

Hepatitis B in healthcare workers: Transmission events and guidance for management

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are at risk for exposure to HBV from infected patients and, if infected, are similarly at risk of transmitting HBV to patients. Published cases of HBV transmission from HCW to patient are relatively rare, having decreased in frequency following the introduction of standard (universal) precautions, adoption of enhanced percutaneous injury precautions such as double-gloving in surgery, and routine HBV vaccination of HCWs. Here we review published cases of HCW-to-patient transmission of HBV, details of which have helped to guide the creation of formal guidelines for the management of HBV-infected HCWs. We also compare the published guidelines for the management of HBV-infected HCWs from various governing bodies, focusing on their differences with regard to vaccination requirements, viral load limits, frequency of monitoring, and restrictions on practice. Importantly, while there are differences among the recommendations from governing bodies, no guidelines uniformly restrict HBV-infected HCWs from performing invasive or exposure-prone procedures.

Key words: Hepatitis B; Healthcare worker; Blood-borne pathogens; Transmission; Invasive procedures

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Core tip: Reports of transmission of hepatitis B virus (HBV) from infected healthcare workers (HCWs) to patients have been rare but are highly instructive when they do occur. These events have helped instruct formal recommendations for the management of HBV-infected HCWs. However, guidelines from various governing bodies differ in their recommendations for the monitoring of infected HCWs, as well as in their restriction of the practice of invasive, exposure-prone procedures.

Abstract

Hepatitis B virus (HBV) is the most efficiently transmissible of the bloodborne viruses that are important in healthcare settings. Healthcare workers (HCWs)

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INTRODUCTION

Hepatitis B virus (HBV) is one of numerous blood-borne pathogens known to be transmissible in healthcare settings. HBV, among the blood-borne viruses including hepatitis C virus (HCV) and human immunodeficiency virus (HIV), is of particular importance because it is the most efficiently transmissible following percutaneous exposure. The incidence of transmission *via* needlestick injury in one study was approximately 2% with HBV e antigen (HBeAg)-negative blood and 19% with HBeAg-positive blood^[1]. Thus, healthcare workers (HCWs) are at risk for exposure to HBV from infected patients, and correspondingly, HBV-infected HCWs may potentially transmit HBV to patients. Fortunately, reported instances of HCW-to-patient transmission of HBV have been rare and have substantially decreased in frequency over the past four decades. Here, we examine the limited data available on the prevalence of HBV infection in HCWs, review published cases of HCW-to-patient transmission of HBV, and evaluate the guidelines and recommendations for the management of HBV-infected HCWs with a particular focus on the variability of guidelines across geographic regions and governing bodies.

PREVALENCE OF HBV INFECTION IN HEALTHCARE WORKERS

Since the development of a vaccine to prevent acute HBV infection in the early 1980s, the incidence of acute HBV infection in the general population of the United States has sharply fallen. The Centers for Disease Control and Prevention (CDC) estimates that the incidence of new HBV infections had fallen 5-fold between 1980 and 2010, from 208000 to 38000 new infections per year^[2].

Historically, HCWs shouldered the burden of HBV infection in the United States. A study conducted in the United States Army between 1972 and 1974 found a HBV seropositivity rate of 5.8% among officers involved in direct patient care, compared to a seropositivity rate of 2.8% in those in non-patient care-oriented positions^[3]. A serologic study conducted in physicians between 1975 and 1976 found serologic evidence of prior HBV infection in 18% of subjects, with a higher rate among pathologists (27%) and surgeons (28%)^[4]. Following the 1982 Advisory Committee on Immunization Practices (ACIP) recommendation for HBV vaccination for HCWs^[5], studies continued to demonstrate that HCWs were at increased risk for HBV infection, although the rates of seropositivity steadily declined. A voluntary study of 943 HCWs at a large urban academic medical

center conducted over 8 mo in 1991 demonstrated HBV core antigen (HBcAg) positivity in 6.2% of HCWs compared to 1.8% in the comparator group of local blood donors^[6]. Though the current prevalence of HBV in HCWs is not known, it likely mirrors that of the general population, significantly decreasing following the introduction of routine infant vaccination, catch-up adolescent vaccination, and pre-employment vaccination for HCWs who may potentially be exposed to blood or bodily fluids.

REVIEW OF PUBLISHED CASES OF HEALTHCARE WORKER-TO-PATIENT TRANSMISSION OF HBV

Table 1 summarizes the published cases of HCW-to-patient transmission of HBV^[7-39]. Confirmed transmissions are defined as cases where the HCW and patient(s) were epidemiologically linked and genetic relatedness of the viruses was confirmed through partial or complete DNA sequencing. Probable transmissions are defined as cases in which the subtype of HBV infecting the HCW and patient were identical in investigations of epidemiologically-linked HCW and patient HBV infections. Possible transmissions are defined as cases in which epidemiologic links were established, infected patients had no other risk factors for HBV acquisition but virologic subtyping data was not available to confirm transmission. It should be noted that, based on the availability of molecular technology at the time, chronologically earlier reports were limited in their ability to confirm transmission. Additionally, earlier reports often do not include the HBV viral burden of the transmitting HCW.

Summarizing published cases of HCW-to-patient transmission of HBV, recognized breaches in infection control practices were implicated in the transmission event in a notable minority of cases. Early reports of transmission occurred in association with dental procedures during which the dentist or oral surgeon did not wear gloves^[8,14,16,22], which was not a standard recommended practice until the 1980s^[40]. In addition, several early reports of HBV transmission occurred during surgical procedures where the surgeon did not routinely double-glove, which was not a standard recommended practice until the early 2000s^[41,42]. It is also notable that transmission of HBV from infected HCWs in primary care or other specialties that do not perform exposure-prone procedures (EPPs) is exceedingly rare. When transmissions did occur with these providers, they were more likely to be associated with breaches in infection control practices, such as reuse of syringes for access of indwelling arterial catheters^[10], reuse of subdermal electroencephalogram electrodes^[31], or failure to wear gloves in the setting of a skin condition involving the hands of the provider^[10,18,20]. Overall, in the 35 cases in which HBeAg testing results were available,

Table 1 Published cases of healthcare worker-to-patient transmission of hepatitis B virus

Ref.	Year	Location	Type of provider	HBeAg status	Viral load	HBV status known to provider	HBV status known to institution	No. of patients infected	Breach in infection control identified
[7]	1969	United States	Nurse	Not done	Not done	No	No	11 ^a (11 possible)	None
[8]	1969-1974	United States	Oral surgeon	Positive	Not done	Not specified	Not specified	55 (10 probable, 45 possible)	HCW did not wear gloves
[9]	1973-1977	Switzerland	General practitioner	Positive	Not done	Yes	Not specified	41 (41 possible)	None
[10]	1974	United States	Respiratory therapist	Positive	Not done	No	No	4 (4 probable)	HCW did not wear gloves, had an exudative dermatitis on hands, and reused syringes when accessing indwelling arterial catheters
[11]	1975	United States	Oral surgeon	Not done	Not done	Not specified	Not specified	43 (43 probable)	None
[12]	1976-1979	United Kingdom	Surgical registrar	Positive	Not done	No	No	9 (7 probable, 2 possible)	None
[13]	1977-1978	United Kingdom	Surgical registrar, gynecologic surgery	Positive	Not done	No	No	8 (6 probable, 2 possible)	None
[14]	1978	United States	Dentist	Positive	Not done	Yes	Not specified	6 (2 probable, 4 possible)	HCW did not wear gloves
[15]	1978	Norway	Cardiac surgeon	Positive	Not done	No	No	5 (5 probable)	None
[16]	1978-1979	United States	Oral surgeon	Positive	Not done	No	No	12 (4 probable, 8 possible)	HCW did not wear gloves and had a generalized eczematous dermatitis, including hand involvement
[17]	1979-1980	United States	Obstetrician-gynecologist	Positive	Not done	Yes	Yes	4 (1 probable, 3 possible)	HCW held needle in hand rather than a needle holder when suturing, noted several episodes of blood on hands after removing gloves
[18]	1979-1981	The Netherlands	Cardiac surgeon	Not reported	Not done	Not specified	Not specified	3 (3 probable)	None
[18]	1979-1981	The Netherlands	Perfusion technician	Positive	Not done	Not specified	Not specified	11 (8 probable, 3 possible)	Bleeding warts on HCW's hands
[19]	1980	United States	Oral surgeon	Not done	Not done	Not specified	Not specified	3 (3 probable)	None
[20]	1980-1983	United Kingdom	Perfusion technician	Positive	Not done	Yes	Not specified	6 (6 probable)	HCW did not wear gloves, and had cuts and abrasions on hands
[20]	1980-1983	United Kingdom	Surgical registrar	Not reported	Not done	Not specified	Not specified	5 (5 possible)	None
[20]	1980-1983	United Kingdom	House officer	Not reported	Not done	Not specified	Not specified	1 (1 possible)	None
[21]	1984	United States	Obstetrician-gynecologist	Positive	Not done	Not specified	Not specified	6 (6 probable)	None
[22]	1984-1985	United States	Dentist	Positive	Not done	No	No	24 (6 probable, 18 possible)	HCW did not wear gloves
[23]	1987	United States	General surgeon	Positive	Not done	Yes	Not specified	5 (3 probable, 2 possible)	None
[24]	1987	United Kingdom	Obstetrician-gynecologist	Positive	Not done	No	No	22 (6 probable, 16 possible)	None

[25]	1988	United Kingdom	General surgeon	Negative	1×10^7 copies/mL	No	No	1 (1 confirmed)	None
[25]	1988	United Kingdom	Obstetrician-gynecologist, trainee	Negative	4.4×10^6 copies/mL	No	No	3 (3 confirmed)	None
[25]	1988	United Kingdom	Obstetrician-gynecologist, trainee	Negative	5.5×10^6 copies/mL	Yes	Not specified	1 (1 confirmed)	None
[25]	1988	United Kingdom	General surgeon, urologist, clinical assistant	Negative	2.5×10^5 copies/mL	No	No	1 (1 confirmed)	None
[26]	1988	United Kingdom	Cardiothoracic surgeon, trainee	Positive	Not done	No	No	17 (9 probable, 8 possible)	None
[27]	1991	United Kingdom	Surgeon	Positive	Not done	No	No	3 (3 possible)	None
[28]	1991	Canada	Orthopedic surgeon	Positive	Not done	Yes	Yes	2 (1 probable, 1 possible)	None
[29]	1991-1992	United States	Thoracic surgeon	Positive	1×10^9 copies/mL	Yes	Not specified	19 (9 confirmed, 4 probable, 6 possible)	None
[30]	1991-1993	United Kingdom	Cardiothoracic surgeon	Positive	Not done	Yes	No	20 (14 confirmed, 6 probable)	None
[31]	1991-1996	Canada	Electroencephalogram technician	Positive	Not done	No	No	75 (4 confirmed, 71 possible)	HCW did not wear gloves and used reusable subdermal EEG electrodes
[32]	1993	United Kingdom	General surgeon	Positive	Not done	No	No	2 (2 confirmed)	None
[33]	1993-1994	United Kingdom	General surgeon, trainee	Positive	Not done	Not specified	Not specified	11 (1 confirmed, 10 possible)	None
[33]	1994	United Kingdom	General surgeon, trainee	Positive	Not done	Not specified	Not specified	2 (2 possible)	None
[33]	1994	United Kingdom	Urologist, trainee	Positive	Not done	Not specified	Not specified	1 (1 possible)	None
[34]	1995-1999	The Netherlands	General surgeon	Positive	5×10^9 GE/mL	No	No	28 (8 confirmed, 20 possible)	HCW noted glove perforations
[35]	1996	United Kingdom	Orthopedic surgeon	Negative but anti-HB e positive (pre-core mutant)	Not done	Yes	Yes	1 (1 confirmed)	None
[36]	1999	United Kingdom	Cardiothoracic surgeon	Negative but anti-HB e positive (pre-core mutant)	1.03×10^6 GE/mL	Yes	Yes	2 (2 confirmed)	None
[37]	2001	United Kingdom	General surgeon	Negative	$> 10^6$ copies/mL	No	No	3 (3 confirmed)	None
[38]	2009	United States	Orthopedic surgeon	Positive	> 17.9 million IU/mL	No	No	8 (2 confirmed, 6 possible)	None
[39]	2010	Japan	Obstetrician-gynecologist	Positive	1.6×10^9 copies/mL	No	No	1 (1 confirmed)	None

^aCases included only admitted pts with a dx of icteric "serum hepatitis". HBeAg: Hepatitis B virus e antigen; HBV: Hepatitis B virus; GE: Genome equivalents; HCW: Healthcare worker; EEG: Electroencephalogram.

the vast majority (77%) of transmissions occurred as a result of an HBeAg-positive HCW. The lowest measured viral load at which transmission occurred was 2.5×10^5 copies/mL, which notably occurred in a HCW with HBeAg-seronegative chronic HBV^[25]. In another study that included six HBeAg-seronegative surgeons who had previously been implicated in HCW-

to-patient transmission events, all were viremic and the lowest HBV DNA viral load measured was 4×10^4 copies/mL^[43]. Accordingly, the authors suggest that this viral load may represent a lower limit above which HBV transmission during invasive procedures cannot be definitively ruled out^[43]. However, confidence in this viral load has some limitations, as it was measured at

least 3 mo after the transmission event occurred.

REVIEW OF GUIDELINES FOR MANAGEMENT OF HEPATITIS B VIRUS-INFECTED HEALTHCARE WORKERS

Guidelines for the management of HBV-infected HCWs are largely based on the anecdotal data gleaned from cases of HCW-to-patient transmission and attempt to ethically balance the risk of viral transmission to the patient with the right of the infected HCW to perform his/her work in a safe manner without loss of the right to confidentiality about his/her own health issues. Here we summarize the guidelines on the management of HBV-infected HCWs from various governing bodies worldwide. Table 2 summarizes the recommendations, allowing direct comparison of guidelines on key factors, including screening and vaccination for HBV in HCWs, monitoring recommendations for HBV-infected HCWs, and restrictions on practice for those HCWs if any. Although there are slight differences among guidelines, it is important to note that none universally prohibits the practice of invasive procedures by an HBV-infected HCW. Table 3 summarizes each governing body's definition and categorization of EPPs where delineated.

The Society for Healthcare Epidemiology of America, in guidelines updated in 2010^[44], recommends that HCWs with a positive HBeAg or circulating HBV burden of greater than or equal to 10^4 genome equivalents (GE) per mL of blood be prohibited from performing certain pre-defined high-risk (Category III) EPPs and use double-gloving for all invasive procedures, for all contact with mucous membranes or non-intact skin, and for all instances in patient care for which gloving is recommended otherwise^[44]. For HCWs with a circulating HBV burden of less than 10^4 GE/mL of blood, it is suggested that providers may perform all Category I and II (minimal- and low-risk) and Category III (high-risk) procedures as long as they (1) have not transmitted HBV infection to patients; (2) obtain advice from an expert review panel; (3) undergo routine follow-up by occupational medicine including twice yearly viral testing to ensure that viral burden remains less than 10^4 GE/mL; (4) receive follow-up care by a personal physician who has expertise in the management of HBV infection and who may communicate with the expert review panel about the HCW's clinical status; (5) consult with an expert about optimal infection control procedures and strictly adhere to them; and (6) agree to and sign a contract or letter from the expert review panel that characterizes their responsibilities^[44].

CDC guidelines from 2012 recommend that all HCWs receive HBV vaccination followed by assessment of hepatitis B surface antibody (anti-HBs) status and, in the case of non-response to vaccination,

revaccination^[45]. If HCWs do not achieve protective levels of anti-HBs after a second three-dose series of HBV vaccine, they should be tested for HBV surface antigen (HBsAg) and HBV core antibody (anti-HBc) to determine if previously or chronically infected. Pre-vaccination serology is recommended for HCWs who were born to mothers from endemic countries, who are sexually active men who have sex with men, and/or who perform EPPs^[45]. CDC guidelines for management of chronic HBV infection apply only to those HCWs who perform EPPs. They recommend that HBV-infected HCWs that perform EPPs may continue to do so if a low (less than 1000 IU/mL or 5000 GE/mL) or undetectable HBV viral load is documented every 6 mo. If the viral load is above the recommended threshold, performance of EPPs should be restricted until subsequent retesting occurs^[45]. CDC also recommends that institutions have written policies and procedures in place for the management of HBV-infected HCWs, including the ability to form an expert review panel to assist with management of these providers^[45].

In its most recent guidelines, updated in 2003, the American College of Surgeons (ACS) recommends that surgeons know their HBV immunization and antibody status^[46]. Surgeons who do not have protective anti-HBs levels should be vaccinated, with follow-up documentation of seroconversion. Failure to seroconvert should prompt a second vaccination series. Surgeons with antibody to HBV should know their HBsAg status and, if positive, their HBeAg status. ACS recommends that surgeons who are HBeAg-positive or have high viral loads be guided by expert panels regarding their continuation of clinical practice. These guidelines do not specify what constitutes a high viral load, the viral load limit at which a surgeon's practice should be restricted, or what procedures constitute EPPs^[46].

Canadian guidelines, set forth by the Laboratory Centre for Disease Control of Health Canada in 1998, recommend mandatory HBV immunization of HCWs who perform EPPs with follow-up testing 4-8 wk later for anti-HBs response^[47]. Those who are found to be non-responders on post-immunization testing should be screened for infection annually, with HBsAg and anti-HBc. HCWs who perform EPPs and test positive for HBsAg should undergo testing for HBeAg and if positive, should be referred to an expert panel and cease practice pending the panel's recommendations. If HBeAg-negative, they may continue to practice but should still be referred to an expert panel. Provided that the HCW follows recommendations set forth by the expert panel, disclosure of HBV status to patients before an EPP is not recommended.

The United Kingdom Department of Health (UKDH) released guidelines for management of HBV-infected HCWs in 2000^[48], with an update focusing on HBV-infected HCWs on antiviral therapy in 2007^[49]. UKDH recommends that all HCWs who perform EPPs be immunized against HBV and be tested for anti-HBs

Table 2 Guidelines for management of hepatitis B virus-infected healthcare workers

	CDC	SHEA	ACS	Canada	UK	Europe	Australia
Screening	All HCWs at risk for HBV infection should be tested	Not addressed in guideline	All surgeons should know their HBV status	Mandatory for all HCWs who perform EPPs	Mandatory for all HCWs who perform EPPs, can be done post-vaccination	Mandatory for all HCWs who perform EPPs, can be done post-vaccination	Annual testing recommended for all HCWs who perform EPPs
Vaccination	All HCWs susceptible to HBV infection should be vaccinated	Not addressed in guideline	All surgeons who are antibody negative should be vaccinated	Mandatory for all HCWs who perform EPPs	Mandatory for all HCWs who perform EPPs	Recommended for all HCWs	Recommended for all HCWs
Post-vaccination serology	Recommended	Not addressed in guideline	Recommended	Recommended	Recommended	Recommended	Not addressed in guideline
Frequency of testing/monitoring	Every 6 mo	Every 6 mo	Not specified	Every 12 mo	Every 12 mo, or every 3 mo while on antiviral therapy	Every 12 mo if HBeAg negative, every 3 mo if HBeAg positive or on antiviral therapy	Every 3 mo if on antiviral therapy, every 12 mo if cleared HBsAg
Viral load limit	1000 IU/mL or 5000 GE/mL	10 ⁴ GE/mL	Not specified	Not specified	10 ³ GE/mL	10 ⁴ GE/mL	Undetectable by PCR assay
HBeAg	Not required to be negative	Not required to be negative	Not required to be negative	Not required to be negative	Must be negative	Not required to be negative	Not addressed in guideline
Restriction of practice	EPPs restricted if viral load greater than set threshold	Category III procedures restricted if viral burden greater than or equal to 10 ⁴ GE/mL or HBeAg positive	Determined by expert panel	Determined by expert panel	If HBeAg positive or if viral load greater than 10 ³ GE/mL	If viral load greater than 10 ⁴ GE/mL	If HBV DNA level detectable
Definition of EPPs	Yes	Yes	No	Yes	Yes	Yes	Yes
Expert panel recommended	Yes	Yes	Yes, if HBeAg positive or high viral load	Yes, if HBsAg positive	No, recommend monitoring by an occupational health physician	No	Yes
Pre-emptive patient notification	No	No	Not specified	No	No	Optional for HCWs with HBV DNA levels above the cut-off level in order to continue practicing EPPs	No

CDC: Centers for Disease Control and Prevention, United States; SHEA: Society for Healthcare Epidemiology of America, United States; ACS: American College of Surgeons, United States; Canada: Laboratory Centre for Disease Control of Health Canada; UK: Department of Health, United Kingdom; Europe: European Consensus Group; Australia: Australian Government, Department of Health and Aging; HCW: Healthcare worker; HBV: Hepatitis B virus; IU: International units; GE: Genome equivalents; HBeAg: Hepatitis B e antigen; EPP: Exposure-prone procedure; PCR: Polymerase chain reaction; HBsAg: Hepatitis B surface antigen.

response post-vaccination^[50]. If there is failure to respond to one vaccination series, the HCW should be tested for HBsAg, and if negative, should be tested for anti-HBc to determine if they have had prior infection or are true vaccine non-responders^[50]. The guidelines recommend that all HCWs who are HBsAg-positive be tested for HBeAg^[48]. Those that are HBeAg-positive or those who are HBeAg-negative but with a HBV viral load greater than 10³ GE/mL should be restricted from performing EPPs^[48]. If HBeAg is negative and viral load is less than 10³ GE/mL without antiviral treatment, annual monitoring should be conducted, and practice should not be restricted^[48]. The 2007 guidelines, developed in response to advances in antiviral treatment for HBV infection, recommends that HCWs who are HBeAg-negative should be permitted

to perform EPPs while on antiviral therapy as long as their viral load remains < 10³ GE/mL on monitoring done every 3 mo, and their pretreatment viral load was < 10⁵ GE/mL^[49]. Though the UKDH guidelines do not recommend formation of an expert panel to guide management of HBV-infected HCWs, they do recommend the involvement of an occupational health physician^[48].

The European Consensus group guidelines published in 2003 recommend HBV vaccination of all HCWs in contact with patients, blood, or other bodily fluids, with vaccine response tested one month post-vaccination^[51]. Non-responders should undergo additional vaccine series and if they continue to fail to respond, an investigation into their HBV status is recommended based on their job functions. Specifically

Table 3 Categories of exposure-prone procedures

CDC

Category I. Procedures known or likely to pose an increased risk of percutaneous injury to a healthcare provider that have resulted in provider-to-patient transmission of HBV. These procedures are limited to major abdominal, cardiothoracic, and orthopedic surgery, repair of major traumatic injuries, abdominal and vaginal hysterectomy, caesarean section, vaginal deliveries, and major oral or maxillofacial surgery. Techniques that have been demonstrated to increase the risk for healthcare provider percutaneous injury and provider-to-patient blood exposure include: digital palpation of a needle tip in a body cavity and/or the simultaneous presence of a health care provider's fingers and a needle or other sharp instrument or object in a poorly visualized or highly confined anatomic site

Category II. These procedures pose low or no risk for percutaneous injury to a HCW or, if a percutaneous injury occurs, it usually happens outside of a patient's body and generally does not pose a risk for provider-to-patient blood exposure. These include: surgical and obstetrical/gynecologic procedures that do not involve the techniques listed for Category I, the use of needles or other sharp devices when the HCW's hands are outside a body cavity, dental procedures other than major oral or maxillofacial surgery, insertion of tubes, endoscopic or bronchoscopic procedures, internal examination with a gloved hand that does not involve the use of sharp devices, and procedures that involve external physical touch

SHEA

Category I. Procedures with *de minimis* risk of bloodborne virus transmission: regular history-taking and/or physical or dental examinations; routine dental preventive procedures, diagnostic procedures, orthodontic procedures, prosthetic procedures, cosmetic procedures not requiring local anesthesia; routine rectal or vaginal examination; minor surface suturing; elective peripheral phlebotomy; lower gastrointestinal tract endoscopic examinations and procedures; hands-off supervision during surgical procedures and computer-aided remote or robotic surgical procedures; and psychiatric evaluations

Category II. Procedures for which bloodborne virus transmission is theoretically possible but unlikely: locally anesthetized ophthalmologic surgery; locally anesthetized operative, prosthetic, and endodontic dental procedures; periodontal scaling and root planing; minor oral surgical procedures; minor local procedures under local anesthesia; percutaneous cardiac procedures; percutaneous and other minor orthopedic procedures; subcutaneous pacemaker implantation; bronchoscopy; insertion and maintenance of epidural and spinal anesthesia lines; minor gynecological procedures; male urological procedures; upper gastrointestinal tract endoscopic procedures; minor vascular procedures; amputations; breast augmentation or reduction; minimum-exposure plastic surgical procedures; total and subtotal thyroidectomy and/or biopsy; endoscopic ear, nose, and throat surgery and simple ear and nasal procedures; ophthalmic surgery; assistance with an uncomplicated vaginal delivery; laparoscopic procedures; thorascopic procedures; nasal endoscopic procedures; routine arthroscopic procedures; plastic surgery; insertion of, maintenance of, and drug administration into arterial and central venous lines; endotracheal intubation and use of laryngeal mask; and obtainment and use of venous and arterial access devices that occur under complete antiseptic technique, using universal precautions, "no-sharp" technique, and newly gloved hands

Category III. Procedures for which there is definite risk of bloodborne virus transmission or that have been classified previously as "exposure-prone:" general surgery; general oral surgery; cardiothoracic surgery; open extensive head and neck surgery involving bones; neurosurgery, other intracranial procedures, and open-spine surgery; nonelective procedures performed in the emergency department; obstetrical/gynecological surgery; orthopedic procedures; extensive plastic surgery; transplantation surgery except skin and corneal transplantation; trauma surgery; interactions with patients in situations during which the risk of the patient biting the physician is significant; and any open surgical procedure with a duration of more than 3 h, probably necessitating glove change

ACS

Not provided

Canada

Procedures during which transmission of HBV, HCV, or HIV from a HCW to patients is most likely to occur and includes the following: (1) digital palpation of a needle tip in a body cavity 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; (2) repair of major traumatic injuries; or (3) major cutting or removal of any oral or perioral tissue, including tooth structures, during which there is potential for the patient's open tissues to be exposed to the blood of an injured HCW

UK

Exposure-prone procedures are those invasive procedures where there is a risk that injury to the worker may result in the exposure of the patient's open tissues to the blood of the worker. These include procedures where the worker's gloved hands may be in contact with sharp instruments, needle tips or sharp tissues inside a patient's open body cavity, wound, or confined anatomical space where the hands or fingertips may not be completely visible at all times

Europe

Exposure-prone procedures are invasive procedures where there is potential for contact between the skin of the HCW and sharp surgical instruments, needles, or sharp tissues in body cavities or poorly visualized/confined body sites

Australia

Category 1: A procedure where the hands and fingertips of the HCW are visible and outside of the body most of the time and the possibility of injury to the worker's gloved hands from sharp instruments and/or tissues is slight

Category 2: A procedure where the fingertips of the HCW may not be visible at all times but injury to the worker's gloved hands from sharp instruments and/or tissues is unlikely. If injury occurs it is likely to be noticed and acted upon quickly to avoid the HCW's blood contaminating a patient's open tissues

Category 3: A procedure where the fingertips are out of sight for a significant part of the procedure, or during certain critical stages, and in which there is a distinct risk of injury to the worker's gloved hands from sharp instruments and/or tissues. In such circumstances it is possible that exposure of the patient's open tissues to the HCW's blood may go unnoticed or would not be noticed immediately

CDC: Centers for Disease Control and Prevention, United States; SHEA: Society for Healthcare Epidemiology of America, United States; ACS: American College of Surgeons, United States; Canada: Laboratory Centre for Disease Control of Health Canada; UK: Department of Health, United Kingdom; Europe: European Consensus Group; Australia: Australian Government, Department of Health and Aging; HCW: Healthcare worker; HBV: Hepatitis B virus; HCV: Hepatitis C virus; HIV: Human immunodeficiency virus.

for HCWs who perform EPPs, the group recommends proof of anti-HBs response and if negative or unavailable, they should receive a booster dose of HBV

vaccination, with vaccine response tested one month later. Non-responders should be investigated for HBV infection, with testing of HBsAg or anti-HBc, and only

those who are HBsAg-negative should be permitted to proceed with EPPs. HCWs who are HBsAg-positive should have HBeAg tested and if HBeAg-negative, can proceed with performing EPPs if the HBV DNA level is less than 10^4 GE/mL. The HBV DNA level should be monitored annually. If HBeAg-positive, the HCW should not perform EPPs unless their viral load is below the designated cut-off and they are evaluated by an expert panel that has approved the performance of EPPs. In this case, it is recommended that the HBV viral load be monitored every 3 mo.

Finally, Australian guidelines from 2012^[52] recommend that all HCWs be vaccinated against HBV and that all HCWs who perform EPPs be tested for HBV and other blood-borne pathogens annually. A HCW is not permitted to perform EPPs if HBV DNA is detectable by an approved polymerase chain reaction assay. If the HCW is HBsAg-positive and on antiviral therapy, they are permitted to perform EPPs as long as HBV DNA is undetectable *via* testing every 3 mo. If HBsAg becomes negative on two consecutive occasions, the HCW may perform EPPs but will require annual testing thereafter. The guidelines also recommend formation of an expert review panel to advise on the management of HBV-infected HCWs.

The majority of governing bodies recommend the formation of an expert review panel or committee to assist with management and monitoring of HCWs infected with HBV and other bloodborne viruses. Guidelines generally recommend the inclusion of individuals who have expertise in the infected HCW's specialty and the procedures they perform, healthcare epidemiologists, infectious disease specialists, hepatologists, occupational medicine physicians, hospital administrators, human resources personnel, and the HCW's primary physician. Other suggested panel members include a public health official if such issues are managed at the state level, legal counsel, and experts in ethics.

CONCLUSION

HBV infection among HCWs is of particular concern given its high transmissibility relative to other blood-borne viruses, including documented transmissions from infected HCW to patient. Fortunately, instances of HCW-to-patient transmission of HBV have been relatively rare and have substantially decreased in frequency over the past four decades, presumably due to more vigilant screening and vaccination of HCWs, the use of universal precautions and double-gloving during EPPs, and formal recommendations from governing bodies on the appropriate restrictions of practice of infected HCWs. Our review of the published cases of HCW-to-patient transmission of HBV provides historical data for these formal recommendations. Our review also highlights the differences between recommendations for management of HBV-infected HCWs by various governing bodies, though a common

feature is that no governing body uniformly prohibits the practice of EPPs by an HBV-infected HCW. While HBV is highly transmissible through parenteral and mucous membrane exposures, the formal recommendations set forth by the various governing bodies discussed above have helped to codify the manner in which we manage HBV-infected HCWs, thus reducing the risk of transmission to patients while balancing the need to protect the private health information of HCWs and their ability to continue to perform the work for which they are trained to do.

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