Transmission of Human Immunodeficiency Virus in a Dental Practice

Carol Ciesielski, MD; Donald Marianos, DDS, MPH; Chin-Yih Ou, PhD; Robert Dumbaugh, DDS, MPH; John Witte, MD, MPH; Ruth Berkelman, MD; Barbara Gooch, DMD, MPH; Gerald Myers, PhD; Chi-Ching Luo, PhD; Gerald Schochetman, PhD; James Howell, MD, MPH; Alan Lasch, DDS, MSPH; Kenneth Bell, BS; Nikki Economou, BS; Bob Scott, BS; Lawrence Furman, DDS, MPH; James Curran, MD, MPH; and Harold Jaffe, MD

■ *Objective:* To determine if patients of a dentist with the acquired immunodeficiency syndrome (AIDS) became infected with human immunodeficiency virus (HIV) during their dental care and, if so, to identify possible mechanisms of transmission.

■ *Design:* Retrospective epidemiologic follow-up of the dentist, his office practice, and his former patients.

■ *Setting:* The practice of a dentist with AIDS in Florida.

■ *Participants:* A dentist with AIDS, his health care providers and employees, and former patients of the dentist, including eight HIV-infected patients.

■ *Measurements:* Identification of risks for HIV transmission (if present), degree of genetic relatedness of the viruses, and identification of infection control and other office practices.

■ *Results:* Five of the eight HIV-infected patients had no confirmed exposures to HIV other than the dental practice and were infected with HIV strains that were closely related to those of the dentist. Each of the five had invasive dental procedures, done by the dentist after he was diagnosed with AIDS. Four of these five patients shared visit days ($P > 0.2$). Breaches in infection control and other dental office practices to explain these transmissions could not be identified.

■ *Conclusion:* Although the specific incident that resulted in HIV transmission to these patients remains uncertain, the epidemiologic evidence supports direct dentist-to-patient transmission rather than a patient-to-patient route.

Annals of Internal Medicine. 1992;**116:**798-805.

From the Centers for Disease Control, Atlanta, Georgia; the Florida Department of Health and Rehabilitative Services, Tallahassee and West Palm Beach, Florida; and Los Alamos National Laboratories, Los Alamos, New Mexico. For current author addresses, see end of text.

In July 1990, the Centers for Disease Control (CDC) published the first of a series of reports describing human immunodeficiency virus (HIV) transmission from a health care worker to a patient (1-3). No case of such transmission had been previously reported, although transmission of another blood-borne pathogen, hepatitis B virus (HBV), from infected health care workers to patients has been well documented, and the theoretic possibility that HIV transmission could also occur had been previously acknowledged (4-6). These reports intensified the ongoing debate concerning whether HIV and HBV-infected health care workers should do invasive medical and dental procedures. Resolution of this question has been hampered by the lack of accurate quantitation of the risk for transmission and also by misinformation and misconceptions regarding the likely mechanism of HIV transmission in the dental practice.

We review updated epidemiologic findings which led to the conclusion that five patients of a dentist with the acquired immunodeficiency syndrome (AIDS) were infected with HIV during their dental care. We also discuss the possible mechanisms of disease transmission.

Methods

The investigation began when a young woman without identified risk factors for HIV infection (Patient A) was reported to have AIDS. During a routine health department follow-up interview, Patient A provided the name of her dentist who, 2 years previously, had extracted her maxillary third molars. She was aware that the dentist had become ill and suspected that he might have AIDS. The dentist was known to the Florida Department of Health and Rehabilitative Services investigator as a previously reported AIDS case.

After publication of a report describing the possible HIV transmission to Patient A, the dentist publicly requested that his former patients seek HIV testing. The dentist was no longer in practice, and he could not provide a complete list of his former patients. However, a partial list was compiled from names provided by insurance companies, Medicaid records, billing and other records from the practice, and from other dental offices in the area. Patients who had not been tested for HIV at the local county public health unit were notified by the Florida Department of Health and Rehabilitative Services. By the end of 1991, 2 of the approximately 1 100 former patients tested were found to be HIV-seropositive (Patients B and C).

A fourth patient (Patient D) was identified by confidentially matching the names of the former patients to the state's reported AIDS cases. Three former patients (Patients E, G, and H) notified the CDC that they were infected with HIV. Another patient (Patient F) was identified during the epidemiologic investigation of Patient E.

Table 1. Characteristics of the Dentist and the HIV-infected Patients Identified in the Dental Practice*

Patient	Identified Risk Factor for HIV	CD4 +/ μL†	MHA-TP FTS-ABS†	HBsAg†	Anti-HB_c†
A	No	< 50	Negative	Negative	Negative
B	No	222	Negative	Not done	Negative
C	Unconfirmed	< 50	Negative	Not done	Negative
D	Yes	Not done	Negative	Negative	Positive
E	No	567	Negative	Negative	Negative
F	Yes	253	Negative	Negative	Negative
G	No	400	Negative	Negative	Negative
H	Yes	640	Negative	Positive	Positive
Dentist	Yes	190‡	Negative	Negative	Positive

* CD4+ = CD4 lymphocytes; FTA-ABS = fluorescent *Treponema pallidum* antibody absorption; HBsAg = hepatitis B surface antigen; anti-HBc = antibody to hepatitis B core antigen; MHA-TP = microhemagglutination assay for antibodies to *Treponema pallidum*.
† At initiation of epidemiologic investigation.
‡ At time of AIDS diagnosis.

Epidemiologic Investigations of the Patients and Dental Practice

The patient investigations included interviews with the patients and with their families and friends; discussions with their health care providers about possible exposures to HIV; review of medical, dental, and related records; and serologic testing of the patients' sex partners.

In March 1990, the dentist permitted a single interview with the CDC. During this interview, the dentist was informed that one of his patients had been diagnosed with AIDS and that this patient had no identified risk factors for HIV infection. With the dentist's consent, a blood sample was drawn for DNA sequence analysis to determine the degree of relatedness of his virus to that of Patient A. Information about the dentist's medical history was obtained from interviews with his health care providers and family and from a review of his medical and dental records.

Employees of the dental practice were tested for HIV infection and were interviewed on multiple occasions regarding infection control and other work practices in the dental office. The dental office was inspected in October 1990, approximately 14 months after it had been sold to another dentist.

Laboratory Investigation

Human immunodeficiency virus strains from persons with an epidemiologic transmission link have been shown to exhibit a closer genetic relatedness than do strains from persons without such a link (7-9). To determine the relatedness of the viruses, blood specimens were obtained from the dentist and from the eight infected patients. Samples from 35 HIV-infected patients receiving care at clinics within the same geographic area as the dental practice served as controls. Computer-based methods including genetic distance measurements and amino acid signature pattern analysis were used to compare the DNA sequences of an approximately 240-nucleotide portion of the C2-V3 domain of the dentist's virus to that of the other viral strains (50). The C2-V3 domain of the envelope gene was chosen because this domain contains nucleotide sequences with sufficient variability to distinguish strains and because this region has been used in previous studies of epidemiologically linked infections (7-9).

Results

Characteristics of the eight infected patients identified in the dental practice are summarized in Table 1. An illness possibly compatible with acute retroviral syndrome was found only for Patients A and F. No patient received blood or blood products.

Patient A denied injecting drugs, and her two reported boyfriends before her AIDS diagnosis tested seronegative for HIV in 1990. Her six dental visits, which occurred between November 1987 and June 1989, included one examination, two prophylaxes, two cosmetic bondings, and one visit for extraction of her maxillary third molars (Table 2). The patient recalled that the dentist wore gloves and a mask during the procedures. Dental x-rays taken during the spring of 1990 showed no additional extractions.

Medical records indicated that 4 weeks after the dental extraction, she was evaluated for a sore throat. She was afebrile, and her ulcerated tonsils and anterior cervical lymph nodes were moderately enlarged. The diagnosis was pharyngitis and aphthous ulcers; no indication exists that an acute retroviral syndrome was considered. She was diagnosed with oral candidiasis in May 1989 (17 months after the extraction) and with AIDS in December 1989 (24 months after the extraction), when she developed *Pneumocystis carinii* pneumonia. At that time, she was first tested for HIV antibody and was found to be seropositive.

Patient B reported that her only sex partner since 1978 was her husband, who tested seronegative for HIV. She denied injecting drugs.

Her 21 dental visits, between December 1987 and July 1989, included four extractions (*see* Table 2). Other procedures included three prophylaxes, three periodontal scalings, one examination, two restorative fillings, and ten fixed and removable prosthodontics. She recalled that the dentist wore gloves and a mask. She also recalled cutting her tongue on a tooth that was "sharply filed" during preparation for a bridge; however, she was unaware of any injury that the dentist may have sustained at that time.

Patient C denied having sex with men and injecting drugs. He reported multiple heterosexual partners but could name only 14 former female sex partners since 1978, and he was unaware that any were infected with HIV. Nine of these former partners were located and were found to be HIV seronegative. The possibility that Patient C had engaged in high-risk behaviors was raised during interviews and record reviews; however, behavioral exposures to HIV could not be documented.

He made 14 visits to the dental office between December 1984 and May 1989; the procedures included two extractions, two examinations, six restorative fillings, four prophylaxes, one periodontal scaling and one

Table 2. Dental Appointment Dates for Patients A, B, C, E, and G*

Year	January	February	March	April	May	June	July	August	September	October	November	December
1987											A(16)	A&B(17)† B(21)
1988					B(12)	E(18,23,30)	B&E(11)† E(5,28) G(18,25)	B(1,4,8,15, 16,18) B&E(29)†	B(1,8,23,26) E(2,9,19)	B(20)	B(8) E(3,7,10)	A(23,29,30) C(6) E(8)
1989	B&C(20)†	C(10,16)		B(10)	C(19)	A(29)	B(21,27)	Practice closed				

* Letters indicate patients; numbers in parentheses indicate day of the month.
† Shared-visit days.

cosmetic bonding (*see* Table 2). Nine of these visits, including both of the extractions, occurred in 1984 and 1985, before the dentist began to wear gloves routinely (Figure 1). The patient did recall that the dentist wore gloves and a mask during his visits in 1988 and 1989.

Patient D, a man who had behavioral risks for HIV infection, was diagnosed with AIDS in 1989. He had 18 visits to the dental office between June 1985 and May 1989. The procedures included five examinations, five extractions, six prophylaxes, two periodontal scalings, four removable prosthodontics, and two restorative fillings.

Patient E denied injecting drugs. Of her ten known sex partners since 1978, two had died from non-HIV-related causes and were not known to be at risk for HIV infection. Each of the remaining eight was tested for HIV antibody; one was seropositive. This man (Patient F) had other risk factors for HIV infection and was also a patient of the dentist. Patient E reported infrequent sexual contact with Patient F, the last contact occurring in the fall of 1988. Because of her concern about Patient F's high-risk behavior, she was first tested for HIV antibody in October 1988. Patient E was seropositive, whereas Patient F was seronegative.

Billing records and receipts indicated that Patient E made 14 visits to the dentist between June 1988 and December 1988 (*see* Table 2). The procedures included four examinations and radiographs, two prophylaxes, two root canal therapies, one restorative filling, six fixed prosthodontics, and one fluoride treatment. She reported that the dentist wore gloves and a mask during her visits.

Patient F tested negative for HIV antibody in October and December 1988, but he tested positive during the epidemiologic follow-up investigation in December 1990.

In September 1989, his medical records indicate a 1-week history of sore throat, loose stools, and headache; other symptoms included decreased appetite, fatigue, myalgia, and an earache. He had a temperature of 38.1 °C and tender anterior cervical adenopathy; his leukocyte count was 3300/μL, and he had a lymphocyte count of 693/μL. A diagnosis of tonsillitis was made, and a throat culture yielded "normal respiratory flora." No HIV-antibody test was done at that time, nor does any indication exist that an acute retroviral syndrome was considered. This illness occurred approximately 1 year after Patient F's last reported dental appointment (August 1988) and his last sexual contact with Patient E (Autumn 1988) and 9 months after his last negative HIV antibody test (December 1988).

Review of Patient F's medical and other records established a history of behavioral risk factors for HIV infection. Only one dental visit was documented by billing records, although he reported five or six visits during July and August 1988 for examination, radiographs, prophylaxis, extraction, restorative fillings, and root canal therapy.

Patient G denied, since 1978, sex with men and injecting drugs. He first tested positive for HIV during screening for plasma donation in November 1990. He had been HIV seronegative when he donated blood in 1986, and his two reported female sex partners since 1986 were HIV seronegative.

Patient G's dental records could not be located, but records from an alcohol rehabilitation facility documented two visits in July 1988 for root canal therapy and a restorative filling (*see* Table 2). He could not recall whether the dentist wore gloves or a mask.

Patient H has acknowledged behavioral risks for HIV infection. He made three visits to the dentist between September 1985 and July 1986 for prophylaxes, examination, and gingivectomy.

With the exception of patients E and F, none of these patients named each other as a sex partner, and all denied sexual contact with the dentist. For all of the patients, local anesthesia was the only anesthetic administered, and none could recall an injury to the dentist that would have exposed them to his blood (for example, a needlestick or a cut with a sharp instrument).

Laboratory Findings on Patients

The nucleotide sequences of the C2-V3 domain of the viruses from Patients A, B, C, E, and G were closely related to those of the dentist's virus. The average nucleotide variation ranged from 3.4% to 4.9% (50), a range similar to those previously observed for HIV strains from persons whose infections were known to be epidemiologically linked (7-9). In contrast, the viruses from Patients D, F, and H, each of whom had high-risk behaviors, were not closely related to the dentist's virus, and differed by 13.6% and 10.7% for Patients D and F, respectively (50). This degree of genetic difference has been found among strains of HIV that were epidemiologically unrelated. Preliminary analysis indicates that the virus from Patient H is also not closely related to that of the dentist. No instance of comparable viral

sequence relatedness was identified among the viruses from the 35 local controls (50). The HIV strains from patients A, B, C, E, and G were significantly closer in their DNA sequences to the dentist's virus than control patients ($P = 6 \times 10^{-6}$, Wilcoxon rank-sum test) (50).

An unusual pattern or signature of eight noncontiguous amino acids encoded by V3 nucleotides was found in the dentist's virus. The viruses from Patients A, B, C, E, and G, had at least 7 of the 8 signature amino acids. This degree of agreement was not found in the viruses from the dental patients with behavioral risks for HIV infection, the local controls, or a reference set of sequences from 32 HIV-1 strains ($P = 8 \times 10^{-6}$, Wilcoxon rank-sum test) (50). This finding, together with the genetic distance analysis, suggests that the virus from the dentist and those from Patients A, B, C, E, and G formed a cluster of genetically similar strains that were distinct from the viruses of the patients with identified risks for HIV infection and from the viruses of 35 local control patients.

Interview with the Dentist

The dentist recalled having sustained needlestick injuries from anesthetic needles before he was diagnosed with HIV infection, but did not recall sustaining any percutaneous injuries after learning he was HIV positive.

The dentist reported nonoccupational exposures to HIV, and he believed that he had been infected through these exposures, although the exact time of infection remains unknown. He was unaware that any of his patients were infected with HIV, although he suspected that as many as ten patients may have been at risk for HIV infection. He denied sexual contact with any of his patients.

Medical History of the Dentist

Review of the dentist's medical records showed that he was diagnosed with symptomatic HIV infection in late 1986 and with AIDS in September 1987, as indicated by a biopsy result diagnostic of Kaposi sarcoma of the palate and a CD4 + lymphocyte count of 190/μL. Zidovudine therapy was begun in early November 1987 but was discontinued from 16 December through 23 December 1987 because of neutropenia (*see* Figure 1). It was then continued at different doses throughout the time he remained in clinical practice.

In May 1988, examination of the palate showed purplish discoloration of the mucosa of the entire hard palate without ulceration or exophytic growth. The remainder of his physical examination was unremarkable. From 6 June through 20 June 1988, he received a total of 2750 rads of radiation therapy to his palate. This treatment resulted in mucositis at the end of therapy. By 6 July 1988, the palatal lesions had regressed, and the mucositis reaction had subsided. According to his medical records and interviews with his health care providers, he remained relatively asymptomatic except for fatigue until March 1989, when several lesions indicative of Kaposi sarcoma were noted on his abdomen and thorax. In June 1989, he was hospitalized with a presumptive diagnosis of *P. carinii* pneumonia. According to medical records, in the summer of 1989 his cutaneous Kaposi sarcoma lesions were treated with liquid nitrogen, and he reported that he used an electrocautery unit kept at his home to self-cauterize some of the lesions. In the summer of 1989, he stopped practicing dentistry. During the time he was in practice, his medical records did not indicate thrombocytopenia or any other bleeding disorder, hand dermatitis, injury, or dementia. No indication of peripheral neuropathy was present, although no record of a detailed neurologic examination or testing for neurologic dysfunction was found in the medical records.

In October 1989, the Kaposi sarcoma progressed to involve his lungs, and he was treated with alpha-interferon and chemotherapy. He died in September 1990.

The Dental Practice

The dentist had a general practice at one location from 1981 to 1989. He was in solo practice except from September 1985 through February 1986, when he had an associate. In the summer of 1989, the office was sold to another dentist. The patient records were dispersed and many office records, such as appointment books, were

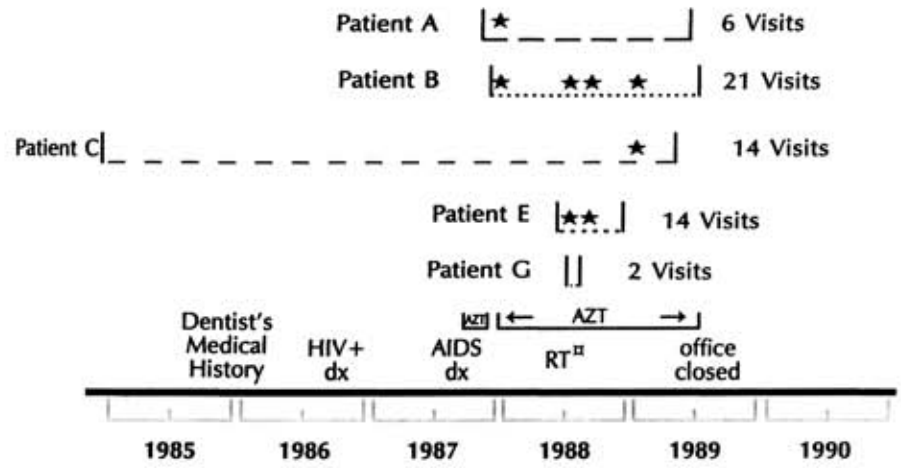

Figure 1. Chronology of the dentist's medical history and patient visit dates. * Days that Patients A, B, C, E, and G shared visits. ¤ The dentist's radiation therapy for Kaposi sarcoma of his palate. dx = diagnosis.

discarded. The office was remodeled, and most of the dental equipment was replaced. The office staff stated that there had been no electrocautery unit in his office practice.

All 16 persons identified as having been employed in the dental practice, including receptionists, hygienists, and assistants, were located and interviewed. All tested seronegative for HIV antibody. Staff members were not aware of any patients who were known to be infected with HIV or of any who had been sex partners of the dentist.

Staff members reported that since 1987, the dentist had received one prophylactic treatment from the hygienist and on one or two occasions had had an unspecified liquid medication placed on a palatal lesion using a cotton-tipped applicator that was then discarded. To the knowledge of staff members, the dentist received no other treatment and did not perform any treatment on himself in his office.

Infection Control Practices

Barrier precautions were fully introduced into the practice by early 1987; all staff with patient contact wore latex gloves and surgical masks for patient-care activities when appropriate. On most occasions, gloves were changed and hands were washed between patient contacts. Occasionally, however, gloves were washed rather than changed. Masks reportedly were changed infrequently. No staff member reported noticing any dermatitis or other lesions visible on the dentist or witnessing the dentist sustain a percutaneous injury during patient treatment.

By 1987, all surgical instruments used in the practice were autoclaved; other heat-tolerant instruments were autoclaved when time and instrument supply allowed or were immersed in a 2% glutaraldehyde solution for varying periods, usually of at least 20 minutes duration. Dental equipment such as prophylaxis angles and air and water syringe tips were either wiped with alcohol or immersed in 2% glutaraldehyde after each patient encounter. Some disposable items, such as saliva ejectors, high-speed evacuation tubes, and prophylaxis cups, were occasionally reused after being immersed in 2% glutaraldehyde, usually for at least 20 minutes. Handpieces were wiped with alcohol after each patient encounter; water lines were not flushed between patients.

The dental practice had no written infection control protocol or consistent pattern for operatory cleanup and instrument reprocessing. No office protocol existed for reporting or recording injuries such as needlesticks or other percutaneous injuries involving sharp instruments or devices.

Only local anesthetic was used in this practice, and anesthetic needles were either recapped by the dentist using a two-handed technique or remained uncapped and were recapped by the assistant on completion of the dental procedure. By 1983, only single-use disposable anesthetic carpules and disposable needles were used. Staff members reported no instance in which a needle or carpule was reused on different patients; however, the same needle was routinely used multiple times on the same patient when multiple injections of local anesthetic were required. The dentist did not document his use of local anesthetic in patient records.

Days of Shared Visits

On four occasions, two of the five infected patients whose viruses were related to that of the dentist were seen in the dental office on the same day (*see* Table 2, Figure 1). Those with shared visit days included Patients A, B, C, and E; Patient G did not share any visit days with the other four patients.

The five patients made a total of 48 visits to the dental office from November 1987 until the close of practice in July 1989. To examine the likelihood that the five patients shared visit days, conditional probabilities were calculated based on the number of visits made by each patient between November 1987 and July 1989, the interval during which at least two of these five HIV-infected persons were patients of the dentist. The probabilities were calculated assuming that visits occurred during days on which the dentist's office was open, without allowing multiple visits for the same patient on the same day. These shared-visit days probably occurred by chance alone ($P > 0.2$). Because appointment books no longer existed, neither the order nor the time of day could be determined for any of the shared-visit days.

Patients A and B were seen on 17 December 1987 (*see* Table 2). Patient A had two extractions while receiving local anesthetic. Patient B was examined for a toothache, and a radiograph was taken; no invasive procedures were done, although she had an extraction 4 days later. No indication exists that a handpiece was used on either of these patients on this day.

On 11 July 1988, Patient B had periodontal scaling and an extraction. Patient E had a crown placed on a maxillary bicuspid tooth. Patient B received local anesthetic, but we could not determine whether an anesthetic was used for placement of Patient E's crown because the tooth had previously had a completed root canal. It is unlikely that instruments used for the periodontal scaling and extraction would also be used to place a crown.

On 29 August 1988, Patient B had a bridge placed, and Patient E had plastic restorations placed on two maxillary anterior teeth. Although it is probable that local anesthetic was used on both patients on this day, the other instrumentation would differ. We could not determine whether the dental handpiece was used during the placement of the bridge; however, it would have been used for the restorations on patient E.

On 20 January 1989, Patients B and C had prophylaxes. Patient B's prophylaxis was done by the dental hygienist; however, we could not determine whether Patient C's prophylaxis was performed by the dentist or by the hygienist. It is unlikely that either patient had local anesthetic administered on that day.

Discussion

The findings of this investigation led us to conclude that five patients of a dentist with AIDS became infected with HIV during their dental care. We support

this conclusion because the five patients had no other confirmed exposures to HIV; all had invasive procedures done by the dentist; and DNA sequence analyses of the HIV strains from these five patients indicate a high degree of similarity among the strains and that which infected the dentist. These HIV strains were distinct from those infecting the three patients in the practice who had identified risk factors for HIV infection and from 35 HIV-infected persons residing in the same geographic area.

Our investigation is the first to report the transmission of HIV to patients during receipt of health care, although HIV transmission from infected patients to health care workers is well documented (10-12). In addition, transmission of HBV, another blood-borne virus, from infected health care workers to patients has been reported repeatedly since the early 1970s. More than 330 cases of HBV transmission from health care workers to patients occurring during invasive procedures have been reported (13-32) (Shapiro CN, CDC, unpublished data). Virtually all cases have involved clusters associated with care by 33 HBV-infected health care workers, including 9 dentists and 20 surgeons. Although percutaneous transfer of blood was the most likely mechanism of HBV transmission from health care worker to patient, the specific incident which resulted in transmission was not identified in any of the 33 episodes investigated.

In none of these studies involving an HBV-infected surgeon or dentist was patient-to-patient transmission of HBV believed to have been a mechanism of transmission. However, in other health care settings, patient-to-patient transmission of HBV has been attributed to contaminated common-source vehicles, including jet guns, multidose vials of heparin and local anesthetic, and fingerstick devices (33-36).

Although the precise circumstances or mechanism of HIV transmission in this Florida dental office remains unclear, the preponderance of data support direct dentist-to-patient transmission rather than a patient-to-patient route. The dentist continued to do many invasive procedures after he was diagnosed with AIDS. This period includes the interval during which his zidovudine was discontinued and during which a course of radiation therapy was administered. All five patients had invasive procedures done after the dentist was diagnosed with AIDS and had evidence of severe immunosuppression. Low CD4 + lymphocyte counts are associated with higher viral titers in the blood (37) and therefore could be associated with an increased likelihood of transmission if an injury to the dentist occurred. In addition, interviews with the dentist's health care providers and his office staff indicated that, after he was diagnosed with AIDS, he frequently experienced fatigue, a factor which may have increased the likelihood of injury.

There were multiple opportunities for the dentist to have injured himself during invasive procedures done on these patients, especially during periods of fatigue and ill health. In a survey of self-reported sharps injuries in 89 dentists, 32% reported 2 or more per month, and 3% indicated more than 15 such injuries per month (38). Another survey of 1132 dentists found a median of one sharps injury per month (39). Further, although undocumented, the possibility that the dentist had a peripheral neuropathy cannot be ruled out; peripheral nervous system dysfunction has been noted in 9% to 35% of patients with AIDS (40-43).

All five patients received multiple injections of local anesthetic, and a sharps injury during anesthetic administration could have resulted in contamination of the syringe apparatus with the dentist's blood, after which additional anesthetic may have been injected into the same patient. A sharps injury could also result in direct contact of the dentist's blood with the patient's inflamed or nonintact oral tissues during the invasive procedures. Although the dentist began to routinely wear gloves in 1987, gloves do not prevent most injuries caused by sharp instruments.

Human immunodeficiency virus does not remain viable for extended periods outside the body, and it is susceptible to commonly used germicides, including those used in the practice (4). Interviews of staff members indicate that, before use on patients, all instruments were cleaned and reprocessed by methods known to inactivate HIV, although these methods may not comply with recommendations designed to kill more resistant organisms.

If contaminated instruments or equipment are assumed to be the principal factor in these transmissions, one would expect to see a clustering of patient appointments. Although some shared-visit days were documented, these probably occurred by chance alone. Additionally, the procedures done on these shared visit days probably did not involve the use of the same instruments on more than one of the infected patients. Questions have been raised about the possible role of the dental handpiece in these transmissions. It is unlikely that a high-speed dental handpiece was used on both patients on any of the shared-visit days, and, to date, no studies have confirmed the transmission of blood-borne viruses such as HIV or HBV through the dental handpiece or other dental equipment.

The dentist denied having sex with any of his patients. One HIV-infected person subsequently contacted the CDC and reported having had sex with the dentist in the early 1980s and occasionally receiving dental care from this dentist before moving from the area in 1985. However, no patient records exist to confirm these data. No other persons who were both sex partners and patients of the dentist have been identified.

The possibility that these infections were intentionally transmitted has been hypothesized. Interviews with family, staff, health care providers, patients, and others who knew the dentist have not provided any support for this hypothesis. The dentist initially cooperated with our investigation and provided a blood specimen for genetic sequencing to be compared with patients' specimens. Additionally, most of the procedures done by the dentist were routinely observed by staff, all patients were awake during the procedures, and no unusual behavior was noted or suspected by either patients or staff members.

Some have hypothesized that the dentist might have had an exceptionally high titer of virus or an easily transmittable strain of HIV. The titer of HIV in the dentist's blood obtained in March 1990 is currently be-

ing determined, although it is unclear how accurately this result would reflect the viral titer in his blood between 1987 and 1989. Strain-specific virulence factors for HIV transmission have not been identified; further, no evidence was found to suggest HIV transmission from these patients to their sex partners.

The five patients identified in our investigation remain the only reported cases of HIV transmission from an infected health care worker to patients during invasive procedures. Results from six other studies of patients exposed to HIV-infected surgeons or dentists have not shown transmission (44-49). Of the 1246 patients of these health care workers who are known to have been tested, one was positive for HIV infection; however, this patient had behavioral risks for HIV infection and was probably infected before his surgical procedure (48).

The risk for transmission of blood-borne infections, including HBV and HIV, from an infected health care worker to a susceptible patient during an invasive dental or surgical procedure may depend on several factors, including the type of procedure, the infection control precautions, and the individual technique of the health care worker. The relative importance of these and perhaps other factors in predicting the risk for such transmission is poorly understood and requires further study.

Currently available information indicates that when health care workers adhere to recommended infection control procedures, the risk for transmitting HBV from an infected health care worker to patients is small, and the risk for transmitting HIV is probably even smaller. These small risks should not deter patients from seeking necessary surgical or dental care.

Acknowledgments: The authors thank Charles Schable, Betty Kroesen, Linda Ryan, Mark Miller, Thomas Liberti, Spencer Lieb, and Drs. Glen Satten, Meade Morgan, David Bell, Martin Favero, Walter Bond, and Ken Wilcox for technical assistance.

Requests for Reprints: Carol Ciesielski, MD, Division of HIV/AIDS, E-47, Centers for Disease Control, 1600 Clifton Road N.E., Atlanta, GA 30333.

Current Author Addresses: Drs. Ciesielski, Ou, Berkelman, Luo, Schochetman, Curran, and Jaffe and Mr. Bell and Ms. Economou: Division of HIV/AIDS, Centers for Disease Control, 1600 Clifton Road N.E., Atlanta, GA 30333.

Drs. Marianos and Gooch: Division of Oral Health, National Center for Preventive Services, Centers for Disease Control, 1600 Clifton Road, N.E., Atlanta, GA 30333.

Drs. Dumbaugh, Howell, and Lasch and Mr. Scott: Florida Department of Health and Rehabilitative Services, District IX, 111 Georgia Avenue, West Palm Beach, FL 33401.

Dr. Witte: Florida Department of Health and Rehabilitative Services, 1317 Winewood Blvd., Talahassee, FL 32301.

Dr. Myers: T10, MSK710, Los Alamos National Laboratories, Los Alamos, NM 87545.

Dr. Furman: USPHS, Parklawn Bldg, Room 6A-30, 5600 Fishers Lane, Rockville, MD 20857.

References

1. **Centers for Disease Control.** Possible transmission of human immunodeficiency virus to a patient during an invasive dental procedure. MMWR. 1990;39:489-93.
2. **Centers for Disease Control.** Update: transmission of HIV infection during an invasive dental procedure—Florida. MMWR. 1991;40: 21-7, 33.
3. **Centers for Disease Control.** Update: transmission of HIV infection during invasive dental procedures—Florida. MMWR. 1991;40:377-81.
4. **Centers for Disease Control.** Recommendations for prevention of HIV transmission in health-care settings. MMWR. 1987;36:(2S):1-18.
5. **Centers for Disease Control.** Recommendations for preventing transmission of infection with human T-lymphotropic virus type III/ lymphadenopathy-associated virus during invasive procedures. MMWR. 1986;35:221-3.
6. Report of the Presidential Commission on the Human Immunodeficiency Virus Epidemic. June 1988:33.
7. **Burger H, Gibbs R, Nguyen PN, Flaherty K, Gulla J, Belman A, et al.** HIV-1 Transmission within a family: generation of viral heterogeneity correlates with duration of infection. In: Brown F, Chanock RM, Ginsberg HS, Kerber RA; eds. Vaccines 90: Modern Approaches to New Vaccines Including Prevention of AIDS. Cold Spring Harbor, New York: Cold Spring Harbor Laboratory; 1990: 255-62.
8. **Balfe P, Simmonds P, Ludlam CA, Bishop JO, Brown AJ.** Concurrent evolution of human immunodeficiency virus type 1 in patients infected from the same source: rate of sequence change and low frequency of inactivating mutations. J Virol. 1990;64:6221-33.
9. **Myers G, Rabson AB, Berzofsky JA, Smith TF, Wong-Staal F.** Human retroviruses and AIDS, 1990. Los Alamos, New Mexico: Los Alamos National Laboratory; 1990.
10. **Henderson DK, Fahey BJ, Willy M, Schmitt JM, Carey K, Koziol DE, et al.** Risk of occupational transmission of human immunodeficiency virus type 1 (HIV-1) associated with clinical exposures: a prospective evaluation. Ann Intern Med. 1990;113:740-6.
11. **Marcus R, and the CDC Cooperative Needlestick Study Group.** Surveillance of health-care workers exposed to blood from patients infected with the human immunodeficiency virus. N Engl J Med. 1988;319:1118-23.
12. **Chamberland ME, Conley LJ, Bush TJ, Ciesielski CA, Hammett TA, Jaffe HW.** Health care workers with AIDS: National surveillance update. JAMA. 1991;266:3459-62.
13. Acute hepatitis B associated with gynecological surgery. Lancet. 1980;1:16.
14. **Carl M, Blakey DL, Francis DP, Maynard JE.** Interruption of hepatitis B transmission by modification of a gynecologist's surgical technique. Lancet. 1982;1:731-2.
15. **Grob PJ, Bischof B, Naeff F.** Cluster of hepatitis B transmitted by a physician. Lancet. 1981;2:1218-20.
16. **Coutinho RA, Albrecht-van Lent P, Stoutjesdijk L, Meebur-Snarenberg P, Courouce-Pauty AM, Vandijk BA.** Hepatitis B from doctors. Lancet. 1982;1:345-6.
17. **Welch J, Webster M, Tilzey AJ, Noah ND, Banatvala JE.** Hepatitis b infections after gynecological surgery. Lancet. 1989;1:205-6.
18. Acute hepatitis B following gynecological surgery. J Hosp Infect. 1987;9:34-8.
19. **Levin ML, Maddrey WC, Wands JR, Mendeloff AI.** Hepatitis B transmission by dentists. JAMA. 1974;228:1139-40.
20. **Hadler SC, Sorley DL, Acree KH, Webster HM, Schable CA, Francis DP.** An outbreak of hepatitis B in a dental practice. Ann Intern Med. 1981;95:133-8.
21. **Shaw FE, Barrett CL, Hamm R, Peare RB, Coleman PJ, Hadler SC.** Lethal outbreak of hepatitis B in a dental practice. JAMA. 1986; 255:3260-4.
22. **Lettau LA, Smith JD, Williams D, Lundquist WD, Cruz F, Sikes RK.** Transmission of Hepatitis B with resultant restriction of surgical practice. JAMA. 1986;255:934-6.
23. **Goodman RA, Ahtone JL, Finton RJ.** Hepatitis B transmission from dental personnel to patients: unfinished business [Editorial]. Ann Intern Med. 1982;96:119.
24. **Rimland D, Parkin WE, Miller GB, Schrack WD.** Hepatitis B outbreak traced to an oral surgeon. N Engl J Med. 1977;296:953-8.
25. **Goodwin D, Fannin SL, McCracken BB.** An oral surgeon related hepatitis B outbreak. California Morbidity. No. 14; April 16, 1976.
26. **Centers for Disease Control.** Outbreak of hepatitis B associated with an oral surgeon—New Hampshire. MMWR. 1987;36:132-3.
27. **Reingold AL, Kane MA, Murphy BL, Checko P, Francis DP, Maynard JE.** Transmission of Hepatitis B by an oral surgeon. J Infect Dis. 1982;145:262-8.
28. **Ahtone J, Goodman RA.** Hepatitis B and dental personnel:transmission to patients and prevention issues. J Am Dent Assoc. 1983;106: 219-22.
29. **Syndman DR, Hindman SH, Wineland MD, Bryan JA, Maynard JE.** Nosocomial viral hepatitis B. A cluster among staff with subsequent transmission to patients. Ann Intern Med. 1976;85:573-7.
30. **Haeram JW, Siebke JC, Ulstrup J, Geiram D, Helle I.** HBsAg transmission from a cardiac surgeon incubating hepatitis B resulting in chronic antigenemia in four patients. Acta Med Scand. 1981;210: 389-92.
31. **Flower AJE, Prentice M, Morgan G, Mitchell CJ, Nicholson KG, Rana B.** Hepatitis B infection following cardiothoracic surgery [abstract]. 1990 International Symposium on Viral Hepatitis and Liver Diseases. Houston; 1990:94.
32. **Heptonstall J.** Outbreaks of hepatitis B virus infection associated with infected surgical staff in the United Kingdom. Communicable Disease Reports. 1991;1:R81-5.
33. **Canter J, Mackey K, Good LS, Roberto RR, Chin J, Bond WW, et**

al. An outbreak of hepatitis B associated with jet infections in a weight reduction clinic. Arch Intern Med. 1990;150:1923-7.
34. **Alter MJ, Ahtone J, Maynard JE.** Hepatitis B virus transmission associated with a multiple-dose vial in a hemodialysis unit. Ann Intern Med. 1983;99:330-3.
35. **Oren I, Hershow R, Ben-Porath E, Krivoy N, Goldstein N, Rishpon S, et al.** A Common source outbreak of fulminant hepatitis B in a hospital. Ann Intern Med. 1989;110:691-8.
36. **Polish LB, Shapiro CN, Bauer F, Klotz P, Ginier P, Roberto RR, et al.** Nosocomial transmission of hepatitis B virus associated with the use of a spring-loaded finger-stick device. N Engl J Med. 1992;326: 721-5.
37. **Ho DD, Moudgil T, Alam M.** Quantitation of human immunodeficiency virus type 1 in the blood of infected persons. N Engl J Med. 1989;321:1621-5.
38. **Flynn NM, Pollet SM, Van Horne JR, Elvebakk R, Harper SD, Carlson JR.** Absence of HIV antibody among dental professionals exposed to infected patients. West J Med. 1987;146:439-42.
39. **Klein RS, Phelan JA, Freeman K, Schable C, Friedland GH, Trieger N.** Low occupational risk of human immunodeficiency virus infection among dental professionals. N Engl J Med. 1988;318:86-90.
40. **So YT, Holtzman DM, Abrams DI, Olney RK.** Peripheral neuropathy associated with acquired immunodeficiency syndrome. Arch Neurol. 1988;45:945-8.
41. **Levy RM, Bredesen DE, Rosenblum ML.** Neurologic manifestations of the acquired immunodeficiency syndrome (AIDS): experience at UCSF and review of the literature. J Neurosurg. 1985;62:475-95.
42. **Miller RG, Kiprov DD, Parry G, Bredesen DE.** Peripheral nervous system dysfunction in acquired immunodeficiency syndrome. AIDS and the Nervous System. New York: Raven Press; 1988:65-78.
43. **Snider WD, Simpson DM, Nielsen S, Gold JW, Metroka CE, Posner JB.** Neurologic complications of acquired immunodeficiency syndrome: analysis of 50 patients. Ann Neurol. 1983;14:403-18.
44. **Danila RN, MacKonald KL, Rhame FS, Moen ME, Reier DO, LeTourneau JC, et al.** A look-back investigation of patients of an HIV-infected physician. N Engl J Med. 1991;325:1406-11.
45. **Sacks JJ.** AIDS in a surgeon. N Engl J Med. 1985;313-1017-8.
46. **Armstrong FP, Minor JC, Wolfe WH.** Investigation of a health care worker with symptomatic human immunodeficiency virus infection: an epidemiologic approach. Milit Med 1987;152:414-8.
47. **Porter JD, Cruickshank JG, Gentle PH, Robinson RG, Gill ON.** Management of patients treated by surgeon with HIV infection. Lancet. 1990;335:113-4.
48. **Mishu B, Schnaffner W, Horan JM, Wood LH, Hutcheson RH, McNabb PC.** A surgeon with AIDS; Lack of evidence of transmission to patients. JAMA. 1990;264:467-70.
49. **Comer RW, Myers DR, Steadman CD, Carter MJ, Rissing JP, Tedesci FJ.** Management considerations for an HIV positive dental student. J Dent Educ. 1991;55:187-91.
50. **Ou CY, Ciesielski CA, Meyers G, Bandea CI, Luo CC, Korber BT, et al.** Molecular epidemiology of HIV transmission in a dental office. Science. 1992;255: (In press).

Dreary will be the morning when you and I awake and leopards are gone; when starlings in hordes no longer chatter in the plane trees gossiping about the adventures of the day to come; when the lone tomcat fails to return from his night's excesses; when robins cease to cry out their belligerent challenges to the bushes beyond the lawns; when the skies lack larks and the shrubbery lacks sex-obsessed rabbits hopping after each other; when hawks cease their eternal, circling searching and the gullery by the rocks falls silent; when the diversity of species no longer illuminates the morning hour and the diversity of men has vanished like the last dawn-afflicted star: if this be the morning we must awaken to, then may I, please God, have died in my sleep.

Yet it is the morning that, knowing or unknowing, we strive for: you, I, capitalists, socialists, yellow, white, brown. It is the morning that professors demand in common with policemen, that the philosophies of two centuries have praised, the morning of identicality, of the commonly induced conditioned reflex, the morning of egalitarian actuality, of the brave new world, of order beyond argument, of gray shadows beyond distinction, of uniform response to uniform stimulus, the morning of a tinkling bell and sheep proceeding to pasture. Let me never wake.

Robert Ardry
The Social Contract
New York: Atheneum, 1970 p. 367

Submissions from readers are welcomed. Please include a complete citation, as done for any reference.—The Editors.