Vaccines

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infants, measles vaccine is recommended routinely at age 12 to 15 months.[2,79]

Another example is the recommended age of pertussis vaccination. Early infancy is the time of greatest risk of serious complications from naturally occurring pertussis, but infants who are younger than 1 month do not respond as well immunologically to pertussis vaccine as older infants do.[80–83] Initiation of routine immunization with pertussis vaccine is recommended at age 2 months.[84,85] This scheduling represents a compromise between factors affecting the immune response and the epidemiology of the disease necessitating early protection against pertussis.[82,86,87]

Vaccination too early in life also may affect the immune response to subsequent doses of vaccine. For example, neonatal administration of diphtheria and tetanus toxoids (DT) may result in suppression of antibody responses to subsequent doses of Hib conjugate vaccines covalently linked to forms of those toxoids.[88] When children who receive measles vaccine before the age of 1 year are revaccinated, they develop vaccine-induced immunity against disease but may have a somewhat diminished antibody response compared with children vaccinated initially after their first birthday.[89,90]

The recommended routine childhood immunization schedule for infants, children, and adolescents for the United States is revised annually, and is approved by the ACIP, the AAP, and the American Academy of Family Physicians. A vaccine schedule for adults is now available for routine use as well as for immunocompromised and high-risk persons.[91] Recent U.S. vaccination schedules are given in Figures 8–1 and 8–2.[92,93] The most current vaccination schedules are available from the National Immunization Program of the Centers for Disease Control and Prevention website at *www.cdc.gov/nip*. The recommended and minimum ages and recommended and minimum acceptable intervals between doses of vaccines commonly used in the United States are listed in Table 8–3. Other vaccination schedules are discussed in Chapters 53 through 55.

Spacing of Vaccine Doses

Spacing of Multiple Doses of the Same Vaccine

Although administration of one dose of some vaccines may induce a protective antibody response, most vaccines require administration of multiple doses in a primary series for development of immunity. Examples of the former are rubella, yellow fever, and hepatitis A vaccines; examples of the latter are poliovirus, hepatitis B, and pertussis vaccines. In addition, periodic revaccination ("booster doses") with certain vaccines may be necessary to maintain immunity. Examples are typhoid vaccines and tetanus and diphtheria toxoids.

Because of immunologic memory, longer than routinely recommended intervals between doses do not impair the immunologic response to live and inactivated vaccines that require more than one dose to achieve primary immunity. Similarly, delayed administration of recommended booster doses does not adversely affect the antibody response to such doses.[2,5] Thus the interruption of a recommended primary series or an extended lapse between booster doses does not necessitate re-initiation of the entire vaccination series. For example, lengthening the interval between two doses of inactivated poliovirus vaccine (IPV) may increase the antibody response to the second dose.[94,95] In the case of oral typhoid (Ty21a) vaccine, an exception has been proposed. Specifically, if the primary vaccination series is interrupted for longer than 3 weeks, the primary series should be started again (see Chapter 39). A practical question arises when a person fails to complete the full course of immunization with 3–4 doses of Ty21a. Does one need to simply complete the number of doses or must one complete the full schedule? A definitive answer is not available. However, as a rule of thumb, if less than three weeks have passed since the last dose, one may continue to complete the immunization with the missing doses. If more than three weeks have passed, the full series of this well-tolerated vaccine should be administered.

Vaccination providers should strive to adhere as closely as possible to recommended childhood immunization schedules. Clinical studies confirm that recommended ages and intervals between doses of multidose antigens provide optimal protection or have the best evidence of efficacy. Table 8–3 lists recommended intervals between doses of commonly used vaccines.

In certain circumstances, administering doses of a multidose vaccine at shorter than the recommended intervals might be necessary. Examples include when a person is behind schedule and needs to be brought up-to-date as quickly as possible, or in cases of impending international travel. In these situations, an accelerated schedule with intervals between doses shorter than those recommended for routine vaccination can be used. Although the effectiveness of all accelerated schedules has not been evaluated in clinical trials, immune responses with accelerated intervals are likely to induce adequate protection.[5] Accelerated, or minimum, intervals and ages that can be used for scheduling catch-up vaccinations are listed in Table 8–3.

Vaccine doses generally should not be administered at intervals less than these minimum intervals or earlier than the minimum age. Administration of doses of a vaccine at intervals less than the minimum intervals or earlier than the minimum age may result in a reduced immune response with diminished vaccine efficacy and should be avoided.[2,5] Multiple doses of some live vaccines are recommended to stimulate an immune response to different types of the same virus, such as poliovirus types 1, 2, and 3, or to induce immunity in persons who failed to mount an immune response to an earlier dose of vaccine, such as measles.[39,79] These multiple doses constitute a primary vaccination series and are not "booster doses."

Spacing of Different Vaccines

Guidelines for spacing the administration of different vaccines are given in Table 8–4. Inactivated vaccines do not interfere with the immune response to other inactivated vaccines or to live vaccines. An inactivated vaccine can be administered either simultaneously or at any time before or after a different inactivated vaccine or live vaccine.

The possibility that two doses of the same or different live virus vaccines administered within too short an interval