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The Physician with Blood-Borne Viral Infection: What are the Risks to Patients and What is an Appropriate Approach to the Physicians?

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EXECUTIVE SUMMARY

The risk of a physician transmitting a blood-borne viral (BBV) infection to a patient is exceptionally low and will continue to fall as more effective methods of prevention and treatment are developed. Paradoxically, despite evidence that the risk of transmission of BBVs by health care workers (HCWs) is low and falling, a growing number of Canadian provincial/territorial medical regulating authorities (Colleges) are now collecting information about the HBV, HIV and HCV status of physicians at the time of initial licensure and/or at the time of license renewal. Some Colleges and many hospitals do not yet have a plan for how they will respond to positive tests. To guide policy development in this rapidly evolving area, a group of six specialists from four relevant specialties was convened by the Canadian Medical Protective Association (CMPA). The panel met in person, reviewed the modern literature, discussed the current state of knowledge and made 11 recommendations, which follow. The six authors developed the recommendations independent of the CMPA.

Recommendation 1: The policies governing physician screening for BBV and the management of BBV-infected physicians should be evidence-based.

Recommendation 2: Provincial Colleges should develop policies that encourage a safe working environment and maximize the use of measures to prevent BBV disease transmission. Some of these opportunities include but are not limited to 1) mandating professional obligations to always use universal precautions when appropriate and always report occupational blood exposures to and from patients; and 2) identifying additional financial resources to support BBV-infected physicians who face practice restrictions.

Recommendation 3: When a blood exposure occurs during an exposure prone procedure (EPP), the involved physician and patient should both be tested for BBVs. If a patient is exposed to blood from a BBV-infected physician, the patient should be told about the exposure as well as the specific BBV, and the estimated risk of transmission, but the patient should not be told the identity of the BBV-infected HCW. Appropriate follow-up of the patient and the physician should be provided. Both the patient and the physician should be offered baseline and follow-up testing, and where appropriate, post-exposure prophylaxis at no cost to the patient or physician.

Recommendation 4: The available evidence does not support mandatory testing for BBVs for physicians who do not perform EPPs.

Recommendation 5: Current data support mandatory testing of physicians who perform EPPs for immunity to HBV (presence of anti-HBs).

Recommendation 6: Current data do not support mandatory HIV testing of physicians who perform EPPs.

Recommendation 7: Current data are inconclusive to make a recommendation regarding mandatory HCV testing of physicians who perform EPPs. If a decision to test is undertaken, HCV antibody negativity is sufficient to exclude HCV infection, but only HCV RNA positivity indicates infectivity. Decisions about the frequency of HCV testing will be arbitrary, as there is no available evidence on effectiveness to guide this recommendation.

Recommendation 8: For BBV-infected HCWs who do not perform EPPs, there are no grounds to restrict their practice on account of the BBV infection, provided that they adhere to universal precautions.

Recommendation 9: HIV-infected physicians should not perform EPPs, but can perform other medical duties until they are on antiretroviral therapy (ART) and their plasma HIV RNA is undetectable. Once documented to have undetectable plasma HIV RNA on ART, HIV-infected physicians should be permitted to perform EPPs using double gloves with the proviso that their personal physician provides regular (every 3 to 4 month) confirmation to an appropriate designated physician that his/her plasma HIV RNA is undetectable.

Recommendation 10: HBV-infected physicians with plasma HBV DNA over 2000 IU/mL should not perform EPPs, except on patients who are HBV-immune (anti-HBs positive) or HBV-infected (HBsAg positive), until or unless their infectivity status changes -— whether by natural immunity or from antiviral therapy. HBV-infected physicians with plasma HBV DNA consistently below 2000 IU/mL should be permitted to perform EPPs using double gloves and universal precautions, regardless of their HBeAg status, with the proviso that their personal physician provides regular (every 3 to 4 month) confirmation that his/her plasma HBV DNA is suppressed below this level to an appropriate designated physician.

Recommendation 11: HCV-infected physicians (HCV RNA positive) should not perform EPPs, but they can perform other medical duties. They may resume EPPs while on anti-HCV therapy once HCV RNA is negative. Once anti-HCV therapy is completed, they should once again refrain from EPPs for at least 12 weeks following completion of antiviral therapy until a repeat HCV RNA test done at least 12 weeks after completion of treatment is confirmed to be negative, after which they can resume EPPs.

INTRODUCTION

The recommendations for the management of health care workers (HCWs) with blood-borne viral (BBV) infections are evolving. In 1998, Health Canada published the proceedings of a Canadian consensus conference on infected HCWs and risk for transmission [1]. Their recommendations were subsequently modified by the Canadian Medical Association and the Canadian Dental Association. Since that time, there have been significant advances in knowledge about BBVs and significant changes in the physician licensing environment. To guide policy development in this rapidly evolving area, a group of six specialists from four relevant specialties (the authors of this paper) was convened by the Canadian Medical Protective Association (CMPA). The authors undertook a comprehensive literature review with the assistance of a medical librarian, and then met in person to create modern, evidence-based recommendations for the management of physicians infected with hepatitis B virus (HBV), hepatitis C virus (HCV) and human immunodeficiency virus (HIV). The six authors developed the recommendations independent of the CMPA. The CMPA provided background information outlining the need for such guidelines and logistical support.

BACKGROUND

The risk of physicians transmitting BBV infections to patients is exceptionally low and will continue to fall as more effective methods of prevention and treatment are identified. **To date, there are no documented cases of transmission of either HIV or HCV from Canadian physicians to patients. There is only one report of a Canadian physician (an orthopedic surgeon) implicated in transmitting HBV to two patients; these infections occurred prior to the implementation of universal precautions and before the availability of modern antiviral therapy for HBV [2].**

Paradoxically, despite evidence that the risk of transmission of BBVs by HCWs is low and falling, a growing number of Canadian provincial medical licensing colleges have started to collect information about the HBV, HIV and HCV status of physicians at the time of initial licensure and/or at the time of license renewal. Some colleges and many hospitals do not yet have a plan for how they will respond to positive tests. Some provincial colleges now even request information on the BBV infection status of physicians who do not perform any exposure prone procedures (EPPs). These licensing changes have occurred despite the expert opinion of the United States Centers for Disease Control and Prevention (CDC) that “infected HCWs who adhere to universal precautions and who do not perform EPPs pose no risk for transmitting HIV or HBV to patients” [3]. Many changes have contributed to a decreased incidence of the transmission of BBVs. The implementation of universal precautions substantially reduced the risk of transmission of BBV both to and from HCWs by reducing exposures to patient blood and body fluids [4, 5, 6]. Also, a majority of HCWs, as well as a growing number of patients have now received the hepatitis B vaccine [7]. Likely as a result of this, between 1976 and 1993, the annual incidence of HBV infection decreased from 3.0% to 0.1% among hemodialysis patients and from 2.6% to 0.02% among hemodialysis staff in the United States [8]. Additionally, there have been significant advances in antiviral therapy. Indeed, the majority of HBV- and HIV-infected patients currently receiving antiviral therapy have plasma viral loads (pVL) below the limit of detection in highly sensitive nucleic acid tests, such as polymerase chain reaction (PCR). HCV infection can be cured in approximately 55% of patients with current therapy (pegylated interferon alfa plus ribavirin) [9], but the cure rate is expected to be about 75% in the next few years when HCV NS3/NS4A protease inhibitors become available [10, 11]. Finally, we have entered an era with an increased focus on

patient safety. There is an acknowledged need to reduce risks to patients. However, as discussed below, some of the measures recently undertaken by some provincial licensing colleges with respect to BBV-infected physicians appear to contravene the just culture component of the patient safety movement and may actually result in increased patient risk [12].

Most HCWs acquire their BBV infections as a result of a parenteral exposure to an infected patient's blood. The estimated risk per needlestick injury (NSI) from an infected, untreated source patient to a susceptible recipient is 30% for HBV [3], 1.8% for HCV [13] and 0.3% for HIV [14]. Studies conducted prior to the availability of HBV vaccine clearly demonstrated that physicians had higher rates of HBV antibodies than the general population [15], and that the prevalence of serologic markers of HBV infection in physicians increased with the number of years in practice, as well as being higher in specialties with more exposure to patient blood, such as surgery and pathology [15, 16]. In contrast, the prevalence of HCV antibody is not higher among HCWs than the general population [17], likely reflecting the considerablye lower infectivity of HCV relative to HBV. Nevertheless, exposure to BBVs is an occupational hazard that physicians must face, and in addition to HBV, there are well-documented cases of physicians acquiring HCV [18] or HIV [19] infection from occupational parenteral exposures. However, it is considered unethical for a physician to refuse to provide medically required care simply because the patient has a BBV [20]. While physicians should practice universal precautions [21] and receive hepatitis B vaccine to protect them from HBV [3, 13], it is recognized that some persons are vaccine non-responders, and there are no vaccines for either HIV or HCV, nor is it likely that they will become available any time soon.

The risk of a non-immune patient acquiring HBV from an infected physician during an exposure prone procedure is significant. There have been many documented cases in which HBV-infected physicians (nearly always surgeons or obstetricians-gynecologists) or dentists (including oral surgeons) have transmitted HBV to patients [3]; most of these cases occurred prior to the practice of universal precautions. Recognition of the risk of transmission of infections from HCWs to patients led to the development of guidelines to identify those physicians at risk for transmitting HBV by ascertaining the degree of infectivity, best assessed by pVL, and the specific medical procedures performed by that practitioner [13, 22-25]. Thus, HBV-infected physicians with high plasma levels of HBV DNA are appropriately advised to refrain from performing EPPs [3, 22-25].

The risk of a patient acquiring a HCV or HIV infection from an infected HCW is very low. Most patients receive care from HCV-infected physicians and surgeons without acquiring HCV infection [25, 31, 32, 33], although there have been a few cases of documented transmission of HCV from physicians to patients [25, 29, 30]. To date, 29 years into the HIV/AIDS epidemic, there have been only two documented cases of physician-to-patient transmission of HIV worldwide, both of which occurred from surgeons who were unaware of their HIV infection and were not receiving antiretroviral therapy [26, 27]. In contrast, there have been over 22,000 patients who have received care from HIV-infected physicians with no documented transmission [28].

BLOOD EXPOSURES DURING SURGERY

Frequency and Mechanisms

Surgeons acquire and transmit infections through exposure to patient blood during surgery; these exposures are more common than many HCWs appreciate. In a landmark study by Panlilio et al. in 1991 [34], trained observers monitored operations at one hospital for 6 months. In 62 (30.1%) of 206 operations, at least one blood contact was observed. Of 1828 operating room person-procedures observed, 96 (5.3%) had 147 blood contacts (133 skin contacts (90%), 10 percutaneous injuries (7%), and 4 eye splashes (3%)). The mean number of blood contacts per 100 person procedures was highest for surgeons (18.6%). Percutaneous injuries carry the highest risk of transmitting BBVs.

Glove perforations and NSIs typically occur when surgical personnel: a) load or reposition the needle by hand onto the needle holder; b) pass the needle hand-to-hand between team members; c) sew toward the surgeon or assistant while the surgeon or assistant holds back other tissue; d) tie the tissue with the needle still attached; or e) leave the needle on the operative field [35]. These practices should be avoided. NSIs are typically located on the non-dominant hand, on the palmar surface, and on the distal forefinger [36]. Surgeons perceive only 30-66% of glove perforations [37, 38]. Nonetheless, busy senior surgical staff self-reported an average of 17 injuries over a two-year period [39]. In another study, 99% of surgical trainees reported at least one injury by the conclusion of their training [40]. Patients are exposed to the surgeon's blood when the sharp object that caused the injury re-contacts the patient; one study reported that this happened as often as 28 (32%) of 88 sharp object injuries to surgeons [36].

Exposure Prone Procedures (EPP)

In 1998, the CDC defined an EPP as follows: 1) digital palpation of a needle tip in a body cavity (a hollow space within the body or one of its organs) or the simultaneous presence of the HCW's fingers and a needle or other sharp instrument or object in a blind or highly confined anatomic site (e.g., during major abdominal, cardiothoracic, vaginal and/or orthopaedic operations), or 2) repair of major traumatic injuries, or 3) manipulation, cutting or removal of any oral or perioral tissue, including tooth structures, during which blood from a HCW has the potential to expose the patient's open tissue to a blood-borne pathogen. This definition has been adopted by the College of Physicians and Surgeons of Ontario and by many other regulatory agencies.

What types of surgery are associated with the highest risk of a blood exposure? In the Panlilio study [34], risk factors for surgeons' blood contacts included: (1) performing a trauma, burn, or orthopedic emergency procedure (odds ratio (OR) 4.1; 95% confidence interval (CI), 2.0 to 8.7); (2) patient blood loss exceeding 250 mL (OR 2.1; 95% CI, 1.2 to 3.7); and (3) being in the operating room longer than 1 hour (OR 3.3; 95% CI, 1.6 to 7.1); similar results were reported by Tokars et al. [36] and Sullivan et al. [37]. A logistic regression model by Tokars et al. examining risk factors for percutaneous injuries during surgery controlled for the procedure duration, surgical technique, and shift and found evidence to support the categorization of operations into low, middle (odds ratio 3.1; 95% CI, 1.7-5.9; $p < 0.001$); and high risk classes (odds ratio 8.6; 95% CI, 3.7-19.8; $p < 0.001$) [36]. The data from this study and others provide the rationale to consider the types of procedures that are being performed when deciding about practice restrictions for surgeons with BBV infection [25].

Risk Reduction Measures

Universal precautions are the most important measure to ensure that HCWs are not exposed to a patient's blood (and conversely, to also ensure that a patient is not exposed to a HCW's blood) [21]. In the Panlilio study, 81 (74%) of the 110 blood contacts among surgeons were potentially preventable by additional barrier precautions, such as face shields and fluid-resistant gowns [34]. Immunization is a highly effective method to prevent the transmission of hepatitis B infections [3]. All physicians who perform EPPs should be immunized for HBV and tested to confirm the presence of an effective antibody response [3].

The replacement of conventional sharp-tip suture needles with blunt-tip suture needles for the suturing of muscle and fascia is strongly recommended as an effective method to reduce injury rates to surgical personnel [41] since 59% of suture needle injuries occur during wound closure [37, 41].

Double-gloving could also be used routinely by BBV-infected surgeons and ideally by all surgeons since the BBV infection status of most patients is unknown. Double-gloving reduces total glove perforation rates by 50% and reduces the exposure to blood by up to six-fold [41, 42, 43]. Because glove perforations are more likely to occur in cases lasting more than one hour [36], changing gloves during long cases is a prudent practice.

As discussed above, handling tissues with fingers is associated with higher rates of glove perforations [36]. While different surgical techniques have not been evaluated in a prospective fashion, the available data strongly suggest that handling tissues and sharp objects with instruments only is likely another effective method of reducing the risks of sharp object injuries.

When sharp object injuries occur, it should be mandatory to report the injury to the occupational health and safety program and seek appropriate medical follow-up and treatment, if necessary. Self-reporting of blood exposures is a critical step in preventing disease transmission to surgeons (and subsequent transmission to patients). Post-exposure prophylaxis for HBV (in those who are both HBsAg and anti-HBs negative) with hepatitis B-immune globulin plus HBV vaccine is safe and effective. Most acute HCV infections can be cured with treatment started within 12 weeks of infection [9] and most HIV infections can be prevented with early post exposure prophylactic treatment. Unfortunately, only a small fraction of sharp object injuries are currently being reported [39]. The reasons for the low rate of reporting of parenteral exposures have not been well investigated. Knowledge of the benefits of early detection of BBV infection ought to promote reporting. On the other hand, concern about a punitive response to the identification of BBV-infected surgeons is a potential explanation for underreporting.

Ironically, despite increasing concerns about NSI and a better understanding about how to prevent these events, a recent study found that sharp object injuries during surgical procedures in the United States actually increased by 6.5% during the past decade [44]. Whether this is due to an increased number of reported injuries, rather than an increased number of actual injuries is unknown. This observation emphasizes the importance of administrators, educators, policy makers and regulators working together to ensure the rapid adoption of safer surgical technologies and the promotion of policies and practices that have been shown to reduce blood exposures to surgeons, their coworkers, and patients.

HUMAN IMMUNODEFICIENCY VIRUS

Occupational Transmission in the Absence of Antiretroviral Therapy

The HIV epidemic was first described in June 1981 [45]. The causative virus was initially characterized in 1983 [46], but serologic testing was not widely available until 1985. Nevertheless, the first documented case of patient-to-HCW transmission from a NSI was published in 1984 [47]. Subsequent studies prior to the era of modern antiretroviral therapy (ART) found that the risk of HIV transmission following a NSI from an infected person is about 0.3% per exposure [14]. A case-control study conducted from 1987 to 1994 identified 4 factors associated with an increased risk of HIV transmission following percutaneous exposure: a deep injury, visible blood on the device, a procedure involving a needle in an artery or vein, and death of the source patient within two months following the parenteral exposure [48]. Of note, in the same study, the use of post exposure prophylaxis with zidovudine alone was associated with a statistically significant 81% reduction in transmission, underscoring the need for prompt reporting of occupational NSIs.

As of September 1997, 94 documented and 170 possible cases of occupational patient-to-HCW transmissions of HIV infection had occurred worldwide [49]. That number has likely increased in the intervening 13 years.

It was not until 1990 that the first cases of occupational transmission of HIV from an infected HCW to patients were reported from a dentist in Florida [50]. Subsequent investigation revealed that the same dentist infected 6 patients [51]. The circumstances that led to multiple infections in that practice are still poorly understood. The most likely explanation is a combination of a very high pVL in the dentist plus egregious disregard to infection control and prevention practices.

In the early 1990s the practices of many HIV-infected physicians and a few dentists were investigated for possible occupational transmission of HIV infection [28, 52-61]. As of January 1, 1995, over 22,000 patients treated by 64 HIV-infected HCWs had been evaluated and no occupationally transmitted cases of HIV infection were found outside the single dental practice noted above [33].

It was not until 1999 that first case of physician-to-patient transmission of HIV infection was reported [31]. The source of infection was an orthopedic surgeon in France and the surgery associated with HIV transmission lasted 10 hours. The surgeon was unaware that he was HIV-infected until after he retired from performing surgery. No other cases of occupationally transmitted HIV infection were found in this surgeon's practice after another 982 patients were evaluated [31]. Seven years later in 2006, the second case of physician-to-patient transmission of HIV infection was described following caesarean section by a Spanish obstetrician who had sustained a NSI during the surgery [32]. The obstetrician was also unaware that he was HIV-infected at the time of surgery. In summary, there have only been these two cases of documented physician-to-patient cases of HIV transmission. In both cases, transmission occurred during surgery from surgeons unaware that they were HIV-infected, and thus not receiving ART. In one case, surgery was prolonged and complicated. In the other, the surgeon sustained a recognized NSI.

The only other possible case of HCW-to-patient transmission of HIV infection occurred in France where there was a close genetic match of the patient's HIV isolate and one of the patient's nurses [62] who had unrecognized advanced HIV infection with HCV co-infection. The nurse had contact with the patient on two night shifts only, but the published report does not describe any EPPs performed by the nurse nor does it exclude non-occupational

routes of transmission. The fact that the nurse was co-infected with HCV raises the distinct possibility that she abused intravenous drugs, since injection drug use is the leading mode of acquisition of HCV in developed countries [63]. Intravenous drug abusing HCWs have been documented to negligently transmit BBVs to patients by "sharing" the patients' intravenous narcotic medication [64-69]; however, according to the report, the nurse denied a history of injection drug use [70].

Shortly after the report of the occupational transmission of HIV from the Florida dentist to patients, Bell and colleagues described a model to estimate the probability of transmission of HIV from an infected surgeon to patients [71]. Risk was estimated as the product of three probabilities: (i) that the surgeon will sustain a percutaneous injury during an invasive procedure (risk 2.5%); (ii) that the sharp object causing the injury and now contaminated with the surgeon's blood will contact the patient's wound (32%); and (iii) that infection would be transmitted to the patient after such an exposure (0.3%). (It should be noted, the 0.3% estimated probability was derived from parenteral exposures from HIV-infected persons not receiving ART). These three individual probabilities (2.5%, 32% and 0.3%, respectively) would give a total estimated probability of occupational transmission of 0.0024%, or 1 in 42,000 procedures. However, since the use of double surgical gloves is associated with up to a 10-fold reduction in the amount of blood transferred [72], Bell et al. noted that the risk might be as low as 0.00024% or 1 in 420,000 procedures.

HIV Viral Load Testing and Combination Antiretroviral Therapy

In 1996, it became standard practice to quantify HIV RNA in the plasma of HIV-infected patients, commonly called pVL, because of its ability to predict a more rapid clinical progression to AIDS [73].

In patients not receiving ART, pVL is the chief determinant of infectivity for sexual transmission [74] and for mother-to-child transmission [75-78]. It is highly probable that pVL is also the major determinant of occupational transmission, but the studies evaluating the risks for occupational HIV transmission were undertaken prior to the availability of pVL testing.

The year 1996 also heralded the modern era of combination ART. PVL testing demonstrated that single and even double therapy with nucleoside HIV reverse transcriptase inhibitors had only a modest effect on reducing pVL, and almost never reduced it to below the lower limit of detection (at the time 400-500 RNA copies/mL). However, triple therapy with a combination of two nucleoside reverse transcriptase inhibitors plus an HIV protease inhibitor could suppress the pVL to undetectable in about 70% of patients, resulting in the introduction of the term "highly active antiretroviral therapy" (HAART), ergo - an admission that previous ART was not very active [79]. The introduction of HAART resulted in dramatic reductions in HIV-related mortality and morbidity [80, 81]. HIV infection has now become a chronic controllable, yet incurable disease [82], considered by many to be not unlike diabetes mellitus, Crohn's disease, and rheumatoid arthritis.

As of 2010, 23 distinct antiretroviral drugs are approved in Canada, several of which are available in fixed-dose combinations to reduce pill burden and enhance patient adherence. Additional investigational antiretroviral drugs are under clinical development. Furthermore, antiretroviral resistance testing is readily available to assist in the selection of appropriate antiretroviral regimens. It is now possible to suppress the pVL of nearly all HIV-infected patients to below the lower limit of detection of current tests (25-50 RNA copies/mL).

Role of pVL in Mother-to-Child Transmission of HIV

The obstetrical literature provides compelling evidence that combination ART markedly reduces infectivity. First, zidovudine monotherapy reduced the risk of mother-to-child transmission (MTCT) of HIV from 25.5% to 8.3% [83] despite the fact that zidovudine monotherapy decreases maternal pVL by less than 1 log10 [76]. The use of combination ART in pregnant HIV-infected women has further decreased the risk of MTCT to less than 1% [83,84] and in women with pVL below 50 copies/mL at delivery, the risk is about 0.4% [86]. Nevertheless, a small number of cases of MTCT of HIV have been documented despite low maternal pVL [87, 88]. These cases of MTCT can be explained by two factors; (i) while maternal pVL is the dominant determinant of MTCT, it is not the only one [89]; and (ii) some cases of MTCT occur *in utero* prior to the pregnant woman initiating ART. A recent analysis of cases of MTCT despite maternal pVL below 500 copies/mL at the time of delivery found that predictors of MTCT were lack of receipt of ART at conception, and viremia at weeks 14, 28 and 32 of gestation [88]. Assuming a background rate of MTCT in the absence of ART of 25.5% [83] and noting that the rate of MTCT observed with maximal virologic suppression (pVL < 50 copies/mL) in the ANRS French perinatal cohort was 0.4% [86], ART with a suppressed pVL results in a 64-fold reduction in transmission.

Role of pVL in Sexual Transmission of HIV

The risk of sexual transmission of HIV depends on the specific sexual activity. The per episode risk of acquiring HIV infection from sex with an infected partner is estimated at 0.5% for receptive anal intercourse, 0.1% for receptive vaginal intercourse, 0.65% for insertive anal intercourse and 0.05% for insertive vaginal intercourse [14, 90, 91]. In untreated HIV-infected subjects, pVL is the major predictor of infectivity via heterosexual intercourse [74]. Quinn et al. found no instances of HIV transmission among the 51 serodiscordant heterosexual couples in which the HIV-infected partner had a pVL below 1500 copies/mL [74]. A systematic review of 5021 heterosexual couples and 461 HIV transmissions found no transmissions from an infected partner with a pVL below 400 copies/mL receiving ART [92]. However, a single case of sexual transmission from a patient with an undetectable pVL (<50 copies/mL) on ART has now been reported in a gay male couple [93] and one in a heterosexual couple [94]. These rare cases of sexual transmission despite aviremia may be explained by the observation that some patients can have detectable HIV RNA in semen when it is undetectable in plasma [95].

Risk of Occupational HIV Infection in the Era of Combination Antiretroviral Therapy

To date, there has not been a single documented case of occupational transmission of HIV from an infected HCWs receiving ART and there are no published reports of risk estimates. A reasonable estimate of the risk of occupational transmission of HIV from an HIV-infected surgeon who is receiving ART and has an undetectable pVL may be calculated by taking the risk of transmission from an HIV-infected surgeon not receiving ART (calculated by Bell et al. [71] as 1 in 42,000 to 1 in 420,000 procedures) and dividing by the 64-fold reduction in HIV transmission observed by the ANRS French perinatal cohort in pregnant HIV-infected women receiving ART who had pVL below 50 copies/mL at the time of delivery [86]. This calculation results in an estimated risk of 1 in 2,688,000 to 1 in 26,880,000 procedures, a risk slightly lower than the current risk of 1 in 2 million of acquiring HIV infection

from a single unit of blood, despite screening for both HIV antibody and HIV RNA [96]. The risk is also markedly lower than the risk of mortality following elective open abdominal aneurysm repair (5.6%; n=115,273) [97], elective colorectal resection (5.3%; n=21,074) [98], and slightly lower than the risk of mortality from general anesthesia of about 1.1 per million [99]. The above calculation may be an underestimate of the protection provided by suppressive ART in the occupational setting, since MTCT is affected not only by HIV maternal pVL at the time of delivery, but also by maternal pVL at conception, weeks 14, 28 and 32 [88], and other factors, such as the use of invasive fetal monitoring [89]. Similarly, the two documented cases of sexual transmission of HIV from persons on ART with a suppressed pVL are explainable by detectable HIV RNA in semen. Unlike sexual transmission or MTCT, only the concentration of virus in blood and the volume of blood exposed at the time of the parenteral exposure are relevant for one-time parenteral exposures. Thus, it is likely that the pVL of an infected surgeon will be a stronger predictor of infectivity for parenteral exposure than it is for either sexual transmission or MTCT.

The greatest risk of physician-to-patient transmission of HIV (and this risk is still extremely small) is from surgeons who are unaware that they are HIV-infected. These surgeons would obviously not be taking ART and would be unlikely to be routinely double-gloving. Indeed, the only two documented cases of physician-to-patient transmission of HIV occurred in exactly this setting [26, 27]. It is estimated that 21% of all cases of HIV infection in adults and adolescents in the United States are undiagnosed [100]. If the same proportion of surgeons with HIV infection were undiagnosed (about 1 in 5), and if the 4 in 5 with known HIV infection were receiving ART with undetectable pVL and were permitted to perform EPPs using double-gloves, and finally assuming that there is a 64-fold reduction in HIV transmission in the latter group, it is estimated that 94% of all HIV transmissions would occur from the 20% of HIV-infected surgeons unaware of their HIV infection. Expressed differently, one would expect 16 transmissions from surgeons unaware of their HIV infection for every case from HIV-infected surgeons receiving ART with an undetectable pVL.

HEPATITIS B VIRUS

Epidemiology

HBV is an important human pathogen with an estimated 350 million chronic carriers worldwide. Most infections worldwide are transmitted from mother to child, usually during parturition or in early childhood. An estimated 500,000 persons die annually from the complications of chronic HBV infection, such as primary liver cancer (hepatocellular carcinoma), esophageal variceal bleeding or liver failure, with the greatest burden of disease in Asia. Acute HBV infection in immune competent adults is usually cleared spontaneously, but up to 5% can develop chronic HBV infection and approximately 1% can develop fulminant liver failure. Although Canada is considered a low-endemic area for HBV, there are certain populations and geographic regions in which the prevalence of HBV is significantly higher, especially immigrants to Canada from HBV endemic areas. Currently, there are an estimated 350,000 chronic HBV carriers in Canada [101]. Since 1982, a safe and effective HBV vaccine has been available and widely used. The initial vaccine formulation produced from human plasma containing high titres of hepatitis B surface antigen (HBsAg), and whilst very effective, has since been replaced by a “synthetic” recombinant HBsAg vaccine which is equally safe and effective but more widely accepted than the human plasma derived formulation. All Canadian provinces have adopted a policy of publicly funded HBV vaccination either at birth or pre-adolescence. Most (>95%)

immunocompetent children and adults will develop protective antibodies to HBsAg (anti-HBs) and a robust, long-lasting memory B cell response to the HBV, despite waning of anti-HBs titres over time (15-20 years), hence revaccination or booster shots are not routinely recommended [102]. Vaccine non-response can occur, particularly in older, heavier and immunodeficient persons. All medical schools in Canada require immunization against HBV for students before entry, and overall, a growing proportion of patients and HCWs [7] will have received the HBV vaccine. However, there are still cases of HBV-infected HCWs that were infected vertically (mother-to-child) or via early horizontal childhood transmission prior to the era of screening pregnant women for HBV in Canada. In addition, it is recognized that international medical graduates moving from HBV endemic areas to low prevalence countries such as the United States and Canada may represent another potential group of infected HCWs [103].

Hepatitis B Diagnosis and Monitoring

Over the last two decades, there has been exponential progress in the clinical management and concomitant understanding of the natural history of chronic hepatitis B, both of which have been facilitated by the availability of sensitive diagnostic assays and potent anti-HBV antiviral therapies [104]. The definition of chronic HBV infection is persistence of serum HBsAg for greater than 6 months. The detection of hepatitis B e antigen (HBeAg) was conventionally used as a surrogate marker of high level HBV viremia [105], and loss of HBeAg with anti-HBe antibodies, an indicator of quiescent, “nonreplicative” or inactive disease. However it is now well-recognized that in some patients, seroconversion to anti-HBe seropositive status can occur along with ongoing moderate levels of HBV replication and active disease, due to a mutation in the HBV core gene that abolishes production of HBeAg (i.e., precore or basal core promoter mutant HBV) [106]. The presence of antibodies to hepatitis B surface antigen (anti-HBs) is indicative of either prior vaccination against HBV or natural immunity from prior infection (which is frequently symptomatic). Prior HBV infection is typically confirmed by the concomitant presence of antibodies to hepatitis B core antigen (anti-HBc), which do not develop in response to HBV vaccine.

As noted above, the presence of HBeAg had been used as a surrogate marker of HBV viremia. First generation molecular testing for HBV DNA relied on a slot-blot HBV DNA hybridization assay with a lower limit of detection (i.e., sensitivity) of 5 pg/mL or approximately 1,000,000 virus copies per mL. In the early 2000s, the advent of sensitive PCR-based assays for detection of HBV DNA has significantly lowered the detection limit of HBV DNA. Due to wide variation and poorly standardized HBV DNA assays in use, the World Health Organization has adopted the convention of international units per mL (IU/mL), which is estimated to equal 5.2 virus copies per mL. The current gold standard for detection of HBV DNA is the TaqMan real-time PCR-based assay that has a lower limit of detection of 12 IU/mL– at least 5 log10 greater sensitivity than the first generation slot-blot hybridization assay. Hence an important end-point of current anti-HBV therapy, along with biochemical (i.e., liver enzyme) normalization and HBeAg seroconversion (in patients initially HBeAg positive) is undetectable plasma HBV DNA according to TaqMan PCR assay, equal to < 12 IU/mL [101].

HBV Therapy

The goal of anti-HBV therapy is durable virological suppression and avoidance of antiviral resistance to prevent the development of progressive liver disease [107, 108]. Approved anti-HBV therapies

include several formulations of interferon given by subcutaneous injection. However, interferon is often poorly tolerated due to its significant side effect profile [101, 107, 108]. In 1998, lamivudine was the first oral nucleoside analogue approved for treatment of HBV, although it had been used as an anti-HIV agent for several years previously. Lamivudine is well tolerated, has an excellent safety profile and moderate antiviral potency; however prolonged therapy results in high rates of antiviral resistance development – up to 70% after 3 years, so that it is no longer a preferred first-line agent [108]. Over the past 5 years, physicians have an increasing number of newer nucleoside/nucleotide analogues available for management of HBV. Entecavir, approved for use in Canada in June 2006, was the first HBV antiviral that could reliably suppress pVL to below the limit of detection of the TaqMan assay with minimal side effects and minimal risk for treatment failure due to resistance. Tenofovir, approved in Canada in September 2008, was the second very potent antiviral, but the first that could also reliably control HBV variants that were resistant to lamivudine [101, 108, 109, 110].

Occupational Transmission of HBV from Infected Health Care Workers to Patients

As noted in the introduction, since the availability of serologic testing for HBV infection in the early 1970s, there have been a number of reported cases of HBV-infected HCWs transmitting HBV to their patients during invasive procedures. **Figure 1** provides a summary of cases to date. In 1991, the CDC reviewed 20 clusters of over 300 patients who were infected with HBV in association with treatment by an HBV-infected HCW [3]. In 12 of 20 of these "clusters" the implicated HCWs did not practice universal precautions such as routinely wearing gloves; several had open skin lesions that may have facilitated transmission. HBeAg status was assessed in 17 of the 20 HCWs and all were positive. All of these transmissions occurred before the advent of sensitive PCR-based HBV DNA assays. In 1991, the CDC recommended restricting HBeAg positive HCWs from performing EPPs [3].

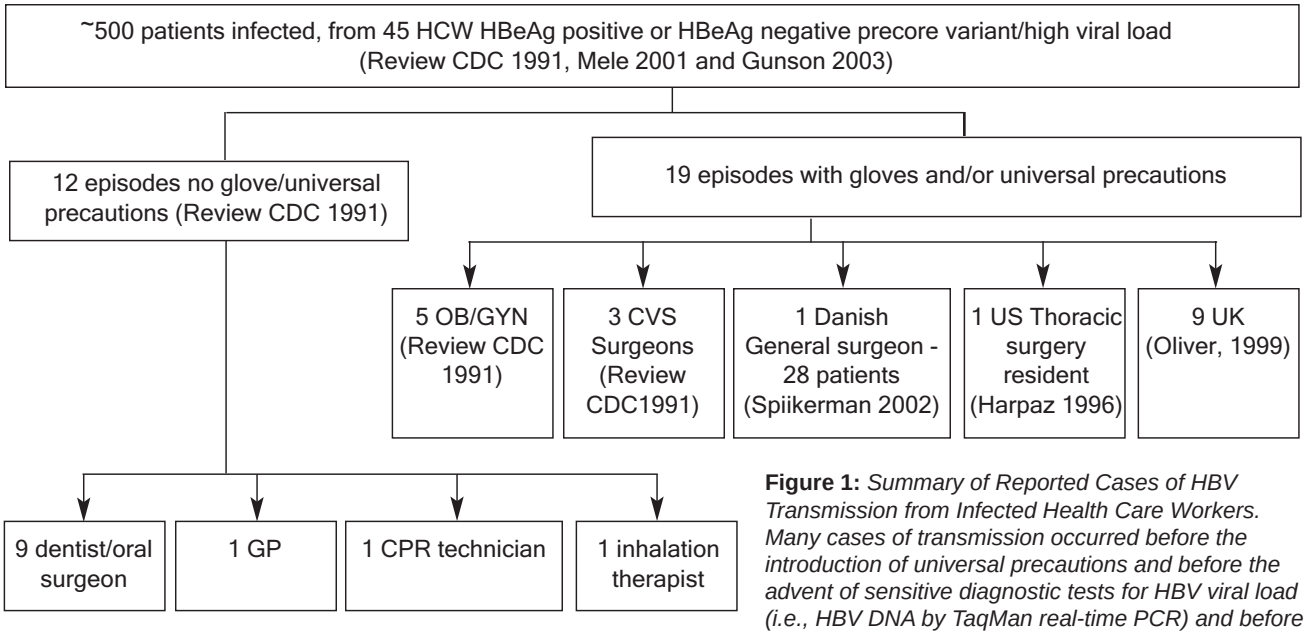

Figure 1: *Summary of Reported Cases of HBV Transmission from Infected Health Care Workers. Many cases of transmission occurred before the introduction of universal precautions and before the advent of sensitive diagnostic tests for HBV viral load (i.e., HBV DNA by TaqMan real-time PCR) and before the availability of suppressive antiviral therapy for HBV.*

Since 1991, 11 episodes of HBV transmission to patients from infected surgeons have been reported, nine from the United Kingdom [111, 112, 113], one from the Netherlands [114], and one from the United States [115]. In several cases, the surgeons were HBeAg positive, but unaware of their diagnosis [112, 114, 115]. However, in 1997, the first reports of HBV transmission from HBeAg negative surgeons were published [116]. The four HBeAg negative surgeons implicated in transmission had plasma HBV DNA concentrations ranging from 250,000 to 10 million copies/mL (50,000 to 2 million IU/mL). By 2003, a total of 7 HBeAg negative HBV-infected surgeons had been implicated in HBV transmission to patients [23], including the 4 surgeons described above [116]. Plasma HBV DNA was quantified in 6 of the 7, and the lowest value was 40,000 copies/mL (~8000 IU/mL), with all others above 200,000 copies/mL (40,000 IU/mL). The lowest value of 40,000 copies/mL (~8000 IU/mL) was from a blood sample collected more than 3 months after transmission.

On the basis of these data, the European Consensus Group in 2003, prior to the availability of effective HBV antiviral therapy, proposed a pVL cut-off of <10,000 copies/mL (2000 IU/mL) for HBV-infected HCWs performing EPPs, as a balance between risk of HBV transmission and loss of HCWs [23]. The Netherlands has chosen to permit HBV-infected surgeons to perform EPPs as long as their pVL is below 100,000 copies/mL (~20,000 IU/mL), regardless of their HBeAg status [23]. From 2000 to 2008, the Dutch Committee for the Prevention of Iatrogenic Hepatitis B evaluated 99 HBV-infected HCWs and noted that of 36 HBV-infected Dutch physicians performing EPPs, 11 (31%) had pVL > 100,000 copies/mL (~20,000 IU/mL) without antiviral therapy and were required to stop performing EPPs [117]. Dutch authorities have attempted to keep HBV-infected surgeons in surgical practice by offering anti-HBV therapy to HBV-infected HCWs with pVL >100,000 copies/mL (~20,000 IU/mL) who perform EPPs [118]. When last evaluated in 2009, no cases of HCW-to-patient transmission of HBV have been recognized in Holland since this pVL cutoff of was implemented in the year 2000 [117].

In contrast, the United Kingdom (UK) has chosen to prohibit HBeAg positive physicians from performing EPPs regardless of pVL or whether they are receiving antiviral therapy, and to prohibit HBeAg negative physicians from performing EPPs if their pVL is >1000 copies/mL (200 IU/mL) [119]. If the Dutch used this pVL cutoff as in the UK, then 32 of 36 (89%) of their HBV-infected HCWs performing EPPs would be restricted from performing EPPs [96]. Very recently, the Society for Healthcare Epidemiology of America (SHEA) recommended the same pVL cut-off of <10,000 copies/mL (2000 IU/mL) for HBV-infected HCWs performing EPPs as chosen by the European Consensus Group [25].

HEPATITIS C

Epidemiology

The existence of HCV was inferred in the mid-1970s, when a parenterally transmitted form of non-A, non-B hepatitis was described [121]. In 1989, a collaboration between scientists at the CDC and the Chiron Corporation led to the “discovery” of HCV by molecular cloning [122]. HCV has an incubation period averaging 2 months. Most acute HCV infections are asymptomatic or result in anicteric disease [123]. Approximately 25% of cases of HCV infection are cleared spontaneously whereas about 75% become chronic [123]. Chronic HCV infection can lead to cirrhosis, liver failure and hepatocellular carcinoma [124]. Excess alcohol consumption [125] and HIV or HBV co-infection [126] increase the rate of progression of HCV liver disease.

Hepatitis C is a global public health problem, with about 170 million people chronically infected [63]. Hepatitis C is the leading cause of chronic liver disease and hepatocellular carcinoma in North America and Europe, and is the leading indication for liver transplantation [124].

HCV Therapy

Current standard antiviral therapy for chronic hepatitis C consists of the combination of pegylated interferon alfa-2a or 2b administered subcutaneously once weekly plus ribavirin administered orally twice daily, for 24 weeks (for infection with HCV genotypes 2 or 3) or 48 weeks (for all other HCV genotypes) [9]. The goal of therapy is a sustained virologic response (SVR), defined as HCV RNA negativity in serum or plasma 6 months following completion of therapy, although recent data indicate that HCV RNA negativity 12 weeks after completion of therapy has 99.7% accuracy in predicting SVR [127]. SVR appears to be equivalent to virologic cure and is achieved in about 55% of patients with chronic HCV infection (about 45% in genotype 1, 85% in genotype 2, 75% in genotype 3 and 65% in genotype 4). However, if antiviral therapy is administered to patients with acute hepatitis C, SVR rates are high (57 to 94%), and ribavirin is probably unnecessary [123]. The high SVR rate with acute HCV infection underscores the need for prompt reporting to the occupational health program when HCWs sustain NSIs.

HCV Transmission

Over 90% of HCV infections are transmitted via a parenteral exposure. In developed countries, most cases of HCV infection are acquired from illicit injecting drug use [63], but in developing countries, many cases are acquired from inadequately sterilized reused needles and syringes used in health care [63]. Transmission through blood products has virtually disappeared in the developed world since blood banks began screening donated blood for both HCV antibody and HCV RNA [78]. Unfortunately, other (non blood transfusion) healthcare related transmissions of HCV continue to occur via breaches in infection control measures [128, 129, 130].

Heterosexual transmission of HCV can occur, but is rare [63, 131]. Male homosexual transmission via unprotected receptive anal intercourse is increasingly reported, mainly among those co-infected with HIV [132]. Mother-to-child transmission occurs in about 4-7% of pregnancies in HCV-infected women, with the higher rates noted in women co-infected with HIV [133].

Occupational Transmission of HCV from Patients to Healthcare Workers

The first evidence that HCV potentially can be transmitted via a NSI was the recognition in 1980 that non-A, non-B hepatitis could be transmitted from a patient to a HCW [134]. In 1990, it was confirmed that HCV could be transmitted from a single NSI [18, 135].

The risk of HCV transmission following a NSI from an HCV-infected source is about 1.8% [136]. A source needle that had been placed in a patient's vein or artery carries about a 100-fold increased risk of HCV transmission compared with needles not placed in a blood vessel [137]. A deep puncture and male sex of the injured HCW were also found to increase the risk of HCV transmission following occupational exposure [137]. Furthermore, the HCV viral load of the source patient also influences the risk of transmission. Specifically, the risk of HCV transmission was 11-fold greater from source patients with HCV RNA >6 $\log_{10}$ copies/mL compared with those with HCV RNA <4 $\log_{10}$ copies/mL [137].

Occupational Transmission of HCV from Healthcare Workers to Patients

Surgeons

To date, there have been 33 documented instances of HCV transmissions from 9 HCV-infected surgeons [31]. The per patient transmission probability from these 9 surgeons ranged from 0.0004% to 0.0225% (or one in 4,444 to one in 250,000 cases) [31]. However, this overestimates the risk of surgeon-to-patient transmission of HCV, since it only includes surgeons implicated in transmission. A look-back exercise of patients operated upon by an HCV-infected general surgeon in Germany found no cases of HCV transmission in 1192 patients [30]. To date, there has been no documented physician-to-patient transmission of HCV in Canada, and a look-back investigation of 231 patients who had undergone EPPs by an HCV-infected Canadian general surgeon failed to demonstrate HCV transmission [31].

Anesthesiologists

Regrettably, there are three well-documented cases in which narcotic addicted anesthesiologists caused multiple cases of HCV infection in patients by self-injecting the patients' narcotic and then using the same syringe on the patient [64, 65, 68, 69]. Similar cases have been described in a nurse anesthetist [66] and a surgical technician [67].

In 2000, Ross et al. reported a case in which an anesthesiology assistant acquired HCV infection from a patient and then transmitted the identical HCV strain to 5 patients [138]. In 2002, a single case of HCV transmission from an anesthesiologist to a patient was described [139]. No evidence of HCV transmission was found in 343 other patients treated by this anesthesiologist and who were tested. In 2005, Mawdsley et al. reported a single case of HCV transmission from an anesthetist to a patient [140]. It is impossible to determine if any of the above cases may also be attributable to illicit drug diversion. The fact that there have been no documented cases of transmission of HBV from anesthetists to patients, despite the fact that HBV carries a substantially higher risk per NSI, increases the suspicion that the above cases were also related to drug diversion [25].

RECOMMENDATIONS

General Principles

Recommendation 1: The policies governing physician screening for BBV and the management of BBV-infected physicians should be evidence-based. Mandatory testing of physicians and/or practice restrictions for BBV-infected physicians are costly and an intrusion of physician privacy. There should be evidence of benefit in order to justify these costs and intrusion of privacy.

Recommendation 2: Provincial/territorial medical regulating authorities (Colleges) should develop policies that encourage a safe working environment and maximize the use of measures to prevent disease transmission. Some of these opportunities include but are not limited to: 1) mandating professional obligations to use universal precautions when appropriate; 2) always reporting occupational blood exposures to and from patients; and 3) identifying additional financial resources to support BBV-infected physicians who face practice restrictions. Colleges are encouraged to explore measures that will encourage reporting of occupational exposures and contribute to a culture of patient and physician safety that is likely to be more effective and less costly than the current disproportionate emphasis on costly BBV disease monitoring.

Recommendation 3: When a blood exposure occurs during an EPP, the involved physician and patient should both be tested for BBVs. If a patient is exposed to blood from a BBV-infected physician, the patient should be told about the exposure as well as the specific BBV, and the estimated risk of transmission, but the patient should not be told the identity of the BBV-infected HCW. Appropriate follow-up of the patient and the physician should be provided. The patient should be offered baseline and follow-up testing, and where appropriate, the HCW or patient should be offered post-exposure prophylaxis at no cost. This recommendation is analogous to the longstanding approach taken in contact tracing for sexually transmitted infections.

Screening of Physicians for BBV

Physicians Who Do Not Perform EPPs

Recommendation 4: The available evidence does not support mandatory testing for BBVs for physicians who do not perform EPPs. To date, BBV infections transmitted by physicians have only occurred during EPPs. Thus, there are no data to justify either the cost or the intrusion of privacy associated with mandatory testing of physicians who do not perform EPP. However, voluntary anti-HBs testing is strongly encouraged to determine each physician's HBV-immune status in light of the known effectiveness of HBV vaccination. Physicians not performing EPP, but at increased risk for one or more BBV for non-work related reasons, are also encouraged to undergo testing for their own personal health benefit.

Physicians Who Perform EPPs

HBV Testing

Recommendation 5: Current data support mandatory testing of physicians who perform EPPs for immunity to HBV (presence of anti-HBs). This recommendation is based on the significant number of documented surgeon-to-patient transmissions of HBV, the widespread use of HBV vaccine among HCWs and the recognition that most surgeons will only require testing once. Those testing anti-HBs positive are considered immune and no further testing is required. Those testing anti-HBs negative should be tested for HBV infection (HBsAg positivity), and if positive, should be managed as below. Those testing negative for both HBsAg and anti-HBs (i.e. vaccine non-responders and those who never received vaccine) should receive another series of HBV vaccine and be retested for anti-HBs following immunization. In those in whom both HBsAg and anti-HBs remain negative, annual testing is recommended.

HIV Testing

Recommendation 6: Current data do not support mandatory HIV testing of physicians who perform EPPs. This recommendation is based on the negligible risk of surgeon-to-patient transmission (2 cases worldwide in 29 years; none in North America; one occurred after a recognized NSI, which would result in testing and reporting under recommendation 3), and, taking into account observed risk, the lack of any evidence of not only cost-effectiveness but also effectiveness. Even prior to the HAART era, screening surgeons for HIV infection was found not to be cost-effective [141]. Specifically, annual screening was estimated to cost 1.1 million 1995 U.S. dollars per life-year saved [141]. The cost per life-year saved in the HAART era would be markedly higher. Furthermore, if HIV testing of physicians were to be implemented, there are no data on which to base a recommendation for the frequency of such testing.

HCV Testing

Recommendation 7: Current data are inconclusive to make a recommendation regarding mandatory HCV testing of physicians who perform EPPs. It is recognized that the infectivity of HCV is intermediate between that of HBV and HIV, and that the risk estimates for surgeon-to-patient transmission of HCV are wide. Thus, reasonable people might arrive at different conclusions regarding whether mandatory HCV testing of surgeons should be undertaken. If HCV testing is to be done, HCV antibody negativity can exclude HCV infection, but only HCV RNA testing can determine whether that person carries a risk of transmitting HCV infection. There are no high quality data to guide decisions about the frequency of testing, so these decisions will be arbitrary. If HCV testing is to be mandated, a testing frequency of once every 3 years might be a reasonable balance between risks and costs/inconveniences.

Approach to the Physician with BBV Infection

General Principles

The overall approach to a BBV-infected physician should not differ from the approach to physicians with any other chronic illness. The physician should receive appropriate medical care and should be able to continue to practice medicine as long as his/her health permits and as long as the risk to the patient is not disproportionate. The BBV-infected physician should have a personal physician qualified in the management of the particular BBV infection that he/she has. As with any patient, the BBV-infected physician is entitled to confidentiality.

BBV-Infected Physicians Who Do Not Perform EPPs

Recommendation 8: For BBV-infected HCWs who do not perform EPPs, there are no grounds to restrict their practice on account of the BBV infection, provided that they adhere to universal precautions. As stated by the CDC, "infected HCWs who adhere to universal precautions and who do not perform EPPs pose no risk for transmitting HIV or HBV to patients" [3]. Since the vast majority of physicians do not perform EPPs, most BBV-infected physicians do not pose a risk for occupational transmission to patients. The criteria for initiating antiviral therapy in BBV-infected HCWs who do not perform EPPs should not differ from BBV-infected patients who are not HCWs.

BBV-Infected Physicians Who Perform EPPs

The approach to BBV-infected physicians who perform EPPs is based on assessing the risk of transmission and reducing it as much as possible. Since the risk of transmission of BBVs is related to the amount of virus to which a patient is exposed, the pVL of the infected HCW is critical in assessing infectivity. When the pVL of the BBV-infected surgeon is high, prohibiting EPPs in susceptible patients is appropriate and necessary. In individual cases, it is reasonable to consider antiviral therapy in the BBV-infected physician who performs EPPs, even if that physician doesn't meet the conventional criteria for antiviral therapy, since antiviral therapy can reduce pVL to very low levels, allowing the physician to continue practice. This approach is similar to treating HIV-infected pregnant women with ART even if they have high CD4 counts. In the latter case, ART is given to prevent transmission, rather than for direct maternal benefit. As there are some differences with each of the three BBVs, the recommendations for each will be discussed separately.

HIV-Infected Physicians Who Perform EPPs

The risk of transmitting HIV during EPPs from HIV-infected surgeons not receiving ART is estimated at 1 in 42,000 to 1 in 420,000 procedures [71]. It is estimated that this risk can be reduced to 1 in 2.7 to 1

in 27 million procedures if the surgeon is receiving ART and has an undetectable pVL and wears double-gloves. The current policy which prohibits all HIV-infected physicians from performing EPPs possibly increases the risk to patients. Since only physicians known to be HIV-infected are subject to restrictions on their practice, there is a clear disincentive against voluntary testing of physicians who perform EPPs. Furthermore, a surgeon who leads a lifestyle which places him/her at increased risk of contracting HIV-infection might be even more inclined to avoid testing, when a positive test means that his/her livelihood is at risk. Mandatory testing of physicians who perform EPPs would potentially overcome this problem, but we do not believe it to be an appropriate response, given the incredibly low risk.

A better approach, we believe, is one that achieves the dual benefits of protecting more patients from occupational HIV infection and allowing more HIV-infected surgeons to remain in practice, and is congruent with the just culture of the patient safety movement. We encourage surgeons to undergo voluntary HIV testing, especially if they are at increased risk by lifestyle or by previous residence in an endemic country.

Recommendation 9: HIV-infected physicians who perform EPPs should be started on ART as soon as possible. HIV-infected physicians should not be able to perform EPPs until they are on ART and their pVL is undetectable. Once documented to have an undetectable pVL on ART, they should be permitted to perform EPPs using double-gloves, as was recently permitted for an Israeli cardiothoracic surgeon [142], with the proviso that their personal physician provides regular (every 3 to 4 month) confirmation to an appropriate designated physician that his/her pVL is suppressed. During the period of unsuppressed viremia, HIV-infected physicians would not be permitted to perform EPPs. They would, however, be permitted to perform other clinical duties. If physicians experience loss of income during the time that they are not permitted to perform EPPs, efforts should be made to supplement the income loss, possibly through insurance, since any disincentive to identifying HIV-infected surgeons puts patients at increased risk of HIV infection. In the event that public health officials choose to pursue a look-back study when an HIV-infected surgeon is newly identified, and it is recognized that this is not routinely required [25], it is important that the identity of the infected surgeon not be disclosed publicly, in order to respect the confidentiality of the HIV-infected surgeon [25, 143].

HBV-Infected Physicians Who Perform EPPs

The vast majority of transmissions of BBVs from HCW to patient have been with HBV. There are four probable explanations. The first, and likely most important, is that HBV is the most infectious of the three on a per exposure basis, possibly because the pVL of untreated hepatitis B can be exceedingly high (a thousand to a million fold higher than either HIV or HCV). The risk per parenteral exposure is about 10-fold higher than HCV and about 100-fold higher than HIV. Second, there have been many more years to identify HBV outbreaks. Testing for HBV has been available since the early 1970s. In contrast, testing for HIV became available in 1985 and testing for HCV in late 1989. The third factor is that most of the HCW-to-patient transmissions occurred in a period of time when infection control practices were much more lax than the present era of universal precautions. For example, most dentists did not wear gloves in the 1970s. Fourth, the global prevalence of chronic HBV infection is about 350 million, in comparison with 170 million for HCV and 33 million for HIV.

There are several reasons why the incidence of HCW-to-patient transmission of HBV appears to be diminishing. First, universal precautions substantially reduce risk [4,5,6]. Second, a growing proportion of both HCWs and patients have been immunized against HBV [7]. Third, policies such as those put forward by the CDC in 1991 [3], have led to restrictions of some HBV-infected HCWs (that particular document recommends prohibiting HBeAg positive HCWs from performing EPPs). Fourth, many dental schools have been screening students for HBV infection after acceptance and not permitting HBeAg positive students to complete training, since it is considered impossible to train a dentist without EPPs.

When the CDC guidelines were published in 1991 [3], sensitive PCR based assays for HBV DNA were not yet available, but it was known that the presence of HBeAg was predictive of increased infectivity [103]. Hence, the state of knowledge in 1991 supported the recommendation to prohibit HBeAg positive HCWs from performing EPPs.

It has become recognized that some HBeAg negative patients have moderately high levels of viremia due to mutations in the precore gene [144]. Thus, it is not surprising that a few transmissions of HBV were subsequently documented from HBeAg negative surgeons with precore mutant virus [116]. Similarly, it is also known that a minority of HBeAg positive persons have low levels of plasma HBV DNA. Furthermore, HBeAg positive patients who start on antiviral therapy typically experience marked reductions in pVL (often below the limit of detection of sensitive PCR assays) before HBeAg is cleared. It is not unusual for such patients to have undetectable pVL by currently available assays on antiviral therapy but remain HBeAg positive for months to years. For example, of 354 HBeAg positive patients with a median baseline pVL of 9.63 log10 copies/mL who were treated with entecavir, 67% had HBV DNA below 300 copies/mL (<50 IU/mL) at week 28, but only 22% were HBeAg negative at that time [145]. For these reasons, it no longer makes sense to assess HBV infectivity on the basis of HBeAg status alone. Plasma HBV DNA measured by a sensitive PCR assay appears to be the most appropriate measure of infectivity.

The evidence supports a pVL cut-off of 10,000 copies/mL (2000 IU/mL) chosen by the European Consensus Group in 2003 [23] and SHEA in 2010 [25] is an appropriate cut-off for the performance of EPPs.

Recommendation 10: HBV-infected physicians with pVL over 2000 IU/mL should not perform EPPs, except on patients who are HBV- immune (anti-HBs positive) or HBV- infected (HBsAg positive), until or unless their infectivity status changes—whether by natural immunity or from antiviral therapy. HBV-infected physicians with pVL consistently below 2000 IU/mL should be permitted to perform EPPs using double-gloves and universal precautions, regardless of their HBeAg status, with the proviso that their personal physician provides regular (every 3 to 4 month) confirmation that his/her pVL is suppressed below this level to an appropriate designated physician.

HCV-Infected Physicians Who Perform EPPs

The infectivity of HCV is intermediate between HBV and HIV. However, unlike HBV, where the range of pVL in untreated subjects is extremely wide (undetectable to 1 trillion IU/mL), there is much less variability in HCV, with a mean pVL of about 2 million IU/mL using the TaqMan PCR assay. A European study has confirmed what would be logically predicted, in that pVL predicts risk of transmission of HCV following parenteral exposures [137], as it does for MTCT [146]. However, a transmission threshold is

not currently clear. The UK prohibits all HCV viremic HCWs from performing EPPs [147], whereas SHEA recommends that those with pVL below 10,000 copies/mL may perform EPPs with double-gloves and universal precautions [25]. In practice, few HCV-infected persons have pVLs below this cut-off. For example, in a recent study of 3070 patients with HCV genotype 1 infection, only 18% had pVL below 600,000 IU/mL [148].

Recommendation 11: HCV RNA positive physicians should not perform EPPs, but they can perform other medical duties. They may resume EPPs while on anti-HCV therapy once HCV RNA is negative, but should refrain from EPPs for at least 12 weeks following completion of antiviral therapy. If HCV RNA done at least 12 weeks after completion of treatment is negative [127], they can resume EPPs.

If HCV viremic surgeons can maintain a rewarding practice in their own specialty without performing EPPs, then no retraining would be necessary. However, if this is not possible, retraining in another medical field is recommended so that both the surgeon and society can benefit from the surgeon's experience and training. Efforts should be made to conduct this retraining in a manner that does not publicly disclose the reasons for retraining. In addition, efforts should be make to supplement any income loss related to the time that the surgeon was unable to perform EPPs or underwent retraining, possibly from an insurance plan.

CONCLUSIONS

Physicians are at much greater risk of acquiring BBVs from patients than patients are of acquiring them from physicians. Nevertheless, there are documented cases of BBV transmission from infected, but untreated physicians to patients during EPPs, especially with HBV, which has the highest per NSI risk of transmission. Universal precautions have substantially decreased the number of blood exposures throughout health care, protecting both patients and HCWs from BBVs. The risk of HBV infection has additionally been reduced by the increasing use of hepatitis B vaccine, especially among HCWs. Nucleic acid amplification tests can accurately quantify the amount of BBVs in plasma, and pVL has proven to be an accurate measure of infectivity. Current antiviral therapy can cure more than half of HCV infections and can suppress the level of viremia in HBV and HIV infection to below the level of detection in sensitive PCR assays in most patients, reducing the transmission risk to minimal levels.

BBV-infected physicians who do not perform EPPs require no restriction of their medical practice, but are expected to practice universal precautions, as all HCWs should. BBV-infected physicians who perform EPPs should be assessed on a case-by case basis. HBV-infected physicians with plasma HBV DNA <2000 IU/mL, whether naturally (i.e. the immune control/inactive phase of chronic HBV infection) or because of antiviral therapy should be permitted to perform EPPs, regardless of their HBeAg status. HIV-infected physicians should not perform EPPs until they are receiving ART and have undetectable pVL, at which time they should be permitted to perform EPPs. HCV viremic physicians should not perform EPPs, but they should be encouraged to undergo anti-HCV therapy and may resume EPPs if they become aviremic.

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