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 parenteral physician-to-patient transmission of bloodborne pathogens like HCV. There-
METHODS

DETERMINANTS OF RISK

The likelihood of physician-to-patient HCV transmission during an invasive procedure according to well-established risk assessment models9,10 depends 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.11 Given that the operating department personnel frequently contracts blood contaminations and injuries,12,13 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-analysis18 comprising all 33 relevant studies published 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%14 in a United Kingdom survey to 6.7% among Italian workers employed in dialysis wards and in pathology services.20 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.6 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.潘利和同事们96 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 590 person-procedures.6 Tokars et al17 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.10 The estimates in these studies ranged from 17%35 to 32%.12 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 cited16 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%25) and, therefore, nowadays the risk of HCV transmission after needlesticks is regarded to be within a 1% to 10% range.26 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,27 and the 9.2% incidence of HCV infection after needlesticks acquired from HCV RNA–positive patients described by a group of Japanese researchers.28

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×B×C×D. If the surgeon is viremic, the likelihood can be estimated by P=B×C×D. In both settings, the chance that no HCV transmission occurs is 1−P. Since an individual surgeon performs multiple invasive procedures (N) during his career, the estimated probability of HCV transmission to a patient is at least 1 of these operations (PN) can be calculated according to PN=1−(1−P)N.7

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

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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>
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<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>(D) 2.2 (1.18-3.22)</td>
</tr>
</tbody>
</table>

†Data in parentheses are SEs calculated according to the following equation: SE = s/√(n); where s represents SD and n the number of observations.

‡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.
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 already been successfully applied to deduce the occupational HCV risk of surgeons and nurses within 15 years, respectively. The average probability of 140 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>0.62 × 10⁻² (0.52–0.72 × 10⁻²)</td>
</tr>
<tr>
<td>D = 2.2</td>
<td>1.4 × 10⁻² (1.2–1.6 × 10⁻²)</td>
</tr>
<tr>
<td>D = 9.2</td>
<td>5.7 × 10⁻² (3.7–7.7 × 10⁻²)</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.

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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.17 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: \( P_n = 1 - (1 - P)^n \). The journal regrets the error.