NOTES

Characterization of Neisseria gonorrhoeae Reference Strains Used in Development of Serologic Classification Systems

GRACIA M. EVINS* AND JOAN S. KNAPP

Bacterial Diseases Division1 and Sexually Transmitted Diseases Laboratory Program,2 Center for Infectious Diseases, Centers for Disease Control, Atlanta, Georgia 30333

Received 8 July 1987/Accepted 15 October 1987

Certain strains of Neisseria gonorrhoeae have been used by numerous investigators to develop serologic classification systems. Some of these strains have been used by investigators to study gonococcal virulence. A reference consisting of strain classification by auxotype and serovar, a strain history, and a selected bibliography are provided cohesively.

It is not uncommon for investigators working with the same organism to exchange strains and, in some instances, give them different designations that prevail over the original names. When we reviewed the literature for strains of Neisseria gonorrhoeae that were used to develop various serologic classification systems, we found that some strains were repeatedly used. Frequently, strains were exchanged by investigators and not obtained from the original source. Strain numbers in some published studies contained typographical errors, which have confused readers.

In addition, we typed strains of N. gonorrhoeae labeled F62 that had been provided by different investigators and found that these strains were not identical. This observation indicates the need for a reference against which investigators can confirm the identity of isolates.

We characterized, by auxotype and serovar, reference strains that have been used to develop serologic classification systems and to study gonococcal virulence. In addition, we have provided a strain history and references.

We cited most but not all publications naming strains used in serologic classification studies of N. gonorrhoeae since 1966 (Table 1). One should also recognize that some of the strains may have been used in more published studies than those cited but could not be identified because they were not specifically named. Some information not contained in publications was available from records in the Neisseria Reference Laboratory (NRL) at the University of Washington, Seattle.

One strain, F62, has been used more extensively than many others in studies of gonococcal virulence. Sandström and Danielsson (55) received strain F62 from three sources, namely, T. M. Buchanan, K. H. Wong, and K. K. Holmes,
<table>
<thead>
<tr>
<th>Acid polysaccharide serogroup&lt;sup&gt;a&lt;/sup&gt;</th>
<th>MOMP class&lt;sup&gt;b&lt;/sup&gt;</th>
<th>POMP serotype&lt;sup&gt;c&lt;/sup&gt;</th>
<th>MIF subtype&lt;sup&gt;d&lt;/sup&gt;</th>
<th>W sero-group&lt;sup&gt;e&lt;/sup&gt;</th>
<th>Auxotype&lt;sup&gt;f&lt;/sup&gt;</th>
<th>Serovar&lt;sup&gt;g&lt;/sup&gt;</th>
<th>NRL no.</th>
<th>Source of strain&lt;sup&gt;h&lt;/sup&gt;</th>
<th>Additional information and references</th>
</tr>
</thead>
<tbody>
<tr>
<td>*A-1</td>
<td>Pro</td>
<td>B</td>
<td></td>
<td></td>
<td>Pro</td>
<td>Pro</td>
<td>7926</td>
<td>KJ, A-1/F62 - DK, F62 (29)</td>
<td>Isolated from urethra of female in 1962 in Atlanta, Ga.: F of F-62 is &quot;female&quot; (DK); also called f (7, 69, 70); used by DK to show virulence genetically linked to colonial variation (32) (7, 9, 11-13, 19-21, 25, 26, 29-32, 40, 43-45, 47-49, 53, 55, 57, 59-70)</td>
</tr>
<tr>
<td>*N-10</td>
<td>Arg</td>
<td>Arg</td>
<td></td>
<td></td>
<td>Arg</td>
<td>Arg</td>
<td>5042</td>
<td>A fr, d64351</td>
<td>13, 16-18, 29, 51, 53-55, 65</td>
</tr>
<tr>
<td>*S-12</td>
<td>Pro</td>
<td>Proto</td>
<td></td>
<td></td>
<td>Proto</td>
<td>Proto</td>
<td>5091</td>
<td>PP, Eth55</td>
<td>13, 17, 18, 24, 27, 51, 53, 55, 65</td>
</tr>
</tbody>
</table>

*Continued on following page*
<table>
<thead>
<tr>
<th>Acid polysaccharide serogroup</th>
<th>MOMP class</th>
<th>POMP serotype</th>
<th>MIF subtype</th>
<th>W serogroup</th>
<th>Auxotype</th>
<th>Serovar</th>
<th>NRL no.</th>
<th>Source of strain</th>
<th>Additional information and references</th>
</tr>
</thead>
<tbody>
<tr>
<td>*5</td>
<td>B3</td>
<td>II (53)</td>
<td>Proto</td>
<td>IB-3</td>
<td>5767</td>
<td>TB, NRL 5767/M (13) · RA, M (14)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*6</td>
<td>II (53)</td>
<td>Proto</td>
<td>IB-3</td>
<td>8035</td>
<td>TB, NRL 8035/99 (13) · ?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*7</td>
<td>B2</td>
<td>II</td>
<td>Pro</td>
<td>IB-1</td>
<td>5766</td>
<td>TB, NRL 5766/B (13) · RA, B (14)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*A1</td>
<td>I</td>
<td>Pro</td>
<td>IA-6</td>
<td>4286</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*A2</td>
<td>I</td>
<td>AHU</td>
<td>IA-1</td>
<td>1859</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*A3</td>
<td>I</td>
<td>AHU</td>
<td>IA-1</td>
<td>1567</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*B2</td>
<td>II (53)</td>
<td>Proto</td>
<td>IB-1</td>
<td>5288</td>
<td>DK, no. 9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*B3</td>
<td>II</td>
<td>Pro</td>
<td>IB-1</td>
<td>5001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*C1</td>
<td>III (53)</td>
<td>Pro</td>
<td>IB-4</td>
<td>5016</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*C2</td>
<td>III</td>
<td>Pro</td>
<td>IB-4</td>
<td>1955</td>
<td>Met IA-9 5029 AR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GE, GC340/V1 · RA, GC340/V1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CVI (chimpanzee-virulent strain no. 1) was isolated in Atlanta, Ga., from the urethra of chimpanzee named Mel; isolate used to inoculate Mel was from urethral exudate of male patient (6) (6, 11, 13, 14, 35, 50, 56, 65, 68) 12, 13, 20, 53, 64, 65

CVII (chimpanzee-virulent strain no. 2) was isolated in Atlanta, Ga., from the urethra of chimpanzee named Black; isolate used to inoculate Black was from urethral exudate of male patient (6) (6, 11–15, 21, 53, 55, 58, 65, 68)

Isolated in the Philippines (68) (18, 53, 55, 65, 68)

Isolated in Seattle, Wash. (68) (18, 53, 55, 65)

Isolated in Seattle, Wash., from patient with DGI (68); grows poorly (18, 53, 55, 65, 68)

Isolated in 1972 from cervix of patient in Atlanta, Ga. (DK); also called CDC no. 9 (68), this strain is not NRL 5029 as stated in reference 56; NRL 5029 was isolated in Denmark (68); strain 9 was found to have an antigenic moiety or moieties common to a diverse group of gonococcal strains (46) (18, 46, 53, 55, 56, 65, 68)

Isolated in 1978 from genital source in Atlanta, Ga.; distinct immunotype with high capacity to induce immunity in mice and guinea pigs to a broad spectrum of heterologous strains (70, 71)

Continued on following page
TABLE 1—Continued

<table>
<thead>
<tr>
<th>Acid polysaccharide serogroup&lt;sup&gt;a&lt;/sup&gt;</th>
<th>MOMP class&lt;sup&gt;c&lt;/sup&gt;</th>
<th>POMP serotype&lt;sup&gt;c&lt;/sup&gt;</th>
<th>MIF subtype&lt;sup&gt;c&lt;/sup&gt;</th>
<th>W serogroup&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Auxotype&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Serovar&lt;sup&gt;c&lt;/sup&gt;</th>
<th>NRL no.</th>
<th>Source of strain&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Additional information and references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pro</td>
<td>IA-1</td>
<td>37717</td>
<td>GE, GC1931/V2 · RA, GC1931/V2</td>
<td>Isolated in 1978 from a genital source in Atlanta, Ga.; distinct immunotype with high capacity to induce immunity (70, 71)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pro</td>
<td>IA-6</td>
<td>37720</td>
<td>GE, 2686 · RA, 2686</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pro</td>
<td>IA-5</td>
<td>8041</td>
<td>TB, 2686 · DK, 2686 (14)</td>
<td>Isolated in 1972 in Atlanta, Ga., from urethra (DK); also called 2686/g (7), N001 (28), and CA (chimpanzee avirulent [6]) (5–7, 10, 14, 15, 20, 28, 29, 41, 42, 55, 64, 69, 70)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Abbreviations: MOMP, major outer membrane protein; POMP, principal outer membrane protein; MIF, microimmunofluorescence; Proto, prototrophic; AHU, requires arginine, hypoxanthine, and uracil; Pro, proline requiring; Arg, arginine requiring; Met, methionine requiring; RA, Robert Arko, TB, Tom Buchanan; GE, Gracia Evins; KJ, Kenneth Johnston; DK, Douglas Kellogg; WM, William McCormack; PP, Peter Perine; AR, Alice Reyin; ES, Eric Sandström; Unc, unclassified; DGI, disseminated gonococcal infection; ELISA, enzyme-linked immunosorbent assay.

<sup>b</sup> Asterisks denote the reference strains of the particular classification systems; unless other references are given, the information in these columns was obtained from the references given in the footnotes through h. In columns 6 and 7, the information given is from the authors’ testing unless other references are given.

<sup>c</sup> The strain pedigree given in the following manner: TB, NRL 8687 · MA, 1342 indicates that M. Apicella supplied strain 1342 to T. Buchanan, who submitted the strain to the NRL and subsequently used the NRL designation in his publications.

<sup>d</sup> Crude extracts of antigen were made by alkaline hydrolysis and tested in a hemagglutination inhibition system by the method of Apicella et al. (2, 4).

<sup>e</sup> Major outer membrane protein antigens were determined by electrophoresis and immunodiffusion by the method of Johnston et al. (28).

<sup>f</sup> Principal outer membrane protein antigens were determined in an enzyme-linked immunosorbent assay by the method of Buchanan and Hildebrandt (13).

<sup>g</sup> Microimmunofluorescence subtypes were determined by the method of Wang et al. (66). Strains W-16, D-4, and V-15 could not be classified in the microimmunofluorescence system according to a personal communication from Wong to Sandström (55).

<sup>h</sup> W serogroups were determined by coagglutination, by the method of Sandström and Danielsson (55).

<sup>i</sup> Auxotypes (nutritional requirements for growth) were determined by the method of Knapp et al. (33, 34).

<sup>j</sup> Serovars were determined by coagglutination with monoclonal antibodies by the method of Tam et al. (65).

<sup>k</sup> 712 was originally AHU but subsequently lost its requirement for uracil.

and reported that the strain obtained from Wong gave different results from the other two strains. Further, the two similar strains F62 reacted similarly to strain 2686, also received from K. H. Wong (55). Johnston et al. (29) received strains F62 and 2686 from D. S. Kellogg, Jr., but reported test results with 2686 only. However, Johnston submitted F62, not 2686, to the NRL as the reference strain for major outer membrane protein class A-1. Sandström and Danielsson (55) received strain 2686 from Johnston as A-1 but submitted strain F62 to the NRL labeled as A-1. We again obtained strain F62 directly from D. S. Kellogg, Jr., in 1985, to determine whether any of the cultures received earlier as F62 were identical to this recently obtained strain. We found that all strains labeled F62 belonged to auxotype-serovar class Pro/IB-7, with one exception. A strain labeled F62 and obtained from R. A. Arko belonged to the auxotype-serovar class Pro/IB-3. We were not able to test strain F62 provided to Sandström and Danielsson by K. H. Wong. At the NRL previous testing of strains labeled F62 obtained from other sources showed that they were not strain F62. Strain 2686 from R. J. Arko belonged to auxotype-serovar class Pro/IA-6 (Table 1), whereas strain 2686 from D. S. Kellogg, Jr., belonged to class Pro/IA-5.

The problem of strains incorrectly labeled as F62 and 2686 illustrates the importance of verifying the identity of strains used widely in studies of gonococcal virulence.

LITERATURE CITED


