THE DISTRIBUTION OF FRIEDLÄNDER'S BACILLI OF DIFFERENT TYPES

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In 1926 (1), a number of strains of Friedländer's bacillus were classified by the immunological reactions of agglutination, agglutinin adsorption and passive protection against infection, into three specific types, which were arbitrarily designated as Types A, B, and C. The strains falling into the specific types comprised the great majority of those studied, and the remaining cultures which were found to differ serologically from each other and from the specific types were included in a heterogeneous group called Group X. The distinctions in type were referable to the presence of a specific carbohydrate in the capsular material. The carbohydrate (2), or soluble specific substance, was shown to be chemically different for each of the three types.

Cultures of Friedländer's bacillus have been collected in the meantime in order to study the relative frequency and distribution of the organism of various immunological types.

EXPERIMENTAL

In the present survey a total of 80 strains have been isolated from a variety of disease conditions; in most instances the organisms were considered to be the inciting agent of the disease, in other cases secondary invaders. All the organisms studied were encapsulated, nonmotile, non-spore-bearing, Gram negative rods with the cultural characteristics usually attributed to Friedländer's bacillus. In each instance the serological type was determined by the agglutination of live young cultures (4 to 6 hours) in type-specific sera.

The fermentation of carbohydrates by the different strains was also studied to determine possible serological and biochemical relationships.

The Frequency of Occurrence of Friedländer's Bacilli of the Different Specific Types.—In Table I is given the relative number of strains of the different types isolated from disease. It is seen that of the 80 strains, about 75 per cent fall in one or other of the three specific types. To Type A, belong 42 of the strains (52 per cent); to Type B, 12 (15 per cent); to Type C, 7 (9 per cent). Group X includes 19 (24 per cent) of the cultures. It is interesting to compare these figures with those obtained from the original study (1) of 30 strains. At that time, it was found that 50 per cent of the strains were of Type A, 20 per cent of Type B, 10 per cent of Type C, and 20 per cent belonged in Group X.

The Incidence of the Various Specific Types in Different Diseases.—This is shown in Table II. Most of the strains studied were isolated from cases of pneumonia in man. Of the strains isolated from this

TABLE I

The Distribution of Specific Types of Friedländer's Bacillus

Total number of strains studied	Distribution by types			Group X
	Type A	Type B	Type C	
80	42	12	7	19

source about 75 per cent were of Type A. In the original study (1) it was found that about 70 per cent of the total strains associated with pneumonia belonged to Type A. Most of the Type A strains were isolated from human cases where the majority of Type B strains were isolated from animals. The organisms of Group X were obtained from a variety of conditions in animals and man.

The Specific Precipitin Reaction in the Urine in Pneumonia.—In a preceding paper (3) it was shown that rabbits experimentally infected with Friedländer's bacillus eliminate the soluble specific substance through the kidney, and that the urine of infected animals may give a precipitation reaction in the corresponding type-specific serum. Blake (4) first demonstrated the presence of a positive precipitin reaction in a case of pneumonia in man due to Friedländer's bacilli. Recently in a case of pneumonia in the Hospital of The Rockefeller Institute, due to Friedländer's bacillus, the opportunity was offered

for studying the type-specific precipitin reaction in the urine. On the day of admission, which was the second day of the disease, Friedländer's bacillus Type A was isolated both from the blood and sputum, and the presence of the soluble specific substance was demonstrated in the urine by a type-specific precipitation reaction which was positive even when the urine was diluted sixteen times. On the following

TABLE II

The Incidence of the Various Types of Friedländer's Bacillus in Different Diseases

Type	Human pneumonia	Throat	Liver abscess	Animal source	Miscellaneous
Type A (42 strains)	33	3	1	Guinea pig—2 (not pneumonia) (fatal abscess)	Cystitis—1 Adenoid tissue—2
Type B (12 strains)	2	1	1	Guinea-pig—5 (pneumonia) Mare—2 (G. U. infections)	Feces—1 (colitis)
Type C (7 strains)	3	0	0		Antrum—1 (sinusitis) Nose—1 (sinusitis) Unknown—2
Group X (19 strains)	7	2	1	Guinea-pigs—2 (not pneumonia) (fatal abscess)	Sputum—2 (not pneumonia) Cystitis—3 Lung abscess—1 Feces—1 (Pellagra)

day the disease terminated fatally and this day the precipitation reaction was positive when the urine was diluted 1:64.

The Fermentation of Carbohydrates by Friedländer's Bacilli of the Different Types.—The fermentation reactions of bacteria of the *Encapsulatus* group have been studied by a number of workers, but the results have been contradictory and confusing. While certain authors have found that Friedländer's bacillus ferments lactose with the formation of acid and gas (5, 6, 7, 8) or of acid alone (9, 10, 11, 12), other writers (13, 14, 15) have observed that it does not ferment

lactose. Still other authors (16, 17, 18, 19) state that different strains may vary in their ability to ferment lactose, and it is the opinion of these authors that the fermentation reactions of the bacteria of the

TABLE III

The Fermentation Reactions of Friedländer's Bacillus of the Different Specific Types

Friedländer bacilli		Reactions in				
Type	Number of strains	Dextrose	Lactose	Sucrose	Maltose	Mannitol
A	30	AG	AG	AG	AG	AG
B	8					
C	3					
Group X	8					
A	9					
B	None	AG	Negative	AG	AG	AG
C	1					
Group X	1					
A	2					
B	2	A	A	A	A	A
C	None					
X	5					
A	4					
B	None	A	Negative	A	A	A
C	None					
X	None					
X	1	AG	AG	Negative	AG	Negative
X	1	A	Negative	Negative	Negative	Negative
X	1	A	Negative	Negative	AG	Negative

A indicates presence of acid.
AG indicates presence of acid and gas.
Negative indicates absence of acid and gas.

Encapsulatus group are too inconstant to be of value in classification or identification.

It seemed, however, important to study again this question with reference to the specific types of organism employed in making the tests.

Five carbohydrates (dextrose, lactose, sucrose, maltose and mannitol) were employed, since earlier observations indicated that these five offered the greatest possibilities for use in differentiation. Samples of meat extract broth containing 1 per cent of the respective carbohydrates were inoculated, and the final readings were made after an incubation period of 7 days.

The results of this study are given in Table III. It is seen that the majority of the strains ferment all 5 carbohydrates with the formation of acid and gas. There is, however, a great variability in the fermentative activities of the different strains, and it is obvious that a classification of Friedländer's bacilli on the basis of fermentation activity is of little value. Furthermore, the fermentation reactions do not aid in the identification of the specific types. It is interesting to note, nevertheless, that of 15 strains which form neither acid nor gas in lactose, 13 are of Type A. In other words, the inability to ferment lactose is most characteristic of Type A cultures. Of further interest is the fact that the strains of Group X show the greatest variability in the fermentation of carbohydrates.

DISCUSSION

The present communication records the distribution of Friedländer's bacilli of the different specific types in disease. It was found that most of the Type A strains are obtained from human cases and the majority of them from cases of pneumonia. On the other hand, the greatest number of strains of Type B are derived from animal sources, while Group X contains organisms isolated from the greatest variety of diseases. In this connection, it should be pointed out that in confirming the existence of specific types among the Friedländer bacilli, Edwards (18, 19) characterizes his Type I (corresponding to Type B) as the animal type, and Type II (corresponding to Type A) as the human type. Edwards (19) also shows that certain strains of *Bacterium aerogenes* are serologically identical with Friedländer's bacilli. This is not surprising, however, when it is recalled that Avery, Heidelberger and Goebel (20) had previously demonstrated the immunological similarity of Type B Friedländer's bacillus to the more widely remote species, Pneumococcus Type II.

It has been possible to confirm Blake's observations on the occur-

rence of a specific precipitin reaction in the urine during the course of pneumonia due to Friedländer's bacillus. Dochez and Avery (21), also demonstrated during their original studies on the soluble specific substance of Pneumococcus that the specific urine precipitation tests in immune sera offered a procedure of diagnostic as well as prognostic importance.

A study of the fermentation reactions of Friedländer's bacillus confirms an earlier opinion (17) that a classification based on these reactions possesses little value. Fitzgerald (16) previously and Edwards (18, 19) more recently reached similar conclusions. In the present study, it was not possible to show any constant relationship between serological reactions and biochemical activity as measured by the fermentation of carbohydrates, although it was found that among the strains of all types there is a much greater tendency for Type A strains not to form acid or gas from lactose.

SUMMARY AND CONCLUSIONS

In a study of the distribution of the specific types of Friedländer's bacillus, it is shown that: (1) Of 80 strains 52 per cent belong to Type A, 15 per cent to Type B, 9 per cent to Type C, and 24 per cent to Group X. (2) Type A contains for the most part strains derived from diseases of man and more than 70 per cent are associated with pneumonia in man. (3) Type B includes the greatest number of strains from animal sources, while the heterogeneous strains comprising Group X come from the greatest variety of diseases.

It was demonstrated that in a patient suffering with pneumonia due to Friedländer's bacillus (Type A), a specific precipitin reaction of the urine occurred in the corresponding (Type A) immune serum.

A study of the sugar fermentation reactions of Friedländer's bacillus shows that (1) there is no correlation between serological type and fermentative activity; (2) the fermentation reactions are variable and therefore not reliable for distinguishing Friedländer's bacillus from closely allied organisms; (3) the strains of Group X show the greatest variation in fermentation, and (4) of 15 strains unable to ferment lactose, 13 belong to Type A.

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