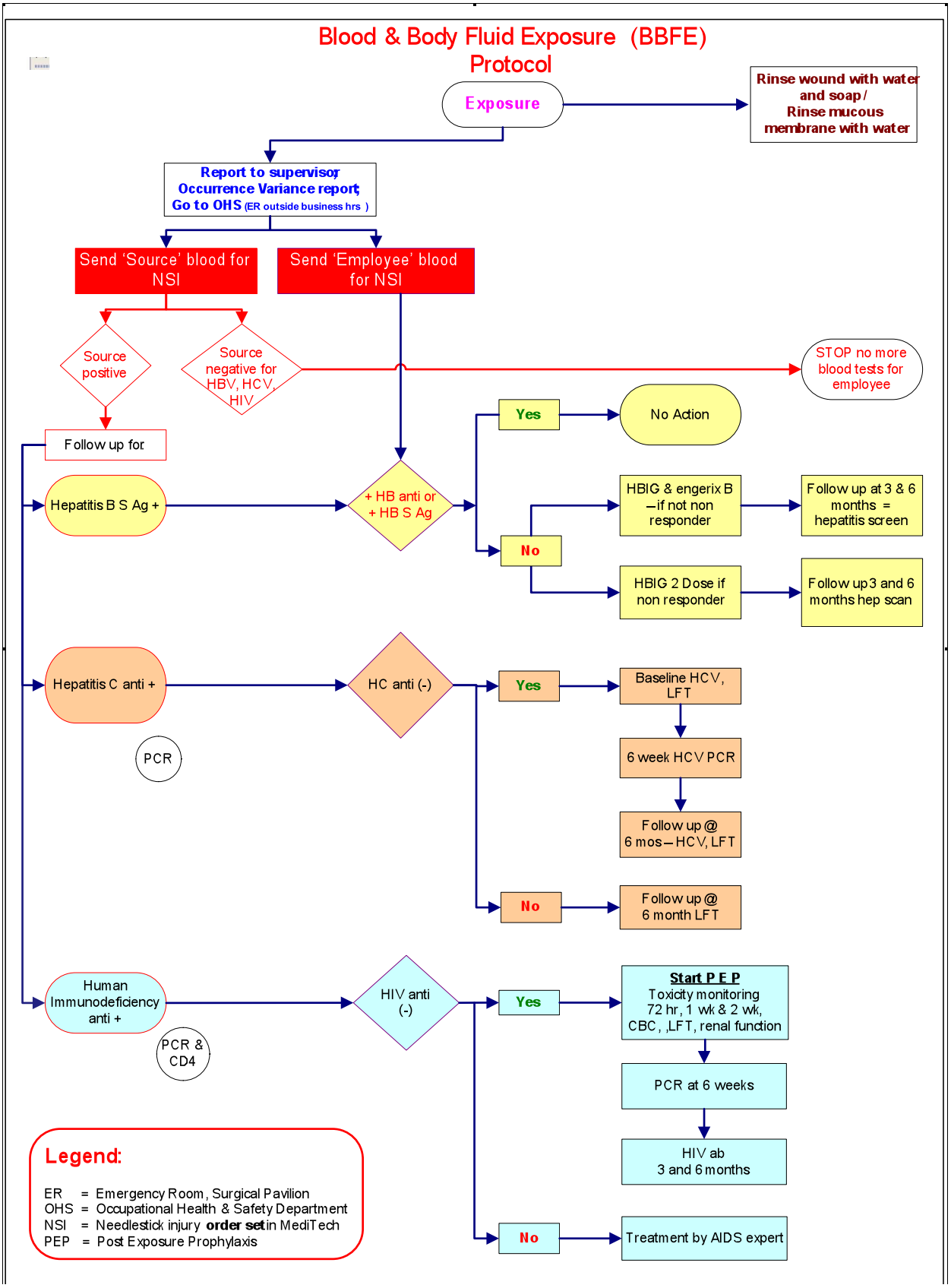

Figure 1: Protocol used by Sheikh Khalifa Medical City

feces, nasopharyngeal washings, saliva, semen, sweat, and synovial fluid (13). Risk of HBV infection is primarily associated to the amount of contact with blood and presence of Hepatitis e Antigen (HBe Ag) status of the source. Studies show that if the source is positive of both Hepatitis B surface antigen (HBsAg) and Hepatitis e Antigen (HBe Ag), the risk of developing clinical hepatitis was 22- 31%. Serological evidence of HBV infection was 37- 62%. Whereas if the exposure was to blood from a source which was only HBsAg positive, the risk of developing clinical hepatitis was 1- 2%, and developing serological evidence of HBV infection was 23- 37% (14). Recent studies have shown that emergence of HBeAg-minus HBV in wild-type HBV carriers is associated with an exacerbation of liver disease. It also showed the presence of antibodies against HBeAg (anti-HBe) in serum in 50% of the cases. In majority anti-HBe-positive patients, HBeAg-minus HBV was the predominant virus: HBeAg-minus HBV was shown to be associated with a course of hepatitis which leads to flare-ups of liver cell necrosis interspersed with periods of asymptomatic HBV carriage. This evidence supports the hypothesis that genetic heterogeneity of HBV significantly influences the infectivity and outcome of chronic HBV (15). Bonino and colleagues showed that the ratio between wild-type HBV virus and HBV mutant, unable to secrete "e" antigen (HBeAg minus HBV), appeared to be an effective determinant in the outcome of chronic HBV and its infectivity. Their study showed that quantitative analysis of HBeAg minus HBV in the blood is a useful tool to monitor infectivity in chronic HBV patients (16). Hepatitis B virus has been demonstrated to survive dried blood at room temperature on environmental surfaces for at least one week, an extremely important factor in transmission (17). Therefore it's possible to get HBV infection by direct or indirect blood or body fluid exposure that inoculates HBV into cutaneous scratches, abrasions, burns, or other lesions or mucosal surfaces (18).

Due to the high risk of HBV infection among HCPs, routine pre exposure vaccine for healthcare providers against HBV, and universal precautions, have been recommended since the 1980s (19). Compliance with this recommendation increased after Occupational Safety and Health Administration (OSHA) (20) issued a standard regulating occupational exposure to bloodborne pathogens (5). Since June 2002, 22 US states have enacted this regulation to some form of legislation to prevent blood and body fluid exposure.

In cases of individuals who were not vaccinated pre-exposure to contaminated body fluid, the efficacy of post exposure prophylaxis (PEP) has been studied . Both HBV immune globulin (HBIG) and /or HBV vaccine have been found to be effective. Regimens involving either multiple dose of HBIG alone or the HBV vaccine series alone are reported to be 70-75% effective in preventing HBV infection. HBIG, if initiated in the first week of the exposure to HBsAg positive blood, provides 75% protection from HBV infection (21).

Table 3: The Cost of Needle stick injury
Time and money to investigate the source
Post exposure care
Lost work time & productivity
Treatment of resulting illness
Workers lives
Psychological trauma
Family's emotional stress

Hepatitis C

Hepatitis C virus (HCV) is not efficiently transmitted through occupational exposure to blood and body fluids. Occupational exposure to blood and body fluid of a HCV positive patient on average has an incidence of 1.8% (range: 0- 7%) seroconversion for HCP (22). One study indicated

that transmission for HCV occurred only from hollow-bore needles when compared with other sharps (23). There is limited data on the survival of HCV in the environment. The Advisory Committee on Immunization Practices (ACIP) in 1994 reviewed the available data regarding the prevention of HCV infection with immunoglobulin (IG) as a prophylactic treatment for HCV post exposure. The ACIP concluded that they did not support IG or interferon as PEP for HCV (24). Their conclusion was based on the fact that no protective antibody response has been identified following HCV infection in experimental studies in chimpanzees with IG. From that research, anti-HCV IG failed to prevent transmission of infection after exposure (8). The FDA has not approved antiviral medications such as interferon for post exposure prophylaxis of HCV infection.

In the absence of an effective post exposure prophylactic treatment for occupational exposure to HCV, recommendations for post exposure management are based on interventions to achieve early identification of the disease. Studies have shown that if serum ALT increases considerably (500-1000 IU/L), early therapy in the acute phase can be beneficial. There have been no studies, to evaluate the efficacy of early therapy HCV RNA –positive with normal ALT levels (8). Treatment initiated early in the chronic phase of HCV infection (within 6 months after onset of infection), might be as effective as treatment started during the acute phase (25).

HIV Infection

HCPs are at risk of occupational transmission of HIV after exposure to blood and body fluid infected with HIV. Studies show the risk of HIV transmission after percutaneous exposure to HIV infected blood is estimated to be approximately 0.3% (range: 0.2- 0.3%) whereas the risk of transmission after mucous membrane exposure is approximately 0.09% (range: 0.006- 0.5%) (26). Risk of HIV transmission after exposure to other body fluid and tissues has been quantified but is probably much lower than that for blood (27). Occupational exposure to HIV infected blood should be evaluated *within hours* not days. If the source is determined to be HIV positive, the occurrence should be investigated as to what type of sharp caused the infection, the amount of blood involved, the exact method of contact with the HCP, and at what stage of infection is the source. These details will help in deciding which post exposure prophylactic drug regimen should be used. Less severe exposure qualifies for two-drug regimen whereas severe exposure requires a three- drug regimen for four weeks duration (28). Optimal duration for post exposure prophylaxis is unclear but according to the CDC, the hospital guideline for prophylaxis treatment is continued for four weeks. Basic two-drug regimen includes Zidovudine 300mg plus Lamivudine 150mg (Combivir®); 1 tablet PO BID (with meals) for four (4) weeks as the primary/basic regimen. The expanded regimen consists of Combivir (as above) plus Lopinavir / Ritonavir 200 / 50mg; 2 tablets PO BID (with meals) for four (4) weeks as the expanded regimen (28, 26). It is recommended not to start with abacavir and nevirapine as prophylactic treatment and efavirenz should be avoided even in treatment for pregnant patients (29).

Personal And Economic Cost Of Needle Stick Injury

The Developing World Perspective

A single needle stick injury can cause anywhere from a few hundred thousand to a million dollars. More important than the economical factors of blood and body fluid exposure is the psychological trauma to the individual as well as the co-workers and family members. This includes delayed childbearing, altered sexual practices, and side effects of post exposure prophylactic treatment. These challenges are further complicated if potential chronic disability is developed leading to loss of employment, denial of compensation claims,and even liver disease requiring liver transplant (Table 3

The American Hospital Association reported that one case of serious occupational exposure to infection by bloodborne pathogens can add up to $1 million or more in expenditures for testing, follow-up, lost time, and disability payments. Whereas the cost of follow-up for a high-risk exposure per needle stick injury with out infection is generally in the range of $3,000. Therefore the total cost of simply testing without subsequent seroconversion in the US approaches US $2.4 billion (8).

At Sheikh Khalifa Medical City the cost ranges from 1300-3500 AED (US$ 400- 1000) for follow up of one incident of blood or body fluid injury without seroconversion. Millions of dollars invested in follow up and treatment after exposure to blood and body fluid can be saved with proper planning for funding to purchase safe needles and equipment. Safe needle devices cost only 28 cents more than standard devices. Still the unitization of these devices even in hospitals in the US remains less than 15% (4).

Challenges of needle stick injuries in the developing world are even more complicated. The World Health Organization (WHO) estimated that the global burden from occupational exposure to blood and body fluid results in 40% of known

cases of HBV and HCV, and 2.5% of HIV. The WHO stated while 90% of infections among HCPs are attributed to occupational exposure in the developing world, 90% of the reporting of an occupational exposure to BBF is from the developed world (30). This highlights the importance of sensitization and advocacy for both reporting and post exposure follow up in the developing world. However, at the present time, there are limited research data published from the middle east as an example, despite the predictable high risk of bloodborne transmission in the clinical practice. Out the total of 2710 hits in Medline in response to the term search "needle stick injuiries", only 46 reports came from this region. 24 came from Turkey and Iran, 10 from Saudi Arabia, 4 from Egypt, 3 from Jordan 2 from Morroco, one each from Libya, Lebanon, Plaestine and Syria. No reports were available from UAE, Iraq, Tunisia, Alegeria, yemen, Qatar and Bahrain.

Final Remarks

Millions of health care providers are exposed to blood and body fluid due to needle stick or sharps injuries annually. Blood and body fluid exposures have resulted in many cases of HIV, HCV, and HBV. Many different protocols for post exposure management of needle stick injuries or blood and body fluid exposure have been proposed. The key element for the effectiveness of a protocol depends on early initiation of post exposure management. Healthcare institutions should strive to develop policies and procedures to reduce needle stick injuries by working proactively to vaccinate all HCP for HBV and incorporating improved engineering controls into a comprehensive needle stick injury prevention program.

References

1. Stoker R. Anatomy of Needle stick Injury: Business Briefing [document on the Internet]. Global Healthcare – Advanced Medical Technologies. 2004: pp [cited 2009 Nov 25]. Available from http://www.bbriefings.com/download.cfm? fileID=2938.
2. No Author. CIA's World Fact Book. [document on the Internet]. [cited 2009 Sep 1] Available from: https://www.cia.gov/library/publications/the-world-factbook/geos/xx.html.
3. Needle sticks Injuries and Sharps Injuries to Healthcare Workers and others. [document on the Internet]. [cited 2009 Sep 1] Available from: http://www.ids-healthcare.com/hospital_management/global/ISIPS/Needle_Stick_Injury/7_0/g_supplier_2.html.
4. Nursing Facts. American Nursing Association: ANA fact sheet on Needle stick injury. [document on the Internet]. [cited 2009 Sep 1] Available from: http://www.nurses.info/biohazars_terrorism_needle stick.htm
5. Tatelbaum MF. Health Law Review: Needle stick Safety and Prevention Act. Pain Physician 2001; 4: 193-5.
6. No Author. Directive 2000/54/EC of the European Parliament and of the Council of 18 September 2000 on the protection of workers from risks related to exposure to biological agents at work (seventh individual directive within the meaning of Article 16(1) of Directive 89/391/EEC). Official Journal of The European Communities. 2000; L 262: 0021-0045
7. Crepel J-P. Contamination through needle stick injuries risks, Regulation, Means of prevention. [document on the Internet]. [cited 2009 June 15]. Available from: http://www.pda.org/Presentation/
8. Stoker, R. Needle stick Injury Prevention: Business Briefing: Long Term Healthcare 2004:144-146. [document on the Internet]. [cited 2009 Sep. 1]. Available from: http://www.touchbriefings.com
9. Tabak N, Shiaabana AM, Shasha S. The health beliefs of hospital staff and the reporting of needle stick injury. J Clin Nurs. 2006;15:1228-39.
10. CDC. NIOSH alert: Preventing needle stick injuries in health care settings. Cincinnati, OH: Department of Health and Human Services, CDC, 1999; DHHS publication no. (NIOSH) 2000-108.
11. Davidson G and Gillies P. Safe working practices and HIV infection: knowledge, attitudes, perception of risk, and policy in hospital. Qual Health Care 1993;2:21-6.
12. Mast EE, Alter MJ. Prevention of hepatitis B virus infection among health-care workers. In: Ellis RW, ed. Hepatitis B vaccines in clinical practice. New York: Marcel Dekker, 1993: pp 295-307.
13. Bond WW, Petersen NJ, Favero MS. Viral hepatitis B: Aspects of environmental control. Health Lab Sci 1977;14:235-52.
14. Werner BG, Grady GF. Accidental hepatitis-B-

surface-antigen-positive inoculations: use of e antigen to estimate infectivity. Ann Intern Med 1982;97:367-9.
15. Brunetto MR, Giarin MM, Oliveri F, Chiaberge E, Baldi M, Alfarano A, et al. Wild-type and e antigen-minus hepatitis B viruses and course of chronic hepatitis. Proc Natl Acad Sci U S A 1991; 88:4186–90.
16. Brunetto MR, Randone A, Ranki M, Jalanko A, Piantino P, Giarin M, Capra G, Calvo PL, Oliveri F, Bonino F. 1994. Quantitative analysis of wild-type and HBeAg minus hepatitis B viruses by a sequence-dependent primer extension assay. J Med Virol 1994; 43:310-5.
17. Bond WW, Favero MS, Petersen NJ, Gravelle CR, Ebert JW, Maynard JE. Survival of hepatitis B virus after drying and storage for one week [Letter]. Lancet 1981;1:550-1.
18. Lauer JL, VanDrunen NA, Washburn JW, Balfour HH Jr. Transmission of hepatitis B virus in clinical laboratory areas. J Infect Dis 1979;140:513-6
19. CDC. Recommendation of the Immunization Practices Advisory Committee (ACIP) inactivated hepatitis B virus vaccine. MMWR 1982;31:317-28.
20. Department of Labor, Occupational Safety and Health Administration. 29 CFR Part 1910.1030. Occupational exposure to bloodborne pathogens; final rule. Federal Register 1991; 56:64004-182.
21. Grady GF, Lee VA, Prince AM, Gitnick GL, Fawaz KA, Vyas GN. et al. Hepatitis B immune globulin for accidental exposures among medical personnel: final report of a multicenter controlled trial. J Infect Dis 1978;138:625-38.
22. Alter MJ. The epidemiology of acute and chronic hepatitis C. Clin Liver Dis. 1997;1:559-68.
23. Puro V, Petrosillo N, Ippolito G, Italian Study Group on Occupational Risk of HIV and Other Bloodborne Infections. Risk of hepatitis C seroconversion after occupational exposure in health care workers. Am J Infect Control 1995;23:273-7.
24. Alter MJ. Occupational exposure to hepatitis C virus: a dilemma. Infect Control Hosp Epidemiol 1994;15:742-4.
25. CDC. Recommendations for the prevention and control of hepatitis C virus (HCV) infection and HCV-related chronic disease. MMWR 1998;47:1-33.
26. Ippolito G, Puro V, De Carli G, Italian Study Group on Occupational Risk of HIV Infection. The risk of occupational human immunodeficiency virus in health care workers. Arch Int Med 1993;153:1451-8.
27. Henderson DK, Fahey BJ, Willy M, et al. Risk for occupational transmission of human immunodeficiency virus type 1 (HIV-1) associated with clinical exposures: a prospective evaluation. Ann Intern Med 1990;113:740-6.
28. CDC. Updated U.S Public health Service Guidelines for the Management of Occupational Exposure to HIV and Recommendations for Postexposure Prophylaxis MMWR 2005;54;1-17.
29. Preboth M; PHS guidelines for management of occupational exposure to HBV, HCV and HIV: HIV postexposure prophylaxis regimens. Am Fam Physician 2002;65: 322-5.
30. Wilburn, SQ and Eijkemans G. Preventing Needle stick injuries among Healthcare Workers: A WHO-ICN Collaboration. Int J Occup Environ Health 2004;10:451-6.