Risk of Hepatitis C Transmission From Infected Medical Staff to Patients

Model-Based Calculations for Surgical Settings

R. Stefan Ross, MD; Sergei Viazov, PhD; Michael Roggendorf, MD

Context: Concern is increasing in both the medical community and among the general public about the possible transmission of hepatitis C virus (HCV) from infected health care workers to their patients. Until now, no reliable estimates for the risk of such transmission exist.

Objective: To estimate the probability of HCV transmission from a surgeon to a susceptible patient during invasive procedures.

Design: A model consisting of 4 probabilities was used: (A) the probability that the surgeon is infected with HCV, (B) the probability that the surgeon might contract percutaneous injuries, (C) the probability that an HCV-contaminated instrument will recontact the wound, and (D) the probability of HCV transmission after exposure. Values for the calculations were taken from published studies.

Results: When the surgeon's HCV status is unknown, the risk of HCV transmission during a single operation is 0.00018%±0.00002% (mean±SD). If the surgeon is HCV RNA positive, this risk equals 0.014%±0.002%. The likelihoods of transmission in at least 1 of 5000 invasive procedures performed by a surgeon during 10 years are 0.9%±0.1% (HCV status unknown) and 50.3%±4.8% (HCV RNA positive), respectively.

Conclusions: The calculated risks for HCV transmission from a surgeon to a susceptible patient during a single invasive procedure are comparable to the chance of acquiring HCV by receiving a blood transfusion. These figures could provide a basis for further discussions on this controversial subject and might also be relevant for future recommendations on the management of HCV-infected health care workers.

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During recent years, health care authorities as well as patients are increasingly concerned about possible professional-to-patient transmission of hepatitis C virus (HCV), eg, through exposure to the blood of an infected health care worker after an inadvertent injury. Such general anxiety is well reflected in our daily counseling practice and, in our opinion, this emerging issue should be more extensively discussed in the medical community. Until now, only a few reports were published about physician-to-patient transmission of HCV infection by surgeons performing cardiothoracic and gynecological procedures. These 3 reports have been complemented by the amazing announcement of Spanish authorities that an HCV-positive anesthesiologist has intentionally infected almost 200 of his patients with HCV. In general, owing to the mostly unspecific course of the infection, one cannot exclude, however, that HCV physician-to-patient transmission occurred more often than what has yet been reported, but has remained undetected.

The best way to obtain accurate estimates for the risk of health care professional-to-patient HCV transmission would be to perform retrospective studies of large numbers of patients treated by HCV-infected health care workers as has been done by the Centers for Disease Control and Prevention, Atlanta, Ga, for human immunodeficiency virus (HIV). Since such data most probably will be unavailable for HCV in the near future, it seems reasonable to use a model based on existing scientific evidence to determine the average risk of sporadic HCV transmission from health care workers to susceptible patients. Invasive procedures are clearly associated with a high risk of percutaneous injuries and, hence, of a paren-
METHODS

DETERMINANTS OF RISK

The likelihood of physician-to-patient HCV transmission during an invasive procedure according to well-established risk assessment models depends at least on 4 probabilities (Table 1). When the serologic status of the surgeon performing the procedure is unknown, probability A (that he might be infected with HCV) has to be considered. The most comprehensive study on HCV prevalence in surgeons revealed a seropositivity of 0.9% among 770 hospital-based surgeons of different specialties. Given that the operating department personnel frequently contracts blood contaminations and injuries, the HCV positivity in all surgeons is likely to be higher than indicated by this estimate, but so far, no calculations on a broader basis are available. Therefore, we adopted a conservative criterion, assuming that HCV antibody positivity in surgeons might be in the same range recorded for medical staff in general. A meta-analysis comprising all 33 relevant studies performed between 1990 and 1996 in 16 countries included more than 65,000 health care workers from all medical specialties. Hepatitis C virus prevalence rates varied from 0.28% in a United Kingdom survey to 6.7% among Italian workers employed in dialysis wards and in pathology services. The mean HCV positivity calculated from these investigations was 1.8%. However, not all HCV antibody-positive individuals are also positive for HCV RNA, ie, not all of them are infective. To minimize this bias, we have assumed that only 70% of HCV antibody-positive subjects are viremic. Thus, the mean HCV RNA prevalence in medical staff was estimated to be 1.3%. Probability B reflects the risk that a surgeon will sustain percutaneous injuries. Panlilio and coworkers monitored operations performed by 6 surgical services at a 950-bed municipal hospital in Atlanta, Ga, during a 6-month period. The services studied were gynecology, general surgery, orthopedic surgery, burn unit, and plastic and reconstructive surgery. Among surgeons, they observed 7 percutaneous injuries in 390 person-procedures. Tokars et al recorded the number of percutaneous injuries that occurred within 9 months in 1 inner-city hospital and 1 suburban hospital each in the New York City and Chicago areas. At all hospitals a sample of abdominal, gynecologic, and orthopedic surgical procedures was observed. Among resident and attending surgeons, a total of 88 percutaneous injuries occurred in 3514 person-procedures. From these studies an average rate of 2.3% of percutaneous injuries was inferred. The third determinant of risk to patients is probability C that an instrument after causing an injury to an HCV-infected surgeon and thereby being contaminated with HCV will recontact the patient’s wound. In 4 investigations addressing this issue, 3242 procedures in orthopedic surgery, trauma surgery, cardiovascular surgery, plastic and reconstructive surgery, and gynecologic surgery were surveyed. Of 176 injuries to surgeons 48 (27.0%) resulted in a recontact with the contaminated sharp instrument. The estimates in these studies ranged from 17% to 32%. Finally, probability D that HCV infection would be transmitted after exposure to HCV can be deduced from surveillance studies of health care workers after needlestick injuries. The meta-analysis already cited included more than 1000 individuals from all 9 relevant incidence studies performed in 5 countries and published between 1990 and 1996. From these investigations an average HCV transmission rate of about 2.2% was calculated. The reported range of HCV seroconversions after such exposures, however, was rather broad (0%-23.24-9.2%) and, therefore, nowadays the risk of HCV transmission after needlesticks is regarded to be within a 1% to 10% range. To cover this interval, we have used the following 3 different percentages for probability D: the mean risk of 2.2%, the low rate of 1.0% reported by Puro et al, and the 9.2% incidence of HCV infection after needlesticks acquired from HCV RNA-positive patients described by a group of Japanese researchers.

ESTIMATES OF RISK

We calculated 2 sets of risk estimates. When the serologic HCV status of the surgeon is unknown, the probability (P) of physician-to-patient HCV transmission is the product of all 4 probabilities: 

\[
P = A \times B \times C \times D
\]

For each probability, we have chosen a surgical setting to calculate the chance of a patient becoming HCV infected because of inadvertent blood exposure.

Table 1. Determinants of the Risk of Hepatitis C Virus (HCV) Transmission to Patients During Invasive Surgical Procedures

<table>
<thead>
<tr>
<th>Determinant</th>
<th>Probability, %†</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCV positivity in medical staff</td>
<td>(A) 1.3 (1.14-1.46)</td>
</tr>
<tr>
<td>Percutaneous injuries</td>
<td>(B) 2.3 (1.64-2.96)</td>
</tr>
<tr>
<td>Sharp object’s recontact</td>
<td>(C) 27.0 (23.93-30.07)</td>
</tr>
<tr>
<td>with susceptible patient</td>
<td></td>
</tr>
<tr>
<td>HCV transmission after exposure</td>
<td>(D) 2.2 (1.18-3.22)</td>
</tr>
</tbody>
</table>

*All values are expressed as the arithmetic mean. For an explanation of the 4 probability categories (A through D), see the “Determinants of Risk” subsection of the “Methods” section.
†Data in parentheses are SEs calculated according to the following equation: 

\[
SE = \frac{s}{\sqrt{n}}
\]

where s represents SD and n the number of observations.

In Table 2, the risk estimates derived from this model are given. When the surgeon’s serologic HCV status is unknown, the risk of HCV transmission during a single operation is about 0.00008% (probability D = 1.0%) and 0.00074% (probability D = 9.2%), corresponding to approximately 1 chance in 135000 to 1.2 million. If the surgeon is HCV RNA positive, the risk of HCV transmission to a patient is 0.0062% to 0.057%, resulting in
1 chance in about 1750 to 16000. Assuming that a surgeon may perform 500 operations a year, the mean likelihood (probability D = 2.2%) of transmitting HCV infection in at least 1 procedure can be calculated to be 0.09% (HCV status unknown) or 6.8% (HCV RNA positive). The corresponding mean cumulative values for a 10-year career are 0.9% and 50.3%. If the surgeon remains HCV RNA positive for an even longer period, the risk of transmitting HCV in at least 1 of 15 000 procedures performed, eg, during 30 years is almost 88.0%.

### Table 2. Estimated Risk for Hepatitis C Virus (HCV) Transmission to Patients During Invasive Surgical Procedures

<table>
<thead>
<tr>
<th>HCV Status of the Surgeon/Risk of HCV Transmission After Exposure (Probability D), %</th>
<th>Risk of HCV Transmission (%) to Patients During Multiple Invasive (N) Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = 1</td>
</tr>
<tr>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>D = 1.0</td>
<td>0.8 × 10⁻⁴ (0.7-0.9 × 10⁻⁴)</td>
</tr>
<tr>
<td>D = 2.2</td>
<td>1.8 × 10⁻⁴ (1.6-2.0 × 10⁻⁴)</td>
</tr>
<tr>
<td>D = 9.2</td>
<td>7.4 × 10⁻⁴ (4.1-10.7 × 10⁻⁴)</td>
</tr>
<tr>
<td>HCV RNA positive</td>
<td></td>
</tr>
<tr>
<td>D = 1.0</td>
<td>6.2 × 10⁻⁵ (0.52-0.72 × 10⁻⁵)</td>
</tr>
<tr>
<td>D = 2.2</td>
<td>1.4 × 10⁻⁵ (1.2-1.6 × 10⁻⁵)</td>
</tr>
<tr>
<td>D = 9.2</td>
<td>5.7 × 10⁻⁵ (3.7-7.7 × 10⁻⁵)</td>
</tr>
</tbody>
</table>

*Data in parentheses are SEs for the risk estimates of HCV transmission to patients, which were calculated by gaussian formula of error propagation from the probabilities A through D used in the risk assessment model. For an explanation of the 4 probability categories (A through D), see the "Determinants of Risk" subsection of the "Methods" section.

The model-based estimates presented here clearly depend on the validity of the underlying assumptions. The 4 different probabilities used in our risk assessment model were derived from all relevant studies published between 1990 and 1996 and, therefore, provide a reliable basis for calculating the chance of HCV transmission from an infected surgeon to a susceptible patient. Very similar assumptions have been already successfully applied to deduce the occupational HCV risk of surgeons28,29 and the potential transmission rates of hepatitis B virus and HIV from infected surgeons to patients.8,9 The general suitability of such model-based approaches was unequivocally demonstrated for occupationally acquired HIV infections in France.20 Based on estimates like those used for our calculations, a total number of occupational HIV infections of 0.45 to 4.5 and 3.5 to 35 was assumed for surgeons and nurses within 15 years, respectively. The actual numbers of documented cases reported to the national authorities (1 surgeon and 19 nurses infected) were within the ranges predicted by the risk assessment model, indicating that such calculations may very closely reflect the real situation.

Nevertheless, the model used here to assess the risk of HCV physician-to-patient transmission suffers from some limitations.8 Most important, several factors essential for the efficacy of HCV transmission had to be neglected to keep the model feasible. These factors include the following: the surgeon’s HCV titer,3 a possible decrease in the probability of infection transmission for needles or other sharp surgical instruments passing through glove material,30,31 the fact that some surgical procedures are exposure prone and, therefore, are more often associated with physician-to-patient transmission of bloodborne pathogens than others.32 and the possibility that HCV transmission may occur not only by a contaminated instrument’s recontact but also by other modes of exposure such as direct bleeding into the patient’s wound. Considering these principal shortcomings, our risk estimates suggest that HCV physician-to-patient transmission at least in some health care settings might occur more often than yet reported. Our figures for HCV transmission from infected surgeons to their patients are well below those already reported for hepatitis B virus (0.24% during a single procedure3), but significantly exceed the calculated HIV transmission rates (0.0024% during a single procedure3). The average probability of 140 per million (0.014%) calculated in this study for a sporadic HCV transmission from an HCV-infected surgeon to a patient during a single invasive procedure (Table 2) is comparable to the chance of acquiring HCV infection by transfusion of blood from first-time donors that has been previously screened as negative for HCV antibodies (eg, 30 per million units in Germany33) and also equals the likelihood of anesthesia-associated mortality (100 per million34). The risk estimates given here might be useful for further discussions on the complex legal and ethical questions associated with health care professional-to-patient transmission of HCV. In the absence of general mandatory regulations, the most important one is whether health care workers infected with HCV should be restricted in their practice in a similar way, eg, as hepatitis B e antigen (HBeAg)–positive medical personnel in the United States32 or England.60 Other controversial topics comprise the problem of disclosing the health care provider’s HCV status to a prospective patient, as well as the claim that medical staff in general should be routinely tested for markers of HCV infection. Perhaps our data might be of some relevance for future revisions of national guidelines on the management of health care workers infected with bloodborne pathogens. It is expected that the update of these regulations has to address the different aspects of possible HCV health care professional-to-patient transmission and should provide solutions that would be acceptable for the infected health care worker and the patient.
RECOMMENDATIONS


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REFERENCES
assessed by investigators contemplating future clinical trials. While pursuing data on groups who have not been studied, however, we should not neglect those who have clearly been shown to benefit in available trials. It is important to remember there is still an enormous gap in the United States with respect to treating patients with lipid disorders. We have a clear mandate to target these patients for treatment based on the substantial evidence currently available.

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REFERENCES


Correction

Erroneous Equation. In the article titled “Risk of Hepatitis C Transmission From Infected Medical Staff to Patients,” published in the August 14/28, 2000, issue of the ARCHIVES (2000;160:2313-2316) on page 2314 in the “Estimates of Risk” subsection of the “Methods” section, line 11, the equation should have read as follows: \( P_s = 1 - (1 - P)^n \). The journal regrets the error.