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DANGER
DUE TO INFECTIOUS AEROSOLS
IN THE LABORATORY

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DANGER DUE TO INFECTIOUS AEROSOLS IN THE LABORATORY

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Fort. der biologischen Aerosol-Forschung
(Progress in Biological Aerosol Research)
1957-1961; pp 148-152.

The task of medical-microbiological laboratories is the detection and investigation of infectious agents. For this purpose it is necessary to work up infected material, prepare cultures of the pathogenic agents and subject the pure cultures to various procedures. Although the microorganisms have become visible in the form of their cultures and the personnel has been trained and has acquired adequate practice in regard to the contact with these cultures as well as with infectious material in general, there nevertheless exist many ways in which the infectious agents may escape controls, in view of the large number of manipulations to which they are subjected; manipulations which become more numerous and more complicated with the advance of technique. As a result the laboratory personnel is exposed to certain hazards. The inclusion of virological investigation in routine diagnoses has the consequence that in addition to bacterially determined diseases one must count in many laboratories also with diseases of viral origin (15, 16).

As is the case in nature, the spreading of infectious diseases in the laboratory can take place in many ways, namely, through contact, by means of vehicles, by vectors and through the air. In regard to the transmission of infectious agents, particularly transmission through the air (called "air-borne transmission" in the English literature) there are now in existence several solid if sketchy concepts relating to occurrence and mechanism of action (5).

In addition to the usual manner of air-transmitted infection, which in most cases originates from an infected person, there exist in the laboratory particularly favorable possibilities for the aerogenic spreading of those germs with which one works experimentally or which are being subjected to investigational techniques. This spreading originates predominantly from bacterial cultures, and less frequently

from infected materials, and is further distinguished from the known air-transmission of diseases by the type of infectious agent and the mechanism of formation of the bacterial aerosol. Depending on the area, method and type of investigation, the following groups of microorganisms may be transmitted in the laboratory through the air:

a) Germs which otherwise are also transmitted through the air (e.g. tubercle bacilli, diphtheria bacteria, streptococci, influenza- and ornithosis viruses, fungi such as histoplasma, coccidioides, etc).

b) Germs in whose case the aerogenic mode of infection is rare (e.g. anthrax bacilli, plague bacteria, staphylococci), and

c) Agents whose natural place of entry is practically never the respiratory system (e.g. tularemia bacteria, glanders bacilli, brucellae, rickettsia, yellow-fever- and encephalitis viruses).

Diseases caused by bacteria belonging to the first group represent the main contingent of the aerogenic laboratory infections. Depending on the number and properties of the agents and the resistance of the host they exhibit, in general, known disease phenomena. When anthrax- or plague bacteria are incorporated by the organism via the respiratory system one must count in most cases with severe illnesses. The inhalation of microorganisms belonging to the third group results in unusual, partly novel disease pictures whose understanding and treatment are made difficult by the lack of appropriate experience.

Infectious aerosols may be produced in the laboratory in many ways. According to Reitman and Wedum (12) almost every operation in the laboratory leads to the formation of an aerosol, which under certain circumstances will contain bacteria, and in most cases the aerosol source is only slightly removed from the face of the laboratory worker (19). The case is almost always that of a polydispersed aerosol, which results mainly from the abrupt arrestment and subsequent atomization of a rapidly moving liquid. In general only a small number of particles are immediately of such order of magnitude that they can remain suspended also in stationary air. The ability of bacteria to float is mainly attained as follows: Either the liquid evaporates quickly from larger particles in the dry laboratory air so that "droplet nuclei" form, or the bacteria sprayed on surfaces will, after drying, be carried into the air together with dust or adhering to the surface of the latter ("air-borne" and "dust-borne" infection, respectively) (5).

We shall now list a few laboratory procedures which are particularly apt to lead to a spraying or atomization of infectious material:

1. When bacteria-containing liquids are mixed by means of pipettes or are blown out from the latter, there results, not infrequently, a spray consisting of numerous droplets. In this way both the laboratory air and the work location may be infected without the awareness of the

laboratory worker (1, 6, 10, 12).

2. The inoculation and other forms of processing of bacterial cultures are carried out mainly by means of ignitable metallic loops. When such a loop is moved quickly through the air the liquid film adhering to it may be torn apart and in this way the air may become infected. Aerosols may also result during the ignition of loops, the dipping of hot loops into liquids or the vibration of loops during striking, knocking or sliding over uneven surfaces (for example on the smearing of cultures in the preparation microscopic slides, or for slide agglutination)(1, 10, 12).

3. It is generally known that the breaking of ocean waves leads to the formation of sea-water aerosols. A similar process, if on a small scale, takes place when liquid bacterial cultures are vigorously and abruptly agitated in shaking devices, mixers, fermenters, sprayers, by means of stirrers, ultrasonic waves or centrifuges. If the container enclosing the culture is firmly closed, the aerosol escapes only when the vessel is opened. This escape of contaminated aerosol will be just as unnoticed by the personnel as the fact that the stoppers (corks, cotton plugs, screw caps) of the agitated vessels are also contaminated (1, 6, 10, 12, 14, 17, 19, 20).

4. The processing of solid bacterial cultures or infected materials (particularly of human or animal organs) in mortars or similar apparatus can also lead to the formation of an aerosol (2, 9, 12).

5. Recourse is often had at the present time to the freezing-drying method for the preservation of bacterial cultures. Microorganisms may escape, unchecked, into the surrounding atmosphere both during the process of drying and after the opening of the glass container kept under vacuo (10, 12, 14).

6. Infected laboratory animals represent a source of hazard of the first order for the laboratory personnel. In the cages the excretions of the animals cause the atmosphere to become enriched in bacterium-containing droplets, droplet nuclei or infectious dust particles. The constantly active animals bring about a continuous agitation of the cage atmosphere and stir up the dust infected by the excretions. An intranasally infected experimental animal can produce a spray of germ-containing particles, and thus endanger the environment, for a prolonged period of time (3, 8, 9, 14, 19).

7. It is general laboratory practice to thoroughly disinfect the visibly contaminated sites following a decay of bacterial cultures or the breaking of a culture container, particularly when the accident occurs in the centrifuge. It often escapes the awareness of the personnel, however, that in this way an infectious spray is produced through which not only the vicinity of the site of the accident but also the entire laboratory atmosphere becomes infected (1, 10).

In order to mention still further possibilities of environment-determined, aerogenic hazards, it must be pointed out that in addition to infectious aerosols, other types of aerosols -having toxic or allergic effects- may also be produced in the laboratory.

There can be no doubt that work with infectious material increases the risk of infection (3, 7, 8, 10, 11, 12, 14, 15, 16, 18, 19). In Germany Schafer (13) reported more than 200 laboratory infections which occurred between the years of 1939 and 1949. On the basis of the literature and by means of a questionnaire Sulkin and Pike (16) collected 1342 laboratory infections which occurred in the U.S., 3 percent of which had a fatal outcome. According to a report by Cook (3) there have been 22 laboratory infections over a period of 28 years in a research station in the State of Texas. Investigations regarding the occurrence of pulmonary tuberculosis led Reid (11) to the conclusion that the personnel of medical laboratories are considerably more exposed to the danger of tuberculosis than are the other, comparable occupational groups.

It is not yet clear which of the modes of transmission mentioned at the beginning of this article plays the greatest role in laboratory infections. Probably most of the illnesses originating from cultures or infected materials are transmitted through direct or indirect contact (8, 16). Sulkin and Pike (16) could establish an aerogenic mode of infection in 12.9 percent of their cases.

The formation of infectious as well as of toxic or allergic aerosols in the laboratory takes place, in most cases, unobserved and invisibly. The laboratory personnel does not know where the aerosol sources are located. They consider that certain work processes are harmless which in reality are connected with serious health hazards. The personnel working in the laboratory believe themselves adequately protected by the usual accident-prevention measures (4) and are not aware of the fact that it is possible for infections to occur a long time after the formation of an aerosol on account of the flotation duration of the latter. On the basis of all this the assumption seems justified that a not insignificant proportion of laboratory infections are caused by infectious aerosols. Perhaps there are among these infections some that have a clinically mild course and which are considered to be natural infections and not related to the laboratory environment.

The studies which have indicated the possibility of the formation of bacterial aerosols in the laboratory make it appear fitting that the accident-prevention measures be extended to include also this sector. In the case of occurrence of illnesses among laboratory personnel one should, for the sake of clarifying the epidemiology involved, as well as for assessing the legality of insurance claims, keep in mind that work in microbiological laboratories makes the personnel particularly disposed to health hazards related to the type and formation of infectious aerosols.

Summary

Many technical operations in the microbiological laboratory may lead to the formation of a bacterial aerosol. The hazards to the laboratory personnel created by these aerosols are particularly important for the following reasons:

1. Depending on the type and number of the infectious agents mild or even unusual and severe disease syndromes may be produced, the latter especially in those cases in which the bacteria reaching the laboratory atmosphere are of a type which under natural circumstances are rarely or practically never transmitted by the atmospheric route.

2. The formation of the infectious aerosol takes place unobserved and invisibly. The aerosol-producing operations are considered to be harmless. The personnel believes that the customary safety measures afford adequate protection and are not aware of the fact that due to the duration of flotation of the aerosol infections may come about over a prolonged period of time.

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