ABSTRACT. Palivizumab and Respiratory Syncytial Virus Immune Globulin Intravenous (RSV-IGIV) are licensed by the Food and Drug Administration for use in preventing severe respiratory syncytial virus (RSV) infections in high-risk infants, children younger than 24 months with chronic lung disease (formerly called bronchopulmonary dysplasia), and certain preterm infants. This report summarizes the clinical trial information on which the guidance in the accompanying policy statement for administering RSV prophylaxis to certain children with a history of preterm birth, chronic lung disease, or congenital heart disease is based. On the basis of results of a recently completed clinical trial, palivizumab is appropriate for infants and young children with hemodynamically significant congenital heart disease. RSV-IGIV should not be used in children with hemodynamically significant heart disease. Palivizumab is preferred for most high-risk infants and children because of ease of intramuscular administration. Monthly administration of palivizumab during the RSV season results in a 45% to 55% decrease in the rate of hospitalization attributable to RSV. Because of the large number of infants born after 32 to 35 weeks’ gestation and because of the high cost, immunoprophylaxis should be considered for this category of preterm infants only if 2 or more risk factors are present.

ABBREVIATIONS. RSV, respiratory syncytial virus; RSV-IGIV, Respiratory Syncytial Virus Immune Globulin Intravenous; CLD, chronic lung disease; CHD, congenital heart disease; BPD, bronchopulmonary dysplasia; ICU, intensive care unit.

Currently, there are 2 options for immunoprophylaxis for preventing respiratory syncytial virus (RSV) infection in high-risk infants. Respiratory Syncytial Virus Immune Globulin Intravenous (RSV-IGIV) is a polyclonal hyperimmune globulin prepared from donors selected for having high serum titers of RSV neutralizing antibody. Palivizumab is a humanized murine monoclonal anti-F glycoprotein immunoglobulin G1 antibody with neutralizing and fusion inhibitory activity against RSV. Both preparations have been licensed for prevention of RSV disease in selected infants and children younger than 24 months with chronic lung disease (CLD [formerly called bronchopulmonary dysplasia or BPD]) or with a history of preterm birth (≤35 weeks’ gestation). Only palivizumab is indicated for use in children with hemodynamically significant congenital heart disease (CHD). Choosing which product to use in a patient will depend on the nature of the underlying disease, the preferred route of administration, and other factors. However, immunoprophylaxis should be reserved for use in infants and children at greatest risk of severe RSV infection because of the high cost of this intervention.

BACKGROUND

RSV-IGIV (RespiGam, Massachusetts Public Health Biological Laboratories and MedImmune Inc, Gaithersburg, MD) was licensed by the Food and Drug Administration in January 1996 for prevention of severe RSV lower respiratory tract disease in infants and children younger than 24 months with CLD or a history of preterm birth (≤35 weeks’ gestation). Two randomized, controlled clinical trials demonstrated that monthly RSV-IGIV infusions in high-risk infants resulted in a 41% to 63% decrease in the rate of hospitalization attributable to RSV infection of the lower respiratory tract.1,2 Although this was the first agent with demonstrated efficacy for prophylaxis against RSV infections of the lower respiratory tract, several disadvantages are associated with this product. RSV-IGIV is contraindicated for use in children with hemodynamically significant heart disease, particularly cyanotic heart disease, because of safety concerns detailed later in this report. Further, RSV-IGIV prophylaxis requires intravenous access with a 4-hour infusion each month during the RSV season and infrequently presents problems with volume overload. Immune Globulin Intravenous is known to interfere with the immune response to some live-virus vaccines. Although no issues of contamination with adventitious agents have been encountered, this is a theoretic concern. Finally, shortages of RSV-IGIV occurred during 2 RSV seasons.

In June 1998, the Food and Drug Administration
licensed palivizumab (Synagis, MedImmune, Gaithersburg, MD) for administration as a monthly intra-
muscular injection for the prevention of serious respira-
tory disease caused by RSV in infants and children with a history of preterm birth (≥35 weeks’
gestation) or CLD. Approval was based on results of a randomized, placebo-controlled trial (IMPact-RSV
trial) that demonstrated a 55% decrease in the rate of hospitalization among children with a history of pre-
term birth and/or CLD. A second trial with palivi-
zumab has been completed in infants and children
with hemodynamically significant CHD that demon-
srated safety and a 45% decrease in the rate of RSV-associated hospitalization compared with pla-
cebo recipients. Because palivizumab is not derived
from Human Immune Globulin, it is free of potential
contamination by infectious agents. It can be pro-
duced readily in batch lots, and therefore shortages
are not anticipated. Palivizumab will not interfere
with the immune response to any vaccine in the
immunization schedule. Thus, palivizumab has be-
come the agent of choice for monthly prophylaxis in
most high-risk infants. Recommendations for the use
of both products have been summarized by the
American Academy of Pediatrics. The purpose of
this report is to update clinicians on the appropriate
use of RSV-IGIV and palivizumab on the basis of
data from 5 clinical trials.

CLINICAL STUDIES WITH RSV-IGIV

Results of the first multicenter randomized con-
trolled trial with prophylactic RSV-IGIV in infants
younger than 48 months at enrollment with under-
lying BPD, CHD, or a history of preterm birth (≥35
weeks’ gestation) are shown in Table 1. Eighty-one
infants received RSV-IGIV at a dosage of 750 mg/kg
per infusion, 79 infants received 150 mg/kg, and 89
infants received no infusions. Participants in the in-
tervention arms received monthly RSV-IGIV infu-
sions from mid-November through March or April;
at least 75% of the dose was infused at 85% of the
visits. Infants receiving RSV-IGIV at a dosage of 750
mg/kg had significantly decreased RSV-associated
lower respiratory tract disease severity, frequency of
hospital admissions, and number of days in the hos-
pital or intensive care unit (ICU). Monthly RSV-IGIV
infusions were well tolerated. Serum RSV-neutraliz-
ing antibody titers in infants receiving RSV-IGIV at a
dosage of 750 mg/kg usually exceeded 1:200, a titer
close to the threshold required for protection in ani-
mals. Adverse reactions occurred in 3% of 580 infu-
sions and consisted of mild decreases in oxygen sat-
uration, fever, and mild fluid overload. Six deaths
occurred (3 in the high-dose group and 3 in the
low-dose group); none of the deaths were considered
related to infusion of RSV-IGIV or to RSV infection,
and 3 of the deaths were related to complications of
cardiac surgery. Monthly RSV-IGIV infusions during
the respiratory season resulted in a 63% and 82%
decrease in the rate of RSV-associated hospitalization
and disease severity, respectively. Patients benefit-
ing most were preterm infants and infants with BPD.

Results from a second multicenter randomized al-
bumin placebo-controlled trial (PREVENT study) in
510 infants younger than 24 months with BPD
and/or history of preterm birth are shown in Table 2.
Monthly RSV-IGIV infusions decreased the RSV-as-
ociated illness frequency and severity by 41% to
60%. The decrease in the rate of RSV-associated hos-
pitalization was greater for infants and children with
BPD than for those with history of preterm birth only
(49% vs 20%, respectively; Table 2). Moderate to
severe adverse events consisting of fever, increased
respiratory distress, and rash were no more frequent
in patients receiving RSV-IGIV than in control pa-
tients. These adverse events were easily managed
medically and did not occur with subsequent infu-
sions. Of additional interest, children receiving RSV-
IGIV had a 50% decrease in the rate of hospitaliza-
tion for respiratory illness of any cause. In addition,
recipients of high-dose RSV-IGIV experienced signifi-
cantly fewer episodes of acute otitis media than did
children in the control group.

RSV-IGIV USE IN PATIENTS WITH CHD

Two trials with RSV-IGIV included infants and
children with CHD. As part of the initial National
Institutes of Health-sponsored RSV-IGIV trial, 87
infants with CHD were enrolled among 249 high-risk
subjects. Results of this trial demonstrated an overall
63% decrease in the rate of RSV-associated hospital-
ization compared with the control group, but the
trial was not powered for subgroup analysis, and thus
the results for children with cardiac disease were not
analyzed separately. A second trial con-
ducted in 1994–1995 evaluated 416 children younger
than 48 months with CHD who were assigned to a
group receiving monthly RSV-IGIV or a control

| TABLE 1. | RSV-IGIV Prophylaxis in High-Risk Infants* |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Measurement     | Control | High-Dose RSV-IGIV† | Reduction (%) | P Value |
| 100 children    | 89     | 81               |                  |      |
| RSV lower respiratot tract illness Any   | 22%     | 9%               | 62              | .01 |
| Moderate to severe       | 13%     | 4%               | 73              | .03 |
| Respiratory disease score Hospitalization | 23%     | 1.6              | 32              | .01 |
| Total hospital days per 100 children ICU admission | 144    | 53               | 63              | .02 |
| ICU admission | 7%      | 1%               | 82              | .12 |
| Total ICU days per 100 children | 38     | 1.2              | 97              | .05 |

* Modified from Groothius et al.† 750 mg/kg infusion; low-dose (150 mg/kg) data in 79 patients are not shown.
Results showed a trend in RSV disease prevention that did not reach statistical significance. Interpretation of results in the second study was confounded by an unexplained difference in randomization between treatment and control groups, resulting in a significantly higher proportion of children with cyanotic CHD in the treatment group than in the control group. In both trials, an unexpected increase in surgically related adverse events, including mortality, in RSV-IGIV recipients occurred. Although the precise explanation for the increase in mortality in infants with cyanotic heart disease is unclear, it may have been caused by an alteration in blood viscosity after administration of RSV-IGIV to patients with an elevated hematocrit concentration. As a consequence of the concerns raised by these studies, RSV-IGIV is contraindicated for use in infants with severe CHD.

**CLINICAL STUDIES OF EFFICACY OF PALIVIZUMAB**

**Primary Analysis**

Two randomized, placebo-controlled trials with palivizumab have demonstrated safety and efficacy in high-risk infants and children. In the IMPACT-RSV trial, 1502 infants were enrolled in a multicenter, double-blind, randomized clinical trial of palivizumab (2:1 randomization, treated versus placebo group). Beginning at the onset of the RSV season, 5 intramuscular injections (15 mg/kg) of palivizumab or placebo were administered at 30-day intervals. This dose was selected to maintain serum concentrations of palivizumab ≥30 μg/mL, a concentration that decreases pulmonary RSV replication in the cotton rat model by >100-fold. Children eligible for participation in the clinical trial were younger than 24 months with CLD who required continuing medical therapy (supplemental oxygen, bronchodilator, diuretic, or corticosteroid therapy within the past 6 months) and children born at 35 weeks’ gestation or less who were younger than 6 months at the start of the RSV season. The primary endpoint was efficacy of prophylaxis in decreasing the incidence of hospitalization for RSV infections. Secondary endpoints included the total number of hospital days attributable to RSV and other respiratory viruses, days of moderate to severe lower respiratory tract infection, days of ICU management, days of mechanical ventilation, and incidence of otitis media.

One hundred thirty-nine sites in the United States, Canada, and the United Kingdom participated in the IMPACT-RSV trial. Placebo and prophylaxis groups were matched at study entry for demographics and RSV infection risk factors (ie, preterm birth or CLD). Prophylaxis resulted in a 55% overall decrease in the rate of RSV-related hospitalization (10.6%–4.8% in placebo versus palivizumab recipients, respectively [P < .001]; Table 3). Differences in rates of hospitalization between placebo and prophylaxis groups were similar in different geographic regions. These rates were 10.3% for prophylaxis compared with 4.6% for placebo groups in the United States, 14.7% for prophylaxis compared with 8.8% for placebo groups in Canada, and 10.3% for prophylaxis compared with 3.6% for placebo groups in the United Kingdom.

The number of days of hospitalization for RSV infection per 100 children was decreased from 62.6 days of ICU management, days of mechanical ventilation, and incidence of otitis media.

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The number of days of hospitalization for RSV infection per 100 children was decreased from 62.6 days of moderate to severe lower respiratory tract infection, days of ICU management, days of mechanical ventilation, and incidence of otitis media.

Differences in injection-related adverse events were not significant. Overall, the development of erythema, pain, and induration at the site of intramuscular injection occurred in 1.8% of placebo recipients and in 2.7% of infants receiving palivizumab. There were no significant differences in adverse event rates or in the appearance of antibodies to the monoclonal antibody.
Subgroup Analysis

Palivizumab decreased the severity of clinical illness in all subgroups evaluated (Table 4). Preterm infants without CLD had an overall 78% decrease in rate of hospitalization (8.1% in the placebo group vs 2.0% in the palivizumab group \( P < .001 \)). Preterm infants with CLD had a 39% decrease in rate of hospitalization (12.8% in the placebo group vs 7.9% in the palivizumab group \( P = .038 \)). In a retrospective subgroup analysis, a decrease in the rate of RSV-associated hospitalization from 10.0% in the placebo group to 1.8% in the palivizumab group was noted for children born between 32 and 35 weeks’ gestation who did not have CLD (82% decrease \( P = .001 \)).

CARDIAC TRIAL

A randomized, double-blind, placebo-controlled trial with palivizumab was conducted between 1998 and 2002 involving 1287 infants and children with hemodynamically significant CHD. Subjects were randomized 1:1 to receive 5 monthly intramuscular injections of palivizumab (15 mg/kg) or placebo and stratified at entry by cardiac lesion to a cyanotic or noncyanotic group. Palivizumab recipients had a 45% decrease in the rate of RSV-related hospitalization (9.7% in the placebo group vs 5.3% in the palivizumab group \( P = .003 \)). There was a 56% decrease in total days of RSV-associated hospitalization per 100 children (\( P = .003 \)) and a 73% decrease in total RSV-associated hospital days with supplemental oxygen per 100 children (\( P = .014 \)). Serious adverse events occurred in 63.1% of placebo recipients and 55.4% of palivizumab recipients (\( P < .005 \)). No serious adverse events were related to palivizumab. There was not a significant difference in deaths between groups (3.7% in placebo recipients vs 3.3% in palivizumab recipients). No deaths were attributed to the study drug. After cardiac bypass surgery, the mean serum palivizumab concentration was decreased by 58%. The results of this study demonstrated safety and efficacy of monthly palivizumab immunoprophylaxis in infants and children with hemodynamically significant CHD.

OVERALL CONSIDERATIONS

A critical aspect of RSV prevention in high-risk infants is the education of parents and other caregivers about the importance of decreasing infants’ exposure to and acquisition of RSV. Preventive measures include eliminating exposure to cigarette smoke and settings where RSV or other respiratory viruses may be transmitted (eg, child care centers). Emphasis on hand hygiene also is important in all settings including the home, especially during periods when contacts of high-risk children have respiratory tract infections or when infants are at risk of

### Table 3

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Placebo (%)</th>
<th>Palivizumab (%)</th>
<th>Reduction (%)</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSV hospitalization</td>
<td>10.6</td>
<td>4.8</td>
<td>55</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>RSV hospitalization days per 100 children</td>
<td>62.6</td>
<td>36.4</td>
<td>42</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>RSV hospital days receiving oxygen per 100 children</td>
<td>50.6</td>
<td>30.3</td>
<td>40</td>
<td>&lt;.001</td>
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<tr>
<td>Incidence of RSV ICU admissions</td>
<td>3.0%</td>
<td>1.3%</td>
<td>57</td>
<td>.026</td>
</tr>
<tr>
<td>ICU days per 100 children</td>
<td>12.7</td>
<td>13.3</td>
<td>—</td>
<td>NS</td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>0.2%</td>
<td>0.7%</td>
<td>—</td>
<td>NS</td>
</tr>
<tr>
<td>Mechanical ventilation, total number of days</td>
<td>1.7</td>
<td>8.4</td>
<td>—</td>
<td>NS</td>
</tr>
<tr>
<td>All respiratory hospitalizations, %</td>
<td>22%</td>
<td>16%</td>
<td>27</td>
<td>.008</td>
</tr>
<tr>
<td>Respiratory hospital days per 100 children</td>
<td>180</td>
<td>124</td>
<td>31</td>
<td>.004</td>
</tr>
<tr>
<td>(includes RSV)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Otitis media</td>
<td>40%</td>
<td>42%</td>
<td>—</td>
<td>NS</td>
</tr>
<tr>
<td>Deaths</td>
<td>1.0%</td>
<td>0.4%</td>
<td>—</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS indicates not significant.

* Includes 3 infants who required prolonged ventilatory support.

### Table 4

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Placebo (%)</th>
<th>Palivizumab (%)</th>
<th>Reduction (%)</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All respiratory hospitalizations</td>
<td>21.8</td>
<td>16.1</td>
<td>26</td>
<td>.008</td>
</tr>
<tr>
<td>RSV hospitalizations</td>
<td>10.6</td>
<td>4.8</td>
<td>55</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Non-RSV hospitalizations</td>
<td>14.4</td>
<td>13.0</td>
<td>—</td>
<td>NS</td>
</tr>
<tr>
<td>All preterm infants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With CLD (( n = 762 ))</td>
<td>12.8</td>
<td>7.9</td>
<td>39</td>
<td>.038</td>
</tr>
<tr>
<td>Without CLD (( n = 740 ))</td>
<td>8.1</td>
<td>1.8</td>
<td>78</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Infants 32–35 weeks’ gestation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All (( n = 373 ))</td>
<td>9.8</td>
<td>2.0</td>
<td>80</td>
<td>.002</td>
</tr>
<tr>
<td>Without CLD (( n = 335 ))</td>
<td>10.0</td>
<td>1.8</td>
<td>82</td>
<td>.001</td>
</tr>
<tr>
<td>Infants &lt;32 weeks’ gestation (( n = 1111 ))</td>
<td>11.0</td>
<td>5.8</td>
<td>47</td>
<td>.008</td>
</tr>
<tr>
<td>Infants &gt;5 kg (( n = 617 ))</td>
<td>10.7</td>
<td>5.2</td>
<td>51</td>
<td>.014</td>
</tr>
<tr>
<td>Infants ≤5 kg (( n = 885 ))</td>
<td>10.5</td>
<td>4.5</td>
<td>57</td>
<td>.001</td>
</tr>
</tbody>
</table>

NS indicates not significant.
exposure to respiratory infections from siblings who are in child care or who attend school.

Both palivizumab and RSV-IGIV have been shown to decrease the risk of severe RSV disease in high-risk infants and children. No direct studies have been conducted to compare the relative efficacy of the 2 interventions. Because of its ease of administration, monthly palivizumab generally is favored over RSV-IGIV (an intramuscular injection vs a 4-hour intravenous infusion).

Limited data are available regarding the use of palivizumab for 2 consecutive seasons. No difference was noted between incidence of adverse events among children who received palivizumab prophylaxis for a second season and children receiving prophylaxis for only 1 season. In addition, limited experience from postmarketing data suggest that adverse events occurring after more than 5 doses in a single season are no different from adverse events occurring after the initial 5 doses.

Postmarketing surveys indicate that the effect of palivizumab prophylaxis on the rate of hospitalization for RSV is similar to that found in controlled clinical trials. Rare cases of severe hypersensitivity reactions (<1 case per 100 000 recipients) have been described after an initial dose as well as after reexposure to palivizumab.

Palivizumab attaches to a well-conserved epitope in the A-antigenic site of the F protein of RSV. Although resistant RSV strains can be generated in laboratory experiments, naturally occurring escape mutants (ie, resistant viruses) to palivizumab have not been identified after the administration of this product. Ongoing surveillance of RSV isolates has failed to identify any decrease in sensitivity to palivizumab.

**COST-BENEFIT ANALYSES**

Several economic analyses of RSV immunoprophylaxis have been published and reviewed. The primary benefit of immunoprophylaxis with either agent is a decrease in the rate of RSV-associated hospitalization. None of the 5 randomized, controlled clinical trials have demonstrated a significant decrease in rate of mortality attributable to RSV infection in infants who receive prophylaxis. Most of the economic analyses fail to demonstrate overall savings in health care dollars because of the high cost if all at-risk children were to receive prophylaxis. Estimates of cost per hospitalization prevented have been inconsistent because of considerable variation in the baseline rate of hospitalization attributable to RSV in different high-risk groups. Other considerations that will influence results include the effect of prophylaxis on outpatient costs and a resolution of the question of whether prevention of RSV infection in infancy decreases wheezing and lower respiratory tract problems later in childhood.

Factors other than degree of prematurity, CHD, and CLD that may influence the decision regarding prophylaxis include presence of other underlying conditions that predispose to respiratory complications (eg, neurologic disease in very low birth weight infants), number of young siblings, child care center attendance, anticipation of cardiac surgery, and distance to and availability of hospital care for severe respiratory illness. For many infants who qualify for the approved indications, risk of hospitalization for serious respiratory illness will be low, and the cost and logistic difficulties associated with prophylaxis may outweigh potential benefits.

**INDICATIONS FOR RSV PROPHYLAXIS**

Detailed recommendations for RSV prophylaxis are available in the accompanying policy statement.
REFERENCES


All technical reports from the American Academy of Pediatrics automatically expire 5 years after publication unless reaffirmed, revised, or retired at or before that time.
Revised Indications for the Use of Palivizumab and Respiratory Syncytial Virus Immune Globulin Intravenous for the Prevention of Respiratory Syncytial Virus Infections

H. Cody Meissner, Sarah S. Long and Committee on Infectious Diseases, and Committee on Fetus and Newborn

Pediatrics 2003;112;1447

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