

Smallpox

Disease, Vaccine and Response



Progression of Smallpox

- Incubation Period
- Prodrome Stage
- Macules
- Papules
- Vesicles
- Pustules
- Scabs
- Scars



The rash typically progresses over a period of about 2 weeks. There are 2 pre-rash stages; the incubation period and pre-eruptive stage. We'll talk about these stages in more detail later. The actual rash stages (which are the stages of infectivity) include: macular, papular, vesicular, and pustular stages. Finally the skin lesions scab over and patients are often left with permanent scarring.

Smallpox Prodrome

- Incubation period 12 days (range 7-17 d)
- Prodrome
 - abrupt onset of fever $\geq 101^{\circ}\text{F}$
 - malaise, headache, muscle pain, nausea, vomiting, backache
 - lasts 1- 4 days



The incubation period can last up to 17 days, during which the patient appears well. Then the prodrome begins and the patient feels extremely ill, with high fever, malaise, headache, muscle pain, nausea, vomiting, and backache. Usually these patients take to their beds.

Smallpox Rash

- Enanthem (mucous membrane lesions) appears ~ 24 hours before skin rash
 - Minute red spots on the tongue and oral/pharyngeal mucosa
 - Lesions enlarge and ulcerate quickly
 - Become infectious from lesions in mouth
 - Virus titers in saliva highest and most infectious during first week of exanthem (skin rash)



The smallpox rash may begin in the mouth and go unnoticed. At this point the patient becomes infectious, shedding virus into the saliva. This period may last a few hours and then the skin rash begins.

Smallpox Rash

- Exantham (skin rash) – (21 days)
 - Stages: macules, papules, vesicles, pustules, scabs
 - Pustules raised, round, firm - like small beads in the skin (“shotty”)
 - Umbilication common
- Begins and most dense on face and extremities (centrifugal distribution)
- Lesions on palms and soles ($\geq 50\%$ of cases)
- Lesions in same stage and evolve slowly (1-2 days/stage)



Once the rash begins, it is usually first noticed on the face and extremities, and lasts about 21 days. On any one part of the body the lesions are in the same stage of development and last for about 2 days before moving to the next stage.

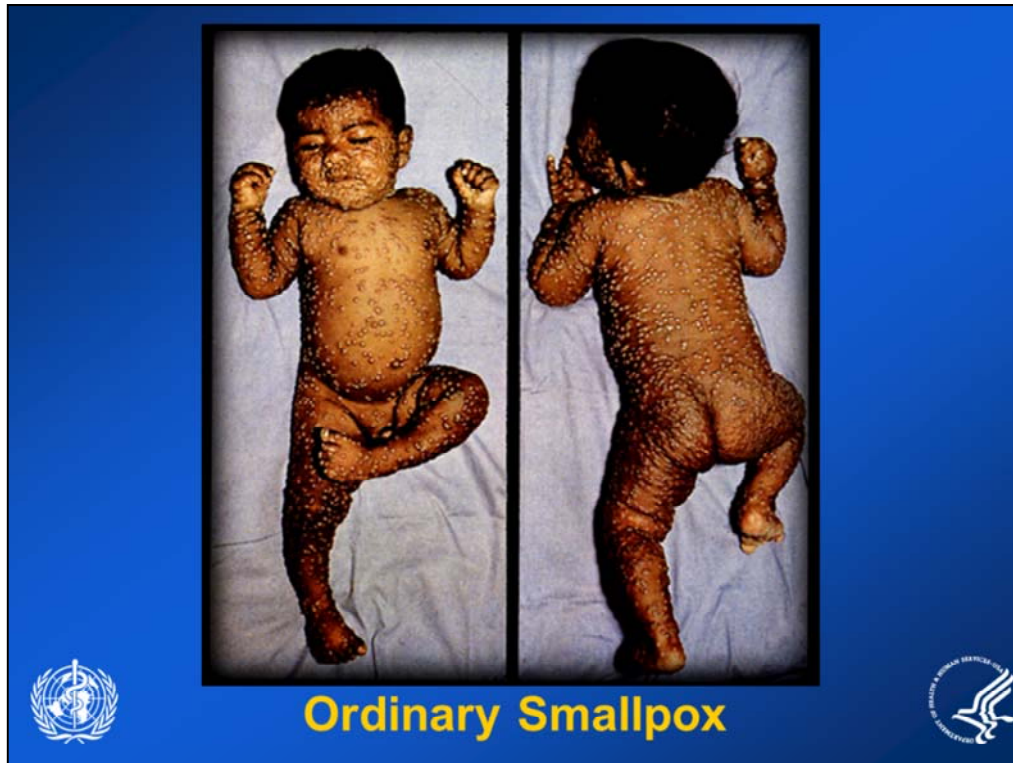
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Let's review some of the photographs you have already seen of a typical case of smallpox and focus on the progression of the rash. Note that on the day 2, the rash is mild, is macular and papular and could easily be overlooked. If this were the first case, smallpox would not be considered at this stage.

On day 4 the rash is more significant and has progressed to the papule stage with some vesicles. If there had been a febrile prodrome, we may be considering smallpox in the differential at this point.

On day 4 and 5, the rash is now vesicular. Over the next 24-48 hours, the clear fluid becomes cloudy and begins to thicken leading to pustules which reach their maximum size by day 11. Note that in both photos, the lesions are all in the same stage of development



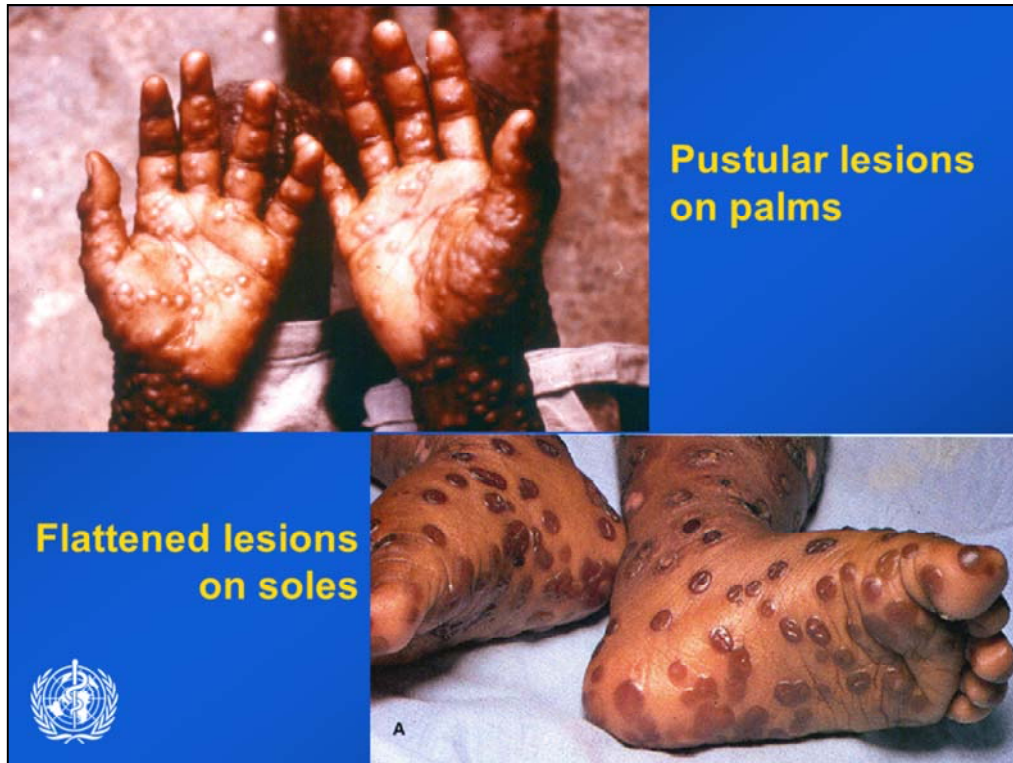
Here we see the typical, monotonous head to toe rash of ordinary smallpox. Note the greater concentration of lesions on the face and extremities (also involving the palms and soles).



Here is the rash up close. The lesions are in the papular stage and all look the same.



In this photo, we can see that some of the lesions may be umbilicated (have indentations in the middle).



Note in this slide how patients with smallpox have lesions on the palms of their hands. They are also found on the soles of the feet. Patients with chickenpox rarely have lesions in these areas.

Smallpox Ordinary Type (Discreet lesions)



Discrete refers to the type of rash in which areas of normal skin appear between the pustules, even on the face where the pustules tend to be very close together. This rash follows the typical progression we spoke of earlier.

Smallpox Ordinary Type (Dense lesions)



This patient has the rash of ordinary smallpox, however has an extremely dense presentation of the lesions.

Smallpox Flat-type



This patient has a rare type of smallpox called “flat type” that carries a 96% mortality rate. These patients are very ill from the outset. By the seventh or eighth day, the lesions are flat and appear to be buried in the skin. Unlike ordinary type smallpox, the vesicles contain very little fluid and do not appear umbilicated. The lesions are soft and velvety to the touch. Lesions may contain hemorrhages.

Patients with flat type smallpox often appear toxic and have crusting around the mouth from oral lesions. The prognosis for this form of smallpox is grave and most cases are fatal. Flat type smallpox can be difficult to diagnose because the typical skin lesions do not develop.

Flat type smallpox is not caused by a different virus – instead it is a difference in the host’s response to the variola virus. These responses are not yet well understood.

Smallpox Hemorrhagic Type



Hemorrhagic smallpox is another severe and uncommon form of smallpox that is almost always fatal. It involves extensive bleeding into the skin, mucous membranes and gastrointestinal tract. In the large Indian series, hemorrhagic disease occurred in about 2% of cases, and occurred mostly in adults. The prodrome, which can be prolonged, is characterized by fever, intense headache and backache, restlessness, a dusky flush or sometimes pallor of the face, extreme prostration and toxicity. There is little or no remission of fever throughout the illness. Hemorrhagic manifestations can occur early or late in the course of the illness.

Hemorrhagic manifestations appear on the second or third day as subconjunctival bleeding, bleeding from the mouth or gums, and other mucous membranes, petechia in the skin, epistaxis, and hematuria.

Death often occurs suddenly between the fifth and seventh days of illness, when only a few insignificant maculopapular cutaneous lesions are present.

This woman has late hemorrhagic manifestations. In patients who survive for 8 to 10 days the hemorrhages appear in the early eruptive period. The rash is flat and does not progress beyond the vesicular stage. Hemorrhagic smallpox could be easily misdiagnosed as meningococcal bacteremia because of the hemorrhages and lack of typical smallpox vesicles and pustules.

Varicella



Differential Diagnosis

SMALLPOX

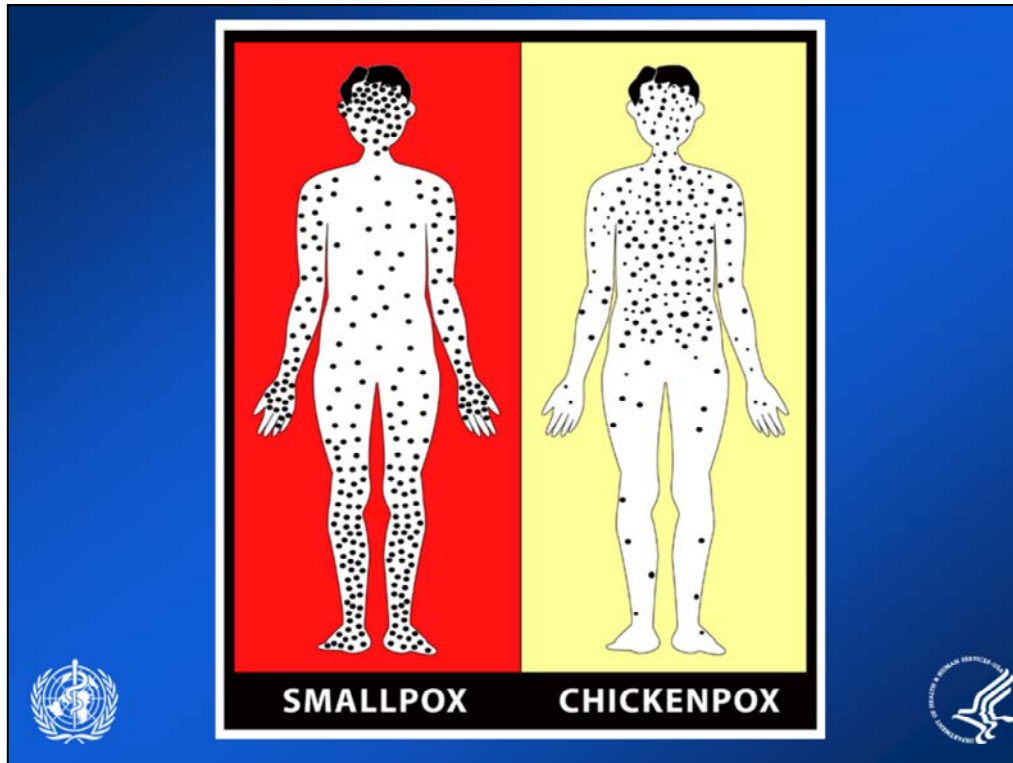
- Deep, hard lesions
- Round, well circumscribed
- Confluent or umbilicated
- Lesions at same stage of development



CHICKEN POX

- Superficial
- Not well circumscribed
- Confluence and umbilication uncommon
- Lesions at all stages of development





The disease most likely to be confused with smallpox is CHICKENPOX. Let's talk about the differences between these 2 diseases. The typical pattern of smallpox rash distribution is demonstrated in this cartoon. Note that the lesions are concentrated distally in the head and the extremities in contrast with the central distribution (more lesions on the trunk) typically seen in varicella.



An important differentiating feature of smallpox and varicella is the appearance, evolution, and distribution of the rash. Although there may be some overlap in the appearance of the lesions, particularly early after rash onset, classic smallpox looks quite different than varicella. In this and the next few slides, we will examine photographs to highlight differences between smallpox and varicella.

Smallpox



Chickenpox



Note in this slide how patients with smallpox have lesions on the palms of their hands. They are also found on the soles of the feet. Patients with chickenpox rarely have lesions in these areas.

Smallpox

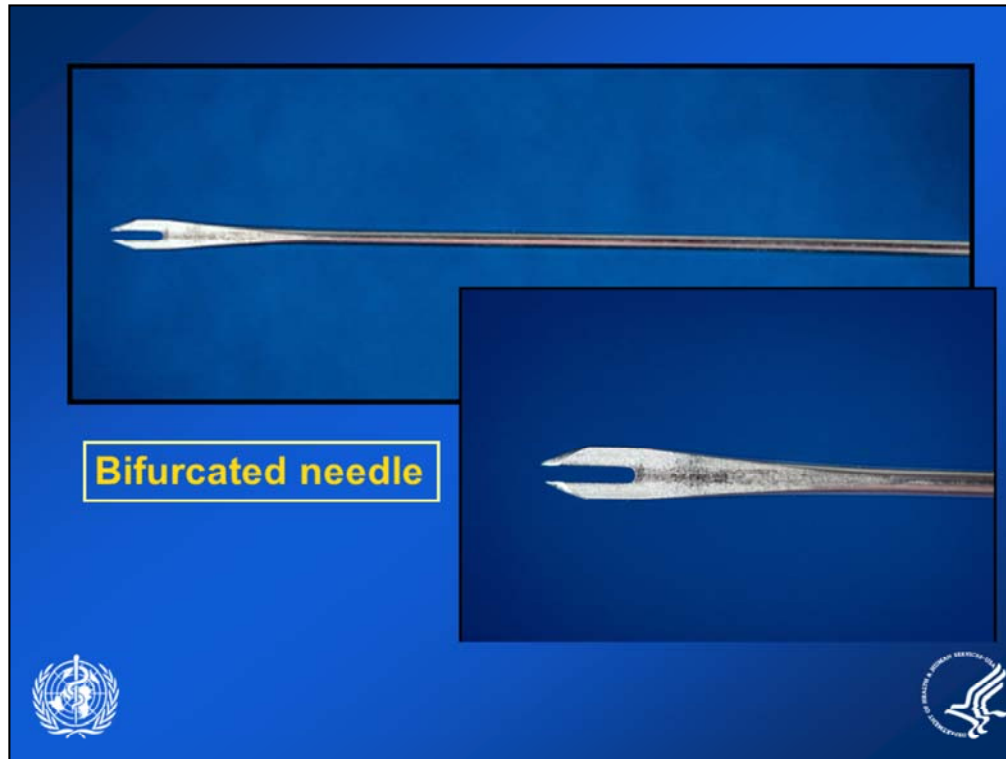


Varicella



Here is another photograph of smallpox pustular lesions that clearly demonstrates their deep seated nature. One can imagine just from the photo that these lesions, if pressed on, would feel hard and pea-like and could be rolled around under the skin.

Classic varicella is often described as “dew drop on a rose petal.”



To administer the smallpox vaccine, a special bifurcated needle is used. No other vaccine uses this type of needle, and smallpox vaccine must never be administered by any other method. You should review the package insert or protocol that is provided with the vaccine for any additional instructions regarding vaccine administration.



The number of pricks to the skin for successful vaccination depends upon the type of vaccine being used and whether or not the person has been vaccinated before. Check the instructions that accompany the vaccine you will be using for this information.

Smallpox Eradication Strategy

The Bifurcated Needle

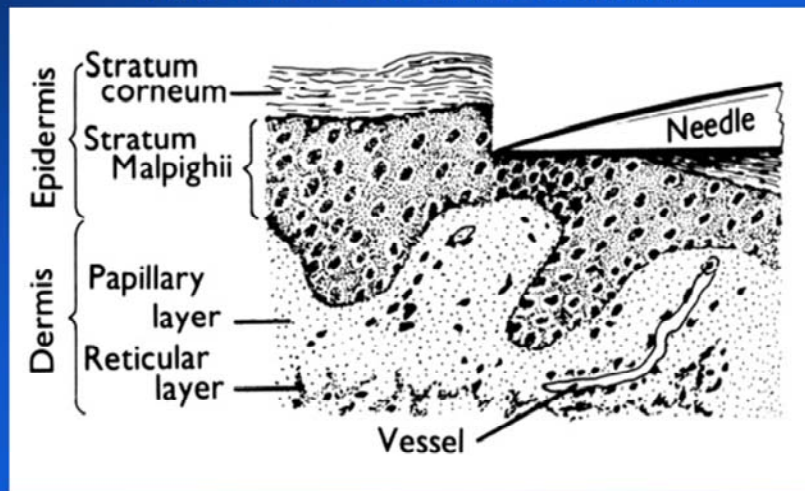


Fenner F et al.
Smallpox and its
Eradication, pp 570

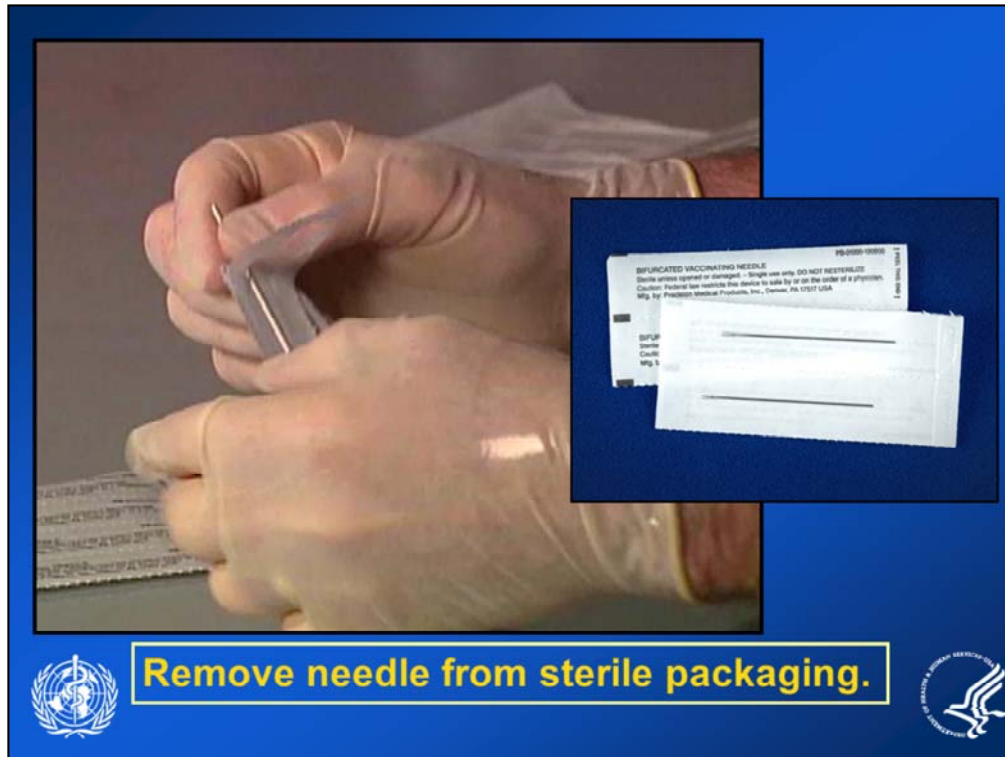


Here we see that the pricks or insertions are given with enough pressure to depress the skin.

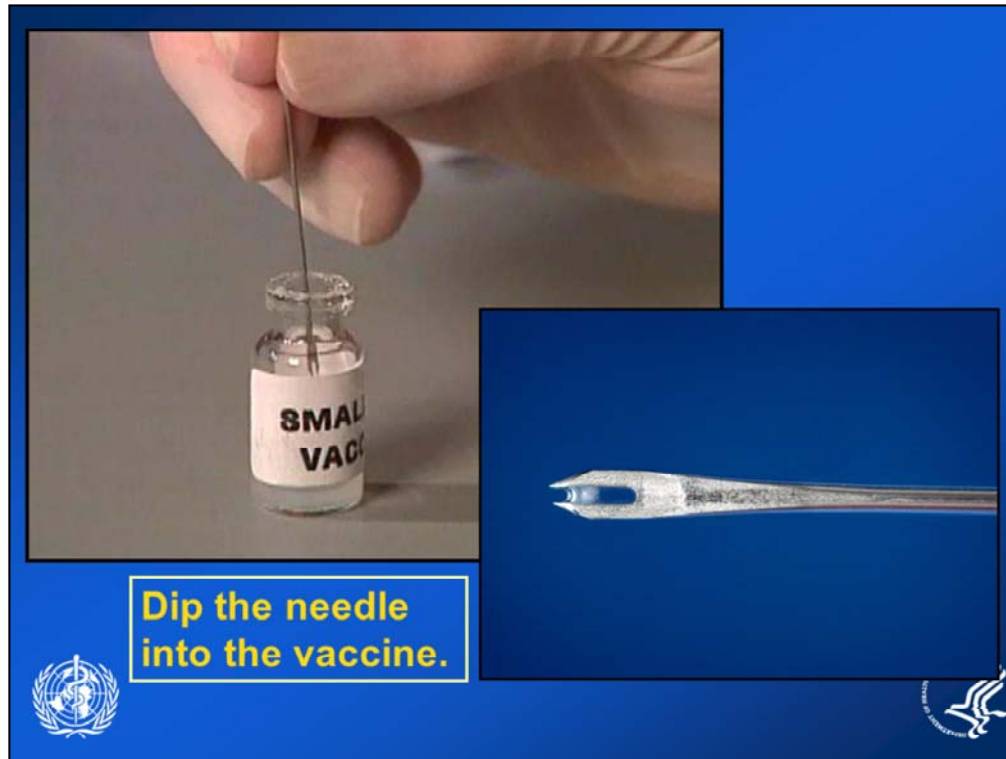
Vaccine Administration



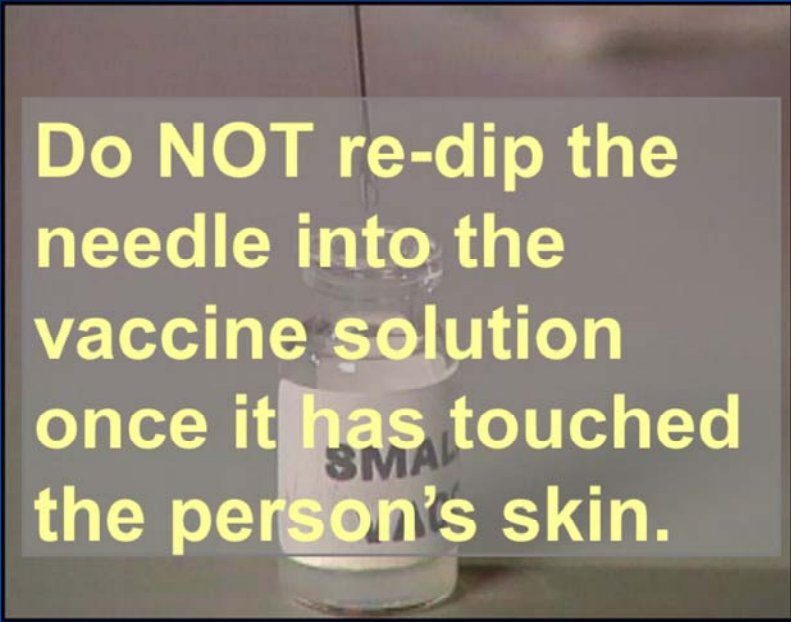
Smallpox vaccine is unique in that it is not administered by injection. It's administered into the superficial layer of the skin with a two pronged, or bifurcated, needle. Bifurcated needles can be supplied in 100 needle "shaker tubes" or in individual sterile wrappers.



Now we will review the steps in administering the vaccine. First, remove the bifurcated needle from its packaging. The needle is sterile, so be careful not to touch the bifurcated, pointed end.



Dip the bifurcated point of needle into the vaccine solution- so that the needle is perpendicular to the floor. The needle will pick up a drop of the vaccine in the space between the two prongs. Inspect the needle tip after dipping to assure that vaccine is present between the prongs. DO NOT shake the needle after it has been dipped into the vaccine vial. If no vaccine is between the prongs of the needle, and the needle has not touched the skin of the vaccinee (i.e., it is still sterile), it may be dipped again.



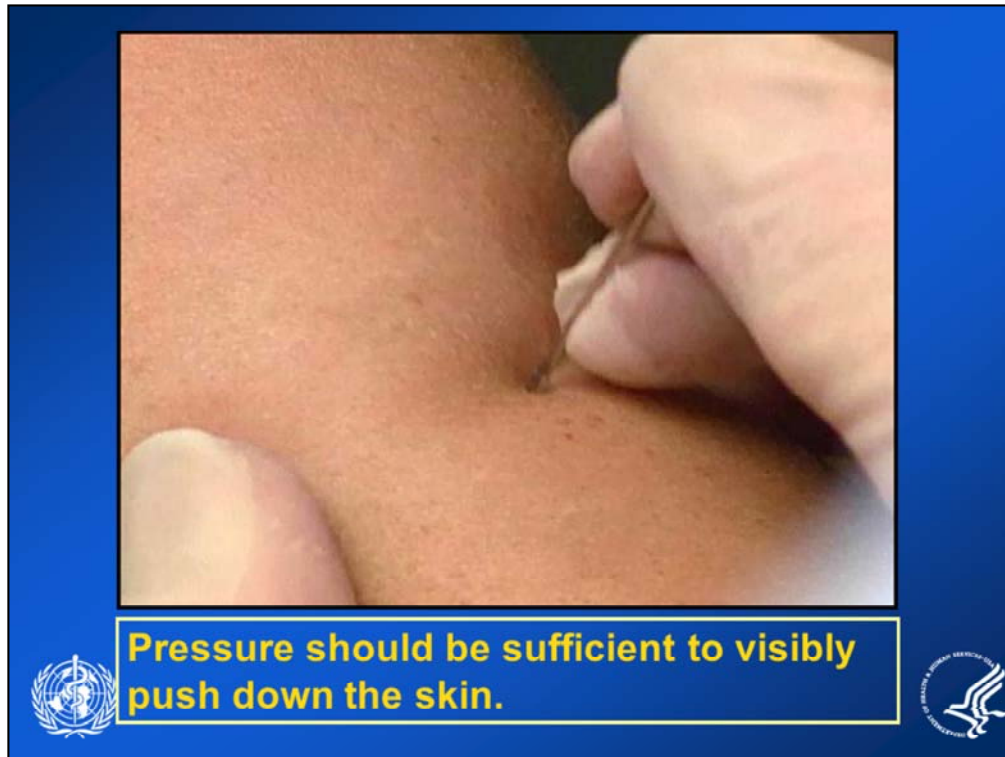
**Do NOT re-dip the
needle into the
vaccine solution
once it has touched
the person's skin.**



A single dip into the vaccine will prevent contamination of the vaccine vial.



Pull the skin on the arm taut, rest your wrist on the arm, and prick the skin the recommended number of times. This should be done rapidly, perpendicular to the skin, within an area 5 millimeters in diameter. The intention is to break the skin and introduce the vaccine into the skin. The wrist of the vaccinator should be resting on the arm while pricking the skin.



Administering the strokes rapidly, within about 3 seconds, also helps induce enough pressure by the needle to produce this small amount of bleeding and assure that the vaccine was administered appropriately. This method allows the live vaccinia virus to penetrate the superficial layers of the skin so that viral multiplication can occur and produce immunity.



A trace of blood should be present after 10-20 seconds.



Bifurcated needles should never be re-used.



Cover the vaccination site to prevent dissemination of the virus. The site should be covered by a gauze pad then tape applied over the gauze. For hospital personnel, the gauze should in turn be covered by a semi-permeable occlusive dressings. Semi-permeable dressing alone should not be used because it cause skin maceration and may increase the risk of secondary bacterial cellulitis.

Smallpox Vaccine Administration

Prior to administration of smallpox vaccine, please refer to the package insert for the number of bifurcated needle punctures to use.

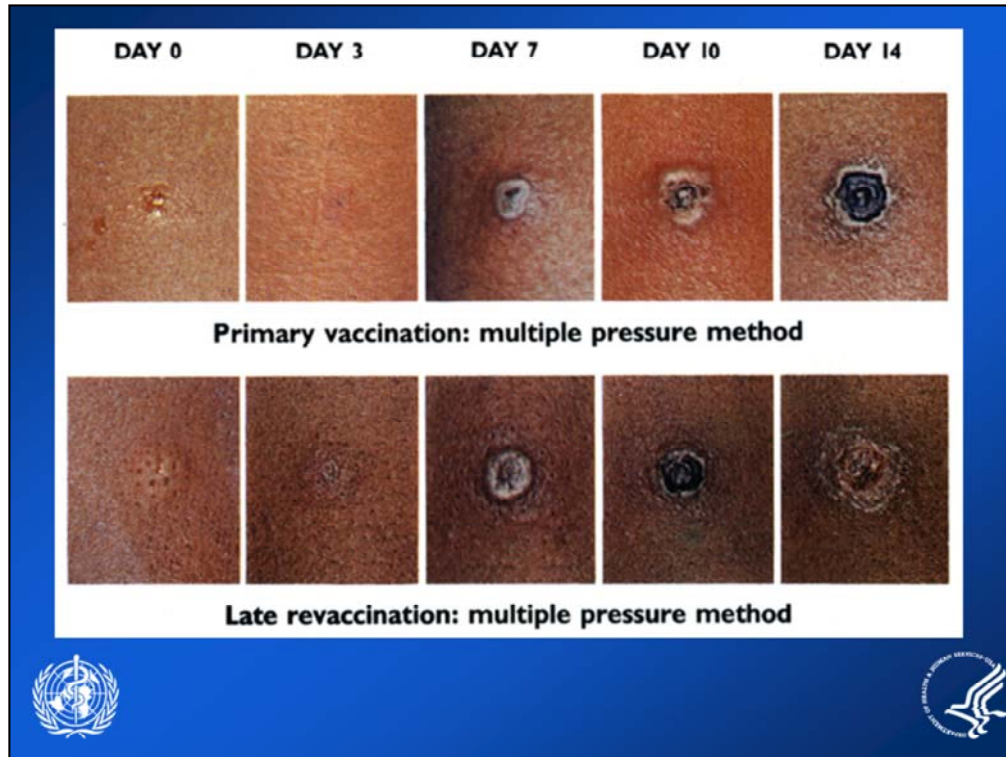
“Successful” Smallpox Vaccination



The usual response to a “first-time” or primary vaccination, or to a repeat vaccination after a long period of time is called a “major” response.

This involves the development of a papule at the vaccination site about 3-5 days following vaccination. It then evolves into a pustule by days 5-8. The peak site response occurs around days 8 to 10, and is when the greatest amount of erythema or swelling is seen.

Axillary lymph nodes may also be more swollen at this time and the vaccinee may experience fever for a couple of days. The site lesion then starts to dry up to form a scab at about day 14, with separation of the scab beginning about 14-21 days after vaccination.



Vaccine sites should be examined for the expected vesicle or pustule around day 7 following vaccination to confirm the vaccination was successful.

Contraindications for Vaccination

1. Immunodeficiency
2. Immunosuppressing therapies
3. Atopic Dermatitis/Eczema; including past history
4. Acute or chronic skin conditions (until resolved)
5. Allergies to polymyxin B, streptomycin, tetracycline, or neomycin
6. Pregnancy



In the pre-event setting, people with certain conditions should not receive smallpox vaccine. These conditions include:

- Immunosuppression or immunodeficiency in the recipient or a household contact
- Atopic dermatitis or eczema or a history of these conditions in the vaccinee or a household contact
- Acute or chronic skin conditions that cause breaks in the skin like, burns, impetigo, or contact dermatitis (until the condition is resolved)
- A serious allergic reaction to a prior dose of vaccine or a vaccine component (some vaccines contain antibiotics, so check your vaccine's package insert)
- Pregnancy in the recipient or a household contact
- Breastfeeding in the vaccinee (due to the close skin to skin contact)

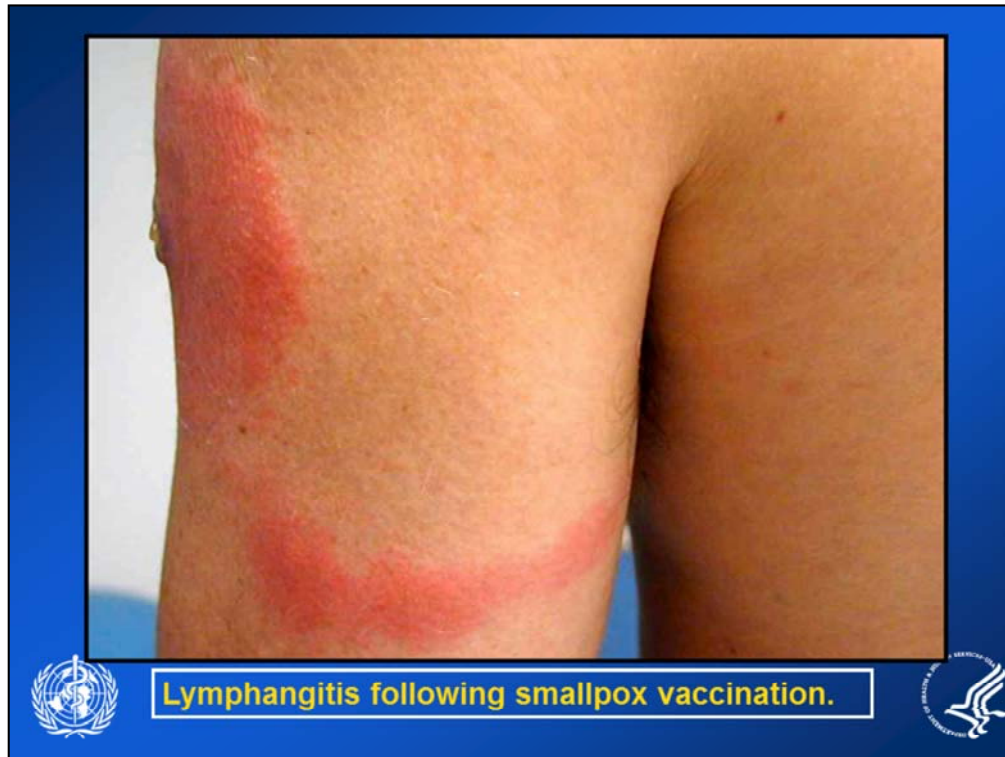
Contraindications for Vaccination of Contacts

During a smallpox outbreak...

NONE!



In the event of an exposure to smallpox, there would be no contraindications to vaccination. In this situation, the benefit of vaccination would outweigh the risk of a complication from the vaccine.



Now we'll talk about some the reactions and adverse events that can follow smallpox vaccination. This image demonstrates the red streaking of lymphangitis. This is usually due to a normal robust reaction at the site that peaks around days 8-10, but can be seen in secondary bacterial cellulitis. It can also be confused with allergic reactions to the dressing tape.



Robust take with lymphangitis.



Some individuals can have a robust primary reaction that presents with a large amount of erythema, swelling, pain, and warmth at the vaccine site. The redness and swelling can sometimes be greater than 3 inches or may even involve the entire upper arm. This large reaction is usually seen on days 8-10, corresponding to the same time when the peak vaccine inflammatory reaction usually occurs. In recent studies, this robust reaction, or take, occurred in 5%-15% of vaccine recipients. Both people getting vaccinated for the first time and people getting revaccinated after a long period since their last vaccination can have these robust takes. These robust reactions are expected variants of the evolution of the vaccination site and generally improve on their own within 24-72 hours.

However, sometimes these large vaccination reactions have been reported as adverse events and misinterpreted as a “bacterial cellulitis,” prompting antibiotic treatment.



Satellite lesions.

Here is an example of a satellite lesion near the vaccination site. These usually heal at the same rate as the primary vaccination site.



This picture demonstrates a local reaction due to a tape allergy. This can usually be distinguished from lymphangitis by observing that the reaction only occurs in the distribution of the tape. Usually, individuals with reactions to tape have no other systemic symptoms.

Major Complications of Smallpox Vaccination

- Inadvertent autoinoculation (IA)
- Eczema vaccinatum (EV)
- Generalized vaccinia (GV)
- Progressive vaccinia (PV)
(vaccinia necrosum)
- Postvaccinial encephalitis (PE)



Here is a list of some of the complications that are specific to smallpox vaccination. We will talk about each of these conditions in more detail.

Rates* of Reported Complications Following Smallpox Vaccination – U.S., 1968

Complication	Primary Vaccination	Revaccination
IA	529	42
GV	242	9
EV	39	3
PV	1.5	3
PE	12	2
Total	1254	108



*Cases per million vaccinations



The most common complication is inadvertent inoculation and the least common is postvaccinial encephalitis. All complications are less frequent among people who have been vaccinated before.

Inadvertent Autoinoculation



Transfer of vaccinia virus to another person can result in a lesion similar to a typical vaccine site lesion, or can lead to other more severe adverse reactions, especially in people with certain underlying medical conditions like eczema, atopic dermatitis, or immune suppression.

Inadvertent inoculation of the eyelid can lead to significant swelling and redness of the eyelid and periorbital area.

Inoculation of the virus in the eye can result in several clinical manifestations including blepharitis or infection of the eyelid, conjunctivitis, keratitis or iritis, or a combination of these conditions.

Periocular and ocular implantation, otherwise referred to as ocular vaccinia disease, account for the majority of inadvertent inoculations and were often noted within 7-10 days of vaccination in first-time vaccinees.

Because ocular vaccinia disease may occur in several forms, when evaluating a patient with new onset of a red eye or periocular vesicles, vaccinia infection should be considered. The patient should be asked about recent vaccinia exposures including a smallpox vaccination or close contact

with a vaccine recipient.

Postvaccinial Encephalitis

- Signs and symptoms of classical encephalitis, encephalopathy, demyelination, or neuropathy
- Onset 9-14 days after primary vaccination
- Highest risk among children <12 months of age
- VIG not proven useful



Post-vaccinial encephalitis is also a very rare but serious vaccine complication. It was more frequently seen in vaccinated infants less than 1 year old or in older adolescents or adults receiving their first vaccination. It can present with a variety of CNS manifestations from confusion to seizures or coma. Death results in about 15%-25% of the cases, while 25% had some degree of residual neurologic sequelae.

Symptoms of post-vaccinial encephalitis usually occurred between 9 and 14 days following vaccination, and its diagnosis involves excluding other potential causes for encephalitis. The pathophysiology of this complication is not well understood, but it is thought to be a result of a post vaccination immune response, similar to other post-infectious encephalitides. It has not been causally linked to the presence of vaccinia virus in the CNS.

Progressive Vaccinia



Progressive vaccinia or vaccinia necrosum is a rare but serious adverse event that can occur in people with deficiencies of the cell mediated or humoral immune system.

People with progressive vaccinia usually present with a non-healing, expanding vaccination site. The site often ulcerates and central necrosis, or necrosis of the surrounding skin can occur. There is generally little or no inflammation at the site initially, because of the poor local immune response to the infection that is induced by vaccination. This lack of adequate local immune response presumably allows the virus to spread locally and systemically. Medical conditions or medications that suppress the immune system would put a person at risk for this complication. It is currently unknown exactly what level of immune suppression would put a person at risk for this complication.

This woman had chronic lymphocytic leukemia. Notice how the infection from the vaccine site has spread to involve the surrounding skin and the necrotic appearance of the area. This woman also has metastatic lesions on her neck and other areas of her body presumably from hematogenous spread of the virus.

In the photo on the right we see vaccinia necrosum 4 months after vaccination of a 9-month-old child with deficient cellular immunity. The massive necrosis and destruction of tissue caused by the disease is shown.

Eczema Vaccinatum



Eczema vaccinatum is one of the more serious adverse events that can result from smallpox vaccination. This complication can occur in individuals with active eczema or atopic dermatitis, or in those with a history of these conditions even when the condition is not active. A less severe form of eczema vaccinatum can also occur in people with other skin disorders, like psoriasis or burns, that are currently active and effecting the integrity of the skin. Some of the most severe cases of eczema vaccinatum have occurred in people with eczema or atopic dermatitis who were contacts to recently vaccinated individuals.

The rash of eczema vaccinatum can occur anywhere on the body but has a predilection for areas effected by atopic dermatitis or eczema. The rash can be quite extensive and even become confluent with papular, vesicular, or pustular lesions. Patients with significant skin involvement can become severely ill.

This picture demonstrates the extensive skin involvement of eczema vaccinatum in a close contact to a recently vaccinated person. Extensive skin involvement may result from inoculation of vaccinia virus in skin sites with compromised dermal integrity due to eczema or other skin conditions or may be the result of hematogenous spread following initial infection with the

virus. Lesions of eczema vaccinatum can result in skin discoloration or scarring following resolution.

Generalized Vaccinia



Generalized vaccinia usually presents as a rash that develops into vesicular or pustular lesions distal from the vaccination site. This vesicular rash may involve only a few, scattered lesions but can also be more extensive and generalized in nature. Fever and other systemic symptoms may be present but are usually not severe.

Fetal Vaccinia

- 47 cases in world literature (as of 1970)
- Most from primary vaccination early in pregnancy
- Usually results in stillbirth or death soon after delivery
- Pregnancy a relative contraindication to vaccination



Fetal vaccinia is a very rare complication that can occur following primary vaccination of a pregnant woman in the second or third trimester, from hematogenous spread of virus to the amniotic fluid, or directly to the fetus. Only about 50 cases of this complication have been reported in the literature. Studies are contradictory as to whether spontaneous abortions were increased in pregnant women vaccinated during the first trimester. There is no known reliable intrauterine diagnostic test to detect the presence of vaccinia virus.

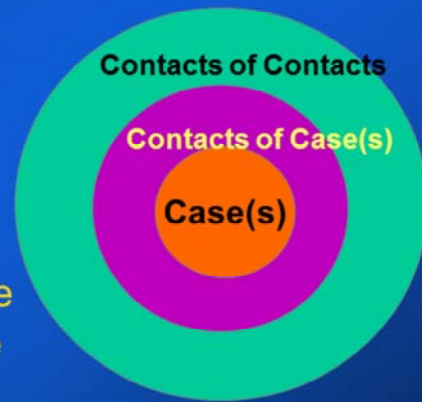
Fetal vaccinia in a child born in the 28th week of gestation. Her mother had received primary vaccination during the 23rd week of pregnancy. The child had typical vaccinal skin lesions and died at 8 days of age. Vaccinia virus was isolated from the placenta.

Smallpox Outbreak Control Activities and Strategies



Surveillance and Containment (Ring Vaccination)

- Search for cases
- Provide a ring of immunity around each case
 - Vaccinate close contacts
 - Vaccinate close contacts of contacts
- Required to control disease
 - most efficient use of vaccine
 - minimize adverse reactions



- Surveillance and containment is the central strategy for containing an outbreak of smallpox. It is sometimes called ring vaccination too, although that term leaves out the infection control measures that also need to be implemented. The principle behind this strategy is to identify cases of smallpox, vaccinate their household and other close contacts, then also vaccinate the close contacts of the primary household and close contacts to the case. Then, if the primary contacts developed smallpox despite vaccination, their close contacts would already be protected and the chain of transmission would have been broken.
- It was possible to have a great impact on smallpox transmission even in areas where overall vaccination coverage was low. This strategy became the key strategy in the global eradication program
- Special surveillance teams were recruited and trained to search for smallpox cases and vaccinate their contacts. They visited each health unit in an area of endemic smallpox to ensure that each week the health officer submitted a report indicating the number of cases seen
- When cases were reported, the teams worked with local health staff to find additional cases and to contain the outbreaks by vaccinating the contacts.
- A special WHO smallpox recognition card was printed and distributed to help in the search for cases

Surveillance

- Pre-Event Surveillance
 - Identify cases with typical presentation
 - Rapid laboratory confirmation
 - Confirmation initiates contact vaccination
 - Passive with more specificity
- Post-Event Surveillance
 - Identify all potential cases (typical/atypical)
 - Clinical diagnosis can initiate contact vaccination
 - Active with increased sensitivity



Surveillance is important both before a smallpox outbreak and after a smallpox outbreak. In the pre-event situation, we might just be able to look for the typical, ordinary type smallpox cases. We will need to confirm the initial case by laboratory testing. A positive laboratory result will lead to the surveillance and containment strategy with vaccination.

In the post-event setting, we will refine our ability to clinically diagnose cases, so we will attempt to find all cases, both typical and atypical. Since the smallpox activities are already underway and we will know that smallpox virus is again circulating, a clinical diagnosis of smallpox is enough to begin vaccination of the contacts. In this setting, we will need active surveillance, with contact being made daily with hospitals in order to track the progression of the outbreak.

Epidemiologic Investigation

- Identify source of initial introduction(s)
- Identify contacts and other population(s) at risk
- Characterize and define outbreak
 - Identify unusual/unexpected features
 - Scope
- Monitor effectiveness of control measures
- Communicate information and define public health recommendations



During the initial phases of an outbreak, the goal of your investigations will be to establish the diagnosis, identify contacts, identify the source of exposure, and ascertain if there are any unusual features of the outbreak.

As the outbreak progresses, we will also need to monitor the progress made in containing the outbreak and we will need to be prepared to change and adjust our outbreak control strategy.

In both stages, public health agencies must be prepared to effectively communicate information about the outbreak and the control strategies to the public, the medical community, and the media.

Contact Tracing

- Goal is to find as many contacts as possible
 - Contact with patient after onset of fever
 - Prioritize based on closeness, length, and date of exposure
 - If too many to find quickly, consider all people in same room (or possibly facility) with smallpox case after onset of fever as contacts



Contact tracing will need to be done quickly and efficiently so that the surveillance and containment strategy works. We have 3 days in which to vaccinate people who have been exposed to the smallpox virus, in order to prevent disease or at least limit the severity of their disease.

(read rest of slide)

Contact Tracing

- Examples:

- Highest priority - people who live full-time in home and other face-to-face contacts after onset of fever
- Next priority – non face-to-face contacts exposed in a medical care facility or in home
- Last priority – people in same facility after onset of fever (other than home or hospital) but without face-to-face contact



Here is one way to prioritize person to receive smallpox vaccination.

Vaccination Strategy



Vaccination

- Already exposed
 - Goal to prevent or decrease illness
 - Must be monitored for smallpox
 - No contraindications (benefits outweigh risk)
- Not already exposed
 - Goal to prevent illness
 - Don't require monitoring for smallpox
 - Contraindications exist
 - Prevent exposure if can't be vaccinated because of contraindications



There are essentially 2 groups of people who may receive smallpox vaccine –

- 1) Those who have been exposed, and
- 2) Those who have not.

Priority Groups for Vaccination

- Those with the greatest risk (exposure or imminent exposure to smallpox virus):
 - Persons targeted by an intentional release
 - Face-to-face contacts with smallpox patients
 - Household members of contacts under surveillance
 - Personnel whose responsibilities will directly expose them to cases or infectious materials (medical, public health responders, etc.)
 - Other essential response personnel (police, military, etc.)



During an outbreak of smallpox, some persons are at greater risk than others for contracting smallpox. Here are those that need to be vaccinated as soon as possible.

Vaccination Strategies

- Contacts to smallpox cases and other priority groups must be vaccinated
- Vaccination of population to support the targeted vaccination needed for outbreak control
 - If enough vaccine
 - If enough personnel resources



As discussed earlier, (read the slide).

Persons who have not been exposed to smallpox virus may be vaccinated if there is enough vaccine and if there is enough personnel to provide the vaccination services. The top priority for vaccine and vaccination resources should always be to find the contacts and vaccinate them quickly.

Isolation and Quarantine



Goals of Smallpox Isolation

- **Protect others from becoming infected**

- Healthcare personnel
- Response personnel
- Other patients

- **Isolate smallpox patient**

- Prevent sharing of airspace (respiratory isolation)
- Prevent direct contact (protective clothing)
- Prevent contact with infectious materials (decontamination)



- Smallpox is transmitted by respiratory droplets and through contact with secretions from smallpox lesions. Droplets can spread about 6 feet and can remain viable for a few hours.

- Isolation of smallpox patients should involve infection control measures to prevent:

- Sharing of air between a smallpox patient and a person susceptible to disease (respiratory isolation and precautions)
- Transmission of the virus to the healthcare provider by direct contact or to others from a healthcare provider with contaminated clothing (contact isolation and precautions)
- Others from coming into contact with infectious materials from the patient (infection control for waste disposal and decontamination measures)

Prevent sharing of airspace with potentially infectious patients

- Negative pressure isolation rooms.
- Separate facilities for larger groups.
- Respirators for unvaccinated care-providers.



This can be accomplished by placing the patient in negative pressure isolation rooms. If the outbreak produces large numbers of patients that can't be accommodated in existing negative pressure rooms, or if no such rooms exist, the patients should be isolated in separate facilities, since there have been documented cases of smallpox transmission in patients housed two floors below.

Personal Protective Equipment

- Use disposable gloves, gowns, and shoe covers.
- Reusable bedding and clothing should be autoclaved or laundered in hot water with bleach.



Personnel should use disposable gloves, gown, and shoe covers for all contact with patients. This precaution is to prevent inadvertent transmission of variola virus from clothing or other contaminated items. Personnel should remove and correctly dispose of all protective clothing before contact with other people.

Reusable bedding and clothing can be autoclaved or laundered in hot water with bleach to inactivate the virus. People who come into contact with materials potentially contaminated with smallpox virus, such as laundry handlers, housekeeping, and laboratory personnel should utilize appropriate protective equipment. If a case of smallpox is confirmed, these personnel should be vaccinated before handling contaminated materials.

Respiratory Protection - Smallpox



- Airborne precautions
- Recommendation: fitted NIOSH N95 or greater respirators for personnel entering patient room



Properly Fitted – air goes through mask filter



For patients with suspected or confirmed smallpox, both Airborne and Contact Precautions should be used in addition to Standard Precautions. Airborne Precautions apply for patients infected with microorganisms potentially transmitted by airborne droplet nuclei 5 microns or smaller. These evaporated droplets contain bugs, that can remain suspended in air, and be widely dispersed by air currents. The respirator should at least meet the NIOSH standard for particulate respirators, type N95. This is the same recommendation that has been made for protecting health care workers against tuberculosis infection.

Isolation Strategies

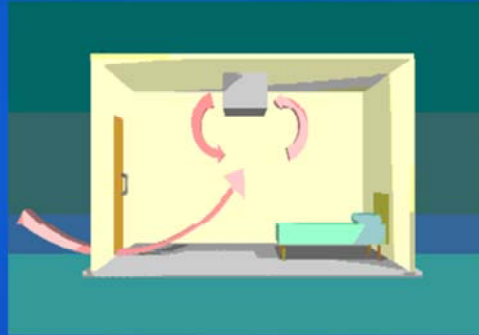
- 3 groups to consider
 - Confirmed or suspected smallpox cases
 - Febrile vaccinated contacts
 - Asymptomatic (vaccinated) contacts under surveillance



- In a smallpox outbreak, there are 3 groups to consider when formulating isolation strategies
 - Confirmed or suspected cases that would be considered immediately infectious to others
 - Vaccinated contacts to smallpox cases that become febrile and may be developing smallpox or may be febrile from the vaccination or some other reason (potentially infectious)
 - and Vaccinated contacts to smallpox case that don't have any symptoms but who are still in the surveillance period for the development of smallpox (not currently infectious but could still develop smallpox)

Confirmed/Suspected Smallpox Cases (Few)

- Known or presumed infectious individuals
- Hospital isolation room(s)
- Rooms under negative pressure
- At least 6 to 12 air changes/hour
- Air vented to outside
- Air not re-circulated to other rooms or areas



- Requirements for individual isolation in hospital or facility where airspace sharing is to be prevented (i.e.. hospital with other patients, unvaccinated people, etc.) have already been discussed
- Isolation rooms should be under negative pressure with engineering controls that assure that air is not re-circulated to other areas of hospital

Confirmed/Suspected Smallpox Cases (Many)

- Designated Facility for smallpox patients
- Aerosol precautions not needed if only potential smallpox cases in facility and no shared ventilation system
 - All people admitted/entering facility vaccinated



- If groups of suspected patients are isolated in a facility designated only for care of smallpox patients, then
 - Special isolation rooms are not needed
 - Make sure that ventilation system (including heating and air conditioning systems) are shared with any other facility
 - All persons entering facility must have been successfully vaccinated recently (including patients admitted to facility)

Febrile Vaccinated Contacts

- Vaccinated contacts with fever (no rash)
 - Two successive temps > 101° F (38°C)
 - Less need for medical care
 - No shared ventilation system
 - Can be housed in same facility with smallpox cases or separate facility
 - All persons in facility require vaccination



Febrile vaccinated contacts must be isolated to assure that they are not experiencing a fever because they have contracted smallpox. This precaution is needed because the first stages of smallpox rash (the time when the patient becomes contagious) may be quite subtle.

Asymptomatic Vaccinated Contacts

- Not infectious
 - Own home or other lodging
 - No special ventilation or medical requirements
- All other persons staying in home must also be vaccinated
 - Household members with contraindications stay elsewhere
- Fever surveillance for 18 days from last exposure or 14 days from vaccination



- Recently vaccinated contacts to smallpox cases that do not have any symptoms (FEVER) are not infectious so don't require facilities with any special ventilation
- They can be monitored in their home for development of a fever (check at least twice a day)
- Can be asked to stay at home during surveillance period for symptoms or may be allowed to travel outside of home if distance is restricted such that a quick return to home is possible if develops fever
- All others staying in home must be vaccinated in case the contact develops smallpox
- Other household members with vaccination contraindications that can't be vaccinated to protect themselves if the contact does develop smallpox while at home under surveillance should stay elsewhere until the contact is no longer at risk of developing the disease

Decontamination

- Air:
 - UV Light Sensitive
 - Exhaust, Good Air Flow
- Surfaces:
 - Diluted bleach solution (Fresh every day)
 - Hospital disinfectants
- Blood, pus contaminated equipment:
 - Wash before disinfecting



- The spaces where smallpox patients have lived or been cared for may require decontamination.
- Smallpox virus is sensitive to UV light inactivation
- Good air flow and exhaust to the outside will help to dilute the concentration of any airborne particles and exposure the virus to UV light
- Contaminated surfaces can be cleaned with fresh, diluted bleach solution or other hospital disinfectants that inactivate virus
- Reusable medical instruments or surfaces contaminated with blood or pus should be washed to remove the material in addition to disinfection

Decontamination

- Laundry:
 - Contain separately
 - Dissolving laundry bags if available
 - Don't sort first, wash, then sort
 - Hot water with detergent and/or bleach
- Household:
 - Basic cleaning
 - Wash all clothing in hot w/ bleach if possible
 - Public health review of home



- Laundry and contaminated personal protective clothing should be placed in appropriate containers upon leaving an isolation area
- For reusable laundry, dissolving laundry bags that can be placed in the wash without removing the laundry are preferable
- Laundry should not be sorted before washing, should be placed directly in the wash, then sorted
- Surfaces in homes where smallpox cases were present should be wiped down
- Contaminated clothing can be washed in hot water with bleach added if possible

Burial Issues

- Contain and seal remains
- No open funeral
- Cremate, if possible:
 - If not, bury, but no embalming
 - Put in ground, not “on surface.”
 - If you can’t bury in ground, move them



- Embalming and open casket funerals should not be done for people who have died from smallpox
- Outbreaks have been associated with open casket funerals
- If possible, the safest way to deal with remains is cremation, but if that is not possible, containing and sealing the remains then burying them in the ground can be done

Specimen Collection





These are examples of lab materials useful for collection of orthopox specimens for laboratory testing including the plastic vials in which lesion crusts would be shipped to the LRN site for analysis.

Specimen Collection Vesicles

Use scalpel or 26 gauge needle to unroof vesicle:

- Roof goes to collection tube.
- Scrape base of vesicle with blunt edge scalpel or wooden applicator, apply to microscope slide.
- If Electron Microscopy grids available
 - Lightly apply EM grid, shiny side down, against lesion:
 - Repeat (x2) using more and less pressure.



For collection of vesicles, it's suggested to use a scalpel or needle to unroof the vesicle. The skin or scab that constitutes the roof goes to the collection tube and is sent otherwise dry. One procedure suggests gently scraping the base of the vesicle with a blunt end of a scalpel or wooden applicator and trying to smear some of this on a microscope slide. An electron microscope grid, with ultra-thin plastic covering, can be gently touched down (shiny side or plastic film-side) against the lesion. This can be repeated perhaps three times per lesion (resulting in three EM grids).

Specimen Collection Vesicles

- Repetitively touch a microscope slide to the lesion (touch-prep)
- Allow slide (and EM grids) to air dry for 10 minutes. Store in slide holder (or grid box)



Touch preparations are made by repetitively touching a glass microscope slide to a lesion. The slide and/or EM grid are allowed to air dry for ten minutes. Store a slide in a slide holder and an EM grid in the appropriate box.



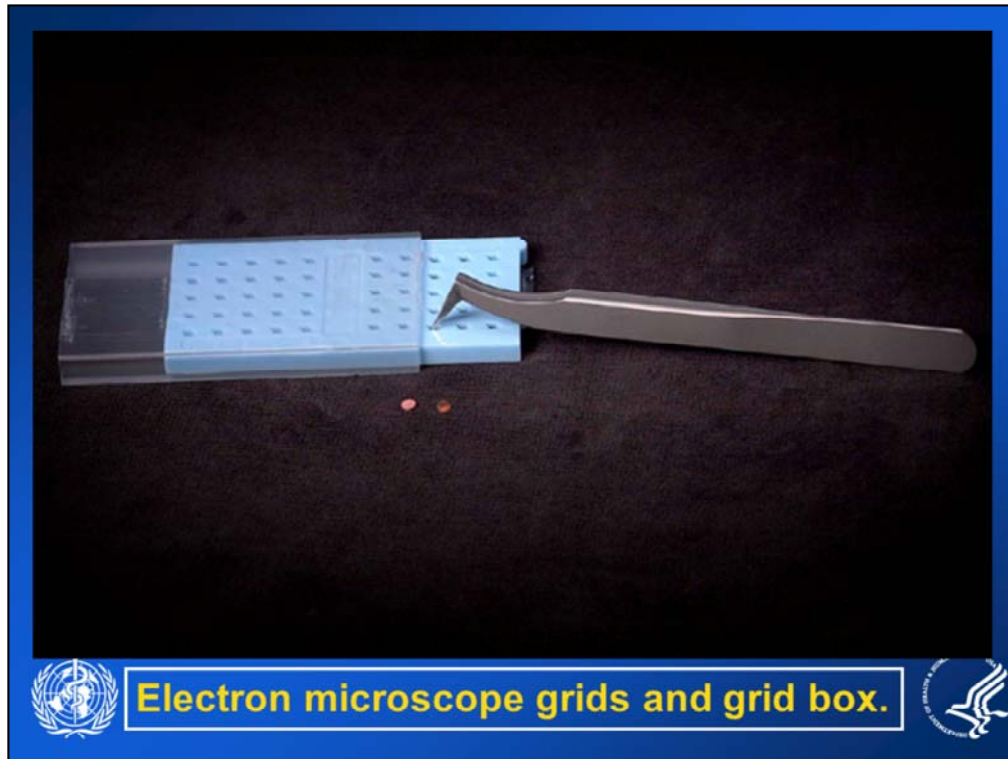
This is an example of lifting a crust – in this case an mature scab from a vaccination site.



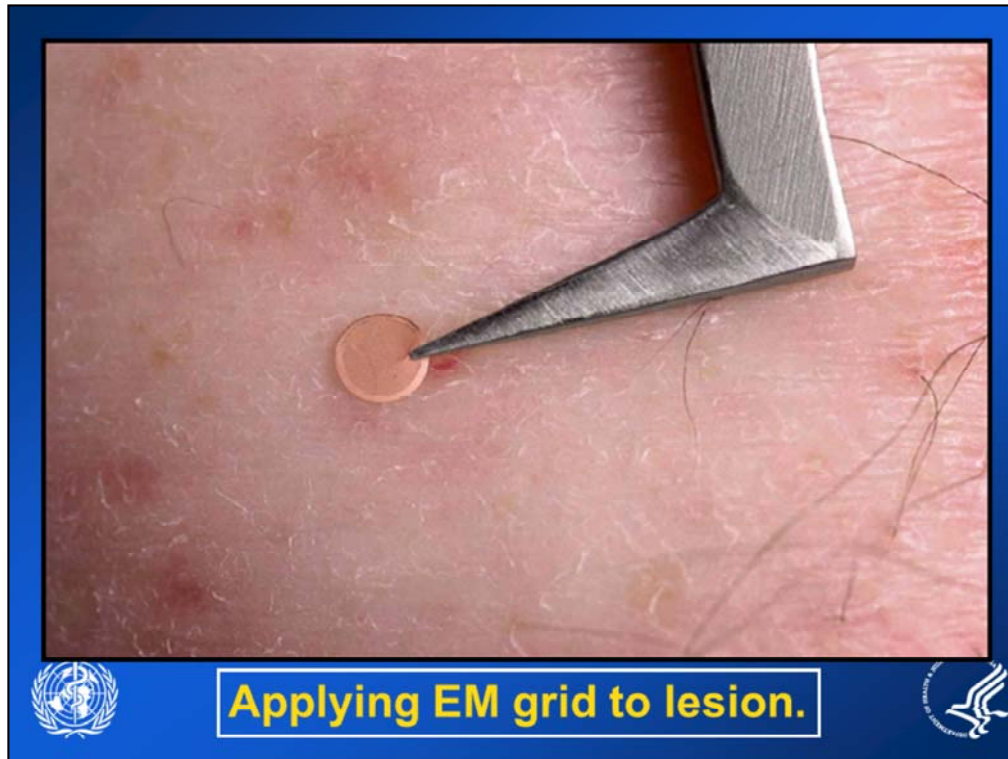
This is the same scab being prepared to be put into a vial as sterilely as possible.



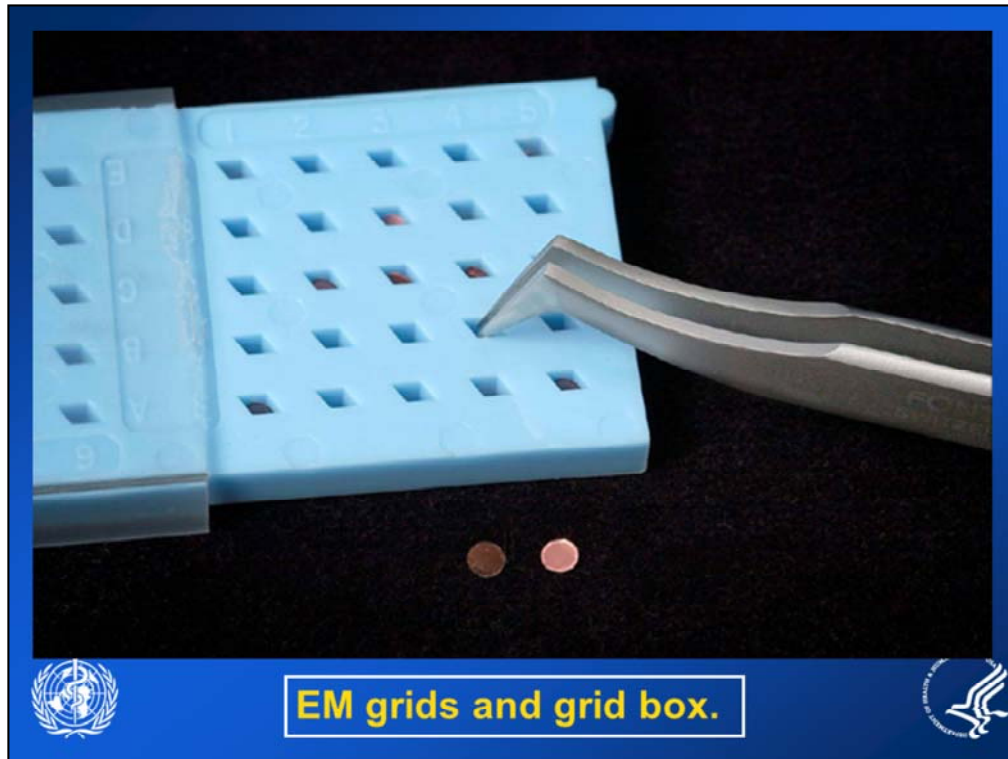
This is a simulated orthopox lesion and the making of a touch-prep with a glass or plastic microscope slide. The same lesion is touched 3 times with the same slide.



These are electron microscope grids, forceps for handling the grids, and the box for the grids.



Here, the electron microscopic grid is being used to touch down on the lesion.



Close-up of the EM grids and the box.

Specimen Collection

- Biopsy: 3.5 - 4 mm punch biopsy, bisect lesion, or obtain 2 biopsies:
 - Place 1 sample in specimen collector tube,
 - Place 1 sample in formalin
- Serum, if serology considered useful



Biopsy specimens should either be split in two or taken in duplicate so that one specimen can be fixed in formaldehyde for histopathology, while the other is used for DNA detection or virus isolation. Serum, if necessary, can be collected as well.

Specimen Transport How to Send

- Standard diagnostic specimen shipping guidelines available:

www.bt.cdc.gov/labissues/PackagingInfo.pdf

- Serum, if collected, should be shipped frozen:
 - If unable to separate serum from blood on-site, send whole blood refrigerated.



For vaccinia testing, standard shipping guidelines are appropriate. Standard diagnostic specimen shipping guidelines are available at the website listed on the slide here (www.bt.cdc.gov/labissues/packaginginfo.pdf). If serum is collected, it is highly advisable to separate the serum from the blood on site. If this is not possible, however, one can send refrigerated whole blood to the LRN laboratory.

Specimen Transport How to Send

- Formalin fixed tissue:
 - Must be shipped at room temperature.
 - DO NOT FREEZE.
- EM grids:
 - Must be shipped at room temperature.



Formalin-fixed tissue must be shipped at room temperature, not frozen. Electron microscopic grids must be shipped at room temperature.

Specimen Transport How to Send

- All other virus-containing material:
 - Must be stored and shipped frozen.
 - If overnight delivery possible, specimen may be shipped immediately at room temperature or refrigerated.
- Keep all virus-containing material out of direct sunlight.



All other virus-containing material must be stored and shipped frozen. However, if overnight transportation to the LRN lab can be arranged, freezing of fresh viral specimens is not necessarily required. Keep all virus-containing material out of direct sunlight.

Shipping Biological Specimens

Infectious Substance

- UN Hazard Class 6
- UN Division 6.2



UN = United Nations



Infectious Substances are defined as United Nations or UN Hazard Class 6, Division 6.2 and must be packaged, marked, and labeled as such.

Shipping Biological Specimens Infectious Substances

- Primary Container
 - Positive Seal



- Absorbent Material



The primary receptacle is the specimen containing the infectious substance. It must be water tight and the lids should be sealed with adhesive tape. The entire content of the primary receptacle is considered infectious.

Multiple primary receptacles must be separated or individually wrapped to prevent breakage. Use enough absorbent material to absorb the entire contents of the primary receptacles. The primary receptacles must then be placed in packaging to protect them against damage and leakage so that the specimens arrive at the destination in good condition and also protect the hundreds of people that will be handling your shipment until it arrives at its final destination.

Shipping Biological Specimens Infectious Substances

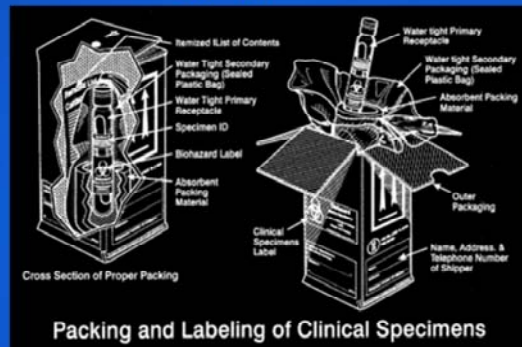
- Secondary Packaging
- Water-tight
- Leak proof



After the primary receptacles are sealed and wrapped, place them in the secondary container. Be sure to add enough filler so that the primary receptacles fit snugly. If the bottom of the primary receptacle isn't wrapped, put some padding in the bottom of the container and add some to the top if necessary to absorb any shock to the outer shipping container.

Shipping Biological Specimens Infectious Substances

- Must be approved by the United Nations.
- Designated as UN Certified Packaging or UN Specified Packaging.



Shipments of infectious substances require special packaging known as UN Specification packaging.

What's so special about this secondary packaging?

This packaging has been rigorously tested and meets the packaging requirements per the DOT and IATA regulations for infectious substances.

Resources

- Smallpox
 - <http://www.bt.cdc.gov/>
 - <http://www.who.int/emc/diseases/smallpox/>
- ACIP Vaccination Recommendations
 - http://www.cdc.gov/nip/smallpox/supp_recs.htm
 - <http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5010a1.htm>
- Smallpox Response Plan
 - <http://www.bt.cdc.gov/DocumentsApp/Smallpox/RPG/index.asp>
- Rash Illness Algorithm
 - <http://www.cdc.gov/nip/smallpox/Providers.htm>

