Transmission of Vaccinia Virus and Rationale for Measures for Prevention

J. Michael Lane1,* and Vincent A. Fulginiti2,3

1Department of Family and Preventive Medicine, Emory School of Medicine, Atlanta, Georgia; 2Department of Pediatrics, University of Arizona, Tucson; and 3Department of Pediatrics, University of Colorado, Denver

Currently, health care workers (HCWs) in the United States are being vaccinated against smallpox, and there is a possibility that this will be expanded to a more widespread vaccination program. Inadvertent transmission of vaccinia virus to patients with illnesses that are contraindications to vaccination is theoretically possible. Vaccinia virus is shed from the vaccination lesion of healthy primary vaccinees from approximately the third day to the end of the third week after vaccination; transmission of vaccinia virus is rare but does occur. Prudent management of the vaccination site by HCWs should virtually eliminate transmission. We recommend that vaccinated HCWs cover the site with loose gauze dressings and, when caring for patients with immunosuppression or extensive disruptive skin disorders, cover the dressings with semipermeable membranes. The evidence for respiratory spread of vaccinia virus is not compelling, and therefore droplet or airborne infection precautions should not be necessary, even for vaccinated HCWs who are caring for patients who experienced serious adverse events after smallpox vaccination in the past.

The United States has embarked on a program to vaccinate a substantial number of military personnel, civilian health care workers (HCWs), and “first responders” against smallpox. Initial plans called for vaccination of 450,000 HCWs, with progressive expansion of the program to 5–10 million HCWs. The program has not developed as rapidly as planned but may expand in the future. A policy of permissive vaccination of citizen volunteers is under discussion, but implementation plans have not yet been put into effect [1].

One concern about the present vaccination policy is the possibility that unvaccinated individuals might acquire infection by contact with vaccinees. Transmission of vaccinia virus from vaccinees to others is rare but has been documented [2, 3]. The Advisory Committee on Immunization Practices (ACIP) and the Healthcare Infection Control Practices Advisory Committee (HICPAC) recommendations state that vaccinated HCWs need not take administrative leave and can continue to work with patients, even patients with contraindications to smallpox vaccination [4]. This recommendation requires scrupulous adherence to recommended hand hygiene practices, use of a semipermeable dressing over gauze on the vaccination lesion, inspection of the vaccination site at the beginning of each work day, and adherence to appropriate infection-control measures to prevent transmission to patients. HCWs have frequent contact with immunosuppressed or atopic patients, which heightens concerns about the possibility of transmission. This article briefly reviews the transmission of vaccinia and comments on the currently recommended infection-control policies.

VACCINIA VIRUS SHEDDING

Vaccinia virus is shed from the primary vaccination lesion of humans and guinea pigs from approximately the third day to the end of the third week after vaccination [5, 6]. It is prudent to assume that virus can be isolated from the lesion until the scab has formed and sloughed. Limited data are available on viral shedding from revaccination sites, but shedding from re-vaccination sites seems to be shorter by ~1 week and possibly of lower titer than shedding from primary vaccination sites [7]. Currently, most vaccinations of HCWs and military personnel
involve individuals who were vaccinated in the remote past. This is prudent, because the risk of developing serious adverse events attributable to vaccination is lower among revaccinees [8, 9].

Vaccinial virulence is apparently strain dependent. The New York City Board of Health (NYCBOH) strain is the only one currently used in vaccines licensed in the United States, and it is generally regarded to be the least reactogenic of the strains in use during the era of smallpox eradication [10]. Limited data from the 1950s and 1960s suggest that viremia, viruria, and pharyngeal shedding in association with use of the NYCBOH strain are uncommon (R. Engler, written communication, 8 April 2003) [11, 12], although such reactions have been documented with the “hotter,” more reactogenic strains often used in Europe and Asia [13]. Viremia and viruria do occur in patients with progressive vaccinia and eczema vaccinatum, which are serious and life-threatening complications of vaccination that occur in individuals with immunodeficiencies and atopic dermatitis, respectively [14] (V.A.F., personal observations). Smallpox itself is generally transmitted from the respiratory tract via large droplets and requires unprotected exposure within ~2 m of the patient. Airborne transmission (at >2 m), probably via small-droplet nuclei, has been documented [15]. The presence of cough was probably an important factor in creating airborne transmission. These reports have made some members of the health care community concerned about the potential for airborne transmission of vaccinia virus, which has implications for infection-control practices for vaccinated HCWs, as well as patients hospitalized because of adverse events that occurred after vaccination.

Two reports suggest that the potential exists for transmission of vaccinia virus from the respiratory tract [3, 16]. Gurvich et al. [16] isolated vaccinia virus from the pharynx from several patients who developed “vaccinal angina,” or tonsillitis, after vaccination. These isolates were from occasional patients vaccinated with a more reactogenic European strain, probably the Tashkent strain used in many parts of the Soviet Union [10]. Sepkowitz [3] recently reviewed nosocomial outbreaks of vaccinia virus infection, mostly from the pre-1960s era. These outbreaks included small numbers of patients who developed vaccinia virus infection when they were in different rooms from index case patients with eczema vaccinatum.

VACCINIA VIRUS TRANSMISSION BY CONTACT

Data on the transmission of vaccinia in the United States and the United Kingdom were reviewed recently by Neff et al. [2]. The conclusions of this review are worth emphasis. First, transmission is rare. It occurred ~20–60 times for each million primary vaccinations in the 1950s and 1960s. Second, transmission generally requires very close personal contact. Such contact includes young siblings playing or sleeping together, students wrestling together competitively, mothers nursing infants, and adults sharing a bed. Third, HCWs rarely spread vaccinia. There were only 4 such transmissions documented in this review. Fourth, most transmission was to patients hospitalized for serious atopic dermatitis. Fifth, transmission did not result in postvaccinial encephalitis or progressive vaccinia. Sixth, apparently no transmission occurred from revaccinees.

Patients with eczema vaccinatum and progressive vaccinia shed copious amounts of virus from the skin lesions and therefore present the greatest risk for secondary transmission. No transmission of vaccinia virus to hospital contacts occurred in the 10-year period 1961–1970 at the University of Colorado Hospital in Denver (then Colorado General Hospital). Several dozen children with progressive vaccinia (many of whom had very prolonged hospital stays), with eczema vaccinatum, and with severe accidental inoculations were housed in single rooms in units that initially had open ward beds; subsequently, all children were housed in individual rooms. Air flow was common to all of these units; there were no laminar airflow rooms or negative-pressure units. Many of the nonvaccinia patients in these wards had been vaccinated in the past, but many were infants too young to be vaccinated, and others simply had not yet been vaccinated. Patients with immunodeficiencies of various types and patients with malignancies and other disorders that might have led to susceptibility to contact vaccinia were housed in these units. In no instance did nosocomial spread of vaccinia virus occur, despite prolonged hospitalization and the presence of large viral lesions in the skin of seriously ill patients with progressive vaccinia or eczema vaccinatum. All staff were instructed in what was then routine infection-control practice: use of cap, gown, and gloves and hand washing before and after visiting patients with vaccinia (V.A.F., personal observations). The absence of transmission under these circumstances suggests that modern contact precautions would prevent vaccinia virus transmission from patients with complications of smallpox vaccination and that airborne infection isolation procedures, such as use of single-patient rooms with negative pressure and N-95 respirators, are not required.

VACCINIA VIRUS TRANSMISSION IN THE MODERN ERA

Israel recently vaccinated ~18,000 HCWs. As of 15 May 2003, there was no transmission to patients. Two transmissions to close household contacts have occurred: from a surgeon to his wife and from a woman to her grandchild. In the current US program, ~36,000 civilian HCWs and 20,000 military HCWs have been vaccinated. There has been no transmission within health care settings. Ten civilians have acquired vaccinia virus from recently
vaccinated military personnel, presumably via sexual contact. These 10 transmissions occurred among ~260,000 primary vaccinees outside of health care settings, from personnel who either did not cover their vaccination sites or covered them with a standard bandage.

**CARE OF THE VACCINATION SITE**

The ACIP and HICPAC currently recommend that persons, especially HCWs, likely to come into contact with patients with enhanced susceptibility to vaccinia virus should cover their vaccination site with 2 gauze pads and that a semipermeable occlusive dressing should be placed over the gauze [4, 17]. Two studies of recombinant NYCBOH-derived vaccinia strains found vaccinia virus on 0 of 100 [5] and 3 of 103 [18] swabs taken from the outer surfaces of such semipermeable dressings. Dry gauze dressings probably do not need to be routinely changed, but when exudate wets the gauze visibly, a new dressing should be applied. We recommend that long sleeves be worn over such dressings and that scrupulous attention be paid to hand hygiene. These rigorous practices may be prudent in situations in which HCWs are in contact with atopic or immunocompromised patients [4]. However, occlusive dressings may predispose to maceration and possible bacterial superinfection, and therefore we recommend that dressings be changed when the vaccination site is examined or when fluid accumulation is noticed. Daily changes may be required during the period of maximum inflammation and shedding of vaccinia virus (days 4–14).

Common sense and reasonable caution should be used in caring for the vaccination lesions of vaccinees who are not in contact with persons with enhanced susceptibility to adverse events associated with smallpox vaccination (e.g., HIV-infected individuals, transplant recipients, atopic patients, and patients with burns). Vaccinees should be educated about the potential for spread. Good hand hygiene practices are essential; any commercial hand soap is acceptable. Alcohol-based hand rubs are effective in removing vaccinia virus [4]. The vaccination site is frequently itchy, and vaccinia virus can be transferred manually after scratching of such a site. The site should be covered with loose gauze dressing, and long sleeves should be worn. This will reduce direct shedding and greatly reduce the amount of virus picked up during scratching.

**RESPIRATORY SPREAD OF VACCINIA VIRUS**

We strongly doubt that transmission from the respiratory tract occurs after normal vaccination with NYCBOH strain vaccinia virus. Vaccinia virus is unlikely to be isolated from the blood, urine, or respiratory tracts of healthy patients immunized with vaccines derived from the NYCBOH strain. Many millions of vaccinations were performed in the past, and therefore the opportunity for spread within families has been considerable. Despite this possibility, only a very few instances of spread, usually to eczematous patients, have occurred. All cases in which intrafamilial spread has occurred have involved intimate contact. Individuals living in the same household as but without physical contact with the vaccinee have not been shown to acquire vaccinia virus. As mentioned above, airborne transmission in the ward at the University of Colorado Hospital was never documented. The manifestations of contact vaccinia are expressed in the skin, which offers further evidence that direct contact, not respiratory spread, is responsible.

The interesting nosocomial outbreaks described by Sepkowitz [3] included remote spread. However, there is no way to rule out the possibility that the virus was spread by fomites or the hands of HCWs. These outbreaks took place before concern about nosocomial infection led to greater emphasis on hand hygiene. Most of the outbreaks occurred in nations in which vaccinia virus strains that are more virulent and reactogenic than the NYCBOH strain were used. Postulation of respiratory spread is unnecessary to explain these outbreaks, although this method of transmission cannot be definitely excluded. Studies are currently under way to examine viral shedding from the respiratory tracts of healthy persons vaccinated for the first time. In a recent study, no vaccinia virus was isolated from cultures of pharyngeal samples obtained at 5 time points during the first 13 days after vaccination from 119 vaccinees, of whom 45% were primary vaccinees (R. Engler and M. Klotz, written communication, 8 April 2003).

**CONCLUSION**

That airborne or droplet spread of vaccinia virus from the respiratory tract of healthy vaccinees occurs is doubtful. Although the virus can be found in the bloodstream and pharynx of patients with adverse events involving vigorous viral replication and/or abnormal host defenses, particularly eczema vaccinatum and progressive vaccinia, epidemiologic evidence for airborne spread is scant. Standard and contact precautions will prevent transmission in routine circumstances. Airborne infection isolation precautions, such as use of negative-pressure rooms and N-95 or greater respirators, are not necessary for care of patients with vaccinia, unless procedures that cause aerosolization of the virus are performed.

Good hand hygiene is essential for HCWs who are in contact with vaccinia virus, including their own vaccination sites. We agree with the ACIP and HICPAC that the vaccination site should be covered with gauze, a semipermeable dressing, and a layer of clothing during patient care and that dressings should be changed every 3–5 days, or more frequently if exudates accumulate. HCWs who are caring for patients with eczema
vaccinatum or progressive vaccinia do not need to use an N-95 respirator; such respirators were not available in the 1960s, and vaccinia did not seem to affect HCWs. It is preferred that vaccinated HCWs provide direct care for patients with serious vaccinial complications. However, if an insufficient number of vaccinated HCWs are available, then only HCWs without contraindications for smallpox vaccination should be allowed to provide direct care.

New data may be acquired as the current vaccination program progresses, and these conclusions should be reviewed and updated as better information is collected. Studies aimed at documenting viral shedding (or lack thereof) with modern techniques, including PCR, are currently under way. HICPAC has recently examined policies to prevent transmission of vaccinia virus [4]. They advocate scrupulous hand hygiene and contact precautions but currently do not recommend airborne infection isolation precautions for patients with complications of smallpox vaccination. We feel that these conclusions are prudent and wise.

References