Occupational Risk of HIV Infection in Health Care Workers

The following is a summary of the presentation on the occupational risk of HIV infection given at the Atlanta course by David M. Bell, MD, from the Centers for Disease Control and Prevention in Atlanta, Georgia.

Documented Cases of Occupational HIV Infection in Health Care Workers

According to statistics from the Centers for Disease Control and Prevention (CDC) as of December 1994, 4.8% of adults with AIDS reported a history of employment in a health care setting. Since 7.7% of the labor force in the United States is employed in health services, health care workers do not appear to be overrepresented in cases of AIDS. As of December 1994, there were 42 documented cases of occupationally-acquired HIV infection in health care workers and 91 cases of possible occupational transmission, with the time or source of infection remaining undocumented in these persons (provisional numbers as of December 1995 are 49 documented cases and 102 possible cases). Of the 42 health care workers with documented cases as of 1994, 38 were exposed to infected blood, 2 were exposed to concentrated virus in a laboratory, 1 was exposed to visibly bloody body fluid, and 1 was exposed to an unspecified body fluid. In total, 36 cases involved percutaneous exposure, four involved mucocutaneous exposure, and one involved both types of exposure, with the exposure route in one laboratory transmission remaining uncertain. Of the 37 percutaneous exposures, 34 involved hollow-bore needles and one each involved a scalpel, a broken vial, and an unknown sharp object. The disease status of the 40 HIV infection-source patients consisted of AIDS in 29 (72%), asymptomatic infection in 4 (10%), symptomatic infection in 2 (5%), and unknown status in 5 (12%). Of the 42 health care workers with documented cases, 15 were clinical laboratory technicians (primarily phlebotomists), 13 were nurses, 6 were physicians, 2 were surgical technicians, 2 were nonclinical laboratory workers, 1 was a respiratory therapist, another was a health aide, 1 was a housekeeper/maintenance worker, and 1 was a dialysis technician.

Seroprevalence Studies in Health Care Workers

Seroprevalence studies in health care workers have consistently documented a very low positive rate when persons with known nonoccupational risk factors are excluded. Table 1 shows results of HIV seroprevalence studies in selected groups of health care workers. Extensive seroprevalence studies have also been conducted in dentists showing low rates of infection. One drawback of these seroprevalence studies is that the extent of exposure to HIV in most of the workers tested is unknown. These surveys are nonetheless helpful in that they do not suggest a high rate of previously undetected infection in those health care workers studied.

Risk Factors for Transmission and Risk Estimates

Another way to assess risk of occupationally-acquired infection is to construct estimates based on the prevalence of HIV infection in the patients with whom the health care worker is involved, the risk of infection transmission following a blood exposure, and the nature and frequency of such exposures. HIV seroprevalence varies widely in different patient populations. The CDC study by Janssen and colleagues involved testing of blood remaining from a sample of patients in 20 acute care hospitals in 15 cities in 1990, with seroprevalences ranging from 0.2% to 14.2%. The seroprevalence rate was 10.4

Table 1. HIV Seroprevalence in Select Groups of Health Care Workers.

Source	Worker group	No. tested	No. positive (%)	Prevalence* (%)
Tokars. *JAMA*. 1992.	Orthopedic surgeons	3420	2 (0.06)	0 (0)
Panlilio. *J Am Coll Surgeons*. 1995.	Surgeons in high-AIDS areas	770	1 (0.13)	1 (0.14)
Cowan. *JAMA*. 1991.	Physicians and dentists: US Army Reserve	3347	3 (0.09)	NA
5 Studies	Hemodialysis staff: NY, Paris, Chicago, Brussels, Florence	356	0 (0)	0 (0)
Chamberland. *Ann Intern Med*. 1994.	HCW blood donors: 6 urban US regions	8519	3 (0.04)	0–1 (0–0.01)
Turner. *Am J Public Health*. 1989. **Gershon.** *Infect Control Hosp Epidemiol*. 1995.	Morticians: Massachusetts, Maryland	259	2 (0.77)	0 (0)

*Excluding health care workers with known risks.

Table 2. HIV Seroconversion Rates in Health Care Workers Enrolled in Prospective Studies After Percutaneous Exposure to Infected Blood.

Source*	Location	No. enrolled	No. seroconverted	Seroconversion rate/100 HCWs
Cardo	United States	1391	4	0.29
Ippolito	Italy	1546	3	0.19
Lot	France	592	3	0.51
Arranz	Spain	883	2	0.23
23 Studies	—	6135	20	0.33 (95% CI: 0.20–0.50)

*Presented as abstracts. HCWs, health care workers; CI, confidence interval.

times the rate of new diagnoses of AIDS per 1000 hospital discharges. This finding provides a way for acute care facilities to estimate seroprevalence in their respective populations; however, it must be remembered that the data from which this finding was derived are from 1990.

The risk of infection following a single percutaneous exposure to HIV-infected blood has been estimated in prospective studies to be about 1 in 300 (0.3%) (Table 2). In six studies involving 1143 mucous membrane exposures, 1 case of seroconversion (0.09%) was observed (95% CI, 0.002% to 0.50%). In a National Institutes of Health (NIH) study, none of 2712 workers who recalled skin contact with infected blood seroconverted, so that the rate was reported to be 0%, with a 95% CI of 0.0% to 0.11%.

The third determinant of occupational risk is frequency of exposure. Prospective studies in various occupations have provided summary estimates of percutaneous, mucocutaneous, or skin contacts with blood and the number of sharp object-related injuries per year. Using data such as these and a number of different methodologies, several authors have estimated cumulative occupational risks of HIV infection for various occupations. As shown in Table 3 these estimates include 1 worker every 3.5 years in the 130 Veterans Administration (VA) hospitals nationwide and rates of 0.008% to 0.026% per year in emergency department workers in high HIV prevalence locales. The estimate of 27 to 46 cases per 100,000 among residents and students at the Los Angeles County Medical Center was comparable to the estimated risk of death from motor vehicle accidents of 32 per 100,000 in the same age group.

It should be noted that these estimates are subject to many limitations, including simplified assumptions and incomplete data. Regarding the estimate by Henry and colleagues of 8 cases of occupationally-acquired HIV infection in hospital workers in 1990, Dr Bell noted that in that same year the CDC received reports of five hospital workers who had documented infection from hollow-bore needle injuries, and that the number of possible cases (the dates of which could not be precisely determined) may have brought the total number of cases for 1990 close to the estimated 8. It is the similarity in the order of magnitude that is important rather than the precise number of cases.

Assessment of Risk by Type of Exposure

The calculated average risk of percutaneous exposure underestimates the risk of some types of exposure and overestimates it for others. Prospective studies do not have sufficient statistical power to analyze risk of infection based on such factors as volume of blood or disease stage of HIV-infected source patients. As an alternative, some investigators have performed laboratory studies to quantify the amount of blood that may be injected in different needle-stick accidents. One such study conducted by Gerberding and colleagues assessed the amount of blood transferred across a filter-paper barrier by a solid 2-0 suture needle (0.69 mm diameter) and by an 18-gauge hollow needle (1.27 mm diameter) penetrating no layers of gloves or 1 or 2 layers of gloves to a depth of 5 mm through the filter. With no gloves, hollow needles injected approximately twice the volume of blood as did solid needles. One glove reduced the injection volume by approximately 6-fold for the solid needle and by about one half for the hollow needle. A further marginal reduction was seen when a

Table 3. Estimates of Cumulative Occupational Risk of HIV Infection in US Health Care Workers.

Source	Population	Estimate
Henry. *Minn Med.* 1995.	Workers in US hospitals	8 cases in 1990
US General Accounting Office	Workers in 130 VA hospitals	1 worker every 3.5 y
Gerberding. *N Engl J Med.* 1990.	Surgical staff at San Francisco General Hospital	1 worker every 8 y
Marcus. *Am J Med.* 1993.	Emergency department workers:	
	- high patient HIV prevalence	0.008%–0.026%/y
	- low patient HIV prevalence	0.005%–0.018%/y
O'Neill. *Arch Intern Med.* 1994.	Residents and students: Los Angeles County Medical Center	0.027%–0.046%/y

VA, Veterans Administration.

second layer of gloves was used with each type of needle. The investigators concluded that risk of infection was reduced when exposure involved solid needles and when gloves were worn, but noted that the amount of blood injected differed by less than a factor of 10. They further concluded that the amount of blood injected was likely to be less important as a determinant of risk than the concentration of HIV in the blood of the source patient.

Dr Bell and colleagues at the CDC recently published exposure risk estimates based on a case-control study that compared 31 cases of occupationally-acquired HIV infection in the United States, France, and the United Kingdom (January 1988 to August 1994) with 679 health care workers from a CDC needle-stick study who had percutaneous exposure to infected blood but did not seroconvert. The independent risk factors for HIV infection following exposure determined in a multivariate analysis are shown in Table 4. Factors associated with significantly increased risk of infection included deep injury (in most cases subjectively assessed), which was associated with the highest risk; visible blood on device prior to injury; and procedures involving a needle placed directly into a vein or artery of the source patient (eg, as opposed to a needle used in a heparin lock or IV tubing or in a subcutaneous injection). These three risk factors are likely surrogates for volume of blood injected. The other independent significant risk factor for infection was terminal illness in the source patient, with this factor likely being associated with high viral titer and perhaps characteristics of the virus in late-stage disease. A factor associated with a significantly decreased risk of infection was postexposure use of zidovudine, with an odds ratio of 0.21 indicating that such use was associated with a 79% reduction in risk following exposure.

Table 4. Independent Risk Factors for HIV Infection After Percutaneous Exposure to Infected Blood.

Risk factor	Adjusted odds ratio (95% CI)	*P*-value
Deep injury	16.09 (6.11–44.57)	<.0001
Visible blood on device	5.22 (1.79–17.69)	.004
Insertion of needle directly into a vein or artery	5.11 (1.94–14.82)	.002
Terminal illness in source patient	6.39 (2.22–18.87)	.001
Postexposure use of zidovudine	0.21 (0.06–0.57)	.005

CI, confidence interval. Adapted from Centers for Disease Control and Prevention. *MMWR.* 1995.

Exposure Prevention

Prospective studies of injury during surgery have shown that at least one injury occurs in 1% to 7% of procedures and that approximately three fourths of injuries are associated with suture needles. A major intervention that has been studied by the CDC and other investigators is the use of blunt-tip suture needles. Blunt needles are useful for suturing a variety of tissues, but are less than optimal for suturing of skin and fragile tissue (eg, vascular tissue). In a CDC study of blunt needle use in gynecologic surgery (a specialty with one of the highest needle-stick rates), in three New York City hospitals use of a blunt needle increased markedly after an introductory period, with injuries per 100 procedures decreasing dramatically as use of a blunt needle increased. A number of other promising devices for surgical use have recently been developed, including electrocautery, stapling, and finger protective devices.

Other devices with safety features to prevent needle-stick injury have been introduced for procedures involving hollow needles, such as phlebotomy or starting an IV access. The risk of injury in phlebotomy, for example, is not limited to the person drawing the blood; most injuries in these settings occur after the needle has been used and is set aside or improperly disposed of, with housekeeping workers and others also being at risk of injury. Studies of these devices conducted by the CDC and other investigators have shown a potential for significant risk reduction. It should be noted, however, that these safety devices can be expensive, and workers have to be trained in their use. As an example of practical problems that can arise with introduction of novel devices, an increase in bloodstream infections has reportedly accompanied use of needleless IV systems. These infections have occurred in cases in which the device was left in place for prolonged periods; this problem appears not to be related to the device itself but to failing to institute or maintain infection control techniques appropriate for using the device.

Postexposure Prophylaxis

Results from animal studies of postexposure prophylaxis with zidovudine, the only antiretroviral agent to be studied in any detail to date in this regard, have not been conclusive. These studies have been hampered, however, by the absence of a good animal model of HIV infection and by the fact that the inocula given in existing models have been large (to ensure adequate challenge) and frequently delivered by routes not characteristic of occupational exposures in humans (eg, intrathymically). These animal studies, however, have revealed that if a postexposure agent is to work at all, it must be given promptly—eg, within several hours—after exposure. The data available indicate that treatment begun later than 24 to 48 hours after inoculation will prove ineffective. A second important finding is that treatment did not prevent infection in some animal studies, but suppressed it. The possibility of this phenomenon occurring in humans must also be considered.

Despite these findings from animal models, there is evidence (eg, in the case-control study mentioned above) that postexposure use of zidovudine in humans decreases risk of infection. Findings from ACTG protocol 076 regarding maternal-fetal transmis-

sion also documented a highly significant effect of zidovudine in preventing transmission. There is some evidence that this benefit was related to a protective effect from the drug as well as to a decrease in viral load achieved with treatment. Recommendations regarding chemoprophylaxis after occupational exposure to HIV are provided by an interagency working group composed of representatives of the CDC, FDA, NIH, and HRSA (see *MMWR*, 1996 below).

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Suggested Readings

Centers for Disease Control and Prevention. Case-control study of HIV seroconversion in health-care workers after percutaneous exposure to HIV-infected blood—France, United Kingdom, and United States, January 1988–August 1994. *MMWR.* 1995;44:929-933.

Centers for Disease Control and Prevention. Public Health Service statement on management of occupational exposure to human immunodeficiency virus, including considerations regarding zidovudine postexposure use. *MMWR.* 1990;39.No. RR-1.

Centers for Disease Control and Prevention. Update: provisional Public Health Service recommendations for chemoprophylaxis after occupational exposure to HIV. *MMWR.* 1996;45:468–472.

Gerberding JL. Management of occupational exposures to blood-borne viruses. *N Engl J Med.* 1995;332:444–451.

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Puro V, Ippolito G, Guzzanti E, et al. Zidovudine prophylaxis after accidental exposure to HIV: the Italian experience. *AIDS.* 1992;6:963–969.

Tokars JI, Marcus R, Culver DH, et al. Surveillance of HIV infection and zidovudine use among health care workers after occupational exposure to HIV-infected blood. *Ann Intern Med.* 1993;118:913-919.