Air Sampling for Respiratory Disease Agents in Army Recruits

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INTRODUCTION

Among the few reports relating to the quantitative parameters of the transmission of many types of respiratory infection, are those of Riley for tuberculosis (4) and Tigrert et al. for Q fever (5). These reports suggest that adequate quantitative information can be obtained in natural situations only if it is possible to sample volumes of air which are very large in relation to the respiratory volume of man.

In a recent epidemiological study, we had the opportunity to employ the Large Volume Air Sampler (LVS) described informally by William Perkins at this meeting. The device has been described in detail by the manufacturer (Rept. 2586 of Litton Industries, Inc., Minneapolis, Minn.). The present report indicates a technological potential of importance, in spite of the preliminary nature of the data and the present lack of estimates of quantitative reliability.

EPIDEMIOLOGICAL PROBLEM

Acute respiratory disease (ARD) in Army recruits occurs in epidemic form in basic training centers all over the United States. The disease is caused mainly by adenoviruses, especially type 4, and occurs regularly each winter in new recruits during the 2nd, 3rd, and 4th weeks of the basic training cycle. Meningococci and group A streptococci are other common respiratory pathogens which may produce epidemic disease in recruits. Rates of infection and febrile illness vary during the year and from year to year, owing to a number of poorly understood factors, including physical and emotional stresses.

The pattern of a typical ARD outbreak at a training camp is depicted in Fig. 1. Adenovirus infections began to occur during the second week of training. Viral isolation attempts were performed at weekly intervals and yielded positive results from 37 of the 48 men (77%). Of the remainder, five had type-specific serum antibody at the time of first sampling and did not develop the infection, and six men showed rises in antibody titers, but without illness. Thus, of the susceptible subjects, all responded either by shedding virus or with antibody production. Twenty-seven of the infections were associated with febrile illness.

Bacterial studies of the throat and nasopharynx showed that meningococcal carrier rates among recruits increased from 42% upon entry in the Army to a peak of 90% during the 5th week of training. The curve for meningococcal incidence laged about 1 week behind that of adenovirus type 4. We questioned whether adenovirus infections were responsible for the spread of meningococci in a manner analogous to the "cloud baby" spread of staphylococci (2). Sulfonamide-resistant strains of meningococci were initially absent, but accounted for 25 to 30% of strains isolated in the 6th through 8th weeks. Group A streptococci carrier rates were rather stable and at a low level during the period of observation. (The excess cases shown in Fig. 1 in the final 2 weeks were associated with nontypable strains.) In the population under study, then, there were at least three different respiratory pathogens, each of which appeared to have a different pattern of transmission.

These recurring epidemiological features presented an excellent opportunity for the study of microbial transmission. The initial studies were concerned with detection of aerosols of the agents, which might serve as a source of infection. The LVS was employed in order to have maximal sensitivity of detection.

LVS STUDIES

In January 1966, during a period when attack rates were high, attempts were made to sample air in the vicinity of ill recruits. A number of patients were studied individually in a hospital room of 1,440 ft³ capacity. Attempts were made to isolate adenovirus type 4 and meningococci from throat gargles and throat swabs, respectively, and from the collecting fluid of the LVS.

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In one such study, the patient was in the room for 10 min coughing frequently, before sampling began. A nasopharyngeal swab sample was found to be positive for group B meningococci, and a throat wash was positive for adenovirus type 4. In 5 min of sampling, a total of 1,785 ft³ of air was drawn through the LVS, and the particulate content was collected in a total of 180 ml of sampling fluid. One group B meningococcal cell was recovered for every 99 ft³ of air, and 1 adenovirus unit per 277 ft³ of air. The latter unit was a tissue-culture infective dose employing 1 ml of sampling fluid as inoculum.

Several attempts at sampling for adenovirus type 4 in barracks were made in training companies in which epidemic disease was beginning. Samples were collected during early evening when activity was at a peak, and again later after "lights out" when recruits were in bed. Results to date are incomplete. Data on adenovirus type 4 recoveries in two trials, however, are given in Table 1.

**DISCUSSION AND CONCLUSIONS**

These examples indicate that the LVS can provide bacterial and viral isolations from air collected in field situations. Meningococci were found in a concentration of one viable particle per 100 ft³ of air, whereas with adenoviruses one tissue culture infective dose was found in 300 to 3,000 ft³ of air. Although the results presented above can only be considered as preliminary data, they do indicate the need for sampling large volumes of air in studies of naturally produced aerosols. It is readily apparent that an all glass impinger, operating at 12.5 liters per min (6), is inadequate for collecting such low concentrations. These results may explain our failure in the past to detect infective particles in epidemiological sampling with an all glass impinger (1).

**Table 1. Results of air sampling for adenovirus type 4 in barracks**

<table>
<thead>
<tr>
<th>Trial no.</th>
<th>Activity</th>
<th>Vol. of air sampled (ft³)</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>15 men making beds, coughing frequently</td>
<td>6,700</td>
<td>1 tissue culture infective unit per 920 ft³</td>
</tr>
<tr>
<td>32</td>
<td>15 men in bed, coughing frequently</td>
<td>5,700</td>
<td>1 tissue culture infective unit per 2,820 ft³</td>
</tr>
</tbody>
</table>

*Room size, 13,347 ft³.
*Infected tissue culture after inoculation of 1 ml of sampler collecting fluid.

The experiments provide some of the information that Morton (3) had in mind in 1963 when he proposed four "postulates" relating to the epidemiology of airborne infection. They were as follows: (i) one must demonstrate the presence of airborne viable infective organisms; (ii) one must measure concentrations and particle sizes; (iii) one must demonstrate experimentally that concentrations and particles of this sort can cause infection; and (iv) one ought to show directly where the particles have come from. The present experiments show that the LVS can recover airborne, viable organisms at very low concentrations in natural aerosols. These studies have not demonstrated infectivity for man of the organisms collected, nor have they proved the source of the organisms.

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**LITERATURE CITED**