

# Preimmunization Anti-Pneumococcal Antibody Levels Are Protective in a Majority of Patients With Cystic Fibrosis

Thomas Lahiri, MD, and David A. Waltz, MD

**ABSTRACT.** *Objective.* Although invasive pneumococcal disease is infrequent in cystic fibrosis (CF), it is recommended that all patients with CF receive pneumococcal immunization. As part of a comprehensive program to immunize our clinic population, we obtained preimmunization anti-pneumococcal antibody levels. We hypothesized that the percentage of CF patients without protective levels of anti-pneumococcal antibody levels would be high, as they are exposed to frequent antibiotic therapy that may eradicate organisms before generation of an antibody response.

*Methods.* An observational study of 100 patients with CF, aged 1 to 39 years, was conducted in a regional CF center. Preimmunization anti-pneumococcal antibody levels against 6 serotypes were measured by enzyme-linked immunosorbent assay. Protective antibody levels were defined as >200 ng/mL.

*Results.* A majority of CF patients—61% to 100%, depending on age and serotype—had protective levels of pneumococcal antibody. There was a significant positive correlation between antibody level and age for 5 of the 6 serotypes tested.

*Conclusions.* In contradistinction to our hypothesis, the majority of CF patients have protective preimmunization anti-pneumococcal antibody levels. However, a significant proportion—between 17% and 39%, depending on the serotype—did not exhibit adequate levels. Therefore, we concur with current recommendations for pneumococcal immunization in CF. *Pediatrics* 2001; 108(4). URL: <http://www.pediatrics.org/cgi/content/full/108/4/e62>; *cystic fibrosis, Streptococcus pneumoniae, immunization, ELISA.*

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ABBREVIATIONS. CF, cystic fibrosis; ELISA, enzyme-linked immunosorbent assay; RIA, radioimmunoassay.

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Invasive disease associated with *Streptococcus pneumoniae* remains a serious problem in pediatric populations. Colonization of the respiratory tract by this organism is frequent and occurs in a majority of normal children.<sup>1-3</sup> Individuals who lack the ability to clear encapsulated bacteria, such as those with sickle cell disease,<sup>4</sup> splenectomy,<sup>5</sup> and chronic renal disease,<sup>6</sup> are at increased risk for the development of severe illness. In patients with cystic fibrosis (CF), *S pneumoniae* has been reported as the

fourth most common bacterial organism isolated from sputa—after *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Haemophilus influenzae*—and this prevalence may be underestimated, as *S pneumoniae* is difficult to isolate from sputa often heavily colonized with these other organisms.<sup>7,8</sup> This pneumococcal colonization has been documented to be transient in CF patients even in the absence of antibiotic therapy.<sup>9,10</sup>

CF patients may have an attenuated antibody response to pneumococcus for the following reasons. Many CF patients have been treated, either prophylactically or intermittently, with oral and/or intravenous antibiotics, which usually cover *S pneumoniae*. This action may eradicate organisms before an antibody response can be generated.<sup>11</sup> The abnormal airway secretions in CF and overgrowth of the respiratory epithelium by other organisms, such as *P aeruginosa*, also may impair the ability to recognize and mount an appropriate antibody response to pneumococcus. Indeed, Burns and May<sup>12</sup> reported a decreased incidence of precipitating antibodies to pneumococcus in patients with CF compared with those with chronic bronchitis and control subjects. If true, this decrease in anti-pneumococcal antibodies may place CF patients at risk for severe illness. It has been recommended that all CF patients who are older than 2 years receive the 23-valent polysaccharide immunization against pneumococcus.<sup>3</sup> With the hypothesis that a large proportion of patients would lack protective levels of anti-pneumococcal antibodies for the above-stated reasons and as part of a comprehensive effort to immunize our CF population, we evaluated preimmunization anti-pneumococcal antibody levels.

## METHODS

From 1994 to 1997, we prospectively obtained antibody titers in adult and pediatric CF patients who presented to our clinic for routine ambulatory follow-up and who had no previous history of anti-pneumococcal immunization. Antibody levels to pneumococcal serotypes 3, 14, 19, 23, 26(6B), and 51(7F) were measured by enzyme-linked immunosorbent assay (ELISA).<sup>13</sup> The serum from each patient initially was absorbed with *S pneumoniae* cell wall polysaccharide, which allows removal of antibodies that react with non-type-specific cell wall components of *S pneumoniae*. Samples then were added to a series of wells coated with the appropriate type-specific pneumococcal antigen (American Type Culture Collection, Manassas, VA). Quantitation was accomplished using US standard reference serum 89-SF2 (FDA, Bethesda, MD).

This panel represents the 6 serotypes against which pneumococcal antibody titers are measured routinely at our institution. For serotypes 26 and 51, the Danish designation is given in parentheses.<sup>3</sup> In addition to the pneumococcal serotypes, total serum IgG was measured in all patients.

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A protective level of antibody was defined as  $\geq 200$  ng/mL.<sup>14</sup> For each serotype, a linear regression analysis of the logarithmic transformation of anti-pneumococcal antibody level versus age was performed.<sup>15</sup> A linear regression analysis also was performed for total serum IgG versus age.<sup>15</sup>

This study was reviewed and approved by the Human Subjects Committee of Children's Hospital.

## RESULTS

Pneumococcal antibody levels were obtained from 101 consecutive CF patients who presented to our clinic for routine ambulatory follow-up. This number represented approximately 25% of our total clinic population. There were 43 male and 58 female patients with a median age of 13.2 years (range: 1–39 years). Fourteen patients were younger than 5 years; 1 patient was younger than 2 years.

A majority of CF patients were found to have protective levels of antibody against the 6 pneumococcal serotypes studied (Table 1). Of the 101 patients examined for antibody against serotype 3, 18 had levels below the protective level of 200 ng/mL. For serotypes 14, 19, 23, 26, and 51, the number of patients with antibody levels  $< 200$  ng/mL was 24, 11, 31, 15, and 16, respectively. The individual antibody levels of each patient for each serotype are depicted in Fig 1. As seen in Fig 1, the geometric means of the antibody levels varied between 456 and 870 ng/mL.

There was a positive correlation between total serum IgG levels and age (Fig 2). The number of patients with elevated IgG levels compared with our institution's reference range increases over the second, third, and fourth decades, as was demonstrated previously.<sup>16</sup> As shown in Fig 3, there also was a positive correlation between anti-pneumococcal levels and age for 5 of the 6 serotypes studied: serotypes 14, 19, 23, 26(6B), and 51(7F). Inspection of Fig 3 also reveals that anti-pneumococcal antibody levels below 200 ng/mL most were often seen in younger individuals.

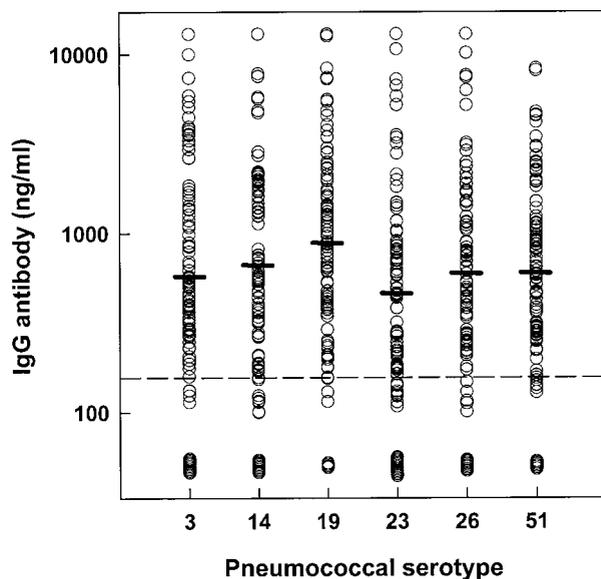
## DISCUSSION

Previous investigations have suggested a specific defect in the CF immune response. Although Abman et al<sup>17</sup> did not detect hypogammaglobulinemia in any of the young CF patients diagnosed through newborn screening, the response to polysaccharide antigen has been questioned. CF patients were found to have a decreased IgG<sub>2</sub> response to *P aeruginosa* lipopolysaccharide and lower levels of polyribosyl-ribitol phosphate antibody (both total and IgG<sub>2</sub> fraction) when compared with healthy control subjects.<sup>18</sup> However, they maintained a normal level of antibody directed against protein antigen, such as teta-

**TABLE 1.** Percentage of CF Patients With Protective Levels of Antibody to Pneumococcal Serotypes\*

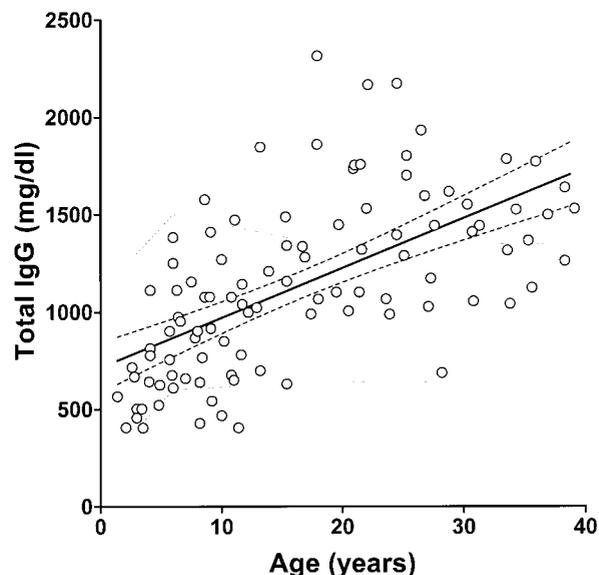
Age (y)	n	Type 3	Type 14	Type 19	Type 23	Type 26	Type 51
1–5	17	76	59	82	59	76	82
6–10	24	67	67	83	67	67	63
11–18	21	86	90	90	71	100	90
$\geq 19$	39	92	87	95	77	92	95
All	101	83	76	91	70	85	84

\* Protective level is defined as  $> 200$  ng/mL.



Geometric mean: 565 649 870 456 586 582

**Fig 1.** Pneumococcal antibody levels in cystic fibrosis patients. The circles represent the individual data points, and the horizontal solid bars represent geometric mean antibody titers. Dashed line represents the cutoff value for protective titers (200 ng/mL).



**Fig 2.** Total serum IgG versus age in 101 CF patients. The dark solid line represents the best fit by regression analysis. The dashed lines represent the 95% confidence intervals ( $r^2 = 0.39$ ,  $P < .0001$ ). The light solid lines represent the upper and lower reference limits in our laboratory.

nus.<sup>18</sup> As CF patients may have an attenuated IgG<sub>2</sub> response to encapsulated organisms and IgG<sub>2</sub> subclass deficiency has been associated with increased susceptibility to pneumococcal disease in children,<sup>19</sup> one might expect to see defective antibody responses to pneumococcus in CF patients. As stated previously, a blunted antibody response to pneumococcal colonization also may be attributed to chronic antibiotic and, in particular, anti-staphylococcal therapy.<sup>11,12</sup> During the period of data collection, approx-

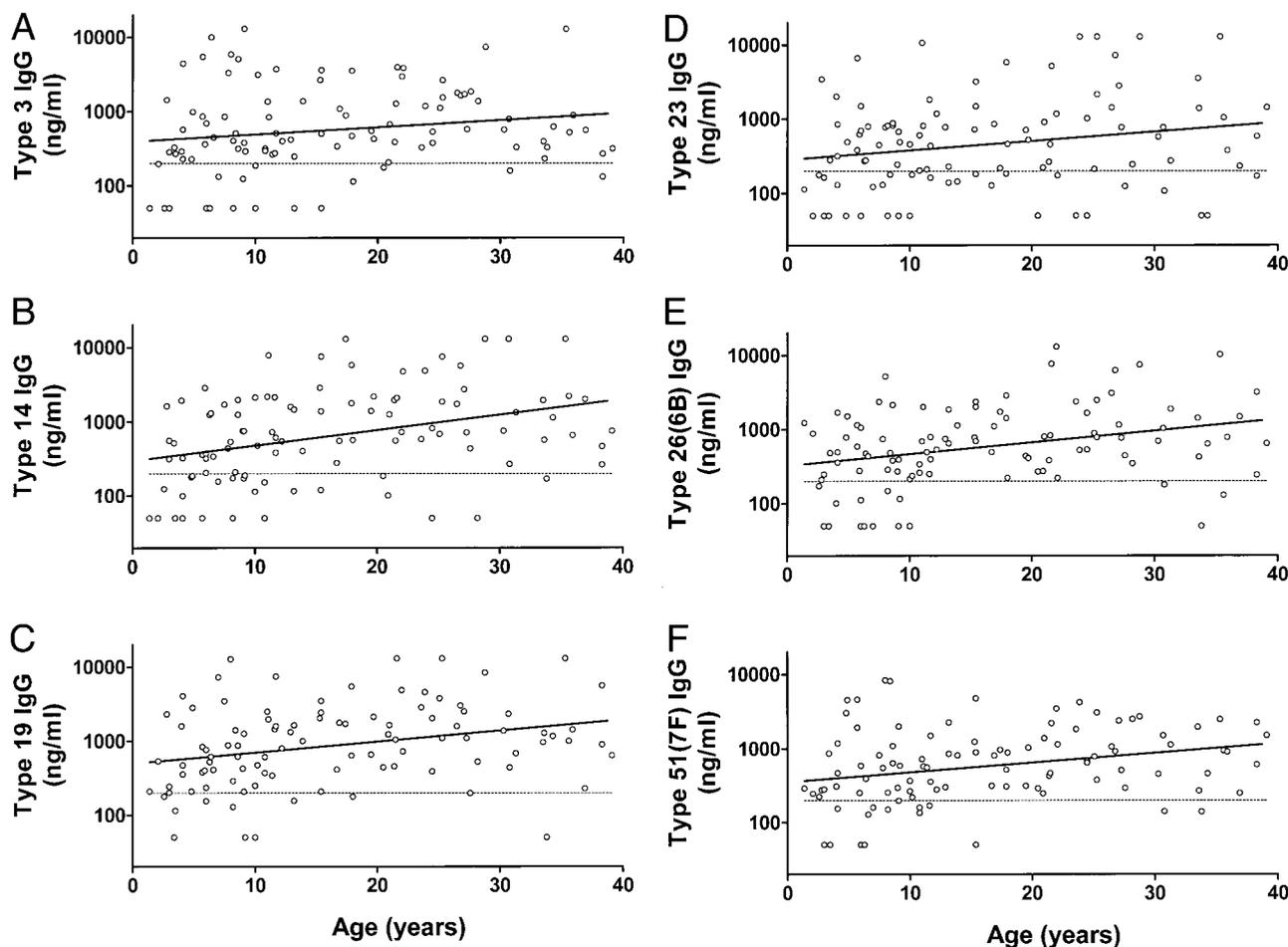


Fig 3. Pneumococcal antibody titers by serotype versus age in 101 CF patients. The solid lines represent the best fit by regression analysis. The dashed lines represent the 95% confidence intervals. A, Serotype 3 ( $r^2 = 0.03$ ,  $P = .08$ ). B, Serotype 14 ( $r^2 = 0.13$ ,  $P = .0003$ ). C, Serotype 19 ( $r^2 = 0.08$ ,  $P = .0042$ ). D, Serotype 23 ( $r^2 = 0.04$ ,  $P = .035$ ). E, Serotype 26(6B) ( $r^2 = 0.10$ ,  $P = .0015$ ). F, Serotype 51(7F) ( $r^2 = 0.07$ ,  $P = .0056$ ).

imately 90% of our CF patients were receiving such therapy (A. Colin, personal communication). For these reasons, we anticipated a blunted response to pneumococcus in our CF population.

Contrary to our original hypothesis, a majority of CF patients had protective levels of anti-pneumococcal antibodies against the 6 serotypes tested. This was true even for young patients. In fact, the percentage of patients with levels  $>200$  ng/mL was similar to that in previously reported healthy control groups. As oropharyngeal colonization rather than lower airway colonization has been suggested to be the major impetus for pneumococcal antibody for-

mation<sup>20</sup> and as we did not examine the incidence of oropharyngeal colonization of *S pneumoniae* in our patients, it is possible that our patients had persistent oropharyngeal pneumococcal carriage and subsequent pneumococcal antibody production despite long-term antibiotic use.

Preimmunization anti-pneumococcal antibody levels were examined by other investigators in both chronically ill and healthy patients. These results are summarized and contrasted to those of the present study in Table 2. Baker et al<sup>21</sup> examined titers to serotype 14 in 44 healthy adults and found only 61% to be immune, using a protective level of 150 ng/mL

TABLE 2. Percentage of Patients With Protective Preimmunization Levels Against Serotypes 3 and 14 in Previous Studies and in the Present Study

Study	Ages	n	% Immune (3)	% Immune (14)	Cutoff Value	Assay	Comment
Baker et al <sup>21</sup> (1980)	24-37	44	N/A	61	150 ng/mL	RIA	Healthy adults
Mufson et al <sup>22</sup> (1987)	Adult	21	67	100	500 ng/mL	RIA	Healthy adults
Musher et al <sup>23</sup> (1993)	18-22	83	28	16	Reactive	ELISA	Military recruits
Musher et al <sup>23</sup> (1993)	23-56	70	34	67	Reactive	ELISA	Healthy controls
Raby et al <sup>14</sup> (1996)	2-17	19	53	37	200 ng/mL	ELISA	Healthy controls
Furth et al <sup>6</sup> (1996)	2-21	41	59	32	150 ng/mL	ELISA	Chronic renal disease
Present study	1-18	62	76	69	200 ng/mL	ELISA	CF
Present study	19-39	39	92	87	200 ng/mL	ELISA	CF
Present study	1-39	101	83	76	200 ng/mL	ELISA	CF

using radioimmunoassay (RIA). A significant proportion of healthy adults were found to be protected against serotypes 3 (67%) and 14 (100%) by Mufson et al,<sup>22</sup> again using RIA, but with a higher defined minimum protective level of 500 ng/mL. In 1993, Musher et al<sup>23</sup> measured antibody titers by ELISA and found that as few as 16% of military recruits had reactive titers against serotype 14. They also demonstrated a low proportion of reactive titers to serotype 3 in both military recruits and other healthy adults.

Preimmunization anti-pneumococcal antibody levels were examined by Raby et al<sup>14</sup> in 19 healthy pediatric patients. The geometric mean titers against serotypes 3 and 14 were 956 ng/mL and 211 ng/mL, respectively. In contrast, we found geometric mean titers of 565 ng/mL and 649 ng/mL, respectively, in CF patients of a similar age. Raby et al<sup>14</sup> found that 53% and 37% had antibody levels >200 ng/mL for serotypes 3 and 14, respectively. Imposing the same age restrictions, our CF patients demonstrated a higher proportion of protective levels of antibody, 72% and 61% for serotypes 3 and 14, respectively. Furth et al<sup>6</sup> investigated anti-pneumococcal antibody levels in children and young adults with chronic renal disease; 59% and 32% of these patients had levels >150 ng/mL by ELISA. Earlier studies on healthy children demonstrated a variable percentage of protected individuals before immunization.<sup>24,25</sup>

Serotypes 3 and 14 have been examined frequently in many previous studies. Close examination of the response to serotypes 3 and 14, therefore, is justified. Type 3 is among the most immunogenic, even in children who are younger than 2 years.<sup>14,26–28</sup> Type 14 has been associated with invasive disease in children, as well as with antibiotic resistance.<sup>29,30</sup> The latter also has been studied in terms of its correlation with type III group B streptococcal antibody in mothers and infants.<sup>21</sup> It is for these reasons that we chose to compare our results for serotypes 3 and 14 with those in the literature.

Several problems arise when attempting to interpret anti-pneumococcal antibody levels. The lack of a uniform standard for defining protective levels is an obvious barrier to interpretation.<sup>27,28</sup> The level of antibody deemed to be protective for this study was 200 ng/mL. Various sources cite levels between 150 and 500 ng/mL as protective.<sup>14,19,28,31,32</sup> Several reports have suggested that anti-pneumococcal titers >200 to 300 ng/mL afford the minimum amount of protection against bacteremia.<sup>24,25,33</sup> These earlier studies used RIA to measure antibody levels. However, RIA overestimates anti-pneumococcal antibody levels because it cannot differentiate between capsular and cell wall polysaccharide.<sup>18</sup> In addition, RIA cannot distinguish different immunoglobulin types, eg, IgG, IgA, and IgM.<sup>34</sup> ELISA has the advantage of measuring only the IgG response. Unless antibody to IgM also is measured, ELISA may underestimate the total level of antibody.<sup>35</sup> Nevertheless, ELISA has become the standard more recently<sup>35</sup> and is the technique used in the present study.

Although pneumococcus has been recovered with regularity from CF sputa, its isolation is hampered by overgrowth with more aggressive organisms.<sup>7,8</sup>

Once *S pneumoniae* grows from either respiratory secretions or blood, the subsequent determination of a particular serotype may be problematic. In addition, colonization of the respiratory tract in CF may be transient.<sup>9,10</sup> For these reasons, it is difficult to correlate anti-pneumococcal antibody levels with the presence of this organism.

If, as our study suggests, the majority of CF patients have protective levels of anti-pneumococcal antibody, then the need for indiscriminate immunization becomes an issue. Exposure to additional polysaccharide antigen potentially could lead to a heightened inflammatory response. This, in turn, could result in additional lung damage, particularly in the presence of chronic colonization. Furthermore, as we measured antibody levels only in 1 child who was younger than 2 years, we cannot make any conclusions concerning the pneumococcal antibody response in infants and very young children with CF. However, we consider the proportion of patients who have nonprotective levels of antibody—7% to 39%, depending on the serotype—as significant enough to warrant immunization. Pending additional study, as the newer conjugated heptavalent vaccine is now available,<sup>36</sup> we believe that this, too, should be given to the infant with CF.

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#### REFERENCES

1. Black S, Shinefield H. Issues and challenges: pneumococcal vaccination in pediatrics. *Pediatr Ann.* 1997;26:355–360
2. Wadwa RP, Feigin RD. Pneumococcal vaccine: an update. *Pediatrics.* 1999;103:1035–1037
3. American Academy of Pediatrics. Pneumococcal Infections. In: Pickering LK, ed. *2000 Red Book: Report of the Committee on Infectious Diseases.* Elk Grove Village, IL: American Academy of Pediatrics; 2000:452, 458–459
4. Vernacchio L, Neufeld EJ, MacDonald K, et al. Combined schedule of 7-valent pneumococcal conjugate vaccine followed by 23-valent pneumococcal vaccine in children and young adults with sickle cell disease. *J Pediatr.* 1998;133:275–278
5. Hosea SW, Burch CG, Brown EJ, Berg RA, Frank MM. Impaired immune response of splenectomized patients to polyvalent pneumococcal vaccine. *Lancet.* 1981;1:804–807
6. Furth SL, Neu AM, Case B, Lederman HM, Steinhoff M, Fivush B. Pneumococcal polysaccharide vaccine in children with chronic renal disease: a prospective study of antibody response and duration. *J Pediatr.* 1996;128:99–101
7. Hoiby N. Epidemiological investigations of the respiratory tract bacteriology in patients with cystic fibrosis. *Acta Pathol Microbiol Scand (B) Microbiol Immunol.* 1974;82:541–550
8. Wong K, Roberts MC, Owens L, Fife M, Smith AL. Selective media for the quantitation of bacteria in cystic fibrosis sputum. *J Med Microbiol.* 1984;17:113–119
9. Hoiby N, Hoff GE, Jensen K, Lund E. Serological types of *Diplococcus pneumoniae* isolated from the respiratory tract of children with cystic fibrosis and children with other diseases. *Scand J Respir Dis.* 1976;57: 37–40
10. Bauernfeind A, Bertele RM, Harms K, et al. Qualitative and quantitative microbiological analysis of sputa of 102 patients with cystic fibrosis. *Infection.* 1987;15:270–277
11. Kilbourn JP. *Streptococcus pneumoniae* in chronic bronchitis. *Lancet.* 1973; 1:1009
12. Burns MW, May JR. Bacterial precipitins in serum of patients with cystic fibrosis. *Lancet.* 1968;1:270–272
13. Siber GR, Priehs C, Madore DV. Standardization of antibody assays for measuring the response to pneumococcal infection and immunization. *Pediatr Infect Dis J.* 1989;8:S84–S91

14. Raby R, Blaiss M, Gross S, Herrod HG. Antibody response to unconjugated *Haemophilus influenzae* b and pneumococcal polysaccharide vaccines in children with recurrent infections. *J Allergy Clin Immunol*. 1996;98:451–459
15. Motulsky H. *Intuitive Biostatistics*. New York: Oxford University Press; 1995
16. Matthews WJ Jr, Williams M, Oliphant B, Geha R, Colten HR. Hypogammaglobulinemia in patients with cystic fibrosis. *N Engl J Med*. 1980;302:245–249
17. Abman SH, Ogle JW, Harbeck RJ, Butler-Simon N, Hammond KB, Accurso FJ. Early bacteriologic, immunologic, and clinical courses of young infants with cystic fibrosis identified by neonatal screening. *J Pediatr*. 1991;119:211–217
18. Moss RB, Hsu YP, Van Eede PH, Van Leeuwen AM, Lewiston NJ, De Lange G. Altered antibody isotype in cystic fibrosis: impaired natural antibody response to polysaccharide antigens. *Pediatr Res*. 1987;22:708–713
19. Sorensen RU, Hidalgo H, Moore C, Leiva LE. Post-immunization pneumococcal antibody titers and IgG subclasses. *Pediatr Pulmonol*. 1996;22:167–173
20. Musher DM, Groover JE, Reichler MR, et al. Emergence of antibody to capsular polysaccharides of *Streptococcus pneumoniae* during outbreaks of pneumonia: association with nasopharyngeal colonization. *Clin Infect Dis*. 1997;24:441–446
21. Baker CJ, Kasper DL, Edwards MS, Schiffman G. Influence of preimmunization antibody levels on the specificity of the immune response to related polysaccharide antigens. *N Engl J Med*. 1980;303:173–178
22. Mufson MA, Krause HE, Schiffman G, Hughey DF. Pneumococcal antibody levels one decade after immunization of healthy adults. *Am J Med Sci*. 1987;293:279–284
23. Musher DM, Groover JE, Rowland JM, et al. Antibody to capsular polysaccharides of *Streptococcus pneumoniae*: prevalence, persistence, and response to revaccination. *Clin Infect Dis*. 1993;17:66–73
24. Lawrence EM, Edwards KM, Schiffman G, Thompson JM, Vaughn WK, Wright PF. Pneumococcal vaccine in normal children. Primary and secondary vaccination. *Am J Dis Child*. 1983;137:846–850
25. Paton JC, Toogood IR, Cockington RA, Hansman D. Antibody response to pneumococcal vaccine in children aged 5 to 15 years. *Am J Dis Child*. 1986;140:135–138
26. Prellner K, Kalm O, Harsten G, Heldrup J, Oxelius VA. Pneumococcal serum antibody concentrations during the first three years of life: a study of otitis-prone and non-otitis-prone children. *Int J Pediatr Otorhinolaryngol*. 1989;17:267–279
27. Go ES, Ballas ZK. Anti-pneumococcal antibody response in normal subjects: a meta-analysis. *J Allergy Clin Immunol*. 1996;98:205–215
28. Hidalgo H, Moore C, Leiva LE, Sorensen RU. Preimmunization and postimmunization pneumococcal antibody titers in children with recurrent infections. *Ann Allergy Asthma Immunol*. 1996;76:341–346
29. Austrian R. Pneumococcal polysaccharide vaccines. *Rev Infect Dis*. 1989;11(suppl 3):S598–S602
30. Lee CJ, Wang TR. Pneumococcal infection and immunization in children. *Crit Rev Microbiol*. 1994;20:1–12
31. Davidson M, Bulkow LR, Grabman J, et al. Immunogenicity of pneumococcal revaccination in patients with chronic disease. *Arch Intern Med*. 1994;154:2209–2214
32. Sorensen RU, Leiva LE, Javier FC 3rd, et al. Influence of age on the response to *Streptococcus pneumoniae* vaccine in patients with recurrent infections and normal immunoglobulin concentrations. *J Allergy Clin Immunol*. 1998;102:215–221
33. Schiffman G. Pneumococcal vaccine: a tool for the evaluation of the B-cell function of the immune system. *Proc Soc Exp Biol Med*. 1983;174:309–315
34. Katz MA, Schiffman G. Comparison of an enzyme-linked immunosorbent assay with radioimmunoassay for the measurement of pneumococcal capsular polysaccharide antibodies. *Mol Immunol*. 1985;22:313–319
35. Konradsen HB, Sorensen UB, Henrichsen J. A modified enzyme-linked immunosorbent assay for measuring type-specific anti-pneumococcal capsular polysaccharide antibodies. *J Immunol Methods*. 1993;164:13–20
36. Rennels MB, Edwards KM, Keyserling HL, et al. Safety and immunogenicity of heptavalent pneumococcal vaccine conjugated to CRM197 in United States infants. *Pediatrics*. 1998;101:604–611

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