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INFECTED INANIMATE OBJECTS (FOMITES) AND THEIR ROLE IN TRANSMISSION OF SMALLPOX

by

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Virtually all cases of smallpox are found, on investigation, to have experienced close contact with an antecedent case. However, there have been a few instances where, despite the best possible efforts on the part of the investigator, no source could be found, with the result that it was presumed that some inanimate object or non-human source played a role in the transfer of the disease. In the majority of episodes in which fomites have been incriminated, the evidence has been indirect, arrived at only by a process of elimination and by circumstantial evidence.

A person suffering from smallpox voids variola virus throughout the course of the disease. Virus can be isolated from nasopharyngeal droplets and discharges, saliva, tears, urine, faeces and scabs. The amount of virus voided seems to depend upon the extent of involvement of the mucous membranes and skin, and hence the clinical variety of the case. It is evident that certain inanimate objects which are used by smallpox patients may become contaminated with variola virus and therefore may be considered as potential sources for transfer of the virus.

Clinical and epidemiological evidence strongly suggest that "to be infective" (capacity to infect) is different from being "infectious" (harbouring a live virus). Any source, inanimate or animate, may be infectious but not all of them are capable of serving as a source for the infection of susceptible persons. As in the case of smallpox patients, they are infectious from "day one" of the disease till the day when the last scab separates, although epidemiological evidence indicates that the maximum infectivity is largely confined to the early acute stage of the disease. Thus, in discussing the role of inanimate objects in transmission of disease, it is important to define firstly whether inanimate objects used by smallpox patients can become infected with variola virus; secondly, how long they retain such infection; thirdly, whether such infected inanimate objects are capable of playing a role in transferring the virus and lastly, to what extent, in fact, such infected inanimate objects play a role in transmission of smallpox in a community.

Common inanimate sources of infection

There are several materials and objects, which have been incriminated as sources of infection in several smallpox outbreaks in the past. The following are some such outbreaks as described by Dixon (1962).[1]

1. Clothing and bedding

Hendon (1927), Barnsley (1947), Brighton (1951), Hague (as reported by de Jong, 1956), Tabriz (as reported by Fredericson et al., 1950).

2. Cotton

Stockport (as reported by Corbin, 1914-15) (1908), Heywood (1910), Colne (1910), Chadderton (1910), Bury (1911), Oldham (1913), Milnrow (1914), Blackburn (1934), Oldham (1936), Wigan (1938), Dewbury (1904), Pennines (1953), Rochdale (1952).

3. Lace-making materials (as reported by Boobbyer, 1895).

4. Toys, coins etc. (as reported by Copeman, 1920; Kamal Bey, 1946 and 1951).

5. Letters

Devonshire (as reported by Karkeek, 1894).
Nottingham (as reported by Boobbyer, 1901).

In addition, currency notes, goose feathers, rags, stationery, etc., also have been mentioned as sources for transmission of smallpox virus. As previously stated, in the majority of these episodes there is no direct evidence to trace the infection to these sources. In a few, the obvious possibility that infection occurred as a result of direct contact with a smallpox patient was overlooked and the remote possibility that infection was acquired from infected inanimate objects was assumed and described.

Laboratory evidence - results of various studies

Clothing and bedding

Studies in Madras (Downie et al., 1961)[2] showed that variola virus can be isolated from throat washings from cases of smallpox from day three (calculated from the date of onset of fever) of the disease up to day 14, with the maximum frequency of isolation during day six to nine. It was also found (Downie et al., 1965)[3] that circumoral skin swabs and swabs taken from pillow covers of pillows used by smallpox patients, yield virus from day six of the disease onwards. Large quantities of virus were isolated from bed-sheets from day eight, probably the result of breaking down of lesions in the early stages and from scabs in the late stages of the disease. Naturally, such clothing has to be considered as a potential source of infection. A limited study has been conducted in our laboratory (Rao et al., 1971)[4] to determine the viability of variola virus in infected clothing.

A standard procedure is followed (except in one case) for the collection of infected bedding. The patient is admitted into a separate cubicle ward and from the day of admission the bed-sheets and pillow cover are not changed. On the sixth day after admission, the patient is transferred from this experimental room to the smallpox ward. The infected bedding is collected and preserved in various ways. In one instance a telegram was sent to the Health Officer by us to request that the bedding used by the patient (an outpatient) not be changed until collected by our epidemiological unit. The dhoti used by the patient was collected on the twenty-first day of disease, though we do not know how long the patient actually wore it. In all probability, as per the custom in such circumstances, he would not have changed it since the onset of rash. To collect specimens for culture from the infected clothes, the infected surface was exposed and about 20 strokes were made on the infected surface with a cotton swab wetted with normal saline. This was inoculated into 2.0 ml of normal saline, agitated, squeezed and then discarded. On a few occasions a one inch square piece of cloth from the infected surface was cut and soaked in 2.0 ml of normal saline, agitated, squeezed and discarded. An aliquot of 0.1 ml of inoculum was used for culture on CAM as per standard techniques.

The infected bedding of three cases was separately folded, bundled with the exposed surfaces turned in and kept on a raised platform in a well-ventilated masonry shed provided with a cement asbestos roofing. The bedding of one case was folded, bundled and kept in one corner of the experimental room. The bedding of two cases was left on the bed itself without disturbance and the bedding of two additional cases was folded and kept in closed airtight wooden boxes. The boxes were kept in a cool but non-airconditioned room. The results of these studies are summarized in Table 1.

Conclusions from this study must be tentative as the number of specimens collected were few and a systematic procedure of sampling at regular intervals was not done. However, some idea of the viability of the virus on such fomites under different conditions of preservation is obtained.

After cessation of exposure, the quantity of virus in the bedding appeared to be invariably low. Except in cases five and seven where the pock lesions on CAM were semi-confluent and confluent, all the CAM membranes showed only a few, discrete pocks.

The viability of the virus appears to vary to some extent depending upon the manner of preservation. The results are not quite comparable from case to case, since in several instances there were long intervals during which samples for cultures were not collected. However, when stored in a cool dark place (as in a box) the virus was viable for a period of 66 days; when kept bundled in a well ventilated shed, it was viable up to 11 days; when kept on the bed undisturbed, with the infected surface exposed to indirect light, virus could be isolated up to day 10 only and when the clothes were bundled and kept in the same room, it could be isolated up to day 12. Thus, it would appear that variola virus is likely to remain viable in infected clothes for a maximum period of 30 to 40 days if kept bundled in a well ventilated room and for 60 to 70 days if kept in a dark, cool and poorly ventilated room. It appears that exposure of the infected surface even to indirect sunlight destroys the virus quickly.

Of the eight patients from whom the infected bedding was collected and studied, two were vaccinated and six were unvaccinated. The quantity of virus appeared to be comparatively less in the clothes of the vaccinated patients. Even on their bed-sheets there was not much virus, and in case five almost no virus could be detected.

Case one was of the flat variety and case five of the modified variety. The others experienced the ordinary variety of smallpox. As noted above, almost no virus could be detected on the infected clothing of the modified case five. Among the others there were no evident differences.

Clothes of all cases were preserved from January to March except in the instance of case four (July to September). In the latter case, the bedding was positive on day 12 and negative on day 46. In the absence of information between day 12 and day 46, it is not possible to state whether seasons of the year influence the duration of viability of virus in the infected bedding.

Cotton

MacCallum & MacDonald (1957)[5] as quoted by Dixon (1962), have carried out studies on the survival of variola virus in scabs preserved in raw cotton at 30°C at different relative humidities. They could recover virus from scabs as late as 185 days when the relative humidity was 58 per cent. and for a shorter duration when the humidity was higher. Virus in the scabs was also found to be viable even after 530 days when stored at room temperature at 55 per cent. relative humidity in indirect sunlight. The results of these studies indicate that the virus is remarkably viable in scabs under such conditions of storage. Whether cotton surrounding scabs could become infected by virus released from the scabs under such storage conditions seemed important to determine because, while handling cotton, the scabs themselves cannot be inhaled as such. Unless free virus is present in very small particles, it would seem unlikely that infection could occur.

Recently, we have undertaken studies to determine whether scabs stored in cotton can release the virus and infect the surrounding cotton. For this purpose, we have cut 10 cm square pads of cotton (about 2 cm thick) from the usual packed absorbent cotton rolls (used for dressings in hospitals). Between two such pads, smallpox scabs weighing 0.2 g (about 20 in number) were kept in an area of 2 cm^2. Two identical pads were taken and the area where the scabs were kept was previously wetted with 1.0 ml of distilled water to keep it humid. These two sets of pads were kept on the verandah exposed to indirect sunlight. On the eleventh day of storage, the scabs were separately taken out and cultured. Cotton around the area where the scabs were kept, to a depth of 0.5 cm, was carefully collected, soaked in 2.0 ml of normal saline, agitated, squeezed and discarded. An aliquot of 0.1 ml was used for culture on CAM. No virus was isolated from the cotton. Thus, no virus was released from the scabs to infect either the moist or dry cotton. Hence it is doubtful whether raw cotton, even if infected with smallpox scabs, could be blamed as a source of infection for the outbreaks described by Dixon. It is noted further that Dixon himself stated that the fact that several towns with major cotton industries remained free from smallpox outbreaks at a time when these so-called cotton-borne outbreaks occurred, is itself evidence against the theory that cotton was the source of infection.

Other miscellaneous inanimate objects

No laboratory studies seemed to have been performed regarding the possibility of coins, toys, stationery, etc., becoming infected from the patients or about the viability of the virus on such objects. We too have had no occasion to make such studies. However, we happened to investigate (Rao et al., 1971)[4] in another connexion the viability of variola virus on filter-paper and on cotton threads (taken from a piece of lint) when artificially infected either with egg passaged variola suspension or vesicular fluid from smallpox patients. On filter-paper, the virus was viable for more than 144 hours and on cotton thread for nearly 216 hours at room temperature. We were able to isolate the virus from samples of vesicular fluid from smallpox cases collected on cotton swabs after seven days. These observations are of interest as it would seem theoretically possible for such materials to become contaminated with virus if handled by a patient.

As regards coins, again a small study was conducted by us. A 0.02 ml aliquot of egg passaged variola virus emulsion (titre 10^6) was placed on a large number of nickel one Naya paise coins. These coins were kept in a Petri dish on the verandah in indirect sunlight. Every day one such coin was taken, 0.18 ml of normal saline was added and 0.2 ml (10^1) of emulsion was diluted to give a dilution of 10^2. The results showed that there was very little virus on the coins at 72 hours and no virus at all at 96 hours.

Effect of direct sunlight on infected inanimate objects

Sun is a wellknown disinfectant but whether the heat, the light or the ultraviolet rays or all three are responsible for the destruction of organisms is not known.

In Madras, naturally infected clothing from smallpox patients was found to become virus free in two to three hours after exposure to direct sun. Virus in smears of vesicular fluid on glass slides was destroyed within an hour and vesicular fluid in capillary tubes was virus free in two hours on exposure to direct sunlight. A piece of cloth 1 in^2, soaked in 1.0 ml of egg passaged virus emulsion, was exposed to the sun during August between 11 a.m. and 3 p.m. At four hours, the cloth was virus free. In fact, the virus might have been destroyed earlier but this was not investigated. Nickel one Naya paise coins with a thick drop of 0.02 ml of egg passaged variola virus, were virus free on exposure to the sun for 30 minutes.

If these inanimate objects which have been artificially heavily contaminated with variola virus become virus free in a matter of 30 minutes to three hours after exposure to direct sun, I am sure any fomites, including blankets, would also be virus free within two to three hours

after exposure to direct sunlight. As previously noted, even indirect sunlight can destroy the virus on these inanimate objects in a matter of a few days. Hence, infected clothing and other fomites, if exposed in a well ventilated room, will be relatively free from virus in a short time. However, storage in a dark, cool, poorly ventilated room permits the virus to remain viable for a much longer duration.

The infectivity and the role inanimate objects play in the transmission of smallpox

Inanimate objects could, of course, become infected when handled by patients but are they capable of transmitting the disease? To our knowledge, smallpox is an inhalation disease. Whatever the source, the virus has to enter through the nose by inhalation. To become infected from these sources, therefore, the virus has to be released into the atmosphere. This may readily happen when clothing or cotton is dusted, provided the virus is in a relatively free form and not in scabs. In fact, in a few instances, infection has been documented to occur through inhalation of virus from heavily infected clothing. As regards other objects, the release of free virus in this manner is impossible. It would seem possible only if a person put his fingers, contaminated with the virus, into his nose.

Summary

Several instances are recorded in the literature where inanimate objects (fomites) such as clothes, rags, cotton, coins, toys, stationery, etc., have been incriminated as sources of infection for the transmission of smallpox, but for the most part this is only circumstantial evidence.

Laboratory evidence is available to show that any or all of the above-mentioned objects can be infected when handled by smallpox patients and hence they have to be regarded as potential sources of infection.

Recent studies of the viability of variola virus in infected clothing have shown that virus can be isolated from such infected clothing for a period of 60-70 days if the clothing is bundled and kept in a cool, dark and poorly ventilated room or box; for 30-40 days if the clothing is bundled and kept in a well ventilated room; for not more than a few days if exposed to indirect sunlight, and for three to four hours only if exposed to direct sun. However, it was found that even after five days continuous exposure to the patient, there was not much virus in the clothes and the virus concentration rapidly declined once exposure ceased.

Though exhaustive studies were not undertaken, it was found that cotton embedded with smallpox scabs does not seem to get infected, indicating that scabs by themselves do not seem to release the virus easily. Unless the cotton is infected with scab dust or nasopharyngeal droplets, it may not be a source of infection.

As regards other objects like filter-paper, cotton thread and cotton swabs infected artificially with smallpox vesicular fluid or egg passaged variola virus, the virus was found to be viable for about seven to 10 days at room temperature (37°C). On metal coins, the virus was viable for only three days kept in indirect sunlight.

Exposure to direct sun is the best method of disinfection. All the objects tested could be rendered virus-free in 30 minutes to three hours by this method.

From the data available it is suggested that although various inanimate objects are likely to become contaminated when handled by smallpox patients, the possibility of these being sources of infection for others is remote for the following reasons:

1. The virus concentration is so low that it is not sufficient to infect human beings.

2. The virus concentration, even if it is initially high, falls rapidly in the course of a few days when the objects are kept in well ventilated rooms or even indirect sunlight.

3. The virus is not easily released from any of these objects except the clothing, which may release the virus on dusting.

4. Epidemiologist experience shows that smallpox is a disease that cannot be contracted easily unless there is heavy, continuous and close exposure.

While susceptible persons may very occasionally contract infection from heavily infected clothing, the likelihood of contracting infection from other objects is most improbable.

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TABLE 1. SUMMARY OF THE RESULTS OF STUDIES OF VIABILITY OF VARIOLA INFECTION

Manner of preservation of bedding	Case Nos	Vaccination status of patient	Clinical variety of case	Period of the year	Day after first exposure when the bedding yielded last positive on culture	Day after first* exposure when bedding yielded first negative culture and was consistently negative after
Bundled and kept in ventilated masonry shed	1	Unvaccinated	Flat	Jan-March	37	76
	2	Vaccinated	Ordinary	Jan-March	33	62
	3	Unvaccinated	Ordinary	Jan-March	36	58
Bundled and kept in the room	4	Unvaccinated	Ordinary	July-Sept	12	46
Spread on the bed	5	Vaccinated	Modified	February	7	9
	6	Unvaccinated	Ordinary	Feb-March	10	12
In wooden box	7	Unvaccinated	Ordinary	Jan-April	66	78
	8	Unvaccinated	Ordinary	Jan-March	56	73

* The interval in days is counted from the first day on which patient was in contact with pillow, bed-sheet, etc.